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Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations

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Abbreviations and Acronyms

AOC	area of concern
bgs	below ground surface
CME	corrective measures evaluation
CMR	Combinable Magnetic Resonance tool
COPC	chemical of potential concern
CRDL	contract-required detection limit
DI	deionized
DOE	U.S. Department of Energy
DP	Delta Prime
EPA	U.S. Environmental Protection Agency
FMI	Formation Micro-Imager
FY	fiscal year
GGRL	Geochemistry and Geomaterials Research Laboratory
HSA	hollow-stem auger
HSWA	Hazardous and Solid Waste Amendments of 1984
I.D.	inside diameter
IDL	instrument detection limit
LANL	Los Alamos National Laboratory
LAPCIR	Los Alamos and Pueblo Canyons Investigation Report
LA/P Watershed	Los Alamos and Pueblo Canyon Watershed
MDA	material disposable area
MP	Multiple Port
NMED	New Mexico Environment Department
NTU	nephelometric turbidity unit
O.D.	outside diameter
ORP	oxidation-reduction potential
OWR	Omega West Reactor
ppm	part per million
PVC	polyvinyl chloride
R&R	reliability and representativeness

SWMU	solid waste management unit
TA	technical area
TD	total depth
TOC	total organic carbon
UTL	upper threshold limit
WWTP	wastewater treatment plant

1.0 INTRODUCTION

This monitoring well network evaluation for the Los Alamos and Pueblo Canyon Watershed (herein referred to as the LA/P Watershed), including the Technical Area (TA) 21 (see Figure 1.0-1), is being conducted pursuant to a requirement set forth by the New Mexico Environment Department's (NMED's) letter on "Well Evaluations for Intermediate and Regional Wells," dated April 5, 2007 (NMED 2007, 095394).

This evaluation of the adequacy of the groundwater-monitoring network around the LA/P Watershed is being conducted to support ongoing investigations and pending corrective measures implemented under the Compliance Order on Consent (Consent Order) and also fulfills the Consent Order requirement for a groundwater investigation in the LA/P Watershed.

In addition to the network assessment for the overall watershed, the corrective measures evaluations (CMEs) for solid waste management units (SWMUs) at Material Disposal Areas (MDAs) B, V, T, and U will also benefit from a demonstration of adequate knowledge of the groundwater environment beneath the sites. This evaluation and the associated recommendations and actions are intended to provide the basis for making that demonstration. The network recommendations that derive from this evaluation are intended to capture the monitoring requirements to support selection and implementation of the corrective measures. Additional monitoring needs, including vadose-zone monitoring as applicable, will be presented as part of the CME reports.

The group of intermediate and regional groundwater-monitoring wells evaluated in this report was predominantly installed during implementation of the "Hydrogeologic Workplan" (LANL 1998, 059599). Although the Hydrogeologic Workplan wells were installed primarily as characterization wells, Los Alamos National Laboratory (the Laboratory) had a "next-phase" objective to evaluate the utility of each well in the context of area-specific objectives, such as MDA remedy selection and implementation of regulatory monitoring requirements. This evaluation is intended to accomplish that goal.

The approach used to evaluate the monitoring network involves examination of well and network performance in three main categories—physical, hydrologic, and geochemical—and these categories are all considered in the context of the monitoring objectives and conceptual models of contaminant pathways as they relate to groundwater systems. The physical and hydrologic criteria include the effectiveness of sampling systems to provide representative groundwater data; well construction; isolation of sampling zones; and a review of factors, such as well locations, screen positions, and screen lengths evaluated in the context of the conceptual model and monitoring objectives. Geochemical criteria include an assessment of whether conditions are present in the aquifer resulting from drilling that prevent sample from meeting monitoring objectives. Information on radioactive materials and radionuclides, including the results of sampling and analysis of radioactive constituents, is voluntarily provided to NMED in accordance with U.S. Department of Energy policy.

2.0 CONCEPTUAL MODELS FOR THE LOS ALAMOS AND PUEBLO CANYON WATERSHEDS

This section is an overview of the Laboratory's current conceptual models for the fate and transport of contaminants in the subsurface beneath the LA/P Watershed. The investigations conducted to date in the LA/P Watershed have led to the understanding of nature and extent of contamination beneath these two watersheds described in this report. This information is used to develop conceptual models for fate and transport of contaminants and to subsequently conduct an evaluation of the intermediate and regional groundwater-monitoring network with respect to contaminants released in these watersheds. Separate conceptual models are developed for the Los Alamos Canyon and Pueblo Canyon and their respective tributaries, as illustrated in Figures 2.0-1 and 2.0-2, and also for TA-21 disposal sites on Delta Prime (DP) Mesa. These descriptions are based on water-level observations and sediment, surface water, and alluvial water contaminant distributions, presented in detail in the “Los Alamos and Pueblo Canyons Investigation Report” (LAPCIR) (LANL 2004, 087390), on water chemistry for the alluvial, perched intermediate, and regional groundwaters, on hydrologic and geochemical observations presented in Appendixes D and E of this report, and on data from site investigations conducted at TA-21 SWMUs and areas of concern (AOCs) (LANL 2006, 094361; LANL 2006, 095046; LANL 2007, 095131).

Los Alamos and Pueblo Canyons fit the “Wet Canyon Conceptual Model” for the Pajarito Plateau as described by Birdsell et al. (2005, 092048). They are broad, deep, naturally wet canyons with headwaters in the mountains that collect large runoff volumes. The LA/P Watershed drainage extends 15.6 mi and drops nearly 5000 ft from its headwaters to its confluence with the Rio Grande, comprising a drainage area of 57.7 mi^2 (LANL 2006, 094004). Segments of persistent to ephemeral surface water occur along portions of the canyons, as indicated in Figure 1.0-1, and perched alluvial groundwater exists beneath large portions of the canyon floors. Lateral downcanyon flow and contaminant transport occur via surface water and near-surface alluvial groundwater. Anthropogenic water sources, such as treatment plant effluent released to the canyon, also support surface and alluvial groundwater occurrences and can add further to lateral transport. Alluvial groundwater eventually percolates into the underlying vadose zone. Percolation may preferentially occur where underlying strata have higher hydraulic conductivity or are fractured (e.g., the Puye Formation or Cerros del Rio basalt). Intermediate-depth perched groundwater is observed beneath wet canyons across the plateau but is generally absent beneath mesas and drier canyons (Robinson et al. 2005, 091682, Appendix D, Section D-2). The combination of high infiltration rates in canyon bottoms and intermediate-depth perching horizons helps create these perched groundwater bodies. In wet canyons, lateral flow of surface and alluvial water and possibly of perched-intermediate water can spread mobile contaminants away from their original source locations before potentially arriving at the regional water table. Lateral spreading can yield different contaminant footprints at depth than are associated with the original release locations at the surface. Net percolation rates in wet canyons are expected to be among the highest across the plateau, approaching a meter per year (Kwicklis et al. 2005, 090069, Table 1). Resulting transport times of mobile contaminants to the regional aquifer beneath wet canyons are predicted to be on the order of decades to hundreds of years (Nylander et al. 2003, 076059.49; Birdsell et al. 2005, 092048). Subsequently, Laboratory-derived contaminants are observed in some regional aquifer monitoring wells.

Dispersed contaminants currently distributed within and beneath the LA/P Watershed predominantly result from the limited number of effluent sources or leaks that discharged to the watershed over the history of the Laboratory, as described below. Moderately and strongly sorbing contaminants (e.g., strontium-90 and plutonium-239, respectively) are found dispersed at shallow depths and are associated mostly with sediments, although very low concentrations in surface and alluvial water are sometimes observed (LANL 2004, 087390). Surface water and alluvial groundwater concentrations for mobile contaminants (e.g., nitrate, perchlorate, and tritium) have dropped dramatically since releases and leaks to the canyons have ceased (LANL 2004, 087390). The contaminants have, however, migrated into the vadose zone and are found in perched-intermediate and regional groundwater beneath the canyons (Appendix E). Field investigations and site knowledge have helped to identify potential locations of focused flow of surface water and alluvial groundwater into the vadose zone, which in turn creates hydrologic and contaminant transport pathways to the deeper perched-intermediate zones and the regional aquifer, as illustrated in Figures 2.0-1 and 2.0-2, especially for mobile constituents.

For the LA/P Watershed, hydrologic pathways are used to define potential breakthrough locations where contaminants might travel through the vadose zone and into perched-intermediate groundwater and the regional aquifer, as shown in Figure 2.0-3 and described in Table 2.0-1. Figure 2.0-3 also indicates the presence or absence of contaminants in perched-intermediate and regional wells, which helps to define these hydrologic pathways. The breakthrough locations are defined as approximate projections of the areas where either (1) contaminants may have already reached or may reach the regional aquifer, or (2) contaminants are disposed of in the subsurface at a mesa-top location. The first case represents effluent releases to canyons for which considerable near-surface migration down the canyon floor with surface water and alluvial groundwater occurs. The resulting breakthrough areas at the regional aquifer are elongated along the length of the canyon. In addition to effluent releases to canyons, potential contaminant transport from mesa-top sources at TA-21 is considered in this network assessment. For mesa-top disposal at TA-21, the sources projected onto the regional water table are simply assumed to be located vertically below the disposal units. Justification for the breakthrough locations follows from the conceptual models developed below.

2.1 Los Alamos and DP Canyons

2.1.1 Contaminant Sources

The Omega West Reactor (OWR) at TA-2, shown in Figures 1.0-1 and 2.0-1, operated from 1956 to 1993 and was a source of tritium releases into alluvial groundwater. A tritium leak from a reactor cooling system was observed in 1993. The leak likely started before 1969 because elevated tritium concentrations were noted in alluvial groundwater at well LAO-1 downstream from the reactor between 1969 and 1993 when the reactor was shut down (Rogers 1998, 059169). In addition, hexavalent chromium was released in cooling tower effluent at the OWR site from approximately 1957 to 1973 (LANL 2006, 091987).

SWMU 21-011(k) (Figure 1.0-1), an outfall that discharged into DP Canyon from TA-21, is the most significant source of contaminants in upper Los Alamos Canyon. Between 1952 and 1986, the outfall received radioactive liquid waste effluent from industrial waste treatment plants (LANL 1991, 007529; LANL 1995, 052350). Cesium-137 and strontium-90 are two of the primary contaminants discharged from this outfall, but these are predominantly retained in sediment and in surface and alluvial waters (LANL 2004, 087390). Mobile constituents from SWMU 21-011(k) that could potentially contaminate deeper groundwater include tritium, perchlorate, and nitrate (Birdsell et al. 2006, 094399).

TA-53 includes a proton accelerator and associated buildings used for research with subatomic particles; it is the current site of the Los Alamos Neutron Science Center (LANL 1994, 034756). Occasional releases occurred from three surface impoundments at the east end of TA-53 [Consolidated Unit 53-002(a)-99, Figure 1.0-1] to a tributary drainage to Los Alamos Canyon. The impoundments received sanitary, radioactive, and industrial wastewater containing inorganic, organic, and radionuclide contaminants from various buildings across TA-53 from the early 1970s to 1998 (LANL 1998, 058841). In addition, cooling water containing a sodium molybdate corrosion inhibitor was released from permitted outfalls at TA-53 during the 1990s and ending in June 2002 (Figure 1.0-1) (LANL 2004, 087390).

Several wastewater treatment plants (WWTP) and septic systems have discharged to Los Alamos Canyon and its tributaries over the past 60 yr. For example, a WWTP at TA-41 [Consolidated Unit 41-002(a)-99, Figure 1.0-1] operated from 1951 to 1987 and released above background levels of radionuclides. The WWTP at the eastern end of DP Mesa released to an outfall [SWMU 21-026(d), Figure 1.0-1] that subsequently flowed into DP Canyon. In addition, solid and liquid releases from other Laboratory facilities in or bordering Los Alamos and DP Canyons have also contributed contaminants to the watershed.

2.1.2 Canyon Hydrology and Contaminant Transport

Los Alamos Canyon is a large canyon with a drainage area of 14.1 mi^2 (LANL 2006, 094004). Figure 2.0-1 shows a conceptual hydrogeologic cross-section for Los Alamos Canyon, including the canyon geology and potential contaminant transport pathways from the surface toward the regional aquifer. The canyon is deeply eroded with alluvium present in the canyon floor. The Otowi Member (Qbof) is the primary Bandelier Tuff unit present beneath the canyon floor downcanyon from major contaminant sources. A short segment with Puye Formation beneath the alluvium may occur east of R-8. Then east of LAOI-7, the Cerros del Rio basalt (Tb 4) lies beneath the canyon-bottom alluvium.

Figure 2.0-1 shows surface water occurrences as summarized in the LAPCIR (LANL 2004, 087390) for investigations conducted in 2001 and 2002. Persistent (continuous) surface flow originating from snowmelt runoff, stormwater runoff, springs, and interflow through hillslope soils is present at the western end of the canyon. This generally terminates west of TA-41 and west of the Laboratory contaminant sources described above. Surface water and alluvial groundwater may also infiltrate the Rendija and Guaje Mountain fault zones to form part of the perched-intermediate zone present in this portion of the canyon. Recharge of noncontaminated water in this area of persistent surface water may explain the background concentration values observed in the perched-intermediate zones in wells LAOI(a)-1.1 and R-7 (see Appendix E Table E-2.0-1 and Figure 2.0-3). Gray (1997, 058208) performed a water balance for Los Alamos Canyon and found this region to have among the highest infiltration rates in the canyon. Farther downcanyon, surface flow is observed less frequently, becoming intermittent to ephemeral. However, below the Pueblo Canyon confluence, persistent surface flow is present, originating from effluent releases from the Bayo WWTP (Figure 1.0-1).

Alluvial groundwater is generally present from the fault zone area to just east of the DP Canyon confluence at about the location of LAP-4 (Figure 2.0-1). In this section, tuff units lie beneath the alluvium. Percolation from the alluvium into the tuffs may be limited by low unsaturated hydraulic conductivity of the tuff, maintaining the perching within the alluvium. Gray (1997, 058208) predicts lower rates of infiltration from the alluvium into the underlying units (the tuff) in this section of the canyon. However, some vertical transport does occur here as evidenced by elevated moisture content in the Otowi Member at LAOI(A)-1.1, LADP-3, and LAOI-3.2/3.2a (see Appendix D, Section D-1), by the presence of chromium and molybdenum in the vadose zone at LAOI(A)-1.1, LADP-3, and LAOI-3.2/3.2a (see Appendix E, Section E-3), and by the presence of contaminants in perched-intermediate zones at wells LADP-3, R-6i, and LAOI-3.2/3.2a (see Appendix E Table E-2.0-1). Infiltration at the confluence with DP Canyon (near wells LAOI-3.2/3.2a) may be further enhanced by surface water runoff and alluvial groundwater that enters Los Alamos Canyon from DP Canyon, creating the perched-intermediate zones observed beneath the confluence of the two canyons. East of approximately LAP-4, alluvial groundwater is seasonal, and infiltration rates are assumed to be even lower. At R-6 and R-8, regional groundwater contaminant concentrations are at background levels. TW-3 appears to be contaminated in the regional aquifer, but this may be more related to well construction than to deep transport in this area based on the other nearby noncontaminated wells (see Appendix A). Therefore, contaminant transport (for mobile species) in this part of the canyon is illustrated in Figure 2.0-1 by the zone that extends into the vadose zone, including the perched-intermediate zones but does not reach the regional aquifer.

Infiltration of contaminants from the SWMU 21-011(k) outfall has occurred in DP Canyon at boreholes LADP-4 and LADP-5 (Figure 1.0-1) as seen in the chlorate, perchlorate and nitrate profiles (Appendix E, Section E-3). LADP-4 is located on the south slope of DP Canyon near where the outfall discharged. There is a thick sequence of Bandelier Tuff units present (approximately 180 m [590 ft]). Vadose-zone core samples were dry relative to those collected in Los Alamos Canyon (Appendix D, Section D-1), and infiltration rates are currently likely to be low. Robinson et al. (2005, 091682) ran numerical simulations and found that an infiltration rate of 1 mm/yr adequately fit moisture data at LADP-4, as opposed to infiltration rates of 200 mm/yr and larger being required to fit moisture data in Los Alamos Canyon proper, such as at LADP-3 and LAOI(A)-1.1. The much higher vadose-zone concentrations of nitrate and perchlorate observed in LADP-4 relative to at other boreholes indicates that very little dilution of outfall concentrations occurs at this dry location. Some of the mobile contaminants released to DP Canyon may have traveled downcanyon with surface water, alluvial water, or reemerged in DP Spring (LANL 2004, 087390) to eventually infiltrate farther downcanyon, such as near the confluence with Los Alamos Canyon.

In the section of Los Alamos Canyon from LAOI-7 to just east of LAWS-03, both surface-water flow and alluvial groundwater are present only seasonally. However, deeper transport has obviously occurred here. The fractured Cerros del Rio basalt is present near the surface, and rapid transport of surface water into this unit has been observed at the Los Alamos Weir Site (at LAWS-03 in Figure 2.0-1, Stauffer and Stone 2005, 090037). Gray (1997, 058208) predicts higher rates of infiltration from the alluvium into the underlying basalt in this canyon section than in the sections to the west. The occurrence of thick perched-intermediate bodies observed within the Cerros del Rio basalt in R-9i and in the weir wells (see Appendix D, Section D-2 and Figure 2.0-1) suggests that infiltration occurs in this area. Finally, the presence of contaminants in the perched-intermediate zones at monitoring wells LAOI-7 and R-9i and in the regional aquifer at monitoring well R-9 indicates transport pathways that reach these deep groundwater systems. Therefore, a deeper contaminant transport zone reaching into the regional aquifer is illustrated in Figure 2.0-1 for this section of Los Alamos Canyon. This transport zone may extend even farther east than shown because the geology is similar and because persistent surface water occurs below the confluence with Pueblo Canyon.

2.1.3 Potential Breakthrough Locations

Five potential breakthrough locations for Los Alamos and DP Canyons were identified, L1 through L5, as illustrated in Figure 2.0-3 and described in Table 2.0-1. These breakthrough locations are used in the simulations presented in Appendix C to assess the adequacy of the monitoring network in terms of detecting contaminant transport from different locations. L1 through L3 are located beneath the western transport zone depicted in Figure 2.0-1 that does not extend to the regional aquifer. However, for completeness, these breakthrough locations are associated with known sources (e.g., L1 represents an OWR source), potential transport pathways (e.g., L2 represents potential TW-3 contamination at the regional aquifer), or other hydrologic conditions (e.g., L3 represents a potential recharge zone as indicated by the high water level measured in R-8 (see Appendix D, Sections D-3 and D-4). L4 and L5 are located beneath and east of the eastern transport zone depicted in Figure 2.0-1 that extends into the regional aquifer. These two locations are directly based on the observations and conceptual model described above.

2.2 Pueblo and Acid Canyons

2.2.1 Contaminant Sources

Outfalls releasing liquid effluent from former TA-01 and former TA-45 to the head of the South Fork of Acid Canyon are the primary sources of radionuclides and other contamination in Acid and Pueblo Canyons (Figures 1.0-1 and 2.0-2). Radioactive effluent included untreated liquid waste from TA-01 from 1944 to 1951 and treated liquid waste from TA-45 from 1951 to 1964. Plutonium-239/240 is a primary contaminant in the surface sediment downcanyon from these outfalls (Reneau et al. 2000, 066867). Mobile constituents released into the South Fork of Acid Canyon that could potentially contaminate groundwater are tritium, perchlorate, and nitrate (Birdsell et al. 2006, 094399).

Several WWTPs (Figure 1.0-1) and septic systems have discharged to Pueblo Canyons over the past 60 yr, most notably the former Pueblo Canyon WWTP, the former Central WWTP (LANL 2004, 087390), and the Bayo WWTP. The Pueblo Canyon WWTP [SWMU 00-018(a)], located in Pueblo Canyon above the Acid Canyon confluence, operated from 1951 to 1991. The Central WWTP (SWMU 00-019) discharged to a tributary of Pueblo Canyon from 1947 to 1961. These two plants treated Los Alamos County and Laboratory wastes that included sewage but also contaminants such as inorganic and organic constituents. The Bayo WWTP discharged to lower Pueblo Canyon (Figures 1.0-1 and 2.0-2) and treated sanitary waste from Los Alamos County residences and businesses from 1963 to October 2007 (LANL 2006, 094004). The Bayo WWTP was replaced in October 2007 by the Los Alamos WWTP, also located in lower Pueblo Canyon (Figures 1.0-1 and 2.0-2). Although these two plants do not contribute Laboratory-derived contaminants to the watershed, they do release elevated concentrations of nitrate, boron, chloride, sodium, and sulfate. They also release a significant volume of water that affects the watershed hydrology. For example, Bayo WWTP effluent volume averaged over 20 million gal. per month for 2003 through 2006.

2.2.2 Canyon Hydrology and Contaminant Transport

Pueblo Canyon is a large canyon with a drainage area of 8.3 mi^2 (LANL 2006, 094004). Figure 2.0-2 shows a conceptual hydrogeologic cross section for Pueblo Canyon similar to that developed for Los Alamos Canyon. The geology beneath Pueblo Canyon is quite different from that in Los Alamos Canyon. Near the Acid Canyon/Pueblo Canyon confluence, Tschicoma dacite is present from beneath the alluvium to the regional aquifer. The Otowi Member and Guaje Pumice Bed (Qbog) are the primary Bandelier units present beneath the canyon floor but are only present for a short distance from about the location of PAO-2 to east of TW-2. A long segment having Puye Formation beneath the alluvium occurs from around R-4 to TW-1. The Cerros del Rio basalt lies beneath the canyon-bottom alluvium at the Los Alamos Canyon confluence.

Figures 1.0-1 and 2.0-2 show surface-water occurrences in Pueblo Canyon, as summarized in the LAPCIR (LANL 2004, 087390) for investigations conducted in 2001 and 2002. From the Rendija Canyon fault zone to the Bayo WWTP, surface flow is intermittent to ephemeral. Some infiltration of surface water into the Rendija and Guaje Mountain fault zones may occur, but no perched intermediate zones are observed, and evidence of historic releases at Acid Canyon reaching the regional aquifer is not measured at R-2 or TW-4 (see Appendix E, Table E-2.0-2). Downstream from the Bayo WWTP, persistent (effectively perennial) flow is maintained through approximately 3 km (1.86 mi) of lower Pueblo Canyon to and beyond the confluence with Los Alamos Canyon. The western extent of persistent surface water is expected to change because of the relocated outfall associated with the new Los Alamos WWTP (Figure 2.0-2).

Alluvial groundwater is generally present from PAO-1 to a location west of TW-2 (Figure 2.0-2). As in Los Alamos Canyon, the Otowi Member lies beneath the area with alluvial groundwater; percolation from the alluvium into the tuff may be limited and create the perched groundwater. Data implying vertical transport at R-2 are elevated moisture contents in the Otowi Member and elevated perchlorate concentrations in the vadose zone into the Puye Formation (see Appendix E, Section E-3). From TW-2 to about R-4, alluvial groundwater is seasonal. Persistent alluvial groundwater may have historically extended farther downcanyon than is currently observed related to the formally active TA-01/TA-45 outfalls and the Pueblo and Central WWTPs. At TW-2a, contaminants are present in the perched intermediate zone, but they are not necessarily present in the regional aquifer at TW-2 (Appendix E, Table E-2.0-2). These observation leads to the limited transport depicted for these areas in Figure 2.0-2. The vadose-zone nitrate profile (Appendix E, Section E-3) and regional aquifer water samples at R-4 (Appendix E, Table E-2.0-2) show the presence of Laboratory contaminants. Therefore, contaminant transport (for mobile species) in this part of the canyon is shown to extend to the regional aquifer, possibly because the suballuvial Bandelier Tuff terminates in this area or there may be preferential pathways through the heterogeneous Puye Formation. Shallow transport is indicated in the area of R-24 and R-5, but this area may also have deeper transport than depicted based on available vadose-zone nitrate data for R-24 (Appendix E, Section E-3) and intermediate and regional groundwater concentrations for R-5 (Appendix E, Section E-2). Finally, another deep transport zone with flow to the regional aquifer is shown for the R-3i/TW-1 area. This area has persistent surface and alluvial waters; thick fractured basalt that hosts an extensive perched intermediate zone is present, and contamination in intermediate well R-3i and regional test well TW-1 is present.

2.2.3 Potential Breakthrough Locations

Nine potential breakthrough locations for Pueblo and Acid Canyons were identified, P1 through P9, as illustrated in Figure 2.0-3 and described in Table 2.0-1. These breakthrough locations are also in the simulations presented in Appendix C to assess the monitoring network in terms of its adequacy for detecting contaminant plumes from different Pueblo Canyon locations. Basically, the nine potential breakthrough locations cover the entire span of the canyon for completeness to monitor potential pathways from the former Acid Canyon and WWTP sources. The small portion not included between P1 and P2 honors the background conditions measured at R-2 (Appendix E, Table E-2.0-2). Data in this part of the canyon are sparse enough that potential transport pathways can be hypothesized for most of the length of the canyon with the greatest certainty near R-4 (P3 through P5) and TW-1 (P8 and P9).

2.3 TA-21 and DP Mesa

2.3.1 Contaminant Sources

Primary SWMUs and AOCs at TA-21 considered are MDAs, waste lines and sumps, and buildings at DP East and DP West. Several MDAs are present at TA-21 (Figure 1.0-1): MDA A, MDA B, MDA T, MDA U, and MDA V. These MDAs generally contain legacy wastes in pits, shafts, and trenches that are dug into the mesa top and are currently stabilized with temporary crushed tuff or asphalt covers. Consolidated Unit 21-022(b)-99 has underground industrial waste lines and sumps. Finally, operations at buildings at DP East may have caused environmental releases. The following information is largely from the PRS Database.

