Drilling Work Plan for Test Well 3r (R-66)

Primary Purpose	Regional aquifer well R-66 (formerly known as TW-3r) will be installed in Los Alamos Canyon near the confluence with DP Canyon, as required by the New Mexico Environment Department's (NMED's) Approval with Modifications, Technical Area 21 Monitoring Well Network Evaluation and Recommendations, Los Alamos National Laboratory, dated December 2, 2010 (NMED 2010, 111462). Well R-66 will replace well TW-3, which was constructed in 1949 and does not meet current monitoring-well construction standards. The proposed location for well R-66 is shown in Figure 1. Well R-66 will augment the groundwater-monitoring network for Technical Area 21 (TA-21). The primary goal of well R-66 is to monitor groundwater in the upper part of the regional aquifer downgradient of TA-21 and associated potential infiltration zones in Los Alamos and DP Canyons. Well R-66 will also be used as a sentinel well for municipal production well O-4 to determine if Laboratory contamination is present in the upper part of the regional aquifer near this well. Well R-66 will be constructed with a single well screen placed near the regional water table. Two additional wells, R-64 and R-65, will be installed at the TA-21 facility boundary before installation of well R-66. Water quality and hydrologic data collected at R-64 and R-65 may result in revision of the conceptual model for contaminant transport in the regional groundwater system presented in this work plan. The R-66 well design will be reassessed in light of the data collected from R-64 and R-65, and this work plan will be revised and resubmitted to NMED for approval, if necessary. The R-66 borehole is expected to penetrate the top of regional saturation at a depth of approximately 807 ft within Miocene sands and gravels of the Santa Fe Group (stratigraphic unit Tcar). The target borehole total depth (TD) is approximately 900 ft. Figure 2 shows the predicted geology and conceptual well design for well R-66. A final well design will be based on data acquired during drilling, including information from lithological logs of cuttings, water-level measurements, video logs, geophysical logs, and drillers' observations. A well design document will be submitted to NMED for approval.
Conceptual Model	At TA-21, contaminant transport in the vadose zone may include vertical pathways with potential contaminants arriving at the regional aquifer within hypothesized arrival areas directly below the surface sites that released contaminants to the environment. These arrival areas are referred to as potential "breakthrough locations." Contaminant impacts on the regional aquifer from these vertical pathways will be addressed by monitoring groundwater at the water table at the downgradient facility boundary by proposed wells R-64 and R-65 (Figure 1). An additional contaminant pathway is likely associated with contaminated effluent that was released to DP Canyon from the Solid Waste Management Unit 21-011(k) outfall near Material Disposal Area T. Contaminants were transported down DP Canyon by surface water before infiltrating canyon-floor sediments and impacting bedrock perched-groundwater bodies in the vicinity of the DP and Los Alamos Canyon confluence. The lower reach of DP Canyon is the likely infiltration location for mobile contaminants such as tritium, nitrate, and perchlorate that are observed in perched groundwater at wells R-6i, LAOI-3.2, and LAOI-3.2a (Figure 1). Historical tritium releases at the former Omega West reactor in Los Alamos Canyon are another potential source of contamination to the regional aquifer via canyon-floor infiltration. Elevated tritium is present in perched intermediate groundwater at depths of 300 ft at well LADP-3, but tritium activity is decreasing over time and potential impacts to the regional aquifer from Los Alamos Canyon are considered less important than those from DP Canyon.

