Work Plan for Redevelopment of Monitoring Well R-61

Introduction	This work plan describes the planned redevelopment of the regional aquifer monitoring well R-61, located on the mesa top to the south of Mortandad Canyon within Los Alamos National Laboratory's (LANL or the Laboratory) Technical Area 05 (TA-05) in Los Alamos County, New Mexico (Figure 1). Well R-61 was drilled in 2011 to a total depth of 1265 ft using fluid-assisted air-rotary techniques with casing advance (LANL 2010, 110998; TerranearPMC 2011, 201256). The well was completed with two screened intervals in the regional aquifer and a dedicated dual-valve Baski sampling system was installed in the well. Figure 2 shows the as-built well construction diagram of monitoring well R-61 along with the borehole lithology and technical details of well completion. Figure 3 shows the as-built technical notes for monitoring well R-61, and Figure 4 shows the dedicated pump performance curve for monitoring well R-61.
Background	The first round of samples was collected from well R-61 in May 2011, at the end of the aquifer tests conducted in each screen shortly after well construction and development. Water-quality samples from screen 1, collected on May 20, 2011, showed the presence of chromium, nitrate, and perchlorate at concentrations exceeding background for the regional aquifer; the filtered chromium concentration was 16.8 µg/L. Analytical data indicate this chromium is hexavalent chromium. The same three constituents were detected within the range of regional background in samples collected from screen 2 on May 24, 2011; for example, the chromium concentration in the filtered sample was 2.2 µg/L, whereas the background value for chromium in the regional aquifer is 10.6 µg/L (LANL 2011, 207447). Concentrations of other water-quality parameters in both screens were generally similar to those in groundwater background. Samples collected from both screens contained dissolved oxygen (DO) exceeding 5 mg/L and total organic carbon (TOC) concentrations less than 1 mg/L. These values are within the normal range for these constituents in the regional aquifer. Following installation of the Baski sampling system on July 26 and July 28, 2011, chromium concentrations were below minimum detection limits in filtered water samples from the two screens. Water samples from both screens contained highly elevated concentrations of iron and manganese; in the absence of detectable concentrations of aluminum, this combination generally indicates reducing conditions. Reducing conditions in both screened intervals are also indicated by the low DO concentrations (≤2 mg/L) measured at the end of purging each screen. Compared with the May 2011 samples, TOC concentrations in July increased to 10 mg/L in screen 1 and 15 mg/L in screen 2. An organic odor was noted throughout purging. Nitrate and perchlorate were still detected in both screens but at lower concentrations than in the previous samples. Water quality in subsequent samples has been similar to that of the samples collected after the Baski system was installed. Two sets of extended-purge events conducted in November 2011 and February 2012 yielded filtered chromium concentrations of ≤3.3 µg/L in screen 1 (i.e., considerably lower than the initial concentration of 16.8 µg/L). Chromium in filtered samples from screen 2 was generally below detection. The significantly lower chromium concentrations detected in recent samples from both screens suggest the chromium may have precipitated out within the formation and filter pack as a result of the reducing conditions within the well. Water quality in both well screens continued to show low DO concentrations and elevated iron and manganese concentrations throughout purging. Nitrate and perchlorate remained above detection limits, and concentrations in samples collected after purging 6 casing volumes (CVs) are similar to those in samples collected at the end of the aquifer tests. This observation suggests reducing conditions may be relatively localized next to the screened intervals, and these conditions do not extend very far into the formation. The cause of the observed conditions in well R-61 is uncertain. Inspection of the raw mass spectra for volatile organic compound and semivolatile organic compound analyses suggests the presence of a complex mixture of heavy organic compounds with very low water solubility. It is suspected that this material may serve as a carbon source for microbial activity in the well. The increasing levels of microbial activity may have caused reducing conditions in both well screens, along with elevated iron and manganese.

