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Date: JUL 27 2017
Refer To: ADEM-17-0178
LAUR: 17-26063
Locates Action No.: n/a

John Kieling, Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

Subject: Completion Report for Regional Aquifer Well R-68

Dear Mr. Kieling:

Enclosed please find two hard copies with electronic files of the Completion Report for Regional Aquifer Well R-68. Monitoring Well R-68 was installed under the September 2016 Groundwater Investigation Work Plan for Consolidated Unit 16-021(c)-99, Including Work Plans for Wells R-68 and R-69. As stated in the fact sheets for R-68 (ADEM-17-0066), the well completion report will be submitted within 150 days of the NMED-complete date of February 27, 2017.

As agreed with your staff in a meeting on July 24, 2017, the types of aquifer property data (e.g. specific capacity) identified in NMED's May 12, 2017 Approval with Modification– Well Completion Report for Chromium Plume Control Interim Measure Wells CrIN-1 through CrIN-5 (AWM) are provided in Appendix E of this well completion report. The presentation and evaluation of these results is consistent with previous well completion reports. Other requirements of the AWM, including evaluation of nearby well pressure response and an updated water table map, will be included in future project-related submittals.

If you have any questions, please contact Stephani Swickley at (505) 606-1628 (sfuller@lanl.gov) or Cheryl Rodriguez at (505) 665-5330 (cheryl.rodriguez@em.doe.gov).

Sincerely,

Bruce Robinson, Program Director
Environmental Remediation Program
Los Alamos National Laboratory

Sincerely,

David S. Rhodes, Director
Office of Quality and Regulatory Compliance
Los Alamos Environmental Management
Field Office

BR/DR/SS:sm

Enclosures: Two hard copies with electronic files – Completion Report for Regional Aquifer Well R-68 (EP2017-0101)

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LA-UR-17-26063
July 2017
EP2017-0101

Completion Report for Regional Aquifer Well R-68

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Associate Directorate for Environmental Management

EP2017-0101

Completion Report for Regional Aquifer Well R-68

July 2017

Responsible project manager:

Printed Name	Signature	Title	Organization	Date
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Responsible LANS representative:

Printed Name	Signature	Title	Organization	Date
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Responsible DOE representative:

Printed Name	Signature	Title	Organization	Date
David S. Rhodes	[signature]	Director	DOE-EM-LA	7-26-2017

EXECUTIVE SUMMARY

This well completion report describes the drilling, well construction, development, aquifer testing, and dedicated sampling system installation for regional aquifer monitoring well R-68, located in Technical Area 09 at Los Alamos National Laboratory, Los Alamos, New Mexico. The R-68 monitoring well is being installed to address the potential contaminant flow path between Cañon de Valle and well R-18. Groundwater chemistry data from this well and from characterization within the vadose zone during drilling will help constrain the nature and extent of perched-intermediate groundwater and contamination in the regional aquifer associated with infiltration along Cañon de Valle. Water-level data from this well will also provide important information for the elevation of the regional water table and groundwater flow direction north of Cañon de Valle.

The R-68 monitoring well borehole was drilled using dual-rotary air-drilling methods. Fluid additives used included potable water and foam. Foam-assisted drilling was used only to a depth of 1224.7 ft below ground surface (bgs). Well R-68 was drilled to a total depth of 1422.8 ft bgs.

The following geologic formations were encountered at R-68: Tshirege Member of the Bandelier Tuff, Cerro Toledo interval, Otowi Member of the Bandelier Tuff, Guaje Pumice Bed of the Otowi Member, and the Puye Formation.

Well R-68 was completed as a single-screen well, allowing evaluation of water quality and water levels within the regional aquifer. The screened interval is set between 1340 ft and 1360.4 ft bgs within the Puye Formation. The static depth to water after well installation was measured at 1325.7 ft bgs.

The well was completed in accordance with the New Mexico Environment Department–approved well design. The well was developed and the regional aquifer groundwater met target water-quality parameters. Aquifer testing indicates that regional aquifer monitoring well R-68 will perform effectively in meeting the planned objectives. A sampling system and transducer were placed within the screened interval, and groundwater sampling at R-68 will be performed as part of the annual Interim Facility-wide Groundwater Monitoring Plan.

CONTENTS

Figures

Tables

Appendixes

Acronyms and Abbreviations

ADEM	Associate Directorate for Environmental Management
amsl	above mean sea level
bgs	below ground surface
Consent Order	Compliance Order on Consent
DO	dissolved oxygen
DTW	depth to water
EES	Earth and Environmental Sciences (Laboratory group)
Eh	oxidation-reduction potential
EPA	Environmental Protection Agency (U.S.)
F	filtered
FD	field duplicate
FTP	field trip blank
gpd	gallons per day
gpm	gallons per minute
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
hp	horsepower
I.D.	inside diameter
LANL	Los Alamos National Laboratory
NAD	North American Datum
NMED	New Mexico Environment Department
NTU	nephelometric turbidity unit
O.D.	outside diameter
ORP	oxidation-reduction potential
PVC	polyvinyl chloride
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
SVOC	semivolatile organic compound
TA	technical area
TD	total depth
TNT	trinitrotoluene
TOC	total organic carbon
UF	unfiltered
VOC	volatile organic compound
WCSF	waste characterization strategy form

1.0 INTRODUCTION

This completion report summarizes borehole drilling, well construction, well development, aquifer testing, and dedicated sampling system installation for regional aquifer monitoring well R-68. The report is prepared in accordance with the guidance in Appendix F, Section II, of the June 2016 Compliance Order on Consent (the Consent Order). The R-68 monitoring well borehole was drilled in accordance with the New Mexico Environment Department– (NMED-) approved drilling work plan (LANL 2016, 601779; NMED 2016, 601855) between January 9 and February 2, 2017, and completed between February 6 and February 27 at Los Alamos National Laboratory (LANL or the Laboratory) for the Associate Directorate for Environmental Management (ADEM).

Well R-68 is located within the Laboratory's Technical Area 09 (TA-09) in Los Alamos County, New Mexico (Figure 1.0-1). Well R-68 was installed to address the potential contaminant flow path between Cañon de Valle and well R-18. Secondary objectives included identifying and establishing water levels in perched-intermediate aquifers, if present, and collecting samples of drill cuttings for lithologic description.

The R-68 borehole was drilled to a total depth (TD) of 1422.8 ft below ground surface (bgs). During drilling, cuttings samples were collected at 5-ft intervals from ground surface to TD. A monitoring well was installed with a screened interval between 1340 ft and 1360.4 ft bgs within the Puye Formation. The depth to water (DTW) of 1325.7 ft bgs was recorded on March 14, after well installation.

Post-installation activities included well development, aquifer testing, surface completion, a geodetic survey, and sampling system installation. Future activities will include site restoration and waste management.

The information presented in this report was compiled from field reports and daily activity summaries. Records, including field reports, field logs, and survey information, are on file at the ADEM Records Processing Facility. This report contains brief descriptions of activities and supporting figures, tables, and appendixes associated with the R-68 project.

2.0 ADMINISTRATIVE PLANNING

The following documents were prepared to guide activities associated with the drilling, installation, and development of regional aquifer well R-68:

- "Groundwater Investigation Work Plan for Consolidated Unit 16-021(c)-99, Including Drilling Work Plans for Wells R-68 and R-69" (LANL 2016, 601779);
- "Field Implementation Plan for Regional Aquifer Well R-68" (TerranearPMC 2016, 602451);
- "IWD [Integrated Work Document] for Drilling and Installation of LANL Wells R-68 and R-69" (TerranearPMC 2016, 602452);
- "Storm Water Pollution Prevention Plan, Regional Wells (R-Wells) Drilling, Los Alamos National Laboratory, Revision 1" (LANL 2014, 601293); and
- "Waste Characterization Strategy Form (WCSF) for Regional Well R-68" (LANL 2016, 601994) and "Amendment #1 to the Waste Characterization Strategy Form (WCSF) for Regional Well R-68 (EP2016-0149)" (LANL 2016, 602000).

3.0 DRILLING ACTIVITIES

This section describes the drilling approach and provides a chronological summary of field activities conducted at monitoring well R-68.

3.1 Drilling Approach

The drilling method, equipment, and drill-casing sizes for the R-68 monitoring well were selected to retain the ability to investigate and case or seal off any perched groundwater encountered above the regional aquifer. Further, the drilling approach ensured that a sufficiently sized drill casing was used to meet the required 2-in.-minimum annular thickness of the filter pack around a 5.88-in.–outside diameter (O.D.) well screen.

Dual-rotary drilling methods using a Foremost DR-24HD drill rig were employed to drill the R-68 borehole. The drill rig was equipped with conventional drilling rods, tricone bits, downhole hammer bits, deck-mounted air compressor, and general drilling equipment. Auxiliary equipment included two Atlas Copco towable air compressors. Four sizes of A53 grade B flush-welded mild carbon-steel casing (18-in. and 16-in.-O.D., and 12-in. and 10-in.–inside diameter [I.D.]) were used for the R-68 project.

The dual-rotary drilling technique at R-68 used filtered compressed air and fluid-assisted air to evacuate cuttings from the borehole during drilling. Drilling fluids, other than air, used in the borehole (all within the vadose zone) included potable water and a mixture of potable water with Baroid AQF-2 foaming agent. The fluids were used to cool the bit and help lift cuttings from the borehole. Use of the foaming agent was terminated at 1224.7 ft bgs, roughly 100 ft above the expected top of the regional aquifer. No additives, other than potable water, were used for drilling below 1224.7 ft bgs. Total amounts of drilling fluids introduced into the borehole are presented in Table 3.1-1.

3.2 Chronological Drilling Activities for the R-68 Well

The DR-24HD drill rig, drilling equipment, and supplies were mobilized to the R-68 drill site on December 21, 2016, and from January 6 to 8, 2017. The equipment and tooling were decontaminated before mobilization to the site. On January 9, following on-site equipment inspections, drilling of the monitoring well borehole began at 1039 h using dual-rotary methods with an 18-in. underreaming hammer bit and 18-in. drill casing.

The 18-in. surface casing was advanced to 55 ft bgs in Unit 4 of the Tshirege Member of the Bandelier Tuff on January 9. Open-hole drilling commenced on January 10 using a 17-in. hammer bit. Drilling proceeded through the Tshirege Member of the Bandelier Tuff, Cerro Toledo interval, the Otowi Member of the Bandelier Tuff, and the Guaje Pumice Bed of the Otowi Member to 810 ft bgs. Laboratory video logs were recorded on January 11 and 12, and Laboratory natural gamma log, induction, and video were recorded on January 14.

Between January 14 and 17, a 16-in. casing string was installed in the open borehole. Beginning on January 18, a 16-in. underreaming hammer bit was used to advance the 16-in. casing through the Puye Formation to 912 ft bgs. A bentonite seal was set from 887.2 ft to 907.5 ft bgs while retracting the 16-in. casing to seal off perched water. The casing was readvanced to 911.8 ft bgs, and the seal was drilled out on January 22. The 16-in. casing shoe was successfully cut the same day at 900.3 ft bgs.

The 18-in. surface casing was removed on January 23. Between January 23 and 26, a 12-in. casing string was installed to a depth of 911 ft bgs. The 12-in. casing string and an underreaming hammer bit were advanced through the Puye Formation to 1225 ft bgs on January 28. A bentonite seal was set from

1202.8 ft to 1222.9 ft bgs while the 12-in. casing was retracted to seal off perched water. The casing was readvanced to 1224.2 ft bgs, and the seal was drilled out on January 29. The 12-in. casing shoe was successfully cut on January 30 at 1219.2 ft bgs.

Between January 30 and February 1, a 10-in. casing string was installed to a depth of 1225 ft bgs. The 10-in. casing string and an underreaming hammer bit were advanced through the Puye Formation to a TD of 1422.8 ft bgs on February 2 at 1323 h. After TD was reached, the 10-in. casing was pulled back 2 ft and water levels were recorded in the borehole. On February 3, a Laboratory natural gamma log was recorded. Two unsuccessful attempts were made to cut the casing shoe on February 3 and 4.

During drilling from January 9 to February 4, field crews worked 24-h shifts, 7 d/wk. Weather delays occurred on January 15 (day shift), January 16 (night shift), January 17 (day shift), January 20 (night shift), and January 21 (day shift).

4.0 SAMPLING ACTIVITIES

This section describes the cuttings and groundwater sampling activities for monitoring well R-68. All sampling activities were conducted in accordance with applicable quality procedures.

4.1 Cuttings Sampling

Cuttings samples were collected from the R-68 monitoring well borehole at 5-ft intervals from ground surface to the TD of 1422.8 ft bgs. At each interval, approximately 500 mL of bulk cuttings was collected by the site geologist from the drilling discharge hose, placed in resealable plastic bags, labeled, and archived in core boxes. Whole rock, +35, and +10 sieve-size fractions were also processed, placed in chip trays, and archived for each 5-ft interval. Radiological control technicians screened the cuttings before they were removed from the site. All screening measurements were below background values. The cuttings samples were delivered to the Laboratory’s archive at the conclusion of drilling activities.

The stratigraphy at well R-68 is summarized in section 5.1, and a detailed lithologic log is presented in Appendix A.

4.2 Water Sampling

Two groundwater-screening samples were collected from the 17-in. open hole before the 16-in. casing was installed. One sample was collected for anions and metals analysis, and one sample was collected for tritium, NMED high explosives suite (NMED HEXP), alkalinity, RDX (hexahydro-1,3,5-trinitro-1,3, 5-triazine), and Earth and Environmental Sciences (EES) 6 tracer analysis. While the 16-in. casing was advanced, five groundwater screening samples were collected for NMED HEXP, RDX, and EES-6 tracer analysis. One groundwater screening sample was collected while advancing the 12-in. casing for RDX, EES-6 tracer, HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine), and trinitrotoluene (TNT) analysis. One groundwater screening sample was collected while the 10-in. casing was advanced for RDX, EES-6 tracer, HMX, and TNT analysis.

Sixteen groundwater-screening samples were collected during development from the pump’s discharge line for RDX analysis, and 10 samples were collected for total organic carbon (TOC) analysis. Seven samples were collected during aquifer testing and analyzed for RDX analysis.

Table 4.2-1 presents a summary of screening samples collected during the R-68 monitoring well installation. The TOC results and field water-quality parameters are presented in Appendix B.

Groundwater characterization samples will be collected from the completed well in accordance with the Consent Order. For the first year, the samples will be analyzed for a full suite of constituents in accordance with the requirements of the Interim Facility-wide Groundwater Monitoring Plan. The analytical results will be included in the appropriate periodic monitoring report issued by the Laboratory. After the first year, the analytical suite and sample frequency at R-68 will be evaluated and presented in the annual Interim Facility-wide Groundwater Monitoring Plan.

5.0 GEOLOGY AND HYDROGEOLOGY

The geologic and hydrogeologic features encountered at R-68 are summarized below. The Laboratory's geology task leader and project site geologist examined cuttings and the natural gamma log to determine geologic contacts and hydrogeologic conditions. Drilling observations and water-level measurements were used to identify groundwater encountered at R-68.

5.1 Stratigraphy

Rock units for the R-68 borehole are presented below in order of youngest to oldest in stratigraphic occurrence. Lithologic descriptions are based on binocular microscope analysis of drill cuttings collected from the discharge hose. Figure 5.1-1 illustrates the stratigraphy at R-68. A detailed lithologic log for R-68 is presented in Appendix A.

Unit 4, Tshirege Member of the Bandelier Tuff, Qbt 4 (0–102 ft bgs)

Unit 4 of the Tshirege Member of the Bandelier Tuff was encountered from 0 to 102 ft bgs. Unit 4 contains large glassy pumice fragments in outcrop that decrease with depth and become devitrified.

Unit 3t, Tshirege Member of the Bandelier Tuff, Qbt 3t (102–135 ft bgs)

The upper part of Unit 3 is further subdivided into Unit 3t (transition) in the western part of the Laboratory. Unit 3t of the Tshirege Member of the Bandelier Tuff was encountered from 102 ft to 135 ft bgs. Unit 3t is moderately to strongly welded crystal-rich tuff.

Unit 3, Tshirege Member of the Bandelier Tuff, Qbt 3 (135–235 ft bgs)

Unit 3 of the Tshirege Member of the Bandelier Tuff was encountered from 135 ft to 235 ft bgs. Unit 3 is a poorly to moderately welded devitrified ash-flow tuff (i.e., ignimbrite) that is crystal-rich, slightly pumiceous and lithic-poor, and exhibits a matrix of fine ash.

Unit 2, Tshirege Member of the Bandelier Tuff, Qbt 2 (235–335 ft bgs)

Unit 2 of the Tshirege Member of the Bandelier Tuff was encountered from 235 ft to 335 ft bgs. Unit 2 represents a moderately to strongly welded devitrified rhyolitic ash-flow tuff (i.e., ignimbrite) composed of abundant quartz and sanidine crystals. Cuttings typically contain abundant fragments of indurated tuff and numerous free quartz and sanidine crystals.

Unit 1v, Tshirege Member of the Bandelier Tuff, Qbt 1v (335–370 ft bgs)

Unit 1v of the Tshirege Member of the Bandelier Tuff was encountered from 335 ft to 370 ft bgs. Unit 1v is a poorly to moderately welded, devitrified rhyolitic ash-flow tuff that is pumiceous, generally lithic-poor and crystal-bearing to locally crystal-rich. Abundant ash matrix is rarely preserved in cuttings. Cuttings commonly contain numerous fragments of indurated crystal-rich tuff with devitrified pumice. Abundant free quartz and sanidine crystals dominate cuttings in many intervals and minor small (generally less than 10 mm in diameter) volcanic lithic inclusions also occur in cuttings.

Cobble Zone (370–386 ft bgs)

The Cobble Zone interval was encountered from 370 ft to 386 ft bgs. The Cobble Zone interval is a poorly to moderately welded, devitrified rhyolitic ash-flow tuff that is pumiceous, generally lithic-poor, and crystal-bearing to locally crystal-rich, in origin. Generally, no difference in cuttings from the Unit 1v of the Tshirege Member of the Bandelier Tuff can be observed. This zone has been worked over into a cobble zone in and from the same source. The zone is cobble size in appearance. Cuttings commonly contain numerous fragments of indurated crystal-rich tuff with devitrified pumice.

Unit 1g, Tshirege Member of the Bandelier Tuff, Qbt 1g (386–459 ft bgs)

Unit 1g of the Tshirege Member of the Bandelier Tuff was encountered from 386 ft to 459 ft bgs. Unit 1g is a poorly welded vitric rhyolitic ash-flow tuff that is poorly to moderately indurated, strongly pumiceous, and crystal-bearing. White to pale orange, lustrous, glassy pumice lapilli are characteristic of Unit 1g. Cuttings contain abundant free quartz and sanidine crystals and glassy pumices.

Cerro Toledo Interval, Qct (459–465 ft bgs)

The Cerro Toledo interval was encountered from 459 ft to 465 ft bgs. The Cerro Toledo interval is a sequence of poorly consolidated tuffaceous and volcaniclastic sediments that occurs intermediately between the Tshirege and Otowi Members of the Bandelier Tuff. Sediments are largely stained with orange oxidation on grain surfaces.

Otowi Member of the Bandelier Tuff, Qbo (465–790 ft bgs)

The Otowi Member of the Bandelier Tuff was encountered from 465 ft to 790 ft bgs. The Otowi Member is composed of poorly welded vitric rhyolitic ash-flow tuffs that are pumiceous and crystal- and lithic-bearing. Drill cuttings contain pale orange to white pumices, volcanic lithic clasts, and quartz and sanidine crystals. Lithic fragments are commonly subangular to subrounded and generally of intermediate volcanic composition, including porphyritic dacites.

Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, Qbog (790–810 ft bgs)

The Guaje Pumice Bed represents an air-fall tephra deposit of rhyolitic pumice that forms the base of the Otowi Member. The Guaje deposit was encountered from 790 ft to 810 ft bgs. Drill cuttings in this interval contain abundant lustrous vitric pumice lapilli (up to 15 mm in diameter) with trace occurrences of small volcanic lithic fragments. The deposit is poorly consolidated.

Puye Formation, Tpf (810–1422.8 ft bgs)

Puye Formation volcaniclastic sediments were encountered from 810 ft to TD at 1422.8 ft bgs. The Puye Formation consists of alluvial fan deposits eroded from volcanic rocks in the nearby Jemez Mountains. Cuttings from this interval consist of grey, red, and purple dacitic and rhyolitic gravels, volcaniclastic sands and minor devitrified pumice clasts. Cuttings are generally angular to subangular.

5.2 Groundwater

Drilling at R-68 proceeded without any indications of groundwater until approximately 770 ft bgs as noted by the drilling crew. The 17-in. open borehole was advanced to 810 ft bgs, groundwater levels were monitored with recordings up to 682.98 ft bgs, and groundwater-screening samples were collected with bailers.

Groundwater levels were monitored while the 16-in. casing was installed with recordings up to 679.95 ft bgs. The borehole was advanced with the 16-in. casing to 912 ft bgs, groundwater screening samples were collected, and groundwater levels were monitored and recorded up to 803.08 ft bgs before the bottom of the borehole was sealed.

The borehole was advanced with 12-in. casing to 1225 ft bgs with one groundwater-screening sample collected at 995 ft bgs. Groundwater monitoring was performed after advancing the 12-in. casing to 1225 ft bgs and water was recorded at 1213.75 ft bgs before the bottom of the borehole was sealed.

The borehole was advanced with 10-in. casing to the TD of 1422.8 ft bgs, with one groundwater-screening sample collected at 1322 ft bgs. The water level was 1325.85 ft bgs on February 4, 2017, before well installation. The DTW in the completed well was 1325.66 ft bgs on March 14.

Table 5.2-1 presents a summary of water levels recorded during R-68 drilling.

6.0 BOREHOLE LOGGING

Video logs were recorded on January 11 and 12, 2017, after the 17-in. open hole was drilled to 650 ft and 730 ft bgs. A natural gamma ray, induction, and video log were recorded on January 14 after the 17-in. open hole was drilled to 810 ft bgs. A natural gamma ray log was recorded on February 3 inside the 10-in. casing from surface to 1422.8 ft bgs after the borehole was advanced to TD. An as-built video log was recorded on March 21, inside the 5-in. well casing after aquifer testing and before the sampling system was installed. Logging was conducted with Laboratory logging equipment and staff (Appendix C). A summary of the geophysical logging run is presented in Table 6.0-1.

7.0 WELL INSTALLATION R-68 MONITORING WELL

The R-68 well was installed between February 6 and 27, 2017.

7.1 Well Design

The R-68 well was designed in accordance with Consent Order guidance, and NMED approved the final well design before the well was installed (Appendix D). The well was designed with a screened interval between 1340 ft and 1360 ft bgs to monitor groundwater quality near the top of the regional aquifer within the Puye Formation.

7.2 Well Construction

From February 2 to 6, 2017, the stainless-steel well casing, screens and tremie pipe were decontaminated, and the workover rig and initial well construction materials were mobilized to the site.

The R-68 monitoring well was constructed of 5.0-in.-I.D./5.56-in.-O.D. type A304 passivated stainless-steel beveled casing fabricated to American Society for Testing and Materials A312 standards. The screened section utilized two 10-ft lengths of 5.0-in.-I.D. rod-based 0.040-in. slot wire-wrapped screens to make up the 20-ft-long screen interval. All individual casing and screen sections were welded together using compatible stainless-steel welding rods. A 2-in. steel tremie pipe was used to deliver backfill and annular fill materials downhole during well construction. A short length of 16-in. (11.5-ft casing and shoe, from 900.3 ft to 911.8 ft bgs) and 12-in. (5.0-ft casing and shoe, from 1219.2 ft to 1224.2 ft bgs) remain in the borehole. The 16-in. and 12-in. casing stubs were entombed in the upper bentonite seal.

A 10.8-ft-long stainless-steel sump was placed below the bottom of the well screen. The well casing was started into the borehole on February 6 at 0945 h. The well casing was hung by wireline with the bottom at 1371.2 ft bgs. Stainless-steel centralizers (two sets of four) were welded to the well casing approximately 2.0 ft above and below the screened interval. Figure 7.2-1 presents an as-built schematic showing construction details for the completed well.

The installation of annular materials began on February 11 after the bottom of the borehole was measured at 1418.7 ft bgs (approximately 4.1 ft of slough had accumulated in the borehole). The bentonite backfill was installed between February 11 and 12 from 1365.8 ft to 1418.7 ft bgs using 44.8 ft^3 of 3/8-in. bentonite chips. A summary of calculated volumes and annular materials used is presented in Table 7.2-1.

