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Completion Report for Regional Aquifer Well R-51

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EXECUTIVE SUMMARY

This well completion report describes the drilling, installation, development, and aquifer testing of regional groundwater monitoring well R-51, located in Pajarito Canyon, within Los Alamos National Laboratory Technical Area 18. The well was installed at the direction of the New Mexico Environment Department (NMED) for the collection of background groundwater data upgradient of Material Disposal Areas H and J.

The R-51 borehole was drilled using dual-rotary fluid-assisted and standard air-rotary drilling methods. Drilling fluid additives included potable water and foaming agent. Injection of foam was discontinued at 776 ft below ground surface (bgs), roughly 100 ft above the anticipated top of the regional aquifer. The R-51 borehole was advanced to a total depth of 1054.3 ft bgs using a combination of dual-rotary casing advance and open-hole drilling methods.

During drilling, an 18-in. casing was advanced through alluvium and the Tshirege Member of the Bandelier Tuff to 100.8 ft bgs. A 17-in. borehole was advanced through the Bandelier Tuff, Puye Formation, and Cerros del Rio volcanic rocks to a depth of 776 ft bgs. A retractable 12-in. casing was then advanced through the volcanic rocks and into the underlying Puye Formation to a total depth of 1054.3 ft bgs. The R-51 monitoring well was completed with two 10-ft screened intervals. The lower screened interval is from 1031.0 to 1041.0 ft bgs and the upper screened interval is from 915.0 to 925.2 ft bgs. The composite depth to water after installation and development was measured at 890.6 ft bgs.

The well was completed in accordance with the NMED-approved well design. Hydrogeologic testing indicated that the well is productive and will perform effectively to meet planned objectives. Groundwater sampling at R-51 will be performed as part of the facility-wide groundwater-monitoring program.

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Acronyms and Abbreviations

amsl	above mean sea level
APV	access port valve
bgs	below ground surface
Consent Order	Compliance Order on Consent
DO	dissolved oxygen
DTW	depth to water
EES-14	Earth and Environmental Sciences Division 14
ECS	Elemental Capture Sonde (log)
Eh	oxidation-reduction potential
EP	Environmental Programs
EPA	Environmental Protection Agency (U.S.)
gpm	gallons per minute
HE	high explosive(s)
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
hp	horsepower
I.D.	inside diameter

LANL	Los Alamos National Laboratory
LH3	low-level tritium
MDA	material disposal area
mV	millivolt
NAD	North American Datum
NMED	New Mexico Environment Department
NTU	nephelometric turbidity unit
O.D.	outside diameter
ORP	oxidation-reduction potential
PETN	pentaerythritol tetranitrate
pH	potential of hydrogen
PVC	polyvinyl chloride
Qal	alluvium
Qbo	Otowi Member of the Bandelier Tuff
Qbog	Guaje Pumice Bed of Otowi Member of the Bandelier Tuff
Qbt	Tshirege Member of the Bandelier Tuff
Qct	Cerro Toledo interval
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RPF	Records Processing Facility
SOP	standard operating procedure
TA	technical area
TATB	triaminotrinitrobenzene
TD	total depth
TOC	total organic carbon
Tb4	Cerros del Rio volcanic rocks
Tpf	Puye Formation
TU	tritium unit
VOC	volatile organic compound
WCSF	waste characterization strategy form
WES-EDA	Waste and Environmental Services Division−Environmental Data and Analysis Group
wt%	weight percent

1.0 INTRODUCTION

This completion report summarizes the drilling, well construction, well development, and aquifer testing for regional monitoring well R-51. Well R-51 was drilled, constructed, developed, and tested from December 3, 2009, to March 4, 2010.

Well R-51 is located in Pajarito Canyon, northwest of Technical Area 18 (TA-18) at Los Alamos National Laboratory (LANL or the Laboratory) (Figure 1.0-1.) The primary purpose of well R-51 is to collect background groundwater quality data upgradient of Material Disposal Areas (MDAs) H and J. These MDAs contain hazardous or radioactive inventory. Data from R-51 will provide upgradient comparisons with data from downgradient wells R-37 and R-52. Additionally, water-level measurements obtained from R-51 will assist in establishing groundwater levels of the regional aquifer in this area.

The borehole was advanced to a total depth (TD) of 1054.3 ft below ground surface (bgs) and completed with two 10-ft screened intervals in the regional aquifer. The lower screen was installed from 1031.0 to 1041.0 ft bgs and the upper screen was installed from 915.0 to 925.2 ft bgs. The regional water table was anticipated at a depth of approximately 887 ft bgs, in gravels of the Puye Formation. The composite depth to water (DTW) after well installation and development was 890.6 ft bgs, as measured on February 17, 2010. Cuttings samples for lithologic evaluation were collected over 5-ft intervals in the R-51 borehole from ground surface to TD. Postinstallation activities included well development, aquifer testing, surface completion, and geodetic surveying. 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 Laboratory's Records Processing Facility (RPF). This report contains brief descriptions of activities and supporting figures, tables, and appendixes associated with the R-51 well installation project. Information on radioactive materials and radionuclides, including the results of sampling and analysis of radioactive constituents, is voluntarily provided to the New Mexico Environment Department (NMED) in accordance with U.S. Department of Energy policy.

2.0 PRELIMINARY ACTIVITIES

Preliminary activities included preparing administrative planning documents and preparing the drill site and drill pad. All preparatory activities were completed in accordance with Laboratory policies, procedures, and regulatory requirements.

2.1 Administrative Preparation

The following documents helped guide the implementation of the scope of work for well R-51:

- Drilling Work Plan for Regional Aquifer Well R-51 (LANL 2009, 107514);
- Well R-51 Drill Plan (North Wind Inc. 2009, 109446);
- Integrated Work Document for Regional and Intermediate Aquifer Well Drilling (LANL 2007, 100972);
- Storm Water Pollution Prevention Plan for SWMUs and AOCs (Sites) and Storm Water Monitoring Plan (LANL 2006, 092600); and
- Waste Characterization Strategy Form for TA-54 Wells R-51 (Well D) and R-52 (Well A) Regional Well Installation and Corehole Drilling (LANL 2009, 107439).

2.2 Site Preparation

Laboratory personnel prepared the drill pad several weeks before mobilization. The drill rig, air compressors, trailers, and support vehicles were initially mobilized to the drill site between November 20 and December 3, 2009. Alternative drilling tools and construction materials were staged at the Pajarito lay-down yard, near the intersection of Pajarito Road and NM 4.

The office trailer, generators, and general field equipment were moved on-site after mobilization of the drilling equipment. Safety barriers and signs were installed around the cuttings containment pit and along the perimeter of the work area. Potable water was obtained from fire hydrant #04-914 near the intersection of Puye and Pajarito Roads, approximately 3.1 mi from the drill site.

3.0 DRILLING ACTIVITIES

This section describes the drilling strategy and approach and provides a chronological summary of field activities conducted at monitoring well R-51.

3.1 Drilling Approach

The R-51 borehole was drilled using a Schramm Inc. T130XD Rotadrill dual-rotary drilling rig with casing rotator. The dual-rotary system allows for advancement of casing with the casing rotator while drilling with conventional air/mist/foam methods with the drill string. The Schramm T130XD drill rig was equipped with a conventional 5.5-in. outside diameter (O.D.) dual-tube drill pipe, tricone bits, downhole hammer bits, and general drilling equipment. Auxiliary equipment included two Ingersoll Rand 1170 ft^3/min trailer-mounted air compressors, one Ingersoll Rand 1070 ft^3/min trailer-mounted compressor, and one Sullair 1150 XHH skid-mounted air compressor. Three sizes of casing were used: 24-in., 18-in., and 12-in. A53 grade B flush-welded mild carbon-steel casing. The dual-rotary technique used filtered compressed air and fluid-assisted air to evacuate cuttings from the borehole. In addition, the casing sizes selected ensured that the required 2-in. minimum annular thickness of the filter pack around a 5.56-in. O.D. well, as required by the Compliance Order on Consent (Consent Order) Section X.C.3, would be met. Cuttings samples were collected at 5-ft intervals in the borehole from 5 to 1054 ft bgs to characterize the hydrostratigraphy of rock units encountered in the borehole.

Potable water and Baroid brand AQF-2 foaming agent were used, as needed, between ground surface and 776 ft bgs (approximately 100 ft above the anticipated top of the regional aquifer). The fluids were used to cool the bit and help lift cuttings from the borehole. Total amounts of drilling fluids introduced into the borehole are presented in Table 3.1-1.

3.2 Chronology of Drilling Activities

On December 3, 2009, dual-rotary borehole advancement began at R-51 with 24-in. steel casing and a 22-in. tricone bit. On December 4, the drill string and 24-in. steel casing were advanced to a depth of 100.8 ft bgs. At that point, the drill string was tripped out and 18-in. steel casing was emplaced inside of the 24-in. conductor casing.

On December 5, the borehole was advanced via open-hole drilling with the 17.5-in. tricone bit from 100.8 to 173 ft bgs. Water was encountered at a depth of approximately 161 ft bgs in the Cerro Toledo interval. Screening groundwater samples were collected, and the perched zone was grouted from 152 to 173 ft bgs.

On December 6, drilling continued, advancing the open borehole from 173 to 533 ft bgs with the 17.5-in. tricone bit. Drilling activities were paused at 213 ft bgs to monitor for perched water; however, no water was encountered at that depth. Perched water was encountered at approximately 530 ft bgs at the top of the Cerros del Rio volcanic rocks, but sampling was unsuccessful. The borehole was advanced with the 17-in. hammer bit from 533 to 553 ft bgs.

Between December 7 and 10, the borehole was advanced from 553 to 766 ft bgs. Laboratory personnel conducted open-hole video, natural gamma, and induction logging on December 11 and again on December 12. The borehole was backfilled with 10/20 sand from 766 to 568 ft bgs on December 12. Using a borehole video camera, small amounts of water were observed to be flowing on the borehole wall at depths from 502 to 568 ft bgs. A water sample was taken with a bailer at 563 ft bgs.

Between December 14 and 15, the borehole was grouted from 568 to 514 ft bgs. Multiple attempts were made to grout to 500 ft bgs to seal off the perched zone, but grout never reached above 514 ft bgs. On December 16, Laboratory personnel ran the video camera, but foam in the borehole prohibited visibility below 489 ft bgs. The decision was made to emplace a bentonite plug to complete the seal of the perched zone, and a supersack (~42 ft^3) of 0.375-in. bentonite chips was pumped downhole. On December 17, the field crew drilled out the borehole materials to 776 ft bgs and began installing 12-in. steel casing across the perched zone. Use of drilling foam was discontinued at approximately 776 ft bgs.

Between December 18 and 20, the borehole and 12-in. casing were advanced to 830 ft bgs. Perched water was monitored for between 789 and 815 ft bgs; none was detected. Drill rig repairs and general site maintenance occurred on December 21, and the site was secured for the holiday curtailment on December 22.

On January 10, 2010, drilling resumed with a new hammer bit; however, it was difficult to raise the bit through the casing shoe. On January 11, 2010, the 12-in. steel casing was tripped out to a string length of 614 ft and a video log was run downhole to inspect the casing and shoe, which were shown to still be intact.

Between January 12 and 14, drilling resumed and the borehole was advanced to the target depth of 1054.3 ft bgs. Regional groundwater was expected at 887 ft bgs, but it was not detected with confidence until 935 ft bgs. Screening samples were collected via air-lifting techniques from near the top of the regional aquifer and at total depth of the borehole. The 12-in. casing was raised to 1052.3 ft bgs and stabilized to prepare for well installation activities; the casing shoe was set at 1052.3 ft bgs. The DTW was monitored throughout the shift on January 14 and was consistently tagged at 891.7 ft bgs.

On January 15, Laboratory personnel ran a natural gamma log and Schlumberger conducted a full-suite of geophysical logs. On January 16, the casing shoe was cut at 1051 ft bgs, leaving 1.3 ft of 12-in. casing in the borehole.

During drilling, 24-h operations consisted of two 12-h shifts per day, 7 d per week. No problems with borehole instability were encountered.

4.0 SAMPLING ACTIVITIES

The following sections describe the cuttings and groundwater sampling activities conducted during the drilling and completion of monitoring well R-51. All sampling activities were conducted in accordance with applicable quality procedures.

4.1 Cuttings Sampling

Cuttings samples were collected from the borehole at 5-ft intervals from ground surface to the TD of 1054.3 ft bgs. Over each interval, approximately 500 mL of bulk cuttings was collected by the site geologist from the discharge cyclone, placed in resealable plastic bags, labeled, and archived in core boxes. Smaller-size fractions (>#10 and >#35 mesh) were sieved from the bulk cuttings and placed in chip trays along with unsieved (whole rock) cuttings. Recovery of drill cuttings was excellent with 96% recovery over the borehole interval. Intervals with no recovery included 165 to 180 ft bgs, 775 to 780 ft bgs, 835 to 845 ft bgs, 865 to 870 ft bgs, 875 to 880 ft bgs, and 1030 to 1035 ft bgs. Radiation control technicians screened cuttings before removal from the site; all screening measurements were within the range of background values. The core boxes and chip trays were delivered to the Laboratory's archive at the conclusion of drilling activities. The borehole lithologic log for R-51 is presented in Appendix A and summarized in section 5.1.

4.2 Water Sampling

Table 4.2-1 presents a summary of screening samples collected during drilling and development of R-51. Groundwater analytical results and field water-quality parameters are discussed in Appendix B.

Perched water samples were collected during borehole drilling at depths of 161 and 563 ft bgs. The upper sample was collected on December 5, and the lower sample was collected on December 12. Both samples were collected using a bailer. Perched-zone screening samples were analyzed for metals, cations, anions (including perchlorate), high explosives (HE), volatile organic compounds (VOCs), and low-level tritium (LH3).

Two screening samples and a trip blank were collected from the regional aquifer during drilling (Table 4.2-1). An initial regional aquifer screening sample was collected at a depth of 935 ft bgs on January 13, 2010, by air-lifting; a trip blank was also collected from this interval. Another screening sample was collected from the regional aquifer near borehole TD at 1054 ft bgs on January 14, 2010, by air-lifting. The two regional aquifer samples were analyzed for metals, anions (including perchlorate), cations, HE, VOCs, and LH3; the trip blank was analyzed only for VOCs.

During well development, two samples from the upper screened interval and five samples from the lower screened interval were collected and analyzed for total organic carbon (TOC). Additionally, samples were collected at the end of development of each screened interval and analyzed for metals, cations, and anions, including perchlorate.

Further groundwater characterization sampling will be conducted from the completed well in accordance with the Consent Order. For the first year, the samples will be analyzed for the full suite of constituents including radioactive elements; anions/cations; general inorganic chemicals; volatile and semivolatile organic compounds; and stable isotopes of hydrogen, nitrogen, and oxygen. 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 will be evaluated and presented in the annual "Interim Facility-Wide Groundwater Monitoring Plan."

5.0 GEOLOGY AND HYDROGEOLOGY

A brief description of the geologic and hydrogeologic features encountered from ground surface to 1054.3 ft bgs at R-51 is presented below.

5.1 Stratigraphy

The stratigraphy for the R-51 borehole is presented below. Lithologic descriptions are based on cuttings samples collected from the discharge cyclone. Cuttings and borehole geophysical logs were used to identify geologic contacts. Figure 5.1-1 illustrates the stratigraphy at R-51. A detailed lithologic log based on analysis of drill cuttings is presented in Appendix A.

Quaternary Alluvium, Qal (0 to 75 ft bgs)

Quaternary alluvium occurred from ground surface to 75 ft bgs. It consisted of fine- to medium-grained alluvial sediments, moderate to highly weathered, light brownish-gray (5YR 6/1) subangular to subrounded fragments.

Unit 1g, Tshirege Member of the Bandelier Tuff, Qbt 1g (75 to 141 ft bgs)

Unit 1g of the Tshirege Member of the Bandelier Tuff occurred from 75 to 141 ft bgs. Unit 1g consisted of very pale-orange to light-brown weakly welded volcanic tuff.

Cerro Toledo Interval, Qct (141 to 175 ft bgs)

The Cerro Toledo interval occurred from 141 to 175 ft bgs and consisted of tuffaceous sedimentary deposits separating the Tshirege and Otowi Members of the Bandelier Tuff. The deposits were predominantly reworked tuff with some sands, gravels, and cobbles derived from Tschicoma dacites in the Jemez Mountains west of the Pajarito Plateau.

Otowi Member of the Bandelier Tuff, Qbo (175 to 495 ft bgs)

The Otowi Member of the Bandelier Tuff occurred from 175 to 495 ft bgs, consisting of a glassy, lithic-bearing, pumiceous, poorly welded ash-flow tuff. It contained lithic clasts of grayish-orange to pale yellowish-brown, subangular to subrounded, intermediate-composition volcanic rocks. Minor oxidation was present on many pumice and lithic fragments.

Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, Qbog (495 to 513 ft bgs)

The Guaje Pumice Bed occurred from 495 to 513 ft bgs. The pumice bed contained abundant pumice fragments (up to 80%) with subordinate amounts of volcanic lithics and quartz and sanidine phenocrysts, with minor oxidation on pumice and lithic fragments.

Puye Formation, Tpf (513 to 545 ft bgs)

The Puye Formation occurred from 513 to 545 ft bgs. The formation consisted of very pale-orange volcaniclastic sediments, with well-graded subangular to subrounded gravels, sands, and silts.

Cerros del Rio Volcanic Rocks, Tb4 (545 to 818 ft bgs)

The Cerros del Rio volcanic rocks occurred from 545 to 818 ft bgs and consisted of an aphanitic to porphyritic, nonvesicular to slightly vesicular basalt containing notable phenocrysts of olivine, plagioclase feldspar, and pyroxene. Fragments were medium dark-gray and dark gray to dusky yellowish-brown basalt, orange to red clay, and trace quartz and sanidine crystals.

Puye Formation, Tpf (818 to 1054.3 ft bgs)

The Puye Formation occurred from 818 to 1054.3 ft bgs. In this interval, the Puye Formation consisted of a sequence of fluvial and lacustrine sedimentary deposits. The deposits ranged from poorly graded to well-graded gravels with angular to subrounded sands, containing up to 100% porphyritic to aphyric intermediate volcanics.

5.2 Groundwater

Two perched-water zones were encountered during drilling of R-51. The first perched zone was penetrated at 161 ft bgs. The second perched-water zone was initially penetrated at approximately 513 ft bgs, and video logs confirmed water coming into the borehole between 502 and 568 ft bgs. Additional monitoring for perched water was conducted between 205 and 213 ft bgs, and again between 789 and 815 ft bgs. None was encountered at those depths.

Regional groundwater was first detected during drilling at 935 ft bgs. The DTW was tagged during drilling at 891 ft bgs on January 14. On February 17, following well development, but before aquifer testing began, the composite DTW was recorded at 890.6 ft bgs.

During the pump test of the lower screened interval (1031.0 to 1041.0 ft bgs), flow rates of approximately 21 gallons per minute (gpm) were maintained, and flow rates of approximately 4 gpm were maintained during the pump test conducted in the upper screened interval (915.0 to 925.2 ft bgs).

6.0 BOREHOLE LOGGING

During the course of drilling activities, video and geophysical logging was conducted by the Laboratory to evaluate borehole conditions. Schlumberger recorded a final suite of cased-hole geophysical logs. Video and geophysical logging results are summarized in Table 6.0-1.

6.1 Video Logging

Laboratory personnel conducted video logging on December 11, December 12, and December 16, 2009, and January 11 and February 2, 2010. On December 11 and December 12, 2009, the video log was run down the open borehole to a depth of 660 ft bgs to evaluate borehole conditions. On December 16, 2009, Laboratory personnel attempted to run a video log downhole to evaluate the effectiveness of grouting efforts through a zone of perched groundwater. On January 11, 2010, Laboratory personnel ran a video log downhole to determine the condition of the casing shoe. On February 2, 2010, Laboratory personnel ran two video logs inside the 5.5-in. well casing to evaluate the condition of the well casing and screens. Borehole video logs are in Appendix C (on DVD included with this document).

6.2 Geophysical Logging

On December 11, 2009, Laboratory personnel attempted to collect induction and natural gamma logs in the R-51 borehole; however the gamma tool could not be advanced past a ledge at 167 ft bgs, and the induction tool was inoperable. On December 12, 2009, Laboratory personnel conducted natural gamma and induction logging of the R-51 borehole to 565 ft bgs. On January 15, 2010, Laboratory personnel attempted to collect a gamma log of the cased borehole to TD, but a winch malfunction allowed data collection only between 992 and 1054 ft bgs. On February 2, 2010, Laboratory personnel conducted a natural gamma log to evaluate the condition of the well screen and to determine the depth of the 12-in. casing string that was dropped during well construction. Schlumberger ran a cased-hole suite of geophysical logs on January 15, 2010. At the time of Schlumberger geophysical logging, 12-in. steel casing was installed in the borehole from ground surface to 1052.3 ft bgs. The Schramm T130XD drill rig was used for all geophysical logging activities. The cased-hole geophysical suite included gamma ray, triple-detector lithodensity, elemental capture spectroscopy, and accelerator porosity sonde logs. Schlumberger's cased-hole suite normally also includes hostile natural gamma spectroscopy, but the tool was inoperable. Interpretation and details of the logging conducted by Schlumberger are presented in the geophysical logging report in Appendix D (on CD included with this document).

7.0 WELL INSTALLATION

The R-51 well was installed between January 16 and February 8, 2010.

7.1 Well Design

The R-51 well was designed in general accordance with the NMED-approved Laboratory Drilling Work Plan (LANL 2009, 107514). NMED approved the final well design before installation. The well was designed with dual screens to monitor regional groundwater quality in the Puye Formation.

7.2 Well Construction

The R-51 monitoring well was constructed of beveled and welded 5.0-in. inside diameter (I.D.)/5.6-in. O.D., type A304 passivated stainless-steel casing fabricated to American Society for Testing and Materials A312 standards. Both screened sections used 10-ft lengths of 5.0-in. I.D. rod-based 0.020-in. wire-wrapped well screen. All casing and screens were steam-pressure washed on-site before installation. A 2-in. I.D. threaded steel tremie pipe (decontaminated before use) was used to deliver annular backfill materials downhole during well construction (Table 7.2-1). The Schramm T130XD rig used to drill the borehole to TD was also used for well-construction activities. Figure 7.2-1 shows the as-built well-construction diagram for R-51.

The well was constructed with two screened intervals as specified in the well design. The lower screen was installed from 1031.0 to 1041.0 ft bgs, with a 5.1-ft stainless-steel sump below the bottom of the screen. The upper screen was installed from 915.0 to 925.2 ft bgs. Between January 14 and January 16, 2010, the 5.5-in. stainless steel well casing was moved on-site and decontaminated. Anticipated quantities of backfill materials were also mobilized to the drill site during this time. General preparations were made in order to begin well construction, and the tremie pipe was tripped into the borehole.

Well construction occurred from January 16 to 19, and emplacement of annular materials took place from January 20 to February 8, 2010. Each joint of well casing and screen was beveled and welded by certified welders. On January 18, installation of the 5-in. well casing in the borehole was completed with the bottom of the casing at a depth of 1046.1 ft bgs. On January 19, the borehole depth was tagged at 1051.2 ft bgs, indicating 3.1 ft of formational slough in the bottom of the borehole.

Annular bentonite backfill around the well-casing sump was placed from 1051.2 to 1045.6 ft bgs. This bottom seal consisted of 0.375-in. bentonite chips for a volume of 6.2 ft^3. The primary filter pack for the lower screen consisted of 21.8 ft^3 of 10/20 clean silica sand from 1045.6 to 1024.8 ft bgs. Swabbing was conducted multiple times above and just below the screen to promote proper settling of the filter-pack sand. The fine sand transition collar (2.6 ft^3 of 20/40 clean silica sand) was placed from 1024.8 to 1022.3 ft bgs. All quantities of backfill materials at this point were within 11% of calculated volumes (Figure 7.2-1).

A bentonite seal was placed above the lower-screen sand pack from 1022.3 to 931.1 ft bgs, 5.9 ft below the upper screen. This interscreen seal consisted of 107.2 ft^3 of 0.375-in. and 0.25-in. bentonite chips. The actual volume used was 25% more than calculated (85.7 ft^3) in this zone, where unconsolidated Puye Formation likely collapsed from the borehole wall creating a larger than anticipated borehole diameter. This is confirmed by the Void flag on the Schlumberger Elemental Capture Sonde (ECS) Log at approximately 970 ft bgs.

The primary 10/20 clean silica sand filter pack was placed around the upper screened interval from 931.1 to 905.6 ft bgs. Backfilling of this zone required 285% more material than calculated (23.9 ft^3 calculated, 68.5 ft^3 used). Large washouts of the borehole in this zone, also in unconsolidated Puye Formation, are shown by earlier video documentation as well as by a Void flag on the Schlumberger ECS log at approximately 930 ft bgs extending vertically over 6 ft. Swabbing was again conducted multiple times above and just below the screen to promote proper settling of the sand pack before installation of the fine sand transition collar, which consisted of 2.0 ft^3 (2.2 ft^3 calculated) of 20/40 clean silica sand from 905.6 to 903.3 ft bgs.

A 5-ft lift of bentonite chips was placed above the transition sand and allowed to hydrate for several hours before the remainder of the seal was placed to 537.6 ft bgs. The seal consisted of bentonite 0.375-in. chips. The quality of materials used in this zone was 508.2 ft^3, about 14% more than the calculated volume of 447.0 ft^3.

The bentonite backfill was tagged at 537.6 ft bgs when, on February 1, approximately 225 ft of 12-in. steel casing was lost downhole. The LANL natural gamma log showed the casing landed between 335.0 and 560.0 ft bgs, about 22 ft into the bentonite seal. The LANL video log showed that the well casing and screened intervals were intact and undamaged. Per Laboratory direction, a neat cement grout seal was placed around the 12-in. casing from 537.6 to 279.2 ft bgs. The volume of cement used was 455.0 ft^3, about 32% more than the calculated volume of 344.1 ft^3. Earlier LANL video showed a void in the borehole wall at 506 ft bgs. Schlumberger cased-hole geophysics also indicated voids in annular space between 100 and 535 ft bgs.

The remainder of the upper bentonite seal of 0.375-in. bentonite chips was placed from to 279.2 to 110.7 ft bgs. The actual volume used was 457.7 ft^3, about 93% more than the calculated volume of 237.6 ft^3. Voids in this portion of the 17.0-in. diameter borehole were indicated by a Void flag on the Schlumberger ECS log from approximately 242 to 238 ft bgs and 118 to 116 ft bgs.

The final surface seal was placed from 110.7 ft bgs to ground surface using a 100 weight percent (wt%) Portland cement seal. The actual volume used (249.6 ft^3) was approximately 20% less than the calculated volume (314.5 ft^3). Placement of the grout seal to surface marked R-51 well completion per NMED standards at 1350 h on February 8, 2010.

8.0 POSTINSTALLATION ACTIVITIES

Following well installation, each screened interval was independently developed through bailing, swabbing, and pumping methods. Following development, an aquifer test was performed on each screened interval by David Schafer and Associates, with assistance from North Wind Inc., and Layne field personnel.

8.1 Well Development

Well development of the screened intervals was performed independently and was completed using the Semco 115000 pulling unit. Well development of the lower screened interval occurred between February 11 and February 15, 2010. Well development of the upper screened interval occurred between February 24 and March 1, 2010.

Well development of each screened interval began with bailing water and swabbing near the screen, which helped to remove formation fines from around the filter pack and sump. The swabbing tool used was a 4.5-in.-diameter, 1-in.-thick rubber disc attached to a weighted-steel rod. The swabbing tool was lowered by wireline and drawn repeatedly across the screened intervals. Bailing and swabbing continued until the water clarity visibly improved. Upon completion of bailing and swabbing, well development continued using a 20-horsepower (hp), 4-in.-diameter Grundfos submersible pump. In total, 21,747 gal. of groundwater was pumped from both screened intervals during well development: 11,774 gal. from the lower screen and 9973 gal. from the upper screen.

8.1.1 Well Development Field Parameters

Field parameters of turbidity, temperature, potential of hydrogen (pH), dissolved oxygen (DO), oxidation-reduction potential (ORP), and specific conductance were monitored at R-51 during the pumping stage of well development at each screened interval, as well as during aquifer testing. At R-51, aquifer testing closely followed well development at each screen, and therefore field parameters for both development and aquifer testing are presented below. In addition, water samples were collected for TOC analysis from both screens. The required values for TOC and turbidity to determine adequate well development are less than 2.0 ppm and less than 5 nephelometric turbidity units (NTU), respectively. Field parameters measured during well development and aquifer testing are shown in Table B-1.2-1 in Appendix B.

Field parameters were monitored using a flow-through cell during well development. It was used briefly during aquifer testing, but it caused backpressure on the pump, which would have affected the aquifer test results, and so its use was terminated. The exposure of the groundwater discharge to air during aquifer testing may have caused a slight variation in the values for temperature, pH, ORP, and DO.

Lower Screen

During sequential well development and aquifer testing of the lower screen, pH varied from 7.7 to 9.8; temperature varied from 15.1°C to 20.6°C; DO varied from 1.1 to 9.9 mg/L; and specific conductance varied from 2 to 348 microsiemens per centimeter (µS/cm). Corrected Eh values decreased from 262.0 millivolts (mV) near the beginning of well development to 122.3 mV near the end of aquifer testing.

Turbidity values for the lower screen fluctuated quite a bit and ranged from 2.0 to 874.0 NTU over the course of development and aquifer testing. Turbidity readings were lowest, between 2.0 and 2.4 NTU, from mid-day to the end of the third day of development and were also relatively low, 2.3 to 2.4 NTU, on the fourth day. But as purge volumes increased on the fifth and final day and on the last two days of aquifer testing, values ranged between 5.6 and 44.3 NTU, with the final recorded value of 19.0 NTU at the end of aquifer testing.

Final measurements for the lower screen were as follows: pH was 9.5, temperature was 20.5°C, specific conductance was 134 µS/cm, and turbidity was 19.0 NTU. The final TOC concentration was 0.83 mg/L (Appendix B). Table B-1.2-1 presents field parameters and discharge volumes recorded during development.

Upper Screen

During sequential development and aquifer testing of the upper screen, pH varied from 6.7 to 10.2, temperature varied from 16.4°C to 20.2°C, DO varied from 0.8 to 5.0 mg/L, and specific conductance varied from 123 to 197 µS/cm. Corrected Eh values ranged from a high of 165.3 mV at the beginning of well development and declined to 97.0 mV at the end. The ORP and corrected Eh values measured during well development are much lower than those measured during aquifer testing and may be erroneous. Turbidity ranged from a high of 82.2 NTU at the beginning of development to 1.1 NTU at the end of aquifer testing.

Final measurements for the upper screen were as follows: pH was 7.1, temperature was 18.1°C, specific conductance was 169 µS/cm, and turbidity was 1.1 NTU. The final TOC concentration was 0.68 mg/L (Appendix B).

8.2 Aquifer Testing

Aquifer pumping tests of R-51 were conducted by David Schafer and Associates between February 19 and 22 for the lower screen, and between March 5 and 8 for the upper screen. Several short-duration pumping intervals with short-duration recovery intervals were performed to determine the optimal pumping rate for the 24-h aquifer tests. A 10-hp, 4-in.-diameter Grundfos submersible pump was used to perform the aquifer tests. The lower screen was pumped at a rate of 21 gpm, while the upper screen was pumped at 4 gpm. A total of 39,826 gal. of groundwater was purged during aquifer testing activities, 6553 gal. from the upper screen and 33,273 gal. from the lower screen. Field parameters and purge volumes recorded during aquifer testing are shown in Table B-1.2-1; field parameters measured during aquifer testing are summarized above with the field parameters obtained during well development. Aquifer test results are presented in Appendix E.

8.3 Dedicated Sampling System Installation

Installation of a dedicated sampling system was completed on May 7, 2010. A 4-in. Grundfos pump with a Franklin Electric Motor and passivated 1-in. stainless-steel pipe were installed with a pump intake depth of 932.0 ft bgs. Two 1-in. polyvinyl chloride (PVC) sounder tubes were installed alongside of the pump assembly for installation of two dedicated transducers, one for the upper screen and one for the lower screen. The upper-screen PVC sounder tube was installed at 925.1 ft bgs with a 1.7-ft screened interval and the transducer inlet at 925.5 ft bgs. The lower-screen PVC sounder tube was installed at 924.7 ft bgs, with the transducer inlet at 924.7 ft bgs, and was connected to a 32.0-ft long, 0.25-in. diameter nylon tube with a screen installed below the packer at 958.8 ft bgs. Two 0.3-ft-long access port valves (APVs) were installed, one for the upper screen at 940.0 ft bgs and one for the lower screen at 1029.9 ft bgs. The liquid inflation chamber was installed from 940.9 to 945.5 ft bgs for inflation of the Baski packer. Details of the dedicated sampling system are shown in Figure 8.3-1a and summarized in Figure 8.3-1b.

8.4 Wellhead Completion

A reinforced concrete pad, 10-ft ×10-ft × 6.0-in. thick, was installed at the R-51 wellhead. The pad was slightly elevated above ground surface and crowned to promote runoff. The pad will provide long-term structural integrity for the well. A brass survey monument imprinted with well identification information was embedded in the northwest corner of the pad. A 16-in. O.D. steel protective casing was installed around the well casing to a depth of 3.0 ft bgs and cemented in place. The protective casing was covered with a mushroom cap with locking bar. A 0.5-in. weep hole was drilled near the base of the protective casing to prevent water accumulation inside the protective casing. A total of four removable bollards, painted bright yellow for visibility, were set approximately 1 ft from each of the pad edges to protect the well from accidental vehicle damage. Details of the wellhead completion are presented in Figure 8.3-1a and technical notes for R-51 are shown in Figure 8.3-1b.

8.5 Geodetic Survey

A geodetic survey of the wellhead components was conducted by a New Mexico licensed professional land surveyor on May 18, 2010, and the 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 83 (NAD 83); elevation is expressed in ft above mean sea level (amsl) using the National Geodetic Vertical Datum of 1929. Survey points included ground-surface elevation near the concrete pad, the top of the brass monument in the concrete pad, the top of the well casing, and the top of the protective casing. The survey data are provided in Table 8.5-1, and the location survey report is provided as Appendix F.

8.6 Waste Management and Site Restoration

Waste generated from the R-51 project includes drilling fluids, purged groundwater, drill cuttings, decontamination water, and contact waste. A summary of the waste characterization samples collected from R-51 is presented in Table 8.6-1.

Waste streams produced during drilling and development activities were sampled in accordance with the Waste Characterization Strategy Form for TA-54 Wells R-51 (Well D) and R-52 (Well A) Regional Well Installation and Corehole Drilling (LANL 2009, 107439).

Fluids produced during drilling and well development are expected to be land-applied after a review of associated analytical results per the waste characterization strategy form (WCSF) and the Environmental Programs (EP) Directorate standard operating procedure (SOP) 010.0, Land Application of Groundwater. If it is determined that drilling fluids are nonhazardous but cannot meet the criteria for land application, the drilling fluids will be evaluated for treatment and disposal at one of the Laboratory's six wastewater treatment facilities. If analytical data indicate that 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 SOP-011.0, Land Application of Drill Cuttings. If the drill cuttings do not meet the criterion for land application, they will be disposed of at an authorized facility. Decontamination fluid used for cleaning the drill rig and equipment is currently 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 in accordance with the waste characterization strategy form and ENV-RCRA SOPs. Additionally, the polyethylene liner and containment berms will be removed and the containment area will be backfilled and regraded, as appropriate.

9.0 DEVIATIONS FROM PLANNED ACTIVITIES

Drilling and sampling at R-51 were performed as specified in the Well R-51 Drill Plan (North Wind Inc. 2009, 109446). Well construction was also performed as planned with one exception: A section of 12-in. casing, 225 ft in length, was left in the borehole from 335.0 to 560.0 ft bgs and cemented in place.

10.0 ACKNOWLEDGMENTS

Layne Christensen drilled the R-51 borehole and installed the well.

Schlumberger Water Services performed geophysical logging of the borehole, and Ned Clayton authored Appendix D (on CD included with this document).