Background (continued)	Biological activity reaction test kits were used to test for the presence of iron-reducing bacteria and slime-forming bacteria in the water. The test results revealed the presence of iron-reducing bacteria and slime-forming bacteria in samples collected throughout the purge sequence from each screen, starting with clearing the drop pipe and extending to purging 2 CVs. The test reaction patterns were consistent with the observed reducing environment in both screens and indicated moderate to high populations of mixed anerobes, pseudomonads, and enteric bacteria are present in the well screens. Water-level data collected during recent sampling events at R-61 suggest declining yield, as indicated by increased drawdown, in screen 1, but not in screen 2.
Technical Approach	Redevelopment of well R-61 is the recommended approach to address the reducing conditions in both well screens. Redevelopment will include (1) physical redevelopment methods using swabbing, surging, jetting, and pumping techniques and (2) chemical treatment using a sequence of Johnson Nu-Well treatment products as described below. The following steps describe the general sequence of activities that will be followed during redevelopment of R-61. *Baski Sampling System Removal* Short-term step tests will be conducted before well redevelopment to determine the specific capacity of each screened interval. The results will be used to estimate the cross-flow between screens 1 and 2 that will occur when the Baski sampling system is removed and will be used to assess the overall effectiveness of the redevelopment effort. Pumping during the step tests will also remove water containing excess iron in solution and solids, potentially facilitating the chemical treatment described below. Water samples will be collected for on-site chemical analysis at the Geochemistry and Geomaterials Research Laboratory (GGRL). Samples will be collected at the beginning, the middle, and the end of the step test in each screen. Analytical data from these samples will be used as a baseline for tracking the effectiveness of the redevelopment activities and for removing chemical products introduced into the well during rehabilitation. Following specific capacity testing, pressure data will be downloaded from the R-61 transducers, and the R-61 Baski sampling system and transducers will be removed. The Baski system components will be inspected for abnormalities or visual indicators of contamination, corrosion, damage, or biofouling. Following the inspection, all system components will be decontaminated by high-pressure washing and will be air-dried, wrapped, and stored on-site. *Downhole Video Logging* The R-61 borehole will be video-logged to document well screen and casing conditions. Well components (screen slot openings, filter pack, and screen joints) will be examined for potential signs of mineral encrustation and biofouling. The video logging results will be evaluated to determine the extent of potential well plugging. *Chemical Treatment and Redevelopment* The Laboratory proposes to use a sequence of chemical well rehabilitation agents, specifically Nu-Well chemical products developed by Johnson Screens, to remove biofilm and/or mineral accumulations and to break down any potential residual organic compounds within and surrounding the well screens and filter pack. Three different applications per screen are proposed in a sequence designed to remove the deposits resulting from biofilm and mineral blockage and residual hydrocarbons and to restore representative conditions within and surrounding each well screen. The sequence will consist of (1) applying a biocaustic dispersant (potassium hydroxide [KOH] and Nu-Well 320 biocaustic dispersant); (2) applying a bioacid polymer to break down biofilm and disperse mineral salts (Nu-Well 120 liquid acid and Nu-Well 310 bioacid dispersant); and (3) sanitizing the well screen and filter pack using Nu-Well 410 chlorine enhancer.