The filter pack was installed between February 12 and 14 from 1334.8 ft to 1365.8 ft bgs using 25.3 ft^3 of 10/20 silica sand. The actual volume of filter pack sand was 177% greater than the calculated volume and is likely the result of an oversized borehole caused by sloughing in the unconsolidated Puye Formation. The filter pack was surged to promote compaction. The fine-sand collar was installed above the filter pack from 1332.9 ft to 1334.8 ft bgs using 2.8 ft^3 of 20/40 silica sand.

From February 14 to 26, the bentonite seal was installed from 100.1 ft to 1332.9 ft bgs using 1823.4 ft^3 of 3/8-in. bentonite chips. On February 26 and 27, a cement seal was installed from 3.0 ft to 100.1 ft bgs. The top of the cement seal was verified on February 27 at 1250 h. The cement seal used 211.2 ft^3 of Portland Type I/II cement. This volume exceeded the calculated volume of 146.8 ft^3 by 70% and is likely the result of cement loss to the near-surface formations.

Operationally, well construction proceeded smoothly 24 h/d, 7 d/wk from February 6 to 27.

8.0 POST-INSTALLATION ACTIVITIES

Following well installation at R-68, the well was developed and aquifer pumping tests were conducted. A dedicated sampling system was installed, the wellhead and surface pad were constructed, and a geodetic survey was performed. Site restoration activities will be completed following the final disposition of contained drill cuttings and groundwater, per the NMED-approved decision trees for land application of drill cuttings and groundwater.

8.1 Well Development

The well was developed between February 28 and March 13, 2017. Initially, the screened interval was swabbed and bailed to remove formation fines in the filter pack and well sump. Bailing continued until water clarity visibly improved. The well was then developed with a submersible pump by lowering and raising the pump intake through the screen interval. Swabbing, bailing, and pumping were performed again for final development.

The swabbing tool employed was a 4.5-in.-O.D., 1-in.-thick nylon disc attached to a weighted steel rod. The wireline-conveyed tool was drawn repeatedly across the screened interval, causing a surging action across the screen and filter pack. The bailing tool was a 4.0-in.-O.D. by 21.0-ft-long carbon-steel bailer with a total capacity of 12 gal. The tool was repeatedly lowered by wireline, filled, withdrawn from the well, and emptied into the cuttings pit. Approximately 225 gal. of groundwater was removed during bailing activities.

After swabbing and bailing on March 2 and 6, a 10-horsepower (hp), 4-in. Berkeley submersible pump was installed in the well. The screened interval was pumped from top to bottom and from bottom to top in 2-ft increments on March 4 and 5 and between March 7 and 13.

During development, the pumping rate varied from 5.5 to 10.8 gallons per minute (gpm) with lower pumping rates at the top of the screened interval and higher pumping rates at the bottom of the screened interval. The average pumping rate was approximately 8.4 gpm. On March 10, the pump was throttled back to reduce aeration in the formation and cavitation of the pump. Approximately 32,954 gal. of groundwater was purged with the submersible pump during well development.

Total Volumes of Introduced and Purged Water

During drilling, approximately 1375 gal. of potable water was added below the top of the regional aquifer at approximately 1325 ft bgs. Approximately 15,083 gal. was added during installation of the annular seals. In total, approximately 16,458 gal. of potable water was introduced to the borehole below 1325 ft bgs during project activities.

Approximately 33,179 gal. of groundwater was purged at R-68 during well development activities. Another 6265 gal. was purged during aquifer testing. The total amount of groundwater purged during post-installation activities was 39,444 gal.

8.1.1 Well Development Field Parameters

During the pumping stage of well development, turbidity, temperature, pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), and specific conductance in microSiemens per centimeter were measured. The required TOC and turbidity values for adequate well development are less than 2.0 ppm and less than 5 nephelometric turbidity units (NTU), respectively.

Field parameters were measured by collecting aliquots of groundwater from the discharge pipe with the use of a flow-through cell. The final parameters at the end of well development were pH of 8.06, temperature of 17.50ºC, specific conductance of 113 µS/cm, and turbidity of 9.5 NTU. Table B-2.2-1 in Appendix B shows field parameters and purge volumes measured during well development.

During the 24-h aquifer test, the turbidity values ranged from 0.8 to 19.3 NTU, with the final recorded value of 6.0 NTU.

8.2 Aquifer Testing

Aquifer pumping tests were conducted at R-68 between March 14 and 20, 2017. On March 14, the aquifer test pump assembly was installed and the well was pumped to fill the drop pipe for subsequent testing. Two short-duration tests with short-duration recovery periods were performed on March 16. A 24-h pump test with the pump intake at 1331.9 ft bgs, followed by a 24-h recovery period, completed the testing of the screened interval. The average pumping rate for the 24-h test was approximately 4.3 gpm.

A 5-hp pump was used for the aquifer tests. A total of approximately 6265 gal. of groundwater was purged during aquifer testing. Turbidity, temperature, pH, DO, ORP, and specific conductance were measured during the aquifer test. Measured parameters are presented in Appendix B. The R-68 aquifer test results and analysis are presented in Appendix E.

8.3 Dedicated Sampling System Installation

The dedicated sampling system for R-68 was installed on March 21 and 22, 2017. The pumping system utilizes an environmentally retrofitted 4-in. 5-hp Grundfos submersible pump set in a shroud near the bottom of the screened interval. The pump column is constructed of 1-in. threaded/coupled passivated stainless-steel pipe. One 1-in. stainless-steel check valve was installed at the top of the lowermost pipe joint above the pump shroud to provide redundancy to the built-in check valve in the top of the pump body. A weep valve was installed at the bottom of the uppermost pipe joint to protect the pump column from freezing. To measure water levels in the well, two 1-in.-I.D. schedule 80 polyvinyl chloride (PVC) pipes were installed to sufficient depth to set a dedicated transducer and to provide access for manual water-level measurements. The PVC transducer tubes are equipped with 5-ft. sections of 0.020-in. slot screen with a threaded end cap on the bottom of each tube. An In-Situ Level Troll 500 30-psig transducer was installed in one of the PVC tubes to monitor the water level in the well's screened interval.

Sampling system details for R-68 are presented in Figure 8.3-1a. Figure 8.3-1b presents technical notes for the well. Figure 8.3-1c presents a performance curve for the submersible pump installed.

8.4 Wellhead Completion

A reinforced concrete surface pad, 10 ft × 10 ft × 10 in. thick, was installed at the R-68 wellhead. The concrete pad was slightly elevated above the ground surface and crowned to promote runoff. The pad will provide long-term structural integrity for the well. A brass survey pin was embedded in the northwest corner of the pad. A 16-in.-O.D. steel protective casing with a locking lid was installed around the stainless-steel well riser. A total of four removable bollards, painted yellow for visibility, were set at the outside edges of the pad to protect the well from traffic. Details of the wellhead completion are presented in Figure 8.3-1a.

8.5 Geodetic Survey

A New Mexico licensed professional land surveyor conducted a geodetic survey on May 30, 2017 (Table 8.5-1). The survey data conform to Laboratory Information Architecture project standards IA-CB02, "GIS Horizontal Spatial Reference System," and IA-D802, "Geospatial Positioning Accuracy Standard for A/E/C and Facility Management." All coordinates are expressed relative to the New Mexico State Plane Coordinate System Central Zone (North American Datum [NAD] 83); elevation is expressed in feet above mean sea level (amsl) using the National Geodetic Vertical Datum of 1929. Survey points include ground surface elevation near the concrete pad, the top of the brass pin in the concrete pad, the top of the well casing, and the top of the protective casing for the R-68 monitoring well.

8.6 Waste Management and Site Restoration

Waste generated from the R-68 project included drilling fluids, purged groundwater, drill cuttings, decontamination water, and contact waste. A summary of the waste characterization samples collected during drilling, construction, and development of the R-68 well is presented in Table 8.6-1.

All waste streams produced during drilling and development activities were sampled and characterized in accordance with the R-68 waste characterization strategy form (WCSF) and Amendment #1 to the WCSF (LANL 2016, 601994; LANL 2016, 602000).

Fluids produced during drilling, well development, and aquifer testing are expected to be land-applied after a review of associated analytical results per the WCSF and the ENV-RCRA-QP-010.2, “Land Application of Groundwater.” If it is determined the drilling fluids are nonhazardous but cannot meet the criteria for land application, they will be evaluated for treatment and disposal at one of the Laboratory’s wastewater treatment facilities. If analytical data indicate the drilling fluids are hazardous/nonradioactive or mixed low-level waste, the drilling fluids will be disposed of at an authorized facility.

Cuttings produced during drilling are anticipated to be land-applied after a review of associated analytical results per the WCSF and ENV-RCRA-QP-011.2, “Land Application of Drill Cuttings.” If cuttings pass land-application criteria, they will be used to backfill the pit. If the drill cuttings do not meet the criteria for land application, they will be disposed of at an authorized facility.

Decontamination fluid used for cleaning equipment is containerized. The fluid waste was sampled and will be disposed of at an authorized facility. Characterization of contact waste will be based upon acceptable knowledge, pending analyses of the waste samples collected from the drill cuttings, purge water, and decontamination fluid.

Site restoration activities will include removing drilling fluids and cuttings from the pit and managing the fluids and cuttings as described above, removing the polyethylene liner, removing the containment area berms, and backfilling and regrading the containment area, as appropriate.

9.0 DEVIATIONS FROM PLANNED ACTIVITIES

Drilling, sampling, and well construction at R-68 were performed as specified in the approved drilling work plan for well R-68 (LANL 2016, 601779; NMED 2016, 601855).

10.0 ACKNOWLEDGMENTS

Holt drilled and installed the R-68 monitoring well.

David C. Schafer designed, implemented, and analyzed the aquifer tests.

TerranearPMC provided oversight on all preparatory and field-related activities.

11.0 REFERENCES AND MAP DATA SOURCES

11.1 References

The following reference list includes documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ERID or ESHID. This information is also included in text citations. ERIDs were assigned by ADEM’s Records Processing Facility (IDs through 599999), and ESHIDs are assigned by the Environment, Safety, and Health Directorate (IDs 600000 and above). IDs are used to locate documents in the Laboratory’s Electronic Document Management System and in the Master Reference Set. The NMED Hazardous Waste Bureau and ADEM maintain copies of the Master Reference Set. The set ensures that NMED has the references to review documents. The set is updated when new references are cited in documents.

LANL (Los Alamos National Laboratory), June 26, 2014. “Storm Water Pollution Prevention Plan, Regional Wells (R-Wells) Drilling, Los Alamos National Laboratory, Revision 1,” Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 2014, 601293)

LANL (Los Alamos National Laboratory), September 2016. "Groundwater Investigation Work Plan for Consolidated Unit 16-021(c)-99, Including Drilling Work Plans for Wells R-68 and R-69," Los Alamos National Laboratory document LA-UR-16-26493, Los Alamos, New Mexico. (LANL 2016, 601779)

LANL (Los Alamos National Laboratory), November 15, 2016. "Waste Characterization Strategy Form (WCSF) for Regional Well R-68," Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 2016, 601994)

LANL (Los Alamos National Laboratory), November 21, 2016. "Amendment #1 to the Waste Characterization Strategy Form (WCSF) for Regional Well R-68 (EP2016-0149)," Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 2016, 602000)

NMED (New Mexico Environment Department), September 27, 2016. "Approval, Groundwater Investigation Work Plan for Consolidated Unit 16-021(c)-99, Including Drilling Work Plans for Wells R-68 and R-69," New Mexico Environment Department letter to D. Hintze (DOE-EM-LA) and M. Brandt (LANL) from J.E. Kieling (NMED-HWB), Santa Fe, New Mexico. (NMED 2016, 601855)

TerranearPMC, December 2016. "Field Implementation Plan for Regional Aquifer Well R-68," Los Alamos, New Mexico. (TerranearPMC 2016, 602451)

TerranearPMC, December 14, 2016. "IWD [Integrated Work Document] for Drilling and Installation of LANL Wells R-68 and R-69," Los Alamos, New Mexico. (TerranearPMC 2016, 602452)

11.2 Map Data Sources

Point Feature Locations of the Environmental Restoration Project Database; Los Alamos National Laboratory, Waste and Environmental Services Division, EP2008-0109; 12 April 2010.

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

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

Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Division; 4 December 2009.

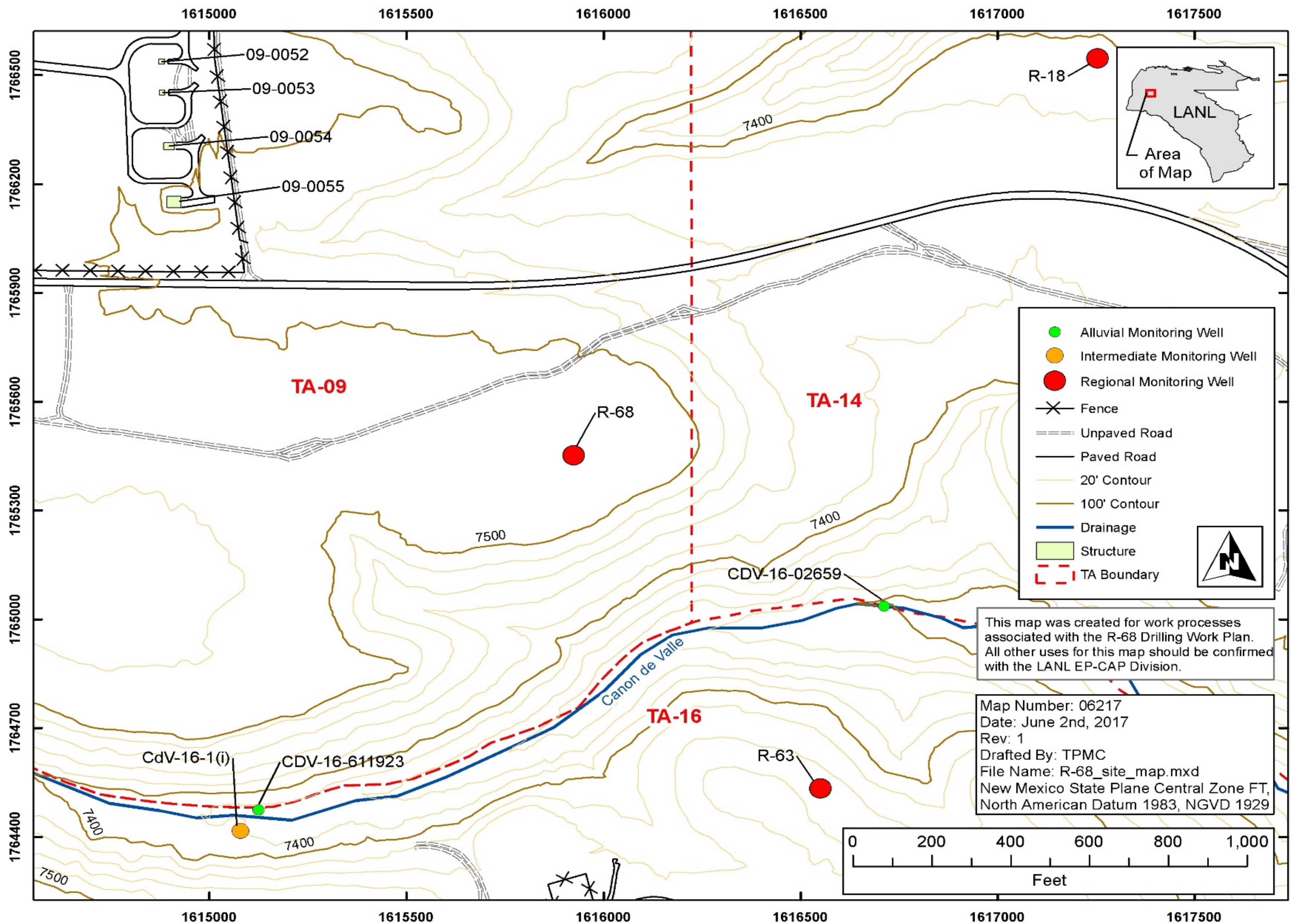


Figure 1.0-1 Location of monitoring well R-68

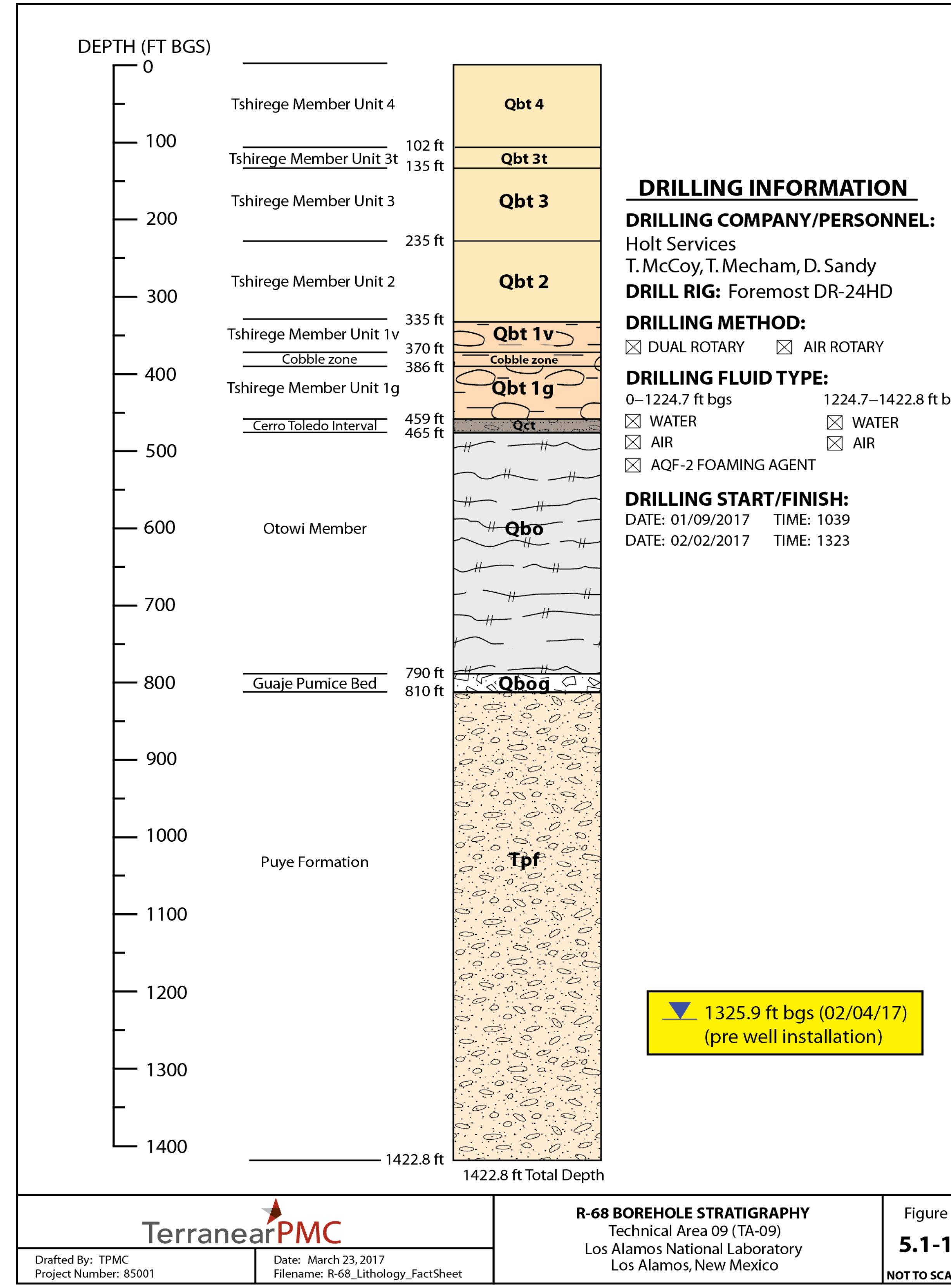


Figure 5.1-1 Monitoring well R-68 borehole stratigraphy

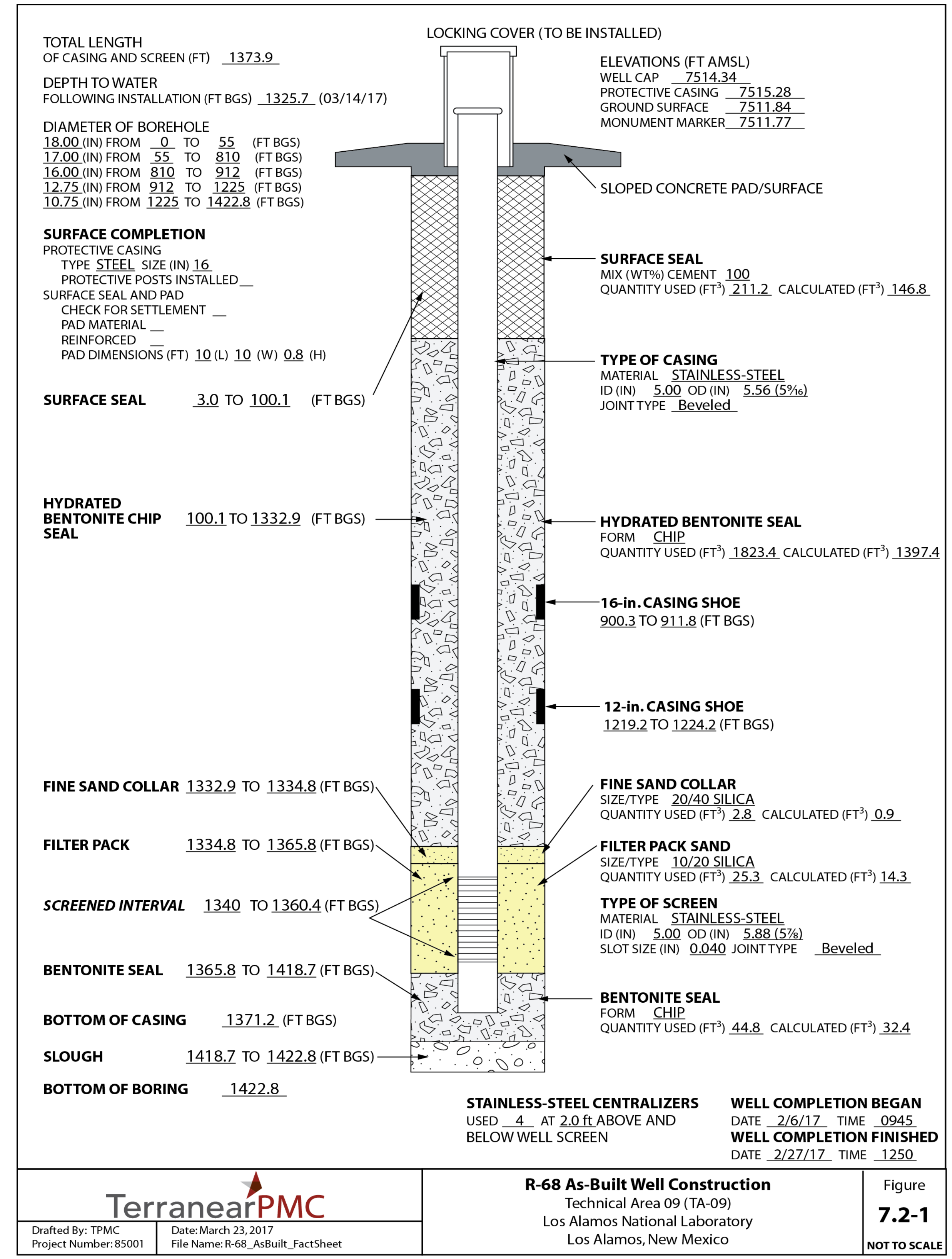


Figure 7.2-1 Monitoring well R-68 as-built well construction diagram

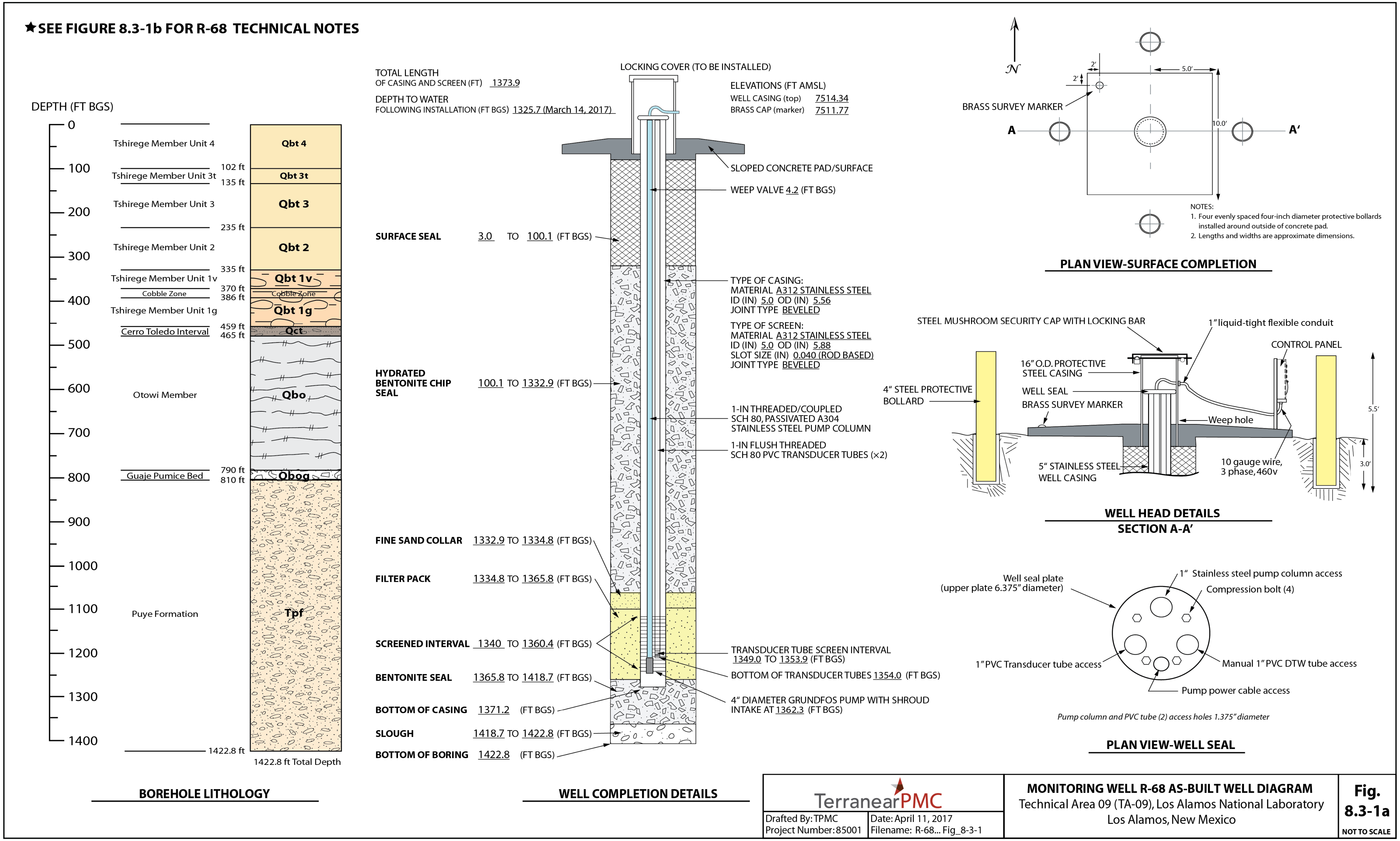


Figure 8.3-1a Monitoring well R-68 as-built diagram with borehole lithology and technical well completion details