- MDA A is a disposal facility that was used intermittently from 1945 to 1946 and from 1969 to 1977 to dispose of radioactively contaminated solid and liquid waste, debris from decontamination and decommissioning (D&D) activities, and radioactive liquid generated at TA-21. It consists of two buried storage tanks (known as the General's Tanks) and three disposal pits. The pits contain mostly solid waste. The General's Tanks were filled in the mid-1940s with liquids contaminated with plutonium and americium from plutonium-processing operations. From 1975 to 1983, the liquid was decanted from the tanks and processed at Building 21-257. An unknown volume of sludge still remains in the tanks. Contaminants in the pits and tanks include plutonium, americium, and uranium. Nitrate, perchlorate, and tritium may also be present.

- MDA B was the first common disposal area for radioactive waste generated at the Laboratory and operated from 1945 until 1948. Comprehensive information is not available, but the site is thought to contain approximately 10 pits, including one hazardous-materials pit. About 90% of the wastes received at MDA B consisted of laboratory waste (e.g., radioactively contaminated paper, rags, rubber gloves and other trash). Potential contaminants include radionuclides and chemicals.

MDA B is scheduled for remediation. Vapor-phase monitoring beneath the site shows very low levels of volatile organic compounds.

- MDA T consists of four inactive absorption beds (layered sand, gravel, and crushed cobble sized tuff), buried sumps and pipelines, shafts, the former Retrievable Waste Storage Area, former and current waste treatment plant equipment. Contaminants at the site include plutonium, uranium, and mixed fission products. Nitrate and perchlorate are also probably present.

  - ❖ The four inactive absorption beds at MDA T were operational between 1945 and 1967. Untreated liquid waste from uranium- and plutonium-processing laboratories was released to the absorption beds from 1945 to 1952. After 1952, a few hundred gallons of treated radioactive liquid wastes were still infrequently released to the absorption beds until 1967. Approximately 18.3 million gal. of wastewater was discharged to the MDA T absorption beds between 1945 and 1967. Some overflow to DP Canyon occurred.
  - ❖ The former retrievable waste storage pit was used from 1975 to 1982. Treated radioactive wastes containing plutonium-239/-240 and americium-241 were mixed with cement and pumped into pipes that were stored on end in the retrievable waste storage pit. The pipes were excavated and disposed of at MDA G at TA-54 in 1984 and 1986, and the retrievable waste storage pit was subsequently backfilled.
  - ❖ Sixty-two asphalt-lined disposal shafts are located at MDA T. The shafts are 6 ft to 8 ft in diameter, 15 ft to 69 ft deep, and were operational from 1968 to 1983. The shafts received wastes containing americium-241, plutonium-239/-240 and other mixed fission products mixed with Portland cement, and some shafts received unspecified volumes of wash water.

- MDA U operated from 1948 to 1968 as a subsurface disposal site for radioactively contaminated liquid wastes. It also received process cooling-water effluent from the Tritium Systems Test Assembly (TSTA) cooling tower until sometime after 1976. MDA U consists of two former absorption beds, an associated former distribution box, and a sump used to collect wastewater. Remediation and stabilization activities have left the site cleanup to industrial standards.

- MDA V received liquid waste effluent from a former laundry facility for radioactive clothing. It included three adsorption beds on the south side of DP Mesa that sometimes overflowed into Los Alamos Canyon. Historical documents show that radioactive strontium, plutonium, and uranium were released to the absorption beds. It is not known if organic or inorganic chemicals were part of the waste stream. The three absorption beds and underlying soils were removed and cleaned to residential standards in

- Consolidated Unit 21-022(b)-99 consists of waste lines (Figure 1.0-1) and their associated underground, plutonium-bearing, liquid-waste sumps. The sumps were built in 1945 along the north side of the TA-21 plutonium-processing complex and removed in 1979 and 1980. The lines and sumps received liquid waste discharges from five buildings that were eventually piped to MDA T for disposal, or later to Buildings 21-35 or 21-257 for treatment. The pipes remain in place, but will be excavated as corrective actions continue at TA-21. Overall, these industrial waste lines carried waste from 1945 until about 1986 when treatment at Building 21-257 ceased. Leaks to soil were evident when the sumps were removed. Therefore, the waste system is included because of its long history of transporting liquid wastes between buildings across the site and because of the known leaks that occurred. Potential contaminants are nitrate, perchlorate, plutonium, uranium, americium, and metals.

- DP East facilities include Buildings 21-152, 21-155 and 21-209. These buildings were used for a variety of projects including the Rover Project (nuclear propulsion systems for long-range missiles) and the TSTA project (tritium processing for fusion reactor research). Potential contaminants from these facilities include uranium, actinium and tritium.
- DP West facilities include Buildings 21-2, 21-3, 21-4, 21-5 and 21-150. These buildings were used primarily for purification, reduction, and recovery of plutonium, uranium, americium, and research on tritium, stable and rare isotopes, and mixed fission products. These building were decommissioned in 1979 and 1980, and some were demolished in the mid-1990s. Potential contaminants are nitrate, perchlorate, plutonium, uranium, americium, and metals.

2.3.2 DP Mesa Hydrology and Contaminant Transport

DP Mesa fits the "Dry and Disturbed Mesa Conceptual Model" for the Pajarito Plateau as defined by Birdsell et al. (2005, 092048). It is a dry finger mesa; the hydrologic conditions on the surface and within such dry mesas generally lead to slow unsaturated flow and transport. Dry mesas shed precipitation as surface runoff to the surrounding canyons such that most deep infiltration occurs episodically following snowmelt, and even then much of the water is lost through evapotranspiration. As a result, annual net infiltration rates for dry mesas are less than ten mm/yr and are more often estimated to be on the order of one mm/yr or less (Kwicklis et al., 2005). Because dry mesas are generally comprised of nonwelded to moderately welded tuffs with low water content, flow is matrix dominated. Travel times for contaminants migrating through mesas to the regional aquifer are expected to be several hundred to thousands of years (Nylander et al. 2003, 076059.49; Birdsell et al. 2005, 092048). Because disposal at MDAs A and B was predominantly dry, long travel times are expected to apply at these two MDAs and to any releases that may have occurred at DP East.

Anthropogenic discharges, such as liquid-waste releases to adsorption beds or water leaks from buried pipes, can cause large, temporary increases in mesa-top infiltration rates. Evidence of fracture transport in a partially welded tuff exists beneath MDA T. Subsurface contaminant data from 1960, 1978 and 1996 collected beneath the adsorption beds show evidence of contaminant transport associated with fractures, while subsurface data collected in boreholes adjacent to the beds shows none (Nyhan et al. 1984, 058906; LANL 2004, 085641). However, the 1978 study, which targeted data collection in fractures beneath the adsorption beds, concluded that most fractures (8 of 10) did not enhance contaminant transport and that most contaminants were much shallower and located in the porous matrix. The two observations of transport in fractures in that investigation occurred at similar depths (less than 7 m below the ground surface) to those cited in the 1960 study, even though the four investigative boreholes drilled in 1978 extended deeper (to 30 m) (Nyhan et al. 1984, 058906). Although the 1996 data show contamination in a 20-m deep fracture, the general assumption is that fracture transport occurred while the beds actively received liquid waste, and that the contaminants associated with the fractures are remnants of previous fracture flow episodes (LANL 2004, 085641). These data support the idea that fracture flow ceases once liquid mesa-top disposals stop (Soll and Birdsell 1998, 070011). Infiltration rates are expected to return to near-background levels when the mesa-top water balance returns to native conditions. However, an extended period of enhanced matrix-dominated transport may occur if vadose-zone moisture contents are elevated compared to background conditions. It is likely that limited fracture transport could have also occurred beneath the adsorption beds at MDAs U and V because waste disposal practices were similar to those used at MDA T. Also, if the liquid waste lines at TA-21 leaked during their 40-yr life span, localized subsurface transport beneath these lines may have occurred. Field investigations during D&D at TA-21 will investigate the waste line areas. Despite a chance of enhanced transport associated with anthropogenic water sources on DP Mesa, transport through the mesa top toward the regional aquifer should lag behind any releases to canyons in the area.

2.3.3 Potential Breakthrough Locations

Three potential breakthrough locations for TA-21 on DP Mesa were identified, 21-1 through 21-3, as shown in Figure 2.0-3 and described in Table 2.0-1. These breakthrough locations are used in the simulations presented in Appendix C to assess the monitoring network in terms of its adequacy for detecting contaminant plumes from future TA-21 releases.

2.4 Regional Flow and Transport

The regional aquifer is a complex, heterogeneous system that includes unconfined (phreatic) and confined zones. The degree of hydraulic communication between these zones is thought to be spatially variable.

The shallow portion of the regional aquifer (near the water table) is predominantly under phreatic (unconfined) conditions and has limited thickness (approximately in the range of 30 to 50 m [98 to 164 ft]). Groundwater flow and contaminant transport directions in this zone generally follow the gradient of the regional water table; the flow is generally east/southeastward (Appendix D). The direction and gradient of flow at the regional water table are predominantly controlled by areas of recharge (e.g., the Sierra de los Valles and variably within some Pajarito Plateau canyons) and discharge (the White Rock Canyon springs and the Rio Grande).

The deep portion of the regional aquifer is predominantly under confined conditions, and it is stressed by Pajarito Plateau water-supply pumping. The production wells located close to the LA and Pueblo Canyons are O-1, O-4, PM-1 and PM-3. The intensive pumping likely has a small impact on the flow directions in the phreatic zone because of poor vertical hydraulic communication between the deep and shallow zones of the regional aquifer. This assumption is supported by the contrasting water-level responses observed in R-35a and R-35b during pumping of PM-3 (LANL 2007, 098129). PM-3 is screened approximately 56 to 536 m (183 to 1759 ft) below the regional water table. The water level in R-35a, which has a well screen opposite the upper part of louvers in PM-3, responds rapidly to pumping at PM-3 (as well as at O-4), whereas R-35b, which is screened near the water table, shows either no or a very small response.

Pumping at PM-3 produces apparent drawdowns at R-8 screen 2 (10 ft), R-24 (2-3 ft), R-4 (1 ft) (Appendix D). Water levels in these screens exhibit confined behavior, and the observed pressures are not characteristic of the water-table elevation. Water-level variations at R-8 screen 1 also correlate to PM-3 pumping (drawdown about 2 ft); however, the water levels at screen 1 are elevated with respect to surrounding monitoring wells, causing local mounding of the regional water table. The occurrence of pumping response and mounding in the same well screen is difficult to explain theoretically. For the most part, pumping at PM-3 does not seem to affect the hydraulic gradients in the phreatic zone of the regional aquifer. Similarly, PM-1 pumping influences the deep regional screen (#4) at R-5 but not the shallow one (#3). There is no apparent response to pumping at O-4 at any of the wells except for R-35a from the available data. There is insufficient data to define the potential effect of O-1 pumping on the water table. Contaminants are observed in O-1 and a recent study (David Schafer & Associates 2006, 094699) concluded that the probable contaminant pathway is along the top portion of the aquifer. Thus, contaminant migration can be expected to follow water-table gradients rather than to divert toward the pumping wells. The poor hydraulic communication between the phreatic and confined zones does not preclude the possibility that some contaminant migration may occur. Between the two zones, the hydraulic gradient has a downward vertical component because of water-supply pumping, creating the possibility that downward contaminant flow may occur along “hydraulic windows.”

Potential pathways along the phreatic zone of the regional aquifer toward the Buckman well field are also analyzed as part of this investigation. Based on the discussion above, the most probable locations of discharge of the potential contaminant flow are expected to be the springs on the west side of White Rock Canyon, rather than the Buckman wells. Pumping of the deep portions of the regional aquifer at the Buckman well field is not expected to propagate to the shallow phreatic portion of the regional aquifer beneath the Pajarito Plateau due to vertical anisotropy caused by the pronounced stratification of the regional aquifer. Besides the regional aquifer stratification mentioned at R-35a and R-35b and elsewhere, other field observations also support the conclusion that there is separation between the upper and lower portions of the regional aquifer. For example, spring discharge rates in White Rock Canyon are independent of intensive pumping in their vicinity, particularly at the Buckman well field. If the aquifer was comprised of relatively uniform and isotropic medium, substantial drawdowns of the pressure heads due to the pumping would substantially reduce or completely dry up groundwater discharges at the springs. In addition, close to the Rio Grande, the deep production wells of the Los Alamos (including LA-5) and Buckman well fields were confined or artesian (i.e. flowing with confined head elevations higher than the ground surface) before the intensive pumping commenced. The confined conditions demonstrate natural protection of production wells against contaminant migration coming from the shallow portions of the regional aquifer with a limited probability for the existence of localized hydraulic windows (Vesselinov 2005, 090040).

Appendix D-3 discusses in detail the existing hydrogeologic information regarding the regional aquifer in the study area. There are substantial uncertainties in the shape of the regional water-table (Appendix D-4), especially related to the potential regional mounding near TW-1 and O-1. As a result, two alternative water-table maps are introduced, and both are incorporated in the numerical modeling. There are also uncertainties with the shape of the regional water table to the north of Pueblo Canyon. In this area it is assumed that the water-table follows the general trend of groundwater flow from west to east.

3.0 MONITORING OBJECTIVES

The purpose of this report is to evaluate the groundwater-monitoring network in the vicinity of Los Alamos/Pueblo Canyons. This section presents the specific objectives of groundwater monitoring in terms of protection of production wells and off-site releases and, to a more limited extent, to aid in the determination of the nature and extent of any contaminant release. Those specific objectives of the groundwater monitoring network are described below.

1. To confidently detect contaminants before their arrival at water-supply wells

To meet this objective, the groundwater network should have a 95% chance of detecting Laboratory contaminants before their arrival at O-1, O-4, LA-5, or the point of regional groundwater discharge in White Rock Canyon in the vicinity of the Buckman well field.

2. To confidently detect contaminants before their arrival at a Laboratory boundary

This objective represents the Laboratory's general desire to detect contaminant migration before the contaminants leave Laboratory boundaries. This objective can and is applied to releases into Los Alamos Canyon and at TA-21, which remain as Laboratory property. In this case, the objective of the groundwater-monitoring network is to have a 95% chance of detecting Laboratory contaminants before their arrival at a Laboratory boundary.

Releases in Pueblo Canyon began when it was Laboratory property. However, due to land transfers, Pueblo Canyon is currently outside of the Laboratory boundary. Existing wells installed in Pueblo Canyon were part of a characterization program. Data from these wells demonstrate that Laboratory releases have been detected in the regional aquifer. Therefore, the objective of detecting contaminants before they leave the Laboratory boundary does not specifically apply in the case of Pueblo Canyon. The existing wells are still valuable because they contribute to objectives 1 and 3.

3. To support an understanding of the nature and extent of contamination sufficient to support the evaluation of potential corrective measures

This objective evaluates the contribution of the groundwater-monitoring network to the understanding of the nature and extent of contaminant migration within the regional aquifer. This objective does not have a quantitative metric because the degree to which the nature and extent of contamination must be understood is a function of which remedial alternative, if any, will be employed, and the remedial decision will not come until the CME phase of work.

These three objectives are addressed by using a groundwater transport model that places hypothetical contaminants in the regional groundwater system at locations where infiltration has been documented and at locations where infiltration is expected to have occurred based on previous investigations. From these points, hypothetical plumes are allowed to migrate downgradient. Uncertainties in the parameters that govern transport are treated probabilistically, yielding a description of possible transport pathways. The results of these simulations are then analyzed to determine whether the groundwater network achieves the objectives.

4.0 MONITORING NETWORK ASSESSMENT

The following table summarizes the evaluation of the physical and geochemical performance of the group of wells considered for Los Alamos and Pueblo Canyons in the context of the monitoring objectives described in Section 3.0. The physical criteria include the effectiveness of sampling systems to provide representative groundwater data, well construction, and isolation of sampling zones. Also included are reviews of factors evaluated in the context of the conceptual model and monitoring objectives, such as screen positions and screen length. A more detailed discussion of the physical and hydrologic conditions is presented in Appendix A. Geochemical criteria consider conditions within the aquifer related to drilling operations that may result in sample data that do not meet monitoring objectives, focusing on key contaminants of concern for groundwater. A more detailed discussion of the geochemical conditions is presented in Appendix B.

Well Name	Physical and Hydrologic Evaluation (Appendix A)	Geochemical Evaluation (Appendix B)
Los Alamos Canyon Wells		
R-6 (Regional)	Meets objectives	Meets objectives
R-7 Screen 1 (Intermediate)	Meets objectives, but the screen has gone dry.	As of last sampled event in August 2002, the sample data were representative.
R-7 Screen 2 (Intermediate)	n/a*—Screen 2 has been dry since installation.	n/a

Well Name	Physical and Hydrologic Evaluation (Appendix A)	Geochemical Evaluation (Appendix B)
R-7 Screen 3 (Regional)	Meets objectives	Conditionally meets objectives. Effective for monitoring tritium known to have been released from OWR. The tritium concentrations in this screen are at background. More generally, residual inorganic chemicals, residual organic chemicals, sulfate-reducing conditions, and carbonate-mineral disequilibria are present in this interval. However, the ability for this well to effectively monitor tritium as the most conservative tracer contaminant in this portion of the watershed makes this an effective well.
R-8 Screen 1 (Regional)	Conditionally meets objectives. Clay-rich slough covers upper 80% of well screen, possibly interfering with the free flow of water through the upper part of the screen. Anomalously high water levels are associated with screen 1	Meets objectives
R-8 Screen 2 (Regional)	Meets objectives. Concerns with the screen 1 interval are compensated by the performance of this screen because of the close spacing of the two screens.	Meets objectives
R-9 (Regional)	Meets objectives. The water-level data are ambiguous because of completion in the Miocene basalt. However, at this location, the R-9 regional screen is in the first permeable zone beneath the water table.	Meets objectives
LAOI(A)1.1 (Intermediate)	Meets objectives	Meets objectives
LADP-3 (Intermediate)	Meets objectives	Meets objectives. Nitrate-reducing conditions and elevated total organic carbon (TOC) concentrations are present. However, these conditions are probably representative of predrilling groundwater conditions because no drilling additives were used.
LAOI-3.2 (Intermediate)	Meets objectives	Meets objectives
LAOI-3.2a (Intermediate)	Meets objectives	Meets objectives
LAOI-7 (Intermediate)	Meets objectives	Meets objectives
R-6i (Intermediate)	Meets objectives	Meets objectives
R-9i Screen 1 (Intermediate)	Meets objectives	Conditionally meets objectives. Manganese-reducing conditions and elevated TOC concentrations are present but are believed to be related to infiltration of post-Cerro Grande stormwater that contained high concentrations of organic carbon. Screen 1 shows different chemistry from screen 2.

Well Name	Physical and Hydrologic Evaluation (Appendix A)	Geochemical Evaluation (Appendix B)
R-9i Screen 2 (intermediate)	Meets objectives	Conditionally meets objectives. Manganese-reducing conditions and elevated TOC concentrations are present but are believed to be related to infiltration of post-Cerro Grande stormwater that contained high concentrations of organic carbon. Screen 2 shows different chemistry from screen 1.
TW-3 (Regional)	Does not meet objectives. Annular seal is inadequate; possible leakage of surface water to regional groundwater along well casing. Corrosion of casing may influence chemistry of water samples.	Does not meet objectives due to evidence of corrosion
Pueblo Canyon Wells		
R-2 (Regional)	Meets objectives	Meets objectives
R-4 (Regional)	Meets objectives	Meets objectives
R-5 Screen 1 (Intermediate)	n/a—Screen 1 has been dry since installation.	n/a—Screen 1 has been dry since installation.
R-5 Screen 2 (Intermediate)	Meets objectives	Meets objectives
R-5 Screen 3 (Regional)	Meets objectives	Meets objectives
R-5 Screen 4 (Regional)	Meets objectives	Conditionally meets objectives. Iron-reducing conditions and possible presence of residual inorganic drilling constituents are indicated by elevated boron and chloride concentrations as well as possible carbonate-mineral disequilibria. The overall trends for key indicators suggest the interval may be improving.
R-24	Meets objectives	Meets objectives. Manganese-reducing conditions that existed up through May 2006 appear to have cleared up. These conditions also did not appear to impact the reliability of perchlorate and nitrate data because these constituents were detected at fairly stable concentrations in every water sample collected since well completion.
TW-1	Annular seal is inadequate; possible leakage of surface water to regional groundwater along well casing. Corrosion of casing may influence chemistry of water samples.	Conditionally meets objectives. Persistent manganese-reducing conditions and carbonate disequilibria are likely representative of groundwater conditions in this area. However, total iron and zinc concentrations and turbidity are persistently elevated above natural background levels, suggesting corrosion of steel-well components, which could affect the reliability of data for some trace metals and organic chemicals of potential concern (COPCs).
TW-2	Annular seal is inadequate; possible leakage of surface water to regional groundwater along well casing. Corrosion of casing may influence chemistry of water samples.	Does not meet objectives. Persistent sulfate-reducing conditions are present. Total iron and zinc concentrations and turbidities are persistently elevated, suggesting corrosion of steel-well components, which could affect the reliability of data for most COPCs.

Well Name	Physical and Hydrologic Evaluation (Appendix A)	Geochemical Evaluation (Appendix B)
TW-4	Annular seal is inadequate; possible leakage of surface water to regional groundwater along well casing. This may not be a problem at this mesa-top location where no intermediate perched groundwater was encountered. Corrosion of casing may influence chemistry of water samples.	Does not meet objectives due to evidence of well corrosion
R-3i (Intermediate)	Meets objectives	Meets objectives
POI-4 (Intermediate)	Meets objectives	Meets objectives
TW-1A (Intermediate)	Annular seal is inadequate; possible leakage of surface water to regional groundwater along well casing.	Does not meet objectives due to evidence of well corrosion
TW-2A (Intermediate)	Annular seal is inadequate; possible leakage of surface water to regional groundwater along well casing.	Does not meet objectives due to evidence of well corrosion

* n/a = Not applicable.

Appendix C presents an assessment of the overall monitoring well network to determine the monitoring efficiency of the existing and proposed regional well locations. The results are presented in detail in Appendix C, and the implications for recommendations are discussed in Section 5.0

5.0 RECOMMENDATIONS

The regional network assessment presented in Appendix C supports the recommendations presented in Section 5. Several regional wells were identified as not currently meeting the physical/hydrologic and geochemical monitoring objectives (TW-1, TW-1A, TW-2, TW-2A, TW-3, and TW-4).

The table below presents the recommended actions and rationale for each of the existing wells evaluated as part of the Los Alamos and Pueblo Canyons groundwater-monitoring well network evaluation. These recommendations are based on the physical, geochemical, and hydrologic factors considered in the context of the monitoring objectives. Following this, recommendations for installation of new wells are made to address gaps in the capability of the existing wells to fulfill the objectives of the monitoring network.

Well Name	Recommended Action	Rationale
Los Alamos Canyon Wells		
R-6 (regional)	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives.
R-7 Screen 1 (Intermediate)	Continue to monitor water levels in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665) and collect samples if water is present	No change is necessary at this time.
R-7 Screen 2 (Intermediate)	Continue to monitor water levels in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665) and collect samples if water is present	No change is necessary at this time.
R-7 Screen 3 (Regional)	Continue to monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665) and collect samples if water is present	No change is necessary at this time.
R-8 Screen 1 (Regional)	Continue to monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Although the ability of R-8 screen 1 to provide representative data is inconclusive, no action is proposed at this time. Screen 1 is in a relatively tight zone, caused by the abundance of clays, and further development would be unlikely to improve its performance. Additionally, monitoring needs at this location can be satisfied by screen 2 due to its proximity to screen 1 and its good production, indicating that it likely is providing samples from a primary potential flow path within the upper portion of the regional aquifer. Further data collection from screen 1 will help reduce uncertainty in the data.
R-8 Screen 2 (Regional)	Continue to monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665).	Well meets monitoring network objectives.
R-9 (Regional)	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives.
LAOI(A)1.1 (Intermediate)	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives.

Well Name	Recommended Action	Rationale
LADP-3 (Intermediate)	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives.
pLAOI-3.2 (Intermediate)	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives.
LAOI-3.2a (Intermediate)	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives.
LAOI-7 (Intermediate)	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives.
R-6i (Intermediate)	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives.
R-9i Screen 1 (Intermediate)	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives.
R-9i Screen 2 (Intermediate)	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives.
TW-3 (Regional)	Plug and abandon well	TW-3 is recommended for plugging and abandonment because the well annulus is a potential pathway for alluvial and intermediate groundwater to reach regional groundwater. R-6 was installed as a replacement well for TW-3 and, along with R-8, meets the monitoring objectives for regional groundwater in that portion of Los Alamos Canyon.
Pueblo Canyon Wells		
R-2 (Regional)	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives.
R-4 (Regional)	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives.
R-5 Screen 1 (Intermediate)	Continue to monitor water levels in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665) and collect samples if water is present	No change is necessary at this time.

Well Name	Recommended Action	Rationale
R-5 Screen 2 (Intermediate)	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives.
R-5 Screen 3 (Regional)	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives.
R-5 Screen 4 (Regional)	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Screen 4 shows an improving trend in its ability to provide representative data, such as for tritium and perchlorate. Overall, R-5 meets monitoring objectives with the performance in screens 2 (intermediate) and 3 (regional). Screen 3 is the primary screen for measurements near the water table and shows good geochemical performance. This supports maintaining the well as is and continuing to monitor overall performance.
R-24	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives. Evaluate the stability of water-quality parameters over a longer period of record
TW-1	Plug and abandon well	TW-1 is recommended for plugging and abandonment because the well annulus is a potential pathway for alluvial and intermediate groundwater to reach regional groundwater. However, due to the importance of this location in the overall monitoring network, it is recommended that TW-1 be replaced. (See discussion on new wells below.)
TW-2	Plug and abandon well	TW-2 is recommended for plugging and abandonment because the well annulus is a potential pathway for alluvial and intermediate groundwater to reach regional groundwater. Regional wells R-2 and R-4 satisfy monitoring requirements in this portion of Pueblo Canyon.
TW-4	Maintain exclusively for water-level monitoring	Because corrosion of the screen is occurring, water-quality data are not reliable. Potential leakage along the annular space might be possible; however, the mesa-top location of this well makes this likely to be unimportant. Therefore, it is recommended that this well be maintained for water-level measurements to help constrain the water-table elevations in this portion of the plateau.
R-3i	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives.
POI-4	Monitor in accordance with the "Interim Facility-wide Groundwater Monitoring Plan" (LANL 2007, 096665)	Well meets monitoring network objectives.