Technical Approach (continued)	These chemicals were selected in close consultation with Johnson Screens technical staff, who are experts in the field of well rehabilitation. The chemicals were selected with a primary objective of safely restoring representative conditions within the well screens and filter packs, while minimizing the risk of damage to the well screen and filter pack. During each step of chemical rehabilitation, the two screens will be hydraulically isolated using a straddle-packer system. Each well screen will be swabbed, surged, and/or jetted to ensure the chemical treatment agents are dispersed throughout the filter pack and the near-screen formation materials. The chemical solution will also be recirculated at intermittent intervals to ensure the solution permeates the filter pack and nearby formation materials and provide physical agitation to loosen potential biofilm in the well. Field parameters (including pH) and chlorine will be monitored to ensure sufficient chemical treatment agent has been added. During each step, the chemical treatment agents will remain in contact with the filter pack and nearby formation for a minimum of 12 to 24 h. Additional agitation of the introduced chemicals will be conducted during this period. Following the contact period, each screen will be pumped to completely remove the spent chemical agent mixture before the next chemical additive is introduced. Field parameters will be monitored during pumping to assess how effectively the residual chemical agents are removed, and pumping will continue until pH levels are within the normal range for the screen. *Final Pumping (Clean Up) and Time-Series Sampling* Both well screens will be pumped to remove all residual chemical agents and to restore geochemical conditions to representative conditions. The pumping rate will be determined based on the hydraulic properties of each screen, primarily specific capacity data measured during step testing. At a minimum, the quantity of water pumped will be sufficient to remove the introduced chemical treatment agent and the calculated cross-flow between screens 1 and 2 during redevelopment. During pumping, discharge will be monitored for pH, temperature, conductivity, oxidation/reduction potential, and DO using a flow-through cell and a YSI 556 MPS multiparameter meter, or equivalent, unit. Turbidity will be measured using a Hach 2100P turbidimeter or equivalent unit, and dissolved iron will be measure using a Hach test kit to provide real-time data. Chlorine will be monitored using a colorimetric test kit, free chlorine test strips, or equivalent. Time-series samples will be collected every 2 h during pumping to monitor key indicators for removing the introduced chemical treatment agents and for stable DO measurements. Samples will be analyzed at GGRL for anions, metals, TOC, alkalinity, pH, sulfide, and total suspended solids. Field parameters, chlorine data, and time-series data will be evaluated to assess the effectiveness of the well redevelopment activities and the geochemical conditions in each screen. Redevelopment activities at either screen may be terminated if field parameters and time-series water-quality data show inadequate progress for yielding representative and stable water-quality parameters. The New Mexico Environment Department (NMED) will be consulted if field parameters and time-series data indicate additional redevelopment or other actions are needed. *Post-Treatment Video Logging and Baski Sampling System Reinstallation* Once the field parameter, chlorine, and time-series data indicate the water quality in each screen is representative and no residual chlorine remains in either screen, the pump/packer assembly will be removed, and a well video log will be made to document the well condition and to compare it with the video log made before well redevelopment. The Baski sampling system will then be reinstalled, and the Baski pump will be used to remove any cross-flow that may have occurred between screens after the redevelopment tools were removed and the Baski sampling system was reinstalled. Time-series samples will be collected every 2 h during pumping to monitor key indicators for removing cross-flow and for stable geochemical conditions. The samples will be analyzed at GGRL for anions, metals, TOC, alkalinity, and pH. Data from these samples will be used as the basis for identifying any rebounding of nonrepresentative water-quality parameters in future samples.

Waste Management	All fluids produced during redevelopment and purging will be managed in accordance with the NMED-approved "Notice of Intent to Discharge" Decision Tree.
Schedule	Redevelopment of R-61 is anticipated to be complete by September 30, 2012, assuming personnel and a pump hoist rig are available to support this completion date and all regulatory permitting requirements have been met. An R-61 well redevelopment summary report will be prepared within 150 d following completion of field activities. The report will document field activities, redevelopment, and sampling activities and will contain an as-built drawing of the final well configuration and sampling system.

REFERENCES

The following list includes all documents cited in this plan. 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), October 2010. "Drilling Work Plan for Regional Aquifer Well R-61," Los Alamos National Laboratory document LA-UR-10-6970, Los Alamos, New Mexico. (LANL 2010, 110998)

LANL (Los Alamos National Laboratory), November 2011. "Groundwater Background Investigation Report, Update to Revision 4," Los Alamos National Laboratory document LA-UR-11-6228, Los Alamos, New Mexico. (LANL 2011, 207447)

TerranearPMC, March 2011. "Drilling Plan for Regional Aquifer Well R-61," plan prepared for Los Alamos National Laboratory, Los Alamos, New Mexico. (TerranearPMC 2011, 201256)