David Schafer and Associates performed the aquifer testing and authored Appendix E, Aquifer Testing Report.

North Wind, Inc. provided oversight on all preparatory and field-related activities.

11.0 REFERENCES AND MAP DATA SOURCES

11.1 References

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

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

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

LANL (Los Alamos National Laboratory), October 4, 2007. "Integrated Work Document for Regional and Intermediate Aquifer Well Drilling (Mobilization, Site Preparation and Setup Stages)," Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 2007, 100972)

LANL (Los Alamos National Laboratory), October 27, 2009. "Waste Characterization Strategy Form for TA-54 Wells R-51 (Well D) and R-52 (Well A) Regional Well Installation and Corehole Drilling," Los Alamos, New Mexico. (LANL 2009, 107439)

LANL (Los Alamos National Laboratory), November 2009. "Drilling Work Plan for Regional Aquifer Well R-51," Los Alamos National Laboratory document LA-UR-09-7263, Los Alamos, New Mexico. (LANL 2009, 107514)

North Wind Inc., November 13, 2009. "Well R-51 Drill Plan, Installation of Well R-51, TA-18, Los Alamos National Laboratory," plan prepared for Los Alamos National Laboratory, Los Alamos, New Mexico. (North Wind, Inc., 2009, 109446)

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; 19 March 2008.

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

Coarse Scale Drainage Arcs; Los Alamos National Laboratory, Water Quality and Hydrology Group of the Risk Reduction and Environmental Stewardship Program; as published 03 June 2003.

Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 19 March 2008; as published 04 January 2008.

Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 19 March 2008; as published 04 January 2008.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 19 March 2008; as published 04 January 2008

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

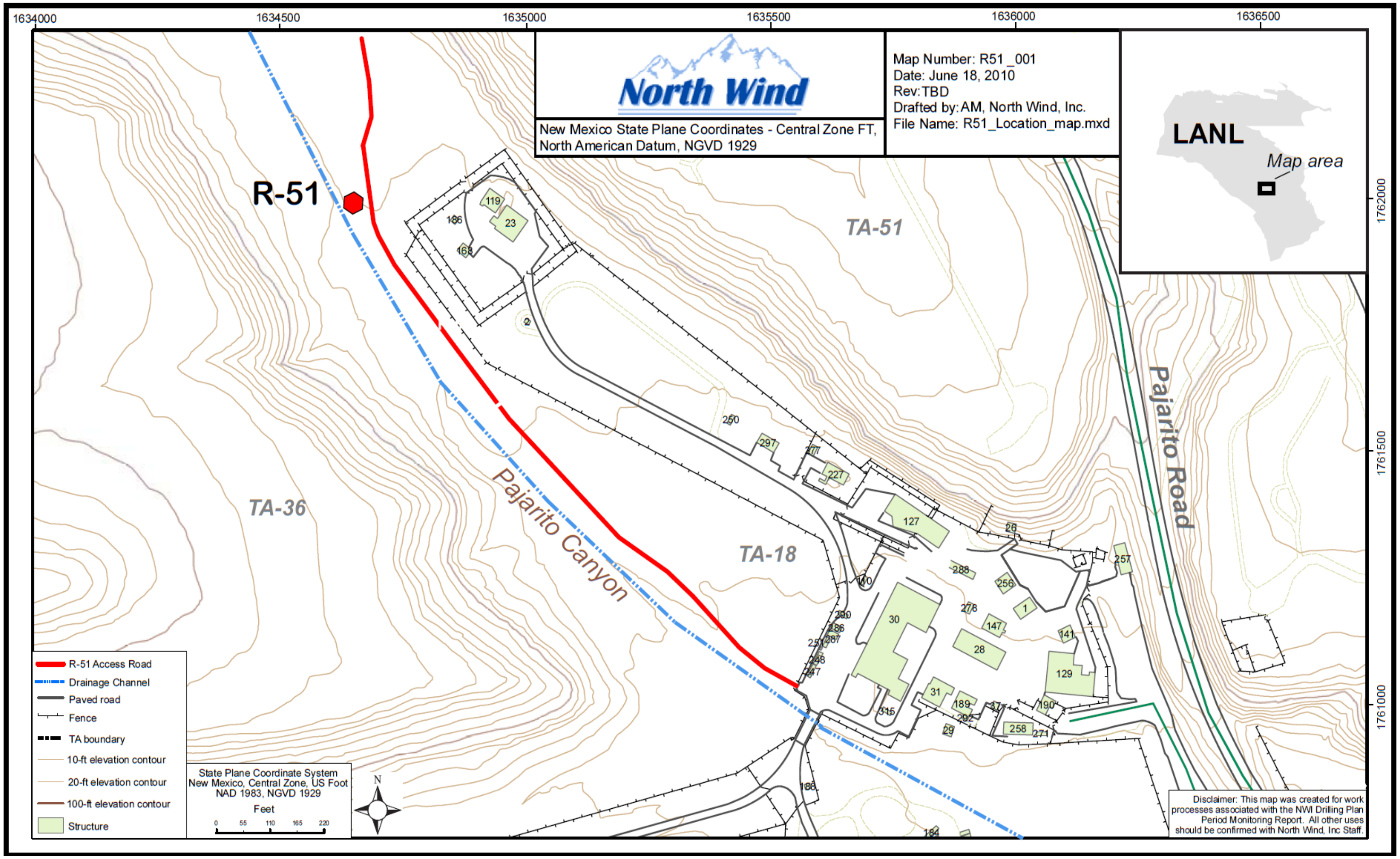

Figure 1.0-1 Regional aquifer well R-51 location

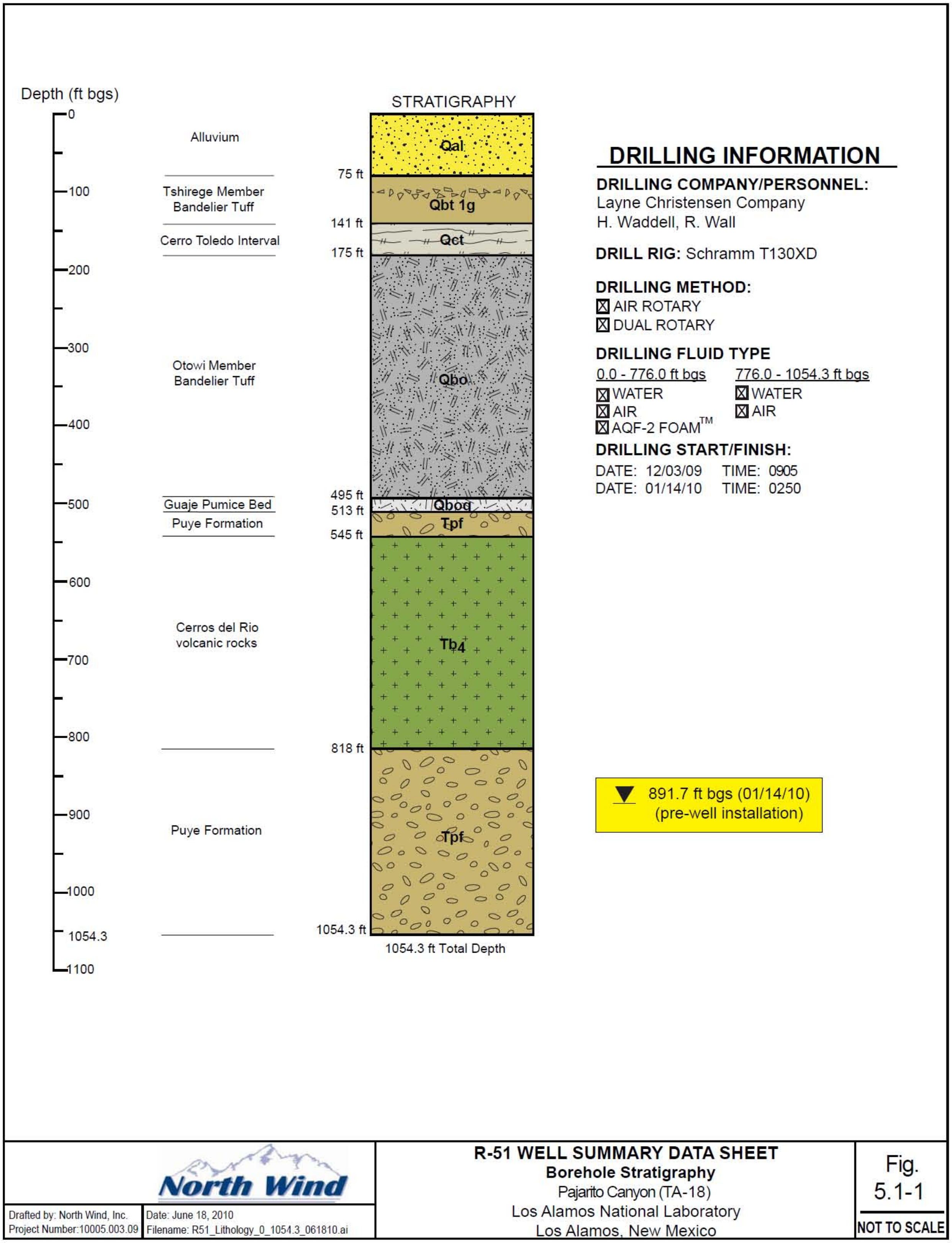

Figure 5.1-1 R-51 borehole stratigraphy

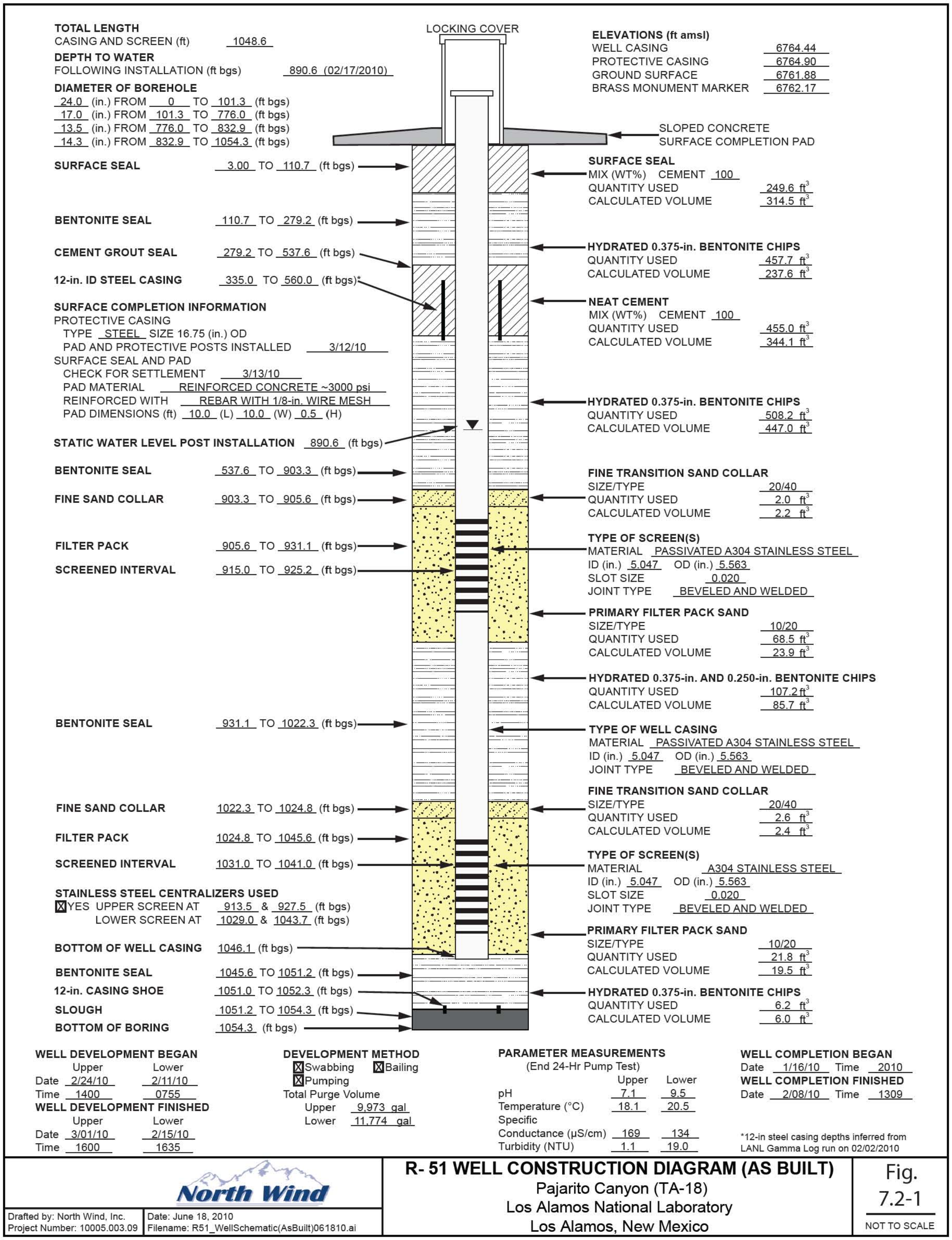

Figure 7.2-1 R-51 as-built well construction diagram

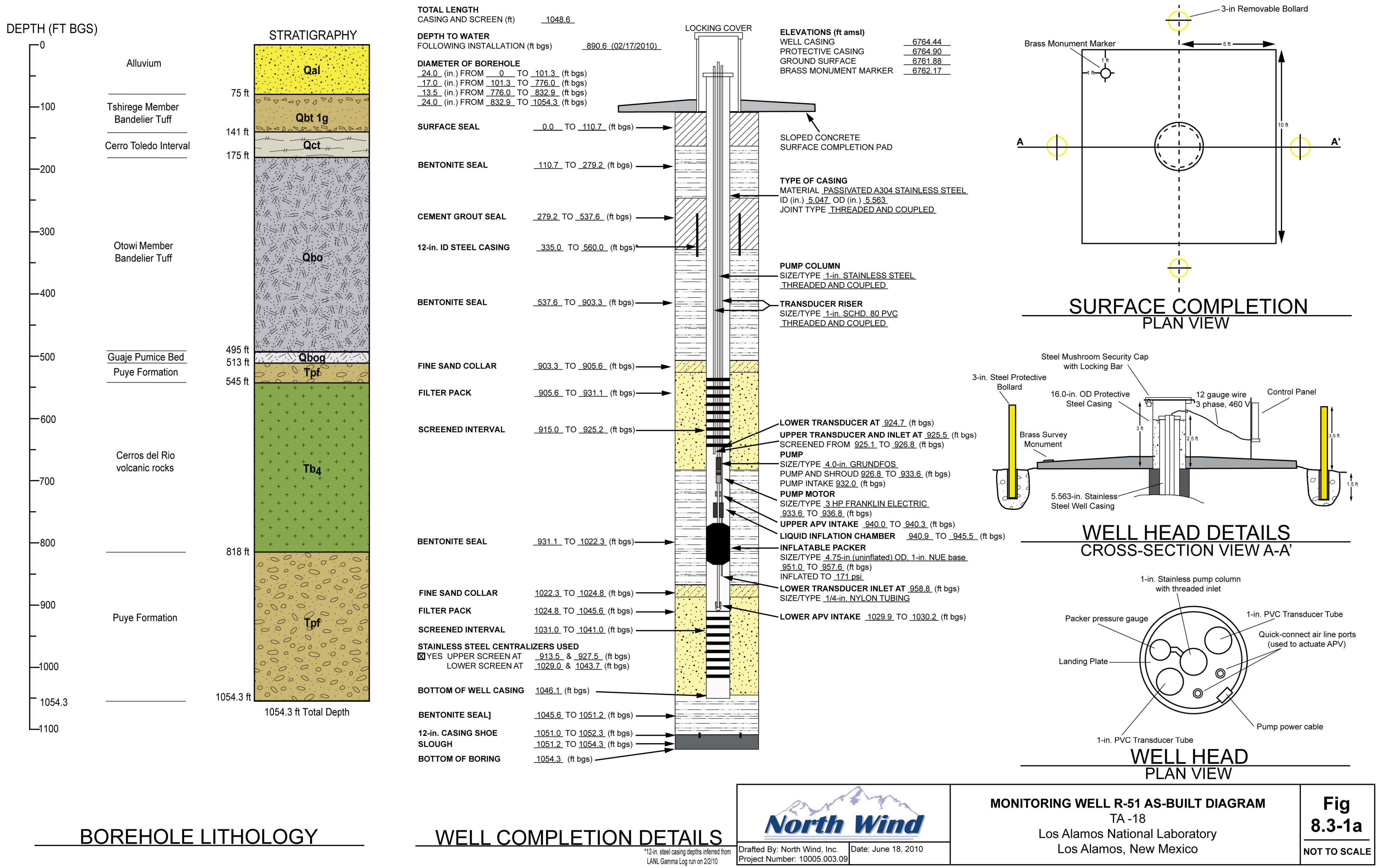

Figure 8.3-1a As-built schematic for regional well R-51

R-51 TECHNICAL NOTES

SURVEY INFORMATION

Brass Marker

Northing:	1761983.36 ft
Easting	1634685.79 ft
Elevation	6762.17 ft amsl

Well Casing (top of stainless steel)

Northing:	1761977.68 ft
Easting:	1634686.87 ft
Elevation:	6764.44 ft amsl

BOREHOLE GEOPHYSICAL LOGS

LANL Gamma and Array Induction Logs (12/12/10)
Schlumberger: Hostile Natural Gamma Spectroscopy (inoperable), Elemental Capture Sonde, Triple Detector Lithodensity, Accelerator Porosity Sonde

DRILLING INFORMATION

Drilling Company

Layne Christensen Company

Drill Rig

Schramm T130XD

Drilling Methods

Fluid-assisted air rotary
Fluid-assisted dual rotary

Drilling Fluids

Air, AQF-2 Foam (to ~776 ft bgs), potable water

MILESTONE DATES

Drilling

Start:	12/03/2009
Finish:	01/14/2010

Well Completion

Start:	01/16/2010
Finish:	02/08/2010

Well Development

Upper Screen

Start:	02/24/2010
Finish:	03/01/2010

Lower Screen

Start:	02/11/2010
Finish:	02/15/2010

NOTE:
Coordinates based on New Mexico State Plane Grid Coordinates, Central Zone (NAD 83); Elevation expressed in feet above mean sea level using the National Geodetic Vertical Datum of 1929.

WELL DEVELOPMENT

Development Methods

Performed swabbing, bailing, and pumping
Volume Purged:
Upper Screen: 9,973 gallons
Lower Screen: 11,774 gallons

Parameter Measurements (End 24 Hr Pump Test)

	Upper Screen	Lower Screen
pH:	7.1	9.5
Temperature:	18.1ºC	20.5ºC
Specific Conductance:	169 µS/cm	134 µS/cm
Turbidity	1.1 NTU	19.0 NTU

AQUIFER TESTING

Constant Rate Pumping Test

	Upper Screen	Lower Screen
Water Produced:	6,553 gal.	33,273 gal.
Average Flow Rate:	4 gpm	21 gpm
Performed on:	03/05/2010-03/08/2010	02/19/2010-02/22/2010

DEDICATED SAMPLING SYSTEM

Pump Type 5S30-820CBM
Make: Grundfos
Model: B96023161
SN#: P10909088
5.0 U.S. gpm, intake at 932 ft bgs
Environmental Retrofit

Motor
Make: 3 HP Franklin Electric
Model: 2343262604
SN#: 09M14-14-2860

Pump Column
1-in. OD Threaded and Coupled
Schedule 80 Stainless Steel

Upper Transducer Riser
1-in. OD Flush Threaded Schedule 80 PVC
with 0.010 slot screen between
925.1 to 926.8 ft bgs.

Lower Transducer Riser and Pressure Transfer Tube
1-in. OD Flush Threaded Schedule 80 PVC
1/4-in. ID, 32.0-ft long nylon tubing routed through packer to 958.8 ft bgs.
Transfers pressure from lower screened interval.

Upper Transducer	Lower Transducer
Installed 05/10/2010	Installed 05/10/2010
Make: In-Situ	Make: In-Situ
Model: Level Troll 500, 30 psig (vented cable, 950 ft, Tefzel jacketed)	Model: Level Troll 500, 30 psig (vented cable, 950 ft, Tefzel jacketed)
S/N: 160220 (Troll 500)	S/N: 160240 (Troll 500)
S/N: 226555 (Cable)	S/N: 226557 (Cable)

North Wind
Drafted by: North Wind, Inc.
Project Number:10005.003.09
Date: June 18, 2010

R-51 TECHNICAL NOTES
(TA-18)
Los Alamos National Laboratory
Los Alamos, New Mexico

Fig 8.3-1b
NOT TO SCALE

Figure 8.3-1b Technical notes for regional well R-51

Table 3.1-1
Fluid Quantities Used during R-51 Drilling and Well Construction

Date	Water (gal.)	Cumulative Water (gal.)	AQF-2 Foam (gal.)	Cumulative AQF-2 Foam (gal.)
12/3/2009	4000	4000	3	3
12/4/2009	1000	5000	n/a*	3
12/5/2009	1700	6700	n/a	3
12/6/2009	13,800	20,500	1	4
12/7/2009	10,000	30,500	40	44
12/9/2009	20,000	50,500	56	100
12/10/2009	12,000	62,500	70	170
12/14/2009	7120	69,620	25	195
12/15/2009	3520	73,140	n/a	n/a
12/16/2009	9100	82,240	n/a	n/a
12/17/2009	1000	83,240	n/a	n/a
12/19/2009	3000	86,240	n/a	n/a
1/10/2010	400	86,640	n/a	n/a
1/12/2010	5000	91,640	n/a	n/a
1/13/2010	8800	100,440	n/a	n/a
1/21/2010	2000	102,440	n/a	n/a
1/22/2010	10,000	112,440	n/a	n/a
1/23/2010	8200	120,640	n/a	n/a
1/24/2010	19,500	140,140	n/a	n/a
1/25/2010	23,500	163,640	n/a	n/a
1/26/2010	28,800	192,440	n/a	n/a
1/27/2010	15,100	207,540	n/a	n/a
1/28/2010	20,000	227,540	n/a	n/a
1/29/2010	20,400	247,940	n/a	n/a
1/30/2010	16,300	264,240	n/a	n/a
1/31/2010	29,900	294,140	n/a	n/a
2/2/2010	2000	269,140	n/a	n/a
2/4/2010	2590	298,730	n/a	n/a
2/5/2010	19,193	317,923	n/a	n/a
2/6/2010	2300	320,223	n/a	n/a
2/7/2010	636	320,859	n/a	n/a
2/8/2010	312	321,171	n/a	n/a
Total Water Volume				
R-51	321,171 gal.			

* n/a = Not applicable.

Table 4.2-1
Summary of Groundwater Screening Samples Collected during Drilling, Well Development, and Aquifer Testing of Well R-51

Location ID	Sample ID	Date Collected	Collection Depth (ft bgs)	Sample Type	Analysis
Drilling					
R-51	GW51-10-8739	12/5/09	161	Groundwater (bailed)	Metals, cations, anions (including perchlorate), HE, VOCs, LH3
R-51	GW51-10-8740	12/12/09	563−568	Groundwater (bailed)	Metals, cations, anions (including perchlorate), HE, VOCs, LH3
R-51	GW51-10-8743	1/13/10	935	Groundwater (air-lifted)	Metals, cations, anions (including perchlorate), HE, VOCs, LH3
R-51	GW51-10-8744	1/14/10	1054	Groundwater (air-lifted)	Metals, cations, anions (including perchlorate), HE, VOCs, LH3
R-51	GW51-10-8745	1/13/10	935	Groundwater (air-lifted)	VOCs (trip blank)
Well Development					
R-51	WST51-10-10135	2/12/10	1031−1041	Groundwater (bailed)	TOC
R-51	WST51-10-10136	2/12/10	1031−1041	Groundwater (bailed)	TOC
R-51	WST51-10-10137	2/13/10	1031−1041	Groundwater (pump intake)	TOC
R-51	WST51-10-10138	2/14/10	1031−1041	Groundwater (pump intake)	TOC
R-51	WST51-10-10139	2/15/10	1031−1041	Groundwater (pump intake)	TOC, metals, cations, anions (including perchlorate)
R-51	WST51-10-13788	3/1/10	930	Groundwater (bailed)	TOC
R-51	WST51-10-13134	3/1/10	915−930	Groundwater (bailed)	TOC, metals, cations, anions (including perchlorate)

Table 6.0-1
R-51 Video and Geophysical Logging Runs

Date	Depth (ft bgs)	Description
12/11/09	0−167	LANL gamma log run attempt. LANL personnel could not advance tool past 167 ft bgs, logging attempt abandoned at this depth, no gamma log data generated for this run.
12/11/10	0−190	LANL Induction log run attempt. Induction tool would not generate data when put into logging mode. Logging attempt abandoned at 190 ft bgs.
12/11/09	0−660	LANL video log run. Noted ledges at 167 and 514 ft bgs. Noted wet borehole walls at 526 ft bgs and rivulets of water running down borehole walls at 526 ft bgs. J. Thomson (LANL subcontractor technical representative) stated that in his opinion water was first observed to be coming into borehole at 502 ft bgs, and then-current DTW was ~661 ft bgs. Foam in borehole water obscured video log below 660 ft bgs.
12/12/09	0−565	LANL gamma log run. Gamma log run successful, but depth calibration was off by 2.5 ft, so generated log shows all depths 2.5 ft deeper than actual depth.
12/12/09	0−565	LANL Induction log run.
12/12/19	0−565	LANL video log run. Video showed foam on borehole walls at 502 ft bgs. Large void in borehole wall at 506 ft bgs, wet borehole walls at 508 ft bgs, rivulets at 510 ft bgs. Flow increased between 510 and 517 ft bgs. Foam in borehole at 563 ft bgs, low visibility (due to foam) terminated video log run at 565 ft bgs.
12/16/09	0−489	LANL video log run. Camera lowered down borehole to 489 ft bgs, where it encountered foam and subsequently ran into obstruction that coated lens, reducing visibility to zero. Camera tripped out and cleaned. Added de-foamer/water to borehole to dissipate foam at 489 ft bgs. Second log attempt encountered foam at 466 ft bgs, and further video logging attempts were abandoned at that time.
1/11/10	0−635	LANL video log run. Camera lowered to inspect bottom of drive casing and shoe, log showed bottom of casing and drive shoe intact, but shoe was missing most of the carbide buttons.
1/15/10	0−1054	LANL gamma log run. While logging up borehole, the winch on logging trailer malfunctioned at 1000 ft bgs, resulting in no data above 992 ft bgs. Good data set generated between 992 and 1054 ft bgs.
1/15/10	0−1054	Schlumberger cased-hole geophysical logs: gamma ray, triple detector lithodensity, elemental capture spectroscopy, and accelerator porosity sonde. Due to tool malfunction, no hostile natural gamma spectroscopy log was run. The Void flag on Elemental Capture Sonde shows voids at approximately 970 to 966, 933 to 927, 832 to 824, 786 to 778, 770 to 720, 534 to 524, 496 to 490, 480 to 420, 242 to 238, 118 to 116, and 100 to 30 ft bgs.
2/2/10	0−1046	LANL video log run inside 5.5-in. well casing to inspect screens after 12-in. casing was dropped on 2/1/10. Highly turbid water prevented inspection of screens, but operator successfully tagged the bottom of well at 1046 ft bgs.
2/2/10	0−1046	LANL gamma log inside 5.5-in. casing to determine depth of dropped section of 12-in. drive casing. Based on log interpretation, casing stopped ~22 ft into bentonite backfill and remains in borehole between approximately 335 and 560 ft bgs.
2/2/10	0−1046	LANL video log run inside 5.5-in. well casing after adding ~2000 gal. water to well casing to improve water clarity. Inspection of both screens revealed no damage to either screen, or to any other part of well casing.

Note: Natural gamma logging equipment was used for all gamma logging runs.

Table 7.2-1
R-51 Annular Fill Materials

Material	Volume (ft^3)
Surface seal: 100 wt% Portland cement	249.6
Upper seal: 0.375-in. bentonite chips	457.7
Grout seal around 12-in. casing: 100 wt% Portland cement	455.0
Intermediate seal: 0.375-in. bentonite chips	508.2
Transition sand collar: 20/40 silica sand	2.0
Primary filter pack (upper screen): 10/20 silica sand	68.5
Inter-screen seal: 0.375-in. bentonite chips and 0.25-in. bentonite pellets	107.2
Transition sand collar: 20/40 silica sand	2.6
Primary filter pack (lower screen): 10/20 silica sand	21.8
Lower seal: 0.375-in. bentonite chips	6.2

Table 8.5-1
R-51 Survey Coordinates

Identification	Northing	Easting	Elevation
R-51 brass monument marker	1761983.36	1634685.79	6762.17
R-51 ground surface	1761991.90	1634682.85	6761.88
R-51 top of protective casing	1761977.63	1634686.85	6764.90
R-51 top of well casing	1761977.68	1634686.87	6764.44

Note: All coordinates are expressed relative to the New Mexico State Plan Coordinate System Central Zone (NAD 83); elevation is expressed in ft amsl using the National Geodetic Vertical Datum of 1929. Surveying was completed on May 18, 2010.

Table 8.6-1
Summary of Waste Samples Collected during Drilling and Development of R-51

Sample ID/Event ID	Date, Time Collected	Description	Sample Type
GW51-10-8959/2533	12/15/09, 1400	Concrete/Soil	Soil
GW51-10-8960/2533	12/15/10, 1400	Concrete/Soil	Soil
GW51-10-8962/2533	12/15/10, 1400	Trip Blank	Soil
WST51-10-9867/2547	12/21/09, 1330	Decon Water	Liquid
WST51-10-9868/2547	12/21/09, 1330	Trip Blank	Liquid
WST51-10-11854/2606	1/25/10, 1440	Trip Blank	Liquid
WST51-10-11855/2606	1/25/10, 1440	Decon Water	Liquid
GW51-10-10149/2560	2/17/10, 1135	Development Water	Liquid
GW51-10-10150/2560	2/17/10, 1135	Trip Blank	Liquid
WST51-10-13282/2653	2/17/10, 1220	Trip Blank	Liquid
WST51-10-13283/2653	2/17/10, 1220	Decon Water	Liquid
WST51-10-13119/2642	2/24/10, 1530	Development Water	Liquid
WST51-10-13121/2642	2/24/10, 1530	Trip Blank	Liquid
WST51-10-13532/2664	2/24/10, 1500	Decon Water	Liquid
WST51-10-13533/2664	2/24/10, 1500	Trip Blank	Liquid
WST51-10-13120/2642	3/4/10, 1450	Development Water	Liquid
WST51-10-13122/2642	3/4/10, 1450	Trip Blank	Liquid

Appendix A

Well R-51 Borehole Lithologic Log

Los Alamos National Laboratory
Regional Hydrogeologic Characterization Project
Borehole Lithologic Log

Borehole Identification (ID): R-51		Technical Area (TA): TA-18		Page: 1 of 13
Drilling Company: Layne Christensen Co.		Start Date/Time: 12/03/09 0905		End Date/Time: 01/14/10 0250
Drilling Method: Air Rotary		MACHINE: Schramm T130XD		Sampling Method: Grab
Ground Elevation: 6761.88 ft amsl				Total Depth: 1054.3 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	Site Geologists: T Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Staires			
Depth (ft bgs)	**Lithology**		**Lithologic Symbol**	**Notes**
0–15	**ALLUVIUM:** Fine to medium grained alluvial sediments (ML), moderately to highly weathered, light brownish gray (5YR 6/1), subangular to subrounded fragments. WR: Fine to medium grained alluvial silts and sands with minor gravels, minor quartz and sanidine crystals. Abundant silts in matrix. +35F: Fine grained alluvial sands and small pebbles with minor intermediate fragments. 90% quartz and sanidine with balance of intermediate composition lithics. +60F: Fine grained alluvial sediments, with 40-45% quartz and sanidine and 55-60% intermediate composition volcanic lithics.		Qal	Alluvium encountered from 0 to 75 ft bgs.
15–40	Fine to coarse grained alluvial sediments (GM), moderately weathered, pale brown (10YR 6/3) to brown (7.5YR 5/3), subangular to subrounded gravels and sands, poorly sorted. WR: Intermediate composition lithics (notably dacite) with minor quartz and sanidine crystals. Abundant clay and silt in matrix. +10F: 40-45% quartz and sanidine (bipyramidal quartz and minor inclusions in quartz crystals noted), 55-60% intermediate composition lithic fragments with minor iron-oxide stained volcanic lithic fragments, trace to no moderately welded tuff fragments. +35F: 55-60% quartz and sanidine (bipyramidal quartz noted). 10% moderately welded tuff fragments, 30-35% intermediate composition lithic fragments, with minor iron-oxide-stained volcanic lithic fragments.		Qal	

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Depth (ft bgs)	**Lithology**		**Lithologic Symbol**	**Notes**
40–75	Fine to coarse grained alluvial sediments (GW), slightly weathered, gray (5YR 6/1) to gray (7.5YR 5/1), angular to subrounded gravels and sands, moderately sorted. WR: Intermediate composition lithics with some quartz and sanidine crystals. Minor silt and sand in matrix. +10F: 85-90% intermediate composition lithic fragments, 10-15% quartz with minor sanidine (bipyramidal milky quartz), trace to no moderately welded tuff fragments. +35F: 40-45% quartz and sanidine (bipyramidal quartz and minor inclusions in quartz crystals noted), 55-60% intermediate composition lithic fragments, with minor iron-oxide-stained volcanic lithic fragments.		Qal	
75–85	**UNIT 1G OF THE TSHIREGE MEMBER OF THE BANDELIER TUFF:** Tuff, light brown (10YR 7/1), weakly to non-welded vitric pumice. WR: Non-welded pumice fragments with intermediate volcanic lithics. Minor silt in matrix. Minor iron-oxide staining on all fragments, (bipyramidal quartz with trace inclusions noted). +10F: 40% weakly to non-welded tuff fragments with minor iron oxide staining, 56% intermediate composition lithics, 4% quartz and sanidine (minor inclusions noted in quartz and sanidine). +35F: 50% non-welded tuff fragments with trace iron-oxide-staining, 35% intermediate composition lithics, 15% quartz and sanidine (trace inclusions noted).		Qbt 1g	Unit 1g of the Tshirege Member of the Bandelier Tuff encountered from 75 to 141 ft bgs.
85–100	Tuff, very pale orange (10YR 8/2) to light brown (5YR 6/4), weakly to non-welded. WR: very sandy matrix with trace to few lithic fragments. +10F: 5-10% quartz and sanidine, 20% pumice, 70-75% lithic fragments. Minor iron-oxide staining on most pumice and lithic fragments. +35F: 65-70% quartz and sanidine, 10-15% pumice fragments, 10-15% lithic fragments, minor iron-oxide staining on pumice and lithic fragments.		Qbt 1g	

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Depth (ft bgs)	Lithology		Lithologic Symbol	Notes
100–110	Tuff, yellow (5Y 8/1) to very pale orange (10YR 8/2), weakly to non-welded. WR: Few lithic fragments, minor quartz and sanidine, primarily pumice fragments with minor iron-oxide staining on pumice and lithics. +10F: 90-95% pumice fragments, 5-10% lithic fragments, minor iron-oxide staining on pumice and lithic fragments. +35F: 55-60% pumice fragments, 35-40% quartz and sanidine, 5% lithic fragments (bipyramidal and minor inclusions in quartz and sanidine). Trace glass shards.		Qbt 1g	
110–115	Tuff, medium gray (N5), weakly to non-welded. WR: 60-65% quartz and sanidine, 10-15% lithic fragments, and 15-20% pumice fragments, minor iron-oxide staining on lithics and pumice, trace glass shards (minor inclusions noted in quartz and sanidine). +10F: 45-50% lithic fragments, 45-50% pumice fragments, minor iron-oxide staining on most fragments. +35F: 65-70% quartz and sanidine, 20-25% pumice fragments, 15-20% lithic fragments, minor iron-oxide staining on pumice and lithic fragments (minor inclusions in sanidine and quartz fragments noted). Trace glass shards.		Qbt 1g	
115–140	Tuff, very pale orange (10YR 8/2) to pale yellowish brown (10YR 6/2), weakly to non-welded. +10F: 5-30% lithic fragments, 60-90% pumice fragments, 5-10% quartz and sanidine. +35F: 5% lithic fragments, 30-35% pumice fragments, 60-90% quartz and sanidine, minor iron-oxide staining on pumice and lithic fragments, minor inclusions in quartz fragments.		Qbt 1g	Note: 130-140 ft bgs interval contains significantly more lithic fragments.
140–165	**CERRO TOLEDO INTERVAL:** Volcaniclastic sediments, grayish orange (10YR 7/4) to pale yellowish brown (10YR 6/2), well-graded gravels and sands (GW), fine to coarse sand, angular to subrounded clasts. +10F: 60-80% intermediate lithic and crystalline fragments, 10-30% vitric pumice, 5-15% tuffaceous sandstone and siltstone. +35F: 5-50% intermediate lithic fragments, 5-40% vitric pumice, 20-65% quartz and sanidine, trace tuffaceous sandstone and siltstone. Minor oxidation on pumice fragments and on tuffaceous sandstones and siltstones.		Qct	Cerro Toledo Interval encountered between 141 to 175 ft bgs. Noticeable drop in gamma log between 141 and 175 ft bgs.