Well Name	Recommended Action	Rationale
TW-1A (Intermediate)	Plug and abandon well	TW-1A is recommended for plugging and abandonment because the well annulus is a potential pathway for alluvial and intermediate groundwater to reach regional groundwater. R-3i was installed as a replacement well for TW-1A and meets monitoring objectives for intermediate groundwater in that portion of Pueblo Canyon.
TW-2A (Intermediate)	Plug and abandon well	TW-2A is recommended for plugging and abandonment because the well annulus is a potential pathway for alluvial and intermediate groundwater to reach regional groundwater.

The assessment concludes that in addition to the recommendations described above, two new regional groundwater-monitoring wells are proposed as described below. These new wells enhance the ability of the groundwater-monitoring well network to confidently detect potential contaminants before their arrival at water-supply wells. Additional wells may be necessary in the future as guided by the results of investigations at TA-21 MDAs.

The configuration of wells in the existing network that meet the physical and geochemical criteria was considered insufficient to meet the monitoring objectives described in Section 3.0. The following discussion and table contain recommendations to augment the existing network to meet monitoring objectives.

For the majority of the watershed, the regional groundwater-monitoring network is performing adequately; however, two key locations warrant additional regional groundwater wells to augment the existing network. Monitoring well R-3 is proposed for lower Pueblo Canyon to improve the characterization of the regional groundwater in the vicinity of Los Alamos County water-supply well O-1. In addition to water-quality data, the well should provide important water-level information to help constrain the direction of groundwater flow in this area. Data from R-3 will also improve the understanding of potential Laboratory contaminants with respect to monitoring for O-1. An additional regional well is recommended to enhance protection monitoring for the City of Santa Fe's Buckman well field. Potential migration pathways from infiltration windows at the Los Alamos and Pueblo Canyon confluence might flow along the phreatic zone of the regional aquifer toward the area where the Buckman well field is located. However, the most probable locations of discharge of the potential contaminant flow are expected to be the springs along the west bank of Rio Grande, rather than the Buckman wells, as discussed in Section 2.4.

The network analysis in this report does not specifically evaluate the need for perched intermediate monitoring wells. However, contaminants are present in perched intermediate monitoring well TW-2A, which is proposed for plugging and abandonment. Therefore, one new perched intermediate monitoring well is proposed to investigate the potential source(s) of contamination.

Well Name	Recommended Action	Rationale
R-3	Install a new single-screen regional groundwater-monitoring well in lower Pueblo Canyon A specific location will be selected in consultation with NMED and presented in a well-specific work plan.	Installation of this well will provide a monitoring location to characterize the groundwater in the area and for protection of water-supply well O-1. The new well will also potentially provide an important refinement of the water-table elevation beneath the lower portion of Pueblo Canyon and therefore help constrain the groundwater flow direction.
New Regional Well to Address	Install a regional groundwater-monitoring well (or two single-	Installation of this well will provide a monitoring location to enhance protection monitoring for the City of

Protection of Buckman Well Field	screen wells) on San Ildefonso land at a key location (to be determined) upgradient of the Buckman well field A specific location will be selected in consultation with NMED and other land owners, as appropriate, and presented in a well-specific work plan. Siting this well will greatly benefit from refinement of the water-table configuration that is expected to be accomplished with new well R-3 and therefore should follow in sequence.	Santa Fe's Buckman well field. This well is recommended to ensure early detection of potential contaminants originating from the LA/P watershed.
TW-2A Replacement	Install a new single-screen perched intermediate groundwater monitoring well in middle Pueblo Canyon. A specific location will be selected in consultation with NMED and presented in a well-specific work plan.	Installation of a new perched intermediate well as a replacement to monitor potential contaminant pathways originating from infiltration windows upcanyon or near this location. Groundwater elevations at TW-2A are apparently currently below the screen, but the well has historically shown tritium contamination.

The monitoring frequency and analyte suites will be specified in annual updates to the "Interim Facility-wide Groundwater Monitoring Plan."

6.0 SCHEDULE

Upon NMED's approval of the recommendations contained in this report, the Laboratory will submit work plan(s) for implementation of the actions. Each work plan will contain specifics for each of the actions and propose a schedule for implementation.

7.0 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 number. This information is also included in text citations. ER ID numbers 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; the U.S. Department of Energy–Los Alamos Site Office; the U.S. Environmental Protection Agency, Region 6; 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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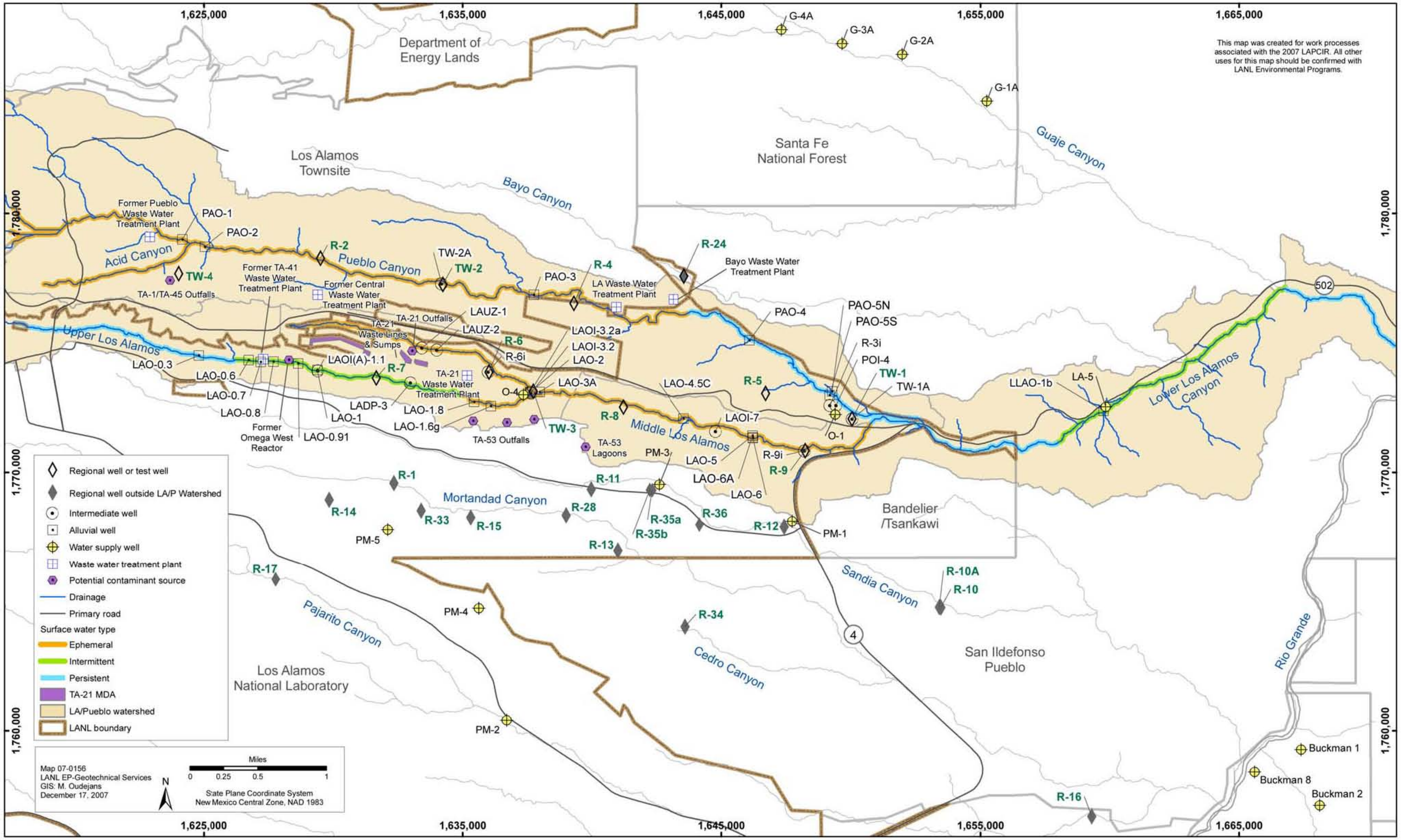
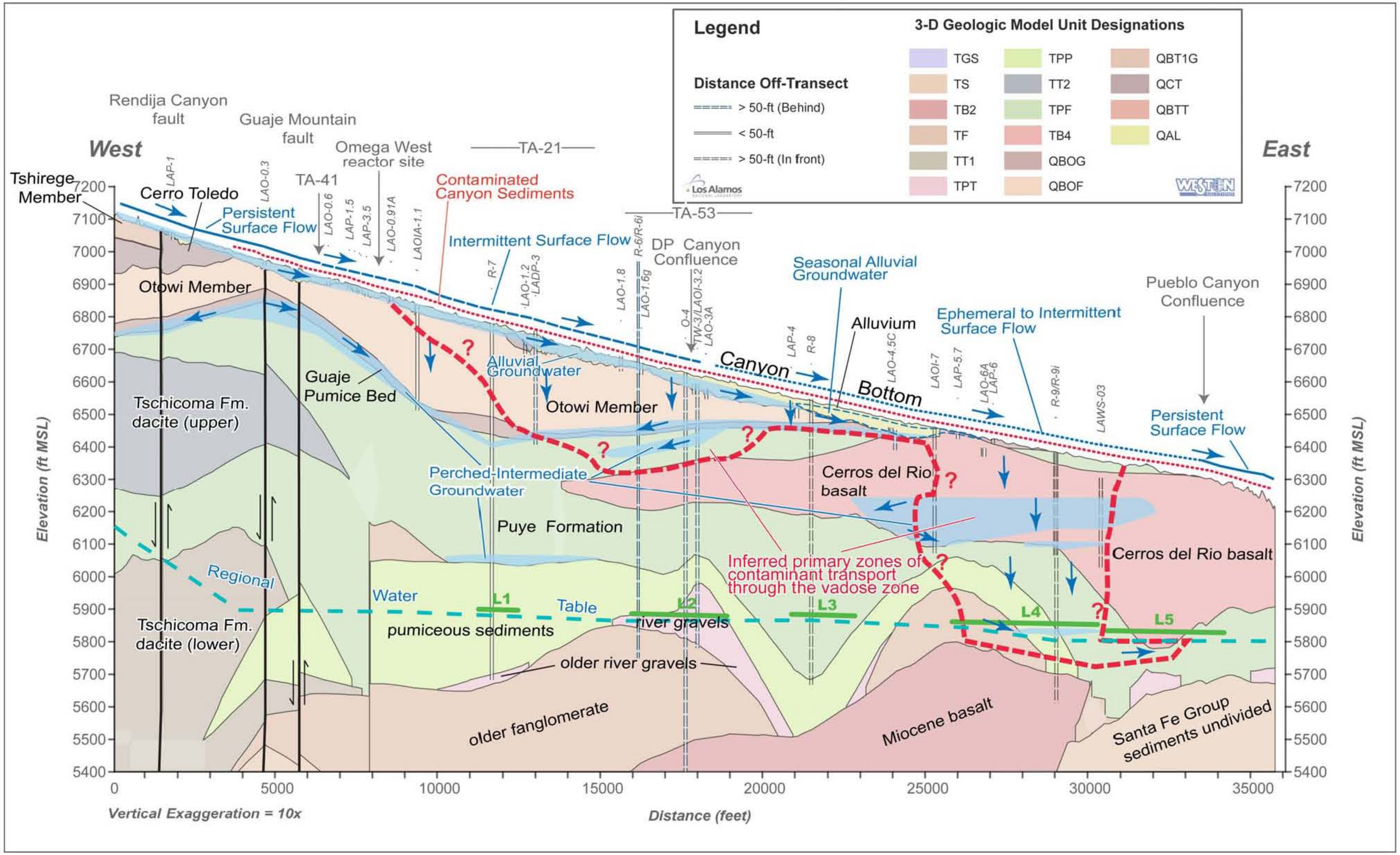
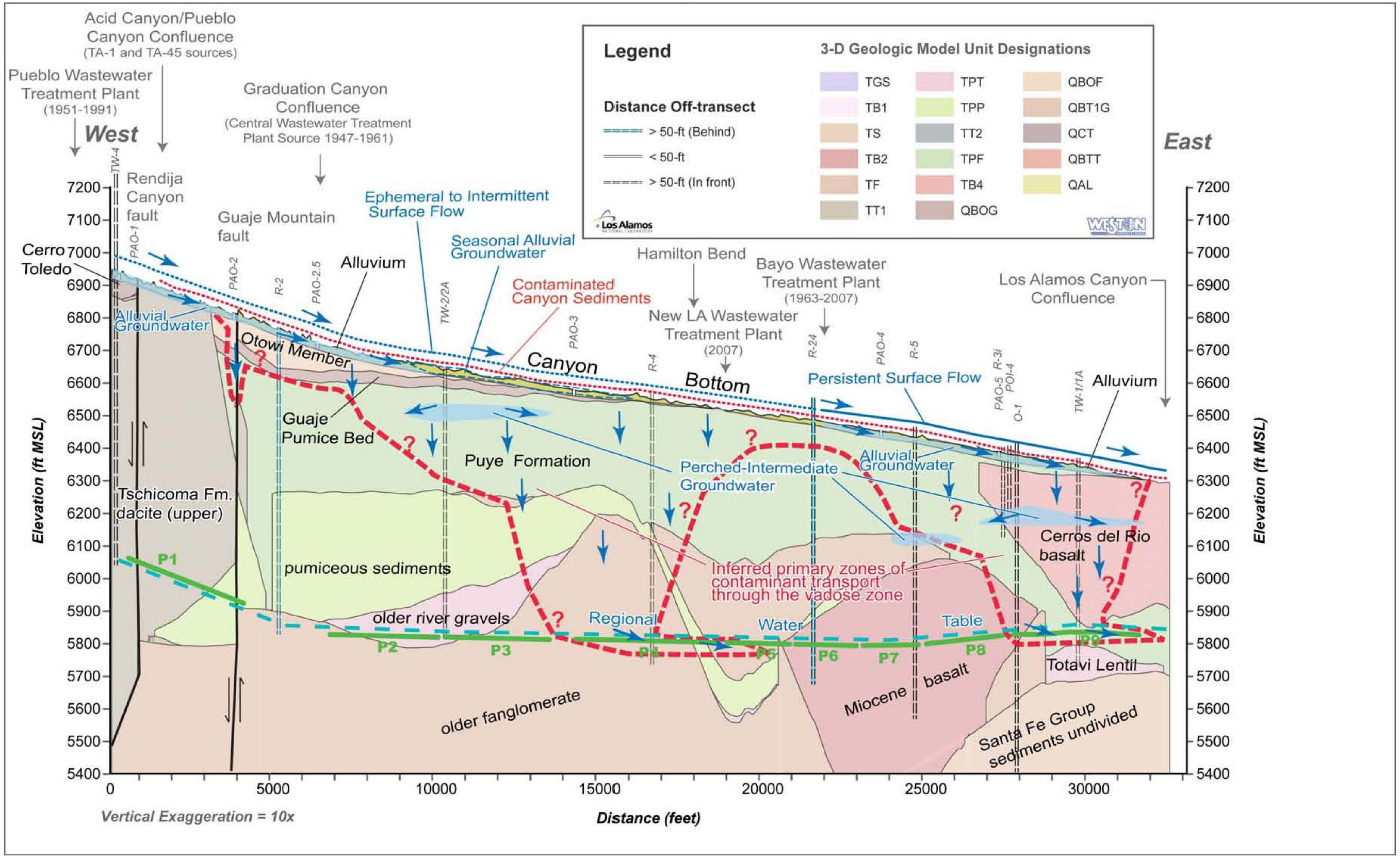


Figure 1.0-1 Location of Los Alamos and Pueblo Canyons including major tributaries, occurrences of surface water, major contaminant release sites, land ownership, boreholes, water supply wells, and alluvial, intermediate, and regional monitoring wells



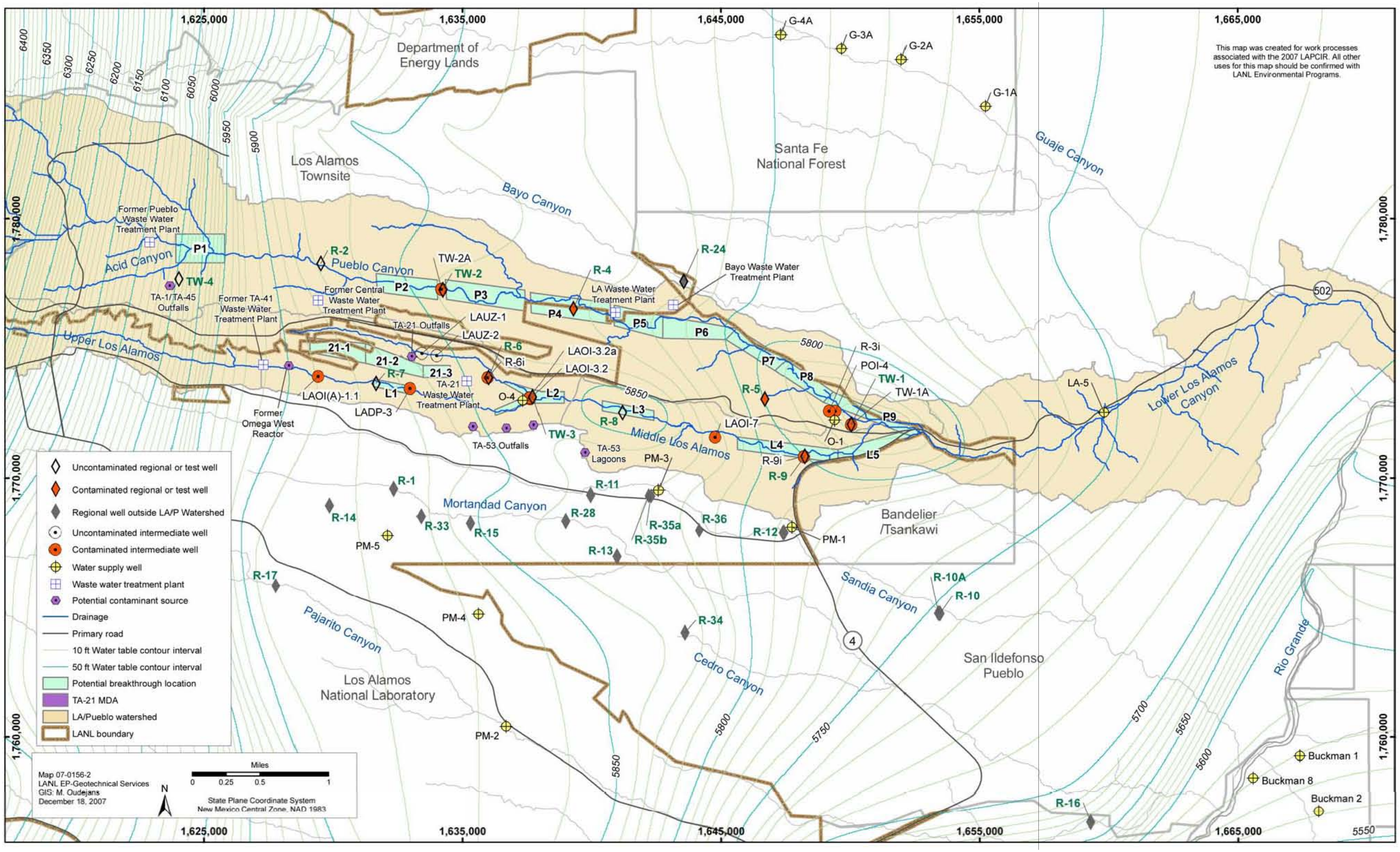
Note: The geology is based on the 2005 site-wide 3-D model for the Laboratory (Cole et al. 2006, 095079).

Figure 2.0-1 Conceptual hydrogeologic cross-section for Los Alamos Canyon showing locations of primary contaminant release sites, surface water extent, alluvial and perched intermediate groundwater (shaded blue areas), regional water table (dashed blue line), inferred zones of contaminant transport for mobile constituents through the vadose zone and regional aquifer (red dashed lines), potential contaminant breakthrough locations (L1–L5), and potential contaminant transport pathways (blue arrows) for contaminants



Note: The geology is based on the 2005 site-wide 3-D model for the Laboratory (Cole et al. 2006, 095079).

Figure 2.0-2 Conceptual hydrogeologic cross section for Pueblo Canyon showing locations of primary contaminant release sites, surface water extent, alluvial and perched intermediate groundwater (shaded blue areas), regional water table (dashed blue line), inferred zones of contaminant transport for mobile constituents through the vadose zone and regional aquifer (red dashed lines), potential contaminant breakthrough locations (P1–P9), and potential contaminant transport pathways (blue arrows) for contaminants



Note: Contamination status of regional and intermediate wells in the LA/P Watershed is indicated, and water table contour map #1 is shown.

Figure 2.0-3 Location map for Los Alamos and Pueblo Canyons showing major contaminant release sites and 17 potential breakthrough locations where mobile contaminants have or may reach the regional aquifer from these sources

Table 2.0-1
Potential Breakthrough Locations at the Regional Aquifer for Los Alamos and Pueblo Canyon Watershed

Breakthrough Location	Original Sources	Footprint at Water Table	Justification
Los Alamos Canyon L1	OWR	OMR site; R-7 to LADP-3	R-7 appears uncontaminated, but intermediate well LADP-3 is contaminated; alluvial groundwater is present.
Los Alamos and DP Canyons L2	21-011(k) outfall, OMR, TA-21 outfalls, and TA-53 outfalls	Confluence of LA/DP Canyons; portion in DP Canyon starts at DP Spring	Intermediate wells LAOI-3.2 and LAOI-3.2(a) and regional test well TW-3 in this segment are all contaminated; alluvial groundwater is present.
Los Alamos Canyon L3	21-011k outfall, OMR, TA-21 outfalls (sewage), and TA-53 outfalls (cooling towers)	Centered around R-8	R-8 is not contaminated; however, high regional water level indicates potential infiltration area; infrequent alluvial groundwater.
Los Alamos Canyon L4	21-011k outfall, OMR, TA-21 (sewage) outfalls, and TA-53 outfalls (cooling towers)	Lower LA Canyon around R-9	R-9 and R-9i are contaminated. At this location, basalt is immediately beneath the alluvium. Alluvial groundwater saturation in this location is infrequent and short-lived.
Los Alamos Canyon L5	21-011k outfall, OMR, TA-21 (sewage) outfalls, and TA-53 outfalls (cooling towers)	Lower LA Canyon above Pueblo Canyon confluence	R-9 and R-9i are contaminated. At this location basalt is immediately beneath alluvium. Alluvial groundwater saturation in this location is infrequent and short-lived.
Pueblo and Acid Canyons P1	TA-1 radioactive waste outfall and TA-45 RLWTF outfall; Pueblo Sewage Treatment Plant	Acid Canyon/Pueblo Canyon confluence	Potential enhanced infiltration at Pueblo/Acid Canyon confluence during releases. Near Rendija Canyon fault zone. R-2 is clean and TW-4 is not contaminated (indeterminate conditions); location retained because of concerns about source rather than observed contamination in regional aquifer.
Pueblo Canyon P2	TA-1 radioactive waste outfall and TA-45 RLWTF outfall; Pueblo and Central Sewage Treatment Plants	Pueblo Canyon, west of TW-2	TW-2A is contaminated. TW-2 is not contaminated (background and indeterminate conditions).