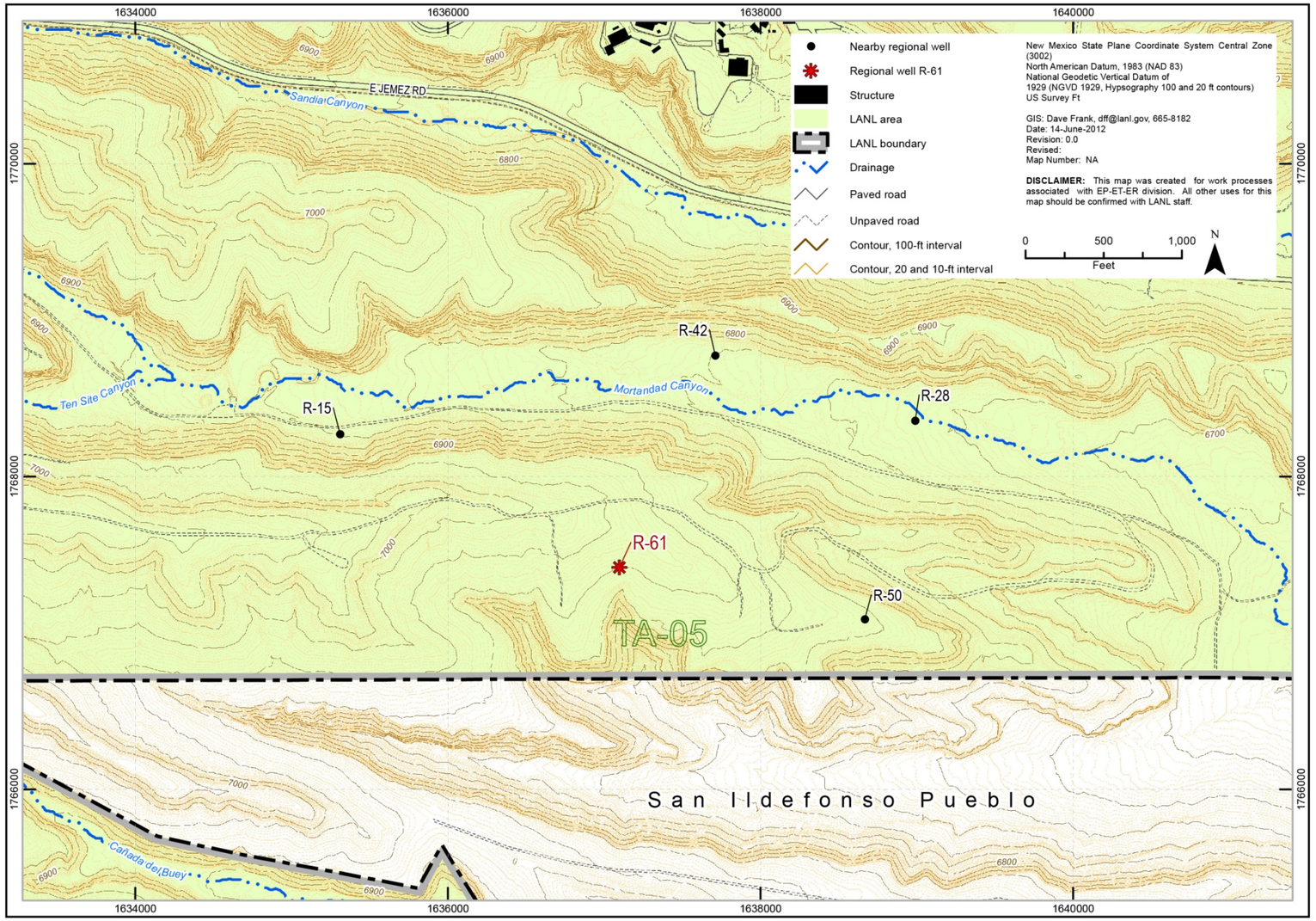


Figure 1 Location of well R-61