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Depth (ft bgs)	Lithology		Lithologic Symbol	Notes
165–180	No cuttings returned in this interval.		Qct	Contact between Qct and Qbo is at 175 ft bgs based on a significant increase in gamma log as well as Qbo type lithology below 175 ft bgs.
180–195	**OTOWI MEMBER OF THE BANDELIER TUFF:** Tuff and volcaniclastic sediments, pale yellowish brown (10YR 6/2), well-graded gravels and sands (GW), fine to coarse sand, subrounded to rounded clasts. +10F: 60-70% intermediate composition lithic fragments, 10-15% pumice fragments, 20-30% tuffaceous sandstone and siltstone. +35%: 60-70% intermediate lithic fragments, 5-10% pumice fragments, 20-30% quartz and sanidine, 15-20% tuffaceous sandstone and siltstone. Minor oxidation on some pumice and lithic fragments.		Qbo	Otowi Member of the Bandelier Tuff encountered between 175 to 495 ft bgs
195–205	Tuff and volcaniclastic sediments, grayish orange (10YR 7/4) to pale yellowish brown (10YR 6/2), well-graded gravels and sands (GW), coarse sand, subangular to subrounded clasts. +10F: 80-90% intermediate composition lithic fragments, 5-10% pumice fragments, trace tuffaceous sandstone. +35%: 50-60% intermediate lithic fragments, 5% pumice, 40-50% quartz and sanidine, 5% tuffaceous sandstone and siltstone. Minor oxidation on some pumice and lithic fragments.		Qbo	
205–240	Tuff, grayish orange (10YR 7/4) to pale yellowish brown (10YR 6/2), weakly to non-welded. WR: silty to gravelly texture. +10F: 50-65% light orange to light gray, vitric, fibrous pumice fragments, 60-65% intermediate composition lithics, trace quartz and sanidine crystals. +35F: 30-35% light orange to light gray, vitric, fibrous pumice fragments, 40-45% lithic fragments, 30-40% quartz and sanidine (trace bipyramidal quartz and minor inclusions in quartz). Minor oxidation on pumice and lithic fragments.		Qbo	

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Depth (ft bgs)	**Lithology**		**Lithologic Symbol**	**Notes**
240–255	Tuff, pale yellowish brown (10YR 6/2) to dark yellowish brown (10YR 6/2), weakly to non-welded. WR: silty to gravelly texture. +10F: 3-5% light orange to light gray, vitric, fibrous pumice fragments, 95-97% intermediate composition lithics. +35F: 15-20% pumice fragments, 60-65% lithic fragments, 55-60% quartz (clear and smokey) and sanidine (some bipyramidal quartz and minor inclusions in quartz and sanidine). Minor oxidation on pumice and lithic fragments.		Qbo	
255–305	Tuff, grayish orange (10YR 7/4) to pale yellowish brown (10YR 6/2), weakly to non-welded. WR: silty to gravelly texture. +10F: 35-50% light orange to light gray/white, vitric, fibrous pumice fragments, 50-65% intermediate composition lithic fragments, trace quartz. +35F: 45-65% pumice fragments, 30-35% lithic fragments, 25-45% quartz (smokey and clear) and sanidine (trace bipyramidal quartz and minor inclusions in quartz and sanidine). Minor oxidation on pumice and lithic fragments.		Qbo	
305–345	Tuff, grayish orange (10YR 7/4) to pale yellowish brown (10YR 6/2), weakly to non-welded. WR: sandy to gravelly texture. +10F: 40-75% light orange to light gray/white, vitric, fibrous pumice fragments, 25-60% intermediate composition lithic fragments, trace quartz with some inclusions. +30F: 55-75% pumice fragments, 30-40% lithic fragments, 25-40% quartz and sanidine (trace bipyramidal quartz and minor inclusions in quartz and sanidine). Minor oxidation on pumice and lithic fragments.		Qbo	
345–450	Tuff, very light gray (N8) to medium light gray (N6), weakly to non-welded. WR: silty to gravelly texture. +10F: 35-90% light gray to white, vitric, pumice fragments, 10-65% intermediate composition lithic fragments. +30F: 35-80% pumice fragments, 30-45% lithic fragments, 25-40% quartz and sanidine (some bipyramidal quartz and some inclusions in quartz and sanidine). Minor oxidation on pumice, lithic fragments, and some quartz.		Qbo	

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Depth (ft bgs)	**Lithology**		**Lithologic Symbol**	**Notes**
450–495	Tuff, grayish orange (10YR 7/4) to pale yellowish brown (10YR 6/2), weakly to non-welded. WR: sandy to gravelly texture. +10F: 40-80% light orange to light gray, vitric, fibrous pumice fragments, 20-60% intermediate composition lithics. +35F: 40-70% pumice fragments, 35-45% lithic fragments, 30-45% quartz and sanidine (trace bipyramidal quartz and minor inclusions in quartz). Minor oxidation on pumice and lithic fragments. (Note: 10F and 35F fraction not recovered for 460-465 and 485-490 ft bgs samples)		Qbo	
495–510	**GUAJE PUMICE BED:** Tuff, very pale orange (10YR 8/2), weakly to non-welded. WR: silty to gravelly texture. +10F: 70-80% pale orange to light gray/white, vitric, fibrous pumice fragments, 20-30% intermediate composition lithics. +35F: 40-70% pumice fragments, 35-45% lithic fragments, 30-45% quartz and sanidine (trace bipyramidal quartz and minor inclusions in quartz). Minor oxidation on pumice and lithic fragments.		Qbog	Guaje Pumice Bed encountered between 495 to 513 ft bgs. Base of Qbog noted in video and gamma log.
510–520	**PUYE FORMATION:** Volcaniclastic sediments, very pale orange (10YR 8/2), poorly sorted, well-graded gravels and sands (GW) with a silty matrix, subangular to subrounded clasts. WR: Intermediate composition lithics, pumice fragments, tuffaceous siltstone and sandstone, minor quartz and sanidine crystals. +10F: 35-55% light gray to white pumice clasts, 45-65% porphyritic and aphyric intermediate volcanic clasts (including dacite), some lithic rich sandstone clasts, trace quartz clasts. +35F: 30-35%-pumice clasts, 30-35% porphyritic and aphyric volcanic clasts, 20-30% quartz and sanidine clasts (trace bipyramidal quartz), 3-10% lithic rich sandstone clasts.		Tpf	Puye Formation encountered between 513 to 545 ft bgs. Noticeable shift on gamma log.

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Depth (ft bgs)	Lithology		Lithologic Symbol	Notes
520–545	Volcaniclastic sediments, gray (7.5YR 5/1) to dark gray (N5), poorly to moderately sorted gravels and sands (GW) with a silty matrix, subangular to subrounded clasts. WR: Intermediate to mafic composition lithic fragments, yellow-orange to red-orange tuffaceous siltstone and sandstone and clay fragments, and minor quartz and sanidine crystals. +10F: 75-95% intermediate composition and basalt volcanic fragments, 10-15% clay and lithic fragments, 2-15% pumice fragments. +35F: 65-85% basalt fragments, 10-25% clay and lithic fragments, 2-5% pumice fragments, trace quartz and sanidine crystals. Some reddish brown oxidation on basalt fragments.		Tpf	
545–580	**CERROS DEL RIO VOLCANIC ROCKS:** Aphanitic to porphyritic, non-vesicular to slightly vesicular basalt containing notable phenocrysts of olivine and plagioclase feldspar, medium dark gray (N4) to dark gray (N5). Some amygdaloidal basalt noted. WR: Slightly vesicular basalt fragments with some orange to red clay and lithic fragments. +10F: 75-95% basalt fragments, 5-25% clay and lithic fragments. +35F: 85-95% basalt fragments, 5-15% clay and lithic fragments. Some oxidation on basalt fragments.		Tb4	Cerros del Rio volcanic rocks encountered between 545 and 818 ft bgs
580–590	Aphanitic to porphyritic, slightly vesicular to highly vesicular basalt and scoria fragments containing notable phenocrysts of olivine and plagioclase feldspar, medium dark gray (N4) and dark gray (N5) to dusky brown (5YR 2/2). WR: Slightly to highly vesicular basalt and scoria fragments with trace orange to red clay and lithic fragments. +10F: 95-97% basalt and scoria fragments, 3-5% clay and lithic fragments. +35F: 85-95% basalt fragments, 5-15% clay and lithic fragments. Some oxidation on basalt fragments.		Tb4	

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Depth (ft bgs)	**Lithology**		**Lithologic Symbol**	**Notes**
590–620	Aphanitic to porphyritic, non-vesicular to slightly vesicular basalt containing notable phenocrysts of olivine, plagioclase feldspar, and pyroxene, medium dark gray (N4) to dark gray (N5). WR: Slightly vesicular basalt fragments with some orange to red clay and lithic fragments. +10F: 75-95% basalt fragments, 5-25% clay and lithic fragments. +35F: 75-90% basalt fragments, 10-25% clay and lithic fragments. Some oxidation on basalt fragments.		Tb4	
620–630	Aphanitic to porphyritic, slightly vesicular to highly vesicular basalt and scoria fragments containing notable phenocrysts of olivine, plagioclase feldspar, and pyroxene, medium dark gray (N4) and dark gray (N5) to dusky brown (5YR 2/2). WR: Slightly to highly vesicular basalt and scoria fragments with trace orange to red clay and lithic fragments. +10F: 100% basalt and scoria fragments. +35F: 75-90% basalt fragments, 10-25% clay and lithic fragments. Some oxidation on basalt fragments.		Tb4	
630–690	Aphanitic to porphyritic, slightly vesicular to moderately vesicular basalt containing notable phenocrysts of olivine, plagioclase feldspar, and pyroxene, medium dark gray (N4) and dark gray (N5) to dusky brown (5YR 2/2). WR: Slightly vesicular basalt fragments with some orange to red clay and lithic fragments. +10F: 75-100% basalt fragments, 0-25% clay and lithic fragments. +35F: 75-97% basalt fragments, 3-25% clay and lithic fragments. Some oxidation on basalt fragments.		Tb4	
690–700	Aphanitic to porphyritic, slightly vesicular basalt, dark gray (N3) with moderate brown (5YR 4/4) weathered basalt fragments. WR: Slightly vesicular basalt fragments with phenocrysts of olivine; trace sanidine and quartz crystals, weathered basalt fragments. +10F: Slightly vesicular basalt fragments with trace weathered basalt fragments. +35F: Basalt fragments with weathered/altered basalt fragments and trace quartz crystals. Some iron staining on basalt fragments.		Tb4	

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700–735	Aphanitic to porphyritic basalt, medium gray (N5) to dark gray (N3) with light brown (5YR 6/4), angular to subrounded silty clay fragments. WR: Slightly vesicular basalt fragments with trace phenocrysts of olivine and iron staining, trace quartz crystals, and silty clay fragments. +10F: Basalt fragments with trace quartz crystals and trace silty clay fragments. +35F: Slightly vesicular basalt fragments with trace quartz crystals and 10% silty clay fragments.		Tb4	
735–740	Aphanitic to porphyritic basalt, dark gray (N3) to dusky brown (5YR 2/2) with light brown (5YR 6/4), angular to subrounded silty clay fragments. WR: Basalt fragments with phenocrysts of olivine and iron staining, silty clay fragments, and trace quartz crystals. +10F: Non-vesicular to slightly vesicular basalt fragments with trace silty clay fragments. +35F: Basalt fragments with 5% silty clay fragments.		Tb4	
740–775	Aphanitic to porphyritic basalt, dark reddish brown (10YR 3/4) to dusky brown (5YR 2/2) with light brown (5YR 6/4) angular to subrounded, silty clay fragments. WR: Basalt fragments with phenocrysts of olivine and iron staining, silty clay fragments, and trace sanidine and quartz crystals. +10F: Non-vesicular to slightly vesicular basalt fragments with trace quartz and sanidine crystals and 2% silty clay fragments. +35F: Basalt fragments with trace quartz crystals and 3% silty clay fragments.		Tb4	
775–780	No cuttings returned in this interval.			
780–785	Aphanitic to porphyritic basalt, dark reddish brown (2.5YR 3/3) to very dark gray (5YR 3/1). WR: Basalt fragments with moderate iron staining. +10F: Non-vesicular to highly vesicular basalt with trace quartz and sanidine crystals. +35F: No samples of this fraction size were retained.		Tb4	

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785–790	Aphanitic to porphyritic basalt, dark reddish brown (2.5YR 3/3) with light brown (5YR 6/4) subrounded to rounded silty clay fragments. WR: Basalt fragments with minor olivine phenocrysts and iron staining. 10F: Non-vesicular to slightly vesicular basalt fragments. 35F: Basalt fragments with quartz and sanidine crystals. 2% subrounded silty clay fragments.	Tb4	
790–815	Aphanitic to porphyritic basalt, dark reddish brown (2.5YR 3/3) to very dark gray (5YR 3/1) with light brown (5YR 6/4) subrounded to rounded silty clay fragments. WR: Basalt fragments with phenocrysts of olivine and iron staining. +10F: Non-vesicular basalt fragments with trace silty clay fragments. +35F: Basalt fragments with trace milky quartz and sanidine crystals and 1-2% silty clay fragments.	Tb4	Base of Tb4 noted on density and elemental capture sonde log.
815–825	**PUYE FORMATION:** Volcaniclastic sediments, poorly to moderately sorted, well-graded coarse sands (SW), subangular to subrounded, with minor gravel component, silty clay coating on gravel, grey (5YR 5/1) to reddish gray (5YR 5/2). +10F: 100% porphyritic and aphyric mafic to intermediate volcanics (up to 10 mm). +35F: 65% volcanic lithic fragments, 35% quartz and sanidine crystals with trace tuff/pumice fragments.	Tpf	Puye Formation encountered between 818 and borehole TD of 1054.3 ft bgs. Contact between Tb4 and Tpf identified by noticeable shift at 818 ft bgs on density log and elemental capture spectroscopy log.
825–835	Volcaniclastic sediments, well-graded coarse sands (SW) angular to subrounded, silty coating on clasts, very pale brown (10YR 7/3) to yellow (10YR 7/6). +10F: 75% porphyritic and aphyric intermediate volcanics (up to 7 mm), 25% silty clay fragments with trace pumice. +35F: 80% mafic to intermediate volcanic lithics, 15% quartz and sanidine crystals, 5% silty clay fragments.	Tpf	
835–845	No cuttings returned in this interval.		

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845–865	Volcaniclastic sediments, poorly graded gravel (GP) with sand in silty clay matrix, angular to subrounded, light brown (7.5YR 6/4) to brownish yellow (10YR 6/6), silty clay matrix more prevalent at bottom of interval. +10F: 65% silty clay fragments (up to 10 mm), 35% porphyritic and aphyric mafic to intermediate volcanics (up to 12 mm). +35F: 65% silty clay fragments, 30% intermediate volcanic lithics, 5% milky quartz and sanidine crystals.		Tpf	
865–870	No cuttings returned in this interval.			
870–875	Volcaniclastic sediments, poorly graded gravel (GP) with sand in silty clay matrix, angular to subrounded, light brown (7.5YR 6/4) to brownish yellow (10YR 6/6), silty clay matrix more prevalent at bottom of interval. +10F: 65% silty clay fragments (up to 10 mm), 35% porphyritic and aphyric mafic to intermediate volcanics (up to 12 mm). +35F: 65% silty clay fragments, 30% intermediate volcanic lithics, 5% milky quartz and sanidine crystals.		Tpf	
875–880	No cuttings returned in this interval.			
880–905	Volcaniclastic sediments, well-graded gravel (GW) with minor silty coating, angular to subrounded, bluish gray (6/10B) to bluish black (2.5/5B). +10F: 100% porphyritic to aphyric intermediate volcanics (up to 15 mm). +35F: 100% intermediate volcanic lithics. Trace quartz fragments noted.		Tpf	
905–915	Volcaniclastic sediments, well-graded gravel (GM-GC) with considerable silty clay coating on clasts, subrounded to rounded, light gray (5YR 7/1). Within this interval there is a notable increase in silty coatings on gravels. +10F: 100% porphyritic to aphyric intermediate volcanics (up to 10 mm), silty coating on some clasts. +35F: 100 % intermediate volcanic lithics, some with minor iron staining. Trace quartz crystals noted.		Tpf	Note: Considerable silty clay coating on clasts in this interval and observed during drilling activities.

Borehole Identification (ID): R-51		Technical Area (TA): TA-18		Page: 12 of 13
Drilling Company: Layne Christensen Co.		Start Date/Time: 12/03/09 0905		End Date/Time: 01/14/10 0250
Drilling Method: Air Rotary		MACHINE: Schramm T130XD		Sampling Method: Grab
Ground Elevation: 6761.88 ft amsl				Total Depth: 1054.3 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	Site Geologists: T Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Staires			
Depth (ft bgs)	Lithology		Lithologic Symbol	Notes
915–925	Volcaniclastic sediments, poorly graded gravel (GP) with minor sand component, angular to sub-angular, silty coating on clasts decreasing toward bottom of interval, light gray (5YR 7/1) to gray (5YR 6/1). +10F: 100% porphyritic and aphyric intermediate volcanics (up to 8 mm), partial silty coating on most clasts. +35F: 100% intermediate volcanic lithics. Trace quartz crystals noted.		Tpf	
925–960	Volcaniclastic sediments, poorly graded gravel (GP) with minor sand component, angular to subangular, minor silty coating on clasts, depleting with depth and nearly absent below 935 ft bgs. Light reddish gray (2.5YR 7/1) to greenish black (2.5/10B). +10F: 100% porphyritic and aphyric intermediate volcanics (up to 10 mm). +35F: 100% intermediate volcanic lithics, some with iron staining.		Tpf	
960–970	Volcaniclastic sediments, well-graded sands (SW) with minor gravel component, subangular to subrounded, light reddish gray (2.5YR 7/1) to greenish black (2.5/10B). +10F: 100% porphyritic and aphyric intermediate volcanics (up to 10 mm). +35F: 100% intermediate volcanic lithics, some with iron staining.		Tpf	
970–1010	Volcaniclastic sediments, poorly graded gravel (GP) with minor sand component, subangular to subrounded. Light reddish gray (2.5YR 7/1) to greenish black (2.5/10B). +10F: 100% porphyritic and aphyric intermediate volcanics (up to 10 mm). +35F: 100% intermediate volcanic lithics, some with iron staining.		Tpf	
1010–1020	Volcaniclastic sediments, poorly graded gravel (GP) with minor sand component, subangular to subrounded. Light reddish gray (2.5YR 7/1) to greenish black (2.5/10B). +10F: 90% porphyritic and aphyric intermediate volcanics (up to 10 mm), 10% pumice fragments (up to 3 mm). +35F: 70% intermediate volcanic lithics, 30% pumice fragments.		Tpf	

Borehole Identification (ID): R-51		Technical Area (TA): TA-18		Page: 13of 13
Drilling Company: Layne Christensen Co.		Start Date/Time: 12/03/09 0905		End Date/Time: 01/14/10 0250
Drilling Method: Air Rotary		MACHINE: Schramm T130XD		Sampling Method: Grab
Ground Elevation: 6761.88 ft amsl				Total Depth: 1054.3 ft bgs
Driller: H. Waddell, K. Keller, R. Wall, J. Allen	Site Geologists: T Klepfer, B. Lucero, G. Kinsman, S. Thomas, M. Whitson, D. Staires			
Depth (ft bgs)	**Lithology**		**Lithologic Symbol**	**Notes**
1020–1030	Volcaniclastic sediments, poorly graded gravel (GP) with minor sand component, subangular to subrounded. Light reddish gray (2.5YR 7/1) to greenish black (2.5/10B). +10F: 100% porphyritic and aphyric intermediate volcanics (up to 10 mm). +35F: 100% intermediate volcanic lithics, some with iron staining.		Tpf	
1030–1035	No cuttings returned in this interval.			
1035–1050	Volcaniclastic sediments, poorly graded gravel (GP) with minor sand component, subangular to subrounded. Light reddish gray (2.5YR 7/1) to greenish black (2.5/10B). +10F: 100% porphyritic and aphyric intermediate volcanics (up to 10 mm). +35F: 100% intermediate volcanic lithics, some with iron staining.		Tpf	
1050–1054.3	No cuttings returned in this interval.			

Bottom of borehole at 1054.3 ft bgs

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.

% = estimated per cent by volume of a given sample constituent.

bgs = below ground surface.

Unified Soil Classification Symbols:

GC = clayey gravel.

GM = silty gravel.

GP = poorly graded gravel.

GW = well-graded gravel, fine to coarse.

ML = silt.

SW = well-graded sand, fine to coarse.

Qal = alluvium.

Qbt 1g = Unit 1g of the Tshirege Member of the Bandelier Tuff.

Qct = Cerro Toledo interval.

Qbo = Otowi Member of the Bandelier Tuff.

Qbog = Guaje Pumice Bed.

Tb4 = Cerros del Rio volcanic rocks.

Tpf = Puye Formation.

WR = whole rock (unsieved sample).

+10F = plus No. 10 sieve sample fraction.

+35F = plus No. 35 sieve sample fraction.

+60F = plus No. 60 sieve sample fraction.

1 mm = 0.039 in.

1 in = 25.4 mm.

Appendix B

Groundwater Analytical Results

B-1.0 SAMPLING AND ANALYSIS OF GROUNDWATER AT R-51

The following six groundwater-screening samples were collected during drilling and well development at well R-51:

Borehole Samples

- Two perched-zone groundwater-screening samples were collected during drilling within perched saturation in the Cerro Toledo interval at 161 ft below ground surface (bgs) and within the Cerros del Rio volcanic rocks at 563.4 ft bgs, respectively.
- Two regional aquifer groundwater-screening samples were collected from the open borehole at R-51 in the Puye Formation at 935 and 1054 ft bgs, respectively. A trip blank was also collected at 935 ft bgs.
- Aliquots of the borehole samples and the trip blank were submitted to external analytical laboratories for analyses of volatile organic compounds (VOCs), high-explosive (HE) compounds, and low-level tritium (LH3). The trip blank was submitted to the external laboratory for VOC analysis only. The four samples were also submitted to Los Alamos National Laboratory's (LANL's or the Laboratory's) Earth and Environmental Sciences Group 14 (EES-14) for analyses of metals, cations, and anions, including perchlorate.

Well Development Samples

Seven groundwater-screening samples were collected from well R-51 during well development. Two were collected from the upper screened interval (915.0 to 925.2 ft bgs) and five were collected from the lower screened interval (1031.0 to 1041.0 ft bgs). These samples were analyzed for total organic carbon (TOC). In addition, the final sample from each screen was also analyzed by EES-14 for metals, cations, and anions, including perchlorate.

B-1.1 EES-14 Sample Preparation and Analytical Techniques

Groundwater samples were filtered (0.45-μm membranes) before preservation and chemical analyses. Samples were acidified at the EES-14 wet chemistry laboratory with analytical-grade nitric acid to a potential of hydrogen (pH) of 2.0 or less for metal and major cation analyses.

Groundwater samples were analyzed using techniques specified by the U.S. Environmental Protection Agency (EPA) methods for water analyses. Ion chromatography (EPA Method 300, rev. 2.1) was the analytical method for bromide, chloride, fluoride, nitrate, oxalate, perchlorate, phosphate, and sulfate. Analytical results for perchlorate are pending; however, the instrument detection limit for perchlorate typically varies from 0.002 to 0.005 ppm in borehole water samples (EPA Method 314.0, rev. 1). Inductively coupled (argon) plasma optical emission spectroscopy (EPA Method 200.7, rev. 4.4) was used for analyses of dissolved aluminum, barium, boron, calcium, total chromium, iron, lithium, magnesium, manganese, potassium, silica, sodium, strontium, titanium, and zinc. Dissolved antimony, arsenic, beryllium, cadmium, cesium, chromium, cobalt, copper, lead, lithium, mercury, molybdenum, nickel, rubidium, selenium, silver, thallium, thorium, tin, vanadium, uranium, and zinc were analyzed by inductively coupled (argon) plasma mass spectrometry (EPA Method 200.8, rev. 5.4). The precision limits (analytical error) for major ions and trace elements were generally less than ±7% for both techniques. Total carbonate alkalinity (EPA Method 310.1) was measured using standard titration techniques. Charge-balance errors for total cations and anions were less than ±3% for complete analyses of the above inorganic chemicals in the groundwater samples. The negative cation-anion charge-balance values indicate excess anions for the filtered samples. TOC analyses were performed on groundwater-screening samples collected during development from the upper screen following EPA Method 415.1.

B-1.2 Field Parameters

B-1.2.1 Well Development and Aquifer Testing

Water samples were drawn from a flow-through cell and field parameters were measured using a YSI multimeter. Results of field parameters, consisting of pH, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), specific conductance, and turbidity measured during well development at R-51, are presented in Table B-1.2-1. Concentrations of dissolved oxygen (mg/L) were measured at well R-51.

Because well development and aquifer testing were conducted sequentially at each screened interval, field parameters for both activities are discussed below.

Lower Screen

During sequential well development and aquifer testing of the lower screen, pH varied from 7.7 to 9.8; temperature varied from 15.1°C to 20.6°C; DO varied from 1.1 to 9.9 mg/L; and specific conductance varied from 2 to 348 microsiemens per centimeter (µS/cm). Corrected Eh values decreased from 262.0 mV near the beginning of well development to 122.3 mV near the end of aquifer testing.

Turbidity values for the lower screen fluctuated quite a bit and ranged from 2.0 to 874.0 nephelometric turbidity units (NTU) over the course of development and aquifer testing. Turbidity readings were lowest, between 2.0 and 2.4 NTU, from mid-day to the end of the third day of development and were also relatively low, 2.3 to 2.4 NTU, on the fourth day. But as purge volumes increased on the fifth and final day and on the last two days of aquifer testing, values ranged between 5.6 and 44.3 NTU, with the final recorded value of 19.0 NTU at the end of aquifer testing.

Final field-parameter measurements for the lower screen were as follows: pH was 9.5, temperature was 20.5°C, specific conductance was 134 µS/cm, and turbidity was 19.0 NTU. The final TOC concentration was 0.83 mg/L. Table B-1.2-1 presents field parameters and discharge volumes recorded during development.

Upper Screen

During sequential development and aquifer testing of the upper screen, pH varied from 6.7 to 10.2, temperature varied from 16.4°C to 20.2°C, DO varied from 0.8 to 5.0 mg/L, and specific conductance varied from 123 to 197 µS/cm. Corrected Eh values ranged from a high of 165.3 mV at the beginning of well development and declined to 97.0 mV at the end. The ORP and corrected Eh values measured during well development are much lower than those measured during aquifer testing and may be erroneous. Turbidity ranged from a high of 82.2 NTU at the beginning of development to 1.1 NTU at the end of aquifer testing.

Final field-parameter measurements for the upper screen were as follows: pH was 7.1, temperature was 18.1°C, specific conductance was 169 µS/cm, and turbidity was 1.1 NTU. The final TOC concentration was 0.68 mg/L.

B-1.3 Analytical Results

Analytical results from the off-site laboratories and from LANL EES-14 are presented below. VOC, HE and tritium results are presented in Table B-1.3-1. Anions, cations, metals, and perchlorate data are included in Table B-1.3-2 and TOC data are listed in Table B-1.3-3.

B-1.3.1 Volatile Organic Compounds, High-Explosive Compounds, and Low-Level Tritium

Four groundwater samples collected during drilling (GW51-10-8739, GW51-10-8740, GW51-10-8743, and GW51-10-8744) were analyzed for VOCs, HE and LH3. GW51-10-8745, a trip blank collected from 935 ft bgs, was analyzed only for VOCs. The VOCs acetone; 2-butanone; ethylbenzene; ortho(1,2)-xylene; and combined meta(1,3)xylene and para(1,4)xylene were detected at estimated concentrations of 12.7, 2.88, 0.35, 0.67, and 1.4 μg/L, respectively, in borehole sample GW51-10-8739 collected at a depth of 161 ft bgs. The VOCs toluene, acetone, 1-butanol, and 2-butanone were detected at estimated concentrations of 0.57, 10.6, 43.2, and 15 μg/L, respectively, in borehole sample GW51-10-8740 collected at 563 to 568 ft bgs. VOCs were not detected in samples GW51-10-8743 and GW51-10-8744 or in the trip blank sample GW51-10-8745.

HE compounds were not detected in samples GW51-10-8739, GW51-10-8740, GW51-10-8743, and GW51-10-8744.

Tritium was detected at 12.2 tritium units (39.3 pCi/L) in borehole sample GW51-10-8739 from 161 ft bgs (Table B-1.3-1) but was not detected in sample GW51-10-8740 from 563 to 568 ft bgs. Tritium was reported at 0.37 tritium units (1.19 pCi/L) in the borehole sample GW51-10-8743 from 935 ft bgs (Table B-1.3-1) and was not detected in borehole sample GW51-10-8744 collected at 1054 ft bgs.

B-1.3.2 Cations, Anions, Perchlorate, and Metals

Borehole Samples

Analytical results for four borehole samples collected at well R-51 during drilling and for two groundwater-screening samples collected from each screen at the end of well development are provided in Table B-1.3-2. The filtered-borehole samples (GW51-10-8739, GW51-10-8740, GW51-10-8743, and GW51-10-8744) consist of disaggregated colloidal aquifer material, drilling material, water used during drilling, and native groundwater.

Analytical results for GW51-10-8739 (161 ft bgs), GW51-10-8740 (563 to 568 ft bgs), and GW51-10-8743 (935 ft bgs) do show elevated concentrations of dissolved molybdenum (0.083, 0.004, and 0.010 ppm), suggesting that these samples contain a component of drilling lubricant used during drilling.

Perchlorate was not detected in any of the borehole water samples or from the samples collected at each screen after well development (Table B-1.3-2).

Well Development Samples

Two groundwater-screening samples (WST51-10-10134 and WST51-10-13139) were collected from the upper and lower screens, respectively, at R-51 after well development; selected inorganic analytical results for these samples are discussed below.

Calcium and sodium are the dominant cations in regional aquifer groundwater pumped from well R-51. During well development, dissolved concentrations of calcium were 11.85 and 13.34 ppm in the two samples collected from the upper and lower screens, respectively (Table B-1.3-2). Dissolved concentrations of sodium were 17.27 and 24.21 ppm in the samples collected from the upper and lower screens, respectively. Dissolved concentrations of chloride were 3.48 and 7.22 ppm, respectively, and fluoride concentrations were and 0.29 and 0.24 ppm, respectively, in the two samples collected from the upper and lower screens (Table B.1-3-1). Dissolved concentrations of nitrate and sulfate were 0.31 and 0.29 ppm and 10.0 and 18.5 ppm, respectively, in samples collected from the upper and lower screens (Table B-1.3-2). Dissolved concentrations of chloride and sulfate exceeded Laboratory median background for regional aquifer groundwater (LANL 2007, 095817). Median background concentrations for dissolved chloride and sulfate in the regional aquifer are 2.17 mg/L and 2.83 mg/L, respectively (LANL 2007, 095817).

During well development conducted at R-51, the following dissolved metal concentrations were measured:

- Dissolved concentrations of iron were 0.45 and 0.07 ppm in two groundwater-screening samples collected from the upper and lower screens, respectively (Table B.1-3-2). The upper screen iron concentration exceeded the maximum background value for iron of 0.147 ppm (147 μg/L) for regional aquifer groundwater (LANL 2007, 095817).
- Dissolved concentrations of boron were 0.062 and 0.091 ppm (Table B.1-3-2) at the upper and lower screens of well R-51, respectively, which exceed the maximum background value of 0.0516 ppm (51.6 μg/L) for the regional aquifer (LANL 2007, 095817).
- Dissolved concentrations of nickel were 0.002 ppm in both groundwater-screening samples collected from the upper and lower screens collected during development conducted at well R-51.
- Dissolved concentrations of zinc were 0.048 and 0.094 ppm in groundwater-screening samples collected from the upper and lower screens, respectively, during development at R-51 (Table B.1-3-2). The background maximum concentration of zinc in filtered samples is 0.032 ppm (32 μg/L) for the regional aquifer (LANL 2007, 095817).
- Total dissolved concentrations of chromium were 0.006 and 0.005 ppm (5 and 6 μg/L) in the two groundwater-screening samples collected from the upper and lower screens, respectively, at well R-51 (Table B.1-3-2). Background mean, median, and maximum concentrations of total dissolved chromium are 3.07 μg/L, 3.05 μg/L, and 7.20 μg/L, respectively, for the regional aquifer (LANL 2007, 095817).

B-1.3.3 Total Organic Carbon

Concentrations of TOC decreased from 0.68 to 0.61 mgC/L in two samples (WST51-10-13134 and WST51-10-10139) collected from the upper screen during development conducted at well R-51 screen 1 (Table B-1.3-3). TOC concentrations from the lower-screen samples ranged from 4.34 mgC/L near the beginning of development to 0.83 mgC/L at the end of well development. Both screens met the target TOC value of less than 2.0 mgC/L for successful development.

B-1.4 Summary

In summary, groundwater at well R-51 is relatively oxidizing, based on corrected positive Eh values and measurable concentrations of DO during well development and aquifer testing. Tritium was detected at concentrations of 39.3 pCi/L in a borehole perched-zone water sample collected from the Cerro Toledo interval and at a concentration of 1.19 pCi/L from regional saturation in the Puye Formation. Presence of detectable tritium suggests a modern component of groundwater postdating 1943. Several volatile organic compounds were detected in two borehole water samples (GW51-10-8739 and GW51-10-8740), suggesting presence of drilling fluid during drilling within perched intermediate zones.