Table 2.0-1 (continued)

Breakthrough Location	Original Sources	Footprint at Water Table	Justification
Pueblo Canyon P3	TA-01 radioactive waste outfall and TA-45 RLWTF outfall; Pueblo and Central Sewage Treatment Plants	Pueblo Canyon, east of TW-2 and west of PAO-3	TW-2a to the west and R-4 to the east show signs of contamination.
Pueblo Canyon P4	TA-01 radioactive waste outfall and TA-45 RLWTF outfall; Pueblo and Central Sewage Treatment Plants	Pueblo Canyon, centered around R-4	R-4 is contaminated.
Pueblo Canyon P5	TA-01 radioactive waste outfall and TA-45 RLWTF outfall; Pueblo and Central Sewage Treatment Plants	Pueblo Canyon, just upstream of the Bayo WWTP outfall	R-4 to the west is contaminated and R-5 to the east is contaminated.
Pueblo Canyon P6	Bayo Sewage Treatment Plant; TA-01 radioactive waste outfall and TA-45 RLWTF outfall; Pueblo and Central Sewage Treatment Plants	Pueblo Canyon, downstream from Bayo Sewage Treatment Plant	Perennial surface water and alluvial groundwater here from Bayo Plant. Alluvium largely on Puye Formation in this area.
Pueblo Canyon P7	Bayo Sewage Treatment Plant; TA-01 radioactive waste outfall and TA-45 RLWTF outfall; Pueblo and Central Sewage Treatment Plants	Pueblo Canyon, downstream from segment P6	Perennial surface water and alluvial groundwater here from Bayo Plant; Upstream of wells POI-4, R-3i, TW-1, TW-1A, TW-2A, and O-1, all of which are contaminated. Alluvium largely on Puye Formation in this area.
Pueblo Canyon P8	Bayo Sewage Treatment Plant; TA-01 radioactive waste outfall and TA 45 RLWTF outfall; Pueblo and Central Sewage Treatment Plants	Pueblo Canyon downstream of segment P7 and upstream of confluence with Los Alamos Canyon	Perennial surface-water flow here from Bayo Plant; upstream of wells POI-4, R-3i, TW-1, TW-1A, and O-1, which are all contaminated
Pueblo Canyon P9	Bayo Sewage Treatment Plant; TA-01 radioactive waste outfall and TA-45 RLWTF outfall; Pueblo and Central Sewage Treatment Plants	Pueblo Canyon to confluence with Los Alamos Canyon	Perennial surface-water flow here from Bayo Plant; adjacent to wells POI-4, R-3i, TW-1, TW-1A, and O-1, which are all contaminated

Table 2.0-1 (continued)

Breakthrough Location	Original Sources	Footprint at Water Table	Justification
TA-21 Mesa Top TA21-1	MDA B	MDA B polygon	Dry disposal and due for excavation. Angled holes beneath site do not show transport.
TA-21 Mesa Top TA21-2	MDAs T, V, and drainlines	Polygon encompassing these areas	MDAs T and V received liquid wastes; Pu and Am to 150 ft beneath MDA T; some indication of tritium beneath MDA V. TA-21 team thinks that acid drainlines between buildings and MDAs and out to outfalls were corroded and leaky. These may have provided wet contaminated source for decades. Field investigations of these sources to come soon. In addition, the team thinks that fire lines may be leaking.
TA-21 Mesa Top TA21-3	DP East buildings and part of MDA A	Polygon encompassing these areas	Tritium operations at DP East are a potential source of tritium. (Field data are not yet available to confirm.) Inclusion of MDA A, although it was a predominantly dry disposal area

Appendix A

Physical and Hydrologic Attributes of Network Wells

A-1.0 INTRODUCTION

The following abbreviations and acronyms are used throughout Appendix A.

bgs	below ground surface
CMR	Combinable Magnetic Resonance tool
DP	Delta Prime
FMI	Formation Micro-Imager
HSA	hollow-stem auger
HSWA	Hazardous and Solid Waste Amendments of 1984
I.D.	inside diameter
LANL	Los Alamos National Laboratory (the Laboratory)
MDA	material disposal area
MP	multiple port
n/a	not applicable
NTU	nephelometric turbity unit
O.D.	outside diameter
PVC	polyvinyl chloride
TA	technical area
TD	total depth
TOC	total organic carbon

LADP-3 Well

LADP-3 Well

	Description	Evaluation
Drilling Method	LADP-3 was drilled using a combination of HSA and air-rotary drilling methods. Air was the only fluid used to advance the borehole.	LADP-3 was drilled from the surface to 232 ft using an 8.5-in. HSA. The borehole was completed to the final depth of 350 ft using air-rotary drilling methods. Rock coring, using a 4.5-in.-diameter rock barrel, alternated with advancement of 5.625-in.-I.D. ODEX casing from 232 to 350 ft. Alluvial and surface groundwater were cased out of the borehole by installing and grouting permanent 8.625-in.-O.D. surface casing to a depth of 90 ft.
General Well Characteristics	LADP-3 is a single-screen well constructed of 2-in. PVC well casing.	The PVC materials used at LADP-3 are chemically inert.
Well Screen Construction	The well screen is constructed of 2-in.PVC with 0.020-in. slots.	The PVC materials used at LADP-3 are chemically inert.
Screen Length and Placement	The well screen extends from 316 to 326 ft and has a length of 10 ft. The most recent measurable water level datum was 321.9 ft on March 2006 (Allen and Koch 2007, 095268), indicating the screen straddled the perched water table at that time. The water level declined below the transducer in April 2006.	LADP-3 is designed to provide water-quality and water-level data for perched groundwater beneath Los Alamos Canyon, and the screen length and placement were selected with the following goals in mind: • Characterize water quality in the uppermost perched intermediate groundwater zone beneath Los Alamos Canyon in the vicinity of TA-21 • Monitor water levels to detect whether perched intermediate groundwater responds to seasonal infiltration beneath Los Alamos Canyon Perched intermediate groundwater was encountered at a depth of 325 ft in the lower part of the Guaje Pumice Bed. Borehole operations were temporarily suspended for several days, and the water level stabilized at about 320-ft depth. Drilling operations resumed to determine the nature and extent of the groundwater. A clay layer a few inches thick at the top of the Puye Formation was interpreted as a paleosol and perching horizon. Drilling stopped at the 350-ft depth within Puye Formation after it was determined that the groundwater is confined to the Guaje Pumice Bed. The screen length and placement for LADP-3 are appropriate for the conditions encountered at this location and meet the goals defined in the bullets above.
Filter Pack Materials and Placement	The primary filter pack consists of 10/20 sand from 316 to 326 ft. There is no mention of a secondary filter pack above the primary filter pack.	The primary filter pack is placed adjacent to the well screen, and there is no mention of the sand extending above or below the slotted well screen.

	Description	Evaluation
Sampling System	Bladder pump	Dedicated pumps allow relatively high-flow sampling. Flow-through cells for measuring field parameters can be used at single-screen wells with dedicated pumps installed. Effective development is typically limited in intermediate wells because of insufficient flow rate and volume; however, development issues are not as critical in wells like LADP-3 that are installed in boreholes where no additives other than air are used during drilling.
Other Issues That Could Affect the Performance of the Well	None	Nitrate-reducing conditions were present in the most recent water sample from the well (April 2007) but are assumed to be representative of the groundwater at this location, and not a residual effect of drilling, because no drilling additives were used (Appendix B).
Additives Used During Drilling		Air
Annular Fill Other Than Filter and Transition Sands		Bentonite: bentonite chips and granules Cement grout surface seal

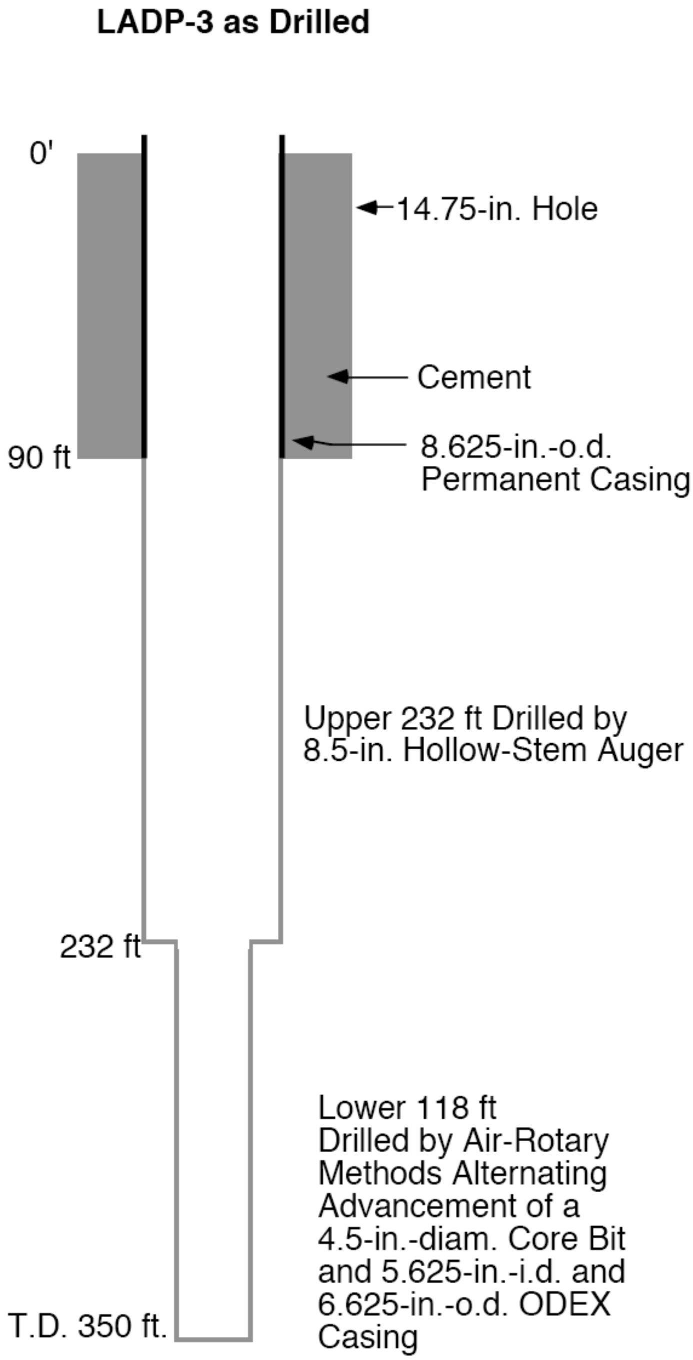


Figure 1 LADP-3 borehole design

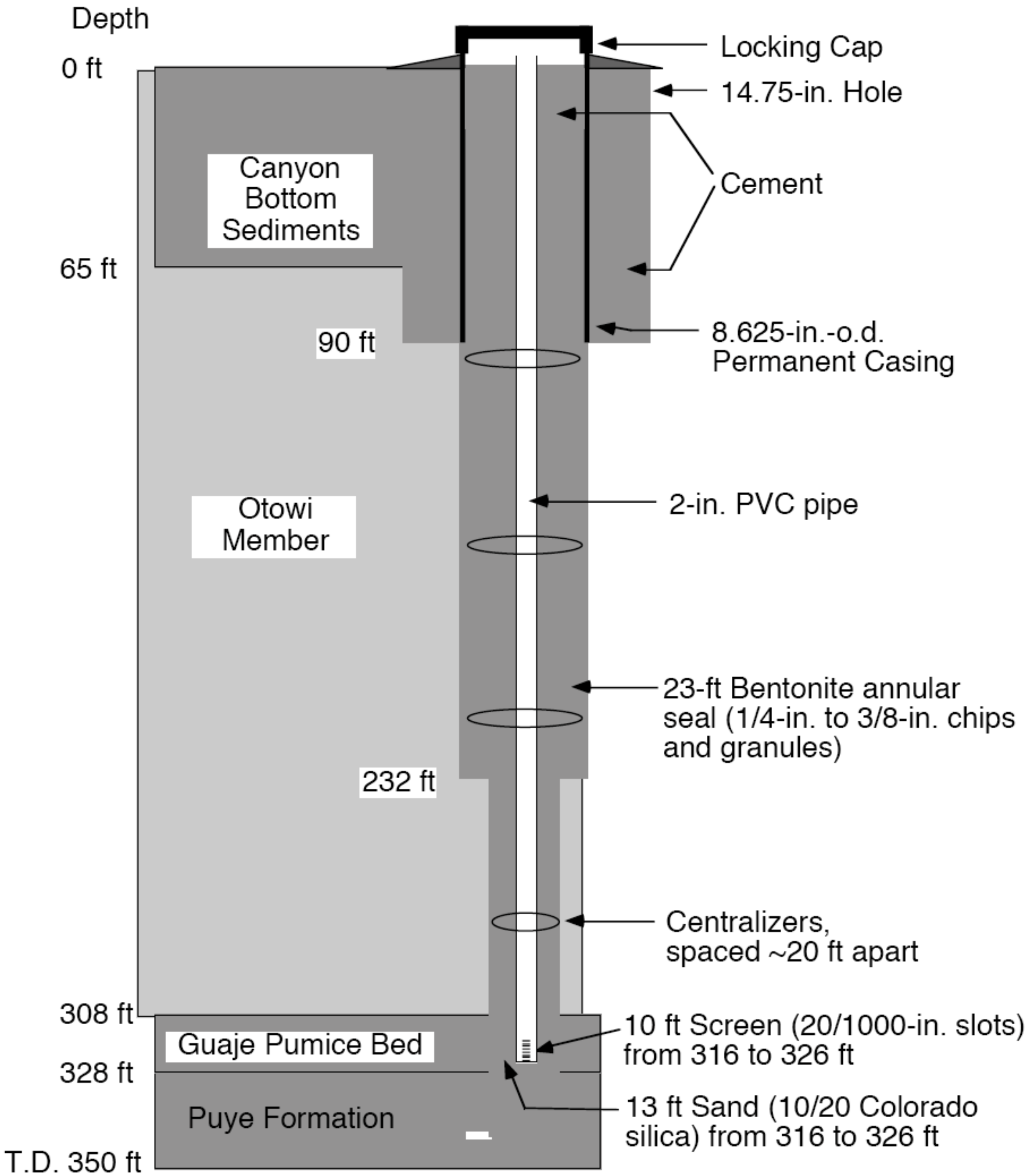


Figure 2 **LADP-3 well design**

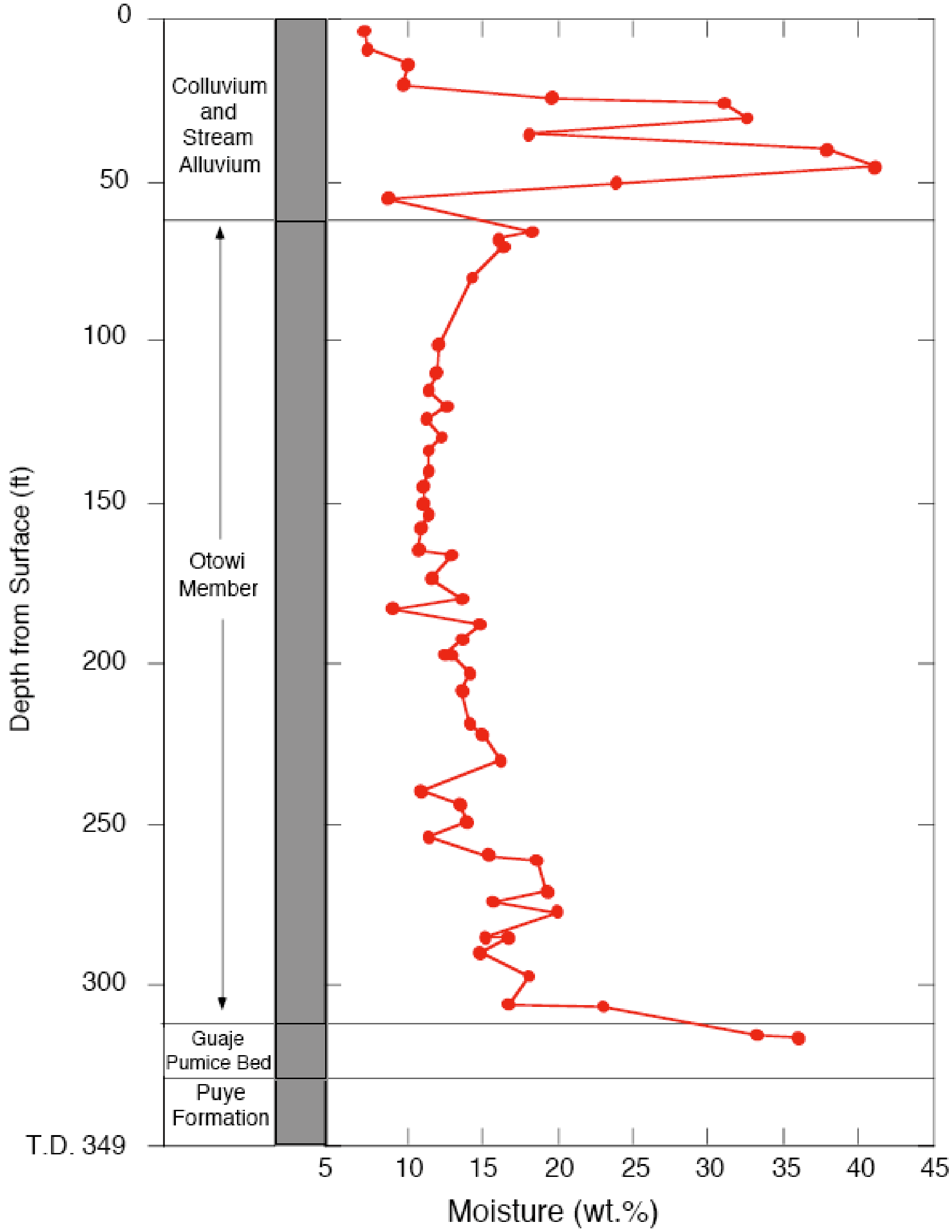


Figure 3 **Geology and moisture distribution in LADP-3 borehole**

LAOI-3.2 and LAOI-3.2a Wells

LAOI-3.2 and LAOI-3.2a Wells

	Description	Evaluation
Drilling Method	LAOI-3.2 and LAOI-3.2a were continuously cored using air as the only fluid to TDs of 165 ft and 266.9 ft, respectively. Drill casing was used to seal off perched groundwater zones above the target horizons in both core holes.	LAOI-3.2 was cored with a target depth of 300 ft; however, drilling was halted at 165 ft bgs to install a perched intermediate zone monitoring well for groundwater encountered in the Otowi Member and the Guaje Pumice Bed. LAOI-3.2 was cored using a Stratastar 15 HSA drill rig equipped with 8.25-in.-O.D./4.5-in.-I.D. augers and a 3.0-in.-O.D. 5-ft-long split-spoon sampler. At approximately 15 ft bgs, a boulder was encountered, and the rig was pulled off of the original location, which was backfilled with bentonite. The rig was moved 4 ft to the north and began collecting core from 15 ft bgs. An alluvial saturated zone extending from approximately 15 to 25 ft bgs was sealed off using 12-in.-O.D. conductor casing set to a depth of 37.5 ft bgs. Coring continued, and perched intermediate groundwater was encountered in the Otowi Member at a depth of approximately 140 ft bgs. The borehole was advanced into the underlying Guaje Pumice Bed to a final TD of 165 ft bgs, and a groundwater monitoring well with a 9.5-ft screened interval was installed. A second well, LAOI-3.2a, was then drilled to reach the original LAOI-3.2 target depth of 300 ft, with the goal of identifying potential deeper perched water zones. LAOI-3.2a was drilled with a Delta Base 540 track-mounted drill rig using the air-rotary casing hammer technique. The initial LAOI-3.2a borehole was drilled to a depth of 234.4 ft, with continuous core being collected from 200 to 234.3 ft. However, when the drill casing was removed from the hole before well construction, the stainless-steel casing shoe could not be retrieved. Another piece of drilling equipment, called an elevator, was lost downhole while attempting to retrieve the casing shoe. After attempts to retrieve both pieces of equipment were unsuccessful, it was decided to plug and abandon the first hole and move the rig 5 ft to the north to drill a new LAOI-3.2a borehole. The relocated LAOI-3.2a was advanced using 6.625 in.-O.D. casing and a 7.5-in.-O.D. hammer bit. The casing was advanced to 230 ft bgs, and the remainder of the borehole was cored continuously to a depth of 266.9 ft. A well with a single 9.6-ft well screen was successfully installed in the new borehole within a perched intermediate zone in the Puye Formation.
General Well Characteristics	LAOI-3.2 is a single-screen well constructed of 2.4-in.-O.D./2.1-in.-I.D. schedule 40-PVC casing. LAOI-3.2a is a single-screen well constructed of 3.1-in.-I.D./3.5-in.-O.D. 304 stainless-steel casing.	The PVC materials used at LAOI-3.2 are chemically inert. All PVC components, including the screen, were factory-cleaned before shipment. The stainless-steel well materials used at LAOI-3.2a are chemically inert and are designed to prevent corrosion.

	Description	Evaluation
Well Screen Construction	The LAOI-3.2 well screen is constructed of 2.1-in.-I.D./3.5-in.-O.D.-PVC prepacked screen containing 10/20 sand and 0.01-in. slots. The LAOI-3.2a well screen is constructed of 3-in.-I.D./3.5-in.-O.D. 304 stainless-steel wire wrap with 0.020-in. slots.	The LAOI-3.2 PVC prepacked screens with 0.010-in. slots developed properly, producing water with an NTU value of 2 and stable water-quality parameters by the end of development. The LAOI-3.2a well screen construction (0.020-wire-wrapped screen) is considered an optimum design that balances the need to prevent fine-grained material from entering the well and the need to promote the free flow of water during well development and sampling. LAOI-3.2a produced water with an NTU value of 2.1 and had stable water-quality parameters by the end of development.
Screen Length and Placement	The LAOI-3.2 well screen extends from 153.3 to 162.8 ft and has a length of 9.5 ft. The top of the well screen is submerged 14.7 ft below the current water level of 138.6 ft below the surface (Allen and Koch 2007, 095268). The LAOI-3.2a well screen extends from 181.4 to 191 ft and has a length of 9.6 ft. The top of the well screen straddles the current water level of 184.9 ft below the surface (Allen and Koch 2007, 095268).	Both LAOI-3.2 and LAOI-3.2a were installed to provide water-quality and water-level data for the perched groundwater near the confluence of Los Alamos and DP Canyons, and the screen lengths and placements were selected with the following goals in mind: • Further investigate the nature and extent of perched groundwater observed at nearby well R-6i and perched water that had been tentatively identified from a borehole video log at Otowi-4 • Characterize water quality in the uppermost perched intermediate groundwater zone located downgradient of contaminant sources in Los Alamos and DP Canyons, particularly TA-21 • Characterize water quality in the deeper perched intermediate groundwater zone located in the Puye Formation • Monitor water levels to detect whether perched intermediate groundwater responds to seasonal infiltration beneath Los Alamos and DP Canyons Two zones of perched saturation were encountered in LAOI-3.2 and LAOI-3.2a. The first zone was encountered within the lower part of the Otowi Member and in the Guaje Pumice Bed. Depth to water in this upper perched zone is currently about 138.6 ft in the completed LAOI-3.2 well. The base of the perched water is uncertain because of incomplete core collection, but most likely it extends to the base of the Guaje Pumice Bed. A second intermediate perched zone was encountered within sedimentary deposits of the Puye Formation that overlie Cerros del Rio basalt. The perching horizon appears to be a stratified sequence of brown homogeneous silts and fine-grained sands, with subordinate clay in the interval from 195 to 266.5 ft. Depth to water in this upper perched zone is currently about 184.9 ft in the completed LAOI-3.2a well. The differences in depth to water in these two wells suggest that two separate water-bearing zones occur at this location. The screen lengths and placements for the LAOI-3.2 and LAOI-3.2a wells are appropriate for the conditions encountered at this location and meet the goals defined in the above bullets.

	Description	Evaluation
Filter Pack Materials and Placement	In addition to the PVC prepack well screen, LAOI-3.2 has a primary filter pack consisting of 10/20 sand from 151.3 ft to 165 ft. A secondary filter pack of 20/40 sand was placed above the primary filter pack from 149.8 to 151.3 ft. In LAOI-3.2a, the primary filter pack consists of 10/20 sand from 176.7 ft to 195.5 ft. A secondary filter pack of 20/40 sand was placed above the primary filter pack from 174.7to 176.7ft.	At LAOI-3.2, the primary filter pack extends 2 ft above and 2.2 ft below the well screen. At LAOI-3.2a, the primary filter pack extends 4.7 ft above and 4.5 ft below the well screen. Placement of the filter pack in the two wells is within the optimum design for well screens.
Sampling System	Submersible pump	Dedicated pumps allow relatively high-flow sampling. Flow-through cells for measuring field parameters can be used at single-screen wells with dedicated pumps installed. Effective development is typically limited in intermediate wells because of insufficient flow rate and volume; however, development issues are not as critical in wells like LAOI-3.2 and LAOI-3.2a that are installed in core holes where no additives other than air are used during drilling.
Other Issues That Could Affect the Performance of the Well	None	n/a
Additives Used During Drilling		Air
Annular Fill Other Than Filter and Transition Sands		LAOI-3.2: Bentonite seal: bentonite chips (30.7 ft^3) Cement grout surface seal (25.4 ft^3) Bentonite backfill (0.2 ft^3) Water removed during well development (1197 gal.) Water removed during aquifer testing (1278 gal.)

	Description	Evaluation
		LAOI-3.2a: Bentonite seal: bentonite chips (16.6 ft^3) Cement grout surface seal (23.3 ft^3) Bentonite backfill: pellets (8.7 ft^3) Municipal water (270 gal.) Water removed during well development (3155 gal.) Water removed during aquifer testing (3797 gal.)