R-68 TECHNICAL NOTES:

SURVEY INFORMATION*

Brass Marker

Northing: 1765454.41 ft
Easting: 1615921.67 ft
Elevation: 7511.77 ft AMSL

Well Casing (top of stainless steel)

Northing: 1765451.28 ft
Easting: 1615924.45 ft
Elevation: 7514.34 ft AMSL

BOREHOLE GEOPHYSICAL LOGS

LANL natural gamma log
LANL video log

DRILLING INFORMATION

Drilling Company
Holt Services

Drill Rig
Foremost DR-24HD

Drilling Methods
Dual Rotary
Fluid-assisted air rotary, Foam-assisted air rotary

Drilling Fluids
Air, potable water, AQF-2 Foam (to 1224.7 ft bgs)

MILESTONE DATES

Drilling
Start: 01/09/2017
Finished: 02/02/2017

Well Completion
Start: 02/06/2017
Finished: 02/27/2017

Well Development
Start: 02/28/2017
Finished: 03/13/2017

WELL DEVELOPMENT

Development Methods
Performed swabbing, bailing, and pumping
Total Volume Purged: 33,179 gal.

Parameter Measurements (Final)
pH: 8.06
Temperature: 17.50°C
Specific Conductance: 113 µS/cm
Turbidity: 9.5 NTU

AQUIFER TESTING

Constant Rate Pumping Test
Water Produced: 6265 gal.
Average Flow Rate: 4.3 gpm
Performed on: 03/14–20/2017

DEDICATED SAMPLING SYSTEM

Pump (Shrouded)
Make: Grundfos
Model: 10S50-1125CBM
S/N: P116091003
Environmental retrofit
Top of pump intake 1359.8 ft bgs
Base of shroud 1362.3 ft bgs

Motor
Make: Franklin Electric
Model: 2343278602
5 hp, 3-phase, 460V

Pump Shroud
Pumps of Oklahoma custom 4.6-in. O.D. schd. 5 A304 stainless steel with schd. 40 pipe connections

Pump Column
1-in. threaded/coupled schd. 80, pickled and passivated A304 stainless steel tubing
Weep valve installed at 4.2 ft bgs
Check valve installed at 1335.9 ft bgs

Transducer Tubes
2 × 1-in. flush threaded schd. 80 PVC tubing, 0.020-in. slot screens at 1349.0-1353.9 ft bgs

Transducer
Make: In-Situ, Inc.
Model: Level TROLL 500
30 psig range (vented)
S/N: 513018

NOTES:
* Coordinates based on New Mexico State Plane Grid Coordinates, Central Zone (NAD83); Elevation expressed in feet amsl using the National Geodetic Vertical Datum of 1929.

TerranearPMC
Drafted By: TPMC
Project Number: 85001
Date: July 6, 2017
Filename: R-68_TechnicalNotes_Fig8.3-1b

R-68 TECHNICAL NOTES
Technical Area 09 (TA-09)
Los Alamos National Laboratory
Los Alamos, New Mexico

Fig. 8.3-1b
NOT TO SCALE

Figure 8.3-1b As-built technical notes for monitoring well R-68

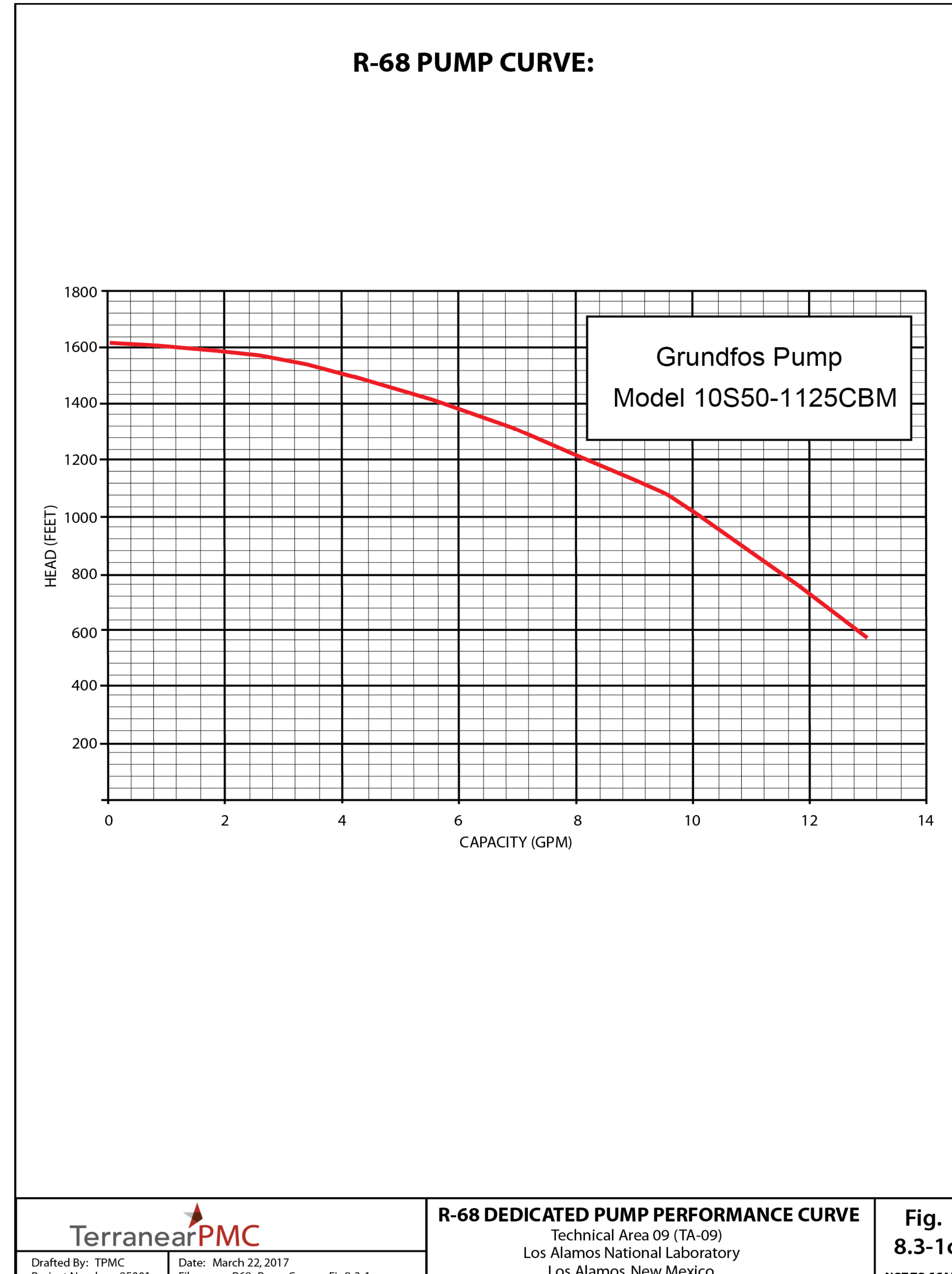


Figure 8.3-1c Pump curve for monitoring well R-68

Table 3.1-1
Fluid Quantities Used during R-68 Drilling and Well Construction

Date	Depth Interval (ft bgs)	Water (gal.)	Cumulative Water (gal.)	AQF-2 Foam (gal.)	Cumulative AQF-2 Foam (gal.)
Drilling					
1/9/17	0–110	1800	1800	10.5	10.5
1/10/17	110–630	8500	10,300	81	91.5
1/11/17	630–730	2050	12,350	20.5	112
1/12/17	730–770	1400	13,750	14	126
1/13/17	770–810	1000	14,750	8	134
1/18/17	810–910	2900	17,650	34	168
1/19/17	910[a]	2150	19,800	30	198
1/21/17	887–910[b]	1410	21,210	10	208
1/22/17	887–910[b]	600	21,810	5	213
1/26/17	910–1015	4250	26,060	40	253
1/27/17	1015–1215	5250	31,310	53.5	306.5
1/28/17	1215–1225[c]	564	31,874	6	312.5
1/29/17	1203–1225[b]	900	32,774	6	318.5
2/1/17	1225–1362	375	33149	n/a[d]	n/a
2/2/17	1362–1422.8	2625	35,774	n/a	n/a
Well Construction					
2/11/17	1418.69–1366	6639	6639	n/a	n/a
2/12/17	1366–1349	2266	8905	n/a	n/a
2/13/17	1349–1336	1366	10,271	n/a	n/a
2/14/17	1336–1325	3790	14,061	n/a	n/a
2/15/17	1325–1252	6561	20,622	n/a	n/a
2/16/17	1252–1236	1315	21,937	n/a	n/a
2/19/17	1236–1160	6936	28,873	n/a	n/a
2/20/17	1160–1045	9271	38,144	n/a	n/a
2/21/17	1045–922	7227	45,371	n/a	n/a
2/23/17	922–776	1893	47,264	n/a	n/a
2/24/17	776–485	2043	49,307	n/a	n/a
2/25/17	485–194	2918	52,225	n/a	n/a
2/26/17	194–23	1611	53,836	n/a	n/a
2/27/17	23–3	228	54,064	n/a	n/a
Total Water Volume (gal.)					
R-68	89,838				

[a] Clean out borehole.

[b] Drill out bentonite seal.

[c] Install bentonite seal.

[d] n/a = Not applicable.

Table 4.2-1
Summary of Groundwater Screening Samples Collected during Drilling, Well Development, and Aquifer Testing at Well R-68

Location ID	Sample ID	Date Collected	Collection Depth (ft bgs)	Sample Type	Analysis
Drilling					
R-68	GW68-17-129616	1/14/17	810	Groundwater, Bailed	Anions, Metals
R-68	GW68-17-129618	1/14/17	810	Groundwater, Bailed	Tritium, NMED HEXP, Alkalinity, RDX, EES-6 tracer
R-68	GW68-17-129620	1/18/17	810	Groundwater, Air-lift	NMED HEXP, RDX, EES-6 tracer
R-68	GW68-17-129621	1/18/17	850	Groundwater, Air-lift	NMED HEXP, RDX, EES-6 tracer
R-68	GW68-17-129622	1/19/17	870	Groundwater, Air-lift	NMED HEXP, RDX, EES-6 tracer
R-68	GW68-17-129623	1/19/17	890	Groundwater, Air-lift	NMED HEXP, RDX, EES-6 tracer
R-68	GW68-17-129624	1/19/17	910	Groundwater, Air-lift	NMED HEXP, RDX, EES-6 tracer
R-68	GW68-17-129625	1/27/17	995	Groundwater, Air-lift	RDX, EES-6 tracer, HMX, TNT
R-68	GW68-17-129626	2/2/17	1322	Groundwater, Air-lift	RDX, EES-6 tracer, HMX, TNT
Well Development					
R-68	GW68-17-129640	3/4/17	1344	Groundwater, Pumped	RDX
R-68	GW68-17-129641	3/4/17	1352	Groundwater, Pumped	TOC
R-68	GW68-17-129642	3/4/17	1352	Groundwater, Pumped	RDX
R-68	GW68-17-129643	3/5/17	1358	Groundwater, Pumped	RDX
R-68	GW68-17-129644	3/5/17	1359	Groundwater, Pumped	RDX
R-68	GW68-17-129645	3/5/17	1359	Groundwater, Pumped	TOC
R-68	GW68-17-129646	3/7/17	1342	Groundwater, Pumped	RDX
R-68	GW68-17-129647	3/7/17	1354	Groundwater, Pumped	RDX
R-68	GW68-17-129648	3/7/17	1358	Groundwater, Pumped	TOC
R-68	GW68-17-129649	3/8/17	1341	Groundwater, Pumped	RDX
R-68	GW68-17-129650	3/8/17	1360	Groundwater, Pumped	RDX
R-68	GW68-17-129651	3/8/17	1360	Groundwater, Pumped	TOC
R-68	GW68-17-129652	3/9/17	1360	Groundwater, Pumped	RDX
R-68	GW68-17-129653	3/9/17	1360	Groundwater, Pumped	RDX
R-68	GW68-17-129654	3/9/17	1360	Groundwater, Pumped	TOC
R-68	GW68-17-129655	3/10/17	1360	Groundwater, Pumped	TOC
R-68	GW68-17-129656	3/10/17	1360	Groundwater, Pumped	RDX
R-68	GW68-17-129657	3/10/17	1360	Groundwater, Pumped	TOC
R-68	GW68-17-129658	3/11/17	1341	Groundwater, Pumped	RDX
R-68	GW68-17-129659	3/11/17	1352	Groundwater, Pumped	RDX
R-68	GW68-17-131620	3/11/17	1348	Groundwater, Pumped	TOC
R-68	GW68-17-131621	3/12/17	1344	Groundwater, Pumped	RDX
R-68	GW68-17-131622	3/12/17	1350	Groundwater, Pumped	RDX
R-68	GW68-17-131623	3/12/17	1346	Groundwater, Pumped	TOC
R-68	GW68-17-131624	3/13/17	1342	Groundwater, Pumped	RDX
R-68	GW68-17-131625	3/13/17	1340	Groundwater, Pumped	TOC

Table 4.2-1 (continued)

Location ID	Sample ID	Date Collected	Collection Depth (ft bgs)	Sample Type	Analysis
Aquifer Testing					
R-68	GW68-17-131626	3/18/17	1342	Groundwater, Pumped	RDX
R-68	GW68-17-131627	3/18/17	1342	Groundwater, Pumped	RDX
R-68	GW68-17-131628	3/18/17	1342	Groundwater, Pumped	RDX
R-68	GW68-17-131633	3/18/17	1342	Groundwater, Pumped	RDX
R-68	GW68-17-131630	3/19/17	1342	Groundwater, Pumped	RDX
R-68	GW68-17-131631	3/19/17	1342	Groundwater, Pumped	RDX
R-68	GW68-17-131632	3/19/17	1342	Groundwater, Pumped	RDX

Table 5.2-1
Water Levels Recorded during R-68 Drilling

Borehole Depth (ft bgs)	Date	Time	Water Level (ft bgs)
810	1/14/17	0250	700.60
		0305	699.10
		0320	697.30
		0335	695.65
		0350	694.40
		0405	693.30
		0420	692.20
		0435	691.45
		0450	690.60
		1500	682.98
	1/15/17	0750	682.22
		1930	681.99
	1/16/17	0743	681.95
		1219	681.98
		1620	681.98
	1/17/17	1047	682.10
		1343	681.56
		1713	681.85
		2110	679.95
		2345	680.75

Table 5.2-1 (continued)

Borehole Depth (ft bgs)	Date	Time	Water Level (ft bgs)
912	1/20/17	0035	813.67
		0050	812.73
		0105	812.14
		0120	811.46
		0135	810.97
		0150	810.58
		0205	810.14
		0220	809.69
		0235	809.26
		0250	808.93
		0305	808.52
		0320	808.10
		0335	807.84
		0350	807.54
		0405	807.20
		0420	806.89
		0435	806.57
		0535	805.64
		0735	804.57
		0829	804.26
		0849	804.17
		0916	803.93
		0932	803.81
		1000	803.67
		1015	803.62
		1306	803.08
1225	1/28/17	1625	1213.75
		1640	1213.75
		1655	1213.75
		1710	1213.75

Table 5.2-1 (continued)

Borehole Depth (ft bgs)	Date	Time	Water Level (ft bgs)
1422.8	2/2/17	1950	1338.32
		2005	1338.07
		2020	1337.88
		2035	1337.75
		2050	1337.66
		2150	1337.50
		2250	1337.46
		2350	1337.46
	2/3/17	0050	1337.46
		0150	1337.46
		0250	1337.45
		0350	1337.45
		0450	1337.45
		0730	1337.55
		0800	1337.55
		0830	1337.55
		1200	1337.55
		1215	1325.38
		1230	1325.46
		1245	1325.37
		1300	1325.60
		1315	1325.87
		1330	1326.07
		1345	1326.30
		1400	1326.42
		1415	1326.47
		1430	1326.53
		1445	1326.57
		1500	1326.65
		1515	1326.70
		1530	1326.75
		1545	1326.82
		1615	1326.87
		1630	1326.92

Table 5.2-1 (continued)

Borehole Depth (ft bgs)	Date	Time	Water Level (ft bgs)
1422.8	2/4/17	1500	1323.91
		1515	1323.90
		1530	1323.88
		1545	1325.88
		1600	1325.85
		1630	1323.87
		1700	1325.85

Table 6.0-1
R-68 Geophysical Logging Runs

Date	Logging Interval	Description
1/11/17	0–648.5	Laboratory video run through 17-in. open hole to 648.5 ft bgs
1/12/17	0–665	Laboratory video run through 17-in. open hole to 665 ft bgs
1/14/17	0–810 ft bgs	Laboratory natural gamma ray log, induction, and video run through 17-in. open hole to 810 ft bgs
2/3/17	0–1422.8 ft bgs	Laboratory natural gamma ray log run through 10-in. casing to TD at 1422.8 ft bgs
3/21/17	0–1371.2 ft bgs	Laboratory as-built video log run of 5-in. well casing and screen to TD at 1371.2 ft bgs

Table 7.2-1
R-68 Monitoring Well Annular Fill Materials

Material	Calculated Volume	Actual Volume
Upper surface seal: cement slurry	146.8 ft^3	211.2 ft^3
Upper bentonite seal: bentonite chips	1397.4 ft^3	1823.4 ft^3
Fine-sand collar: 20/40 silica sand	0.9 ft^3	2.8 ft^3
Filter pack: 10/20 silica sand	14.3 ft^3	25.3 ft^3
Backfill: bentonite chips	32.4 ft^3	44.8 ft^3

Table 8.5-1
R-68 Survey Coordinates

Identification	Northing	Easting	Elevation
R-68 brass pin embedded in pad	1765454.41	1615921.67	7511.77
R-68 ground surface near pad	1765459.30	1615919.55	7511.84
R-68 top of stainless-steel well casing	1765451.28	1615924.45	7514.34
R-68 top of 16-in. protective casing	1765450.36	1615923.87	7515.28

Note: All coordinates are expressed as New Mexico State Plane Coordinate System Central Zone (NAD 83); elevation is expressed in ft amsl using the National Geodetic Vertical Datum of 1929.

Table 8.6-1
Summary of Waste Samples Collected during
Drilling, Development, and Sample System Installation at R-68

Location ID	Sample ID	Date Collected	Description	Sample Type
R-68	WST09-17-129386	1/10/2017	Drill fluids VOC[a]/SVOC[b] initial sample–UF[c]	Liquid
R-68	WST09-17-129389	1/10/2017	Drill fluids VOC/SVOC initial sample–UF FD[d]	Liquid
R-68	WST09-17-129392	1/10/2017	Drill fluids VOC/SVOC initial sample–UF FTB[e]	Liquid
R-68	WST09-17-129387	1/12/2017	Drill fluids VOC/SVOC midpoint sample–UF	Liquid
R-68	WST09-147-129390	1/12/2017	Drill fluids VOC/SVOC midpoint sample–UF FD	Liquid
R-68	WST09-17-12393	1/12/2017	Drill fluids VOC/SVOC midpoint sample–UF FTB	Liquid
R-68	WST09-17-129388	2/02/2017	Drill fluids VOC/SVOC final sample–UF	Liquid
R-68	WST09-17-12391	2/02/2017	Drill fluids VOC/SVOC final sample–UF FD	Liquid
R-68	WST09-17-129394	2/02/2017	Drill fluids VOC/SVOC final sample–UF FTB	Liquid
R-68	WST09-17-129398	2/6/2017	Drill fluids non-VOC sample–UF	Liquid
R-68	WST09-17-129397	2/6/2017	Drill fluids non-VOC sample–F[f]	Liquid
R-68	WST09-17-129380	1/10/2017	Drill cuttings VOC initial sample	Solid
R-68	WST09-17-129383	1/10/2017	Drill cuttings VOC initial sample–FTB	Solid
R-68	WST09-17-129381	1/12/2017	Drill cuttings VOC midpoint sample	Solid
R-68	WST09-17-129384	1/12/2017	Drill cuttings VOC midpoint sample–FTB	Solid
R-68	WST09-17-1129382	2/02/2017	Drill cuttings VOC final sample	Solid
R-68	WST09-17-129385	2/02/2017	Drill cuttings VOC final sample–FTB	Solid
R-68	WST09-17-129400	2/6/2017	Drill cuttings non-VOC sample	Solid
R-68	WST09-17-130606	3/27/2017	Decontamination fluids sample (R-68)–UF	Liquid
R-68	WST09-17-130602	3/27/2017	Decontamination fluids sample (R-68)–F	Liquid
R-68	WST09-17-130605	3/27/2017	Decontamination fluids sample (R-68)–FTB	Liquid
R-68	WST09-17-130604	3/27/2017	Decontamination fluids sample (R-68)–UF FD	Liquid
R-68	WST09-17-130607	2/24/2017	Decontamination fluids sample (Pajarito Laydown Yard)–F	Liquid
R-68	WST09-17-130610	2/24/2017	Decontamination fluids sample (Pajarito Laydown Yard)–UF	Liquid
R-68	WST09-17-130608	2/24/2017	Decontamination fluids sample (Pajarito Laydown Yard)–FD	Liquid

Table 8.6-1 (continued)

Location ID	Sample ID	Date Collected	Description	Sample Type
R-68	WST09-17-130609	2/24/2016	Decontamination fluids sample (Pajarito Laydown Yard)–FTB	Liquid
R-68	WST09-17-130253	3/27/2017	Development fluids sample–F	Liquid
R-68	WST09-17-130115	3/27/2017	Development fluids sample–UF	Liquid
R-68	WST09-17-130116	3/27/2017	Development fluids sample–UF FD	Liquid
R-68	WST09-17-130117	3/27/2017	Development fluids sample–UF FTB	Liquid

[a] VOC = Volatile organic compound.