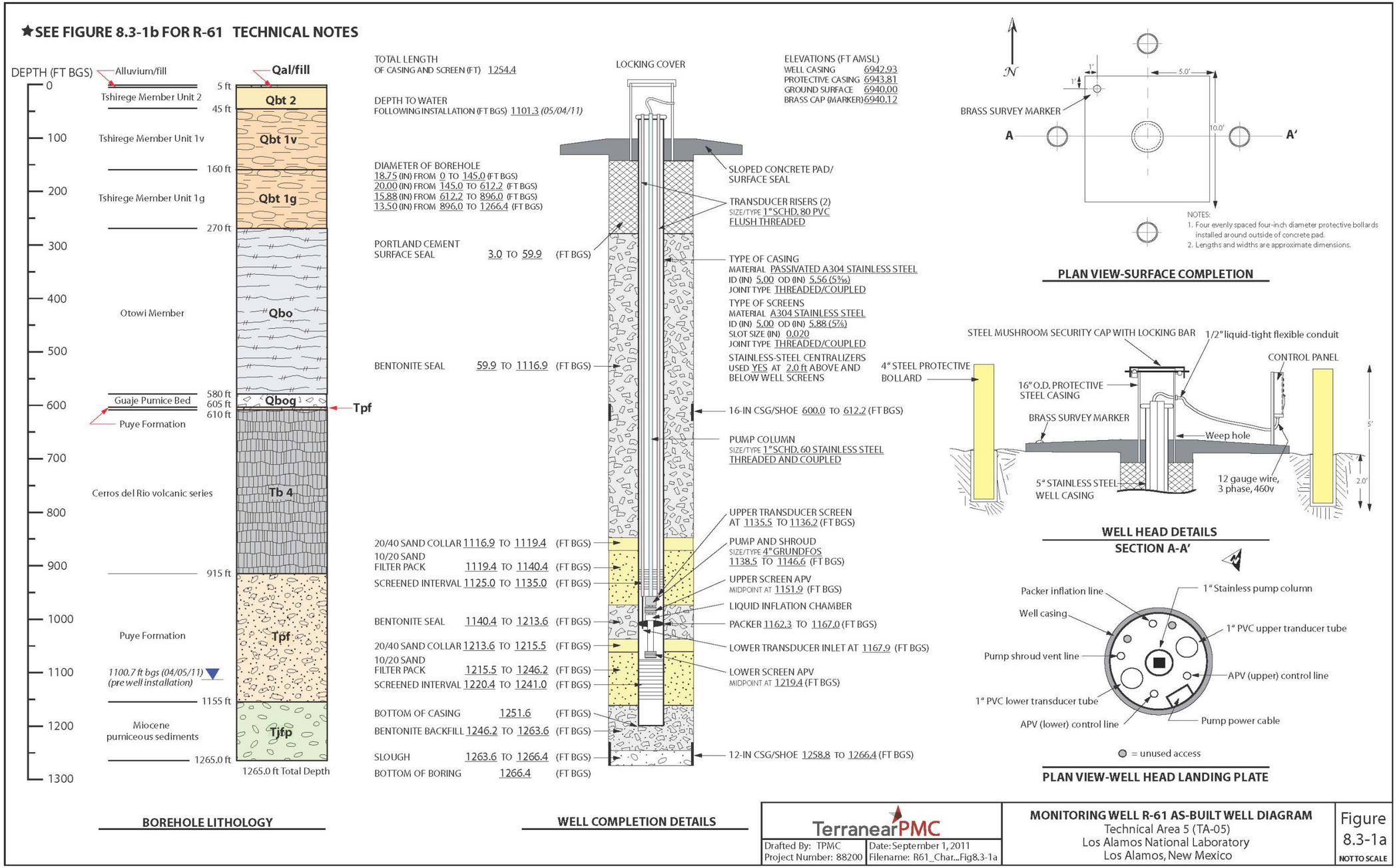
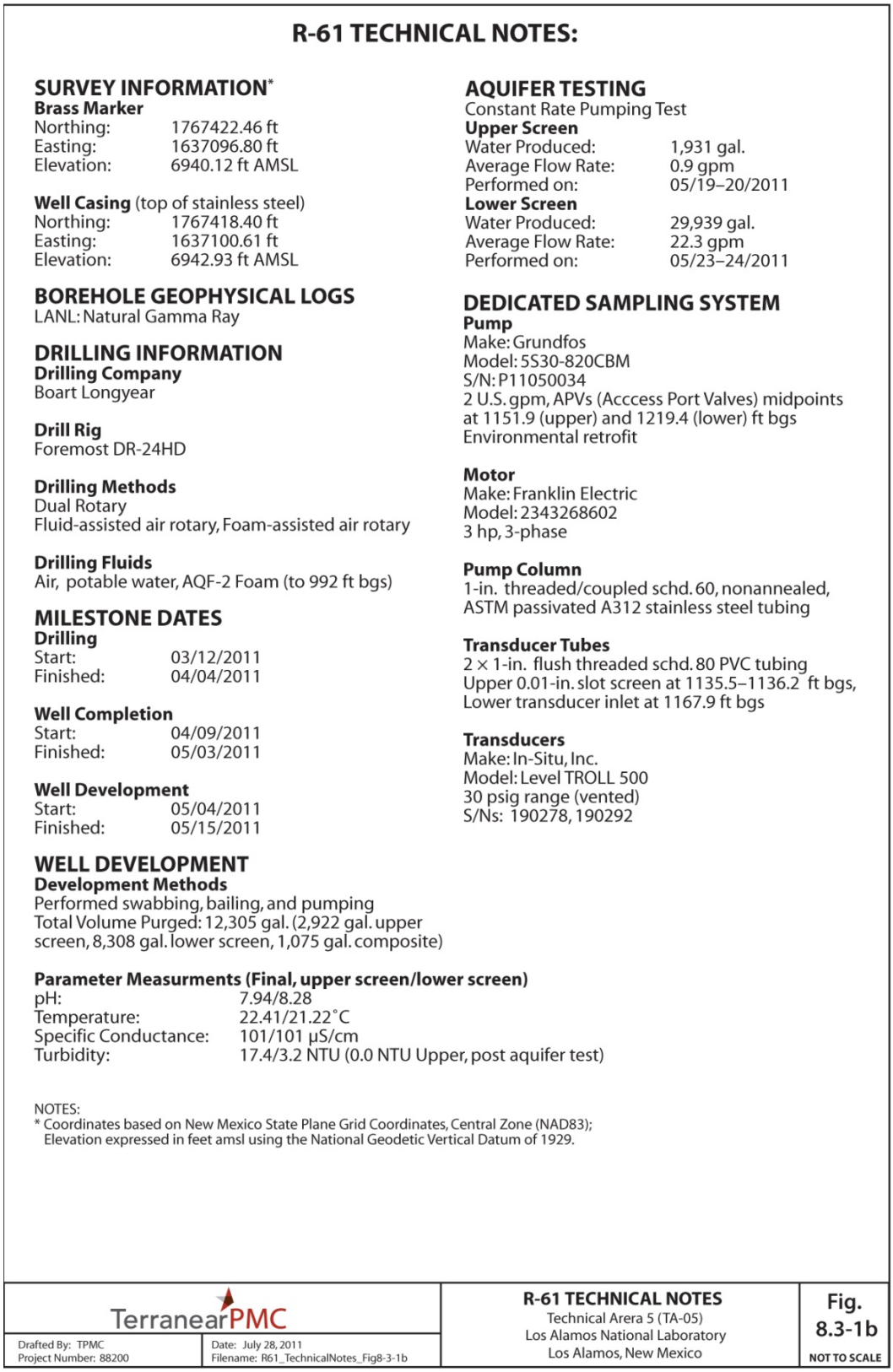