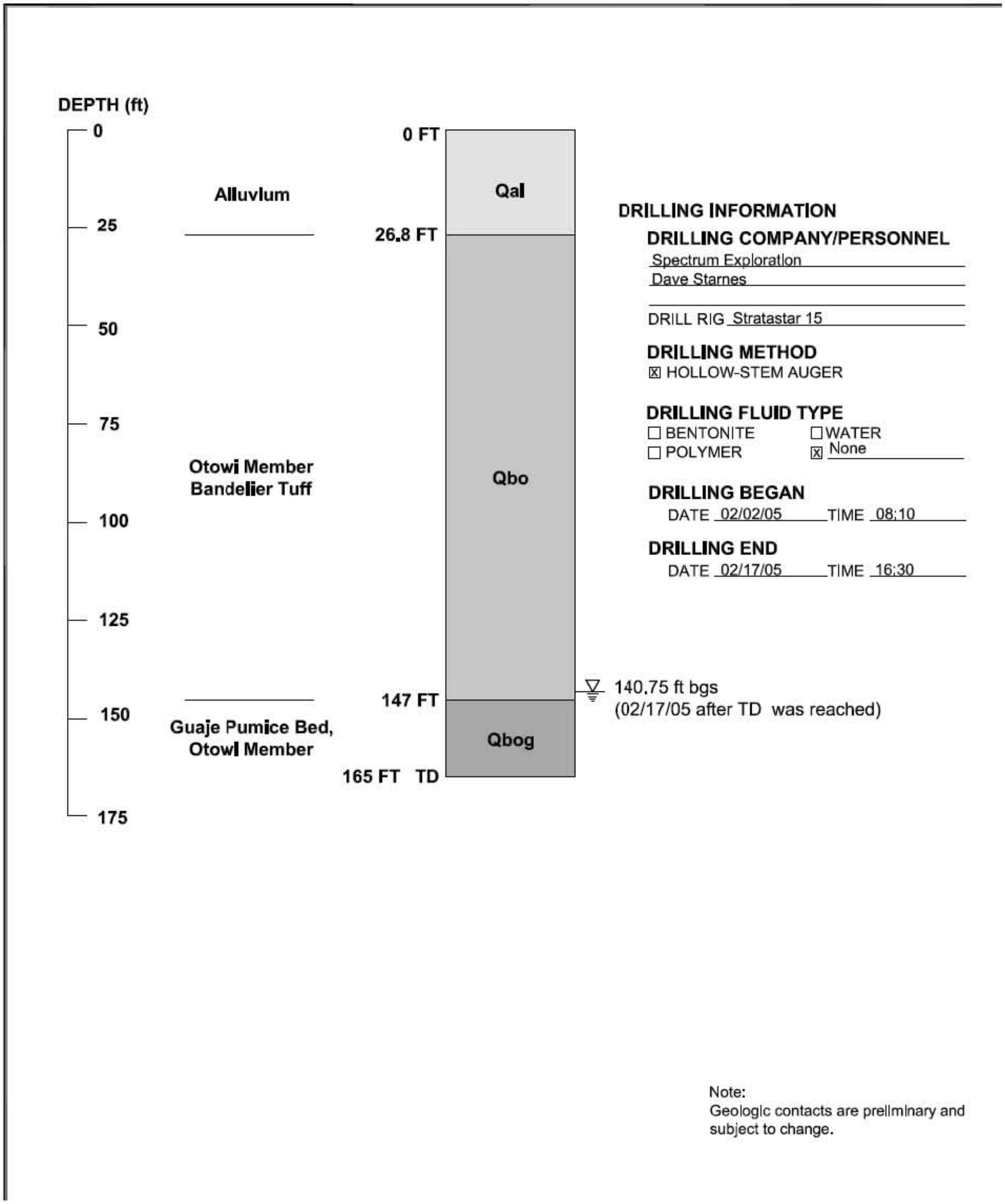


Figure 1 Borehole summary data sheet, intermediate well LAOI-3.2

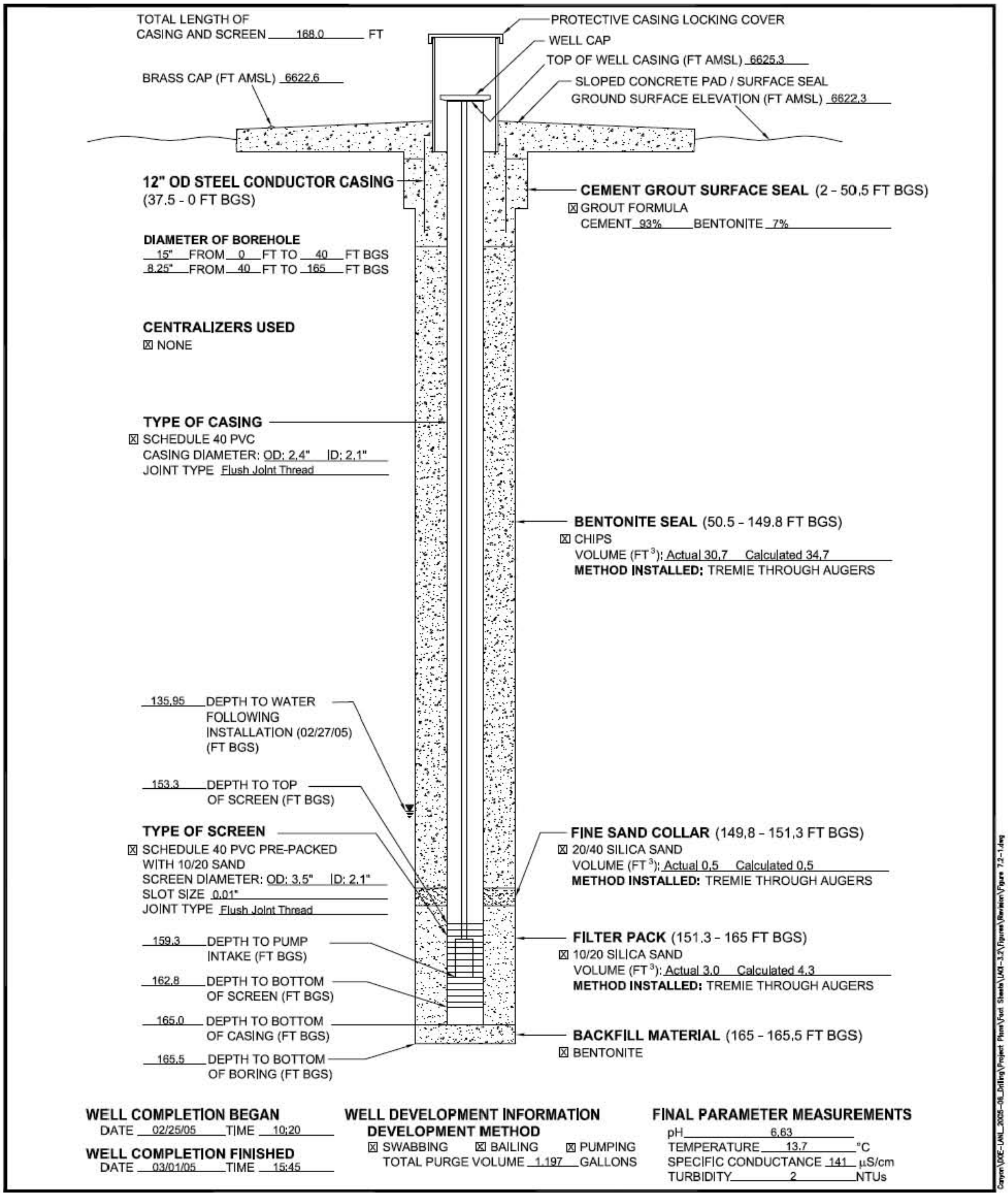


Figure 2 Well schematic, intermediate well LAOI-3.2

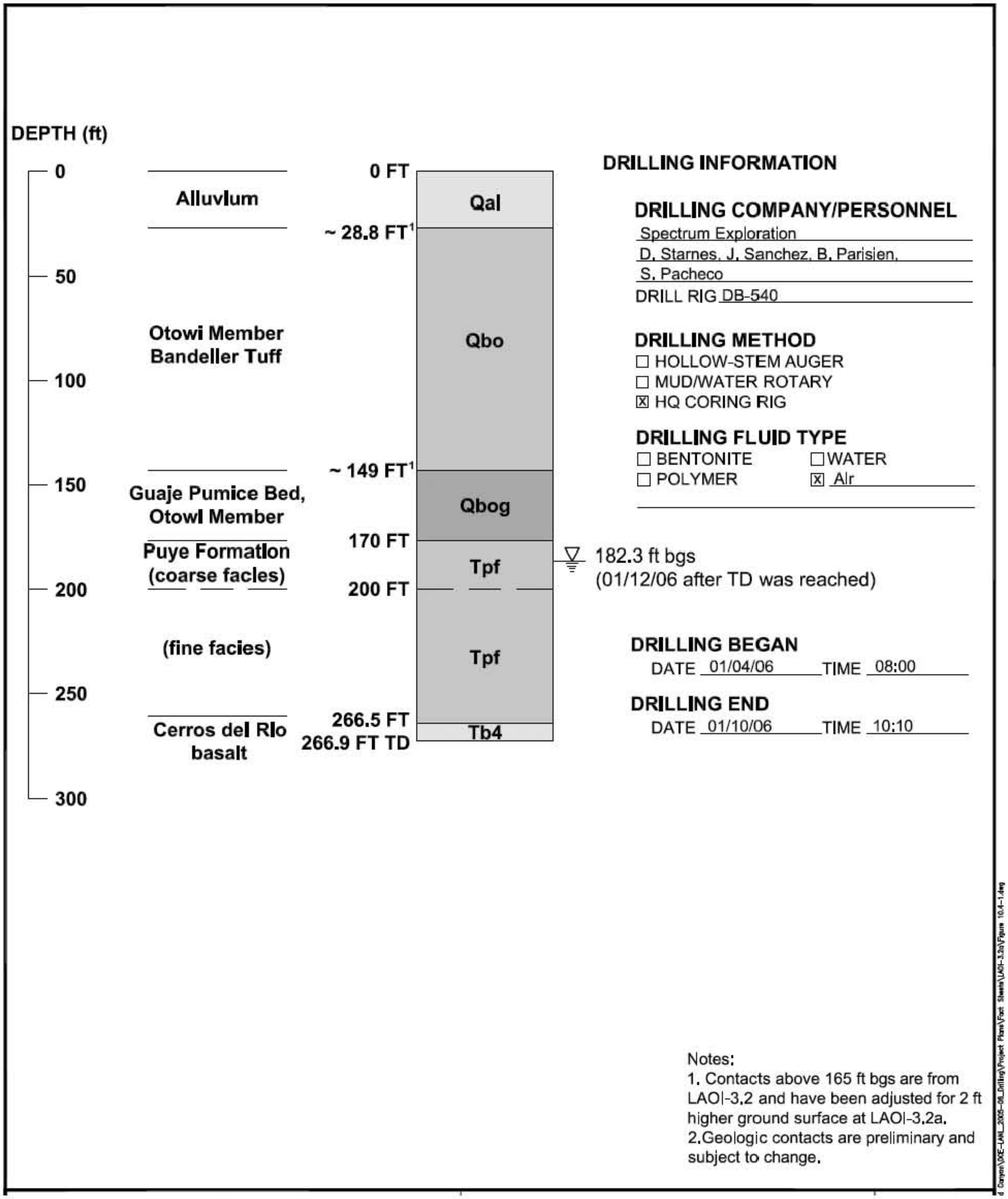


Figure 3 **Borehole summary data sheet, intermediate well LAOI-3.2a**

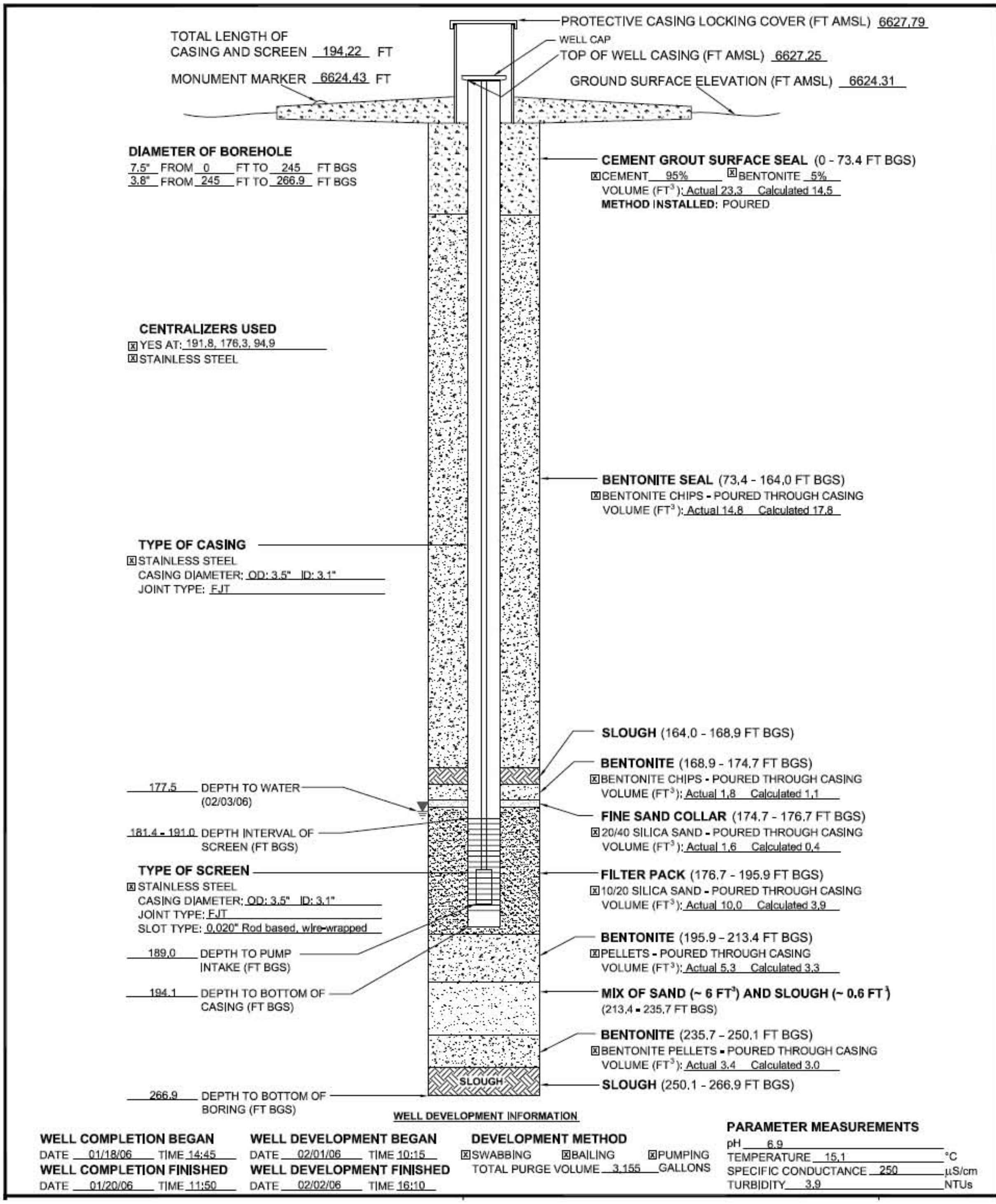


Figure 4 Well schematic, intermediate well LAOI-3.2a

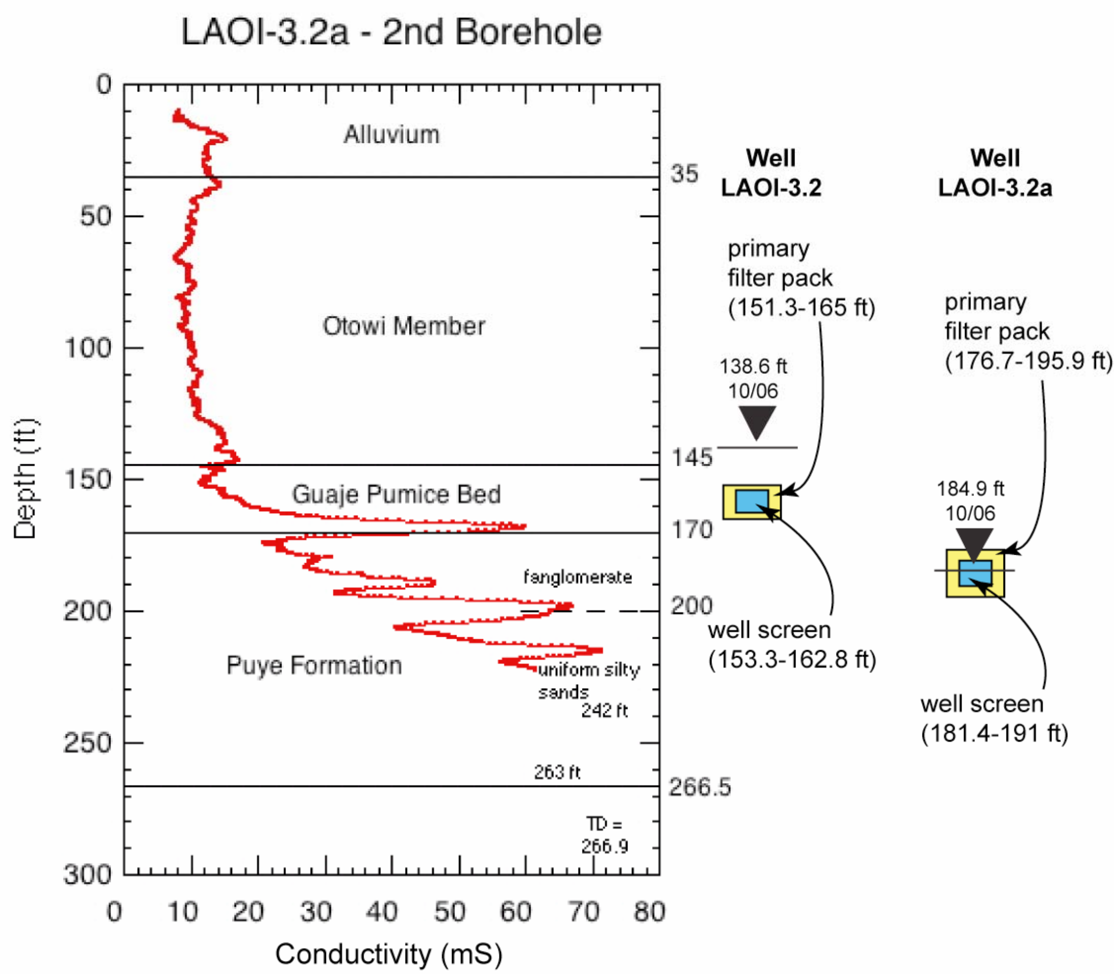


Figure 5 **Position of LAOI-3.2 and 3.2a well screens relative to the conductivity data collected in the initial LAOI-3.2a borehole**

LAOI-7 Well

LAOI-7 Well

	Description	Evaluation
Drilling Method	LAOI-7 was continuously cored to a TD of 382.2 ft.	LAOI-7 was cored by a Delta Base 540 track-mounted HQ coring rig using air as the drilling fluid. A 7.375-in.-diameter core hole was drilled to a depth of 280 ft using a temporary 6.625-in.-O.D. casing set at various depths to seal off perched groundwater. The core hole was completed by advancing a 3.9-in. open core hole from 280 to 382.2 ft.
General Well Characteristics	LAOI-7 is a single-screen well constructed of 3-in.-I.D./3.5-in.-O.D. 304 stainless-steel casing.	The stainless-steel well materials are designed to prevent corrosion.
Well Screen Construction	The well screen is constructed of 3-in. I.D./3.5-in.-O.D. 304 stainless-steel wire wrap with 0.020-in. slots.	The LAOI-7 well screen construction (0.020-wire-wrapped screen) is considered an optimum design that balances the need to prevent fine-grained material from entering the well and the need to promote the free flow of water during well development and sampling.
Screen Length and Placement	The well screen extends from 240 to 259.6 ft and has a length of 19.6 ft. The top of the well screen is submerged within a perched zone that has a current water level of 224.4 ft below the surface (Allen and Koch 2007, 095268).	LAOI-7 is designed to provide water-quality and water-level data for the perched groundwater near the Laboratory's eastern boundary, and the screen lengths and placements were selected with the following goals in mind: • Characterize water quality in the uppermost perched groundwater zone located downgradient of contaminant sources in Los Alamos Canyon, particularly TA-02 and -21 • Determine the lateral extent of perched groundwater in Cerros del Rio basalt first identified in wells R-9 and R-9i • Monitor water levels to detect whether perched intermediate groundwater responds to seasonal infiltration beneath Los Alamos Canyon Two zones of perched saturation were encountered in LAOI-7. The first zone was encountered at shallow depths within the lower part of the Otowi Member and in the Guaje Pumice Bed. Depth to water was 26 ft and is probably closely connected to canyon floor alluvial groundwater. The base of the perched water is uncertain because of incomplete core recovery, but most likely it extends to the top of dry silt-rich sediments comprising Puye deposits that overlie the Cerros del Rio basalt in this area. No well screen was installed in this shallow perched zone.

	Description	Evaluation
Screen Length and Placement (continued)		A second, more complex, perched zone was encountered at several horizons in the interval between 237.2 and 286.8 ft. The saturated horizons seem to be interconnected via high-angle fractures because the saturated zones yielded similar water levels. Water was first noted in the core barrel after drilling the 237.2- to 242.2-ft interval. Coring was halted and the water level stabilized at 221.6 ft, suggesting confinement. Fractures below 234.3 ft commonly contain clay; clay is much less abundant above this depth. Additional zones of saturation in core occurred between depths of 256.8 and 262.2 ft in a basalt rubble zone and between depths of 282.2 and 286.8 ft in a vesicular basalt. Perching appears to occur above sections of massive basalt flows where fractures are rare to absent. The lowermost perching horizon is not known with certainty but may be layered near deposits between 360 and 363.4 ft at the base of the basalt sequence. The well screen targets the upper two intervals of water production in the upper half of the perched zone. The screen length and placement for LAOI-7 are appropriate for the conditions encountered at this location and meet the goals defined in the bullets above.
Filter Pack Materials and Placement	The primary filter pack consists of 10/20 sand from 235 to 265 ft. A secondary filter pack of 20/40 sand was placed above the primary filter pack from 233 to 235 ft.	The primary filter pack extends 5 ft above and 5.4 ft below the well screen. Placement of the filter pack is within the optimum design for the well screen.
Sampling System	Submersible pump	Submersible pumps installed in single completion wells allow groundwater to be purged from the well casing, well-filter pack, and to some degree, near-well formation materials. Water can pumped at a rate of 10–12 gal./min, greatly facilitating effective purging and efficient sampling. Conventional purging and sampling allow water to be drawn from more deeply within formation materials surrounding the well screen in comparison to low-flow systems, and there is a greater likelihood of obtaining water from zones beyond potential near-well drilling effects. Storage and disposal of purged water require additional resources relative to low-flow sampling systems. Water levels can be measured manually or by dedicated pressure transducers.
Other Issues That Could Affect the Performance of the Well	None	Nitrate-reducing conditions and slightly elevated TOC were present in the most recent water sample from the well (July 2007) but are assumed to be representative of the groundwater at this location, and not a residual effect of drilling, because no drilling additives were used (Appendix B).
Additives Used During Drilling		Air

	Description	Evaluation
Annular Fill Other Than Filter and Transition Sands		Bentonite seal: bentonite chips/pellets (44 ft^3) Pelplug: refined elliptical bentonite pellets (12 ft^3) Cement grout surface seal (10.7 ft^3) Municipal water (251 gal.) Water removed during well development (3584 gal.) Water removed during aquifer testing (459 gal.)