[b] SVOC = Semivolatile organic compound.

[c] UF = Unfiltered sample.

[d] FD = Field duplicate.

[e] FTB = Field trip blank.

[f] F = Filtered sample.

Appendix A

Borehole R-68 Lithologic Log

Borehole Identification (ID): R-68	**Technical Area (TA): 09**	
Drilling Company: **Holt Drilling Services**	**Start Date/Time: 1/9/17; 1039**	**End Date/Time: 2/2/17 1323**
Drilling Method: **Dual Rotary**	**MACHINE: Foremost DR-24 HD**	**Sampling Method: Grab**
Ground Elevation: 7511 ft amsl		**Total Depth: 1422.8 ft**
DRILLERS: D. Sandy, T. Mecham, M. McCoy	**SITE GEOLOGISTS: E. Tow, T. Sower, R. McGuill, J. Jordan, L. Anderson, D. Andersen**	

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
0–15	**Unit 4 of the Tshirege Member of the Bandelier Tuff:** Rhyolitic Tuff—Pale orange (10YR 8/2) strongly welded, crystal-bearing tuff with lithic fragments. 0'–15' WR/+10F: 95% welded ash flow tuff fragments; 5% rhyolitic and dacitic lithic clasts. +35F: 90% welded ash flow tuff fragments; 5% rhyolitic and dacitic lithic clasts; <5% quartz and sanidine crystals.	Qbt 4	Unit 4 of the Tshirege Member of the Bandelier Tuff (Qbt 4), encountered from 0 to 102 ft below ground surface (bgs), is 102 ft thick. Note: Drill cuttings for descriptive analysis were collected at 5-ft intervals from ground surface to borehole total depth (TD) at 1423 ft bgs.
15–40	Rhyolitic Tuff—Pale brown (5YR 5/2) strongly welded, crystal-bearing tuff with lithic fragments. 15'–40' WR/+10F: 95% welded ash flow tuff fragments; 5% rhyolitic and dacitic lithic clasts. +35F: 90% welded ash-flow tuff fragments; 5% rhyolitic and dacitic lithic clasts; <5% quartz and sanidine crystals.	Qbt 4	
40–90	Rhyolitic Tuff—Pale orange (10YR 8/2) moderately welded, crystal-bearing tuff with lithic fragments. 40'–90' WR/+10F: 50–70% welded ash flow tuff fragments; 25%–45% quartz and sanidine crystals; <5% rhyolitic and dacitic lithic clasts. +35F: 50–90% quartz and sanidine crystals; 10%–50% welded ash-flow tuff fragments; trace rhyolitic and dacitic lithic clasts.	Qbt 4	
90–102	Rhyolitic Tuff—Light gray (N7 to N8) strongly welded, crystal-bearing tuff with minor lithic fragments. 90'–102' WR/+10F: 50%–70% welded ash-flow tuff fragments; 25%–45% quartz and sanidine crystals; <5% rhyolitic and dacitic lithic clasts. +35F: 50%–80% quartz and sanidine crystals; 20%–50% welded ash-flow tuff fragments; trace rhyolitic and dacitic lithic clasts.	Qbt 4	The Qbt 4/Qbt 3t contact, estimated at 102 ft bgs, is based on natural gamma logging.

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
102–135	**Unit 3t of the Tshirege Member of the Bandelier Tuff:** Rhyolitic Tuff—Light gray (N8) to grayish-orange (10R 8/2) strongly welded, crystal-bearing tuff with minor lithic fragments. 102'–135' WR/+10F: 80%–90% welded ash flow tuff fragments; 10%–20% quartz and sanidine crystals; trace rhyolitic and dacitic lithic clasts. +35F: 60%–90% welded ash-flow tuff fragments; 10%–40% quartz and sanidine crystals; trace rhyolitic and dacitic lithic clasts.	Qbt 3t	Unit 3t of the Tshirege Member of the Bandelier Tuff (Qbt 3t), encountered from 102 ft to 135 ft bgs, is approximately 33 ft thick. The Qbt 3t/Qbt 3 contact, estimated at 135 ft bgs, is based on visual examination of cuttings.
135–190	**Unit 3 of the Tshirege Member of the Bandelier Tuff:** Rhyolitic Tuff—Light gray (N8) to grayish-orange (10R 8/2) moderately welded, crystal-bearing tuff with minor lithic fragments. 135'–190' WR/+10F: 40%–70% welded ash-flow tuff fragments; 25%–55% quartz and sanidine crystals; <5% rhyolitic and dacitic lithic clasts. +35F: 70%–90% quartz and sanidine crystals; 10%–30% welded ash flow tuff fragments; trace rhyolitic and dacitic lithic clasts.	Qbt 3	Unit 3 of the Tshirege Member of the Bandelier Tuff (Qbt 3), encountered from 135 ft to 235 ft bgs, is approximately 100 ft thick.
190–235	Rhyolitic Tuff—Light gray (N8) to grayish-orange (10R 8/2) moderately welded, crystal-bearing tuff with minor lithic fragments. 190'–235' WR/+10F: 60%–80% quartz and sanidine crystals; 20%–40% welded ash-flow tuff fragments; <5% rhyolitic and dacitic lithic clasts. +35F: 90%–95% quartz and sanidine crystals; 5%–10% welded ash-flow tuff fragments; trace rhyolitic and dacitic lithic clasts.	Qbt 3	The Qbt 3/Qbt 2 contact, estimated at 235 ft bgs, is based on natural gamma logging and visual examination of cuttings.
235–250	**Unit 2 of the Tshirege Member of the Bandelier Tuff** Rhyolitic Tuff—gray (N6) to pale brown (5YR 6/2), strongly welded, crystal-rich tuff. 235'–250' WR/+10F: 55%–60% welded ash flow tuff fragments; 40% quartz and sanidine crystals; <5% rhyolitic and dacitic lithic clasts. +35F: 80% quartz and sanidine crystals; 20% welded ash-flow tuff fragments; trace rhyolitic and dacitic lithic clasts.	Qbt 2	Unit 2 of the Tshirege Member of the Bandelier Tuff (Qbt 2), encountered from 235 ft to 335 ft bgs, is approximately 100 ft thick.

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
250–315	Rhyolitic Tuff—Gray (N6) to pale brown (5YR 6/2), strongly welded, crystal-rich tuff. 250'-315' WR/+10F: 85%–95% welded ash flow tuff fragments; 5%–15% quartz and sanidine crystals. +35F: 70%–90% welded ash-flow tuff fragments; 10%–30% quartz and sanidine crystals.	Qbt 2	
315–335	Rhyolitic Tuff—Gray (N6) to pale brown (5YR 6/2), strongly welded, crystal-rich tuff. 315'–335' WR/+10F: 85%–95% welded ash-flow tuff fragments; 5%–15% quartz and sanidine crystals. +35F: 50% quartz and sanidine crystals; 50% welded ash-flow tuff fragments.	Qbt 2	The Qbt 2/Qbt 1v contact, estimated at 335 ft bgs, is based on natural gamma logging and visual examination of cuttings.
335–350	**Unit 1v of the Tshirege Member of the Bandelier Tuff** Rhyolitic Tuff—Light gray (N7), strongly welded, crystal-rich tuff. 335'–350' WR/+10F: 85%–95% welded ash-flow tuff fragments; 5%–15% quartz and sanidine crystals. +35F: 50% welded ash-flow tuff fragments; 50% quartz and sanidine crystals.	Qbt 1v	Unit 1v of the Tshirege Member of the Bandelier Tuff (Qbt 1v), encountered from 335 ft to 370 ft bgs, is approximately 35 ft thick.
350–360	Rhyolitic Tuff—Pale brown (5YR 6/2), strongly welded, crystal-rich tuff. 350'–360' WR/+10F: 85%–95% welded ash-flow tuff fragments; 5%–15% quartz and sanidine crystals. +35F: 50%–70% quartz and sanidine crystals; 30%–50% welded ash-flow tuff fragments.	Qbt 1v	
360–370	Rhyolitic Tuff—Pale brown (5YR 6/2), poorly welded, crystal-rich tuff with minor devitrified pumice. 360'–370' WR: 70%–80% quartz and sanidine crystals; 20%–30% ash-flow tuff fragments; trace devitrified pumice. +10F: 30%–70% rhyolitic tuff fragments; 30%–70% euhedral quartz and sanidine crystals; trace pumice clasts. +35F: 80%–90% quartz and sanidine crystals; 10%–20% rhyolitic tuff fragments.	Qbt 1v	The Qbt 1v/Cobble zone contact, estimated at 370 ft bgs, is based on natural gamma logging.

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
370–386	**Cobble Zone** Rhyolitic Tuff—Pale brown (5YR 6/2), poorly welded, crystal-rich tuff with minor devitrified pumice. 370'–386' WR: 70%–80% quartz and sanidine crystals; 20%–30% ash-flow tuff fragments; trace devitrified pumice. +10F: 30%–70% rhyolitic tuff fragments; 30%–70% euhedral quartz and sanidine crystals; trace pumice clasts. +35F: 80%–90% quartz and sanidine crystals; 10%–20% rhyolitic tuff fragments.	Qbt 1v	The Cobble Zone, encountered from 370 ft to 386 ft bgs, is approximately 16 ft thick. The Cobble Zone/ Qbt 1g contact, estimated at 386 ft bgs, is based on natural gamma logging.
386–420	**Unit 1g of the Tshirege Member of the Bandelier Tuff** Rhyolitic Tuff—Light gray (N6 to N7), poorly welded, crystal-rich tuff with minor glassy pumice. 386'–420' WR: 70%–80% quartz and sanidine crystals; 20-30% ash-flow tuff fragments; <5% dacite lithics; trace devitrified pumice. +10F: 30%–70% rhyolitic tuff fragments; 30%–70% euhedral quartz and sanidine crystals; <5% dacite lithics; trace pumice clasts. +35F: 80%–90% quartz and sanidine crystals; 10%–20% rhyolitic tuff fragments; trace lithic fragments.	Qbt 1g	Unit 1g of the Tshirege Member of the Bandelier Tuff (Qbt 1g), encountered from 386 ft to 459 ft bgs, is approximately 73 ft thick.
420–435	Rhyolitic Tuff—Medium-gray (N6), poorly welded, crystal-rich tuff with minor glassy pumice. 420'–435' WR: 50%–70% quartz and sanidine crystals; 255–30% ash-flow tuff fragments; 5%–20% dacite lithics; trace devitrified pumice. +10F: 30%–70% rhyolitic tuff fragments; 20%–40% dacite lithics; 20%–40% euhedral quartz and sanidine crystals; trace pumice clasts. +35F: 50% quartz and sanidine crystals; 50% rhyolitic tuff fragments; trace lithic fragments.	Qbt 1g	
435–459	Rhyolitic Tuff—Light gray (N6 to N7), poorly welded, crystal-rich tuff with abundant glassy pumice. 435'–459' WR: 30%–50% quartz and sanidine crystals; 20%–40% white to orange pumice clasts; 10%–20% dacite lithics; <10% ash-flow tuff fragments. +10F: 30%–70% rhyolitic tuff fragments; 30%–70% pumice clasts; 5%–15% euhedral quartz and sanidine crystals; <5% dacite lithics. +35F: 30%–40% quartz and sanidine crystals; 70%–60% pumice clasts; 5%–10% ash-flow tuff fragments; trace lithic fragments.	Qbt 1g	The Qbt 1g/ Cerro Toledo interval (Qct) contact, estimated at 459 ft bgs, is based on natural gamma logging.

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
459–460	**Cerro Toledo Interval** Volcaniclastic Sediments—Silt- to sand-size angular quartz grains with orange oxidation staining, reworked white and orange pumice clasts, and dacite and rhyolite clasts. 459'–460' WR: 20%–50% quartz grains; 20%–50% white to orange pumice clasts; 10%–40% dacite clasts. +10F: 30%–70% dacite and rhyolite clasts; 30%–70% pumice clasts; 5%–15% angular quartz grains; +35F: 30%–40% angular quartz grains; 60%–50% pumice clasts; 5%–10% volcanic clasts.	Qct	Qct, encountered from 459 to 465 ft bgs, is approximately 6 ft thick.
460–465	Volcaniclastic Sediments—Silt to sand-size angular quartz grains with orange oxidation staining, reworked white and orange pumice clasts, and dacite and rhyolite clasts. 460'–465' WR: 40%–60% dacite clasts; 20%–40% quartz grains; 5%–20%; white to orange pumice clasts. +10F: 70%–90% dacite and rhyolite clasts; 10%–30% pumice clasts. +35F: 40%–60% angular quartz grains; 20%–30% volcanic clasts; 20%–30% pumice clasts.	Qct	The Qct/Otowi Member of the Bandelier Tuff (Qbo) contact, estimated at 465 ft bgs, is based on natural gamma logging, and visual examination of cuttings.
465–500	**Otowi Member of the Bandelier Tuff** Rhyolitic Tuff—Pale orange (10YR 8/2) poorly welded, pumice- and lithic-rich, crystal-poor tuff. 465'–500' WR: 30%–50% white to orange pumices; 20%–40% dacite lithics; | 20%–30% quartz grains. +10F: 40%–60% dacite and rhyolite lithics; 40%–60% pumice clasts. +35F: 80%–95% angular quartz grains; 5%–20% pumice; 0–5% volcanic lithics.	Qbo	Qbo, encountered from 465 to 790 ft bgs, is approximately 325 ft thick.
500–600	Rhyolitic Tuff—Pale orange (10YR 8/2) to white (N9) poorly welded, pumice- and lithic-rich, crystal-poor tuff. 500'–600' WR: 40%–70% white to orange pumice; 10%–30% dacite lithics; 10%–30% quartz grains. +10F: 50%–80% pumice; 20%–50% dacite and rhyolite lithics. +35F: 40%–60% angular quartz grains; 30%–50% pumice; 5%–10% volcanic lithics.	Qbo	

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
600-650	Rhyolitic Tuff—White (N9) poorly welded, pumice- and lithic-rich, crystal-poor tuff. 600’-650’ WR: 40%–70% white to orange pumice; 10%–30% dacite lithics; 1 0%–30% quartz grains. +10F: 50%–80% pumice; 20%–50% dacite and rhyolite lithics. +35F: 40%–60% angular quartz grains; 30%–50% pumice; 5%–10% volcanic lithics.	Qbo	
650–670	Rhyolitic Tuff—White (N9) poorly welded, pumice- and lithic-rich, crystal-poor tuff. 650’–670’ WR: 30%–50% white to orange pumice; 20%–40% dacite lithics; 20%–30% quartz grains. +10F: 40%–60% dacite and rhyolite lithics; 40%–60% pumice. +35F: 80%–95% angular quartz grains; 5%–20% pumice; 0–5% volcanic lithics.	Qbo	
670–705	Rhyolitic Tuff—White (N9) poorly welded, pumice- and lithic-rich, crystal-poor tuff. 670’–705’ WR: 30%–50% white to orange pumice; 20%–40% dacite lithics; 20%–30% quartz grains. +10F: 40%–60% dacite and rhyolite lithics; 40%–60% pumice. +35F: 50%–65% angular quartz grains; 35%–50% pumice; 0–5% volcanic lithics.	Qbo	
705–750	Rhyolitic Tuff—White (N9) poorly welded, pumice- and lithic-rich, crystal-poor tuff. 705’–750’ WR: 40-70% white to orange pumice; 10%–30% dacite lithics; 10%–30% quartz grains. +10F: 50%–80% pumice; 20%–50% dacite and rhyolite lithics. +35F: 75%–90% angular quartz grains; 5%–20% pumice; 5%–10% volcanic lithics.	Qbo	
750–770	Rhyolitic Tuff—White (N9) poorly welded, pumice- and lithic-rich, crystal-poor tuff. 750’–770’ WR: 40%–60% white to orange pumice; 30%–50% quartz grains; 10%–20% dacite lithics. +10F: 50%–80% pumice; 20%–50% dacite and rhyolite lithics. +35F: 5%–20% angular quartz grains; 75%–90% pumice; 5%–10% volcanic lithics.	Qbo	

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
770–790	Rhyolitic Tuff—White (N9) poorly welded, pumice- and lithic-rich, crystal-poor tuff. 770’–790’ WR/+10F: 80% rounded gray dacite or red-purple rhyolite lithics; 20% rounded white pumice; trace quartz crystals. +35F: 75%–90% angular quartz grains; 5%–20% pumice; 5%–10% volcanic lithics.	Qbo	The Qbo/Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff (Qbog) contact, estimated at 790 ft bgs, is based on natural gamma logging and visual examination of cuttings.
790–800	**Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff** Rhyolitic Tuff—White (N9) poorly welded, pumice- and lithic-rich, crystal-poor tuff. 790’–800’ WR/+10F: 40%–70% white pumice; 30%–60% gray dacite or red-purple rhyolite lithics; trace quartz crystals. +35F: 50%–60% rounded white pumice; 40%–50% rounded gray dacite or red-purple rhyolite lithic fragments; <5% quartz crystals.	Qbog	Qbog, encountered from 790 ft to 810 ft bgs, is approximately 20 ft thick.
800–810	Rhyolitic Tuff—White (N9) poorly welded, pumice- and lithic-rich, crystal-poor tuff. 800’-810’ WR/+10F: 40%–70% white pumice; 30%–60% gray dacite or red-purple rhyolite lithics; trace quartz crystals. +35F: 50%–60% rounded white pumice; 40%–50% rounded gray dacite or red-purple rhyolite lithic fragments; <5% quartz crystals.	Qbog	The Qbog/Puye Formation (Tpf) contact, estimated at 810 ft bgs, is based on natural gamma logging.
810–890	**Puye Formation** Volcaniclastic Sediments—Varicolored grains of dacite and rhyolite. 810’–890’ WR/+10F/+35F: 99%–100% angular to subangular clasts of dacite and rhyolite; <1% devitrified white pumice clasts (possibly falling from above); trace quartz grains.	Tpf	Tpf, encountered from 810 to 1422 ft bgs, is at least 612 ft thick.
890–915	Volcaniclastic Sediments—Varicolored grains of dacite and rhyolite. 890’–915’ WR/+10F/+35F: 99%–100% angular to rounded clasts of dacite and rhyolite; trace quartz grains in +35F.	Tpf	Note: Increased rounding in this interval.
915–1065	Volcaniclastic Sediments—Varicolored grains of dacite and rhyolite. 915’–1065’ WR/+10F/+35F: 99%–100% angular to subangular clasts of dacite and rhyolite; trace quartz grains in +35F.	Tpf	Note: More angular in this interval.
1065-1125	Volcaniclastic Sediments—varicolored grains of dacite and rhyolite. 1065’–1125’ WR/+10F/+35F: 99%–100% subangular to rounded clasts of dacite and rhyolite; trace quartz grains in +35F.	Tpf	Note: More rounded in this interval.

Depth (ft bgs)	Lithology	Lithologic Symbol	Notes
1125–1170	Volcaniclastic Sediments—Varicolored grains of dacite and rhyolite. 1125'–1170' WR/+10F/+35F: 99%–100% angular to subangular clasts of dacite and rhyolite up to 20 mm; trace quartz grains in +35F.	Tpf	
1170–1265	Volcaniclastic Sediments—Varicolored grains of dacite and rhyolite. 1170'–1265' WR/+10F/+35F: 99%–100% rounded to subrounded clasts of dacite and rhyolite up to 15 mm; trace quartz grains in +35F.	Tpf	Note: More angular in this interval.
1265–1325	Volcaniclastic Sediments—Varicolored grains of dacite and rhyolite. 1265'–1325' WR/+10F/+35F: 99%–100% subangular to subrounded clasts of dacite and rhyolite up to 15 mm; trace quartz grains in +35F.	Tpf	
1325–1365	Volcaniclastic Sediments—Varicolored grains of dacite and rhyolite. 1325'–1365' WR/+10F/+35F: 99%–100% angular to subangular clasts of dacite and rhyolite; trace quartz grains in +35F.	Tpf	Note: finer grain material from this interval on.
1365–1380	Volcaniclastic Sediments—Varicolored grains of dacite and rhyolite. 1365'–1380' WR/+10F/+35F: 99%–100% angular to subangular clasts of dacite and rhyolite; trace quartz grains in +35F.	Tpf	Note: More angular in this interval.
1380–1400	Volcaniclastic Sediments—Varicolored grains of dacite and rhyolite. 1380'–1400' WR/+10F/+35F: 99%–100% rounded to subrounded clasts of dacite and rhyolite; trace quartz grains in +35F.	Tpf	
1400–1423	Volcaniclastic Sediments—Varicolored grains of dacite and rhyolite. 1400'–1423' WR/+10F/+35F: 99%–100% angular to subangular clasts of dacite and rhyolite; trace quartz grains in +35F.	Tpf	TD = 1422.8 ft bgs

Borehole Lithologic Log (continued)

ACRONYMS AND ABBREVIATIONS

5YR 8/4 (example) = Munsell rock color notation where hue (e.g., 5YR), value (e.g., 8), and chroma (e.g., 4) are expressed. Hue indicates soil color's relation to red, yellow, green, blue, and purple. Value indicates soil color's lightness. Chroma indicates soil color's strength. Percent (%) = Estimated percent by volume of a given sample constituent.

amsl = Above mean sea level

bgs = Below ground surface

Qf = Post-Tshirege alluvial fan deposit

Qbt 4 = Unit 4 of the Tshirege Member of the Bandelier Tuff

Qbt 3t = Unit 3t of the Tshirege Member of the Bandelier Tuff

Qbt 3 = Unit 3 of the Tshirege Member of the Bandelier Tuff

Qbt 2 = Unit 2 of the Tshirege Member of the Bandelier Tuff

Qbt 1v = Unit 1v (vapor-phase) of the Tshirege Member of the Bandelier Tuff

Qbt 1g = Unit 1g (glassy) of the Tshirege Member of the Bandelier Tuff

Qct = Cerro Toledo interval

Qbo = Otowi Member of Bandelier Tuff

Qbog = Guaje Pumice Bed

Tpf = Puye Formation

TD = Total depth

+10F = plus No. 10 sieve sample fraction

+35F = plus No. 35 sieve sample fraction

WR = whole rock (unsieved sample)

1 mm = 0.039 in.

1 in = 25.4 mm

Appendix B

Groundwater Screening Analytical Results for Well R-68

B-1.0 GROUNDWATER SCREENING ANALYSES AT R-68

Well R-68 is a regional aquifer monitoring well with one well screen from 1340 to 1360.4 ft below ground surface (bgs) within the Puye Formation. This appendix presents screening analytical results for samples collected during well development and aquifer testing at R-68.

Laboratory Analyses

Nine groundwater screening samples were collected during drilling and analyzed for anions, metals, tritium, New Mexico Environment Department (NMED) high explosives suite (NMED HEXP), alkalinity, RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine), Earth and Environmental Sciences (EES) 6 tracer analysis, HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine), and trinitrotoluene (TNT).

Twenty-six groundwater samples were collected during development and seven groundwater samples were collected during aquifer testing. Los Alamos National Laboratory's (LANL's or the Laboratory's) EES-14 analyzed the development samples for total organic carbon (TOC) and RDX and the aquifer test samples for RDX. Table B-1.0-1 lists the samples submitted for TOC analyses from R-68.

Field Analyses

Additionally, groundwater samples were collected from a flow-through cell at regular intervals during well development and aquifer testing and measured for pH, conductivity, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), and turbidity.

B-2.0 SCREENING ANALYTICAL RESULTS

This section presents the TOC concentrations and field parameters measured during well development and aquifer testing.

B-2.1 Total Organic Carbon

TOC concentrations were below the target concentration of 2.0 mgC/L in 10 groundwater samples collected during well development at well R-68 (Table B-2.1-1). Table B-2.1-1 also presents the U.S. Environmental Protection agency (EPA) method by which the samples were analyzed.

B-2.2 Field Parameters

Field parameters measured during well development and aquifer testing are summarized in Table B-2.2-1. Well development was initially conducted for 13 d. Aquifer testing was then conducted for 7 d. These activities were conducted consecutively and the field parameters are summarized below.