B-2.0 REFERENCE

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

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

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

Table B-1.2-1
Purge Volumes and Water-Quality Parameters
for R-51 during Well Development and Aquifer Testing

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP, Eh[a] (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
Well Development – Lower Screen									
02/11/10	0755	n/r[b]	n/r	n/r	n/r	n/r	n/r	0 (Begin Bailing)	0
	1627	n/r	n/r	n/r	n/r	n/r	n/r	113	113
02/12/10	0922	n/r	n/r	n/r	n/r	n/r	n/r	12 (End Bailing)	125
	1553	8.0	17.5	6.3	58.1, 262.0	348	874[c]	270	395
	1642	8.9	17.6	8.1	34.0, 237.9	316	25.7	270	665
02/13/10	0759	8.6	15.1	0.5[c]	−62.5, 141.4	2	100.4	270	935
	0859	8.7	17.7	5.7	4.7, 208.6	105	10.8	270	1205
	0957	8.9	18.0	6.2	8.6, 212.5	85	5.2	270	1475
	1107	9.1	18.1	7.4	9.2, 213.1	86	2.2	270	1745
	1201	9.0	18.2	7.4	11.1, 215.0	88	2.0	270	2015
	1259	9.1	18.4	7.3	13.5, 217.4	83	2.7	270	2285
	1403	9.0	18.4	7.5	14.3, 218.2	82	2.5	270	2555
	1458	9.0	18.6	7.8	13.6, 217.5	82	2.6	270	2825
	1604	9.0	18.3	7.6	14.8, 218.7	70	3.7	270	3095
	1657	8.8	18.1	7.2	15.5, 219.4	57	2.4	270	3365
02/14/10	0754	7.7	17.5	3.4	−6.3, 197.6	176	15.4	280	3645
	0859	9.1	17.9	8.4	−1.5, 202.4	157	6.3	280	3925
	1008	8.9	18.3	9.3	6.2, 210.1	148	2.8	278	4203
	1104	9.0	18.5	9.5	7.5, 211.4	160	2.6	278	4481
	1157	8.9	18.6	9.8	8.9, 212.8	192	2.3	278	4759
	1256	8.9	18.7	9.9	11.0, 214.9	192	2.3	278	5037
	1407	8.9	18.7	9.9	11.6, 215.5	206	2.0	279	5316
	1459	9.0	18.6	9.8	13.5, 217.4	189	2.5	278	5594
	1557	9.1	18.6	9.8	11.5, 215.4	174	2.5	279	5873
	1657	9.0	18.0	9.9	14.1, 218.0	180	2.4	279	6152
02/15/10	0804	9.7	17.8	3.6	−26.7, 177.2	229	12.0	283	6435
	0858	9.1	18.5	6.7	−7.6, 196.3	184	9.5	488	6923
	0958	8.9	18.7	6.7	−4.6, 199.3	179	6.5	488	7411
	1059	9.2	18.9	6.2	−4.0, 199.9	189	5.6	488	7899
	1215	9.1	18.9	4.1	−23.2, 180.7	224	11.8	493	8392
	1318	9.4	18.8	2.9	2.8, 206.7	209	28.8	720	9112

Table B-1.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP, Eh[a] (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
02/15/10 (continued)	1420	9.3	18.7	3.4	10.4, 214.3	174	17.9	720	9832
	1519	9.4	19.2	2.9	10.2, 214.1	196	75.7	967	10,799
	1635	9.4	19.2	2.8	12.6, 216.5	188	47.4	975	11,774
Aquifer Testing – Lower Screen									
02/19/10 (Step Tests)	0821	n/r	n/r	n/r	n/r	n/r	n/r	21	11,795
	1100	n/r	n/r	n/r	n/r	n/r	n/r	2785	14,580
02/21/10 (24-h Pump Test)	0900	n/r	n/r	n/r	n/r	n/r	n/r	0	14,580
	1900	8.6	19.7	1.5	5.8, 209.7	62	44.3	12,747	27,327
	1930	8.7	19.7	1.5	6.1, 210.0	66	40.1	635	27,962
	2000	8.8	19.6	1.5	6.4, 210.3	76	24.2	692	28,654
	2035	8.8	19.6	1.5	6.4, 210.3	76	24.2	573	29,227
	2100	8.6	19.6	1.6	8.6, 212.5	130	21.0	640	29,867
	2130	n/r	n/r	n/r	n/r	n/r	n/r	635	30,502
	2200	8.4	19.5	1.6	8.1, 212.0	136	18.0	730	31,232
	2230	8.9	20.2	3.1	8.3, 212.2	140	15.7	515	31,747
	2330	9.6	20.4	2.9	8.4, 212.3	139	8.3	1307	33,054
02/22/10 (24-h Pump Test)	0030	9.8	20.4	2.9	8.4, 212.3	139	8.0	1244	34,298
	0130	9.7	20.5	2.7	7.4, 211.3	138	13.4	1269	35,567
	0230	9.6	20.6	1.8	7.7, 211.6	139	12.4	1264	36,831
	0330	9.5	20.6	1.5	7.9, 211.8	136	12.5	1267	38,098
	0430	9.7	20.6	1.4	−81.6, 122.3	136	9.0	1266	39,364
	0530	9.7	20.6	1.3	−43.2, 160.7	135	10.4	1266	40,630
	0612	9.5	20.5	1.1	−36.3, 167.6	134	19.0	633	41,263
	0900	n/r	n/r	n/r	n/r	n/r	n/r	3784	45,047
Well Development – Upper Screen									
02/24/10	1400	n/r	n/r	n/r	n/r	n/r	n/r	0 (Begin Bailing)	45,047
	1649	n/r	n/r	n/r	n/r	n/r	n/r	150	45,197
02/25/10	1400	n/r	n/r	n/r	n/r	n/r	n/r	300 (End Bailing)	45,497
02/26/10	1700	n/r	n/r	n/r	n/r	n/r	n/r	1249 (Pumped)	46,746
02/27/10	0920	9.8	18.8	1.4	−38.6, 165.3	194	82.2	318	47,064
	1015	9.4	19.0	1.8	−49.3, 154.6	185	41.1	321	47,385
	1100	9.2	19.2	1.7	−50.9, 153.0	191	29.3	318	47,703
	1200	9.6	19.1	1.8	−54.0, 149.9	155	18.3	240	47,943
	1300	9.3	19.2	1.5	−57.9, 146.0	174	21.2	306	48,249

Table B-1.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP, Eh[a] (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
02/27/10 (continued)	1400	9.5	18.9	1.3	−50.0, 153.9	175	25.0	304	48,553
	1500	9.3	19.0	1.3	−50.0, 153.9	165	15.2	303	48,856
	1600	9.3	18.9	1.1	−49.2, 154.7	168	11.2	303	49,159
	1700	9.2	18.9	1.1	−47.8, 156.1	165	9.7	303	49,462
02/28/10	0730	9.7	16.4	0.9	−179.2, 24.7	140	9.2	158	49,620
	0800	10.2	18.3	1.3	−151.7, 52.2	185	30.8	156	49,776
	0900	9.9	18.4	1.3	−136.8, 67.1	172	41.3	312	50,088
	1000	9.4	18.8	1.3	−134.1, 69.8	166	19.8	313	50,401
	1100	9.2	19.1	1.2	−136.7, 67.2	165	6.5	312	50,713
	1200	9.1	19.2	1.2	−132.6, 71.3	160	4.7	311	51,024
	1300	9.1	19.0	1.0	−134.4, 69.5	157	3.0	311	51,335
	1400	9.2	19.2	0.9	−137.4, 66.5	157	3.7	310	51,645
	1500	9.2	18.6	0.8	−141.7, 62.2	154	4.5	310	51,955
	1600	9.2	18.9	0.9	−138.0, 65.9	153	2.1	307	52,262
	1700	9.1	19.0	0.9	−135.4, 68.5	153	1.9	309	52,571
03/01/10	0900	9.4	19.3	1.6	−115.2, 88.7	165	14.0	309	52,880
	1000	8.9	19.4	n/r	−102.6, 101.3	168	10.7	309	53,189
	1100	9.8	19.4	n/r	−103.1, 100.8	141	5.4	307	53,496
	1200	8.8	19.2	n/r	−104.8, 99.1	123	2.9	307	53,803
	1300	8.7	19.4	n/r	−107.6, 96.3	147	3.7	306	54,109
	1400	8.7	19.3	n/r	−107.0, 96.9	149	2.1	304	54,413
	1500	8.7	19.2	n/r	−109.9, 94.0	145	1.8	304	54,717
	1600	8.7	19.2	n/r	−106.9, 97.0	148	1.7	303	55,020
Aquifer Testing – Upper Screen									
03/05/10 (Step Tests)	0900	n/r	n/r	n/r	n/r	n/r	n/r	0	55,020
	1200	n/r	n/r	n/r	n/r	n/r	n/r	481	55,501
03/07/10 (24-h Pump Test)	0800	n/r	n/r	n/r	n/r	n/r	n/r	0	55,501
	0845	7.3	19.3	5.0	115.5, 319.4	162	8.4	188	55,689
	0945	7.8	17.5	3.9	109.4, 313.3	169	4.8	256	55,945
	1045	7.6	18.1	3.6	124.9, 328.8	181	3.8	256	56,201
	1145	7.5	20.2	3.1	197.3, 401.2	192	2.8	256	56,457
	1245	7.6	20.0	2.6	222.0, 425.9	197	1.7	256	56,713
	1345	7.9	19.2	2.4	213.0, 416.9	192	1.9	256	56,969
	1445	7.5	19.4	2.4	211.4, 415.3	189	1.4	255	57,224

Table B-1.2-1 (continued)

Date	Time	pH	Temp (°C)	DO (mg/L)	ORP, Eh[a] (mV)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Purge Volume between Samples (gal.)	Cumulative Purge Volume (gal.)
	1545	7.5	19.5	1.3	218.6, 422.5	188	1.3	256	57,480
03/07/10 (continued)	1645	7.4	19.5	1.8	222.6, 426.5	182	1.0	256	57,736
	1745	7.4	19.6	1.6	226.6, 430.5	178	1.7	255	57,991
	1845	7.5	19.8	1.5	224.2, 428.1	178	1.6	256	58,247
	1945	7.5	17.8	1.8	170.4, 374.3	178	0.9	256	58,503
	2045	7.3	16.8	1.9	139.4, 343.3	178	1.6	254	58,757
03/07/10 (24-h Pump Test)	2145	7.3	18.4	1.8	151.2, 355.1	174	0.6	256	59,013
	2245	6.9	18.2	1.6	174.2, 378.1	172	0.5	256	59,269
	2345	6.7	18.2	1.8	192.7, 396.6	174	0.3	256	59,525
03/08/10 (24-h Pump Test)	0045	6.8	18.9	1.7	224.1, 428.0	170	0.9	256	59,781
	0145	6.8	18.7	1.7	228.5, 432.4	170	1.3	256	60,037
	0245	6.8	18.0	1.8	226.3, 429.9	171	1.4	256	60,293
	0345	6.8	18.6	1.6	225.4, 429.3	169	1.8	256	60,549
	0445	6.9	18.6	1.7	231.4, 435.3	169	1.3	256	60,805
	0545	7.0	18.4	1.7	230.8, 434.7	170	1.2	256	61,061
	0645	6.8	18.2	1.7	200.0, 403.9	168	1.2	256	61,317
	0745	7.1	18.1	1.7	192.3, 396.2	169	1.1	256	61,573

[a] Eh (mV) is calculated from a Ag/AgCl saturated KCl electrode filling solution at 20ºC by adding a temperature-sensitive correction factor of 203.9 mV.

[b] n/r = Not recorded.

[c] Anomalous reading.

Table B-1.3-1
Off-site Laboratory Analytical Results

Sample Name	Analytical Suite Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
GW51-10-8739	LH3	Tritium	12.2	TU[a]	None
GW51-10-8739	HE	2,4-Diamino-6-nitrotoluene	13	µg/L	UJ[b]
GW51-10-8739	HE	2,6-Diamino-4-nitrotoluene	13	µg/L	UJ
GW51-10-8739	HE	3,5-Dinitroaniline	13	µg/L	UJ
GW51-10-8739	HE	Amino-2,6-dinitrotoluene[4-]	3.25	µg/L	UJ
GW51-10-8739	HE	Amino-4,6-dinitrotoluene[2-]	3.25	µg/L	UJ
GW51-10-8739	HE	Dinitrobenzene[1,3-]	3.25	µg/L	UJ
GW51-10-8739	HE	Dinitrotoluene[2,4-]	3.25	µg/L	UJ
GW51-10-8739	HE	Dinitrotoluene[2,6-]	3.25	µg/L	UJ
GW51-10-8739	HE	HMX[c]	3.25	µg/L	UJ
GW51-10-8739	HE	Nitrobenzene	3.25	µg/L	UJ
GW51-10-8739	HE	Nitrotoluene[2-]	3.25	µg/L	UJ
GW51-10-8739	HE	Nitrotoluene[3-]	3.25	µg/L	UJ
GW51-10-8739	HE	Nitrotoluene[4-]	6.49	µg/L	UJ
GW51-10-8739	HE	PETN[d]	13	µg/L	UJ
GW51-10-8739	HE	RDX[e]	3.25	µg/L	UJ
GW51-10-8739	HE	TATB[f]	13	µg/L	UJ
GW51-10-8739	HE	Tetryl	6.49	µg/L	UJ
GW51-10-8739	HE	Trinitrobenzene[1,3,5-]	3.25	µg/L	UJ
GW51-10-8739	HE	Trinitrotoluene[2,4,6-]	3.25	µg/L	UJ
GW51-10-8739	HE	Tris (o-cresyl) phosphate	13	µg/L	UJ
GW51-10-8739	VOC	Acetone	12.7	µg/L	J[g]
GW51-10-8739	VOC	Acetonitrile	25	µg/L	R[h]
GW51-10-8739	VOC	Acrolein	5	µg/L	R
GW51-10-8739	VOC	Acrylonitrile	5	µg/L	U[i]
GW51-10-8739	VOC	Benzene	1	µg/L	U
GW51-10-8739	VOC	Bromobenzene	1	µg/L	U
GW51-10-8739	VOC	Bromochloromethane	1	µg/L	U
GW51-10-8739	VOC	Bromodichloromethane	1	µg/L	U
GW51-10-8739	VOC	Bromoform	1	µg/L	U
GW51-10-8739	VOC	Bromomethane	1	µg/L	U
GW51-10-8739	VOC	Butanol[1-]	50	µg/L	U
GW51-10-8739	VOC	Butanone[2-]	2.88	µg/L	J
GW51-10-8739	VOC	Butylbenzene[n-]	1	µg/L	U
GW51-10-8739	VOC	Butylbenzene[sec-]	1	µg/L	U
GW51-10-8739	VOC	Butylbenzene[tert-]	1	µg/L	U

Table B-1.3-1 (continued)

Sample Name	Analytical Suite Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
GW51-10-8739	VOC	Carbon Disulfide	5	µg/L	U
GW51-10-8739	VOC	Carbon Tetrachloride	1	µg/L	U
GW51-10-8739	VOC	Chloro-1,3-butadiene[2-]	1	µg/L	U
GW51-10-8739	VOC	Chloro-1-propene[3-]	5	µg/L	U
GW51-10-8739	VOC	Chlorobenzene	1	µg/L	U
GW51-10-8739	VOC	Chlorodibromomethane	1	µg/L	U
GW51-10-8739	VOC	Chloroethane	1	µg/L	U
GW51-10-8739	VOC	Chloroform	1	µg/L	U
GW51-10-8739	VOC	Chloromethane	1	µg/L	UJ
GW51-10-8739	VOC	Chlorotoluene[2-]	1	µg/L	U
GW51-10-8739	VOC	Chlorotoluene[4-]	1	µg/L	U
GW51-10-8739	VOC	Dibromo-3-Chloropropane[1,2-]	1	µg/L	U
GW51-10-8739	VOC	Dibromoethane[1,2-]	1	µg/L	U
GW51-10-8739	VOC	Dibromomethane	1	µg/L	U
GW51-10-8739	VOC	Dichlorobenzene[1,2-]	1	µg/L	U
GW51-10-8739	VOC	Dichlorobenzene[1,3-]	1	µg/L	U
GW51-10-8739	VOC	Dichlorobenzene[1,4-]	1	µg/L	U
GW51-10-8739	VOC	Dichlorodifluoromethane	1	µg/L	UJ
GW51-10-8739	VOC	Dichloroethane[1,1-]	1	µg/L	U
GW51-10-8739	VOC	Dichloroethane[1,2-]	1	µg/L	U
GW51-10-8739	VOC	Dichloroethene[1,1-]	1	µg/L	U
GW51-10-8739	VOC	Dichloroethene[cis-1,2-]	1	µg/L	U
GW51-10-8739	VOC	Dichloroethene[trans-1,2-]	1	µg/L	U
GW51-10-8739	VOC	Dichloropropane[1,2-]	1	µg/L	U
GW51-10-8739	VOC	Dichloropropane[1,3-]	1	µg/L	U
GW51-10-8739	VOC	Dichloropropane[2,2-]	1	µg/L	U
GW51-10-8739	VOC	Dichloropropene[1,1-]	1	µg/L	U
GW51-10-8739	VOC	Dichloropropene[cis-1,3-]	1	µg/L	U
GW51-10-8739	VOC	Dichloropropene[trans-1,3-]	1	µg/L	U
GW51-10-8739	VOC	Diethyl Ether	1	µg/L	U
GW51-10-8739	VOC	Ethyl Methacrylate	5	µg/L	U
GW51-10-8739	VOC	Ethylbenzene	0.35	µg/L	J
GW51-10-8739	VOC	Hexachlorobutadiene	1	µg/L	U
GW51-10-8739	VOC	Hexanone[2-]	5	µg/L	U
GW51-10-8739	VOC	Iodomethane	5	µg/L	U
GW51-10-8739	VOC	Isobutyl alcohol	50	µg/L	R

Table B-1.3-1 (continued)

Sample Name	Analytical Suite Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
GW51-10-8739	VOC	Isopropylbenzene	1	µg/L	U
GW51-10-8739	VOC	Isopropyltoluene[4-]	1	µg/L	U
GW51-10-8739	VOC	Methacrylonitrile	5	µg/L	U
GW51-10-8739	VOC	Methyl Methacrylate	5	µg/L	U
GW51-10-8739	VOC	Methyl tert-Butyl Ether	1	µg/L	U
GW51-10-8739	VOC	Methyl-2-pentanone[4-]	5	µg/L	U
GW51-10-8739	VOC	Methylene Chloride	10	µg/L	U
GW51-10-8739	VOC	Naphthalene	1	µg/L	U
GW51-10-8739	VOC	Propionitrile	5	µg/L	R
GW51-10-8739	VOC	Propylbenzene[1-]	1	µg/L	U
GW51-10-8739	VOC	Styrene	1	µg/L	U
GW51-10-8739	VOC	Tetrachloroethane[1,1,1,2-]	1	µg/L	U
GW51-10-8739	VOC	Tetrachloroethane[1,1,2,2-]	1	µg/L	U
GW51-10-8739	VOC	Tetrachloroethene	1	µg/L	U
GW51-10-8739	VOC	Toluene	1	µg/L	U
GW51-10-8739	VOC	Trichloro-1,2,2-trifluoroethane[1,1,2-]	5	µg/L	UJ
GW51-10-8739	VOC	Trichlorobenzene[1,2,3-]	1	µg/L	U
GW51-10-8739	VOC	Trichlorobenzene[1,2,4-]	1	µg/L	U
GW51-10-8739	VOC	Trichloroethane[1,1,1-]	1	µg/L	U
GW51-10-8739	VOC	Trichloroethane[1,1,2-]	1	µg/L	U
GW51-10-8739	VOC	Trichloroethene	1	µg/L	U
GW51-10-8739	VOC	Trichlorofluoromethane	1	µg/L	U
GW51-10-8739	VOC	Trichloropropane[1,2,3-]	1	µg/L	U
GW51-10-8739	VOC	Trimethylbenzene[1,2,4-]	1	µg/L	U
GW51-10-8739	VOC	Trimethylbenzene[1,3,5-]	1	µg/L	U
GW51-10-8739	VOC	Vinyl acetate	5	µg/L	U
GW51-10-8739	VOC	Vinyl Chloride	1	µg/L	U
GW51-10-8739	VOC	Xylene[1,2-]	0.67	µg/L	J
GW51-10-8739	VOC	Xylene[1,3-]+Xylene[1,4-]	1.4	µg/L	J
GW51-10-8740	LH3	Tritium	0.04	TU	U
GW51-10-8740	HE	2,4-Diamino-6-nitrotoluene	13	µg/L	U
GW51-10-8740	HE	2,6-Diamino-4-nitrotoluene	13	µg/L	U
GW51-10-8740	HE	3,5-Dinitroaniline	13	µg/L	U
GW51-10-8740	HE	Amino-2,6-dinitrotoluene[4-]	3.25	µg/L	U
GW51-10-8740	HE	Amino-4,6-dinitrotoluene[2-]	3.25	µg/L	U
GW51-10-8740	HE	Dinitrobenzene[1,3-]	3.25	µg/L	U

Table B-1.3-1 (continued)

Sample Name	Analytical Suite Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
GW51-10-8740	HE	Dinitrotoluene[2,4-]	3.25	µg/L	U
GW51-10-8740	HE	Dinitrotoluene[2,6-]	3.25	µg/L	U
GW51-10-8740	HE	HMX	3.25	µg/L	U
GW51-10-8740	HE	Nitrobenzene	3.25	µg/L	U
GW51-10-8740	HE	Nitrotoluene[2-]	3.25	µg/L	U
GW51-10-8740	HE	Nitrotoluene[3-]	3.25	µg/L	U
GW51-10-8740	HE	Nitrotoluene[4-]	6.49	µg/L	U
GW51-10-8740	HE	PETN	13	µg/L	U
GW51-10-8740	HE	RDX	3.25	µg/L	U
GW51-10-8740	HE	TATB	13	µg/L	U
GW51-10-8740	HE	Tetryl	6.49	µg/L	U
GW51-10-8740	HE	Trinitrobenzene[1,3,5-]	3.25	µg/L	U
GW51-10-8740	HE	Trinitrotoluene[2,4,6-]	3.25	µg/L	U
GW51-10-8740	HE	Tris (o-cresyl) phosphate	13	µg/L	U
GW51-10-8740	VOC	Acetone	10.6	µg/L	J-[j]
GW51-10-8740	VOC	Acetonitrile	25	µg/L	R
GW51-10-8740	VOC	Acrolein	5	µg/L	UJ
GW51-10-8740	VOC	Acrylonitrile	5	µg/L	UJ
GW51-10-8740	VOC	Benzene	1	µg/L	UJ
GW51-10-8740	VOC	Bromobenzene	1	µg/L	UJ
GW51-10-8740	VOC	Bromochloromethane	1	µg/L	UJ
GW51-10-8740	VOC	Bromodichloromethane	1	µg/L	UJ
GW51-10-8740	VOC	Bromoform	1	µg/L	UJ
GW51-10-8740	VOC	Bromomethane	1	µg/L	UJ
GW51-10-8740	VOC	Butanol[1-]	43.2	µg/L	J-
GW51-10-8740	VOC	Butanone[2-]	15	µg/L	J-
GW51-10-8740	VOC	Butylbenzene[n-]	1	µg/L	UJ
GW51-10-8740	VOC	Butylbenzene[sec-]	1	µg/L	UJ
GW51-10-8740	VOC	Butylbenzene[tert-]	1	µg/L	UJ
GW51-10-8740	VOC	Carbon Disulfide	5	µg/L	UJ
GW51-10-8740	VOC	Carbon Tetrachloride	1	µg/L	UJ
GW51-10-8740	VOC	Chloro-1,3-butadiene[2-]	1	µg/L	UJ
GW51-10-8740	VOC	Chloro-1-propene[3-]	5	µg/L	UJ
GW51-10-8740	VOC	Chlorobenzene	1	µg/L	UJ
GW51-10-8740	VOC	Chlorodibromomethane	1	µg/L	UJ
GW51-10-8740	VOC	Chloroethane	1	µg/L	UJ

Table B-1.3-1 (continued)

Sample Name	Analytical Suite Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
GW51-10-8740	VOC	Chloroform	1	µg/L	UJ
GW51-10-8740	VOC	Chloromethane	1	µg/L	UJ
GW51-10-8740	VOC	Chlorotoluene[2-]	1	µg/L	UJ
GW51-10-8740	VOC	Chlorotoluene[4-]	1	µg/L	UJ
GW51-10-8740	VOC	Dibromo-3-Chloropropane[1,2-]	1	µg/L	UJ
GW51-10-8740	VOC	Dibromoethane[1,2-]	1	µg/L	UJ
GW51-10-8740	VOC	Dibromomethane	1	µg/L	UJ
GW51-10-8740	VOC	Dichlorobenzene[1,2-]	1	µg/L	UJ
GW51-10-8740	VOC	Dichlorobenzene[1,3-]	1	µg/L	UJ
GW51-10-8740	VOC	Dichlorobenzene[1,4-]	1	µg/L	UJ
GW51-10-8740	VOC	Dichlorodifluoromethane	1	µg/L	UJ
GW51-10-8740	VOC	Dichloroethane[1,1-]	1	µg/L	UJ
GW51-10-8740	VOC	Dichloroethane[1,2-]	1	µg/L	UJ
GW51-10-8740	VOC	Dichloroethene[1,1-]	1	µg/L	UJ
GW51-10-8740	VOC	Dichloroethene[cis-1,2-]	1	µg/L	UJ
GW51-10-8740	VOC	Dichloroethene[trans-1,2-]	1	µg/L	UJ
GW51-10-8740	VOC	Dichloropropane[1,2-]	1	µg/L	UJ
GW51-10-8740	VOC	Dichloropropane[1,3-]	1	µg/L	UJ
GW51-10-8740	VOC	Dichloropropane[2,2-]	1	µg/L	UJ
GW51-10-8740	VOC	Dichloropropene[1,1-]	1	µg/L	UJ
GW51-10-8740	VOC	Dichloropropene[cis-1,3-]	1	µg/L	UJ
GW51-10-8740	VOC	Dichloropropene[trans-1,3-]	1	µg/L	UJ
GW51-10-8740	VOC	Diethyl Ether	1	µg/L	UJ
GW51-10-8740	VOC	Ethyl Methacrylate	5	µg/L	UJ
GW51-10-8740	VOC	Ethylbenzene	1	µg/L	UJ
GW51-10-8740	VOC	Hexachlorobutadiene	1	µg/L	UJ
GW51-10-8740	VOC	Hexanone[2-]	5	µg/L	UJ
GW51-10-8740	VOC	Iodomethane	5	µg/L	UJ
GW51-10-8740	VOC	Isobutyl alcohol	50	µg/L	R
GW51-10-8740	VOC	Isopropylbenzene	1	µg/L	UJ
GW51-10-8740	VOC	Isopropyltoluene[4-]	1	µg/L	UJ
GW51-10-8740	VOC	Methacrylonitrile	5	µg/L	UJ
GW51-10-8740	VOC	Methyl Methacrylate	5	µg/L	UJ
GW51-10-8740	VOC	Methyl tert-Butyl Ether	1	µg/L	UJ
GW51-10-8740	VOC	Methyl-2-pentanone[4-]	5	µg/L	UJ
GW51-10-8740	VOC	Methylene Chloride	10	µg/L	UJ

Table B-1.3-1 (continued)

Sample Name	Analytical Suite Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
GW51-10-8740	VOC	Naphthalene	1	µg/L	UJ
GW51-10-8740	VOC	Propionitrile	5	µg/L	R
GW51-10-8740	VOC	Propylbenzene[1-]	1	µg/L	UJ
GW51-10-8740	VOC	Styrene	1	µg/L	UJ
GW51-10-8740	VOC	Tetrachloroethane[1,1,1,2-]	1	µg/L	UJ
GW51-10-8740	VOC	Tetrachloroethane[1,1,2,2-]	1	µg/L	UJ
GW51-10-8740	VOC	Tetrachloroethene	1	µg/L	UJ
GW51-10-8740	VOC	Toluene	0.567	µg/L	J-
GW51-10-8740	VOC	Trichloro-1,2,2-trifluoroethane[1,1,2-]	5	µg/L	UJ
GW51-10-8740	VOC	Trichlorobenzene[1,2,3-]	1	µg/L	UJ
GW51-10-8740	VOC	Trichlorobenzene[1,2,4-]	1	µg/L	UJ
GW51-10-8740	VOC	Trichloroethane[1,1,1-]	1	µg/L	UJ
GW51-10-8740	VOC	Trichloroethane[1,1,2-]	1	µg/L	UJ
GW51-10-8740	VOC	Trichloroethene	1	µg/L	UJ
GW51-10-8740	VOC	Trichlorofluoromethane	1	µg/L	UJ
GW51-10-8740	VOC	Trichloropropane[1,2,3-]	1	µg/L	UJ
GW51-10-8740	VOC	Trimethylbenzene[1,2,4-]	1	µg/L	UJ
GW51-10-8740	VOC	Trimethylbenzene[1,3,5-]	1	µg/L	UJ
GW51-10-8740	VOC	Vinyl acetate	5	µg/L	UJ
GW51-10-8740	VOC	Vinyl Chloride	1	µg/L	UJ
GW51-10-8740	VOC	Xylene[1,2-]	1	µg/L	UJ
GW51-10-8740	VOC	Xylene[1,3-]+Xylene[1,4-]	2	µg/L	UJ
GW51-10-8743	LH3	Tritium	0.37	TU	None
GW51-10-8743	HE	2,4-Diamino-6-nitrotoluene	13	µg/L	U
GW51-10-8743	HE	2,6-Diamino-4-nitrotoluene	13	µg/L	U
GW51-10-8743	HE	3,5-Dinitroaniline	13	µg/L	U
GW51-10-8743	HE	Amino-2,6-dinitrotoluene[4-]	3.25	µg/L	U
GW51-10-8743	HE	Amino-4,6-dinitrotoluene[2-]	3.25	µg/L	U
GW51-10-8743	HE	Dinitrobenzene[1,3-]	3.25	µg/L	U
GW51-10-8743	HE	Dinitrotoluene[2,4-]	3.25	µg/L	U
GW51-10-8743	HE	Dinitrotoluene[2,6-]	3.25	µg/L	U
GW51-10-8743	HE	HMX	3.25	µg/L	U
GW51-10-8743	HE	Nitrobenzene	3.25	µg/L	U
GW51-10-8743	HE	Nitrotoluene[2-]	3.25	µg/L	U
GW51-10-8743	HE	Nitrotoluene[3-]	3.25	µg/L	U
GW51-10-8743	HE	Nitrotoluene[4-]	6.49	µg/L	U

Table B-1.3-1 (continued)

Sample Name	Analytical Suite Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
GW51-10-8743	HE	PETN	13	µg/L	U
GW51-10-8743	HE	RDX	3.25	µg/L	U
GW51-10-8743	HE	TATB	13	µg/L	U
GW51-10-8743	HE	Tetryl	6.49	µg/L	U
GW51-10-8743	HE	Trinitrobenzene[1,3,5-]	3.25	µg/L	U
GW51-10-8743	HE	Trinitrotoluene[2,4,6-]	3.25	µg/L	U
GW51-10-8743	HE	Tris (o-cresyl) phosphate	13	µg/L	U
GW51-10-8743	VOC	Acetone	10	µg/L	UJ
GW51-10-8743	VOC	Acetonitrile	25	µg/L	R
GW51-10-8743	VOC	Acrolein	5	µg/L	R
GW51-10-8743	VOC	Acrylonitrile	5	µg/L	U
GW51-10-8743	VOC	Benzene	1	µg/L	U
GW51-10-8743	VOC	Bromobenzene	1	µg/L	U
GW51-10-8743	VOC	Bromochloromethane	1	µg/L	U
GW51-10-8743	VOC	Bromodichloromethane	1	µg/L	U
GW51-10-8743	VOC	Bromoform	1	µg/L	U
GW51-10-8743	VOC	Bromomethane	1	µg/L	U
GW51-10-8743	VOC	Butanol[1-]	50	µg/L	U
GW51-10-8743	VOC	Butanone[2-]	5	µg/L	U
GW51-10-8743	VOC	Butylbenzene[n-]	1	µg/L	U
GW51-10-8743	VOC	Butylbenzene[sec-]	1	µg/L	U
GW51-10-8743	VOC	Butylbenzene[tert-]	1	µg/L	U
GW51-10-8743	VOC	Carbon Disulfide	5	µg/L	U
GW51-10-8743	VOC	Carbon Tetrachloride	1	µg/L	U
GW51-10-8743	VOC	Chloro-1,3-butadiene[2-]	1	µg/L	U
GW51-10-8743	VOC	Chloro-1-propene[3-]	5	µg/L	U
GW51-10-8743	VOC	Chlorobenzene	1	µg/L	U
GW51-10-8743	VOC	Chlorodibromomethane	1	µg/L	U
GW51-10-8743	VOC	Chloroethane	1	µg/L	U
GW51-10-8743	VOC	Chloroform	1	µg/L	U
GW51-10-8743	VOC	Chloromethane	1	µg/L	UJ
GW51-10-8743	VOC	Chlorotoluene[2-]	1	µg/L	U
GW51-10-8743	VOC	Chlorotoluene[4-]	1	µg/L	U
GW51-10-8743	VOC	Dibromo-3-Chloropropane[1,2-]	1	µg/L	U
GW51-10-8743	VOC	Dibromoethane[1,2-]	1	µg/L	U
GW51-10-8743	VOC	Dibromomethane	1	µg/L	U

Table B-1.3-1 (continued)

Sample Name	Analytical Suite Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
GW51-10-8743	VOC	Dichlorobenzene[1,2-]	1	µg/L	U
GW51-10-8743	VOC	Dichlorobenzene[1,3-]	1	µg/L	U
GW51-10-8743	VOC	Dichlorobenzene[1,4-]	1	µg/L	U
GW51-10-8743	VOC	Dichlorodifluoromethane	1	µg/L	UJ
GW51-10-8743	VOC	Dichloroethane[1,1-]	1	µg/L	U
GW51-10-8743	VOC	Dichloroethane[1,2-]	1	µg/L	U
GW51-10-8743	VOC	Dichloroethene[1,1-]	1	µg/L	U
GW51-10-8743	VOC	Dichloroethene[cis-1,2-]	1	µg/L	U
GW51-10-8743	VOC	Dichloroethene[trans-1,2-]	1	µg/L	U
GW51-10-8743	VOC	Dichloropropane[1,2-]	1	µg/L	U
GW51-10-8743	VOC	Dichloropropane[1,3-]	1	µg/L	U
GW51-10-8743	VOC	Dichloropropane[2,2-]	1	µg/L	U
GW51-10-8743	VOC	Dichloropropene[1,1-]	1	µg/L	U
GW51-10-8743	VOC	Dichloropropene[cis-1,3-]	1	µg/L	U
GW51-10-8743	VOC	Dichloropropene[trans-1,3-]	1	µg/L	U
GW51-10-8743	VOC	Diethyl Ether	1	µg/L	U
GW51-10-8743	VOC	Ethyl Methacrylate	5	µg/L	U
GW51-10-8743	VOC	Ethylbenzene	1	µg/L	U
GW51-10-8743	VOC	Hexachlorobutadiene	1	µg/L	U
GW51-10-8743	VOC	Hexanone[2-]	5	µg/L	U
GW51-10-8743	VOC	Iodomethane	5	µg/L	U
GW51-10-8743	VOC	Isobutyl alcohol	50	µg/L	R
GW51-10-8743	VOC	Isopropylbenzene	1	µg/L	U
GW51-10-8743	VOC	Isopropyltoluene[4-]	1	µg/L	U
GW51-10-8743	VOC	Methacrylonitrile	5	µg/L	U
GW51-10-8743	VOC	Methyl Methacrylate	5	µg/L	U
GW51-10-8743	VOC	Methyl tert-Butyl Ether	1	µg/L	U
GW51-10-8743	VOC	Methyl-2-pentanone[4-]	5	µg/L	U
GW51-10-8743	VOC	Methylene Chloride	10	µg/L	U
GW51-10-8743	VOC	Naphthalene	1	µg/L	U
GW51-10-8743	VOC	Propionitrile	5	µg/L	R
GW51-10-8743	VOC	Propylbenzene[1-]	1	µg/L	U
GW51-10-8743	VOC	Styrene	1	µg/L	UJ
GW51-10-8743	VOC	Tetrachloroethane[1,1,1,2-]	1	µg/L	U
GW51-10-8743	VOC	Tetrachloroethane[1,1,2,2-]	1	µg/L	U
GW51-10-8743	VOC	Tetrachloroethene	1	µg/L	U

Table B-1.3-1 (continued)