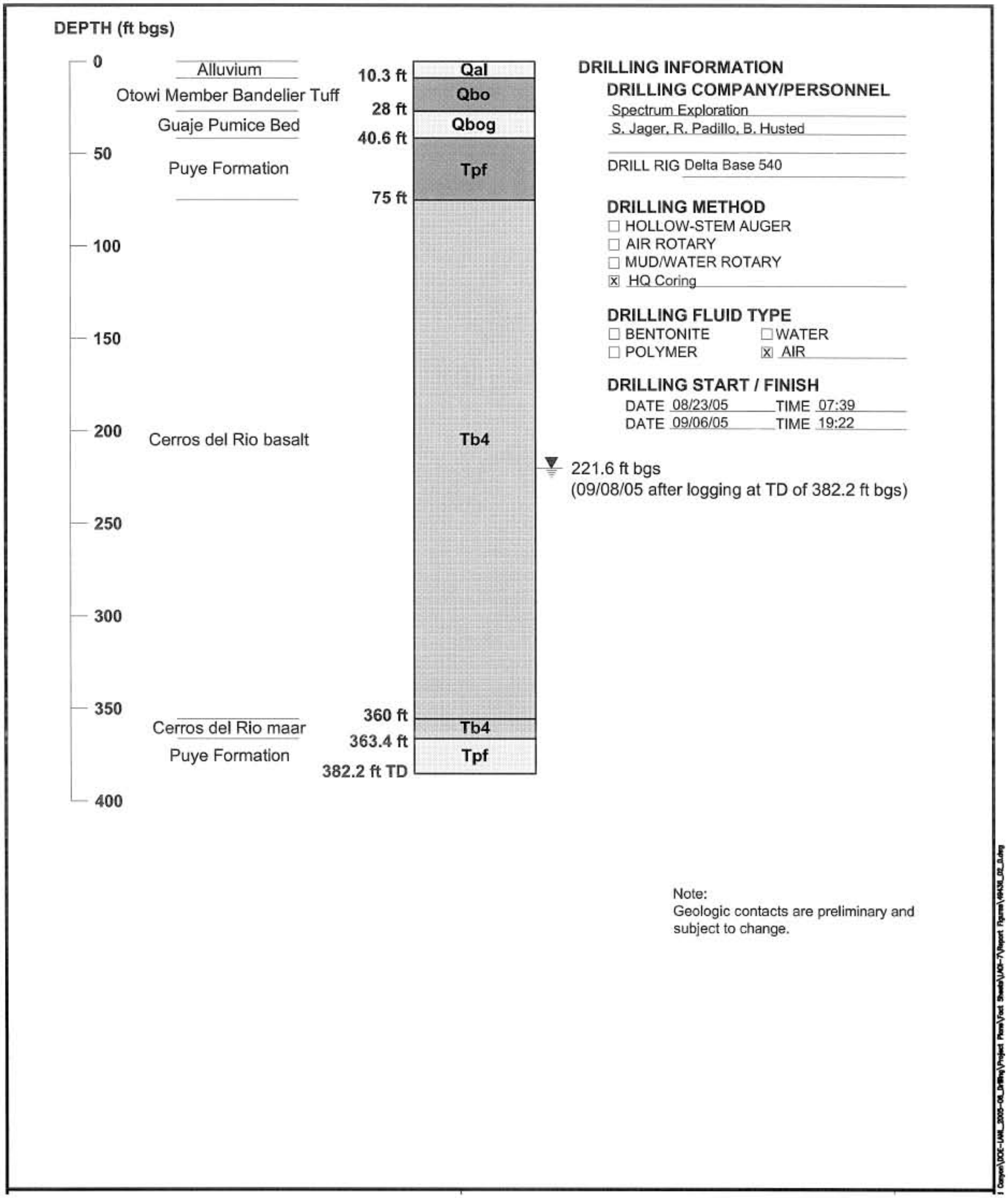


Figure 1 **Borehole summary data sheet, intermediate well LAOI-7**

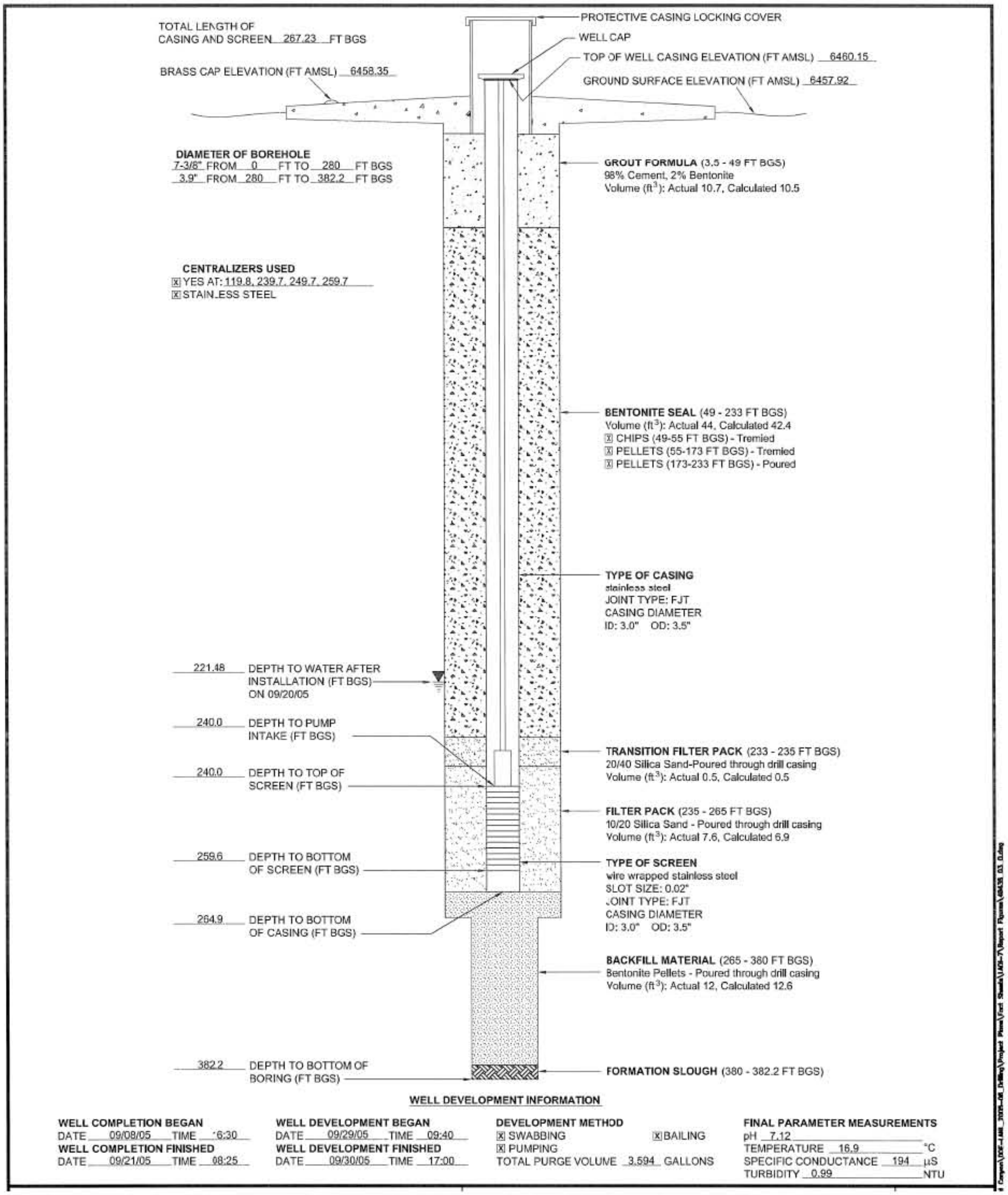


Figure 2 Well schematic, intermediate well LAOI-7

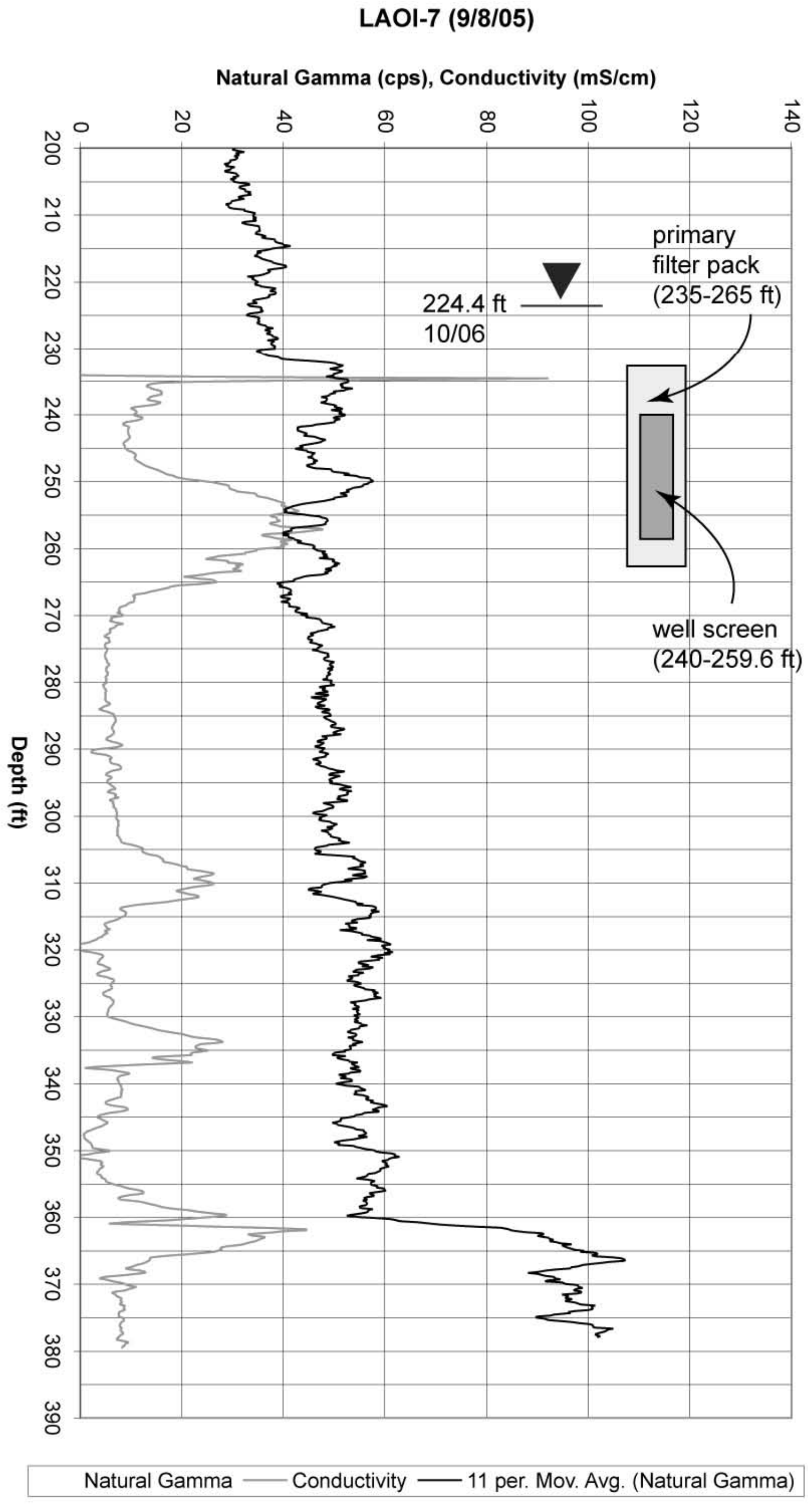


Figure 3 **Position of LAOI-7 well screen relative to geophysical data collected in the borehole**

LAOI(A)-1.1 Well

LAOI(A)-1.1 Well

	Description	Evaluation
Drilling Method	LAOI(A)-1.1 was drilled using a combination of coring, air hammer, and ODEX casing methods.	LAOI-1.1 was the initial borehole drilled at this location using an HSA. The LAOI-1.1 borehole was plugged and abandoned after reaching a depth of 30 ft because the augers could not penetrate boulders in the alluvium. A new borehole designated LAOI(A)-1.1 was drilled 10 ft south of the abandoned borehole and was successfully completed to the final depth of 323 ft using air-rotary drilling methods. Rock coring alternated with advancement of ODEX casing. Surface water and alluvial groundwater were sealed out of the borehole by installing temporary 12.625-in.-O.D. casing to a depth of 20 ft and 10.625-in.-O.D. casing to a depth of 100 ft. The borehole below 100 ft was drilled by rock coring alternating with advancement of 8.625-in.-O.D. ODEX casing to 317 ft. Air was the only fluid used to advance the borehole. Core was collected using a split-barrel system from 0- to 100-ft depth and an air-rotary coring system from 100 to 317 ft. A small-diameter borehole was cored from 317 to 323 ft using a split-barrel sampler.
General Well Characteristics	LAOI(A)-1.1 is a single-screen well constructed of schedule 80 3-in. PVC well casing.	The PVC materials used at LAOI(A)-1.1 are chemically inert. All PVC components, including the screen, were factory-cleaned before shipment.
Well Screen Construction	The well screen is constructed of 3-in. PVC with 0.010-in. slots.	The PVC materials used at LAOI(A)-1.1 are chemically inert. All PVC components, including the screen, were factory-cleaned before shipment. The 0.010-in. slots are less effective for aggressive development than are 0.020-in. slots but are more effective in preventing fine-grained material from being drawn into the well. Turbidity >5 NTUs was a continuing problem at LAOI(A)-1.1 after its installation, suggesting the 0.010-in. slots may have been the appropriate choice for the turbid conditions encountered at this location.
Screen Length and Placement	The well screen extends from 295.2 to 305 ft and has a length of 9.8 ft. The top of the well screen is 4.2 below the current water level of 291 ft (Allen and Koch 2007, 095268).	LAOI(A)-1.1 is designed to provide water-quality and water-level data for perched groundwater beneath Los Alamos Canyon, and the screen lengths and placements were selected with the following goals in mind: • Characterize water quality in the uppermost perched intermediate groundwater zone beneath Los Alamos Canyon in the vicinity of TA-21 • Monitor water levels to detect whether perched intermediate groundwater responds to seasonal infiltration beneath Los Alamos Canyon Perched intermediate groundwater was first recognized in core collected at the top of the Guaje Pumice Bed and was present throughout that unit. Present-day water levels indicate that saturation also extends into the basal ash flow tuffs of the overlying Otowi Member. The contact between the Guaje Pumice Bed and the underlying Puye Formation occurs at a depth of 315.6 ft and is marked by about 5 in. of sandy and silty clay that may represent a soil horizon. Beneath this possible soil, the Puye Formation consists of heterogeneous silts, sands, gravels, and cobbles.

	Description	Evaluation
Screen Length and Placement (continued)		To determine if saturation extended into the Puye Formation, a temporary bentonite seal was placed at a depth of 317 ft, and the 8.625-in.-O.D. ODEX casing was set into the seal. Water was air-lifted from the ODEX casing, and then a 3-in.-diameter borehole was cored from 317 to 323 ft by means of a split-barrel sampler. Saturated cores from this interval suggested that the top of the Puye Formation is saturated at this location. Following HSWA permit requirements, the final well design placed the screen near the top of saturation. The screen length and placement for LAOI(A)-1.1 are appropriate for the conditions encountered at this location and meet the goals defined in the bullets above.
Filter Pack Materials and Placement	The primary filter pack consists of 10/20 sand from 293.5 to 314 ft. There is no mention of a secondary filter pack above the primary filter pack.	The primary filter pack extends 1.7 ft. above and 9 ft below the well screen, respectively. The sand pack below the well screen is slightly longer than the current well design of 5 ft. The primary filter pack is entirely within the Guaje Pumice Bed, and the extra sand pack length below the well screen does not impact the ability of the well to collect representative water samples.
Sampling System	Bladder pump	Dedicated pumps allow relatively high-flow sampling. Flow-through cells for measuring field parameters can be used at single-screen wells with dedicated pumps installed. Effective development is typically limited in intermediate wells because of insufficient flow rate and volume; however, development issues are not as critical in wells like LAOI(A)-1.1 that are installed in boreholes where no additives other than air were used during drilling.
Other Issues That Could Affect the Performance of the Well	None	No obvious drilling-related conditions are indicated by evaluation of water-quality samples from LAOI(A)-1.1 (Appendix B). Total iron concentrations and turbidities are consistently higher than are typically observed in groundwater in the absence of drilling effects, but these conditions are assumed to be representative of the geologic formation because no drilling additives were used during drilling.
Additives Used During Drilling		Air
Annular Fill Other Than Filter and Transition Sands		Bentonite: coarse bentonite chips, placed dry Type I/II Portand Cement: 56 gal. placed on top of bentonite Cement/bentonite grout surface seal (7 gal. of water mixed with each 94-lb bag of cement mixed with 1%–2% bentonite)

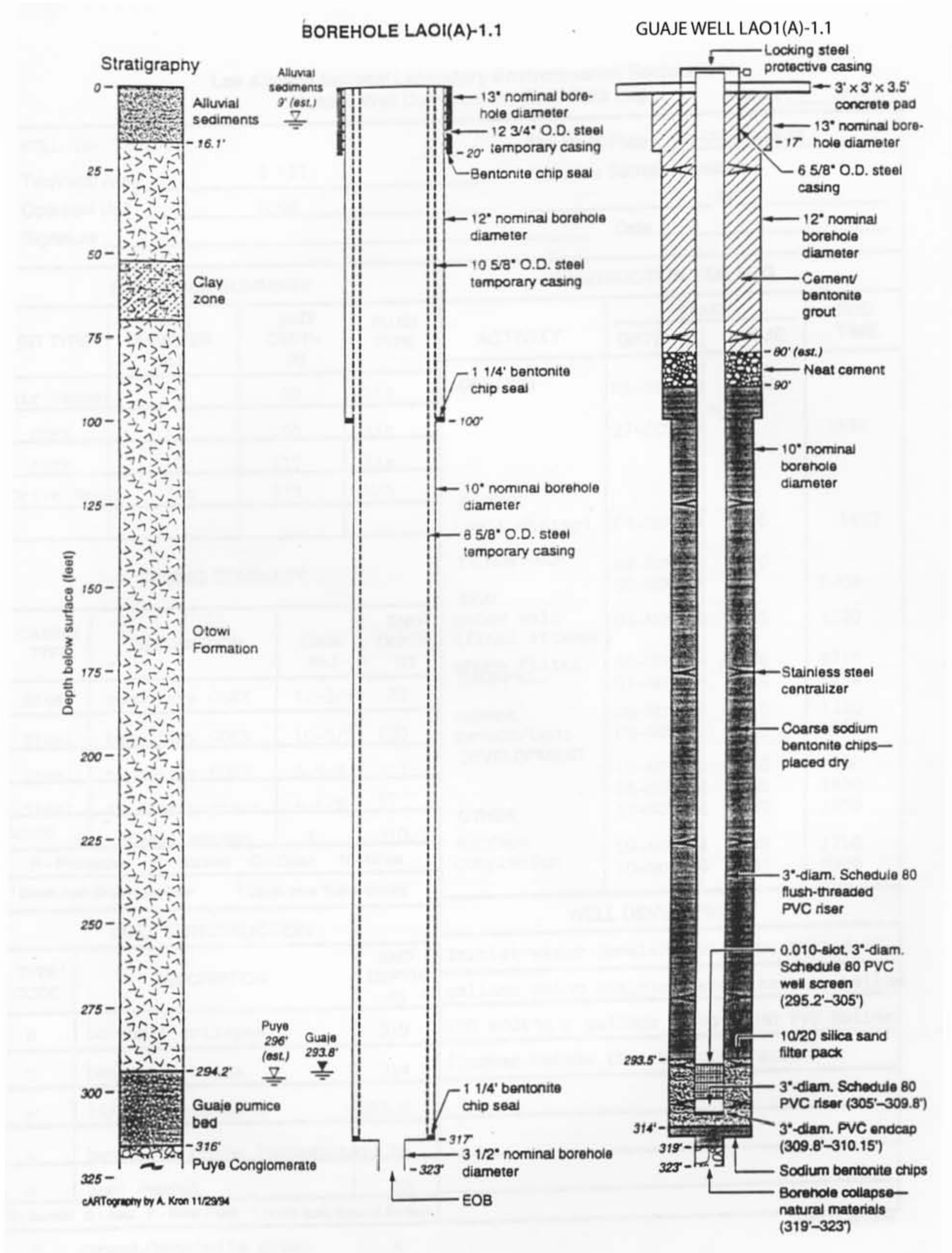


Figure 1 LAOI(A)-1.1 geology, borehole configuration, and well design

POI-4 Well

POI-4 Well

	Description	Evaluation
Drilling Method	POI-4 was drilled using air and was reamed using air plus Volclay (bentonite) grout slurry.	POI-4 was drilled using a 5.625-in. tricone button bit to 181-ft depth, using air-rotary methods. This was followed by reaming with a 8.75-in. tricone button bit to the same depth. In reaming, air-rotary methods were successful to 139 ft, but air losses beginning at 124 to 134 ft required introduction of Volclay bentonite mixed with water drawn from the stream in Pueblo Canyon to form a grout slurry. A total of 350 lb of Volclay was used, along with applications of stream water to both form the grout slurry and to flush cuttings from the borehole.
General Well Characteristics	POI-4 is a single-screen well constructed of 4.0-in.-I.D. schedule 40 PVC.	PVC materials are chemically inert. All PVC components, including the screen, were factory-cleaned before shipment. Details of the well construction are shown in Figure 1.
Well Screen Construction	The well screen is a nominal 15-ft. section of 4.0-in.-I.D. schedule 40 PVC with 0.010-in. slots.	PVC screens are chemically inert. The 0.010-in. slots are less effective for aggressive development than are 0.020-in. slots.
Screen Length and Placement	The screen at POI-4 extends from 159.0 to 174.0 ft (length of 15 ft) and is submerged 0.7 ft below the current depth to water (158.3 ft) (Allen and Koch 2007, 095268).	This screen length and placement were selected with the goals of characterizing water quality in a productive zone of perched saturation within Cerros del Rio lavas, 800 ft upstream from regional well TW-1 and intermediate well TW-1A. POI-4 is 235 ft west of the more recent intermediate well R-3i, emplaced at a somewhat deeper depth within the Cerros del Rio basalt. The replacement of nearby intermediate well TW-1A by these two wells is important because TW-1A has no annular fill and may allow alluvial water to communicate with the deeper perched zone. Moreover, the carbon-steel casing and screen at TW-1A have corroded since construction in 1950. The screen at POI-4 is at approximately the same elevation as that at TW-1A and could represent the same or a connected perched system. This perched zone or perched zones are within an area where contaminants derived from sources such as Acid Canyon, sewage plants in Pueblo Canyon, and Manhattan-era buildings in the townsite could be moving. The screen at POI-4 is placed in the perched zone at a depth where submergence is sufficient to support development. The screen is located within an interflow zone of the Cerros del Rio lavas. The placement of the well screen at POI-4 meets the characterization goals for a well for this location, dependent on adequate flow for sampling.
Filter Pack Materials and Placement	The filter pack and its placement are discussed in the column to the right.	The primary filter pack is made up of 20/40 sand from 154.3 to 175.5 ft. Bentonite seals were placed above the primary filter pack from 148.8 to 154.3 ft and below it from 175.5 to 176.5 ft, overlying slough from 176.5 ft to TD at 181 ft. The primary filter pack extends 3.7 ft above and 1.5 ft below the well screen. The top of the filter pack length is 4 ft above the current top of perched saturation.

	Description	Evaluation
Sampling System	Dedicated pump	Dedicated pumps allow relatively high-flow sampling. Flow-through cells for measuring field parameters can be used at single-screen wells with dedicated pumps installed. Effective development is typically limited in intermediate wells because of insufficient flow rate and volume; this may still be an issue at POI-4 where significant amounts of bentonite slurry were used when the borehole was reamed to TD.
Other Issues That Could Affect the Performance of the Well	Use of bentonite slurry and use of canyon stream water	The introduction of 350 lb of Volclay as a slurry during reaming leaves open the possibility that detection of sorbing contaminants may be impeded at this well. Although the use of water collected from the streamflow in Pueblo Canyon to make the Volclay slurry and to remove cuttings may have introduced contaminants from the Pueblo Canyon wastewater treatment plant (e.g., nitrate and boron), stable concentrations of these and other potential contaminants measured at this location over the past seven years indicate that this effect was probably negligible (figures in Appendix E.2).
Additives Used		Volclay bentonite and Pueblo Canyon stream water; smaller amounts of deionized water
Annular Fill Other Than Filter and Transition Sands		Slough: at 176.5–181.0 ft, below the bentonite under the filter pack Bentonite pellets in seals above and below the filter pack Volclay bentonite grout mixed with potable water (60- to 148.8-ft depth) Dry bentonite pellets (30- to 60-ft depth) Casing cement (surface to 30-ft depth)

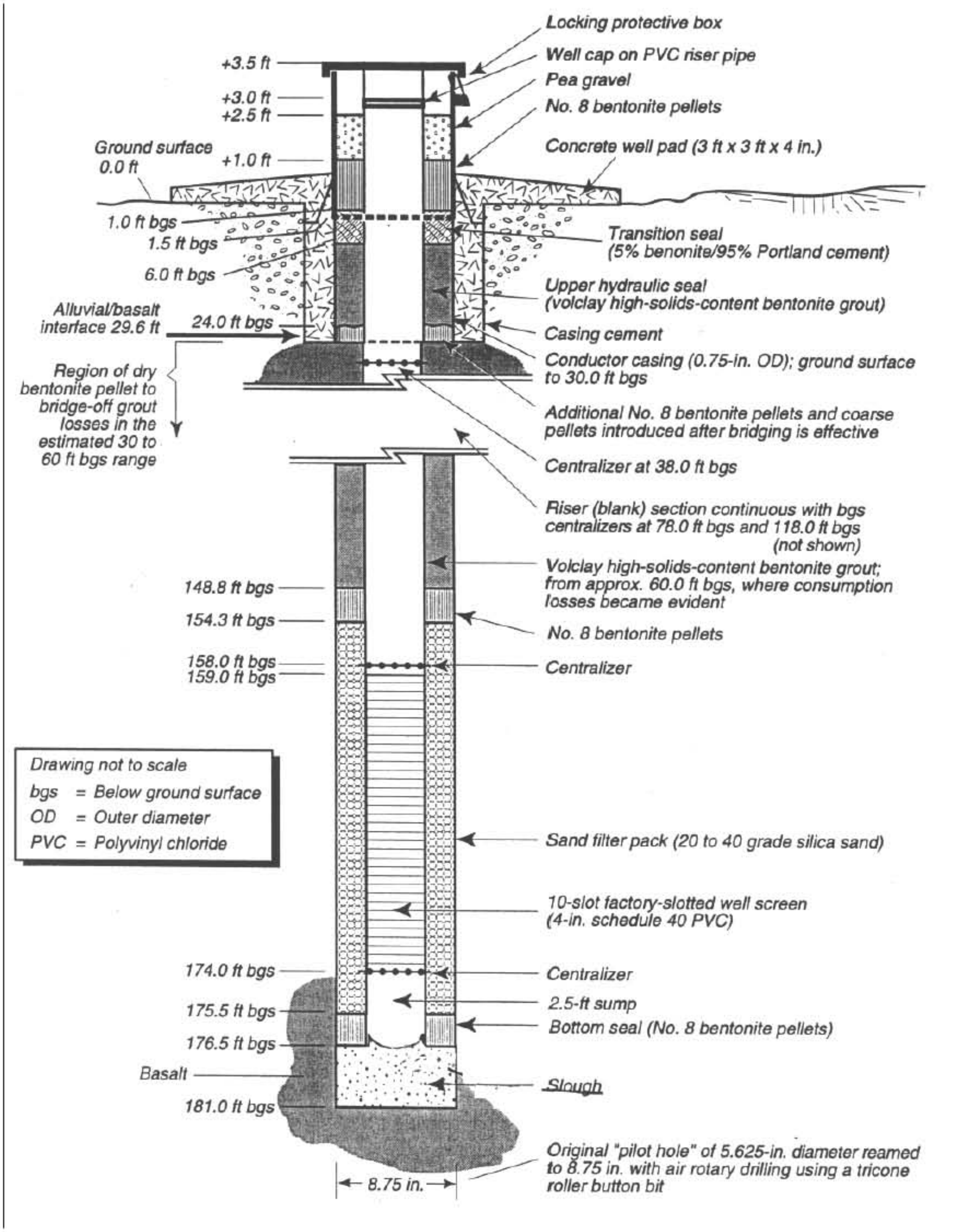


Figure 1 Details of well construction at POI-4

R-2 Well

R-2 Well

	Description	Evaluation
Drilling Method	R-2 was drilled in two phases. Phase I used HSA methods to 241-ft depth to collect core. Phase II stepped aside and used fluid-assisted air-rotary and mud-rotary methods to 944-ft depth. Only the second phase is discussed here because no well installation is associated with Phase I.	Phase II drilling at R-2 used fluid-assisted air-rotary methods to 403-ft depth (Figure 1). Circulation of cuttings was primarily accomplished using air and municipal water mixed with additives including QUIK-FOAM and EZ-MUD, with potassium bromide added as a tracer to aid in determining occurrence of groundwater saturation by dilution of return concentration. At 403-ft depth, borehole instability required introduction of mud-rotary techniques, using drilling mud composed of municipal water mixed with Aqua-Gel, PAC-L (DRISPAC), and soda ash, plus a potassium bromide tracer. A total depth of 944 ft was reached using this method. Although mud methods muted the potassium bromide tracer effect, dilution of this tracer was not a factor in defining depth to saturation.
General Well Characteristics	R-2 is a single-screen well constructed of 4.5-in.-I.D./5-in.-O.D. 304 stainless-steel casing.	The stainless-steel well materials are designed to prevent corrosion. Figure 2 shows the well construction.
Well Screen Construction	The rod-based continuous-slot screen is constructed of 5.27-in.-O.D. 304 stainless steel with 0.020-in. slots.	Rod-based screen provides extensive, uniformly distributed openings for access to the filter pack during development. Also, the 0.020-in. slots in the R-2 screen allow greater water movement during development than 0.010-in. screen openings. The screen at R-2 was developed successfully through air-lifting, bailing, swabbing, and pumping. R-2 consistently yields water samples considered representative of groundwater conditions in the regional aquifer at this location (Appendix B). Field parameters, particularly turbidities (4-12 NTU), are less than optimal and should be monitored as sampling continues. Nevertheless, the screen at R-2 has returned to background concentrations for solutes leached from bentonite, indicating that development has successfully ameliorated the use of mud during drilling.
Screen Length and Placement	The screen at R-2 extends from 906.4 to 929.6 ft (length of 23.2 ft) and is submerged beneath the regional water table (currently 899 ft below the surface) within Santa Fe Group sediments. The top of the screen is currently 7.4 ft below the top of the regional aquifer.	This screen length and placement was selected with the following goals in mind: • Characterize water quality in the uppermost part of regional groundwater, approximately 5100 ft downstream of the confluence of Acid and Pueblo Canyons • Monitor the regional water table for seasonal fluctuations and long-term variation

	Description	Evaluation
Screen Length and Placement (continued)		The screen at R-2 is placed in the regional aquifer at a depth where submergence is sufficient to support aggressive development. However, the screen at R-2 is shallow enough to capture contaminants moving in the upper portion of the regional system where the highest concentrations of contaminants may be encountered before becoming diluted by mixing with uncontaminated groundwater (Figure 3). The screen is located within Santa Fe Group sediments that dip up to 20 degrees toward the southwest (dip azimuths vary between about 180 and 270 degrees). Total porosities within the screen interval range between 20% and 35%, and effective porosities range between 10% and 20%. The electrical resistivity image (FMI log) shows that these deposits consist of thinly laminated beds with small channels and rare clasts up to a few inches in diameter (Figures 4a and 4b). The CMR indication of moveable water is moderately elevated relative to strata above and below the screened interval. The placement of the well screen at R-2 meets the characterization goals for a well for this location.
Filter Pack Materials and Placement	The filter pack and its placement are discussed in the column to the right.	The primary filter pack is made up of 10/20 sand from 899 to 940 ft. A secondary filter pack of 20/40 sand was placed above the primary filter pack from 897 to 899 ft; beneath the primary filter pack is slough (840 ft to TD at 944 ft). The primary filter pack extends 7.4 ft above and 10.4 ft below the well screen. The top of the filter pack length is currently at the water table but was submerged by ~6.5 ft during well development. The lower part of the filter pack extends slightly farther below the well screen than current well designs (about 5 ft below the well screen). However, because the Santa Fe Group sediments at this location are poorly transmissive and likely bounded above and below by more permeable sediments (as indicated by hydrologic testing), a slightly long filter pack allows groundwater to be drawn from a larger volume in rocks where the amount and location of water production are uncertain.
Sampling System	Dedicated pump	Dedicated pumps allow relatively high-flow sampling. Flow-through cells for measuring field parameters can be used at single-screen wells with dedicated pumps installed. Effective development and removal of residual drilling fluids are critical where drilling mud has been used, and the highest possible flow after development is desirable.
Other Issues That Could Affect the Performance of the Well	The screen location is not in a highly productive zone.	Hydrologic testing showed that the screen is not capable of producing water at a rate greater than about 1 gal./min. However, evaluation of the most recent water samples from R-2 shows stable geochemical conditions considered reliable and representative of groundwater at this location.