During well development and aquifer testing, pH varied from 7.64 to 8.85 and temperature ranged from 9.77°C to 17.50°C. DO concentrations varied from 0.0 to 9.51 mg/L. Specific conductance ranged from 90 µS/cm to 164 µS/cm, and turbidity values varied from 0 to 459.6 nephelometric turbidity units (NTU). Corrected oxidation-reduction potential (Eh) values, determined from field ORP measurements, varied from 274.7 mV to 484.7 mV. One temperature-dependent correction factor was used to calculate Eh values from field ORP measurements: 208.9 mV at 15°C. Figure B-2.2-1 shows the field parameters measured over the course of well development and aquifer testing.

The final parameters measured at the end of the aquifer testing period were pH of 7.91, temperature of 15.19°C, and specific conductance of 104 μS/cm. The flow-through cell meter failed recording DO and turbidity approximately 7.5-h before the end of the aquifer test, and the last field parameters measured were DO of 8.85 mg/L and turbidity of 6.0 NTU.

B-3.0 SUMMARY OF SCREENING ANALYTICAL RESULTS

The TOC concentration was below the target level of 2.0 mgC/L and turbidity was 9.5 NTU at the end of well development. Well R-68 will be sampled quarterly for 1 yr and data collected will be assessed and incorporated into the Interim Facility-wide Groundwater Monitoring Plan. Data from ongoing sampling at R-68 will be analyzed and presented in the appropriate Laboratory periodic monitoring reports.

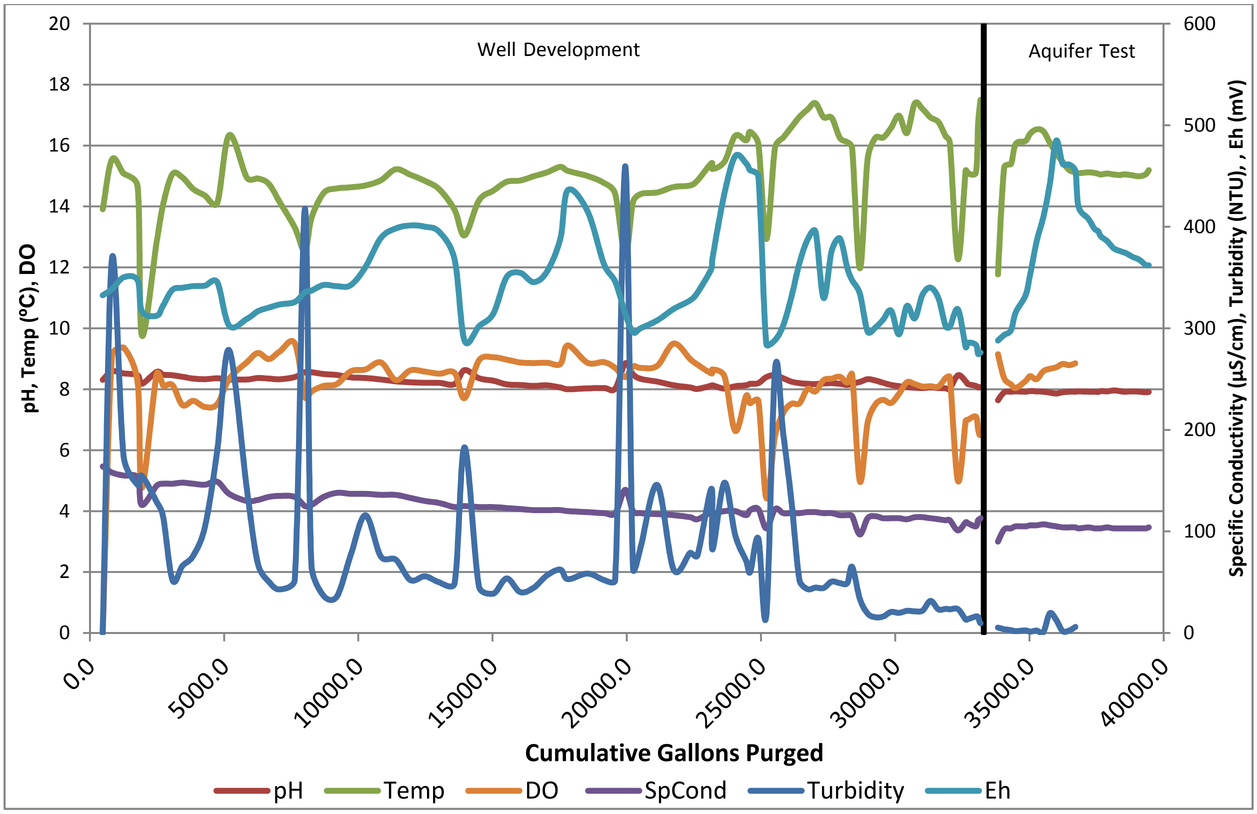


Figure B-2.2-1 Field parameters versus volume purged during R-68 well development and aquifer testing

Table B-1.0-1
Summary of Groundwater Screening Samples Collected during Well Development at Well R-68

Location ID	Sample ID	Date Collected	Collection Depth (ft bgs)	Sample Type	Analysis
Well Development					
R-68	GW68-17-129641	3/4/17	1352	Groundwater, Pumped	TOC
R-68	GW68-17-129645	3/5/17	1359	Groundwater, Pumped	TOC
R-68	GW68-17-129648	3/7/17	1358	Groundwater, Pumped	TOC
R-68	GW68-17-129651	3/8/17	1360	Groundwater, Pumped	TOC
R-68	GW68-17-129654	3/9/17	1360	Groundwater, Pumped	TOC
R-68	GW68-17-129655	3/10/17	1360	Groundwater, Pumped	TOC
R-68	GW68-17-129657	3/10/17	1360	Groundwater, Pumped	TOC
R-68	GW68-17-131620	3/11/17	1348	Groundwater, Pumped	TOC
R-68	GW68-17-131623	3/12/17	1346	Groundwater, Pumped	TOC
R-68	GW68-17-131625	3/13/17	1340	Groundwater, Pumped	TOC

Table B-2.1-1
TOC Results

Sample ID	EPA Method	TOC Concentration (mgC/L)
GW68-17-129641	SW-846:9060	0.75
GW68-17-129645	SW-846:9060	0.66
GW68-17-129648	SW-846:9060	0.67
GW68-17-129651	SW-846:9060	0.61
GW68-17-129654	SW-846:9060	0.59
GW68-17-129655	SW-846:9060	0.74
GW68-17-129657	SW-846:9060	0.65
GW68-17-131620	SW-846:9060	0.85
GW68-17-131623	SW-846:9060	0.56
GW68-17-131625	SW-846:9060	0.60

Table B-2.2-1
Purge Volumes and Field Parameters during Well Development and Aquifer Testing at R-68

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pump Intake Depth (ft bgs)	Pumping Rate at Time of Field Parameter	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development												
3/2/17	n/a[a]	NR[b], bailed after swabbing							n/a	n/a	15.0	15.0
3/4/17	15:04	8.31	13.91	0.00	123.6	332.5	164	0.0	1344	6.10	463	478.0
	16:04	8.59	15.54	9.11	129.6	338.5	158	368.2	1348	7.90	343	821.0
	17:04	8.52	15.08	9.37	141.3	350.2	155	173.8	1352	7.80	436	1257.0
	18:04	8.46	14.66	8.24	138.5	347.4	153	145.9	1354	7.50	520	1777.0
3/5/17	7:05	8.18	9.77	4.76	107.9	316.8	126	154.8	1356	8.30	159.0	1936.0
	8:05	8.57	12.84	8.50	103.5	312.4	145	129.0	1360	9.20	554.0	2490.0
	9:05	8.48	14.06	8.12	113.5	322.4	147	114.6	1343	5.50	238.0	2728.0
	10:05	8.46	15.06	8.14	129.0	337.9	147	52.2	1347	5.90	346.0	3074.0
	11:05	8.41	14.95	7.48	131.0	339.9	148	66.1	1351	6.30	375.0	3449.0
	12:05	8.35	14.57	7.62	132.7	341.6	147	76.2	1355	6.90	404.0	3853.0
	13:05	8.33	14.36	7.42	133.1	342.0	146	104.5	1359	7.20	433.0	4286.0
	14:05	8.36	14.11	7.51	136.6	345.5	149	179.2	1359	7.20	456.0	4742.0
3/6/17	n/a	NR; Bailed after swabbing							n/a	n/a	210.0	4952.0
3/7/17	13:03	8.32	16.34	8.34	93.7	302.6	137	278.4	1340	7.40	237.0	5189.0
	14:00	8.32	14.94	8.89	100.4	309.3	130	141.1	1342	7.30	662.0	5851.0
	15:00	8.37	14.92	9.19	107.9	316.8	131	68.1	1348	7.70	407.0	6258.0
	16:00	8.35	14.74	8.99	111.5	320.4	134	50.5	1352	8.00	408.0	6666.0
	17:00	8.33	14.14	9.24	114.6	323.5	135	42.9	1354	8.30	407.0	7073.0
	18:00	8.40	13.31	9.51	117.0	325.9	134	52.5	1358	8.70	558.0	7631.0

Table B-2.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pump Intake Depth (ft bgs)	Pumping Rate at Time of Field Parameter	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
3/8/17	7:03	8.56	12.53	7.74	126.6	335.5	125	417.8	1360	10.80	380.0	8011.0
	8:03	8.56	13.61	7.93	128.2	337.1	126	67.2	1341	6.70	241.0	8252.0
	9:03	8.50	14.44	8.11	133.8	342.7	134	36.5	1347	7.70	457.0	8709.0
	10:03	8.47	14.59	8.17	132.6	341.5	138	35.8	1349	8.20	491.0	9200.0
	11:03	8.39	14.63	8.59	133.6	342.5	137	76.8	1355	8.90	517.0	9717.0
	12:03	8.37	14.69	8.65	151.5	360.4	137	115.9	1359	9.20	549.0	10266.0
	13:03	8.32	14.86	8.88	180.1	389.0	136	75.2	1359	9.10	575.0	10841.0
	14:03	8.26	15.22	8.30	189.4	398.3	136	72.3	1360	9.20	552.0	11393.0
	15:03	8.23	15.04	8.62	192.4	401.3	133	52.1	1360	9.20	546.0	11939.0
	16:03	8.21	14.84	8.58	191.2	400.1	130	55.8	1360	9.20	540.0	12479.0
	17:03	8.21	14.56	8.51	186.0	394.9	128	49.9	1360	8.90	539.0	13018.0
	18:03	8.17	13.89	8.54	159.1	368.0	124	48.8	1360	8.70	566.0	13584.0
3/9/17	7:01	8.63	13.05	7.71	78.8	287.7	125	182.8	1360	9.50	373.0	13957.0
	8:01	8.36	14.20	8.95	93.2	302.1	124	45.6	1360	8.90	539.0	14496.0
	9:01	8.28	14.52	9.05	105.6	314.5	124	38.7	1360	8.60	533.0	15029.0
	10:01	8.16	14.81	8.97	141.6	350.5	123	53.7	1360	8.40	497.0	15526.0
	11:01	8.14	14.85	8.88	145.8	354.7	122	40.3	1360	8.40	501.0	16027.0
	12:01	8.11	14.99	8.86	136.6	345.5	121	44.5	1360	8.20	503.0	16530.0
	13:01	8.13	15.12	8.87	147.0	355.9	121	56.7	1360	8.30	496.0	17026.0
	14:01	8.06	15.30	8.83	179.5	388.4	121	62.4	1360	8.40	500.0	17526.0
	15:01	8.00	15.17	9.44	227.1	436.0	120	53.0	1360	8.40	275.0	17801.0
	16:01	8.03	15.00	8.87	206.5	415.4	119	58.5	1360	8.60	735.0	18536.0
	17:00	8.04	14.77	8.89	154.2	363.1	118	52.2	1360	8.70	616.0	19152.0
	18:00	8.02	14.41	8.70	137.1	346.0	118	52.1	1360	8.60	416.0	19568.0

Table B-2.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pump Intake Depth (ft bgs)	Pumping Rate at Time of Field Parameter	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
3/10/17	7:02	8.85	12.40	8.40	105.7	314.6	141	459.6	1360	10.00	374.0	19942.0
	7:29	8.49	14.14	8.75	87.3	296.2	120	63.6	1360	9.50	290.0	20232.0
	8:00	8.34	14.41	8.70	91.3	300.2	118	85.5	1362	9.70	293.0	20525.0
	8:59	8.25	14.46	8.77	98.9	307.8	117	145.7	1364	10.30	610.0	21135.0
	9:59	8.13	14.64	9.50	110.2	319.1	116	62.3	1366	10.30	613.0	21748.0
	10:59	8.06	14.69	8.99	118.7	327.6	114	78.9	1366	10.30	614.0	22362.0
	11:54	8.01	14.85	8.81	126.2	335.1	112	76.3	1340	9.10	270.0	22632.0
	12:49	8.12	15.42	8.52	149.9	358.8	119	142.0	1348	9.40	522.0	23154.0
	12:59	8.13	15.23	8.65	160.2	369.1	117	82.2	1348	9.40	39.0	23193.0
	13:59	8.02	15.47	8.43	223.7	432.6	120	147.9	1340	7.00	443.0	23636.0
	14:59	8.10	16.32	6.63	260.6	469.5	120	96.3	1344	6.10	404.0	24040.0
	15:59	8.13	16.17	7.78	253.5	462.4	116	71.2	1348	5.05	404.0	24444.0
	16:59	8.18	16.45	7.54	246.6	455.5	121	60.0	1356	5.10	153.0	24597.0
	17:49	8.20	16.05	7.62	240.5	449.4	122	93.0	1360	5.10	303.0	24900.0
3/11/17	7:25	8.40	12.93	4.43	75.6	284.5	103	17.7	1341	5.00	298.0	25198.0
	8:25	8.46	15.93	6.47	79.5	288.4	122	260.0	1349	5.10	326.0	25524.0
	9:25	8.36	16.26	7.22	94.0	302.9	118	196.7	1357	5.10	303.0	25827.0
	10:25	8.25	16.60	7.52	121.8	330.7	118	130.8	1358	5.10	303.0	26130.0
	11:25	8.20	16.94	7.54	155.3	364.2	118	52.2	1354	5.10	302.0	26432.0
	12:25	8.18	17.18	8.01	178.4	387.3	119	43.2	1346	5.05	300.0	26732.0
	13:25	8.17	17.39	7.93	186.3	395.2	119	44.7	1343	5.10	297.0	27029.0
	14:26	8.19	16.93	8.30	121.0	329.9	118	44.3	1351	5.00	301.0	27330.0
	15:26	8.20	16.91	8.35	167.5	376.4	118	50.6	1359	5.10	304.0	27634.0
	16:26	8.18	16.25	8.41	179.6	388.5	116	49.1	1356	5.10	304.0	27938.0

Table B-2.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pump Intake Depth (ft bgs)	Pumping Rate at Time of Field Parameter	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
3/11/17 (cont.)	17:25	8.14	16.11	8.22	150.4	359.3	116	49.2	1352	5.15	277.0	28215.0
	18:00	8.19	15.92	8.48	138.4	347.3	115	65.1	1348	5.15	179.0	28394.0
3/12/17	7:05	8.24	11.97	4.98	125.2	334.1	97	33.6	1344	4.90	288.0	28682.0
	8:05	8.33	15.56	6.90	87.9	296.8	113	19.2	1344	4.80	289.0	28971.0
	9:05	8.29	16.25	7.50	91.8	300.7	115	15.5	1353	4.85	287.0	29258.0
	10:05	8.21	16.26	7.65	99.7	308.6	113	16.2	1357	4.90	291.0	29549.0
	11:05	8.14	16.58	7.55	108.5	317.4	113	20.7	1360	5.00	296.0	29845.0
	12:05	8.10	16.98	7.85	85.2	294.1	113	19.8	1352	4.95	295.0	30140.0
	13:05	8.07	16.41	8.23	113.1	322.0	112	21.8	1344	4.95	294.0	30434.0
	14:05	8.05	17.38	8.17	100.9	309.8	114	21.3	1341	4.85	292.0	30726.0
	15:06	8.04	17.20	8.09	124.4	333.3	114	22.0	1353	4.90	292.0	31018.0
	16:06	8.06	16.92	8.10	131.2	340.1	113	31.6	1357	5.00	296.0	31314.0
	17:06	8.04	16.77	8.09	120.7	329.6	112	23.2	1354	5.00	296.0	31610.0
	18:00	8.03	16.30	8.37	93.0	301.9	111	23.8	1350	4.95	270.0	31880.0
	18:30	8.02	16.11	8.40	92.5	301.4	111	23.3	1346	4.95	152.0	32032.0
3/13/17	7:20	8.46	12.27	4.99	109.8	318.7	101	23.5	1342	4.95	303.0	32335.0
	8:20	8.26	15.18	6.96	72.7	281.6	109	13.3	1341	5.00	289.0	32624.0
	9:20	8.17	15.08	7.00	77.0	285.9	108	13.7	1341	5.00	86.0	32710.0
	10:13	8.11	15.11	7.10	74.8	283.7	105	16.3	1340	2.90	295.0	33005.0
	10:40	8.06	16.70	6.69	65.8	274.7	111	15.8	1340	2.85	80.0	33085.0
	11:00	8.07	17.25	6.50	66.8	275.7	112	10.8	1340	2.85	58.0	33143.0
	11:11	8.06	17.50	6.52	67.2	276.1	113	9.5	1340	2.85	36.0	33179.0

Table B-2.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pump Intake Depth (ft bgs)	Pumping Rate at Time of Field Parameter	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Aquifer Pump Test												
3/14/16	n/a	NR, pumping, fill discharge lines							1332	n/a	206.8	33385.8
3/16/17	n/a	NR, pumping, mini-tests							1332	n/a	350.4	33736.2
3/18/17 to 3/19/17	8:23	7.64	11.77	9.15	79.0	287.9	90	5.3	1342	3.88	89.3	33825.5
	9:23	7.90	15.28	8.36	84.6	293.5	102	3.7	1342	3.90	233.7	34059.2
	10:27	7.92	15.39	8.16	89.2	298.1	103	2.8	1342	3.93	251.7	34310.9
	11:27	7.93	16.05	8.04	106.8	315.7	105	1.8	1342	2.93	176	34486.9
	12:27	7.92	16.15	8.27	123.6	332.5	105	2.5	1342	6.12	367.2	34854.1
	13:27	7.94	16.39	8.43	143.9	352.8	106	1.3	1342	2.84	170.3	35024.4
	14:27	7.93	16.53	8.33	176.4	385.3	106	2.4	1342	4.00	240	35264.4
	15:30	7.92	16.47	8.59	200.7	409.6	107	0.8	1342	3.98	250.8	35515.2
	16:30	7.89	16.10	8.67	232.5	441.4	106	19.3	1342	3.99	239.1	35754.3
	17:30	7.86	15.75	8.72	275.8	484.7	105	13	1342	3.99	239.3	35993.6
	18:30	7.90	15.46	8.83	253.3	462.2	104	1.9	1342	3.99	239.1	36232.7
	19:30	7.92	15.20	8.79	252.4	461.3	104	2.3	1342	4.04	242.1	36474.8
	20:30	7.92	15.12	8.85	245.9	454.8	104	6	1342	3.91	234.4	36709.2
	21:30	7.93	15.09	NR	210.8	419.7	103	NR	1342	1.98	119	36828.2
	22:32	7.92	15.12	NR	199.0	407.9	104	NR	1342	5.87	364.2	37192.4
	23:30	7.92	15.10	NR	189.1	398.0	103	NR	1342	3.96	229.6	37422.0
	0:05	7.91	15.07	NR	186.7	395.6	103	NR	1342	3.95	138.4	37560.4
	0:30	7.94	15.05	NR	181.7	390.6	103	NR	1342	3.97	99.3	37659.7
	1:33	7.93	15.08	NR	176.9	385.8	104	NR	1342	3.77	237.5	37897.2
	2:28	7.96	15.05	NR	169.9	378.8	103	NR	1342	4.32	237.7	38134.9
	3:27	7.94	15.03	NR	167.3	376.2	103	NR	1342	3.82	225.4	38360.3

Table B-2.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP (mV)	Eh (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Pump Intake Depth (ft bgs)	Pumping Rate at Time of Field Parameter	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
	4:00	7.92	15.05	NR	166.1	375.0	103	NR	1342	3.95	130.5	38490.8
	4:30	7.92	15.05	NR	164.9	373.8	103	NR	1342	3.97	119	38609.8
	5:29	7.93	15.02	NR	161.4	370.3	103	NR	1342	3.97	234	38843.8
	6:30	7.92	14.99	NR	158.7	367.6	103	NR	1342	3.97	242.2	39086.0
	7:31	7.90	15.05	NR	153.6	362.5	103	NR	1342	3.91	238.7	39324.7
	7:58	7.91	15.19	NR	153.1	362.0	104	NR	1342	4.43	119.6	39444.3

Note: One temperature-dependent correction factor was used to calculate Eh values from field ORP measurements: 208.9 mV at 15ºC.

[a] n/a = Not applicable.

[b] NR = Not recorded.

Appendix C

Geophysical Logs
(on CD and DVDs included with this document)

Appendix D

Final Well Design and
New Mexico Environment Department Approval

From:	Dale, Michael, NMENV
To:	Katzman, Danny
Cc:	Swickley, Stephani Fuller; Rodriguez, Cheryl L; White, Stephen Spalding; Goering, Tim J; Everett, Mark Capen; Dhawan, Neelam, NMENV; Murphy, Robert, NMENV
Subject:	RE: R-68 well design package
Date:	Monday, February 06, 2017 1:08:41 PM

Danny,

New Mexico Environment Department (NMED) has reviewed the proposed well design plan (Plan) for monitoring well R-68, and hereby issues this approval. The Plan was received today, February 6, 2017 at 11:32 am. Note that this approval is based on the information available to NMED at time of the approval. LANL must provide the results of groundwater sampling, any modifications to the well design as proposed in the above-mentioned e-mail, and any additional information relevant to the installation of the well as soon as such data or information become available. In addition, please provide NMED reasonable-time (e.g., 1 -2 days) notification prior to the initiation of well development, the step-drawdown test, and constant-rate aquifer testing at R-68. Please call if you have any questions concerning this approval.