Figure 2 Monitoring well R-61 as-built well construction diagram



R-61 TECHNICAL NOTES:

SURVEY INFORMATION*

Brass Marker

Northing:	1767422.46 ft
Easting:	1637096.80 ft
Elevation:	6940.12 ft AMSL

Well Casing (top of stainless steel)

Northing:	1767418.40 ft
Easting:	1637100.61 ft
Elevation:	6942.93 ft AMSL

BOREHOLE GEOPHYSICAL LOGS

LANL: Natural Gamma Ray

DRILLING INFORMATION

Drilling Company
Boart Longyear

Drill Rig
Foremost DR-24HD

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

Drilling Fluids
Air, potable water, AQF-2 Foam (to 992 ft bgs)

MILESTONE DATES

Drilling

Start:	03/12/2011
Finished:	04/04/2011

Well Completion

Start:	04/09/2011
Finished:	05/03/2011

Well Development

Start:	05/04/2011
Finished:	05/15/2011

WELL DEVELOPMENT

Development Methods
Performed swabbing, bailing, and pumping
Total Volume Purged: 12,305 gal. (2,922 gal. upper screen, 8,308 gal. lower screen, 1,075 gal. composite)

Parameter Measurments (Final, upper screen/lower screen)

pH:	7.94/8.28
Temperature:	22.41/21.22˚C
Specific Conductance:	101/101 µS/cm
Turbidity:	17.4/3.2 NTU (0.0 NTU Upper, post aquifer test)

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

AQUIFER TESTING

Constant Rate Pumping Test

Upper Screen

Water Produced:	1,931 gal.
Average Flow Rate:	0.9 gpm
Performed on:	05/19–20/2011

Lower Screen

Water Produced:	29,939 gal.
Average Flow Rate:	22.3 gpm
Performed on:	05/23–24/2011

DEDICATED SAMPLING SYSTEM

Pump
Make: Grundfos
Model: 5S30-820CBM
S/N: P11050034
2 U.S. gpm, APVs (Acccess Port Valves) midpoints at 1151.9 (upper) and 1219.4 (lower) ft bgs
Environmental retrofit

Motor
Make: Franklin Electric
Model: 2343268602
3 hp, 3-phase

Pump Column
1-in. threaded/coupled schd. 60, nonannealed, ASTM passivated A312 stainless steel tubing

Transducer Tubes
2 × 1-in. flush threaded schd. 80 PVC tubing
Upper 0.01-in. slot screen at 1135.5–1136.2 ft bgs,
Lower transducer inlet at 1167.9 ft bgs

Transducers
Make: In-Situ, Inc.
Model: Level TROLL 500
30 psig range (vented)
S/Ns: 190278, 190292