Conceptual Model (cont.)	It is uncertain whether regional groundwater near O-4 is impacted by infiltration in DP and Los Alamos Canyons. Because of its proximity to the nearby canyon-floor infiltration windows, well R-66 should provide early warning of contaminants at the top of the regional aquifer before they can be drawn into the well screen at O-4, the top of which is submerged about 300 ft below the water table. TW-3, the only well in the vicinity of the DP and Los Alamos confluence that has a well screen set at the regional water table, yields groundwater samples that contain slightly elevated tritium (averaging about 7 pCi/L). However, the lack of an annular seal outside the TW-3 well casing makes it uncertain whether the measured tritium concentrations represent regional groundwater conditions or if the water samples include a component of contaminated perched groundwater that has percolated down the annulus of the well. Installation of well R-66 will provide reliable and representative groundwater quality data for the top of the regional aquifer near O-4. A proposal to plug and abandon TW-3 is addressed in a separate work plan. There are uncertainties about water-table depth and groundwater flow direction at well R-66 because of the low spatial density of regional aquifer wells near TA-21. Based on regional aquifer water-table maps, the hydraulic gradient should transport potential contaminants generally towards the east or northeast. However, advective transport of contaminants may not be perpendicular to the equipotential water-table lines (i.e., parallel to the direction of the hydraulic gradients) because of aquifer anisotropy and heterogeneity. Additionally, infiltration mounding beneath nearby Los Alamos and Pueblo Canyons may affect the hydraulic gradients locally. Water-level data collected at well R-66 will help constrain water-table maps used to optimize the TA-21 groundwater-monitoring network. Additionally, vertical hydraulic communication within the aquifer will be assessed by comparing R-66 water-level data with O-4 production data.
Drilling Approach	Drilling will be conducted with methods selected to optimize the potential for completing the well without the use of drilling additives in, or immediately above, the target zone of regional saturation. A combination of open-hole and casing-advance methods will be used. Each interval of open hole or casing advance will be optimized to meet well objectives. Casing will be used to advance the borehole when open-hole drilling is not possible and to secure the borehole through unstable zones or any perched horizons.
Potential Drilling Fluids, Composition, and Use	Fluids and additives may be used to facilitate drilling. These fluids and additives are consistent with those previously used in the drilling program at Los Alamos National Laboratory (LANL or the Laboratory) and have been characterized geochemically. Fluids and additives previously authorized for use by NMED include • potable water, municipal water supply, to aid in delivery of other drilling additives and cool the drill bit; • QUIK-FOAM, a blend of alcohol ethoxy sulfates, used as a foaming agent; and • AQF-2, an anionic surfactant, used as a foaming agent. Complete records will be maintained detailing the type, amount, and volume of drilling fluid used, depth of drilling fluid added to the borehole, amount in storage in the borehole, and recovery volume of drilling fluid. No chemicals other than those listed above will be added without approval from NMED. No drilling fluids will be used within 100 ft of the regional aquifer except potable municipal water.

Well Objectives for R-66	The objectives of well R-66 are as follows: • Monitor water quality in the regional aquifer downgradient of potential release sites at TA-21, particularly those associated with infiltration in DP and Los Alamos Canyons • Act as a sentinel well for the upper regional aquifer near municipal production well O-4 • Establish water levels and gradients in the regional aquifer in this area for water-table maps and thereby enable optimization of the monitoring network • Measure drawdowns at the water table caused by municipal production well O-4 in order to estimate vertical hydraulic separation between different zones of the regional aquifer • Evaluate hydrogeological properties of the aquifer.
Potential Groundwater Occurrence and Detection	*Potential Perched Water:* Perched groundwater was noted in Puye Formation sediments above Cerros del Rio lavas while drilling O-4 (Stoker et al. 1992, 058718). The geologic log for O-4 states "Some perched water was visible in a video log of the 48-in hole at about 253 ft where water cascaded in from a large gravel." Northwest of well R-66, perched water occurs at well R-6i within Puye Formation sediments above Cerros del Rio lavas. Perched groundwater also occurs near the confluence of Los Alamos and DP canyons within the lower Otowi Member and the Guaje Pumice Bed at well LAOI-3.2 and within the Puye Formation at well LAOI-3.2a. West of well R-66, perched groundwater occurs in Los Alamos Canyon at wells LAOI(A)-1.1 and LADP-3 in the Guaje Pumice Bed. These two groundwater occurrences appear to be controlled by the Guaje Pumice Bed that dips southward in this area. Perched water was also suspected in the Puye Formation ~15 ft beneath the Guaje Pumice bed at well R-7, but a screen placed to collect samples from this perched body was pumped dry within 3 yr. Drilling at well R-66 will be halted at a depth of 707 ft, approximately 100 ft above the regional aquifer, to evaluate whether perched groundwater occurs above or within the Guaje Pumice Bed, upper Puye Formation, Cerros del Rio basaltic lavas, lower Puye Formation, or Miocene pumiceous sediments beneath the Puye Formation. *Regional Groundwater:* In well R-66 the regional groundwater is expected to occur at a depth of 807 ft, within Miocene sands and gravels of the upper Santa Fe Group. Methods for groundwater detection may include drillers' observations, water-level measurements, borehole video, and borehole geophysics.
Core Sampling	No core collection or sampling is planned.
Perched Groundwater Screening Sampling	Groundwater screening samples will be collected during drilling if perched groundwater is encountered in the vadose zone and if such zones produce sufficient water for sampling. Screening samples of perched groundwater will be analyzed for cations/metals (dissolved and total) and anions (dissolved) by the Earth and Environmental Sciences Division's Geochemistry and Geomaterials Research Laboratory and for tritium by off-site laboratories.