Thank you,

Michael R. Dale
New Mexico Environment Department
1183 Diamond Drive, Suite B
Los Alamos, NM 87544
LANL MS M894
Cell Phone: (505) 231-5423
Office Phone (505) 476-3078

From: Katzman, Danny [mailto:katzman@lanl.gov]
Sent: Monday, February 06, 2017 11:32 AM
To: Dale, Michael, NMENV <Michael.Dale@state.nm.us>; Dhawan, Neelam, NMENV <neelam.dhawan@state.nm.us>
Cc: Swickley, Stephani Fuller <sfuller@lanl.gov>; Rodriguez, Cheryl L <cheryl.rodriguez@em.doe.gov>; White, Stephen Spalding <ssw@lanl.gov>; Goering, Tim J <goering@lanl.gov>; Everett, Mark Capen <meverett@lanl.gov>
Subject: R-68 well design package

Michael- Thanks for the very quick response on Friday regarding our proposed well design for R-68. That really helped the drillers stay busy over the weekend.
Attached is our official submittal of the well design package. I intentionally did not include the gamma log in the package, since it didn't factor into our decision making. And we did not do induction logging because we were cased to depth.
Let us know if you have any questions.
Danny

R-68 Well-Design Recommendation
February 6, 2017

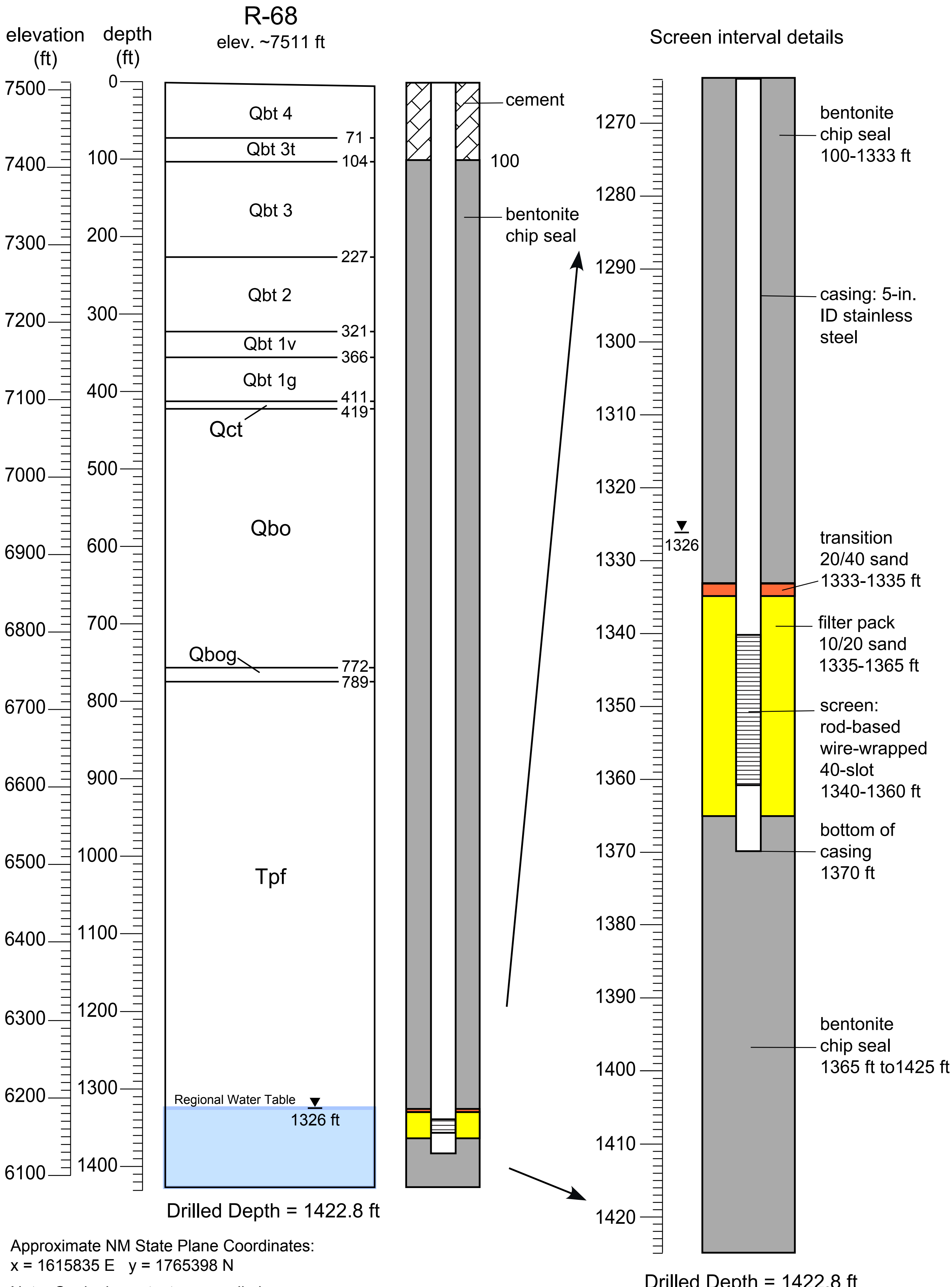
The objective of regional aquifer monitoring well R-68 is to investigate the nature and extent of high explosives (HE) and related contaminants in the area between Canon de Valle and well R-18. Driller's observations taken from the borehole at a total depth of 1422.8 ft, with casing pulled back 2 ft, indicate that the static water level is approximately 1326 ft below ground surface (bgs).

A screening sample was obtained during drilling via air lifting at 1322 ft bgs from what was observed to be a zone sufficiently productive to yield a sample. The sample was analyzed for RDX, HMX, and TNT at GGRL and shows 118.1 ug/L RDX, and nondetect for the other two high explosives. It is not known whether this RDX observation is indicative of perched-intermediate groundwater that may have followed the drilling from an upper perched zone identified from approximately 682 ft - 995 ft bgs that showed similar RDX concentrations, or whether the RDX is indicative of contamination that may be present at or near the regional water table. The nature of the hydraulic connection between the sampled zone at 1322 ft and the 1326 ft water level is not known.

Cuttings samples from the aquifer in the targeted completion zone indicate that Puye exhibits significant silt content within a sandy gravel from the water table down to about 1340 ft. Below 1340 ft, the silt content is lower and drops off more significantly below 1350 ft.

Based on the information described above (water levels, particle size, and potential RDX contamination near the water table), the Laboratory proposes to install a 20-ft screen in the borehole beginning at 1340' bgs, approximately 14 ft below the regional water table. The primary filter pack, consisting of 10/20 sand, will be set from approximately 1335' - 1365' bgs, with 2 ft of 20/40 transition sand from 1335 – 1333 ft bgs (see included design figure).

Please let us know if you have any questions.



Approximate NM State Plane Coordinates:
x = 1615835 E y = 1765398 N

Note: Geologic contacts are preliminary

Appendix E

Aquifer Testing Report for Well R-68

E-1.0 INTRODUCTION

This appendix describes the hydraulic analysis of pumping tests conducted in March 2017 at well R-68, a regional aquifer well located at Technical Area 09 (TA-09) at Los Alamos National Laboratory (LANL or the Laboratory). The tests on R-68 were conducted to characterize the saturated materials, quantify the hydraulic properties of the screened interval, and evaluate the hydraulic connection between R-68 and other R-wells in the vicinity, including R-18; R-25 screens 5, 6, 7 and 8; and R-63. Testing consisted of brief trial pumping, background water-level data collection, and a 24-h constant rate pumping test.

As in most of the R-well pumping tests conducted on the Pajarito Plateau, an inflatable packer system was installed in R-68 to eliminate casing storage effects on the test data. This setup was effective and produced good data.

Conceptual Hydrogeology

Well R-68 is completed within Puye deposits. The well screen is 20.4 ft long, extending from 1340 to 1360.4 ft below ground surface (bgs). The static water level measured on March 14, 2017, before testing, was 1325.66 ft below ground surface. The land surface elevation at the time of testing was estimated at approximately 7511 ft above mean sea level (amsl), making the groundwater elevation estimate approximately 6185 ft amsl. A final survey had not been completed at the time of testing, analysis, and reporting.

Puye sediments extended from above the static water level to a depth of at least 1422.8 ft bgs where the pilot hole was terminated during drilling. The presence of the water table within the permeable Puye sediments implied the likelihood of locally unconfined conditions.

R-68 Testing

Well R-68 was tested from March 14 to 20, 2017. On March 14, the pump was installed and operated long enough to fill the drop pipe to prepare for subsequent trial tests and 24-h testing.

Trial testing of R-68 (trial 1) began at 8:00 a.m. on March 16 at a discharge rate of 4.3 gallons per minute (gpm) and continued for 30 min. Following 30 min of recovery, a second trial test (trial 2) was performed at 9:00 a.m. for 60 min at a discharge rate of 4.3 gpm. Following shutdown, recovery/background data were recorded for 2760 min until the start of the 24-h pumping test. The period between pump installation on March 14 and the start of trial testing on March 16 provided additional background water-level information.

Following background data collection, the 24-h pumping test began at 8:00 a.m. on March 18, at a discharge rate of 4.3 gpm. Pumping continued for 1440 min until 8:00 a.m. on March 19. Following shutdown, recovery data were recorded for 1440 min until 8:00 a.m. on March 20 when the packer was deflated. Following packer deflation, the pump was run from approximately 8:27 to 9:14 a.m. on March 20 to allow water samples to be collected. The discharge rate during water sampling was 6.4 gpm.

E-2.0 BACKGROUND DATA

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

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

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

Subsequent pumping tests, including at R-68, have utilized nonvented transducers, devices that record the total pressure on the transducer, that is, the sum of the water height plus the barometric pressure. This results in an attenuated "apparent" hydrograph in a barometrically efficient well. Take as an example a 90% barometrically efficient well. When monitored using a vented transducer, an increase in barometric pressure of 1 unit causes a decrease in recorded downhole pressure of 0.9 unit because the water level is forced downward 0.9 unit by the barometric pressure change. However, when a nonvented transducer is used, the total measured pressure increases by 0.1 unit (the combination of the barometric pressure increase and the water-level decrease). Thus, the resulting apparent hydrograph changes by a factor of 100 minus the barometric efficiency, and in the same direction as the barometric pressure change, rather than in the opposite direction.

Barometric pressure data were obtained from TA-54 tower site from the Environmental Protection and Compliance Programs (formerly the Waste and Environmental Services Division–Environmental Data and Analysis). The TA-54 measurement location is at an elevation of 6548 ft amsl, whereas the wellhead elevation is at approximately 7511 ft amsl. The static water level in R-68 was 1325.66 ft below ground surface, making the water-table elevation approximately 6185 ft amsl. Therefore, the measured barometric pressure data from TA-54 had to be adjusted to reflect the pressure at the elevation of the water table within R-68.

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

$$P_{WT} = P_{TA54} \exp\left[-\frac{g}{3.281R} \left(\frac{E_{R-68} - E_{TA54}}{T_{TA54}} + \frac{E_{WT} - E_{R-68}}{T_{WELL}} \right) \right] \qquad \textbf{Equation E-1}$$

where, P_{WT} = barometric pressure at the water table inside R-68

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

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

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

E_{R-68} = estimated elevation at R-68 site, in feet (7511 ft)

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

E_{WT} = estimated elevation of the water level in R-68, in feet (6185 ft)

T_{TA54} = air temperature near TA-54, in degrees Kelvin (assigned a value of 46.4 degrees Fahrenheit, or 281.1 degrees Kelvin)

T_{WELL} = air column temperature inside R-68, in degrees Kelvin (assigned a value of 53.6 degrees Fahrenheit, or 285.1 degrees Kelvin)

This formula is an adaptation of an equation Environmental Protection and Compliance Programs provided. It can be derived from the ideal gas law and standard physics principles. An inherent assumption in the derivation of the equation is that the air temperature between TA-54 and the well is temporally and spatially constant and that the temperature of the air column in the well is similarly constant.

The corrected barometric pressure data reflecting pressure conditions at the water table were compared with the water-level hydrograph to discern the correlation between the two and to determine whether water level corrections were needed before data analysis.

E-3.0 IMPORTANCE OF EARLY DATA

When pumping or recovery first begins, the vertical extent of the cone of depression is limited to approximately the well screen length, the filter pack length, or the aquifer thickness in relatively thin permeable strata. For many pumping tests on the Plateau, the early pumping period is the only time the effective height of the cone of depression is known with certainty because soon after startup the cone of depression expands vertically through permeable materials above and/or below the screened interval. Thus, the early data often offer the best opportunity to obtain hydraulic conductivity information because conductivity would equal the earliest-time transmissivity divided by the well screen length.

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

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

Equation E-2

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

D = inside diameter of well casing, in inches

d = outside diameter of column pipe, in inches

Q = discharge rate, in gallons per minute

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

The calculated casing storage time is quite conservative. Often, the data show that significant effects of casing storage have dissipated after about half the computed time.

For wells screened across the water table or wells in which the filter pack can drain during pumping, an additional storage contribution from the filter pack may occur. The following equation provides an estimate of the storage duration accounting for both casing and filter pack storage.

$$t_c = \frac{0.6\left[\left(D^2 - d^2\right) + S_y\left(D_B^2 - D_C^2\right)\right]}{\frac{Q}{s}}$$ **Equation E-3**

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

D_B = diameter of borehole, in inches

D_C = outside diameter of well casing, in inches

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

In some instances, it is possible to eliminate casing storage effects by setting an inflatable packer above the tested screen interval before the test is conducted. This was done successfully in the testing performed on R-68.

E-4.0 TIME-DRAWDOWN METHODS

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

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

where,

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

and

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

and where, s = drawdown, in feet

Q = discharge rate, in gallons per minute

T = transmissivity, in gallons per day per foot

S = storage coefficient (dimensionless)

t = pumping time, in days

r = distance from center of pumpage, in feet

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

$$T = \frac{114.6Q}{s} W(u)$$

Equation E-7

$$S = \frac{Tut}{2693r^2}$$

Equation E-8

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

S = storage coefficient

Q = discharge rate, in gallons per minute

$W(u)$ = match-point value

s = match-point value, in feet

u = match-point value

t = match-point value, in minutes

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

$$s = \frac{264Q}{T} \log \frac{0.3Tt}{r^2 S}$$

Equation E-9

The Cooper-Jacob equation is a simplified approximation of the Theis equation and is valid whenever the u value is less than about 0.05. For small radius values (e.g., corresponding to borehole radii), u is less than 0.05 at very early pumping times and therefore is less than 0.05 for most or all measured drawdown values. Thus, for the pumped well, the Cooper-Jacob equation usually can be considered a valid approximation of the Theis equation. An exception occurs when the transmissivity of the aquifer is very low. In that case, some of the early pumped well drawdown data may not be well approximated by the Cooper-Jacob equation.

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

$$T = \frac{264Q}{\Delta s}$$

Equation E-10

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

Q = discharge rate, in gallons per minute

Δs = change in head over one log cycle of the graph, in feet

Because many of the test wells completed on the Plateau are severely partially penetrating, an alternate solution considered for assessing aquifer conditions is the Hantush equation for partially penetrating wells (Hantush 1961, 098237; Hantush 1961, 106003). The Hantush equation is as follows:

Equation E-11

$$s = \frac{Q}{4\pi T}\left[W(u) + \frac{2b^2}{\pi^2 (l-d)(l'-d')}\sum_{n=1}^{\infty}\frac{1}{n^2}\left(\sin\frac{n\pi l}{b} - \sin\frac{n\pi d}{b}\right)\left(\sin\frac{n\pi l'}{b} - \sin\frac{n\pi d'}{b}\right)W\left(u, \sqrt{\frac{K_z}{K_r}}\frac{n\pi r}{b}\right)\right]$$

Where, in consistent units, s, Q, T, t, r, S, and u are as previously defined and

b = aquifer thickness

d = distance from top of aquifer to top of well screen in pumped well

l = distance from top of aquifer to bottom of well screen in pumped well

d' = distance from top of aquifer to top of well screen in observation well

l' = distance from top of aquifer to bottom of well screen in observation well

K_z = vertical hydraulic conductivity

K_r = horizontal hydraulic conductivity

In this equation, $W(u)$ is the Theis well function and $W(u,\beta)$ is the Hantush well function for leaky aquifers where

$$\beta = \sqrt{\frac{K_z}{K_r}}\frac{n\pi r}{b}.$$

Equation E-12

Note that for single-well tests, $d = d'$ and $l = l'$.

E-5.0 RECOVERY METHODS

Recovery data were analyzed using the Theis recovery method, a semilog analysis method similar to the Cooper-Jacob procedure. In this method, residual drawdown is plotted on a semilog graph versus the ratio t/t', where t is the time since pumping began and t' is the time since pumping stopped. A straight line of best fit is constructed through the data points and T is calculated from the slope of the line as follows:

$$T = \frac{264Q}{\Delta s}$$ **Equation E-13**

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

When the earliest recovery data violate the u value assumption inherent in the semilog method, the data can be analyzed using a log-log plot and Theis curve matching.

Recovery data also can be analyzed using the Hantush equation for partial penetration. This approach is generally applied to the early data in a plot of recovery versus recovery time.

E-6.0 SPECIFIC CAPACITY METHOD

The specific capacity of the pumped well can be used to obtain a lower-bound value of hydraulic conductivity. The hydraulic conductivity is computed using formulas that are based on the assumption that the pumped well is 100% efficient. The resulting hydraulic conductivity is the value required to sustain the observed specific capacity. If the actual well is less than 100% efficient, it follows that the actual hydraulic conductivity would have to be greater than calculated to compensate for well inefficiency. Thus, because the efficiency is not known, the computed hydraulic conductivity value represents a lower bound. The actual conductivity is known to be greater than or equal to the computed value.

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

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

$$s_P = \frac{1-\frac{L}{b}}{\frac{L}{b}}\left[\ln\frac{b}{r_w} - 2.948 + 7.363\frac{L}{b} - 11.447\left(\frac{L}{b}\right)^2 + 4.675\left(\frac{L}{b}\right)^3\right]$$ **Equation E-14**

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

$$K = \frac{264Q}{sb}\left(\log\frac{0.3Tt}{r_w^2 S} + \frac{2s_P}{\ln 10}\right)$$ **Equation E-15**

The Brons and Marting procedure can be applied to both partially penetrating and fully penetrating wells.

To apply this procedure, a storage coefficient value must be assigned. Storage coefficient values generally range from 10^{-5} to 10^{-3} for confined aquifers and 0.01 to 0.25 for unconfined aquifers (Driscoll 1986, 104226). Semiconfined conditions generally are associated with intermediate storage coefficient values between these ranges. For R-68, the well log suggested unconfined conditions, so calculations were performed for an assigned storage coefficient range of 0.01 to 0.2. The lower-bound transmissivity calculation result is not particularly sensitive to the choice of storage coefficient value, so a rough estimate is generally adequate to support the calculations.

The analysis also requires assigning a value for the saturated aquifer thickness, b. For R-68, b was assigned a value of 97 ft, the saturated thickness of Puye Formation penetrated by the borehole before the well was backfilled and well completed. The calculation is not particularly sensitive to the assigned value of saturated thickness. It is only necessary to use a value well in excess of the screen length. Ignoring deeper sediments has little effect on the calculation results because sediments far from the screened interval have minimal effect on yield.

E-7.0 BACKGROUND DATA ANALYSIS

Background aquifer pressure data collected during the R-68 tests were plotted along with barometric pressure to determine the barometric effect on water levels.

Figure E-7.0-1 shows aquifer pressure data from R-68 during the test period along with barometric pressure data from TA-54 that have been corrected to equivalent barometric pressure in feet of water at the water table. The R-68 data are referred to in the figure as the “apparent hydrograph” because the measurements reflect the sum of water pressure and barometric pressure that was recorded using a nonvented pressure transducer. The times of the pumping test periods for the R-68 pumping tests are included in the figure for reference.

A comparison of the apparent hydrograph and barometric pressure curve showed little correlation between the two, suggesting a high barometric efficiency, likely close to 100%. Large changes in barometric pressure caused negligible change in the apparent hydrograph, meaning the changes in water level were equal to and opposite of changes in barometric pressure.

The most noticeable feature of the apparent hydrograph data in Figure E-7.0-1 is that water levels showed a muted diurnal “ripple” effect with a fluctuation amplitude of just a couple hundredths of a foot. This effect is characteristic of Earth tide pressure fluctuations observed in many of the regional wells on the Plateau.

Figure E-7.0-2 shows hydrograph data from R-18, located approximately 1800 ft away, for the period from March 4 to 20, 2017. This time interval was selected to include several days of development pumping performed on R-68 in addition to the test pumping period, as indicated on the plot. The barometric pressure is included on the plot for comparison with the hydrograph. Note that the barometric pressure scale on the graph is reversed, with pressure increasing downward. The hydrograph and barometric pressure curves match reasonably well, suggesting that R-18 water-level fluctuations could be attributed to barometric pressure changes rather than to pumping at R-68. When this plot was prepared, the barometric pressure data were modified for barometric efficiency and the hydrograph data were adjusted for a linear background trend. The match shown corresponded to a barometric efficiency of 91% and a background water level decline of 0.003 ft/d. There was no indication of consistent water-level changes in R-18 attributable to pumping at R-68.

Figure E-7.0-3 shows hydrograph data from R-63, located approximately 1100 ft away, for the period from March 4 to 20. These data were adjusted for a barometric efficiency of 88% and a background water level rise of 0.002 ft/d. Although the curves were similar, the match between the barometric pressure and hydrograph curves was not as good as that observed in R-18, with some significant deviations between the two graphs. Nevertheless, it was not possible to identify a pumping effect on the R-63 data attributable to operation of R-68.

Water-level data were collected from R-25 screens 5, 6, 7 and 8, located approximately 1500 ft from R-68. Data are presented for the R-68 development pumping period from March 4 to 13. Data were not available after March 13 because the transducers were pulled temporarily for maintenance.

Figure E-7.0-4 shows adjusted barometric pressure and water-level data from R-25 screen 5 for this period. The transducers installed in R-25 are nonvented. Therefore, a different algorithm than that used for vented transducers was needed to correct the data for barometric efficiency. Note that the barometric pressure scale on the graph is not reversed as was the case in Figures E-7.0-2 and F-7.0-3, which show water-level data obtained using vented transducers.

The data presented in Figure E-7.0-4 were adjusted to achieve a match between the barometric pressure and hydrograph curves. As indicated, a good match was obtained using a barometric efficiency of 93% and a background water level decline of 0.007 ft/d. The data belie any response in R-25 screen 5 associated with operation of R-68.

Figure E-7.0-5 shows a similar graph for R-25 screen 6. The data showed good agreement between the plots for the assumption of 86% barometric efficiency and a background water level decline of 0.013 ft/d for the screen 6 zone. There was no evidence of a screen 6 zone response to pumping R-68.

Figures E-7.0-6 and E-7.0-7 show similar analyses for R-25 screens 7 and 8, respectively. The curves do not match as well as those for screens 5 and 6 but overall show a correlation for a barometric efficiency of 60% and a background water level decline of 0.0085 ft/d. The data indicate there was no identifiable response to pumping R-68 in either screen 7 or 8. The primary deviation of the hydrographs from the barometric pressure curves is that the hydrograph data showed significant diurnal fluctuations in water levels, having a magnitude ranging from approximately 0.05 to 0.10 ft. These fluctuations are not explained by the observed barometric pressure. It is likely they are attributable to Earth tides.

Most of the regional wells on the Plateau exhibit Earth tide fluctuations having a magnitude no greater than a few hundredths of a foot. The Earth tide effects observed in screens 7 and 8 were unusually large compared to those observed in other wells. Also, the barometric efficiency determined from the data (60%) was less than that seen in most of the regional wells on the Plateau. Thus, the water level response seen in R-25 screens 7 and 8 were unusual with respect to both barometric efficiency and Earth tides.

The raw data from screens 7 and 8, not corrected for background trend, were plotted together on Figure E-7.0-8 to allow comparison of the two responses. As indicated in the figure, the two plots are nearly identical, save for the 23-ft difference in water level elevation between the two zones.

E-8.0 WELL R-68 DATA ANALYSIS

This section presents the data obtained from the R-68 pumping tests and the results of the analytical interpretations. Data are presented for trial 1, trial 2, and the 24-h test.

E-8.1 Well R-68 Trial 1

Brief trial testing was performed to obtain "snapshots" of early pumping and recovery response to try to quantify properties of the subsurface materials immediately around the wellbore.

Figure E-8.1-1 shows a semilog plot of the drawdown data collected from trial 1 on R-68 at a discharge rate of 4.3 gpm. The transmissivity determined from the line of fit on the graph was 1360 gallons per day (gpd)/ft. Based on the well screen length of 20.4 ft, this implied an average hydraulic conductivity value of 67 gpd/ft^2, or 8.9 ft/d. It is possible the calculated transmissivity value corresponded to a sediment thickness somewhat greater than the well screen length, depending on the vertical growth of the cone of depression during the early stages of pumping. This would imply the likelihood of a somewhat smaller hydraulic conductivity than that calculated based on the screen length. In other words, the computed hydraulic conductivity value may be considered a maximum, or upper bound, value.

Note that the data recorded before the line of fit shown on the graph indicated a flatter slope than the subsequent data. It is likely this reflected delayed yield response associated with vertical movement (drainage) of the water table in response to pumping.

The data recorded during the first quarter minute of pumping showed substantially less drawdown than expected. There was no explanation for this unusual response that was not duplicated in any other pumping event on R-68. It is possible a small amount of air or gas in the water could have temporarily affected the pump efficiency and discharge rate, although this is speculative.

Figure E-8.1-2 shows the recovery data obtained from trial 1. The transmissivity determined from the line of fit on the graph was 1330 gpd/ft, implying a maximum hydraulic conductivity value of 65 gpd/ft^2, or 8.7 ft/d.

E-8.2 Well R-68 Trial 2

Figure E-8.2-1 shows a semilog plot of the drawdown data collected from trial 2 on R-68 at a discharge rate of 4.3 gpm. The data showed an early steep slope followed by flattening, presumably from delayed yield and then a resumption of the steep slope. The transmissivity values determined from the first and second lines of fit shown on the graph were 1400 gpd/ft, corresponding to an upper-bound hydraulic conductivity value of 69 gpd/ft^2, or 9.2 ft/d, and 1650 gpd/ft, corresponding to an upper-bound hydraulic conductivity value of 81 gpd/ft^2, or 10.8 ft/d.

Figure E-8.2-2 shows recovery data recorded for 2760 min following cessation of trial 2 pumping. The transmissivity values determined from the first and second lines of fit shown on the graph were 1350 gpd/ft, corresponding to an upper-bound hydraulic conductivity value of 66 gpd/ft^2, or 8.8 ft/d, and 1250 gpd/ft, corresponding to an upper-bound hydraulic conductivity value of 61 gpd/ft^2, or 8.2 ft/d.