Sample Name	Analytical Suite Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
GW51-10-8743	VOC	Toluene	1	µg/L	U
GW51-10-8743	VOC	Trichloro-1,2,2-trifluoroethane[1,1,2-]	5	µg/L	R
GW51-10-8743	VOC	Trichlorobenzene[1,2,3-]	1	µg/L	U
GW51-10-8743	VOC	Trichlorobenzene[1,2,4-]	1	µg/L	U
GW51-10-8743	VOC	Trichloroethane[1,1,1-]	1	µg/L	U
GW51-10-8743	VOC	Trichloroethane[1,1,2-]	1	µg/L	U
GW51-10-8743	VOC	Trichloroethene	1	µg/L	U
GW51-10-8743	VOC	Trichlorofluoromethane	1	µg/L	U
GW51-10-8743	VOC	Trichloropropane[1,2,3-]	1	µg/L	U
GW51-10-8743	VOC	Trimethylbenzene[1,2,4-]	1	µg/L	U
GW51-10-8743	VOC	Trimethylbenzene[1,3,5-]	1	µg/L	U
GW51-10-8743	VOC	Vinyl acetate	5	µg/L	U
GW51-10-8743	VOC	Vinyl Chloride	1	µg/L	U
GW51-10-8743	VOC	Xylene[1,2-]	1	µg/L	U
GW51-10-8743	VOC	Xylene[1,3-]+Xylene[1,4-]	2	µg/L	U
GW51-10-8744	LH3	Tritium	0.03	TU	U
GW51-10-8744	HE	2,4-Diamino-6-nitrotoluene	1.3	µg/L	U
GW51-10-8744	HE	2,6-Diamino-4-nitrotoluene	1.3	µg/L	U
GW51-10-8744	HE	3,5-Dinitroaniline	1.3	µg/L	U
GW51-10-8744	HE	Amino-2,6-dinitrotoluene[4-]	0.325	µg/L	U
GW51-10-8744	HE	Amino-4,6-dinitrotoluene[2-]	0.325	µg/L	U
GW51-10-8744	HE	Dinitrobenzene[1,3-]	0.325	µg/L	U
GW51-10-8744	HE	Dinitrotoluene[2,4-]	0.325	µg/L	U
GW51-10-8744	HE	Dinitrotoluene[2,6-]	0.325	µg/L	U
GW51-10-8744	HE	HMX	0.325	µg/L	U
GW51-10-8744	HE	Nitrobenzene	0.325	µg/L	U
GW51-10-8744	HE	Nitrotoluene[2-]	0.325	µg/L	U
GW51-10-8744	HE	Nitrotoluene[3-]	0.325	µg/L	U
GW51-10-8744	HE	Nitrotoluene[4-]	0.649	µg/L	U
GW51-10-8744	HE	PETN	1.3	µg/L	U
GW51-10-8744	HE	RDX	0.325	µg/L	U
GW51-10-8744	HE	TATB	1.3	µg/L	U
GW51-10-8744	HE	Tetryl	0.649	µg/L	U
GW51-10-8744	HE	Trinitrobenzene[1,3,5-]	0.325	µg/L	U
GW51-10-8744	HE	Trinitrotoluene[2,4,6-]	0.325	µg/L	U
GW51-10-8744	HE	Tris (o-cresyl) phosphate	1.3	µg/L	U

Table B-1.3-1 (continued)

Sample Name	Analytical Suite Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
GW51-10-8744	VOC	Acetone	10	µg/L	UJ
GW51-10-8744	VOC	Acetonitrile	25	µg/L	U
GW51-10-8744	VOC	Acrolein	5	µg/L	U
GW51-10-8744	VOC	Acrylonitrile	5	µg/L	UJ
GW51-10-8744	VOC	Benzene	1	µg/L	U
GW51-10-8744	VOC	Bromobenzene	1	µg/L	U
GW51-10-8744	VOC	Bromochloromethane	1	µg/L	U
GW51-10-8744	VOC	Bromodichloromethane	1	µg/L	U
GW51-10-8744	VOC	Bromoform	1	µg/L	U
GW51-10-8744	VOC	Bromomethane	1	µg/L	U
GW51-10-8744	VOC	Butanol[1-]	50	µg/L	R
GW51-10-8744	VOC	Butanone[2-]	5	µg/L	UJ
GW51-10-8744	VOC	Butylbenzene[n-]	1	µg/L	U
GW51-10-8744	VOC	Butylbenzene[sec-]	1	µg/L	U
GW51-10-8744	VOC	Butylbenzene[tert-]	1	µg/L	U
GW51-10-8744	VOC	Carbon Disulfide	5	µg/L	U
GW51-10-8744	VOC	Carbon Tetrachloride	1	µg/L	U
GW51-10-8744	VOC	Chloro-1,3-butadiene[2-]	1	µg/L	UJ
GW51-10-8744	VOC	Chloro-1-propene[3-]	5	µg/L	UJ
GW51-10-8744	VOC	Chlorobenzene	1	µg/L	U
GW51-10-8744	VOC	Chlorodibromomethane	1	µg/L	U
GW51-10-8744	VOC	Chloroethane	1	µg/L	U
GW51-10-8744	VOC	Chloroform	1	µg/L	U
GW51-10-8744	VOC	Chloromethane	1	µg/L	U
GW51-10-8744	VOC	Chlorotoluene[2-]	1	µg/L	U
GW51-10-8744	VOC	Chlorotoluene[4-]	1	µg/L	U
GW51-10-8744	VOC	Dibromo-3-Chloropropane[1,2-]	1	µg/L	U
GW51-10-8744	VOC	Dibromoethane[1,2-]	1	µg/L	U
GW51-10-8744	VOC	Dibromomethane	1	µg/L	U
GW51-10-8744	VOC	Dichlorobenzene[1,2-]	1	µg/L	U
GW51-10-8744	VOC	Dichlorobenzene[1,3-]	1	µg/L	U
GW51-10-8744	VOC	Dichlorobenzene[1,4-]	1	µg/L	U
GW51-10-8744	VOC	Dichlorodifluoromethane	1	µg/L	UJ
GW51-10-8744	VOC	Dichloroethane[1,1-]	1	µg/L	U
GW51-10-8744	VOC	Dichloroethane[1,2-]	1	µg/L	U
GW51-10-8744	VOC	Dichloroethene[1,1-]	1	µg/L	U

Table B-1.3-1 (continued)

Sample Name	Analytical Suite Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
GW51-10-8744	VOC	Dichloroethene[cis-1,2-]	1	µg/L	U
GW51-10-8744	VOC	Dichloroethene[trans-1,2-]	1	µg/L	U
GW51-10-8744	VOC	Dichloropropane[1,2-]	1	µg/L	U
GW51-10-8744	VOC	Dichloropropane[1,3-]	1	µg/L	U
GW51-10-8744	VOC	Dichloropropane[2,2-]	1	µg/L	U
GW51-10-8744	VOC	Dichloropropene[1,1-]	1	µg/L	U
GW51-10-8744	VOC	Dichloropropene[cis-1,3-]	1	µg/L	U
GW51-10-8744	VOC	Dichloropropene[trans-1,3-]	1	µg/L	U
GW51-10-8744	VOC	Diethyl Ether	1	µg/L	U
GW51-10-8744	VOC	Ethyl Methacrylate	5	µg/L	UJ
GW51-10-8744	VOC	Ethylbenzene	1	µg/L	U
GW51-10-8744	VOC	Hexachlorobutadiene	1	µg/L	U
GW51-10-8744	VOC	Hexanone[2-]	5	µg/L	UJ
GW51-10-8744	VOC	Iodomethane	5	µg/L	U
GW51-10-8744	VOC	Isobutyl alcohol	50	µg/L	R
GW51-10-8744	VOC	Isopropylbenzene	1	µg/L	U
GW51-10-8744	VOC	Isopropyltoluene[4-]	1	µg/L	U
GW51-10-8744	VOC	Methacrylonitrile	5	µg/L	UJ
GW51-10-8744	VOC	Methyl Methacrylate	5	µg/L	UJ
GW51-10-8744	VOC	Methyl tert-Butyl Ether	1	µg/L	U
GW51-10-8744	VOC	Methyl-2-pentanone[4-]	5	µg/L	U
GW51-10-8744	VOC	Methylene Chloride	10	µg/L	U
GW51-10-8744	VOC	Naphthalene	1	µg/L	U
GW51-10-8744	VOC	Propionitrile	5	µg/L	UJ
GW51-10-8744	VOC	Propylbenzene[1-]	1	µg/L	U
GW51-10-8744	VOC	Styrene	1	µg/L	U
GW51-10-8744	VOC	Tetrachloroethane[1,1,1,2-]	1	µg/L	U
GW51-10-8744	VOC	Tetrachloroethane[1,1,2,2-]	1	µg/L	U
GW51-10-8744	VOC	Tetrachloroethene	1	µg/L	U
GW51-10-8744	VOC	Toluene	1	µg/L	U
GW51-10-8744	VOC	Trichloro-1,2,2-trifluoroethane[1,1,2-]	5	µg/L	UJ
GW51-10-8744	VOC	Trichlorobenzene[1,2,3-]	1	µg/L	U
GW51-10-8744	VOC	Trichlorobenzene[1,2,4-]	1	µg/L	U
GW51-10-8744	VOC	Trichloroethane[1,1,1-]	1	µg/L	U
GW51-10-8744	VOC	Trichloroethane[1,1,2-]	1	µg/L	U
GW51-10-8744	VOC	Trichloroethene	1	µg/L	U

Table B-1.3-1 (continued)

Sample Name	Analytical Suite Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
GW51-10-8744	VOC	Trichlorofluoromethane	1	µg/L	U
GW51-10-8744	VOC	Trichloropropane[1,2,3-]	1	µg/L	U
GW51-10-8744	VOC	Trimethylbenzene[1,2,4-]	1	µg/L	U
GW51-10-8744	VOC	Trimethylbenzene[1,3,5-]	1	µg/L	U
GW51-10-8744	VOC	Vinyl acetate	5	µg/L	U
GW51-10-8744	VOC	Vinyl Chloride	1	µg/L	U
GW51-10-8744	VOC	Xylene[1,2-]	1	µg/L	U
GW51-10-8744	VOC	Xylene[1,3-]+Xylene[1,4-]	2	µg/L	U
GW51-10-8745	VOC	Acetone	10	µg/L	UJ
GW51-10-8745	VOC	Acetonitrile	25	µg/L	R
GW51-10-8745	VOC	Acrolein	5	µg/L	R
GW51-10-8745	VOC	Acrylonitrile	5	µg/L	U
GW51-10-8745	VOC	Benzene	1	µg/L	U
GW51-10-8745	VOC	Bromobenzene	1	µg/L	U
GW51-10-8745	VOC	Bromochloromethane	1	µg/L	U
GW51-10-8745	VOC	Bromodichloromethane	1	µg/L	U
GW51-10-8745	VOC	Bromoform	1	µg/L	U
GW51-10-8745	VOC	Bromomethane	1	µg/L	U
GW51-10-8745	VOC	Butanol[1-]	50	µg/L	U
GW51-10-8745	VOC	Butanone[2-]	5	µg/L	U
GW51-10-8745	VOC	Butylbenzene[n-]	1	µg/L	U
GW51-10-8745	VOC	Butylbenzene[sec-]	1	µg/L	U
GW51-10-8745	VOC	Butylbenzene[tert-]	1	µg/L	U
GW51-10-8745	VOC	Carbon Disulfide	5	µg/L	U
GW51-10-8745	VOC	Carbon Tetrachloride	1	µg/L	U
GW51-10-8745	VOC	Chloro-1,3-butadiene[2-]	1	µg/L	U
GW51-10-8745	VOC	Chloro-1-propene[3-]	5	µg/L	U
GW51-10-8745	VOC	Chlorobenzene	1	µg/L	U
GW51-10-8745	VOC	Chlorodibromomethane	1	µg/L	U
GW51-10-8745	VOC	Chloroethane	1	µg/L	U
GW51-10-8745	VOC	Chloroform	1	µg/L	U
GW51-10-8745	VOC	Chloromethane	1	µg/L	UJ
GW51-10-8745	VOC	Chlorotoluene[2-]	1	µg/L	U
GW51-10-8745	VOC	Chlorotoluene[4-]	1	µg/L	U
GW51-10-8745	VOC	Dibromo-3-Chloropropane[1,2-]	1	µg/L	U
GW51-10-8745	VOC	Dibromoethane[1,2-]	1	µg/L	U

Table B-1.3-1 (continued)

Sample Name	Analytical Suite Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
GW51-10-8745	VOC	Dibromomethane	1	µg/L	U
GW51-10-8745	VOC	Dichlorobenzene[1,2-]	1	µg/L	U
GW51-10-8745	VOC	Dichlorobenzene[1,3-]	1	µg/L	U
GW51-10-8745	VOC	Dichlorobenzene[1,4-]	1	µg/L	U
GW51-10-8745	VOC	Dichlorodifluoromethane	1	µg/L	UJ
GW51-10-8745	VOC	Dichloroethane[1,1-]	1	µg/L	U
GW51-10-8745	VOC	Dichloroethane[1,2-]	1	µg/L	U
GW51-10-8745	VOC	Dichloroethene[1,1-]	1	µg/L	U
GW51-10-8745	VOC	Dichloroethene[cis-1,2-]	1	µg/L	U
GW51-10-8745	VOC	Dichloroethene[trans-1,2-]	1	µg/L	U
GW51-10-8745	VOC	Dichloropropane[1,2-]	1	µg/L	U
GW51-10-8745	VOC	Dichloropropane[1,3-]	1	µg/L	U
GW51-10-8745	VOC	Dichloropropane[2,2-]	1	µg/L	U
GW51-10-8745	VOC	Dichloropropene[1,1-]	1	µg/L	U
GW51-10-8745	VOC	Dichloropropene[cis-1,3-]	1	µg/L	U
GW51-10-8745	VOC	Dichloropropene[trans-1,3-]	1	µg/L	U
GW51-10-8745	VOC	Diethyl Ether	1	µg/L	U
GW51-10-8745	VOC	Ethyl Methacrylate	5	µg/L	U
GW51-10-8745	VOC	Ethylbenzene	1	µg/L	U
GW51-10-8745	VOC	Hexachlorobutadiene	1	µg/L	U
GW51-10-8745	VOC	Hexanone[2-]	5	µg/L	U
GW51-10-8745	VOC	Iodomethane	5	µg/L	U
GW51-10-8745	VOC	Isobutyl alcohol	50	µg/L	R
GW51-10-8745	VOC	Isopropylbenzene	1	µg/L	U
GW51-10-8745	VOC	Isopropyltoluene[4-]	1	µg/L	U
GW51-10-8745	VOC	Methacrylonitrile	5	µg/L	U
GW51-10-8745	VOC	Methyl Methacrylate	5	µg/L	U
GW51-10-8745	VOC	Methyl tert-Butyl Ether	1	µg/L	U
GW51-10-8745	VOC	Methyl-2-pentanone[4-]	5	µg/L	U
GW51-10-8745	VOC	Methylene Chloride	10	µg/L	U
GW51-10-8745	VOC	Naphthalene	1	µg/L	U
GW51-10-8745	VOC	Propionitrile	5	µg/L	R
GW51-10-8745	VOC	Propylbenzene[1-]	1	µg/L	U
GW51-10-8745	VOC	Styrene	1	µg/L	UJ
GW51-10-8745	VOC	Tetrachloroethane[1,1,1,2-]	1	µg/L	U
GW51-10-8745	VOC	Tetrachloroethane[1,1,2,2-]	1	µg/L	U

Table B-1.3-1 (continued)

Sample Name	Analytical Suite Code	Analyte Description	Lab Result	Unit	Validation Qualifier Code
GW51-10-8745	VOC	Tetrachloroethene	1	µg/L	U
GW51-10-8745	VOC	Toluene	1	µg/L	U
GW51-10-8745	VOC	Trichloro-1,2,2-trifluoroethane[1,1,2-]	5	µg/L	R
GW51-10-8745	VOC	Trichlorobenzene[1,2,3-]	1	µg/L	U
GW51-10-8745	VOC	Trichlorobenzene[1,2,4-]	1	µg/L	U
GW51-10-8745	VOC	Trichloroethane[1,1,1-]	1	µg/L	U
GW51-10-8745	VOC	Trichloroethane[1,1,2-]	1	µg/L	U
GW51-10-8745	VOC	Trichloroethene	1	µg/L	U
GW51-10-8745	VOC	Trichlorofluoromethane	1	µg/L	U
GW51-10-8745	VOC	Trichloropropane[1,2,3-]	1	µg/L	U
GW51-10-8745	VOC	Trimethylbenzene[1,2,4-]	1	µg/L	U
GW51-10-8745	VOC	Trimethylbenzene[1,3,5-]	1	µg/L	U
GW51-10-8745	VOC	Vinyl acetate	5	µg/L	U
GW51-10-8745	VOC	Vinyl Chloride	1	µg/L	U
GW51-10-8745	VOC	Xylene[1,2-]	1	µg/L	U
GW51-10-8745	VOC	Xylene[1,3-]+Xylene[1,4-]	2	µg/L	U

[a] TU = Tritium unit.

[b] UJ = The analyte was not positively identified in the sample, and the associated value is an estimate of the sample-specific detection or quantitation limit.

[c] HMX = octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine.

[d] PETN = pentaerythritol tetranitrate.

[e] RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine.

[f] TATB = triaminotrinitrobenzene.

[g] J = Estimated concentration.

[h] R = The value is rejected as a result of major problems with quality assurance / quality control parameters.

[i] U = The analyte was analyzed for but not detected.

[j] J- = The analyte was positively identified, and the result is likely to be biased low.

Table B-1.3-2
EES-14 Analytical Results

Sample ID	Date Sampled	Sample Type	Depth (feet)	Ag rslt (ppm)	stdev (Ag)	Al rslt (ppm)	stdev (Al)	As rslt (ppm)	stdev (As)	B rslt (ppm)	stdev (B)	Ba rslt (ppm)	stdev (Ba)	Be rslt (ppm)	stdev (Be)	Br(-) (ppm)	Ca rslt (ppm)	stdev (Ca)	Cd rslt (ppm)	stdev (Cd)
GW51-10-8739	12/5/2009	Borehole	161 (perched)	0.001	U	0.483	0.004	0.0009	0.0000	0.037	0.001	0.019	0.000	0.001	U	0.05	13.52	0.03	0.001	U
GW51-10-8740	12/12/2009	Borehole	563–568 (perched)	0.001	U	0.184	0.002	0.0011	0.0001	0.014	0.000	0.013	0.000	0.001	U	0.06	10.47	0.04	0.001	U
GW51-10-8743	1/13/2010	Borehole	935 (regional)	0.001	U	0.846	0.097	0.0006	0.0000	0.145	0.001	0.828	0.005	0.001	U	0.01, U	18.16	0.14	0.001	U
GW51-10-8744	1/14/2010	Borehole	1054 (regional)	0.001	U	0.058	0.003	0.0004	0.0000	0.077	0.000	0.455	0.002	0.001	U	0.01, U	10.68	0.05	0.001	U
WST51-10-13134	3/1/2010	Well development	915–930 (upper screen)	0.001	U	0.002	U	0.0007	0.0000	0.062	0.000	0.171	0.001	0.001	U	0.04	11.85	0.11	0.001	U
WST51-10-10139	2/15/2010	Well development	1031–1041 (lower screen)	0.001	U	0.005	0.000	0.0009	0.0000	0.091	0.000	0.288	0.000	0.001	U	0.05	13.34	0.09	0.001	U

Cl(-) (ppm)	ClO4(-) (ppm)	ClO4(-) (U)	Co rslt (ppm)	stdev (Co)	Alk-CO3 rslt (ppm)	Alk-CO3 (U)	Cr rslt (ppm)	stdev (Cr)	Cs rslt (ppm)	stdev (Cs)	Cu rslt (ppm)	stdev (Cu)	F(-) (ppm)	Fe rslt (ppm)	stdev (Fe)	Alk-CO3+HCO3 rslt (ppm)	Hg rslt (ppm)	stdev (Hg)	K rslt (ppm)	stdev (K)	Li rslt (ppm)	stdev (Li)	Mg rslt (ppm)	stdev (Mg)
10.15	NA	NA	0.001	U	0.8	U	0.003	0.000	0.001	U	0.003	0.000	0.44	0.22	0.00	88	0.01103	0.00044	7.99	0.03	0.010	0.000	2.45	0.02
5.96	0.002	U	0.001	U	0.8	U	0.004	0.000	0.001	U	0.002	0.000	0.25	0.12	0.00	88	0.00036	0.00001	4.45	0.02	0.011	0.000	2.53	0.00
17.90	0.005	U	0.001	U	0.8	U	0.011	0.002	0.001	U	0.003	0.001	1.02	0.27	0.00	128	0.00021	0.00001	3.12	0.03	0.041	0.002	4.65	0.03
7.09	0.002	U	0.001	U	0.8	U	0.005	0.000	0.001	U	0.001	U	0.66	0.21	0.00	76	0.00005	U	1.42	0.02	0.021	0.001	3.00	0.01
3.48	0.005	U	0.001	U	0.8	U	0.006	0.001	0.001	U	0.001	U	0.29	0.45	0.00	83	0.00005	U	1.70	0.01	0.024	0.000	2.89	0.01
7.22	0.005	U	0.001	U	0.8	U	0.005	0.000	0.001	U	0.001	U	0.24	0.07	0.00	102	0.00005	U	1.86	0.00	0.022	0.002	3.67	0.01

Mn rslt (ppm)	stdev (Mn)	Mo rslt (ppm)	stdev (Mo)	Na rslt (ppm)	stdev (Na)	Ni rslt (ppm)	stdev (Ni)	NO2 (ppm)	NO2-N rslt	NO2-N (U)	NO3 (ppm)	NO3-N rslt	C2O4 rslt (ppm)	C2O4 (U)	Pb rslt (ppm)	stdev (Pb)	Lab pH	PO4(-3) rslt (ppm)	PO4(-3) (U)	Rb rslt (ppm)	stdev (Rb)	Sb rslt (ppm)	stdev (Sb)	Se rslt (ppm)	stdev (Se)
0.072	0.000	0.083	0.004	23.89	0.11	0.010	0.000	0.01	0.003	U	1.90	0.43	0.01	U	0.0014	0.0001	7.72	0.07	0.02	0.038	0.000	0.001	U	0.001	0.000
0.020	0.000	0.004	0.000	20.76	0.12	0.004	0.000	0.01	0.003	U	0.42	0.09	0.01	U	0.0002	U	7.21	0.01	U	0.020	0.000	0.001	0.000	0.001	0.000
0.142	0.002	0.010	0.000	22.78	0.13	0.003	0.001	0.01	0.003	U	3.19	0.72	0.03	0.02	0.0005	0.0001	7.80	0.02	0.02	0.003	0.001	0.001	U	0.002	0.001
0.059	0.002	0.001	0.000	11.41	0.08	0.001	0.000	0.1	0.030	0.003	2.82	0.64	0.01	U	0.0002	U	7.30	0.01	U	0.001	0.000	0.001	U	0.001	U
0.063	0.000	0.002	0.000	17.27	0.02	0.002	0.000	0.01	0.003	U	1.38	0.31	0.01	U	0.0002	U	6.42	0.01	U	0.002	0.000	0.001	U	0.001	0.000
0.033	0.000	0.002	0.000	24.21	0.11	0.002	0.000	0.01	0.003	U	1.27	0.29	0.01	U	0.0002	U	7.48	0.04	0.02	0.002	0.000	0.001	U	0.001	0.000

Si rslt (ppm)	stdev (Si)	SiO2 rslt (ppm)	stdev (SiO2)	Sn rslt (ppm)	stdev (Sn)	SO4(-2) rslt (ppm)	Sr rslt (ppm)	stdev (Sr)	Th rslt (ppm)	stdev (Th)	Ti rslt (ppm)	stdev (Ti)	Tl rslt (ppm)	stdev (Tl)	U rslt (ppm)	stdev (U)	V rslt (ppm)	stdev (V)	Zn rslt (ppm)	stdev (Zn)	TDS (ppm)	Cations	Anions	Balance
24.7	0.2	52.8	0.3	0.001	U	9.67	0.092	0.001	0.001	U	0.020	0.000	0.001	U	0.0019	0.0000	0.002	0.000	0.018	0.000	213	2.13	2.02	0.03
32.9	0.1	70.4	0.2	0.001	U	7.28	0.065	0.000	0.001	U	0.012	0.000	0.001	U	0.0010	0.0000	0.003	0.000	0.015	0.000	212	1.75	1.82	−0.02
22.4	0.1	47.9	0.2	0.001	U	10.59	0.079	0.001	0.001	U	0.026	0.000	0.001	U	0.0013	0.0003	0.004	0.001	0.057	0.007	260	2.39	2.97	−0.11
34.9	0.3	74.6	0.6	0.001	U	5.24	0.046	0.000	0.001	U	0.003	0.000	0.001	U	0.0004	0.0000	0.005	0.000	0.089	0.005	195	1.33	1.67	−0.11
33.7	0.1	72.1	0.1	0.001	U	10.0	0.082	0.001	0.001	U	0.002	U	0.001	U	0.0004	0.0000	0.005	0.001	0.048	0.001	206	1.64	1.74	−0.03
34.3	0.1	73.3	0.2	0.001	U	18.5	0.066	0.001	0.001	U	0.002	U	0.001	U	0.0007	0.0000	0.005	0.000	0.094	0.001	248	2.08	2.33	−0.06

Note: U = Not detected; NA = Not analyzed.

Table B-1.3-3
Total Organic Carbon Concentrations from Well Development Samples

Sample ID	Date Received	Sample Type	Depth (ft)	TOC	Units	Qualifier Code
WST51-10-13788	3/1/2010	Well development	930 (upper screen)	0.61	mgC/L	J*
WST51-10-13134	3/1/2010	Well development	915–930 (upper screen)	0.68	mgC/L	J
WST51-10-10135	2/12/2010	Well development	1031–1041 (lower screen)	3.35	mgC/L	None
WST51-10-10136	2/12/2010	Well development	1031–1041 (lower screen)	4.34	mgC/L	None
WST51-10-10137	2/13/2010	Well development	1031–1041 (lower screen)	1.78	mgC/L	None
WST51-10-10138	2/14/2010	Well development	1031–1041 (lower screen)	1.47	mgC/L	None
WST51-10-10139	2/15/2010	Well development	1031–1041 (lower screen)	0.83	mgC/L	J

* J = Estimated value.

Appendix C

Borehole Video Logging
(on DVD included with this document)

Appendix D

Geophysical Logs and
Schlumberger Geophysical Logging Report
(on CD included with this document)

Appendix E

Aquifer Testing Report

E-1.0 INTRODUCTION

This appendix describes the hydraulic analysis of pumping tests conducted during February and March 2010 at R-51, a dual-screen regional aquifer well located in Pajarito Canyon northwest of Technical Area 18 (TA-18). The tests on R-51 were conducted to quantify the hydraulic properties of the two zones in which the well is screened and evaluate the hydraulic interconnection of the zones.

Testing planned for each screen interval consisted of brief trial pumping, background water-level data collection, and a 24-h constant-rate pumping test. Water levels were monitored in both zones during each of the pumping tests in each screen.

As with most of the R-well pumping tests conducted on the Pajarito Plateau (the Plateau), an inflatable packer system was used in R-51 to both hydraulically isolate the screen zones and try to eliminate casing storage effects on the test data. Storage effects were eliminated successfully from some of the pumping tests. However, it appeared that trapped air in the system may have caused storage effects in some of the tests.

E-1.1 Conceptual Hydrogeology

Well R-51 is screened within sands and gravels of the Puye Formation. Screen 1 is 10 ft long, extending from 915 to 925 ft below ground surface (bgs). Screen 2 is 10 ft long as well, extending from 1031 to 1041 ft bgs. The zone above screen 1 from 905 to 915 ft was clay rich and presumably low in hydraulic conductivity. As such, this zone was expected to provide hydraulic confinement of the screen 1 zone.

The composite static water level measured on February 17, 2010, was 890.62 ft bgs. The estimated ground-level elevation at the well was 6760 ft above mean sea level (amsl), making the composite water-level elevation roughly 5869.38 ft amsl.

When the screen zones were isolated with an inflatable packer, the water level in screen 1 rose 0.80 ft, to a depth of 889.82 ft bgs and an approximate elevation of 5870.18 ft amsl. Simultaneously, the head in screen 2 declined 0.83 ft to a depth of 891.45 ft bgs and an approximate elevation of 5868.55 ft amsl. Thus, the water levels showed a downward hydraulic gradient typical of most locations on the Plateau.

The observed head difference between the two zones suggested some degree of hydraulic separation, implying likely confinement of the lower zone. However, the available data and geologic descriptions of the formation did not permit identifying the location of the presumed aquitard or the thicknesses of the two individual screen 1 and screen 2 aquifers. The hydraulic data from screen 1 did not show an indication of vertical growth of the cone of depression over time and therefore, for the purposes of analysis, the screen 1 zone was considered to be 10 ft thick (fully penetrating). The screen 2 data, on the other hand, showed evidence of vertical growth of the cone of depression and was considered partially penetrating. There was no clue in the data as to the probable contiguous thickness of the screen 2 zone. As described later, an arbitrary thickness of 50 ft was assigned solely for the purposes of analyzing specific capacity data.

E-1.2 R-51 Screen 1 Testing

Screens 1 and 2 were tested in reverse order. Well R-51 screen 1 was tested last, from March 4 to 9, 2010. After filling the drop pipe on March 4, testing began with brief trial pumping on March 5, background data collection, and a 24-h constant-rate pumping test that was started on March 7.

Two trial tests were conducted on March 5. Trial 1 was conducted for 60 min at a discharge rate of 4.1 gallons per minute (gpm) from 9:00 until 10:00 a.m. and was followed by 60 min of recovery until

11:00 a.m. Trial 2 was conducted for 60 min from 11:00 to a.m. until 12:00 p.m. and was followed by 2640 min of recovery until 8:00 a.m. on March 7. The discharge rate for trial 2 began at 4.0 gpm, declining to 3.9 gpm halfway through the test because of malfunction of the electric generator.

On March 7, the 24-h pumping test was begun at a rate of 4.1 gpm at 8:00 a.m. Pumping continued for 1440 min until 8:00 a.m. on March 8. Following shutdown, recovery data were recorded for 1440 min until 8:00 a.m. on March 9 when the pump was pulled from the well.

E-1.3 R-51 Screen 2 Testing

Well R-51 screen 2 was tested from February 18 to 23, 2010. After filling the drop pipe on February 18, testing began with brief trial pumping on February 19, background data collection, and a 24-h constant-rate pumping test that was begun on February 21.

Two trial tests were conducted on February 19. Trial 1 was conducted at a discharge rate of 21.4 gpm for 70 min from 8:20 to 9:30 a.m. and was followed by 30 min of recovery until 10:00 a.m.

Trial 2 was conducted for 60 minutes from 10:00 to 11:00 a.m. at a rate of 21.5 gpm. Following shutdown, recovery/background data were recorded for 2760 min until 9:00 a.m. on February 21.

At 9:00 a.m. on February 21, the 24-h pumping test was begun at a rate of 21.5 gpm. During the test, the discharge rate declined gradually to 21.1 gpm and stabilized there for most of the test. Pumping continued for 1440 min until 9:00 a.m. on February 22. Following shutdown, recovery measurements were recorded for 1440 min until 9:00 a.m. on February 23 when the pump was tripped out of the well.

E-2.0 BACKGROUND DATA

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

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

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

Subsequent pumping tests, including R-51, have used nonvented transducers. These devices simply record the total pressure on the transducer, that is, the sum of the water height plus the barometric pressure. This results in an attenuated "apparent" hydrograph in a barometrically efficient well. Take as an example a 90% barometrically efficient well. When monitored using a vented transducer, an increase in barometric pressure of 1 unit causes a decrease in recorded downhole pressure of 0.9 unit because the water level is forced downward 0.9 unit by the barometric pressure change. However, using a nonvented transducer, the total measured pressure increases by 0.1 unit (the combination of the barometric pressure increase and the water-level decrease). Thus, the resulting apparent hydrograph changes by a factor of 100 minus the barometric efficiency, and in the same direction as the barometric pressure change rather than in the opposite direction.

Barometric pressure data were obtained from the TA-54 tower site from the Waste and Environmental Services Division−Environmental Data and Analysis Group (WES-EDA). The TA-54 measurement location is at an elevation of 6548 ft amsl, whereas the wellhead elevation is approximately 6760 ft amsl. The static water level in R-51 was 890.62 ft below land surface, making the calculated water-table elevation roughly 5869.38 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-51.

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

$$P_{WT} = P_{TA54} \exp\left[-\frac{g}{3.281R}\left(\frac{E1 - E_{TA54}}{T_{TA54}} + \frac{E_{WT} - E_{R-51}}{T_{WELL}} \right) \right]$$ **Equation E-1**

where P_{WT} = barometric pressure at the water table inside R-51

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/degrees kelvin (287.04 J/kg/degrees kelvin)

$E_{R\text{-}51}$ = land surface elevation at R-51 site, in feet (approximately 6760 ft)

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

E_{WT} = elevation of the water level in R-51, in feet (approximately 5869.38 ft)

T_{TA54} = air temperature near TA-54, in degrees kelvin (assigned a value of 33.7 degrees Fahrenheit, or 274.1 degrees kelvin, for screen 1 and 30.0 degrees Fahrenheit, or 272.0 degrees kelvin, for screen 2)

T_{WELL} = air temperature inside R-51, in degrees kelvin (assigned a value of 62.2 degrees Fahrenheit, or 289.9 degrees kelvin, for screen 1 and 64.0 degrees Fahrenheit, or 290.9 degrees kelvin, for screen 2).

This formula is an adaptation of an equation WES-EDA 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.

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 that 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, there can be an additional storage contribution from the filter pack around the screen. 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. (As proof, note that the left-hand term within the brackets is directly proportional to the annular area [and volume] between the casing and drop pipe while the right-hand term is proportional to the area [and volume] between the borehole and the casing, corrected for the drainable porosity of the filter pack. Thus, the summed term within the brackets accounts for all of the volume [casing water and drained filter pack water] appropriately.)

In some instances, it is possible to eliminate casing-storage effects by setting an inflatable packer above the tested screen interval before conducting the test. As described below, this proved effective for some but not all of the tests, likely because of trapped air in either the filter packer above screen 1 or the formation pores.

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. Using these match-point values, transmissivity and storage coefficient are computed 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 (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

$$\beta = \sqrt{\frac{K_z}{K_r}}\frac{n\pi r}{b}\ . \qquad \textbf{Equation E-12}$$

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. This is a semilog analysis method similar to the Cooper–Jacob procedure.

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

$$T = \frac{264Q}{\Delta s}\ . \qquad \textbf{Equation E-13}$$

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.

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 unknown, the computed hydraulic conductivity value represents a lower bound. The actual conductivity is known to be greater than or equal to the computed value.

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

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

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

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

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

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. Confined conditions were assumed for R-51 screens 1and 2. Storage-coefficient values for confined aquifers generally range from 10^{-5} to 10^{-3} (Driscoll 1986, 104226). Values ranging from 10^{-4} to 10^{-3} were used for the calculations presented here. The calculation result is not particularly sensitive to the choice of storage-coefficient value, so a rough estimate of the storage coefficient is generally adequate to support the calculations.

The analysis also requires assigning a value for the saturated aquifer thickness, b. As described below, screen 1 was treated as fully penetrating and assigned a saturated thickness value of 10 ft. For the purposes of this exercise, the saturated thickness for the screen 2 zone was arbitrarily assigned a value of 50 ft. The calculations are not particularly sensitive to the choice of aquifer thickness because sediments far above or below the screen typically contribute little flow.

E-7.0 BACKGROUND DATA ANALYSIS

Background aquifer pressure data collected during the R-51 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-51 screen 1 during the screen 1 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-51 data are referred to in the figure as the “apparent hydrograph” because the measurements reflect the sum of water pressure and barometric pressure, having been recorded using a nonvented pressure transducer. The times of the pumping periods for the R-51 pumping tests are included on the figure for reference.

The apparent hydrograph showed a subtle fluctuation on March 6 and 7 that looked like a muted version of the barometric pressure change during that period. Indeed, when the hydrograph data were plotted on the expanded scale shown in Figure E-7.0-2, the data mimicked the barometric curve fairly well. The relative scales in Figure E-7.0-2 implied an approximate barometric efficiency of 94%.