Regional Groundwater Characterization Sampling	Groundwater samples will be collected from the completed well between 10 and 60 d after well development, in accordance with the Compliance Order on Consent. These samples will be analyzed for the full suite of constituents including radionuclides, metals/cations, general inorganic chemicals, high explosives, volatile organic compounds, and stable isotopes. Subsequent groundwater samples will be collected in accordance with the Laboratory's Interim Facility-Wide Groundwater Monitoring Plan (LANL 2010, 109830).
Geophysical Testing	The Laboratory's borehole video camera and natural gamma and induction tools will be used in the open borehole if conditions allow. A full suite of geophysical logs will be run, if required, for proper placement of the well screen. The logs will be collected by Schlumberger, Inc. For open-hole conditions, the logs will include accelerator porosity sonde (neutron porosity), array induction, combined magnetic resonance, natural and spectral gamma, and formation micro-imager logs. In cased portions of the borehole, neutron porosity, triple lithodensity, elemental capture, natural gamma, and spectral gamma logs will be collected. These logs will be used to define the top of regional saturation and to characterize the hydraulic properties of saturated rocks in the regional aquifer. The suites run and timing of geophysical logging will depend on borehole conditions.
Well Completion Design	Figure 2 shows the conceptual well design for well R-66.
Well Development	The well may be developed by both mechanical and chemical means. Mechanical means include swabbing, bailing, and pumping. Chemical means include the use of additives to remove clay minerals introduced as annular fill and/or chlorination to kill bacteria introduced during well completion. • After initial swabbing and bailing, a submersible pump will be used to complete the development process. • Water-quality parameters will be measured in a flow-through cell. The parameters to be monitored are pH, specific conductance, dissolved oxygen, temperature, turbidity, oxidation-reduction potential, and total organic carbon (TOC). • If it is not possible to bring the water-quality parameters within measurement limits specified below, the use of chemical well development may be discussed with NMED. No chemicals will be added without approval from NMED. • Chemicals that may be used include the addition of sodium acid pyrophosphate and AQUA-CLEAR PFD to remove clay minerals and/or chlorination to kill bacteria introduced during well completion. Well development will be considered complete when target water-quality parameters are met. The target water-quality parameters are turbidity <5 nephelometric turbidity units, TOC <2 ppm, and other parameters stable.
Hydraulic Testing	Hydraulic testing will take place if the well screen is within a significant water-producing horizon. The most likely test will be a 24-h constant-rate pump test. The R-66 water level may be perturbed by pumping at O-4. Los Alamos County will be asked to stop using O-4 during well design and pumping testing.

Investigation-Derived Waste Management	Investigation-derived waste (IDW) will be managed in accordance with standard operating procedure (SOP) 5238, Characterization and Management of Environmental Program Waste (http://www.lanl.gov/environment/all/qa/adep.shtml). This SOP incorporates the requirements of applicable U.S. Environmental Protection Agency and NMED regulations, U.S. Department of Energy orders, and Laboratory requirements. The primary waste streams will include drill cuttings, drilling water, development water, purge water, decontamination water, and contact waste. Drill cuttings will be managed in accordance with the NMED-approved Notice of Intent (NOI) Decision Tree for Land Application of IDW Solids from Construction of Wells and Boreholes (November 2007). Drilling, purge, and development waters will be managed in accordance with the NMED-approved Drilling, Development, Rehabilitation, and Sampling Purge Water NOI Decision Tree (November 2006). Initially, drill cuttings and drilling water will be stored in lined pits. The cuttings may or may not contain residue of drilling/well completion additives (e.g., drilling foam and bentonite clay). The contents of the pits will be characterized with direct sampling following completion of drilling activities, and waste determinations will be made from validated data. If validated analytical data show these wastes cannot be land-applied, they will be removed from the pit, containerized, and placed in accumulation areas appropriate for the type of waste. Cuttings, drilling water, development water, and purge water that cannot be land-applied and are designated as hazardous waste will be sent to an authorized treatment, storage, or disposal facility within 90 d of containerization. Development water, purge water, and decontamination water will be containerized separately at their point of generation, placed in an accumulation area appropriate to the type of waste, and directly sampled. Contact waste will be containerized at the point of generation, placed in an appropriate accumulation area, and characterized using acceptable knowledge of the media with which it came in contact.
Schedule	Well R-66 will be completed by March 1, 2012.