Late data on the left-hand side of the plot showed continuing flattening of the data trace, corresponding to ongoing vertical expansion of the cone of impression at late time. Figure E-8.2-3 shows an expanded-scale plot of these data along with the resulting computed transmissivity value of 3440 gpd/ft. This transmissivity corresponded to some greater, unknown thickness of saturated sediments. Note that the momentary scatter in the data points resulted from temporarily deflating the packer and lowering the pump following the first hour of recovery from trial 2 pumping.

E-8.3 Well R-68 24-h Test

Figure E-8.3-1 shows a semilog plot of the drawdown data collected from the 24-h pumping test at a discharge rate of 4.3 gpm. Initially, the discharge rate was elevated because the upper portion of the drop pipe had been drained overnight to prevent freezing. As a result, the hydraulic head on the pump was reduced temporarily until the drop pipe was refilled and the inline valve imposed backpressure on the pump. It was estimated the instantaneous discharge rate during the first few seconds of pumping was 6.4 gpm—the rate observed during the subsequent water sampling event.

The transmissivity value determined from the early data was 1760 gpd/ft, corresponding to an upper-bound hydraulic conductivity value of 86 gpd/ft^2, or 11.5 ft/d. The transmissivity value determined from the subsequent data was 1330 gpd/ft, corresponding to an upper-bound hydraulic conductivity value of 65 gpd/ft^2, or 8.7 ft/d.

Late data from the 24-h pumping test showed continuing flattening of the drawdown curve corresponding to ongoing vertical growth of the cone of depression. Figure E-8.3-2 shows analysis of the late data, revealing a transmissivity value of 3870 gpd/ft and reflecting the properties of some greater, unknown thickness of saturated sediments.

The drawdown data were plotted on a log-log graph and analyzed using Theis curve matching as shown in Figure E-8.3-3. The analysis showed a transmissivity value of 1810 gpd/ft, corresponding to an upper-bound hydraulic conductivity value of 89 gpd/ft^2, or 11.9 ft/d.

Figure E-8.3-4 shows a semilog plot of the recovery data collected following the 24-h pumping test on R-68. The data showed an early steep slope, followed by a flattening, presumably from delayed yield, and then a resumption of the steep slope. The transmissivity values determined from the first and second lines of fit shown on the graph were 1600 gpd/ft, corresponding to an upper-bound hydraulic conductivity value of 78 gpd/ft^2, or 10.5 ft/d, and 1360 gpd/ft, corresponding to an upper-bound hydraulic conductivity value of 67 gpd/ft^2, or 8.9 ft/d.

Late data from the recovery period in Figure E-8.3-4 showed continuing flattening of the curve corresponding to ongoing vertical growth of the cone of impression. Figure E-8.3-5 shows analysis of the late data, revealing a transmissivity value of 5400 gpd/ft reflecting the properties of some greater, unknown thickness of saturated sediments.

The recovery data were plotted on a log-log graph and analyzed using the more general Theis curve matching solution as shown on Figure E-8.3-6. The analysis showed a transmissivity value of 1700 gpd/ft, corresponding to an upper-bound hydraulic conductivity value of 83 gpd/ft^2, or 11.1 ft/d.

E-8.4 Combined Results

Table E-8.4-1 summarizes the results of the analyses determining the hydraulic properties of the screened zone in R-68. Transmissivity values ranged from 1250 to 1810 gpd/ft, averaging 1490 gpd/ft. The resulting hydraulic conductivity values ranged from 8.2 to 11.9 ft/d, averaging 9.8 ft/d. Because the computed transmissivity values likely incorporated a sediment thickness somewhat greater than the screened interval, this value may be assumed to be an upper-bound hydraulic conductivity value.

E-8.5 Well R-68 Specific Capacity Data

Specific capacity data were used along with well geometry to estimate a lower-bound hydraulic conductivity value for the permeable zone penetrated by R-68 to provide a frame of reference for evaluating the foregoing analyses.

The total saturated thickness of Puye sediments was not known. In applying partial penetration analysis, however, it is only necessary to assign an aquifer thickness substantially greater than the well screen length because sediments far from the screened interval have negligible effect on yield. The aquifer thickness was arbitrarily assigned a value of 97 ft—the length of saturated sediments penetrated during drilling of the borehole. The well screen length of 20.4 ft was used in the partial penetration calculations.

R-68 produced 4.3 gpm with 3.03 ft of drawdown for a specific capacity of 1.42 gpm/ft after the first 1440 min of pumping during the 24-h test. In addition to specific capacity and pumping time, other input values used in the calculations included assigned storage coefficient values ranging from 0.01 to 0.2 and a borehole radius of 0.57 ft (inferred from the volume of filter pack required to backfill the screen zone).

Applying the Brons and Marting (1961, 098235) method to these inputs yielded the lower-bound hydraulic conductivity estimates shown on Figure E-8.5-1. Depending on the assumed storage coefficient value, the calculated lower-bound hydraulic conductivity values ranged from approximately 7.8 to 8.4 ft/d. This result was consistent with the values obtained from test analysis that produced an average upper-bound hydraulic conductivity value of 9.8 ft/d and suggested a fairly efficient well.

E-9.0 SUMMARY

Constant-rate pumping tests were conducted on R-68 to gain an understanding of the hydraulic characteristics of the aquifer. Testing consisted of two brief trial tests and a 24-h constant rate pumping test.

Several important observations and conclusions from the test pumping include the following:

1. A comparison of barometric pressure and R-68 water-level data showed a highly barometrically efficient screen zone. Large changes in barometric pressure caused almost no change in the apparent hydrograph obtained from the well, obtained using a nonvented transducer.

2. The background data showed Earth tide fluctuations of approximately 0.02 ft in R-68, typical of the response seen in many regional wells on the Plateau.

3. Development pumping and test pumping at discharge rates ranging from 4 to 9 gpm between March 4 and 20, 2017, caused no discernable hydraulic response in R-18, R-25, or R-63.

4. Early and middle data supported a determination of aquifer property estimates. Transmissivity values for the screened interval, or a zone somewhat thicker, determined from the analyses ranged from 1250 to 1810 gpd/ft, averaging 1490 gpd/ft. The corresponding upper-bound hydraulic conductivity values ranged from 8.2 to 11.9 ft/d, averaging 9.8 ft/d.

5. The drawdown and recovery data showed temporary flattening at intermediate time, consistent with delayed yield of the unconfined aquifer. Late data showed significant flattening, consistent with ongoing vertical growth of the cone of depression/impression.

6. The specific capacity of R-68 implied lower-bound hydraulic conductivity values in the range of 7.8 to 8.4 ft/d, which is consistent with the results of the hydraulic analyses (9.8 ft/d upper-bound average) and suggested a fairly efficient screen zone in R-68. Thus, the data bracketed the hydraulic conductivity of the screened interval in R-68 between approximately 8 and 10 ft/d.

E-10.0 REFERENCES

The following reference list includes documents cited in this appendix. Parenthetical information following each reference provides the author(s), publication date, and ERID or ESHID. This information is also included in text citations. ERIDs were assigned by the Associate Directorate for Environmental Management's (ADEM's) Records Processing Facility (IDs through 599999), and ESHIDs are assigned by the Environment, Safety, and Health Directorate (IDs 600000 and above). IDs are used to locate documents in the Laboratory's Electronic Document Management System and in the Master Reference Set. The New Mexico Environment Department (NMED) Hazardous Waste Bureau and ADEM maintain copies of the Master Reference Set. The set ensures that NMED has the references to review documents. The set is updated when new references are cited in documents.

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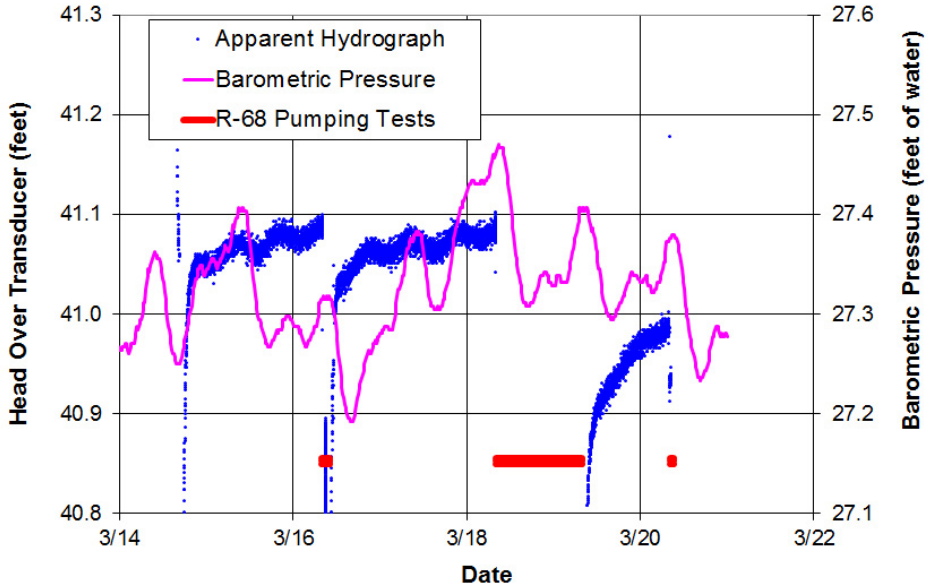

Figure E-7.0-1 Well R-68 apparent hydrograph and barometric pressure

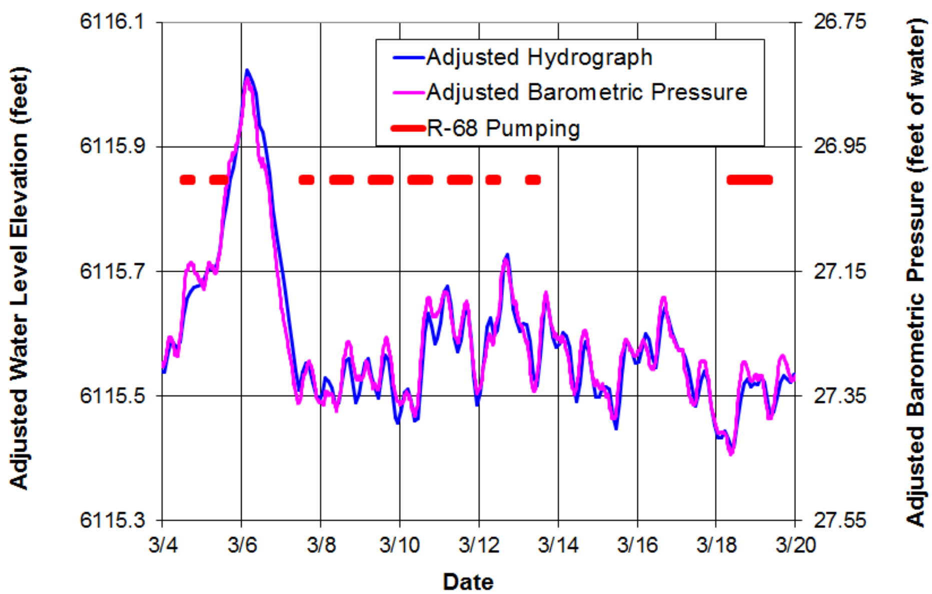

Figure E-7.0-2 Well R-18 adjusted hydrograph for 91% barometric efficiency and 0.003 ft/d water level decline

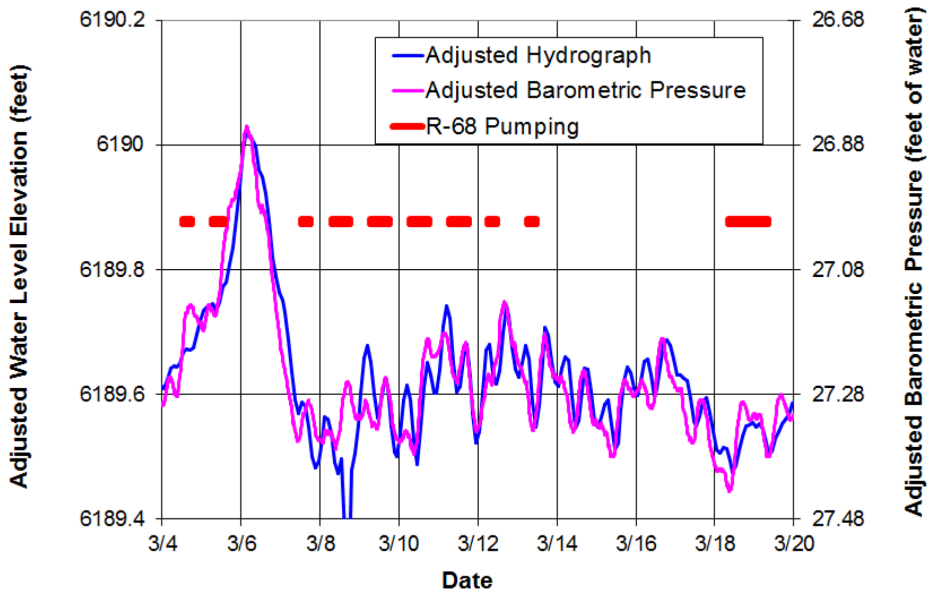

Figure E-7.0-3 Well R-63 adjusted hydrograph for 88% barometric efficiency and 0.002 ft/d water level rise

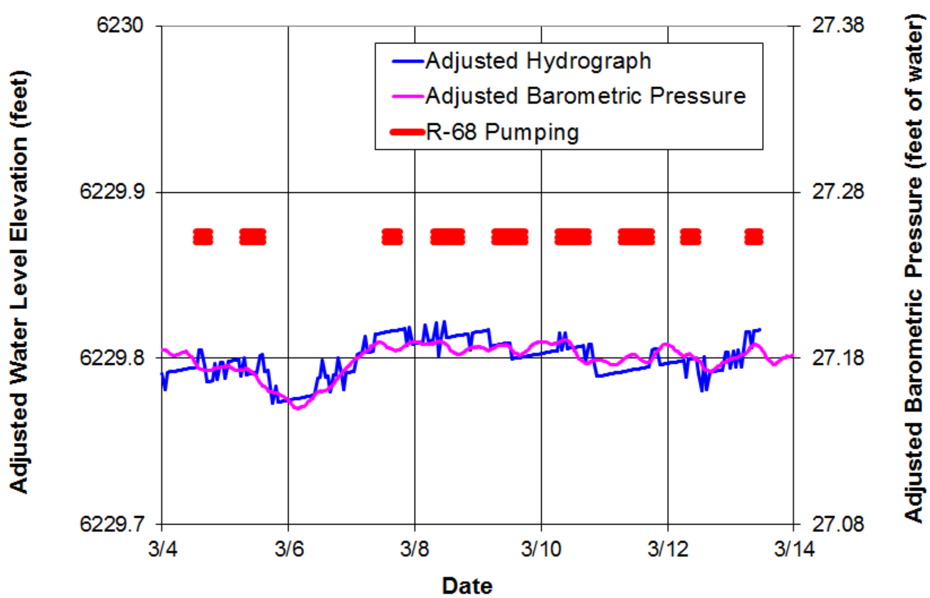

Figure E-7.0-4 Well R-25 screen 5 adjusted hydrograph for 93% barometric efficiency and 0.007 ft/d water level decline

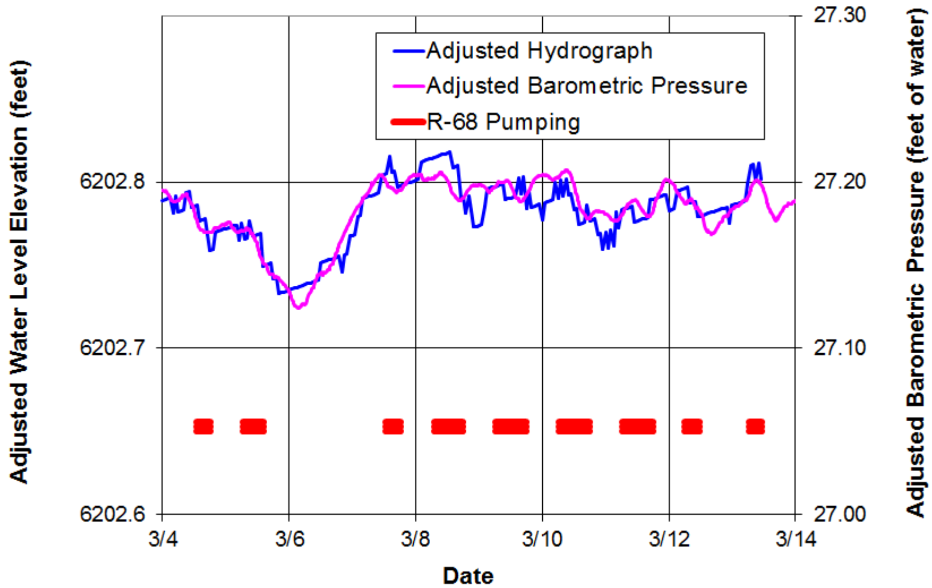

Figure E-7.0-5 **Well R-25 screen 6 adjusted hydrograph for 86% barometric efficiency and 0.013 ft/d water level decline**

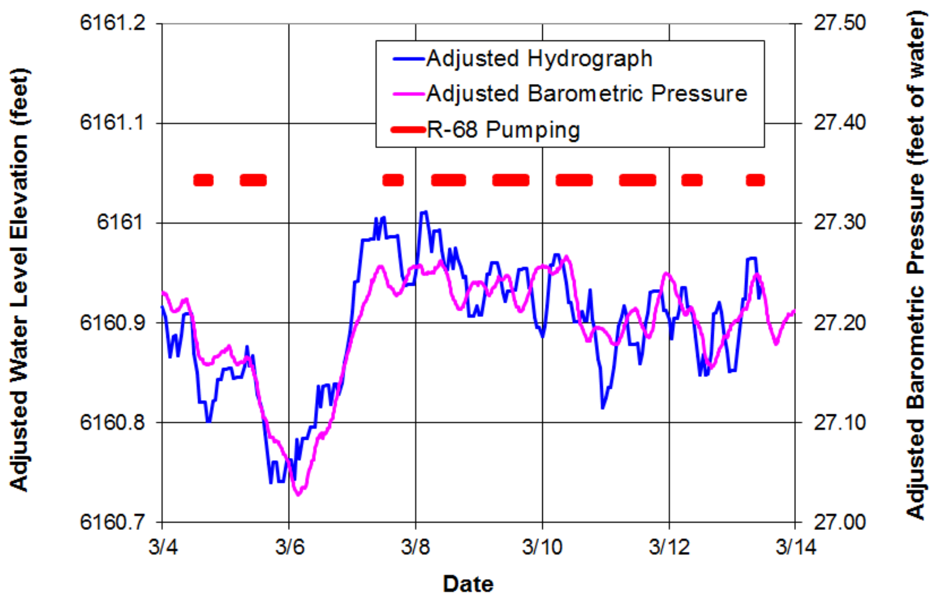

Figure E-7.0-6 **Well R-25 screen 7 adjusted hydrograph for 60% barometric efficiency and 0.013 ft/d water level decline**

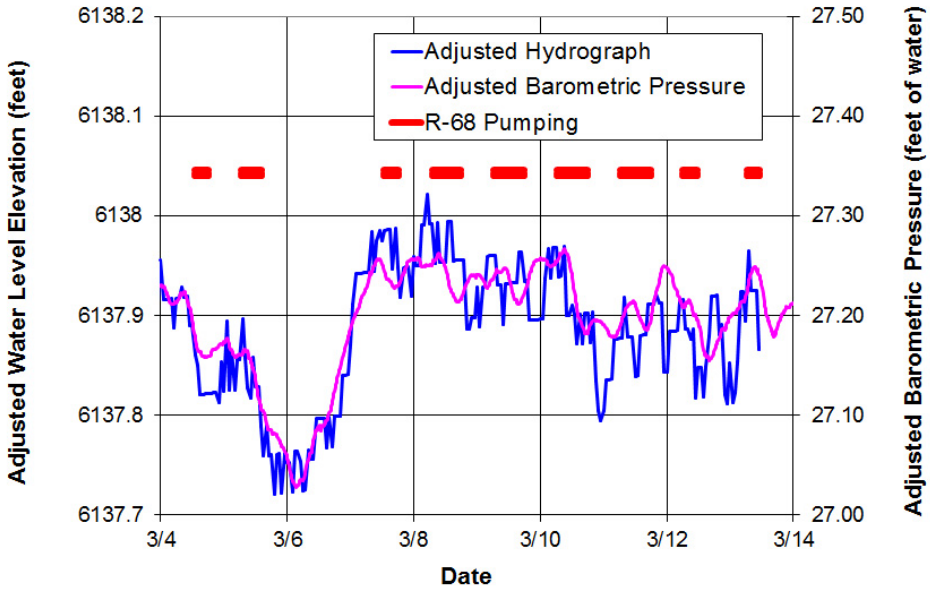

Figure E-7.0-7 Well R-25 screen 8 adjusted hydrograph for 60% barometric efficiency and 0.013 ft/d water level decline