Figure E-7.0-3 shows the comparison of barometric pressure and the apparent hydrograph from R-51 screen 2 during the screen 1 test period. The data from March 5 to 7 suggested a slight correlation between the curves. The hydrograph data were replotted on an expanded scale as shown in Figure E-7.0-4, showing a reasonable correlation. The relative scales on the graph implied a barometric efficiency for screen 2 of about 58%. Note that the screen 2 apparent hydrograph appeared to decline at the beginning of the screen 1 test and rebound some time after the end of the test, suggesting the possibility of a hydraulic response to pumping screen 1. However, this interpretation does not explain the late-time offset between the hydrograph and barometric pressure curve. It is more likely that the decline in hydrograph pressure was barometrically induced and that the rebound was a slightly delayed response to shutting off the pump in Los Alamos County well PM-4, which was operated continuously for more than a week and then shut down just before midnight on March 7. If there was a screen 2 response to pumping screen 1, it may have been masked by other water-level changes. Nevertheless, the lack of any water-level change in screen 2 for several hours following shutdown of the screen 1 pumping test appeared to belie a hydraulic response.

Figure E-7.0-5 shows the comparison of barometric pressure and the apparent hydrograph from R-51 screen 1 during the screen 2 pumping test. The data suggested a drawdown response in screen 1 of about 0.08 ft during the screen 2 pumping test. The balance of the apparent hydrograph showed more fluctuation than was seen during the screen 1 test (Figure E-7.0-1), possibly because of other aquifer stresses. Figure E-7.0-6 shows these data along with pumping times for PM-4 as well as R-54 screen 2, which was tested the day before R-51 screen 2. The hydrograph for R-51 screen 2 appeared to show recovery response to shutting off PM-4 on February 19 and drawdown response to pumping R-54 screen 2 and resumption of pumping PM-4.

Finally, Figure E-7.0-7 shows the apparent hydrograph for R-51 screen 2 during the screen 2 test period. The effects of pumping screen 2 were significant and precluded drawing further conclusions regarding the influences of barometric pressure or other wells on screen 2 water levels during this period.

E-8.0 WELL R-51 SCREEN 1 DATA ANALYSIS

This section presents the data obtained from the R-51 screen 1 pumping tests and the results of the analytical interpretations. Data are presented for drawdown and recovery from trials 1 and 2 as well as the 24-h constant-rate test.

E-8.1 Well R-51 Screen 1, Trial 1

Figure E-8.1-1 shows a semilog plot of the drawdown data collected from trial 1 at a discharge rate of 4.1 gpm. The data showed two distinct slopes, as well as departure of the earliest data points from the line of fit. The early data (first two min) exhibited response consistent with a small, brief storage effect. It is possible that a modest amount of air may have been entrained in the screen and filter pack during development of the well, for example by pulling the pumping water level into the top of screen 1. This would have allowed drainage of a portion of the filter pack behind the blank casing above the screen, trapping a small amount of air beneath the bentonite seal. This trapped air would then expand and contract during pumping and recovery, causing a storage-like effect. This is the interpretation that was pursued in the analysis that follows. It is also possible that air may have been driven into the formation pores during the well-drilling process─a frequently observed phenomenon in recent wells drilled on the Plateau. Such trapped air would cause the same sort of storage response in the drawdown and recovery data.

Note that there are other possible interpretations of the observed data. For example, one could hypothesize that the early data represent the formation properties and that the subsequent flat slope shows vertical growth of the cone of depression and/or a lateral increase in transmissivity. However, in this scenario, the early data that fall off the initial line of fit could be explained only as u-value affected data. This, in turn, would imply a storage coefficient having a magnitude in the unconfined range within the first few seconds of pumping—unlikely for a screen zone submerged 25 ft below the water table and confined by 10 ft of clay-rich sediments.

The early slope on Figure E-8.1-1 yielded a transmissivity of 780 gpd/ft. As described above, it was concluded that the data in this portion of the curve were storage affected, making the computed transmissivity value invalid.

The second slope on Figure E-8.1-1 yielded a transmissivity of 1160 gpd/ft. Based on a screen length of 10 ft, the computed hydraulic conductivity was 116 gpd/ft^2, or 15.5 ft/d.

Figure E-8.1-2 shows the recovery data collected following shutdown of the trial 1 pumping test. As with the pumping data, the steep portion of the data trace was storage affected and produced an unrealistic transmissivity value. The second slope on Figure E-8.1-2 yielded a transmissivity of 1370 gpd/ft. Based on a screen length of 10 ft, the computed hydraulic conductivity was 137 gpd/ft^2, or 18.3 ft/d.

E-8.2 Well R-51 Screen 1, Trial 2

Figure E-8.2-1 shows a semilog plot of the drawdown data collected from trial 2 at a discharge rate of 4.0 gpm. The likely transmissivity determined from the analysis was 1160 gpd/ft, making the hydraulic conductivity 116 gpd/ft^2, or 15.5 ft/d. Halfway through the test, the sound of the electric generator changed significantly and it appeared to be laboring. For the balance of the test, the generator apparently produced less power, as the discharge rate declined to 3.9 gpm, accounting for the offset seen in the drawdown curve shown on the graph.

Figure E-8.2-2 shows the recovery data collected following shutdown of the trial 2 pumping test. As with the pumping data, the steep portion of the data trace was storage affected and produced an unrealistic transmissivity value. The second slope on Figure E-8.2-2 yielded a transmissivity of 1200 gpd/ft, making the computed hydraulic conductivity 120 gpd/ft^2, or 16.0 ft/d.

E-8.3 Well R-51 Screen 1 24-h Constant-Rate Pumping Test

Figure E-8.3-1 shows a semilog plot of the drawdown data collected from the 24-h constant-rate pumping test conducted at 4.1 gpm. The graph shows three slopes. The early-time slope was similar to those seen in the trial tests, presumably a reflection of storage effects. The second slope yielded a transmissivity estimate of 1060 gpd/ft, making the computed hydraulic conductivity 106 gpd/ft^2, or 14.2 ft/d.

The third slope is not easily explained. Usually, such an increase in slope would be indicative of an aquifer boundary or a reduction in transmissivity at some distance from the pumped well. However, as discussed below, this effect was not observed in the recovery data set as it should have been had it been boundary related. A hypothesis is that the steep late-time trend may have reflected a decline in well efficiency over time, possibly in response to release of air/gas from the water that may have partially filled the pore spaces in the formation around the well. Similar reduction in efficiency can occur as a result of compaction of the sediments around the well bore during the pumping test. However, the modest drawdown incurred during this test likely would not be sufficient to cause such compaction and permeability reduction, leaving air-related clogging as the more likely cause.

Figure E-8.3-2 shows the recovery data collected following shutdown of the 24-h constant-rate pumping test. As with the pumping data, the steep portion of the data trace was storage affected and produced an unrealistic transmissivity value. In this test, however, the curve was substantially steeper than the trial test recovery curves—further indication that the extra drawdown was inefficiency related and not a general, area-wide displacement of the cone of depression.

The second slope on Figure E-8.3-2 yielded a transmissivity of 1130 gpd/ft, making the computed hydraulic conductivity 113 gpd/ft^2, or 15.1 ft/d.

The late recovery data did not reproduce the steep late-time slope observed in the time-drawdown graph, further support for the idea that air-related efficiency and permeability reduction was responsible for the steep drawdown slope. In fact, nearly complete recovery was achieved prematurely with no apparent explanation for this effect.

E-8.4 Well R-51 Screen 1 Test Comparison

As described above, the 24-h constant-rate pumping test produced drawdown and recovery data distinctly different from what was obtained from the trial tests. In theory, the recovery data from all tests should produce similar traces. For example, the early data should produce identical plots when calculated recovery is plotted versus recovery time, while the late data should produce identical plots of residual drawdown versus t/t'.

Figure E-8.4-1 shows a comparison of the calculated recovery data from trial 1, trial 2, and the 24-h test. As stated above, the early data on these plots should show identical traces. While the trial data sets matched fairly well, the early recovery data from the 24-h test clearly departed from the trial test data. Also of note was that the very early data from the 24-h test plotted on a straight line on the log-log graph—a characteristic of storage response data.

Figure E-8.4-2 shows a comparison of residual drawdown versus t/t' for all three tests. As stated above, the late data on these plots should show identical traces. While the data sets from the trial tests matched fairly well, again the data from the 24-h test departed from that trend.

The early time discrepancy shown in Figure E-8.4-1 can be explained by the hypothesized efficiency reduction that may have occurred during the 24-h test. The lack of matching residual drawdown data at late time is more difficult to explain but may be related to air entrainment in the formation.

E-8.5 Well R-51 Screen 1 Specific Capacity Data

Specific capacity data were used along with well geometry to estimate a lower-bound transmissivity value for the permeable zone penetrated by R-51 screen 1. This was done to provide a frame of reference for evaluating the foregoing analyses.

During the trial 1 pumping test, the discharge rate remained constant at 4.1 gpm for 60 min. The corresponding drawdown was 4.56 ft. In addition to specific capacity and pumping time, other input values used in the calculations included storage coefficient values ranging from 10^{-4} to 10^{-3} and a borehole radius of 0.6 ft, estimated from documented filter pack usage to backfill the annulus around screen 1.

Applying the Brons and Marting method to these inputs for fully penetrating conditions yielded lower-bound transmissivity values shown in Figure E-8.5-1. As indicated, the lower-bound transmissivity values ranged from about 1100 to 1300 gpd/ft, depending on the assumed storage coefficient value.

Table E-8.5-1 shows a summary of the transmissivity values computed from the pumping-test analyses, showing an average of 1180 gpd/ft. The lower-bound estimates provided reasonable corroboration of the values obtained from the pumping-test data analysis.

E-9.0 WELL R-51 SCREEN 2 DATA ANALYSIS

This section presents the data obtained from the R-51 screen 2 pumping tests and the results of the analytical interpretations. Data are presented for drawdown and recovery data from trials 1 and 2 as well as the 24-h constant-rate test.

E-9.1 Well R-51 Screen 2 Trial 1

Figure E-9.1-1 shows a semilog plot of the drawdown data collected from trial 1 in screen 2 at a discharge rate of 21.4 gpm. The data showed three distinct slopes. The first slope persisted for just a few seconds and was interpreted as reflecting the transmissivity of the 10 ft of formation immediately adjacent to screen 2. The transmissivity value obtained from this portion of the plot was 310 gpd/ft, making the estimated hydraulic conductivity 31 gpd/ft^2, or 4.1 ft/d.

The subsequent progressively flatter slopes can be indicative of variety of conditions including leakage, vertical growth of the cone of depression into a thicker sequence of sediments, and a lateral increase in hydraulic conductivity and transmissivity (subsequent values of 440 and 890 gpd/ft). In this instance, it was likely that the flattening trend indicated vertical growth of the cone of depression beyond the limited 10-ft screen length. The computed transmissivity for any particular segment of the data plot roughly reflects the transmissivity of the unknown sediment thickness penetrated by the cone of depression at that particular time.

Figure E-9.1-2 shows the recovery data collected following shutdown of the trial 1 pumping test. The transmissivity estimated from the early data was 210 gpd/ft, making the computed hydraulic conductivity 21 gpd/ft^2, or 2.8 ft/d. The subsequent data showed the same steady slope decrease observed in the drawdown data set.

E-9.2 Well R-51 Screen 2 Trial 2

Figure E-9.2-1 shows a semilog plot of the drawdown data collected from trial 2 in screen 2 at a discharge rate of 21.5 gpm. The transmissivity value computed from the early data was 240 gpd/ft, making the average hydraulic conductivity of the screened interval 24 gpd/ft^2, or 3.2 ft/d.

The subsequent flatter slopes show likely ongoing vertical growth of the cone of depression beyond the limited screened interval with subsequent transmissivity values of 430 and 870 gpd/ft, similar to trial 1.

Note that the very early data did not fit the initial straight-line trend on the graph. It is believed that this was a u-value effect, where the u value remained greater than 0.05, invalidating the Cooper−Jacob equation. It is unusual to see this in the pumped well, as the r value corresponding to the borehole radius is generally small enough to ensure a u value less than 0.05. In this case, however, the combination of very low transmissivity and early pumping time resulted in the rare situation of the u-value criterion not being met for the first few data points. This meant that the Theis equation was necessary to analyze the earliest data points.

Figure E-9.2-2 shows Theis curve-matching analysis of the early data, yielding a transmissivity of 270 gpd/ft and a hydraulic conductivity of 27 gpd/ft^2, or 3.6 ft/d. Even in this plot, however, the first few data points failed to match the theoretical type curve. This may have been a result of either inertial effects or minor antecedent drainage of a tiny portion of the drop pipe.

Figure E-9.2-3 shows the recovery data collected following shutdown of the trial 2 pumping test. As indicated on the graph, the transmissivity value obtained from the early recovery data was 190 gpd/ft, implying a hydraulic conductivity of 19 gpd/ft^2, or 2.5 ft/d. The later data again showed a continuously flattening slope associated with vertical expansion of the cone of impression (recovery cone) around the well.

As occurred in the drawdown plot, the very early recovery data (right side of the graph in Figure E-9.2-3) fell off the line of fit because the u value was not yet less than 0.05. The data were plotted on a log-log graph, allowing Theis curve matching as shown in Figure E-9.2-4. While the Theis type curve fit more of the early data points than did the straight line of best fit on the semilog plot, the first couple of data points still fell off the theoretical curve. This was likely a subtle inertial effect. The transmissivity value computed from the curve-matching analysis was 220 gpd/ft, making the hydraulic conductivity of the screen zone 22 gpd/ft^2, or 2.9 ft/d.

E-9.3 Well R-51 Screen 2 24-h Constant-Rate Pumping Test

Figure E-9.3-1 shows a semilog plot of the screen 2 drawdown data collected during the 24-h pumping test at a discharge rate that stabilized at 21.1 gpm. During the first hour of pumping, the drawdown plot showed a response similar to that observed during the trial tests, with an initial steep slope (except for the u-value affected data points) followed by steady flattening of the curve. The early data suggested a screen zone transmissivity of 310 gpd/ft, making the hydraulic conductivity 31 gpd/ft^2, or 4.1 ft/d.

After the first hour of pumping, however, the data showed bizarre water-level response. The data plot steepened for two hours; then reversed trend for an hour, actually showing a water-level *rise*; then reversed direction again, showing a steeper slope than any of the earlier data. During the double reversal of water levels, the discharge rate remained stable at about 21.3 gpm, implying that pumping rate variation could not explain the observed response. After that, the discharge rate declined steadily to 21.1 gpm over several hours and remained there for the balance of the pumping test.

The temporary water-level rise observed in the data probably reflected a transient increase in well efficiency, not an uncommon occurrence when pumping new wells. Usually, this effect is caused by movement of sediment and fines near the borehole into the well and generally is accompanied by discoloration of the pumped water. No such production of solids was observed during the time period corresponding to the water-level reversal, however, making it unlikely that movement of solids caused the efficiency fluctuations.

It was concluded that the unusual water-level response was caused by air in the formation pores. Many of the recently drilled R-wells have shown evidence of air either in the formation pores or dissolved in the groundwater around the well. It is likely that the high-pressure compressed air used in drilling many of the R-wells drives significant quantities of air into the formation where it remains in the formation pores and/or dissolves into the groundwater. During pumping/depressurization, dissolved air can come out of solution and can be produced with the pumped water. Presence of air in the formation pores can affect (reduce) the hydraulic conductivity greatly, so head loss and drawdown can fluctuate as a function of the distribution of air in the pores.

The water-level rise seen in Figure E-9.3-1 may have occurred because of an efficiency increase associated with air being expelled from the formation pores near the well bore. Likewise, the subsequent steady steepening of the drawdown slope may have been caused by reaccumulation of additional air near the well—either coming out of solution or migrating toward the well bore from a short distance away. This is conjecture but seems to be the most likely explanation of the unusual hydraulic response, particularly in view of the ample evidence of compressed-air issues in several other R-wells tested recently.

The late-time steep slope shown on the drawdown graph typically can be an indication of a boundary effect, and thus this explanation was considered. However, as discussed below, the effect was not reproduced in the recovery data set (as a boundary effect would be), ruling out this explanation. A final possible cause of the late-time slope increase that cannot be ruled out is gradual compaction of the sediments around the well bore because of the substantial drawdown applied to the well (nearly 80 ft). Such hydraulic compaction can reduce the hydraulic conductivity of the sediments and reduce the specific capacity of the well. As described below, however, the pumping/drawdown results were identical for both 60-min trial tests and the first 60 min of the 24-h test, indicating that no such hydraulic-compaction permeability reduction occurred during any of those three 60-min pumping periods. This made the hydraulic-compaction explanation of the drawdown response unlikely.

The drawdown data were plotted on a log-log graph to see if the Theis type curve would provide a better fit to the early data than the straight line on the semilog plot. Figure E-9.3-2 shows the results of Theis curve matching of the data, yielding a transmissivity of 320 gpd/ft and hydraulic conductivity of 32 gpd/ft^2, or 4.3 ft/d. The minor deviation of the first data point of the graph was likely an inertial effect or an indication of antecedent drainage of a trivial volume of the drop pipe.

Figure E-9.3-3 shows the recovery data collected following shutdown of the 24-h pumping test. As indicated on the graph, the early data produced an impossibly low value of transmissivity, while the late data showed the unusual response of nearly complete recovery in a short time and the obvious lack of the slope increase at late time that was observed in the drawdown graph.

The early data curve showed a response shape typical of storage effects. Any accumulation of air in the formation pores or in the well casing beneath the inflatable packer would have triggered a storage-like effect as the air volume compressed in response to increased pressure when the water level recovered. The erroneously low computed value of transmissivity was consistent with this idea.

The recovery data were plotted on the log-log graph shown in Figure E-9.3-4. As indicated on the graph, a significant portion of the early data showed a linear trend, typical of storage effects.

E-9.4 Well R-51 Screen 2 Test Comparison

As described above, the 24-h constant-rate pumping test produced drawdown and recovery data distinctly different from what was obtained from the trial tests. In theory, the drawdown recovery data from all tests should produce similar traces. Graphs of data from all three tests were plotted for comparison purposes.

Figure E-9.4-1 shows a comparison of the drawdown data from trial 1, trial 2, and the 24-h test. As indicated on the graph, the curves coincided during the 60 min corresponding to the duration of the trial tests. The identical plots showed that no hydraulic conductivity reduction had occurred during those three 60-min pumping periods. Because permeability reduction associated with hydraulic compaction of sediments around the well generally begins soon after pumping starts, it was unlikely that this effect accounted for the subsequent slope increase observed in the 24-h pumping test. This made it more likely that trapped air in the formation was involved.

Figure E-9.4-2 shows a comparison of the calculated recovery data from the three tests. On a calculated recovery plot, the early data from all tests should be identical. Nevertheless, the water-level rebound following the 24-h test lagged that from the trial tests significantly during the first minute of recovery. This observation confirmed that storage effects were present in the 24-h recovery data.

Furthermore, the magnitude of recovery following the 24-h test should exceed that following the trial tests by only a minor amount (a foot or less) during the first several minutes of recovery. Nevertheless, during the first few minutes of recovery, water levels recovered nearly 20 ft more following the 24-h test than they did following the trial tests. This observation confirmed the idea that the efficiency of the well had degraded during the 24-h test and that efficiency reduction accounted for the late-time slope change rather than aquifer boundaries.

In summary, the recovery comparison supported the idea of a dynamic efficiency reduction during the 24-h test and presence of storage effects during the subsequent recovery even though storage effects had been absent in the trial tests. This combination of events suggested the involvement of air in the well and/or formation.

E-9.5 Well R-51 Screen 2 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-51 screen 2. This was done to provide a frame of reference for evaluating the foregoing analyses.

During the 24-h constant-rate pumping test, the discharge rate stabilized at 21.1 gpm for 1440 min. The corresponding drawdown was 77.7 ft. In addition to specific capacity and pumping time, other input values used in the calculations included an arbitrary aquifer thickness of 50 ft, storage coefficient values ranging from 10^{-4} to 10^{-3}, and a borehole radius of 0.6 ft, estimated from documented filter pack usage to backfill the annulus around screen 2.

Applying the Brons and Marting method to these inputs yielded lower-bound hydraulic conductivity values shown in Figure E-9.5-1. As indicated, the lower-bound hydraulic conductivity values ranged from about 21 to 23 gpd/ft^2, depending on the assumed storage coefficient value. Table E-9.5-1 shows a summary of the transmissivity values computed for the screened interval from the pumping-test analyses, showing an average of 260 gpd/ft. Based on the screen length of 10 ft, this made the average hydraulic conductivity 26 gpd/ft^2. The lower-bound estimates provided reasonable corroboration of the values obtained from the pumping-test data analyses.

E-10.0 SUMMARY

Constant-rate pumping tests were conducted on R-51 screens 1 and 2. The tests were performed to gain an understanding of the hydraulic characteristics of the screen zones and the degree of interconnection between them. Numerous observations and conclusions were drawn for the tests as summarized below.

The static water level observed in screen 1 was 1.63 ft higher than that in screen 2, showing a downward hydraulic gradient—typical for multiple-screen wells at the Laboratory.

A comparison of barometric pressure and R-51 screen 1 water-level data showed a high barometric efficiency of around 94%. The data for screen 2, on the other hand, suggested a moderate barometric efficiency for that zone of about 58%.

Both screen zones showed evidence of pumping influence from Los Alamos County well PM-4. Water levels in screen 1 appeared to rebound in response to a shutdown of PM-4 in mid-February. Likewise, screen 2 showed a similar rebound when PM-4 was shut down in early March after a week of nearly continuous pumping.

Tight, clay-rich materials 10 ft thick overlaid the screen 1 zone, suggesting locally confined conditions. Confined conditions were assumed for both screen zones.

Pumping screen 1 at 4.1 gpm for 1440 min had no discernable effect on water levels in screen 2; whereas pumping screen 2 at 21.1 gpm for 1440 min caused about 0.08 ft of drawdown in screen 1.

Analysis of the screen 1 pumping tests suggested a transmissivity of 1180 gpd/ft and a hydraulic conductivity of 118 gpd/ft^2, or 15.8 ft/d.

Screen 1 produced 4.1 gpm for 60 min with 4.56 ft of drawdown for a short-term specific capacity of 0.9 gpm/ft. The lower-bound transmissivity computed from this information fell between about 1100 and 1300 gpd/ft, reasonably consistent with the pumping-test value.

Analysis of the screen 2 pumping tests suggested a hydraulic conductivity of 26 gpd/ft^2 (3.5 ft/d) for the 10-ft-thick screened interval.

Screen 2 produced 21.1 gpm for 1440 min with 77.7 ft of drawdown for a specific capacity of 0.27 gpm/ft. The lower-bound hydraulic conductivity computed from this information ranged from 21 to 23 gpd/ft^2 (2.8 to 3.1 ft/d), consistent with the pumping-test value.

The data showed significant effects of air in the formation and/or filter pack pores. The likely source of the air was the high-pressure compressed air used in drilling the borehole. The presence of air triggered storage effects in the data and dynamic well-efficiency changes.

E-11.0 REFERENCES

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

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

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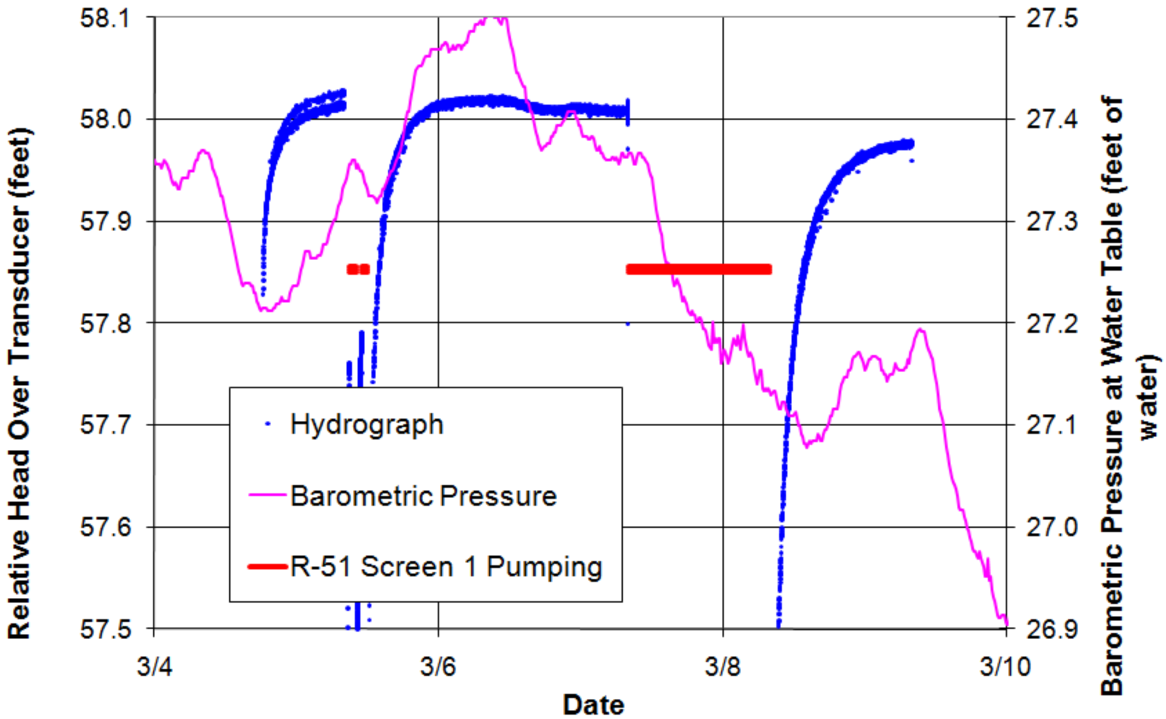


Figure E-7.0-1 Well R-51 screen 1 apparent hydrograph during screen 1 test

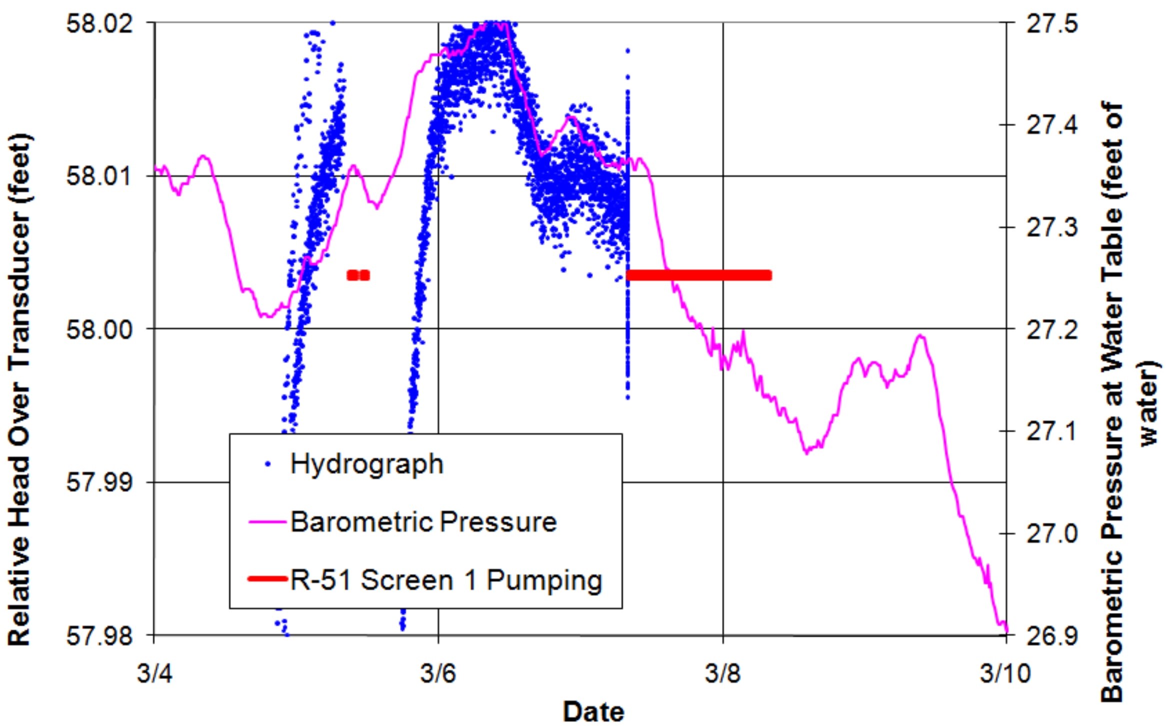


Figure E-7.0-2 Well R-51 screen 1 apparent hydrograph during screen 1 test – expanded scale

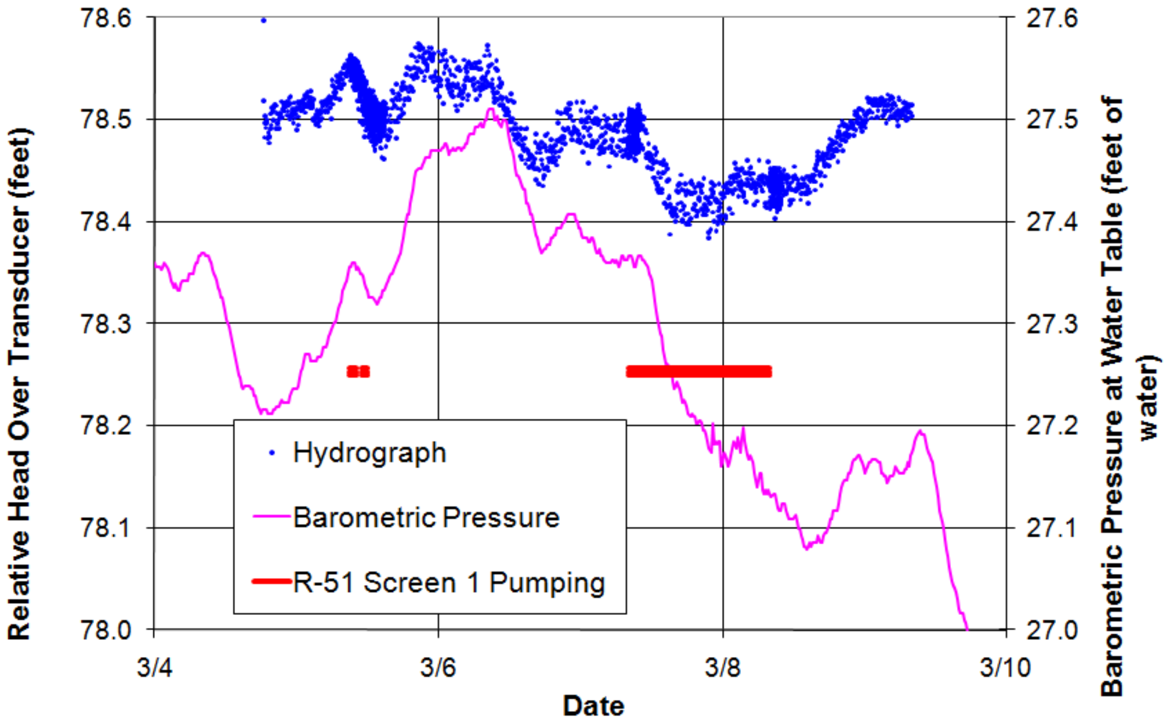


Figure E-7.0-3 Well R-51 screen 2 apparent hydrograph during screen 1 test

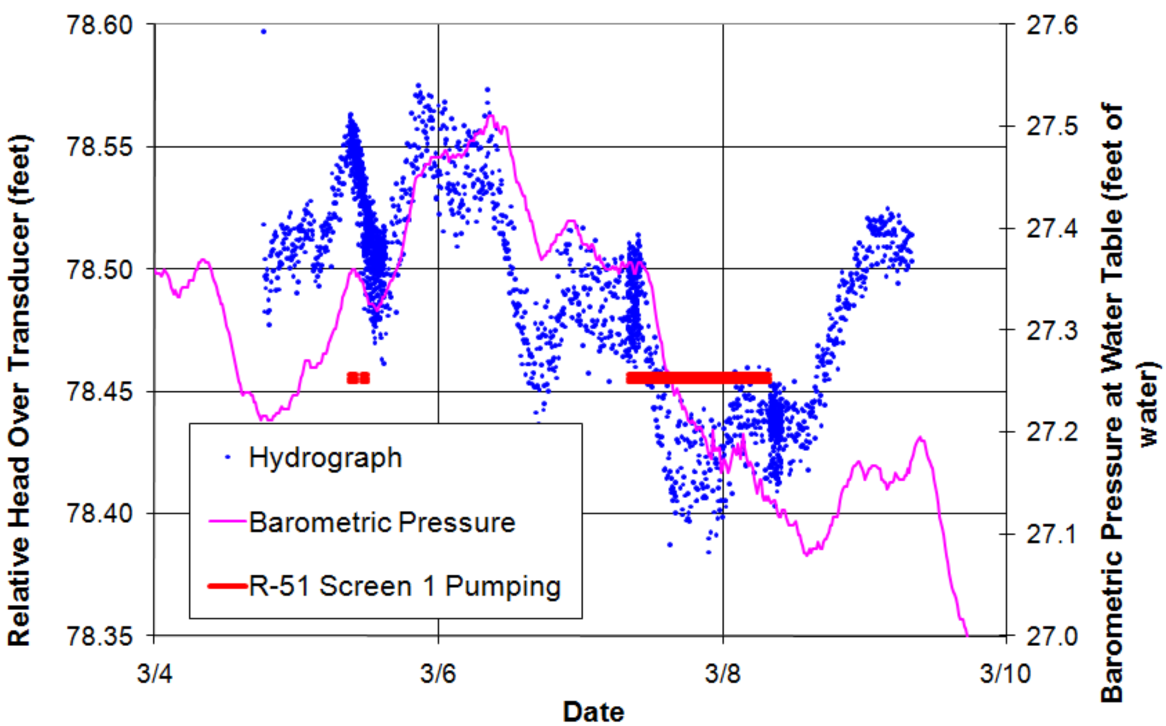


Figure E-7.0-4 Well R-51 screen 2 apparent hydrograph during screen 1 test – expanded scale