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), June 2010. "2010 Interim Facility-Wide Groundwater Monitoring Plan," Los Alamos National Laboratory document LA-UR-10-1777, Los Alamos, New Mexico. (LANL 2010, 109830)

NMED (New Mexico Environment Department), December 2, 2010. "Approval with Modifications, Technical Area 21 Monitoring Well Network Evaluation and Recommendations," New Mexico Environment Department letter to G.J. Rael (DOE-LASO) and M. Graham (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2010, 111462)

Stoker, A.K., S.G. McLin, W.D. Purtymun, M.N. Maes, and B.G. Hammock, May 1992. "Water Supply at Los Alamos During 1989," Los Alamos National Laboratory report LA-12276-PR, Los Alamos, New Mexico. (Stoker et al. 1992, 058718)

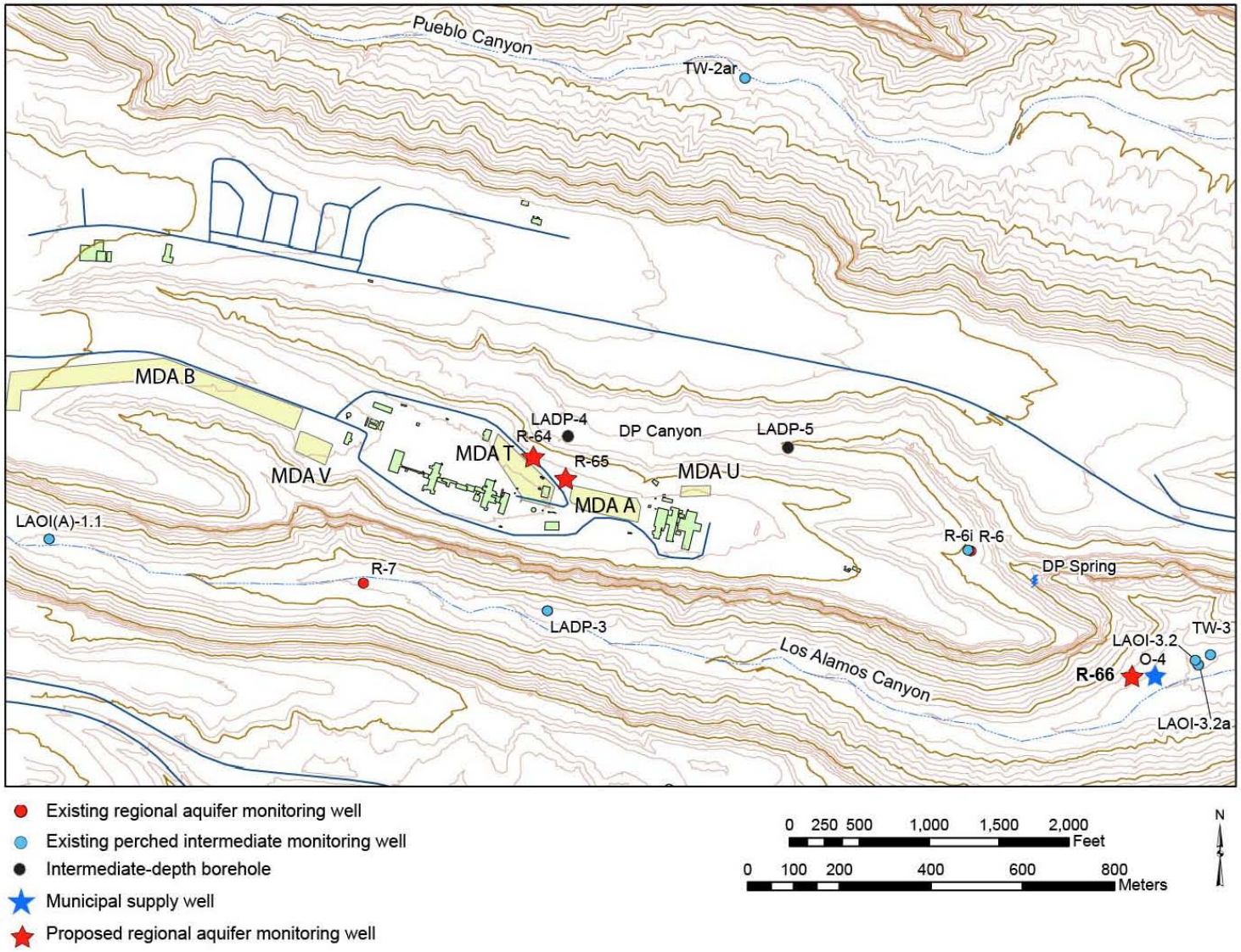

Figure 1 Proposed location for well R-66

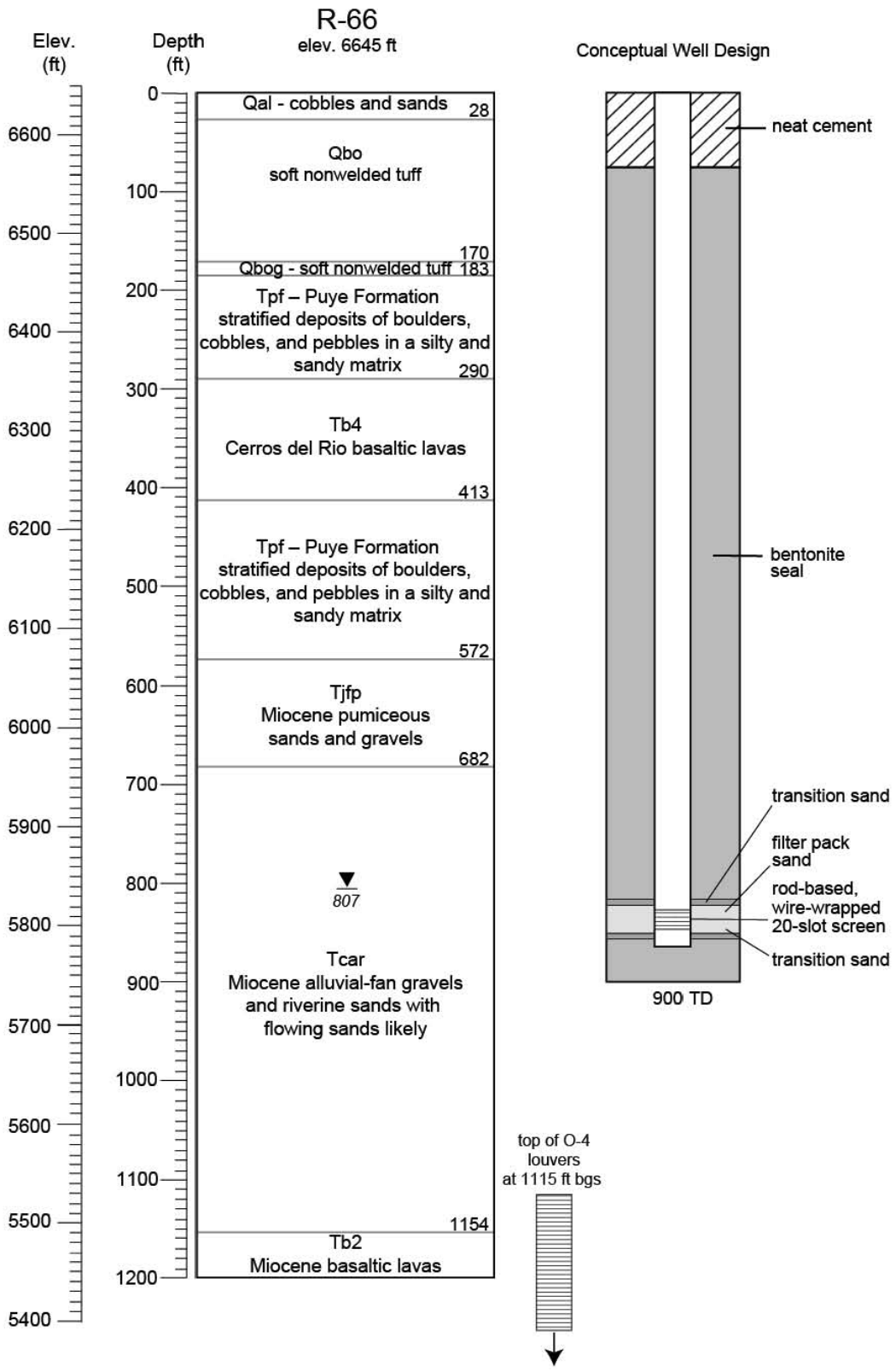

Figure 2 Predicted geology and conceptual well design for well R-66