TerranearPMC
Drafted By: TPMC
Project Number: 88200
Date: July 28, 2011
Filename: R61_TechnicalNotes_Fig8-3-1b

R-61 TECHNICAL NOTES
Technical Arera 5 (TA-05)
Los Alamos National Laboratory
Los Alamos, New Mexico

Fig. 8.3-1b
NOT TO SCALE

Figure 3 As-built technical notes for monitoring well R-61

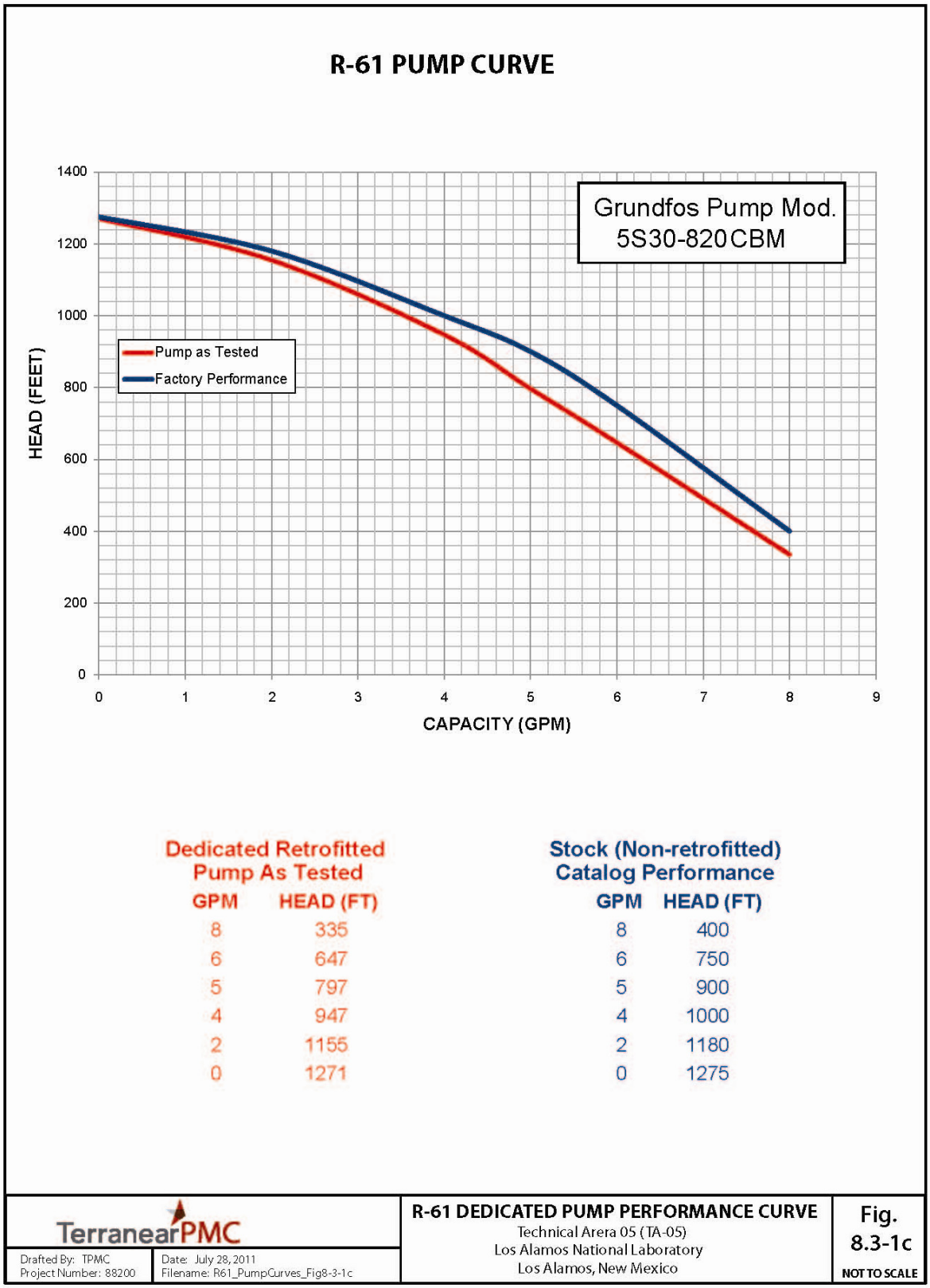


Figure 4 Dedicated pump performance curve for monitoring well R-61