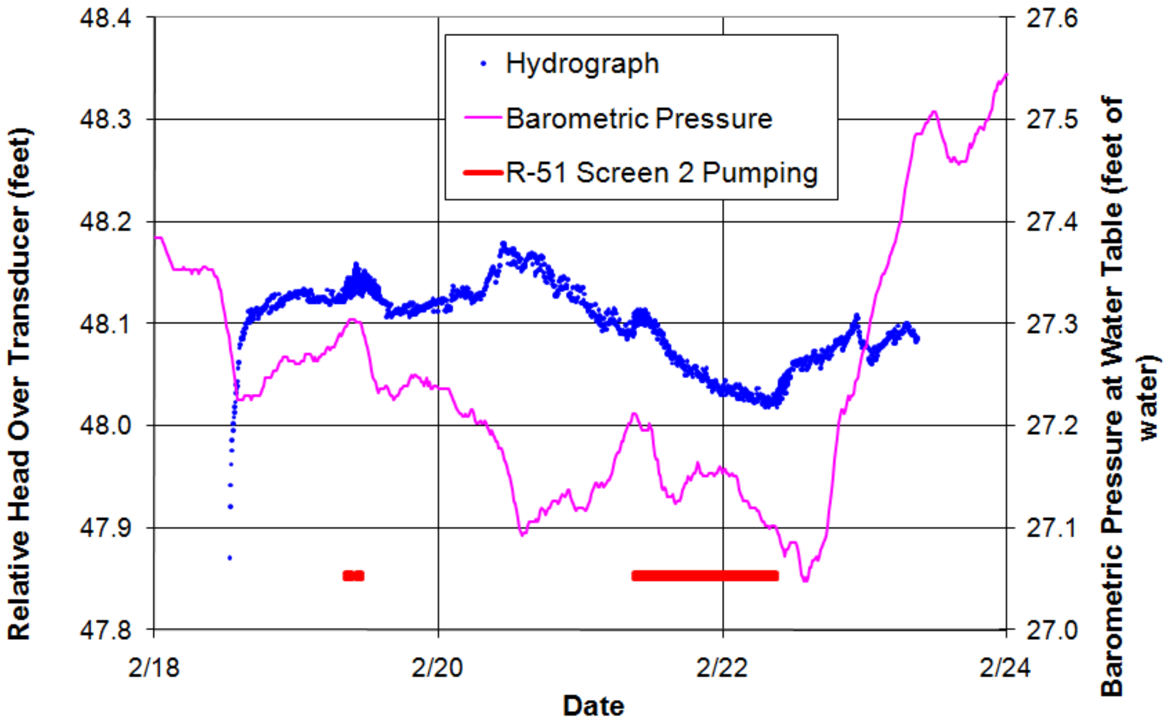


Figure E-7.0-5 Well R-51 screen 1 apparent hydrograph during screen 2 test

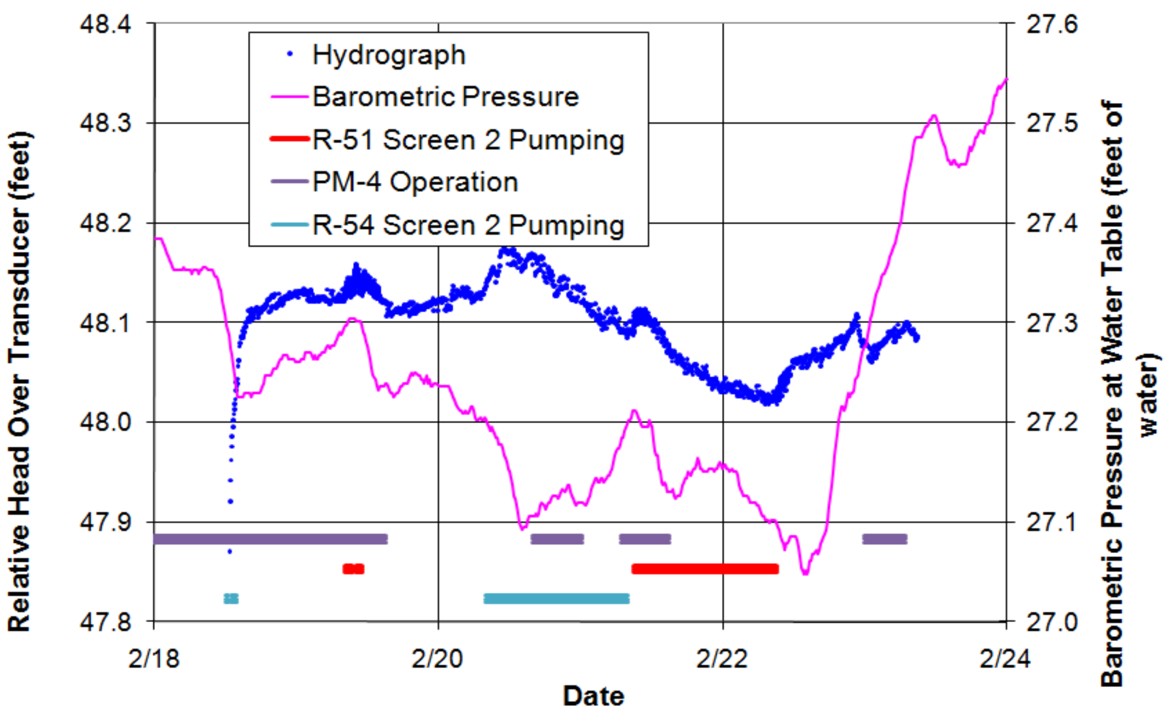


Figure E-7.0-6 Well R-51 screen 1 apparent hydrograph during screen 2 test with PM-4 operation and R-54 screen 2 operation