	Description	Evaluation
Additives Used		Municipal water QUIK-FOAM (above the regional aquifer) EZ-MUD (above the regional aquifer) Aqua-Gel PAC-L (DRISPAC) Soda ash Potassium bromide tracer
Annular Fill Other Than Filter and Transition Sands		Slough: at 940–944 ft, below the primary filter pack, and near surface at 81–85 ft Bentonite: 0.375-in. chips (16 bags and 9 SuperSacks) Concrete with 4% bentonite (2.5 yd^3; surface to 81-ft depth)

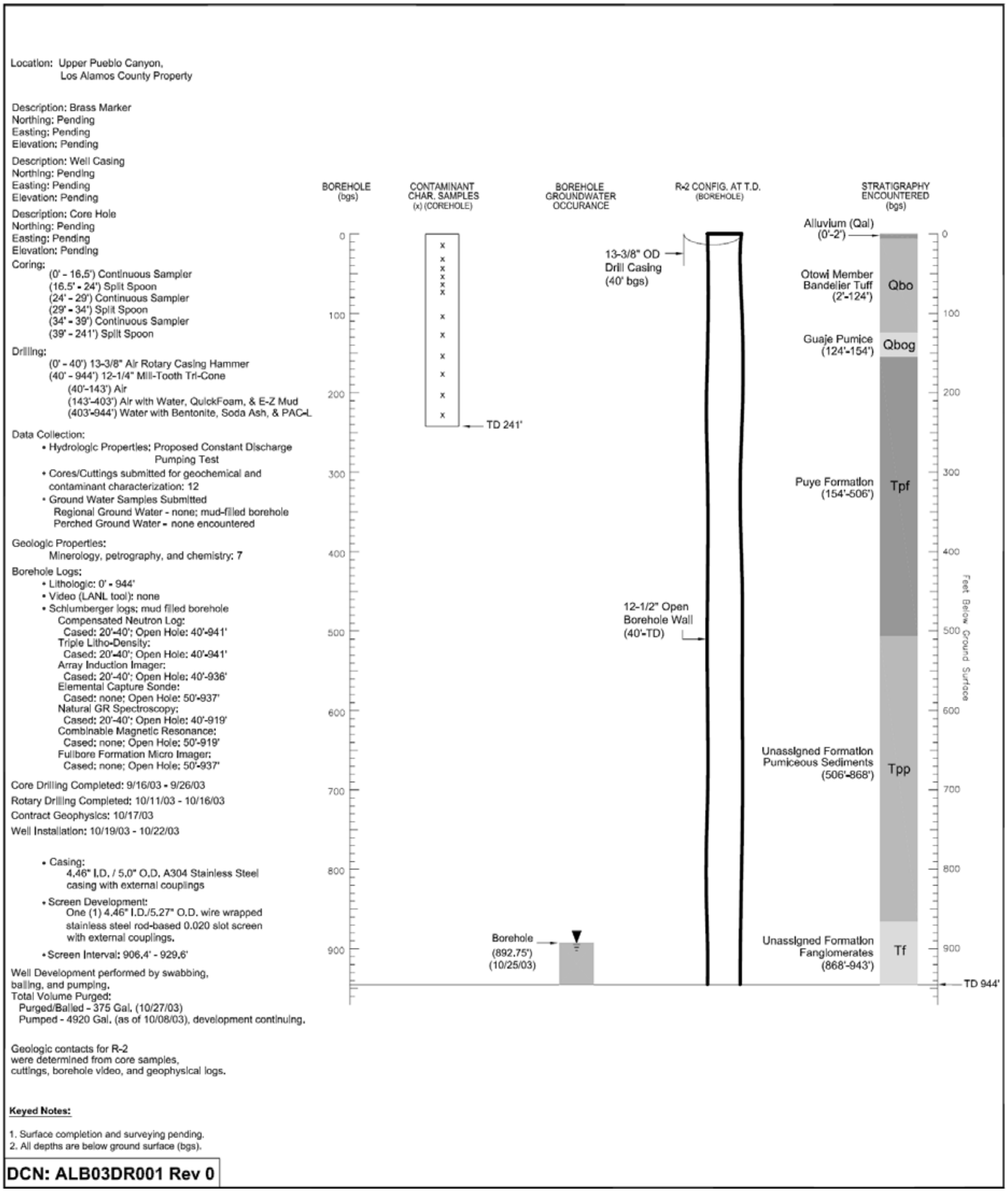


Figure 1 Construction, stratigraphic, and hydrogeologic information for characterization well R-2

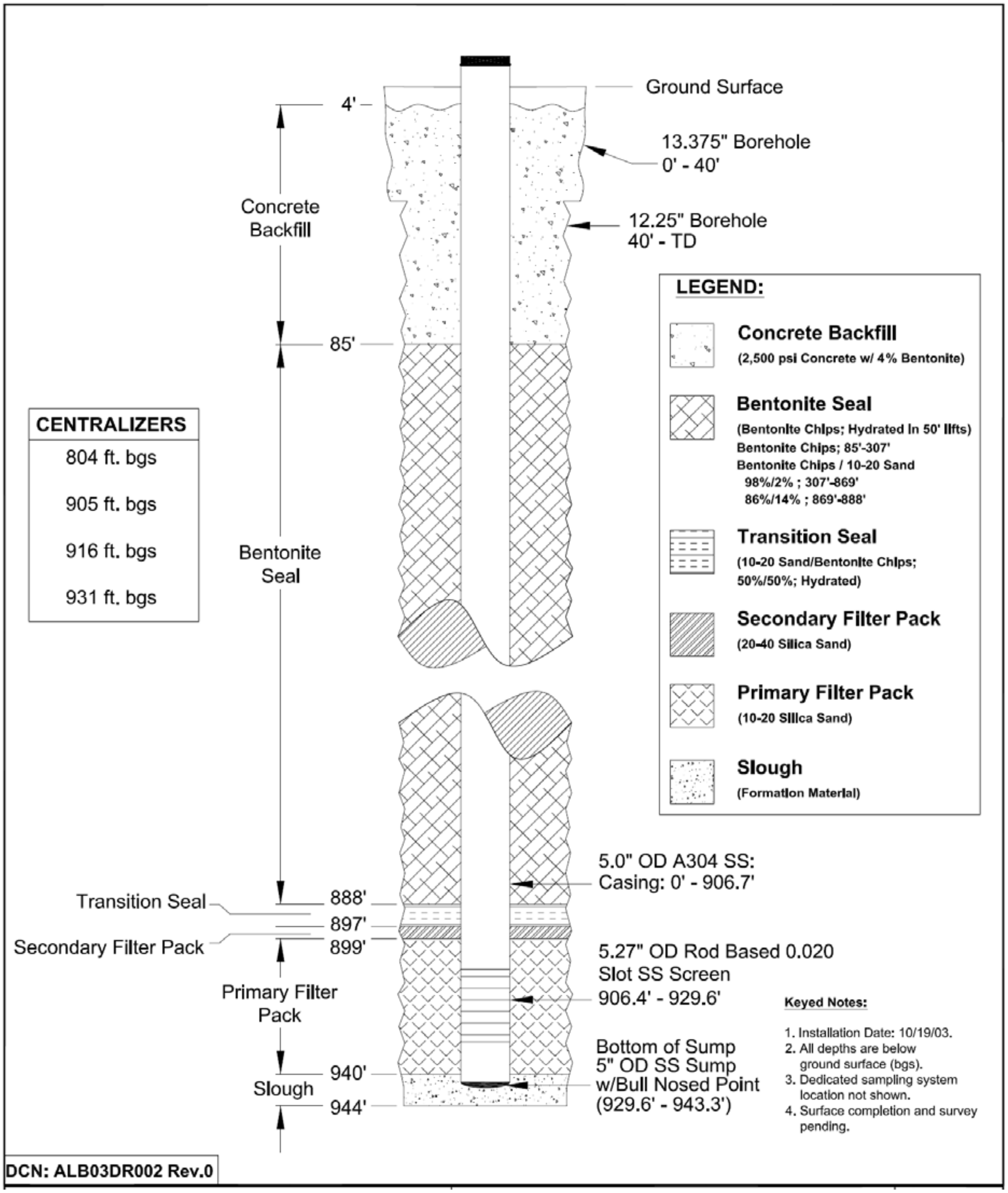


Figure 2 Schematic diagram of characterization well R-2

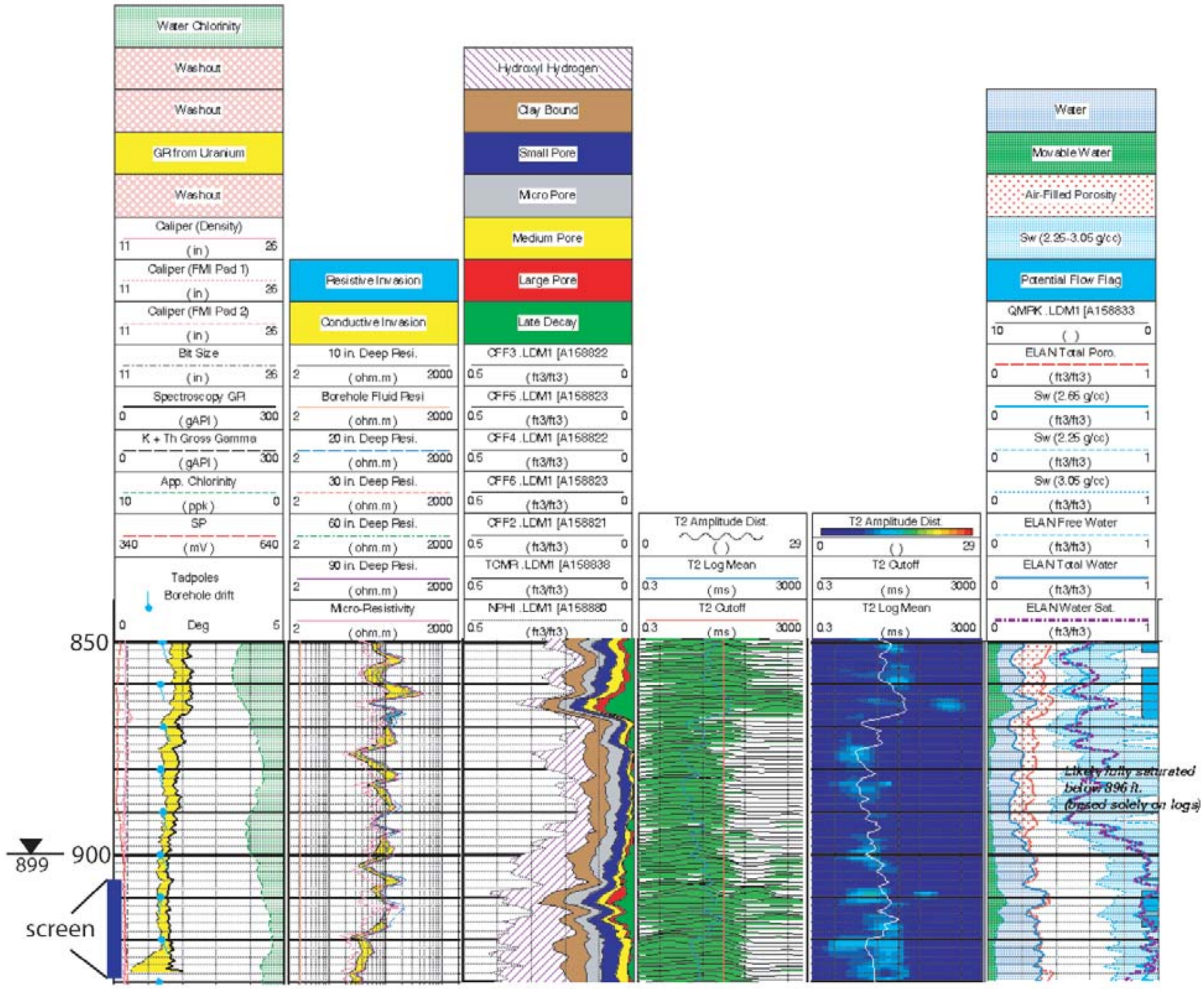


Figure 3 Summary of R-2 borehole geophysical logs for the regional aquifer

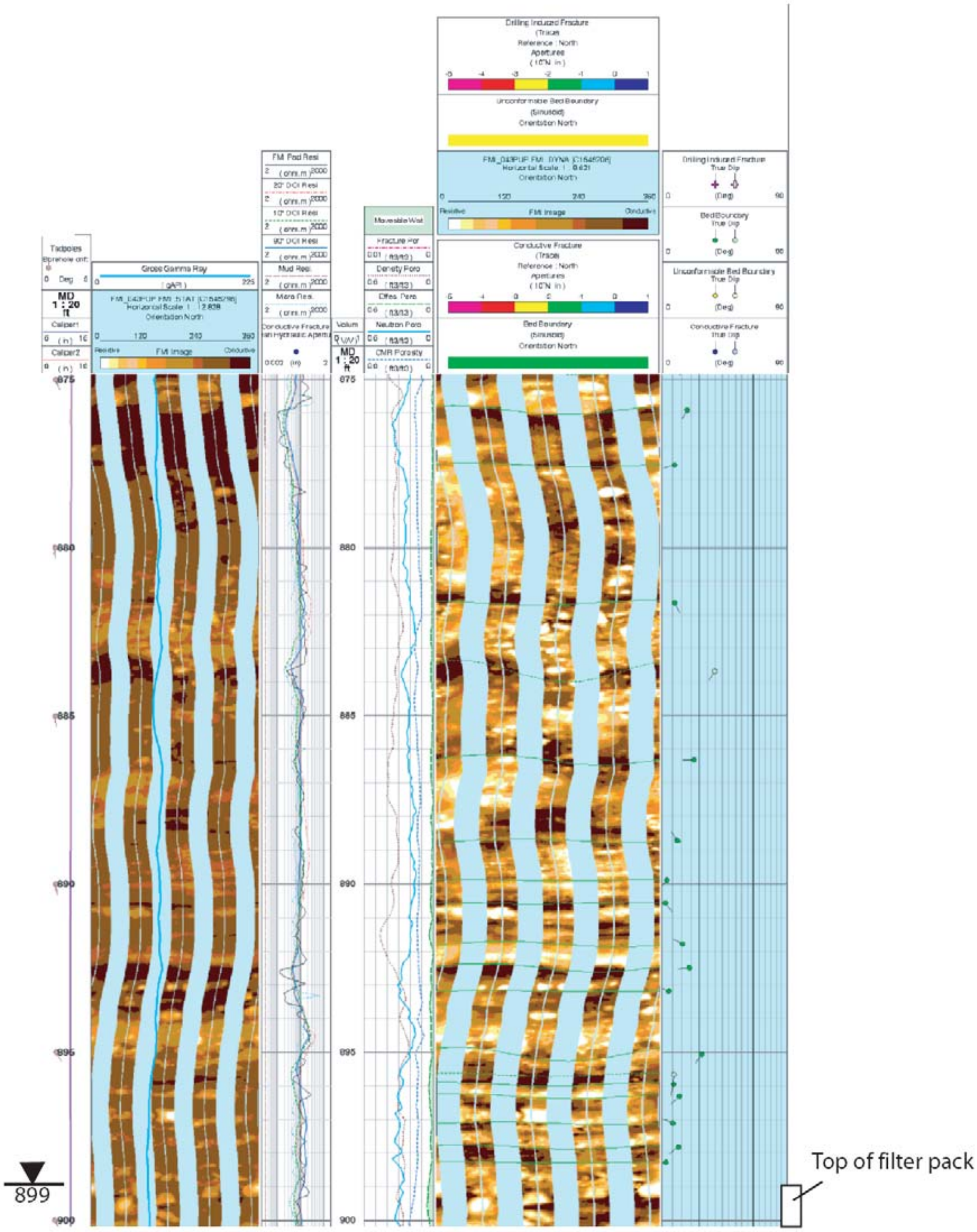


Figure 4a FMI log for R-2 (875 to 900 ft)

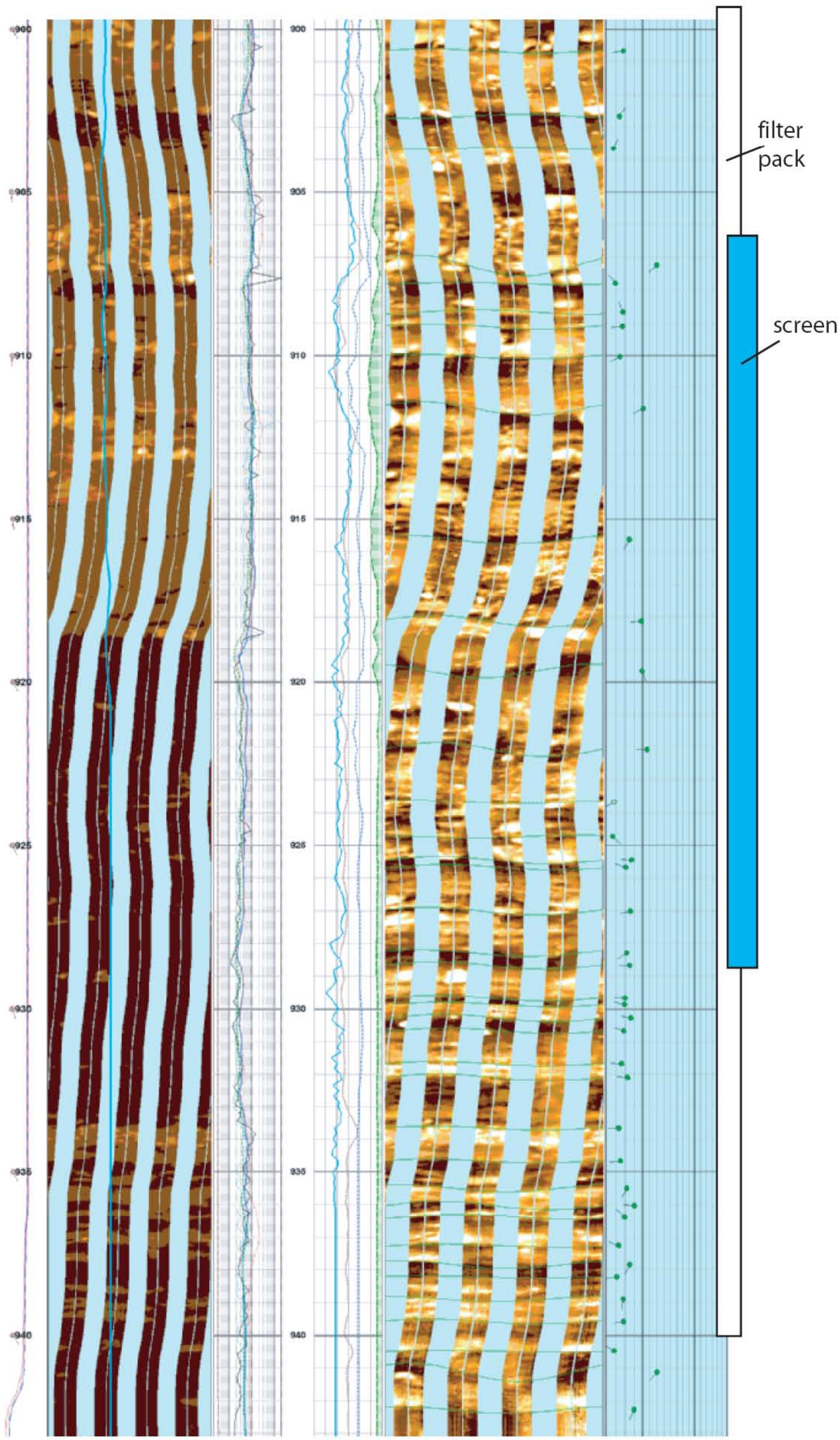


Figure 4b FMI log for R-2 (900 to 943 ft)

R-3i Well

R-3i Well

	Description	Evaluation
Drilling Method	R-3i was cored using air without any other fluids.	R-3i was cored using a 2.0-in. split-spoon sampler to 6-ft depth, followed by a 3.9-in. coring bit to 52.8-ft depth. At this depth, lost circulation problems were addressed by setting 6.625-in. casing to 55-ft depth and advancing beyond this depth with a 3.9-in. coring bit to a depth of 197.3 ft. Casing was then advanced to 195 ft; depth to water at this time was 194.4 ft. The hole was then cored to 218.3 ft, where depth to water was 217.4 ft. After coring to 223.3 ft, the depth to water was 188.5 ft and rose to 177.2 ft within an hour. After further coring to 240 ft, depth to water declined to 216.4-ft depth but rose overnight to 213.9 ft. Casing was then advanced to 239 ft, and bentonite chips were emplaced and allowed to swell to see if the depth to water would rise further. Water level declined to 223.4 ft, so coring was continued to 260.3 ft, where depth to water was measured at 238.9 ft. Coring continued to a TD of 268.3 ft (Figure 1), where with casing at 239 ft, the hole was dry. Inferred perched zones at borehole TD was 184.3 to 193.3 ft, 223.3 ft to unknown depth, and a possible thin zone at 240.0 ft, the contact with the Puye Formation.
General Well Characteristics	R-3i is a single-screen well constructed of 2.0-in.-I.D./2.3-in.-O.D. schedule 40 PVC.	PVC materials are chemically inert. All PVC components, including the screen, were factory-cleaned before shipment. Figure 2 shows the well design.
Well Screen Construction	The well screen is a nominal 5-ft. section (4.8 ft slotted) of 2.3-in.-O.D. schedule 40 PVC with 0.020-in. slots.	PVC screens are chemically inert. The 0.020-in. slots permit aggressive development in perched zones where sufficient flow is attainable.
Screen Length and Placement	The screen at R-3i extends from 215.2 to 220.0 ft (length of 4.8 ft) and is submerged 23.7 ft below the depth to water (191.5 ft) that was measured after well installation.	The screen length and placement were selected with the goals of characterizing water quality in a productive zone of perched saturation within Cerros del Rio lavas, 800 ft upstream from regional well TW-1 and intermediate well TW-1A and 235 ft east of intermediate well POI-4. Screen placement was based on driller's observations of likely perched zones and an induction log (Figure 3). The replacement of nearby intermediate well TW-1A by R-3i and POI-4 is important because TW-1A has no annular fill and may allow alluvial water to communicate with the deeper perched zone. Moreover, the carbon-steel casing and screen at R-3i have corroded since construction in 1950. The screen at TW-1A is ~40 ft lower in elevation than that at POI-4 (Figure 4) but probably represents the same or a connected perched system. This perched zone or set of perched zones is within an area where contaminants derived from sources such as Acid Canyon, sewage plants in Pueblo Canyon, and Manhattan-era buildings in the townsite could be moving. Well R-3i has been placed farther away from the Pueblo Canyon stream channel than TW-1A and POI-4 to minimize vertical mixing of alluvial water. The screen at R-3i is placed in the perched zone at a depth where submergence is sufficient to support development. The screen is located within an interflow zone of the Cerros del Rio lavas.