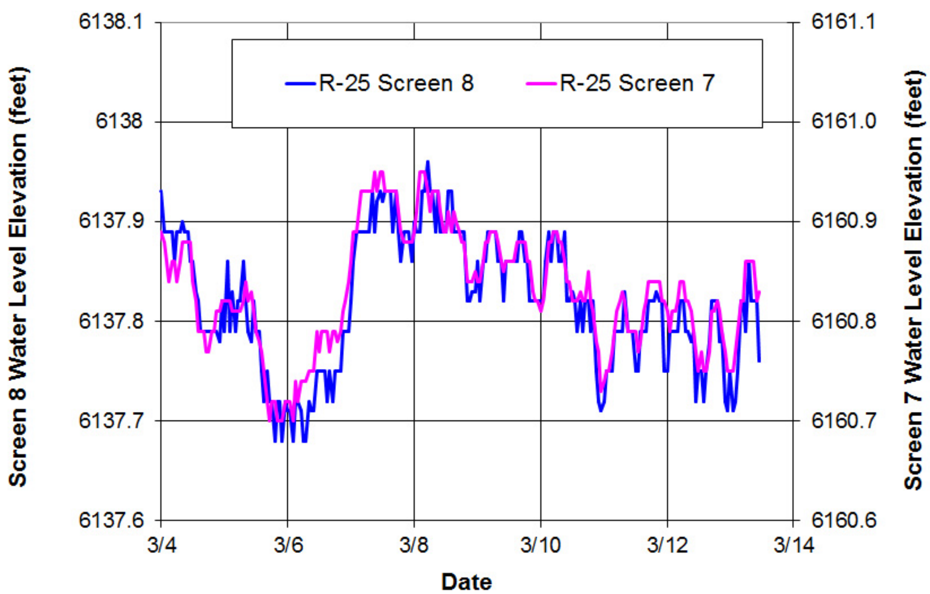

Figure E-7.0-8 Well R-25 screen 7 and 8 hydrograph

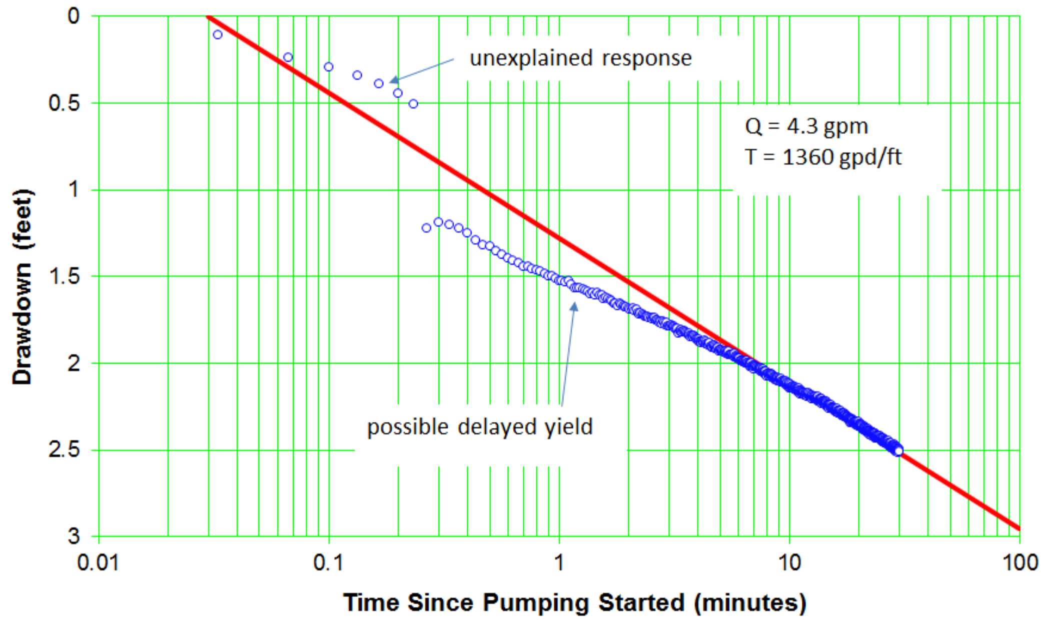

Figure E-8.1-1 Well R-68 trial 1 drawdown

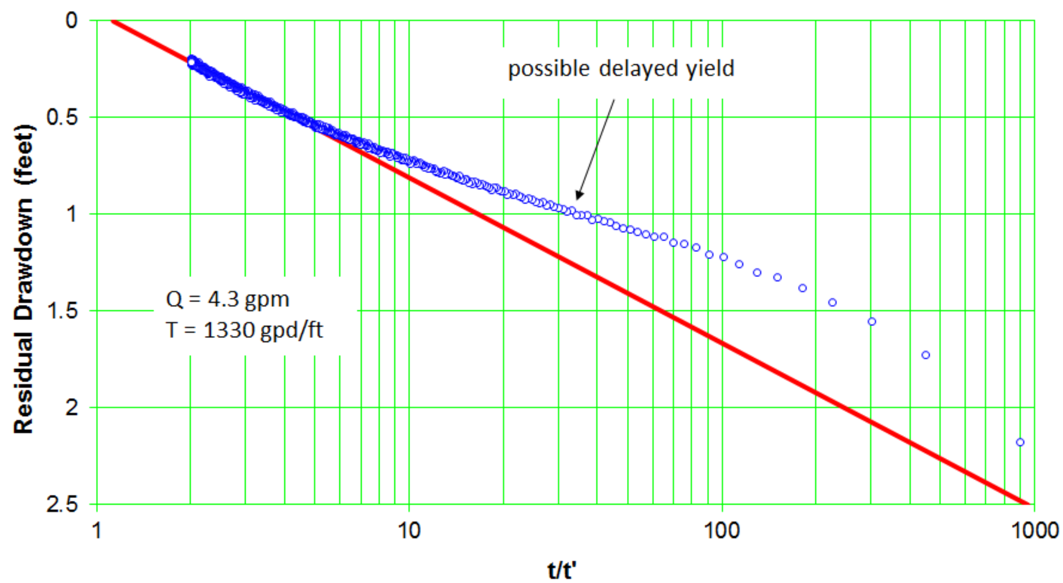

Figure E-8.1-2 Well R-68 trial 1 recovery

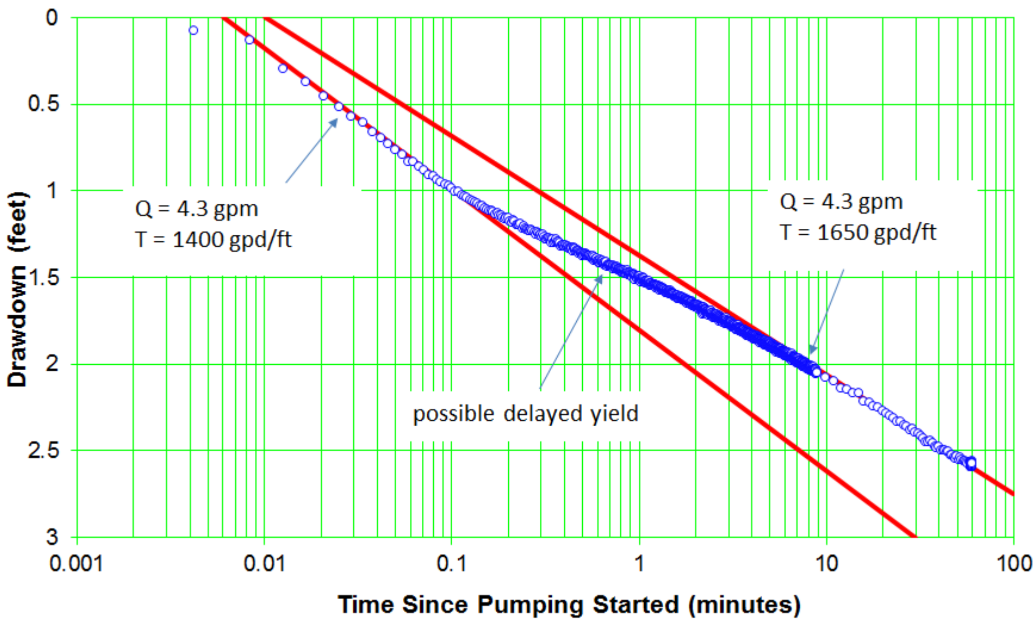

Figure E-8.2-1 Well R-68 trial 2 drawdown

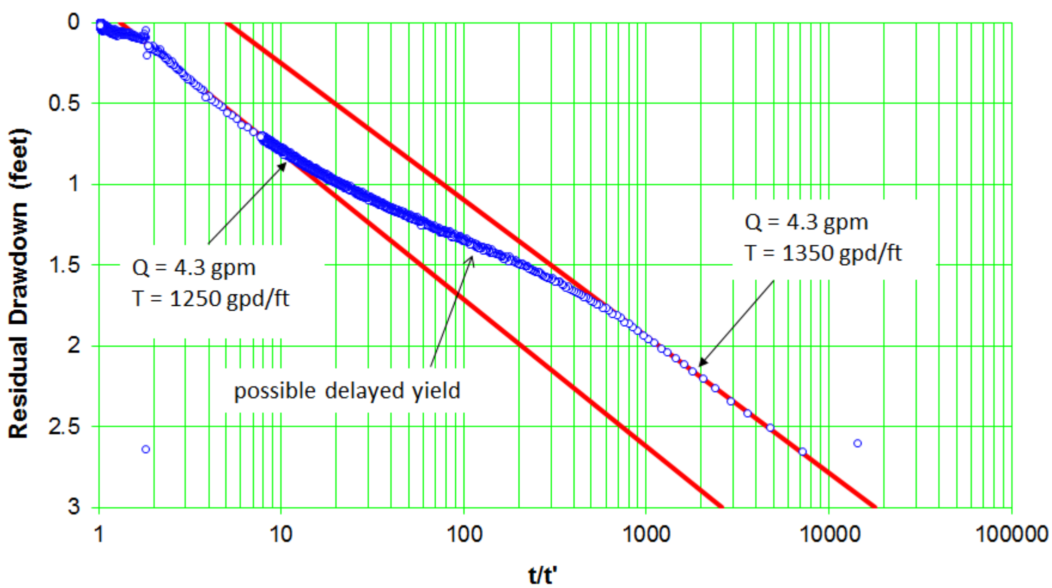

Figure E-8.2-2 Well R-68 trial 2 recovery

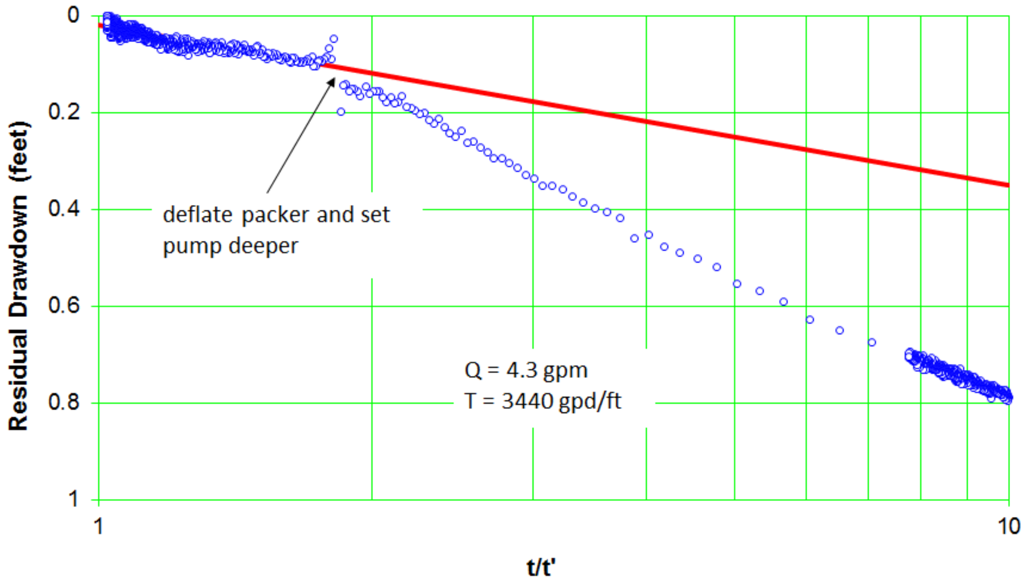

Figure E-8.2-3 Well R-68 trial 2 late time recovery

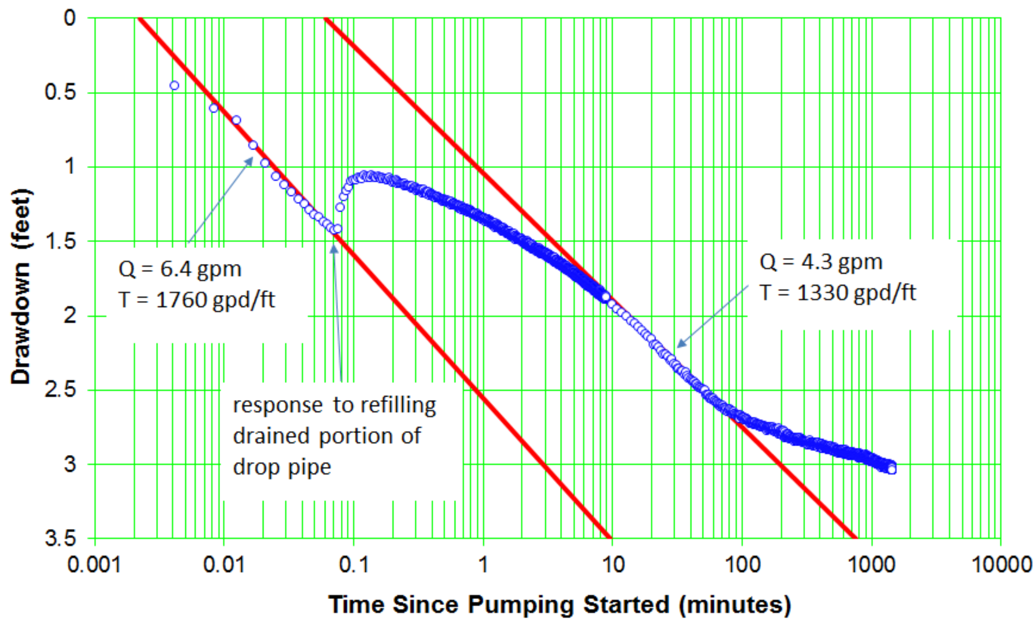

Figure E-8.3-1 Well R-68 drawdown

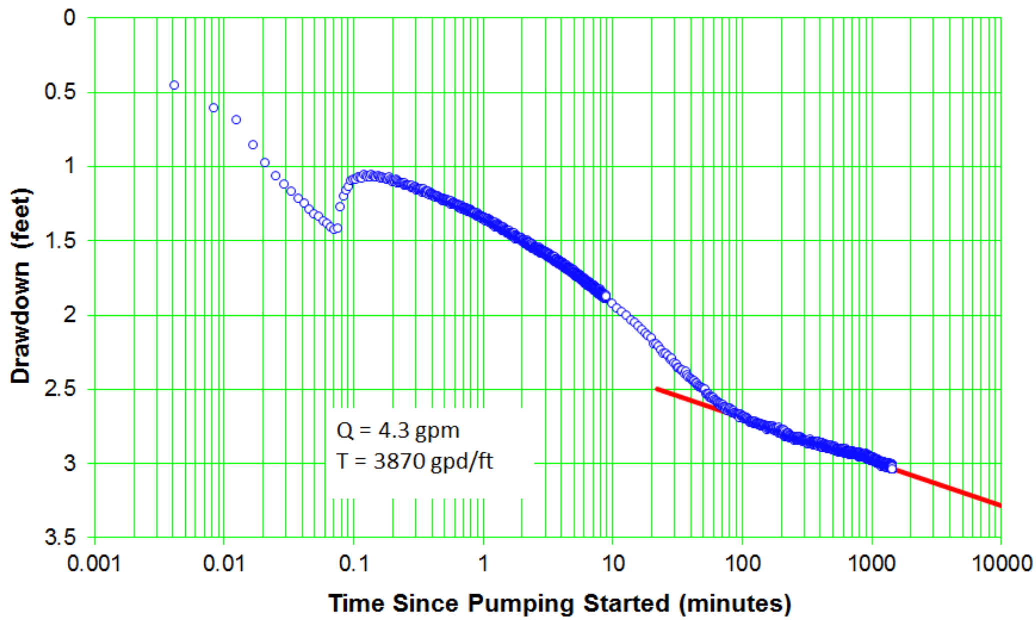

Figure E-8.3-2 Well R-68 late drawdown

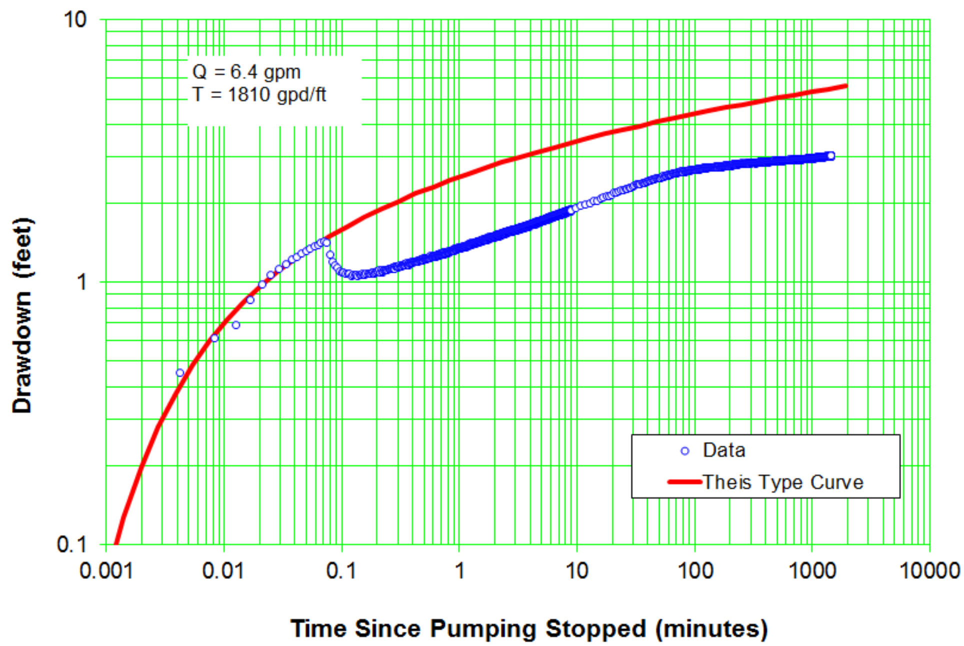

Figure E-8.3-3 Log-log analysis of well R-68 early drawdown

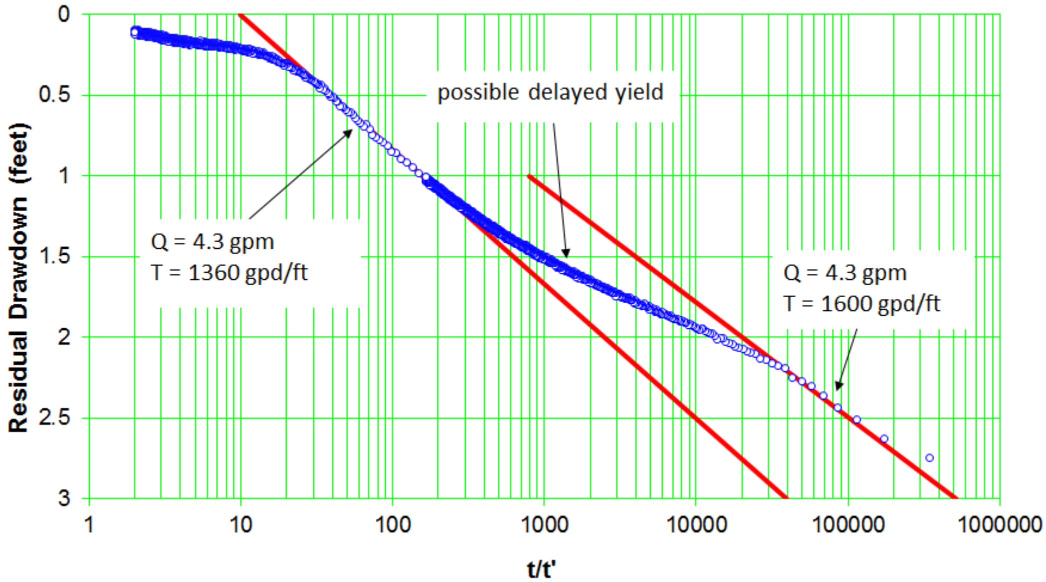

Figure E-8.3-4 Well R-68 recovery

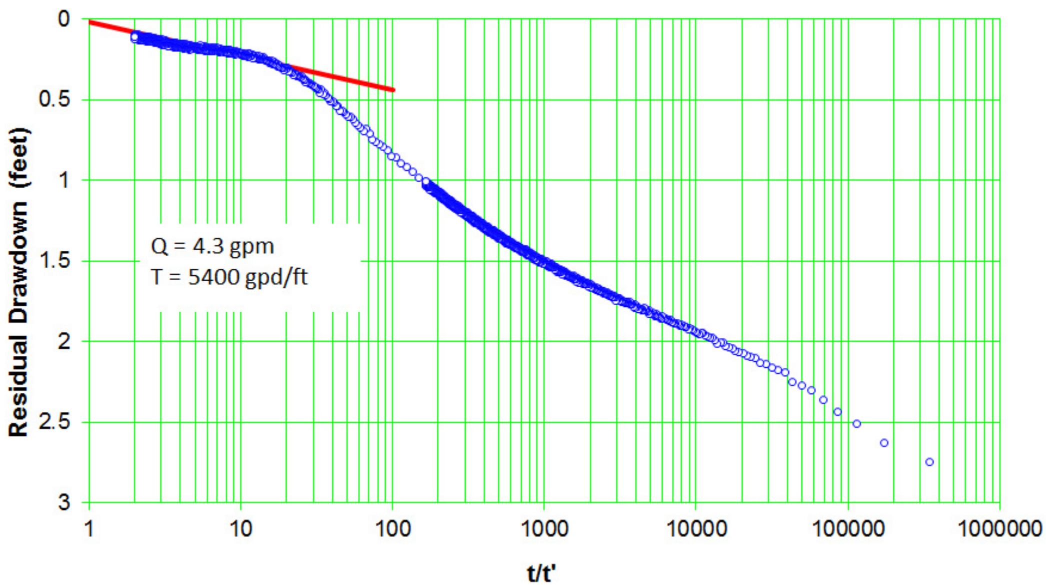

Figure E-8.3-5 Well R-68 late recovery

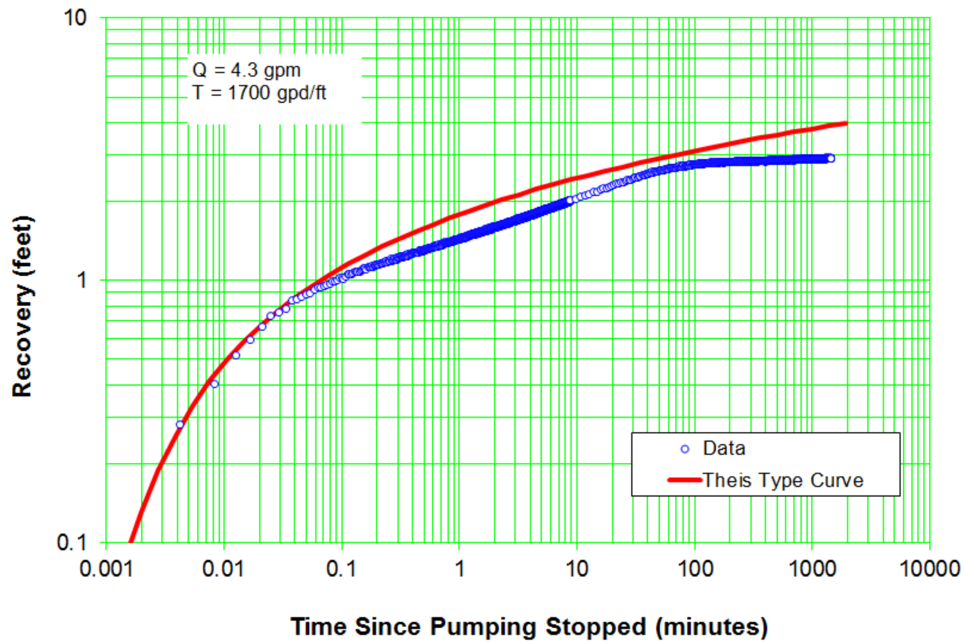

Figure E-8.3-6 Log-log analysis of well R-68 early recovery

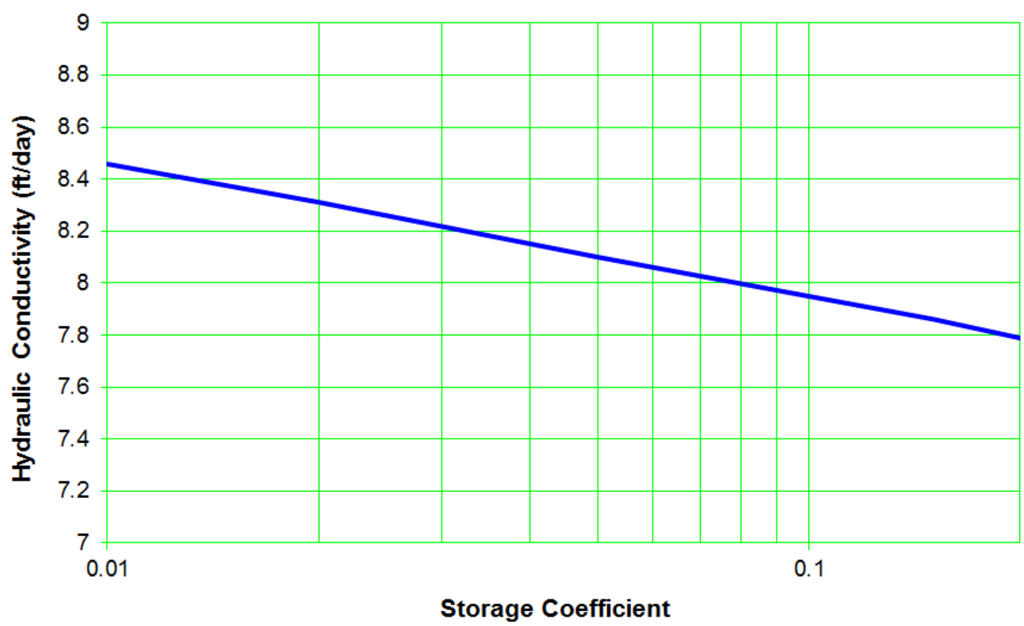

Figure E-8.5-1 Lower-bound hydraulic conductivity

Table E-8.4-1
Aquifer Parameter Values

Test	Method	T (gpd/ft)	K (gpd/ft^2)	K (ft/day)
Trial 1	Drawdown	1360	67	8.9
Trial 1	Residual Drawdown	1330	65	8.7
Trial 2	Drawdown (1st Slope)	1400	69	9.2
Trial 2	Drawdown (2nd Slope)	1650	81	10.8
Trial 2	Residual Drawdown (1st Slope)	1350	66	8.8
Trial 2	Residual Drawdown (2nd Slope)	1250	61	8.2
24-Hour	Drawdown (1st Slope)	1760	86	11.5
24-Hour	Drawdown (2nd Slope)	1330	65	8.7
24-Hour	Log-Log Drawdown	1810	89	11.9
24-Hour	Residual Drawdown (1st Slope)	1600	78	10.5
24-Hour	Residual Drawdown (2nd Slope)	1360	67	8.9
24-Hour	Log-Log Recovery	1700	83	11.1
Average of All	All	1490	73	9.8