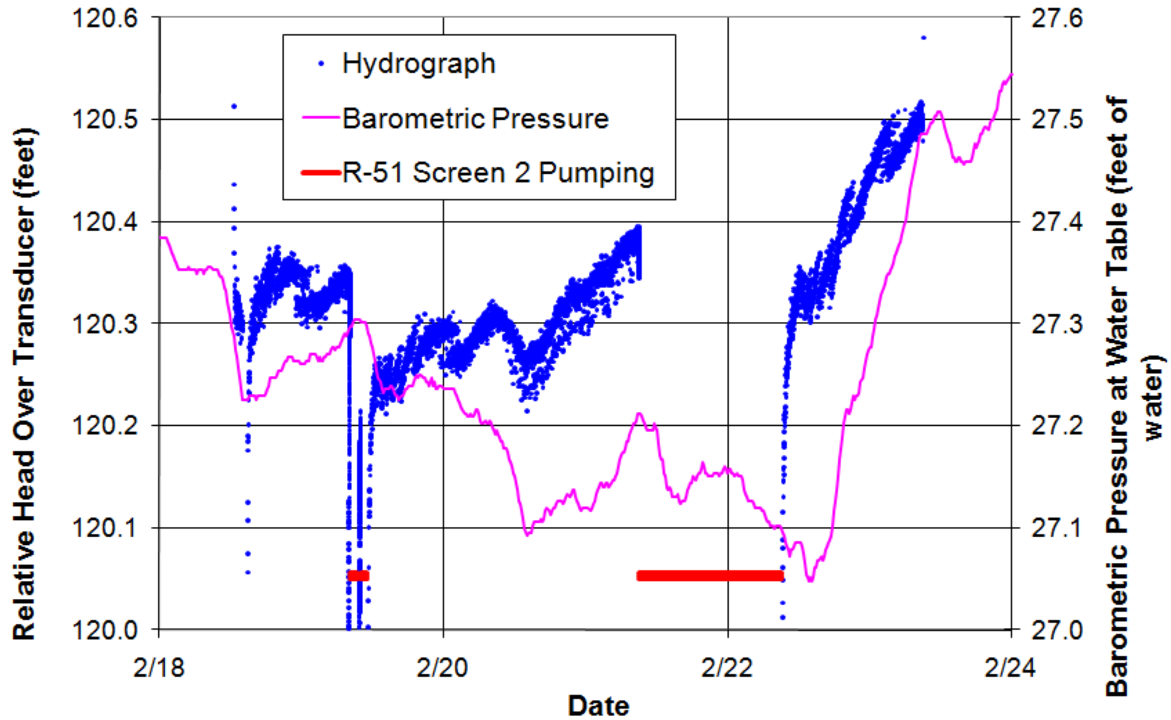


Figure E-7.0-7 Well R-51 screen 2 apparent hydrograph during screen 2 test

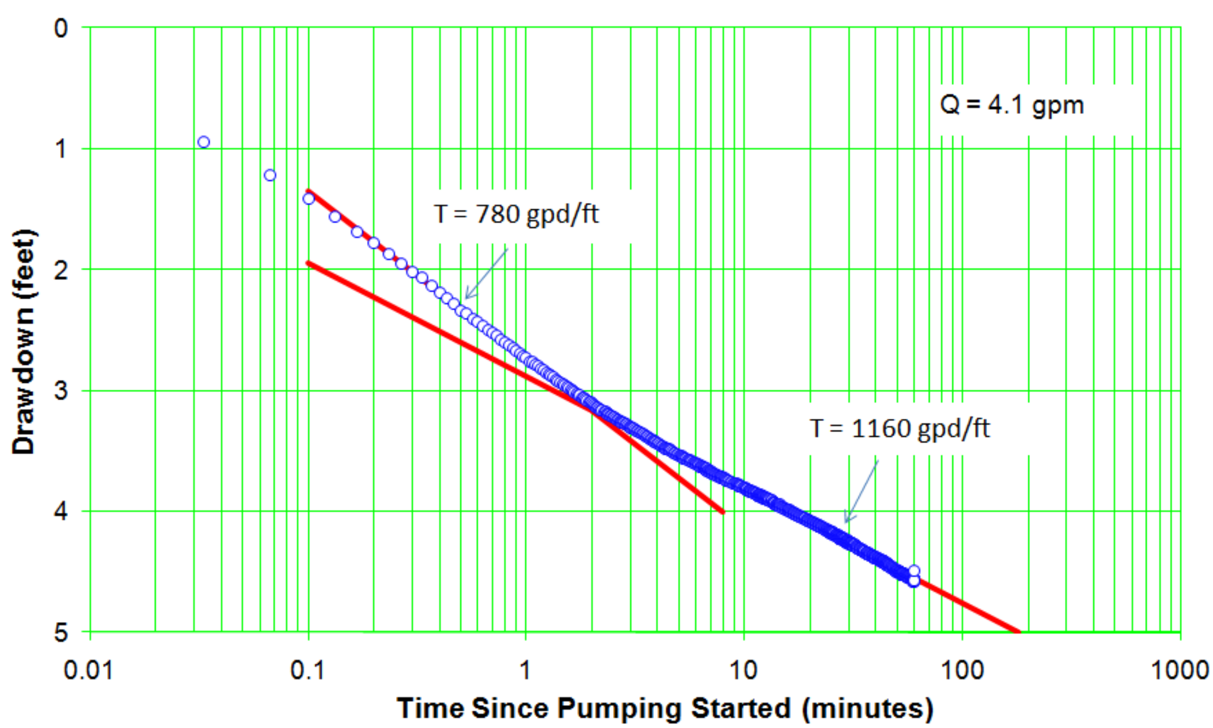


Figure E-8.1-1 Well R-51 screen 1, trial 1 drawdown

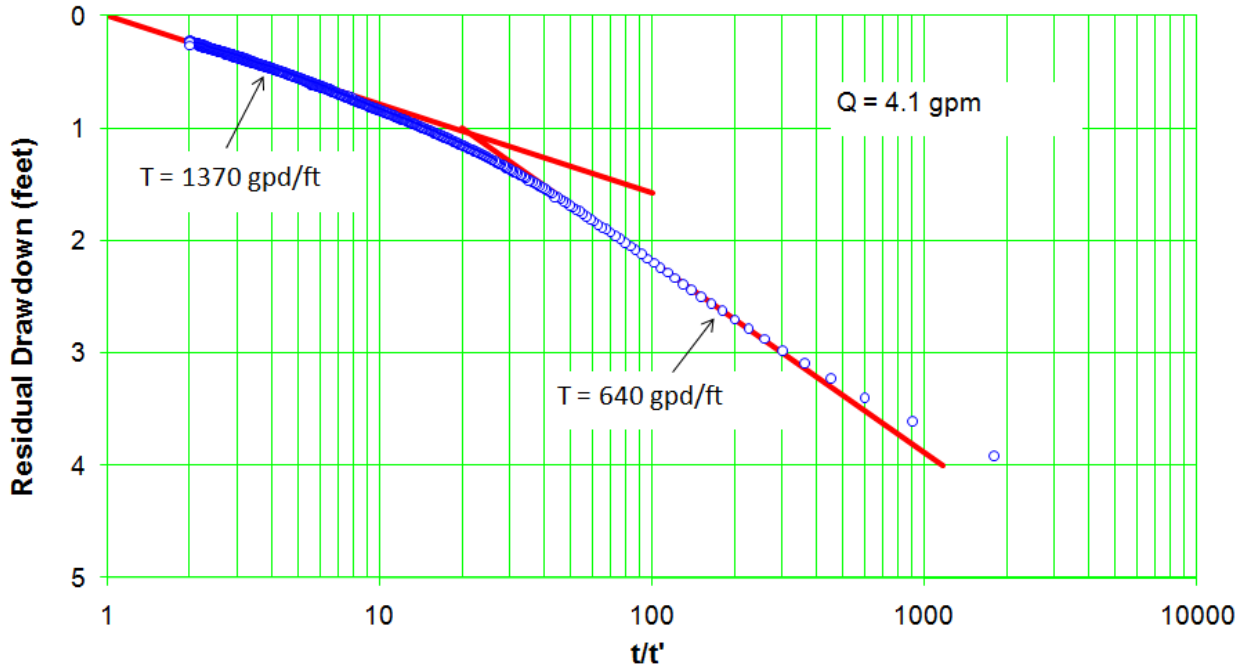


Figure E-8.1-2 Well R-51 screen 1, trial 1 recovery

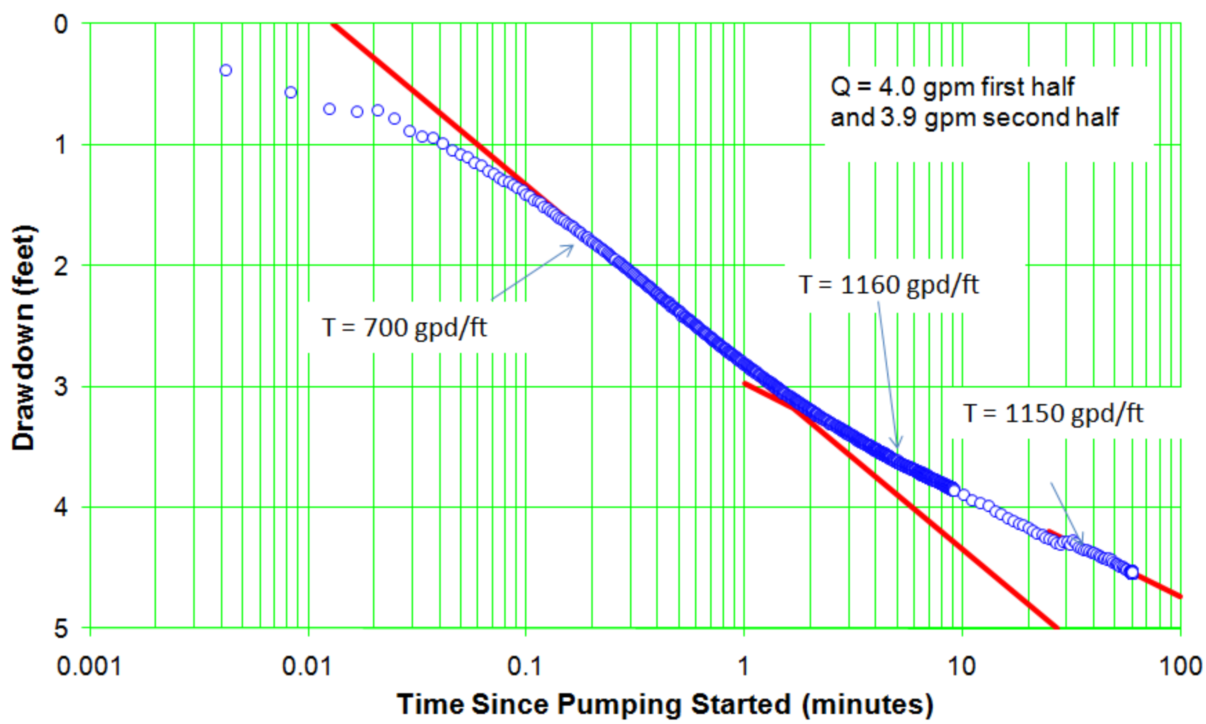


Figure E-8.2-1 Well R-51 screen 1, trial 2 drawdown

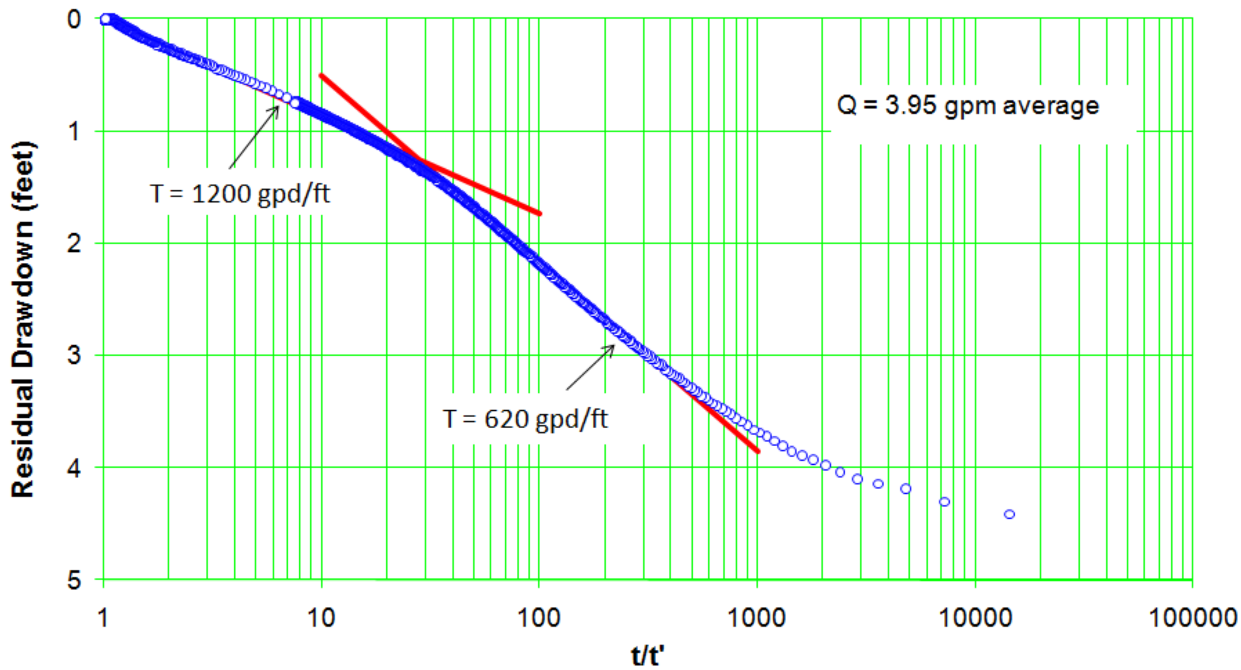


Figure E-8.2-2 Well R-51 screen 1, trial 2 recovery

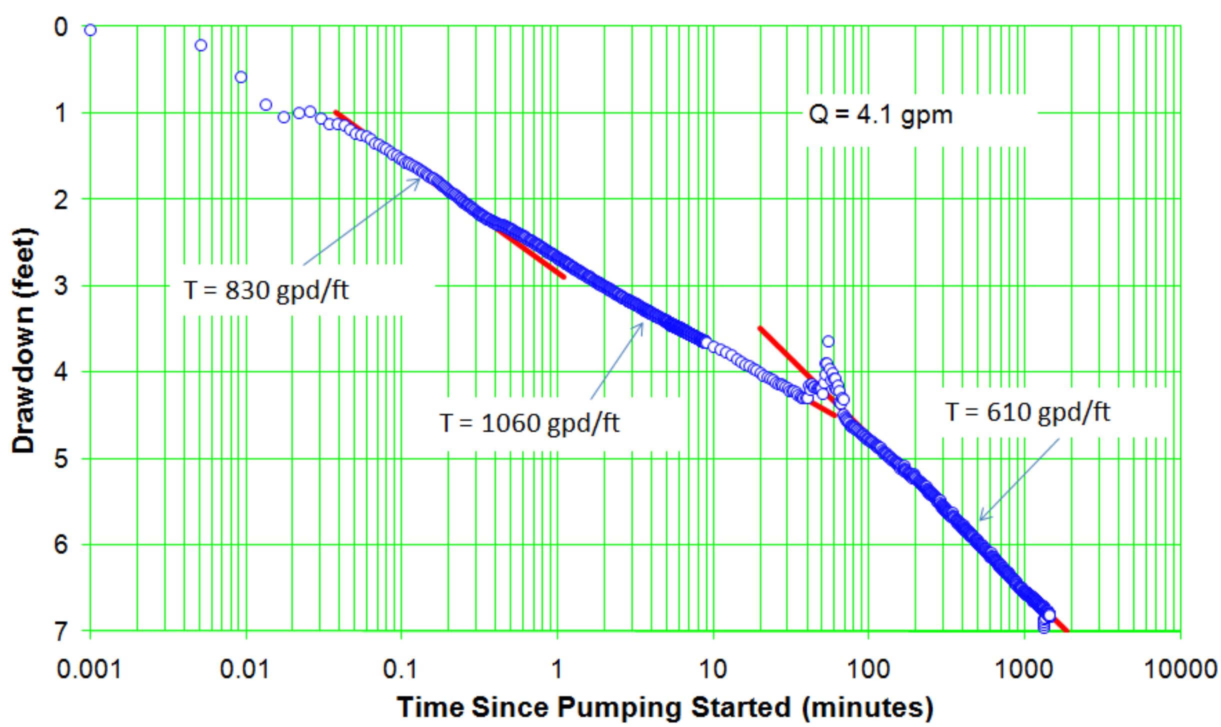


Figure E-8.3-1 Well R-51 screen 1 drawdown

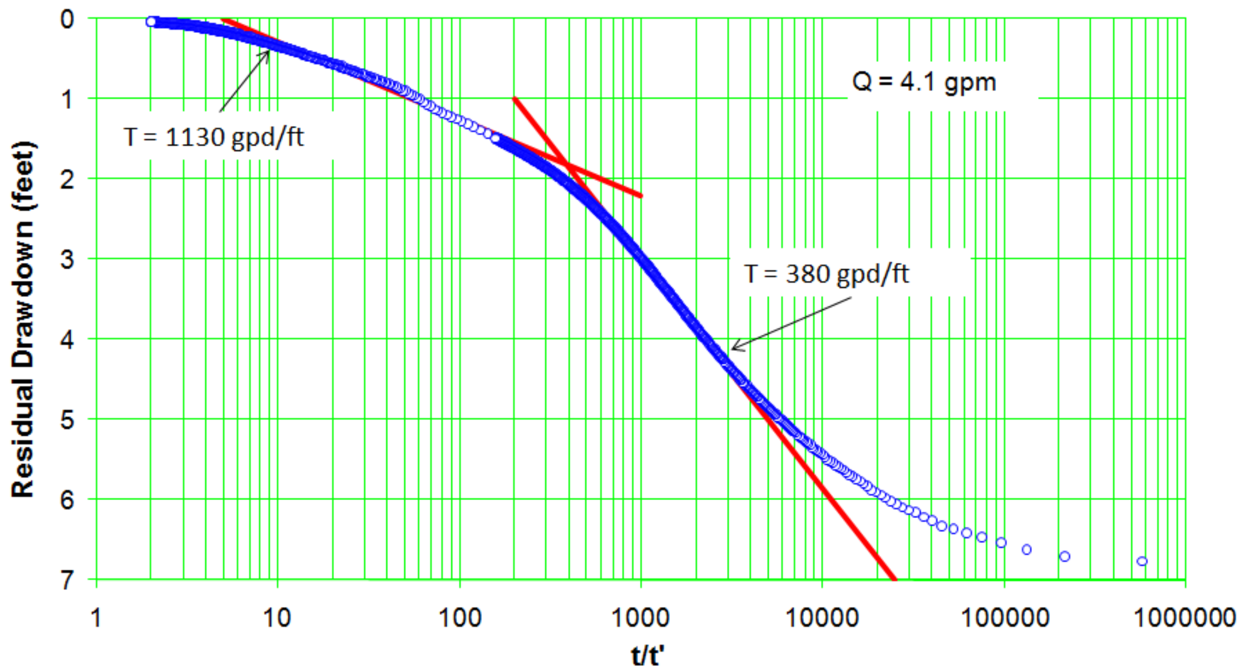


Figure E-8.3-2 Well R-51 screen 1 recovery

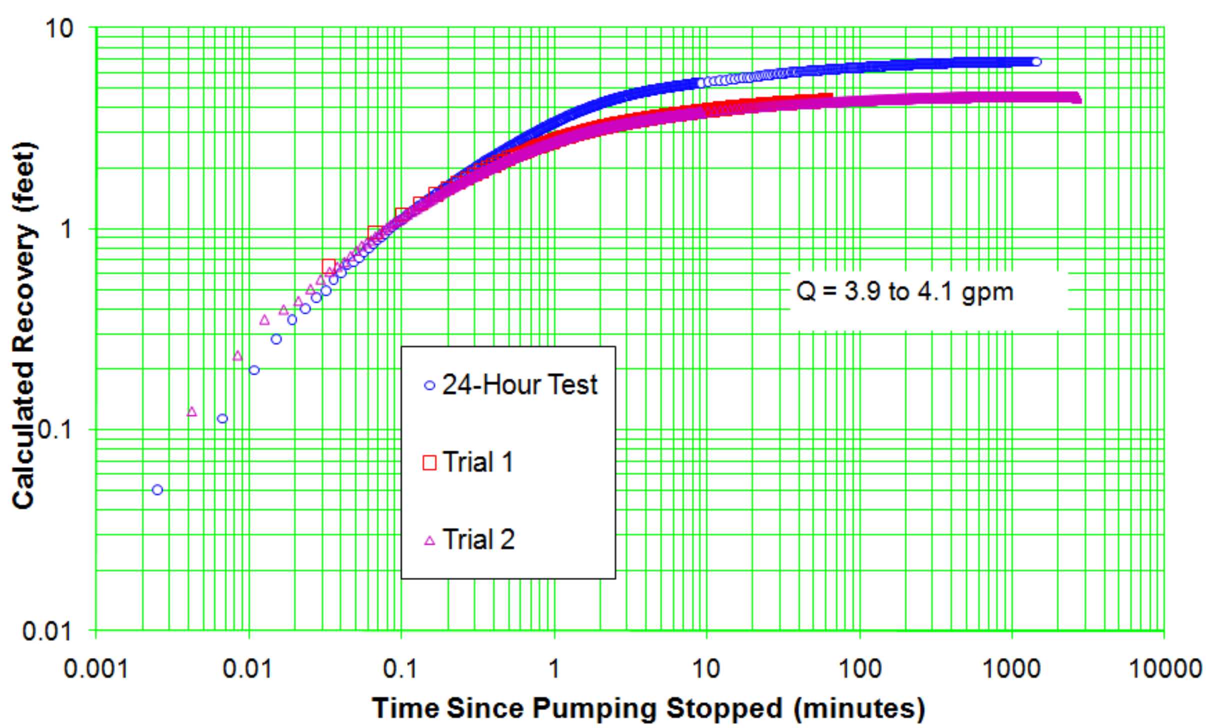


Figure E-8.4-1 Well R-51 screen 1 calculated recovery comparison for all tests

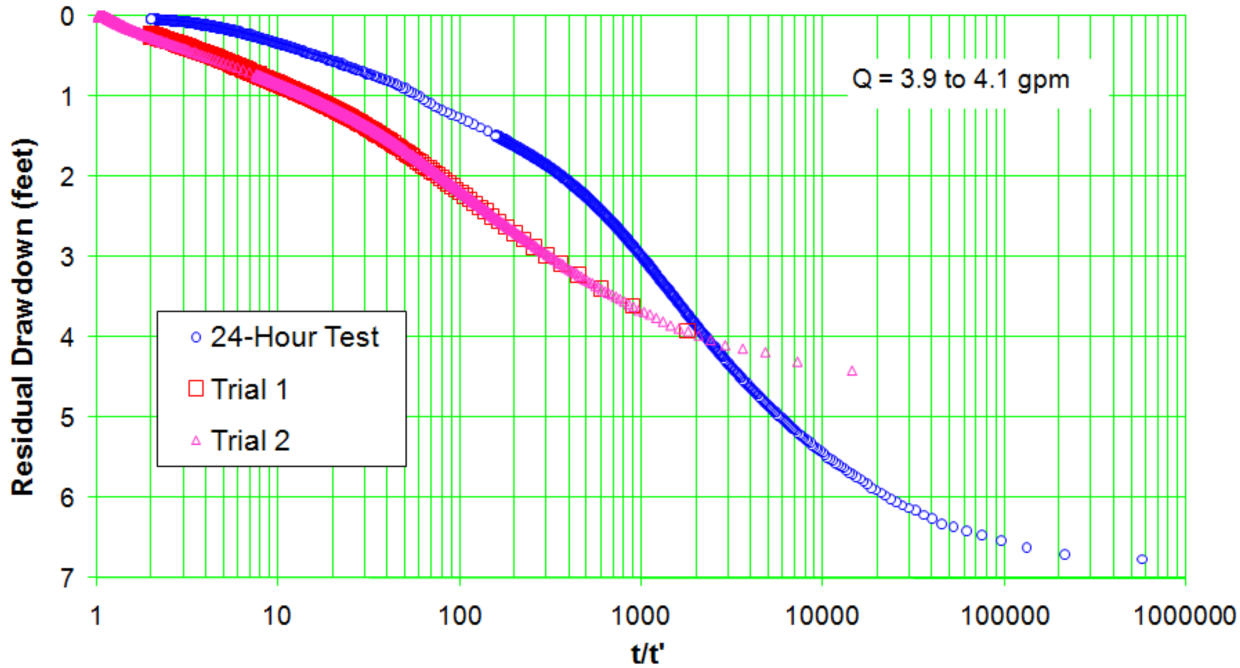


Figure E-8.4-2 Well R-51 screen 1 recovery comparison for all tests

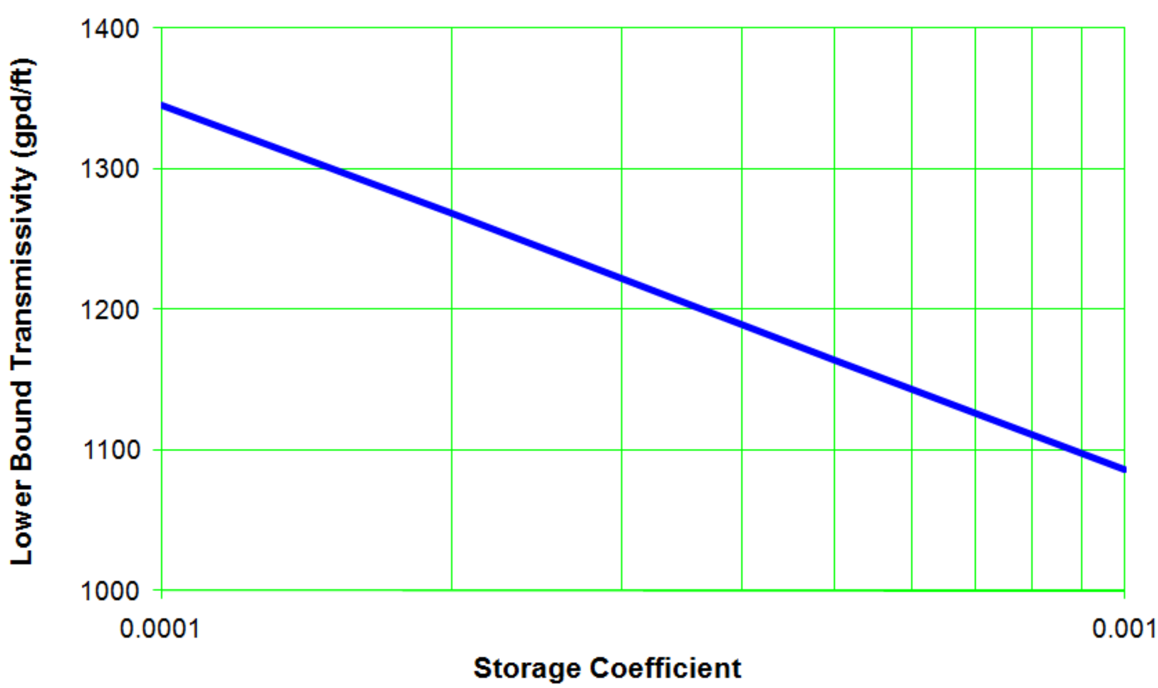


Figure E-8.5-1 Well R-51 screen 1 lower-bound transmissivity

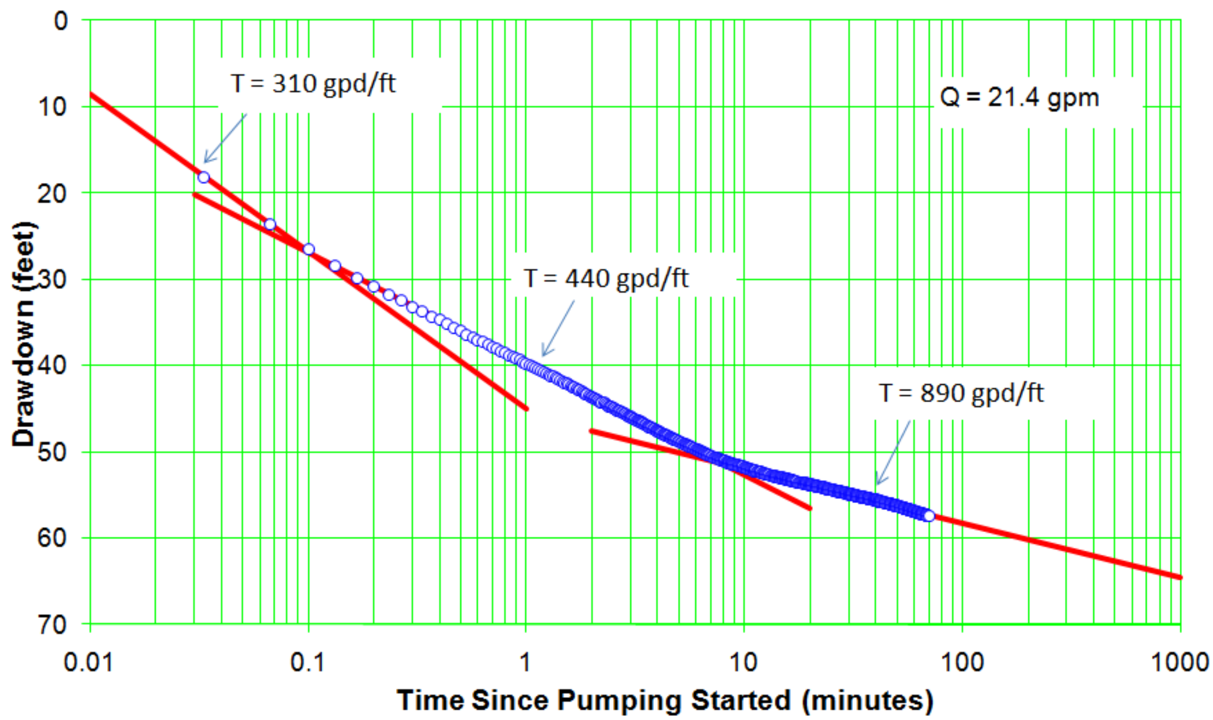


Figure E-9.1-1 Well R-51 screen 2, trial 1 drawdown

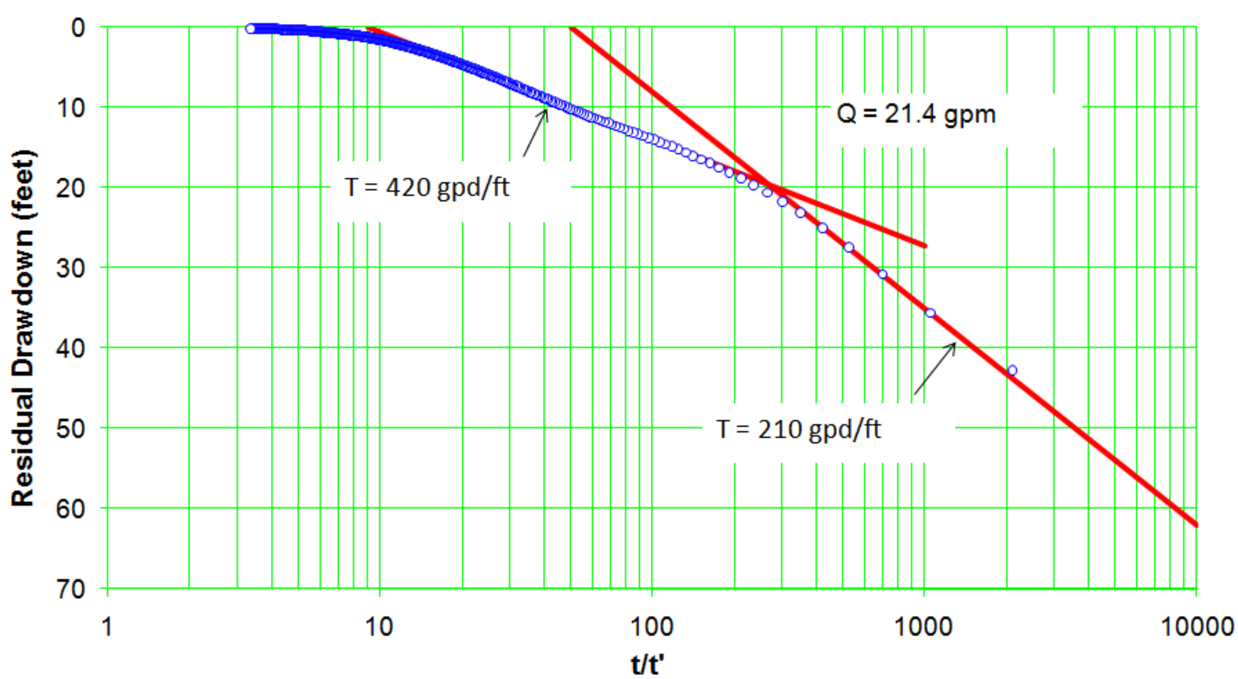


Figure E-9.1-2 Well R-51 screen 2, trial 1 recovery

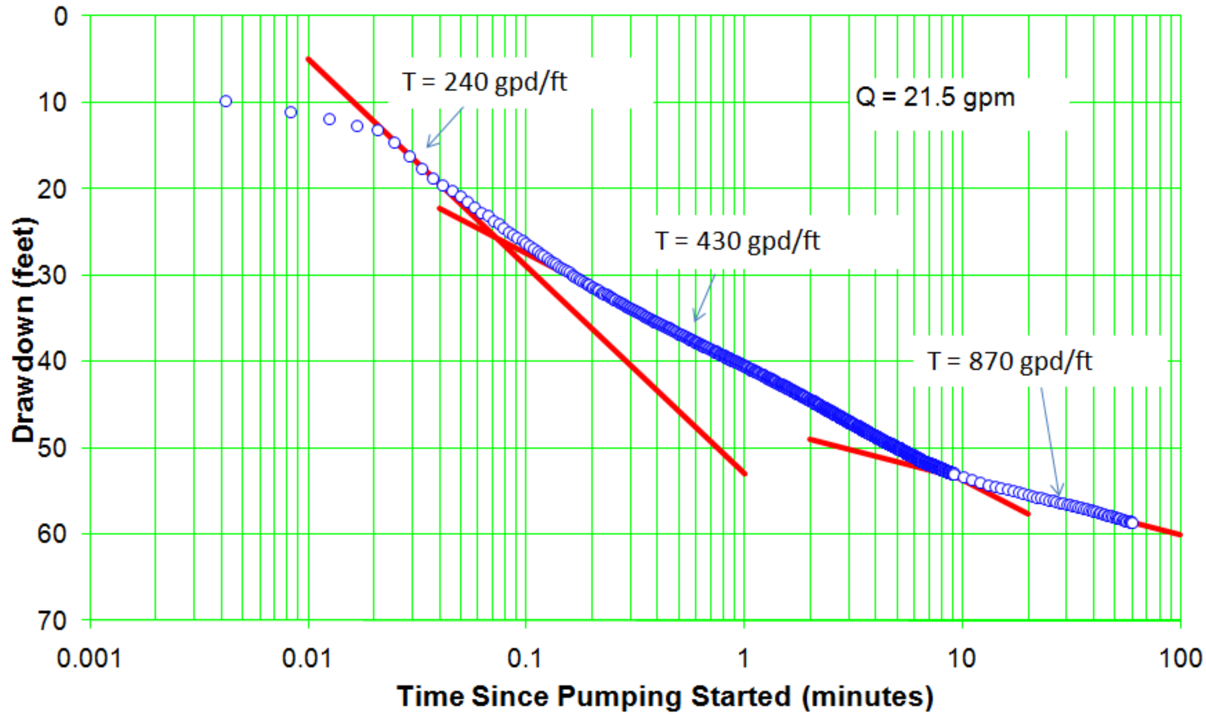


Figure E-9.2-1 Well R-51 screen 2, trial 2 drawdown

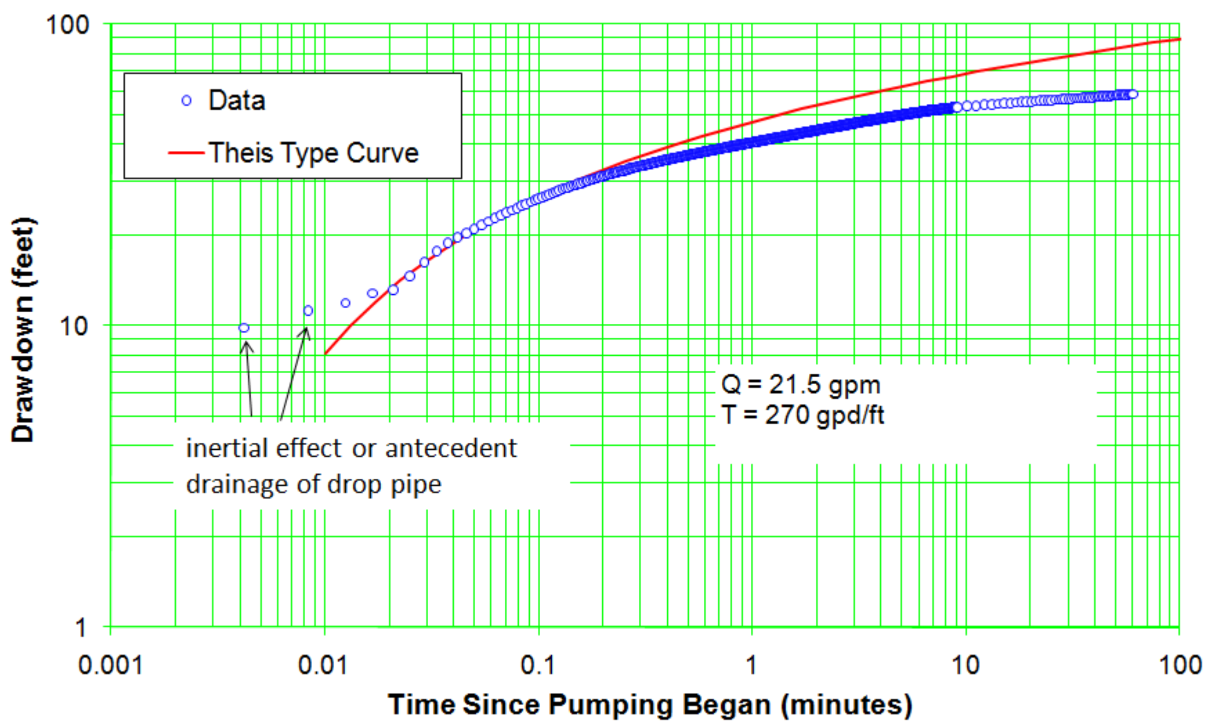


Figure E-9.2-2 Well R-51 screen 2, trial 2 drawdown – Theis analysis

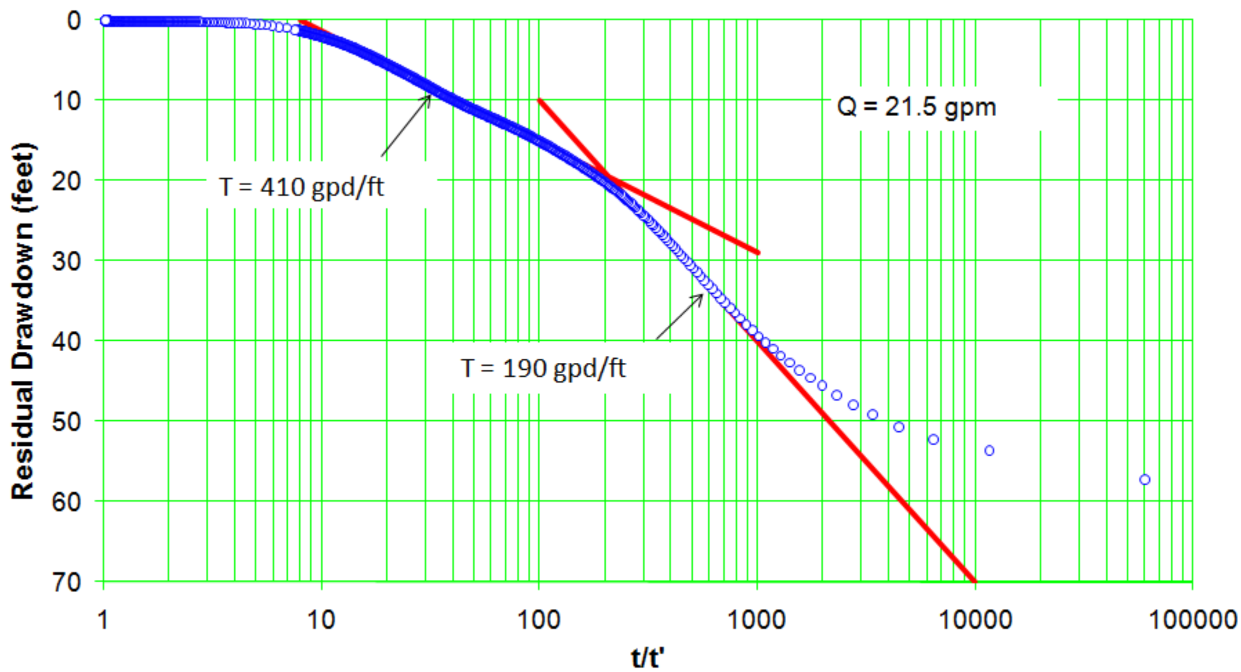


Figure E-9.2-3 Well R-51 screen 2, trial 2 recovery

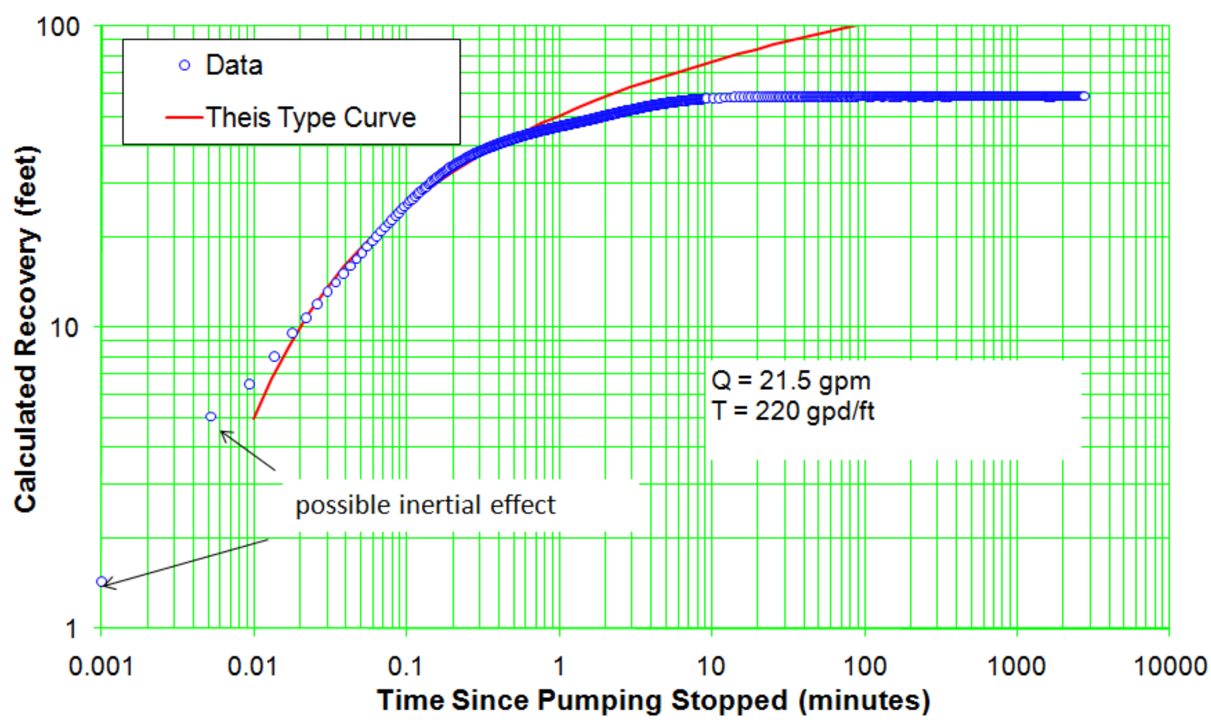


Figure E-9.2-4 Well R-51 screen 2, trial 2 recovery – Theis analysis

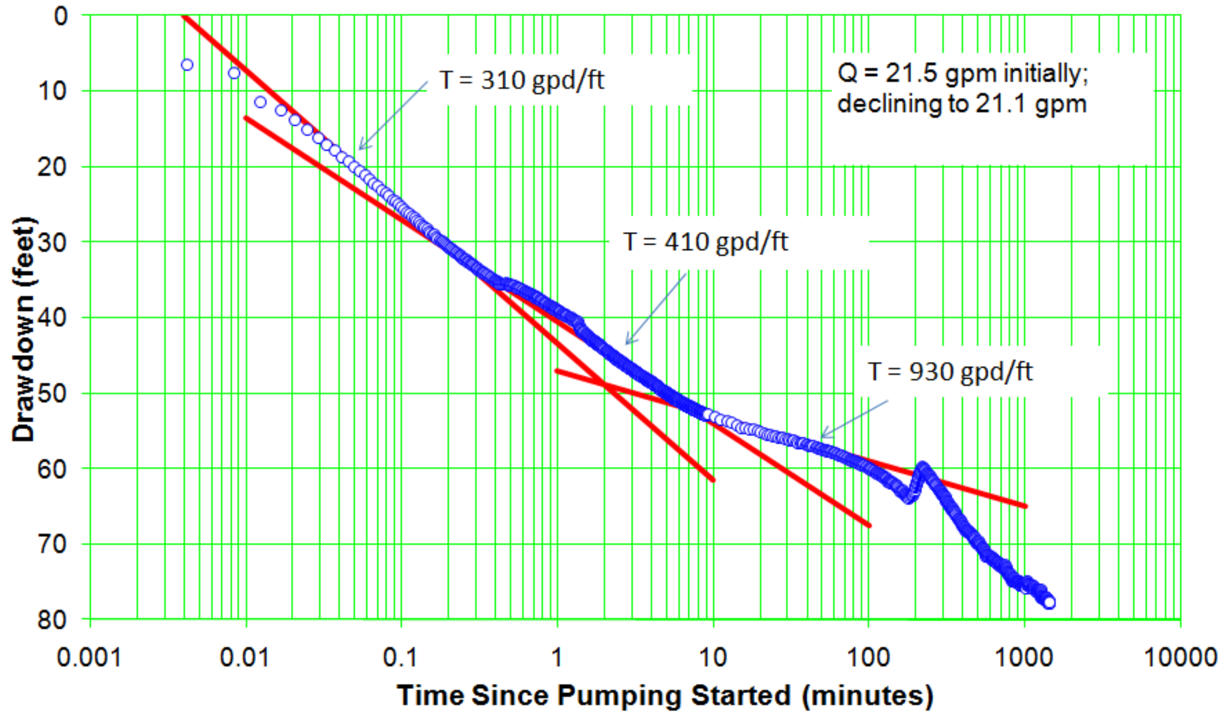


Figure E-9.3-1 Well R-51 screen 2 drawdown

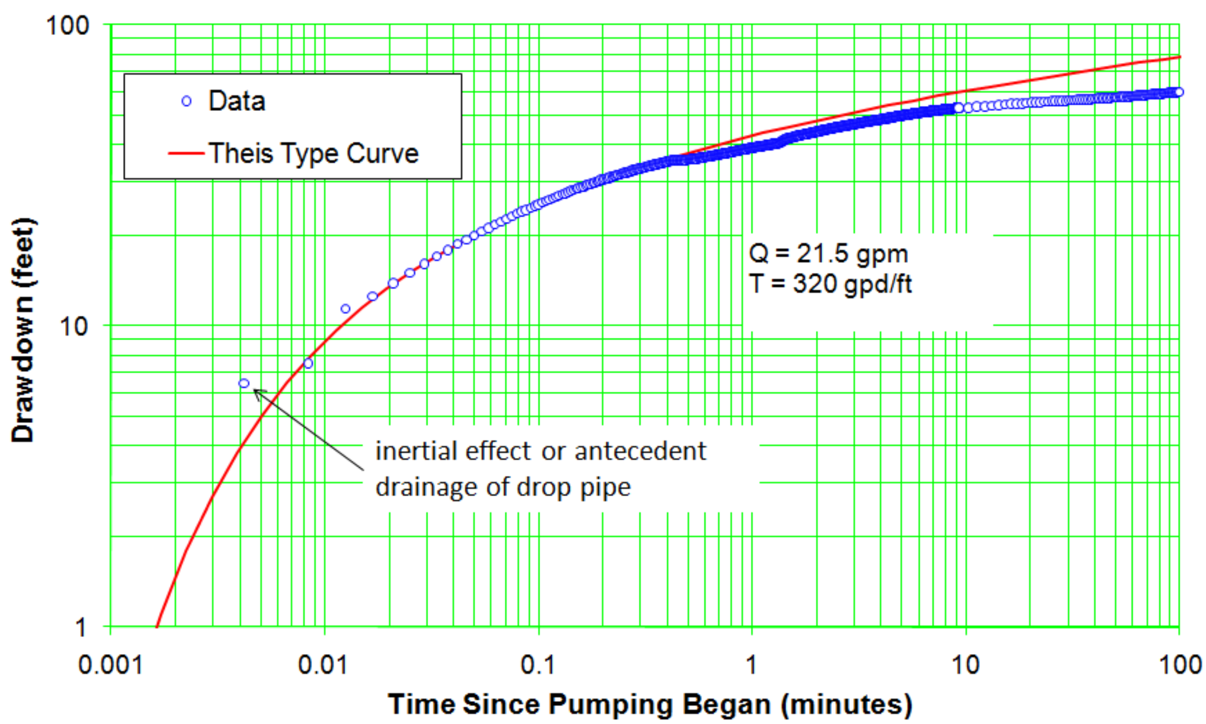


Figure E-9.3-2 Well R-51 screen 2 drawdown – Theis analysis

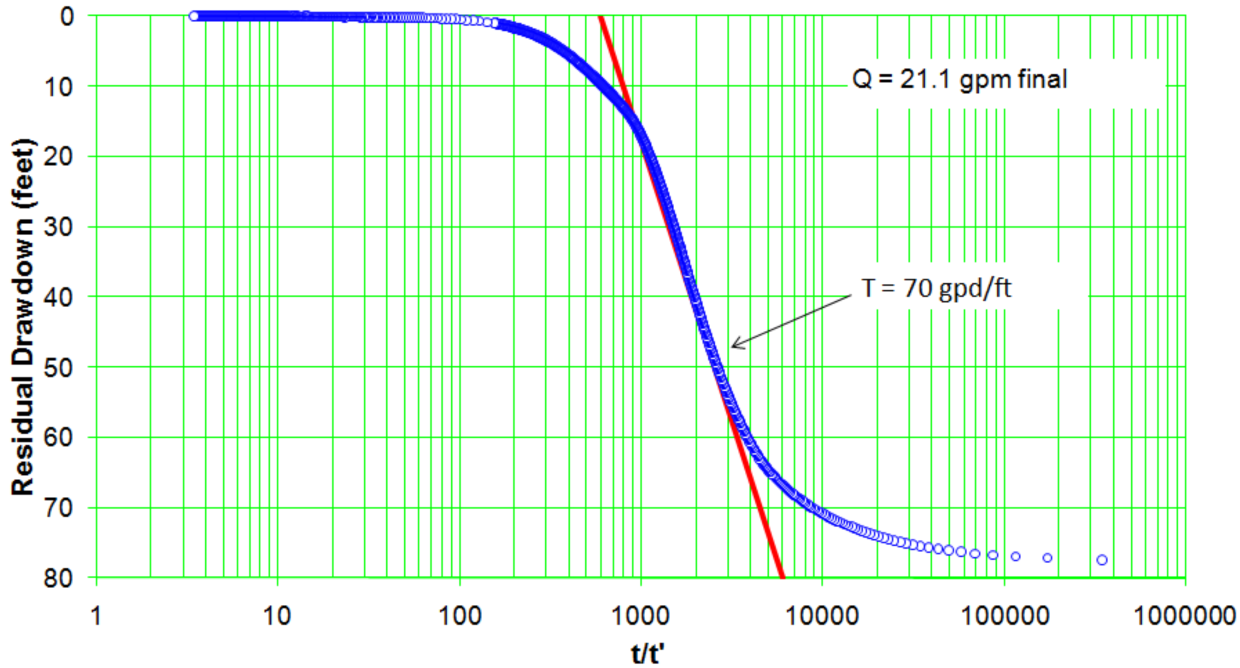


Figure E-9.3-3 Well R-51 screen 2 recovery

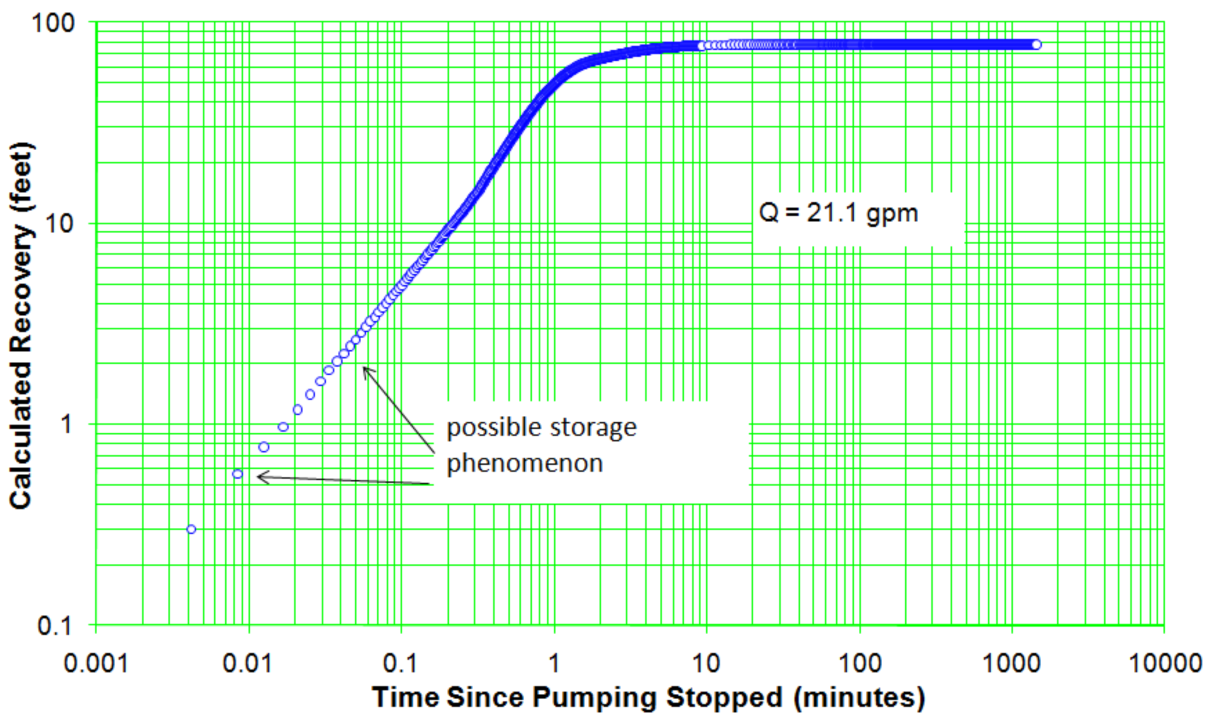


Figure E-9.3-4 Well R-51 screen 2 recovery – Theis analysis

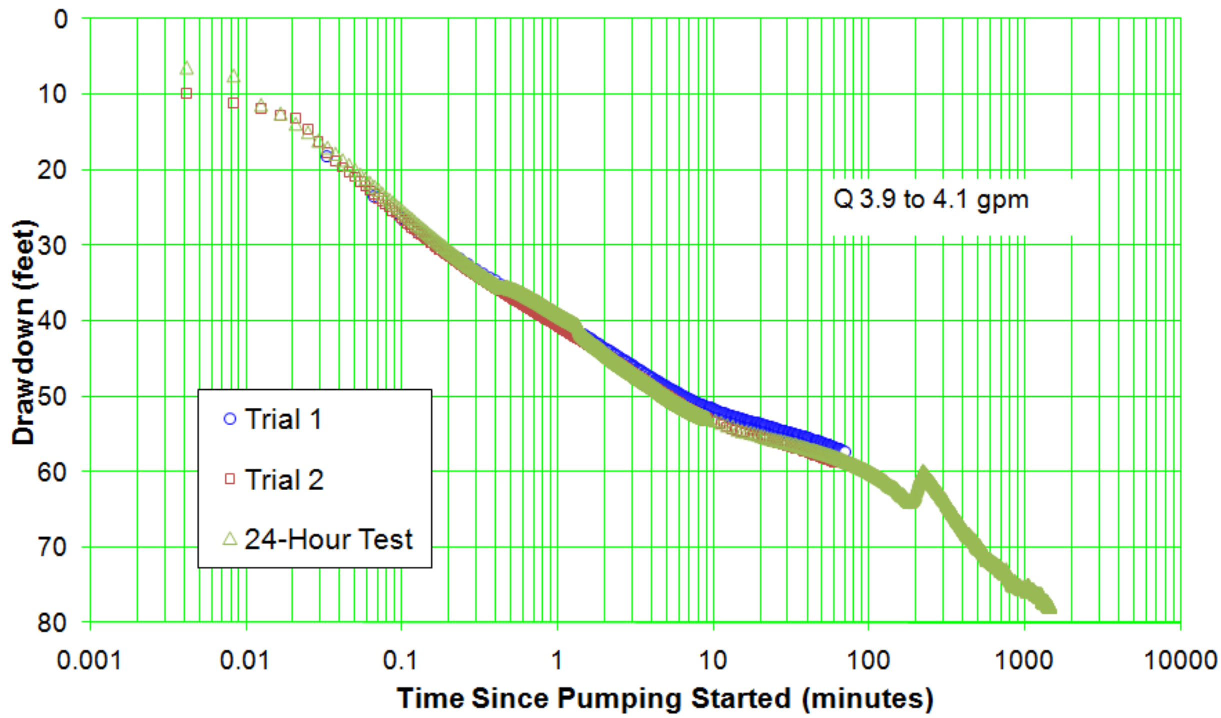


Figure E-9.4-1 Well R-51 screen 2 drawdown comparison for all tests

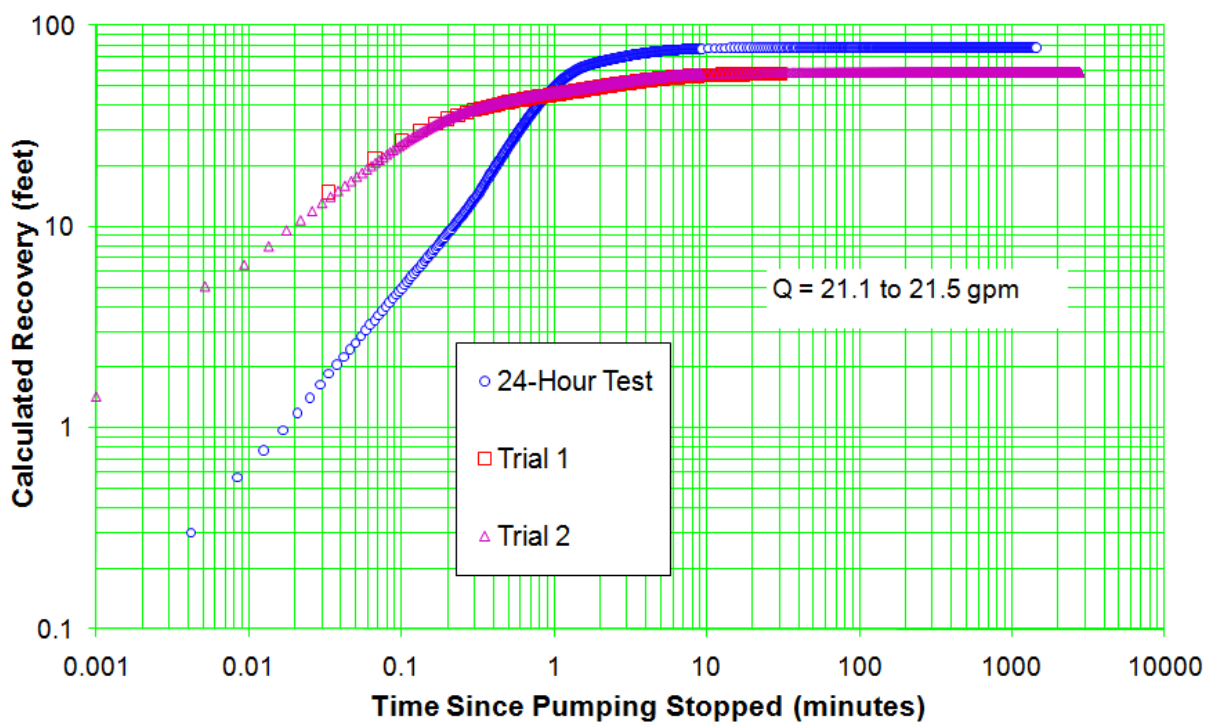


Figure E-9.4-2 Well R-51 screen 2 calculated recovery comparison for all tests

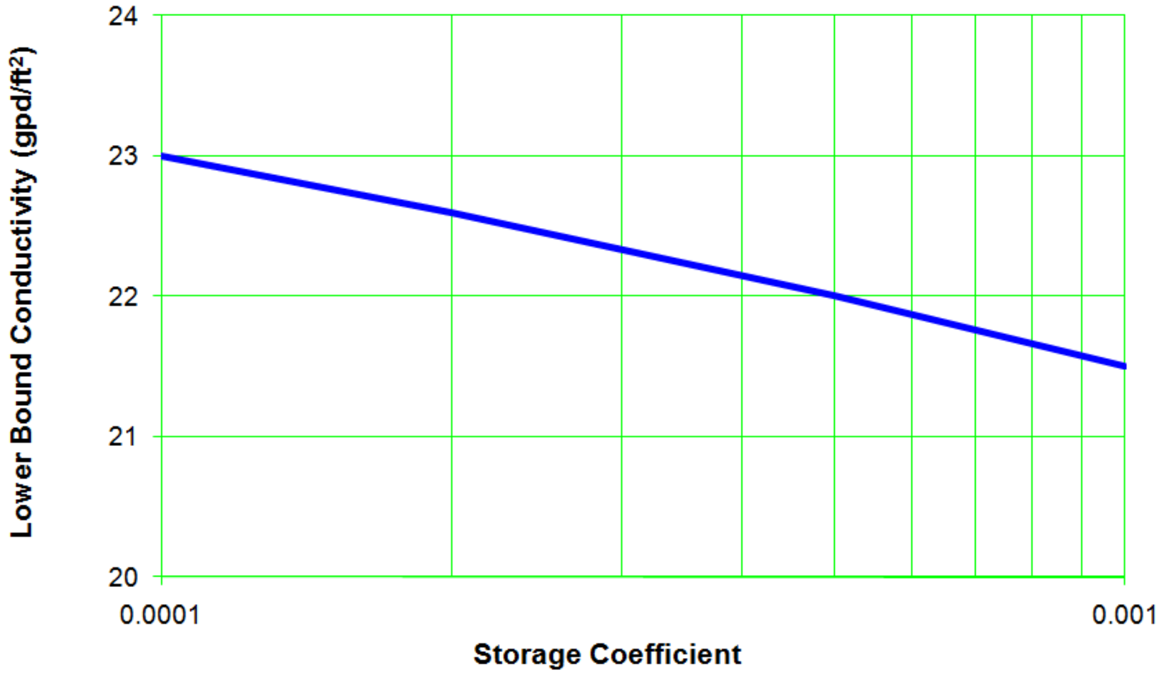


Figure E-9.5-1 Well R-51 screen 2 lower-bound hydraulic conductivity

Table E-8.5-1
R-51 Screen 1 Transmissivity

Test Data	T (gpd/ft)
Trial 1 Drawdown	1160
Trial 1 Recovery	1370
Trial 2 Drawdown	1160
Trial 2 Recovery	1200
24-h Drawdown	1060
24-h Recovery	1130
Average	1180

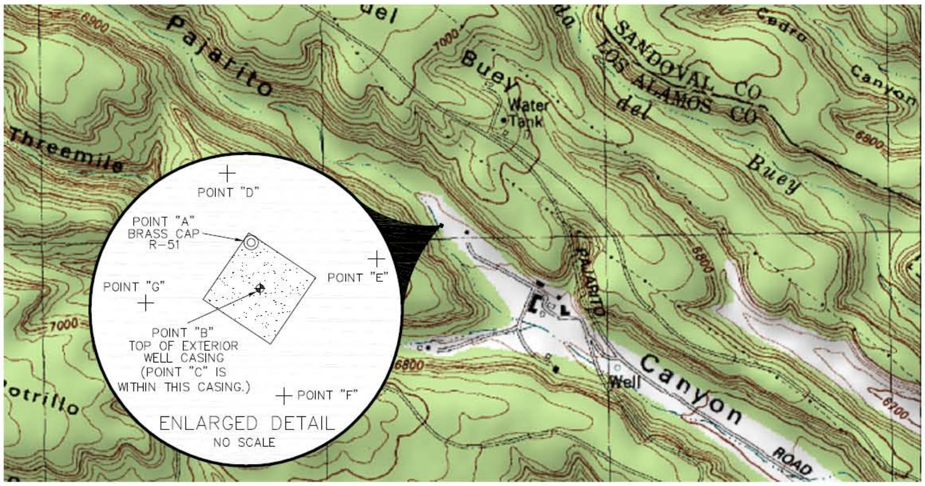
Table E-9.5-1
R-51 Screen 2 Early-Time Transmissivity

Test Data	Method	T (gpd/ft)
Trial 1 Drawdown	Cooper−Jacob	310
Trial 1 Recovery	Cooper−Jacob	210
Trial 2 Drawdown	Cooper−Jacob	240
Trial 2 Drawdown	Theis	270
Trial 2 Recovery	Cooper−Jacob	190
Trial 2 Recovery	Theis	220
24-hour Drawdown	Cooper−Jacob	310
24-hour Drawdown	Theis	320
Average		260

Appendix F

Survey Location Report

LANL MONITORING WELL LOCATION REPORT
DESIGNATED R-51
WITHIN TECHNICAL AREA 18
LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS COUNTY, NEW MEXICO
MAY, 2010



POINT	DESCRIPTION	EASTING (X)	NORTHING (Y)	ELEVATION
A	BRASS CAP R-51	1634685.79	1761983.36	6762.17
B	TOP OF 16" WELL CASING	1634686.85	1761977.63	6764.90
C	TOP OF 6" INNER CASING	1634686.87	1761977.68	6764.44
D	GROUND	1634682.85	1761991.90	6761.88
E	GROUND	1634701.32	1761981.33	6761.53
F	GROUND	1634689.89	1761964.35	6761.22
G	GROUND	1634672.75	1761975.90	6761.60

Notes

1.) FIELD SURVEY COMPLETED ON MAY 18, 2010.

2.) THIS AREA LIES WITHIN LOS ALAMOS NATIONAL LABORATORY PROPERTY IN TECHNICAL AREA 18, LOS ALAMOS COUNTY, NEW MEXICO.

3.) HORIZONTAL COORDINATES CALCULATED USING TOPCON HIPER+ RECEIVER AND ARE BASED UPON GPS LOCALIZATION DERIVED FROM LANL LAB WIDE CONTROL NETWORK MONUMENTS A0001, A0002, A0003, A0006, A0009, A0306, A1607, A1608, B0001, B0002, B0004, B3303, PAJ10, PAJ16, NMSR4 15 AND NMSR4 25. LANL LAB WIDE CONTROL NETWORK HORIZONTAL DATUM: NAD 1983.

4.) VERTICAL COORDINATES ARE BASED UPON GPS LOCALIZATION DERIVED FROM LANL LAB WIDE CONTROL NETWORK MONUMENTS A0003, A0006, A0306, A0602, A1607, A1608, B0001, B0004, B3303, BC1709, NMSR4-2, PAJ10, AND PAJ16. VERTICAL DATUM: NGVD 1929.

5.) HORIZONTAL COORDINATES ARE STATE PLANE GRID COORDINATES, NEW MEXICO CENTRAL ZONE, NAD 83.

AUTHORITY:
THIS MONITORING WELL LOCATION REPORT WAS PREPARED FROM A SURVEY DONE UNDER MY SUPERVISION ON THE 18TH DAY OF MAY, 2010 AND FROM INSTRUCTION PROVIDED TO US BY NORTHWIND, INC.

LARRY W. MEDRANO, N.M.P.L.S. NO. 11993

DATE *05/20/2010*

LARRY W. MEDRANO
NEW MEXICO
11993
REGISTERED PROFESSIONAL SURVEYOR

PRECISION SURVEYS, INC. 1460 TRINITY DRIVE, SUITE 3 LOS ALAMOS, N.M. 87544 **PHONE** (505) 661-4262 **FAX** (505) 661-4263