	Description	Evaluation
Screen Length and Placement (continued)		The placement of the well screen at R-3i meets the characterization goals for a well for this location, dependent on adequate flow for sampling.
Filter Pack Materials and Placement	The filter pack and its placement are discussed in the column to the right.	The primary filter pack is made up of 10/20 sand from 212.7 to 222.6 ft. A secondary filter pack of 20/40 sand was placed above the primary filter pack from 210.8 to 212.7 ft; beneath the primary filter pack is a backfill of bentonite plus sand from 222.6 to 237.5 ft, overlying slough from 237.5 ft to TD at 268.3 ft. The primary filter pack extends 2.5 ft above and 2.6 ft below the well screen. The top of the filter pack length was 21.2 ft below the top of perched saturation at the time of well completion.
Sampling System	Dedicated pump	Dedicated pumps allow relatively high-flow sampling. Flow-through cells for measuring field parameters can be used at single-screen wells with dedicated pumps installed. Effective development is typically limited in intermediate wells because of insufficient flow rate and volume; however, development issues are not as critical in wells like R-3i that are installed in core holes where no additives other than air are used during drilling.
Other Issues That Could Affect the Performance of the Well	None	n/a
Additives Used		None
Annular Fill Other Than Filter and Transition Sands		Slough: at 237.5–268.3 ft, below the bentonite/sand backfill under the filter pack Bentonite chips and pellets (48 ft^3) Bentonite pellets and 10/20 sand beneath filter pack (4.5 ft^3) Cement with 6.2% bentonite (6 ft^3; 2.4 ft to 10-ft depth)

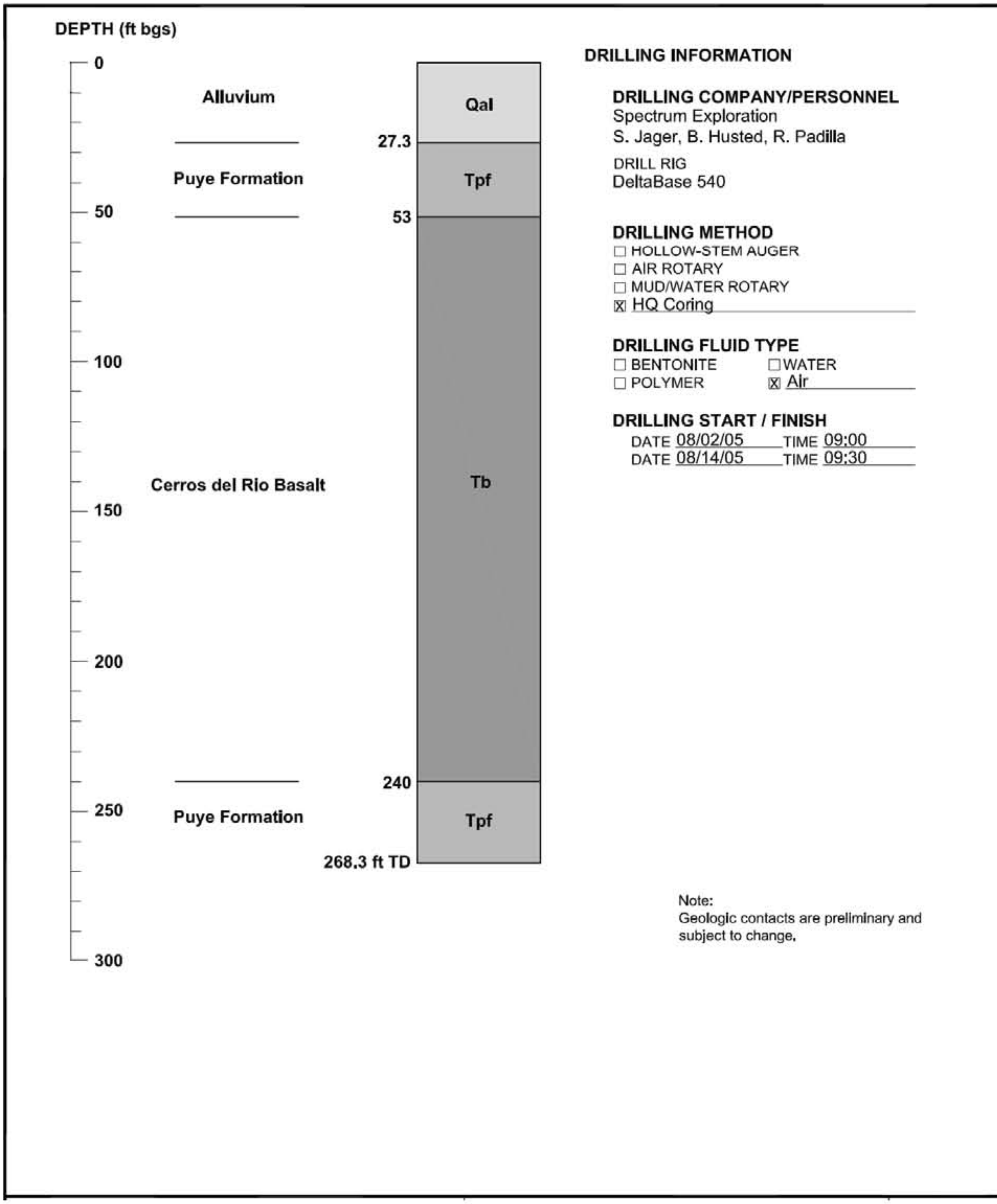


Figure 1 Hydrogeologic stratigraphy at R-3i

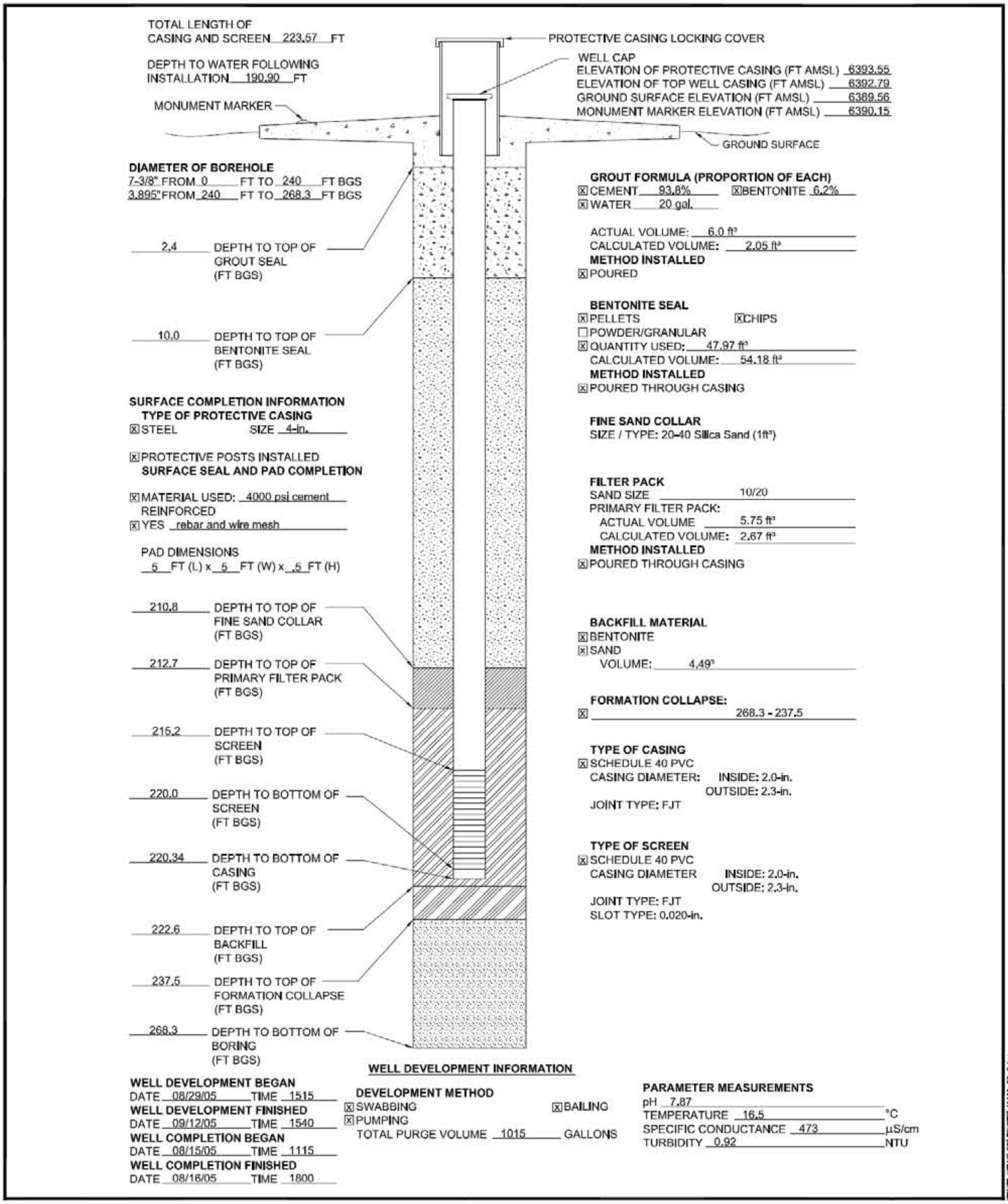


Figure 2 Well construction details at R-3i

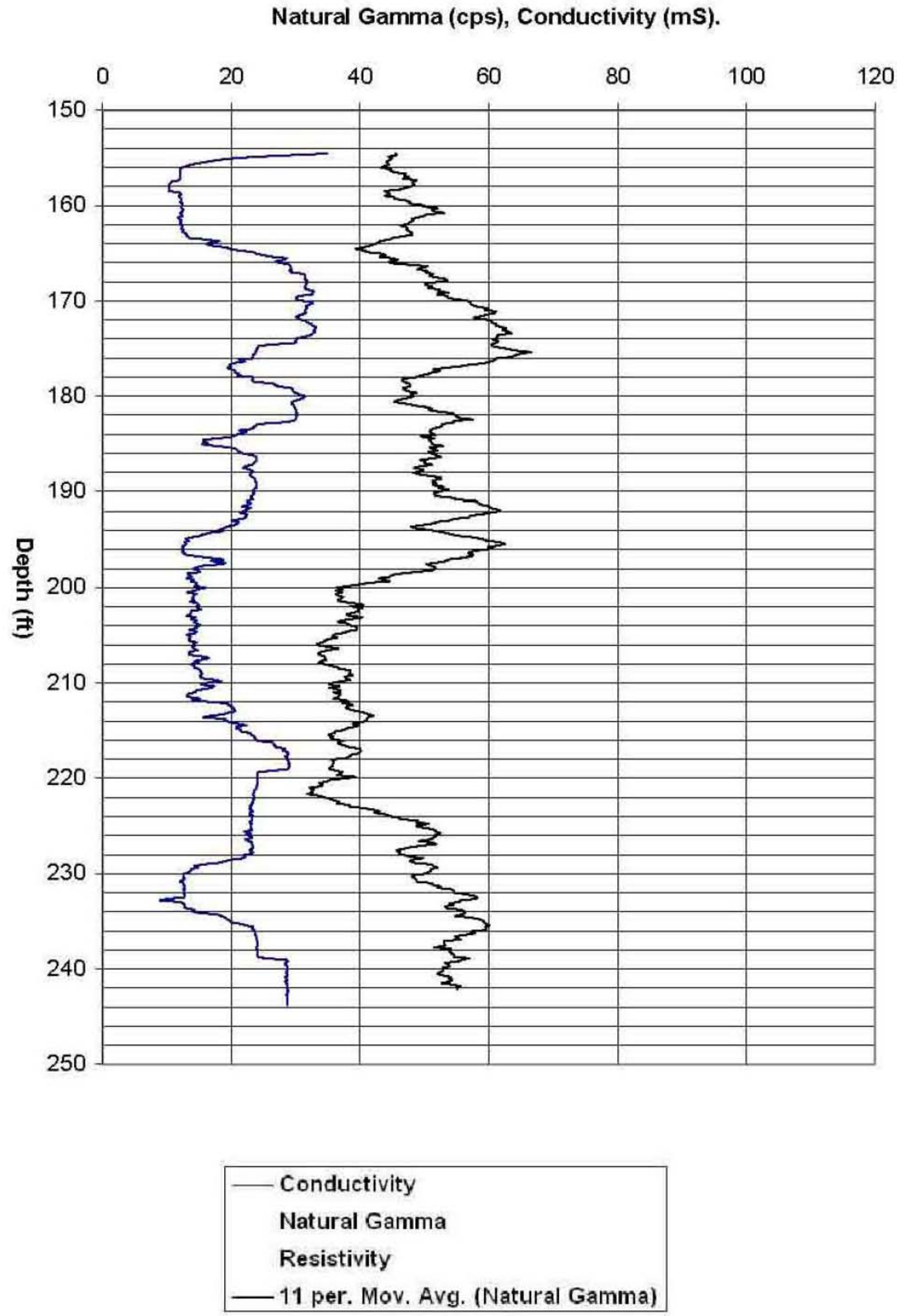


Figure 3 **Induction and natural gamma at R-3i (casing at 150-ft depth)**

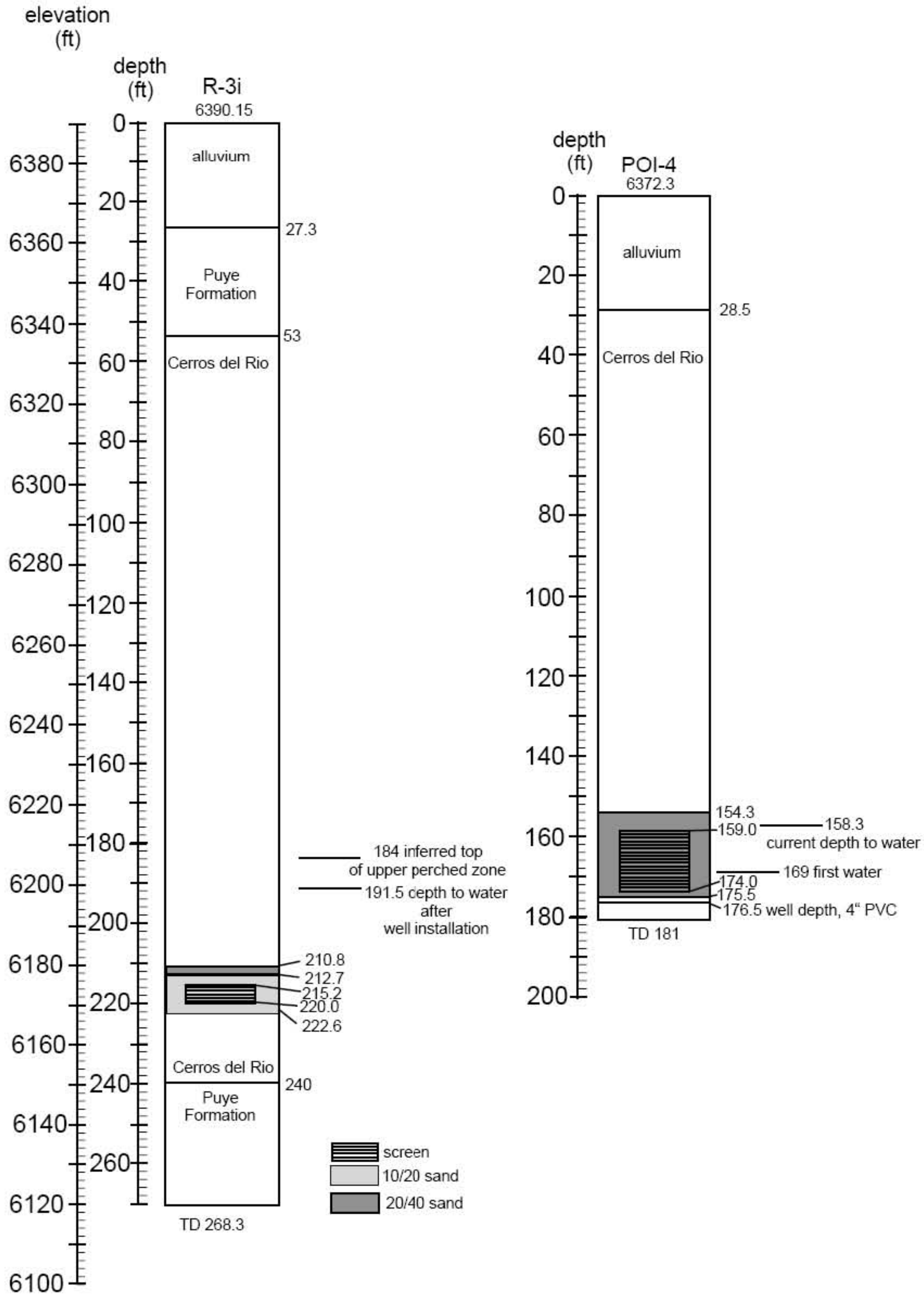


Figure 4 Comparison of R-3i with nearby well POI-4

R-4 Well

R-4 Well

	Description	Evaluation
Drilling Method	R-4 was drilled in two phases. Phase I used HSA methods to 233-ft depth to collect core; Phase I did not result in well emplacement but did guide placement of two piezometers. Phase II stepped aside and used fluid-assisted air-rotary tricone-bit methods to 243 ft, where the tool was switched to a down-the-hole hammer. At 270 ft, the tool was stuck because of excessive slough. Drilling continued to 845 ft using a tremie to air-lift slough. At this depth, the amount of slough critically hampered removal of the drill string, and ultimately 180 ft of tremie and 185 ft of drill pipe plus bit were lost in the borehole. This first hole was plugged and abandoned. A second hole was drilled using air-foam methods to 261 ft and mud-rotary methods to 843 ft.	Phase I coring located potential perched water at 110 to 125 ft and wet conditions at 226 to 230 ft. Two 2-in.-O.D. PVC piezometers were emplaced, one screened at 115 to 125 ft and another at 221 to 231 ft. These piezometers allow sampling of these zones should water appear. Figure 1 summarizes the hydrogeologic stratigraphy determined from Phase II drilling at R-4. The first attempt at Phase II drilling at R-4 used fluid-assisted air-rotary methods to 845-ft depth. Circulation of cuttings below 270 ft was accomplished using air and municipal water mixed with QUIK-FOAM and EZ-MUD, augmented by air-lifting with a tremie beginning at 214-ft depth. Regional saturation was encountered at 736-ft depth and a TD of 845 ft was reached. From this depth, difficulties were encountered in tripping out the drill string. With the bit at 710 ft, the drill string became stuck. Air-lifting the slough above the drill bit (slough up to 480-ft depth) failed with loss of two lengths of tremie (120 ft and 60 ft). Ultimately, 185 ft of drill pipe plus the 12.25-in. tricone bit was lost in the hole, which then had to be plugged and abandoned (Figure 2). The second attempt at Phase II drilling began by stepping over 120 ft to the west where air-foam methods (municipal water mixed with QUIK-FOAM and EZ-MUD) were used to 261-ft depth and mud-rotary methods (Aqua-Gel, PAC-L, and soda ash) to 843 ft. The well at R-4 was successfully constructed in this hole (Figure 3).
General Well Characteristics	R-4 is a single-screen well constructed of 4.5-in.-I.D./5.0-in.-O.D. 304 stainless-steel casing.	The stainless-steel well materials are designed to prevent corrosion.
Well Screen Construction	The rod-based continuous-slot screen is constructed of 5.27 in.-O.D. 304 stainless steel with 0.020-in. slots.	Rod-based screen provides extensive, uniformly distributed openings for access to the filter pack during development. Also, the 0.020-in. slots in the R-4 screen allow greater water movement during development than 0.010-in. screen openings. The screen at R-4 was developed successfully using bailing, swabbing, and pumping. R-4 consistently yields water samples considered representative of groundwater conditions in the regional aquifer at this location (Appendix B). The screen at R-4 has returned to background concentrations for solutes leached from bentonite, indicating that development has successfully ameliorated the use of mud during drilling.

	Description	Evaluation
Screen Length and Placement	The screen at R-4 extends from 792.9 to 816.0 ft (length of 23.1 ft) and is submerged beneath the regional water table (currently 745.5 ft below the surface) within Santa Fe Group sediments. The top of the screen is currently 47.4 ft below the top of the regional aquifer.	The screen length and placement were selected with the following goals in mind: • Characterize water quality in the uppermost part of regional groundwater, approximately 10,600 ft downstream of the confluence of Acid and Pueblo Canyons • Monitor the regional water table for seasonal fluctuations and long-term variations The screen at R-4 is placed in the regional aquifer at a depth where submergence is sufficient to support aggressive development. However, the screen at R-4 is shallow enough to capture contaminants moving in the uppermost zone of high-effective porosity (800 to 810 ft), where the highest concentrations of contaminants may be encountered before becoming diluted by mixing with uncontaminated groundwater (Figure 4). The screen is located within Santa Fe Group sediments that dip up to 15 degrees toward the east and northeast (dip azimuths vary between about 20 and 120 degrees). Total porosities within the screen interval range between 35% and 45%. The electrical resistivity image (FMI log, Figure 5) shows that these deposits consist of thinly laminated beds with small channels and rare clasts up to a few inches in diameter. The CMR indication of moveable water is elevated relative to strata above and below the screened interval. The placement of the well screen at R-4 meets the characterization goals for a well for this location.
Filter Pack Materials and Placement	The filter pack and its placement are discussed in the column to the right.	The primary filter pack is made up of 10/20 sand from 780 to 826 ft. A secondary filter pack of 20/40 sand was placed above the primary filter pack from 778 to 780 ft; beneath the primary filter pack is a backfill of 75% 10/20 sand plus 25% bentonite chips (826 ft to TD at 843 ft). The primary filter pack extends 12.9 ft above and 10 ft below the well screen. The top of the filter pack length is currently 34.5 ft below the water table. The upper and lower filter packs extend slightly farther beyond the well screen than current well designs (about 5 ft above and below the well screen). However, because the Santa Fe Group sediments at this location are heterogeneous, a slightly long filter pack allows groundwater to be drawn from a larger volume in rocks where the amount and location of water production are uncertain.
Sampling System	Dedicated pump	Dedicated pumps allow relatively high-flow sampling. Flow-through cells for measuring field parameters can be used at single-screen wells with dedicated pumps installed. Effective development and removal of residual drilling fluids are critical where drilling mud has been used, and the highest possible flow after development is desirable.
Other Issues That Could Affect the Performance of the Well		Pump production at R-4 is fairly high (~13 gal./min), which facilitates purging prior to collection of water samples.

	Description	Evaluation
Additives Used		Municipal water QUIK-FOAM (above the regional aquifer) EZ-MUD (above the regional aquifer) Aqua-Gel PAC-L (DRISPAC) Soda ash
Annular Fill Other Than Filter and Transition Sands		10/20 sand: 21 bags Bentonite: 0.375-in. chips (56 bags and 8.75 SuperSacks) Concrete with 4% bentonite (2.5 yd^3; surface to 77-ft depth)

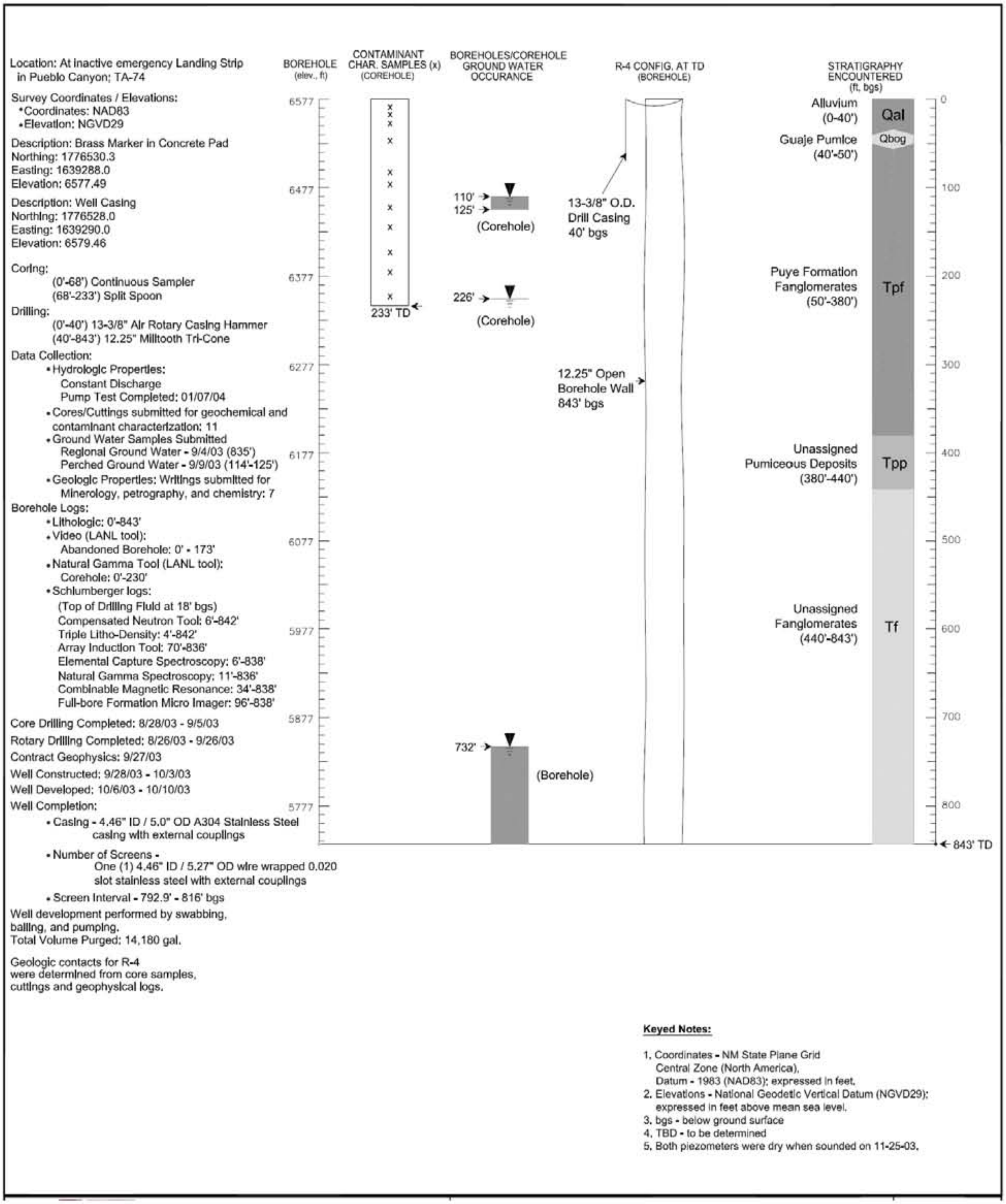


Figure 1 Hydrogeologic stratigraphy for well R-4

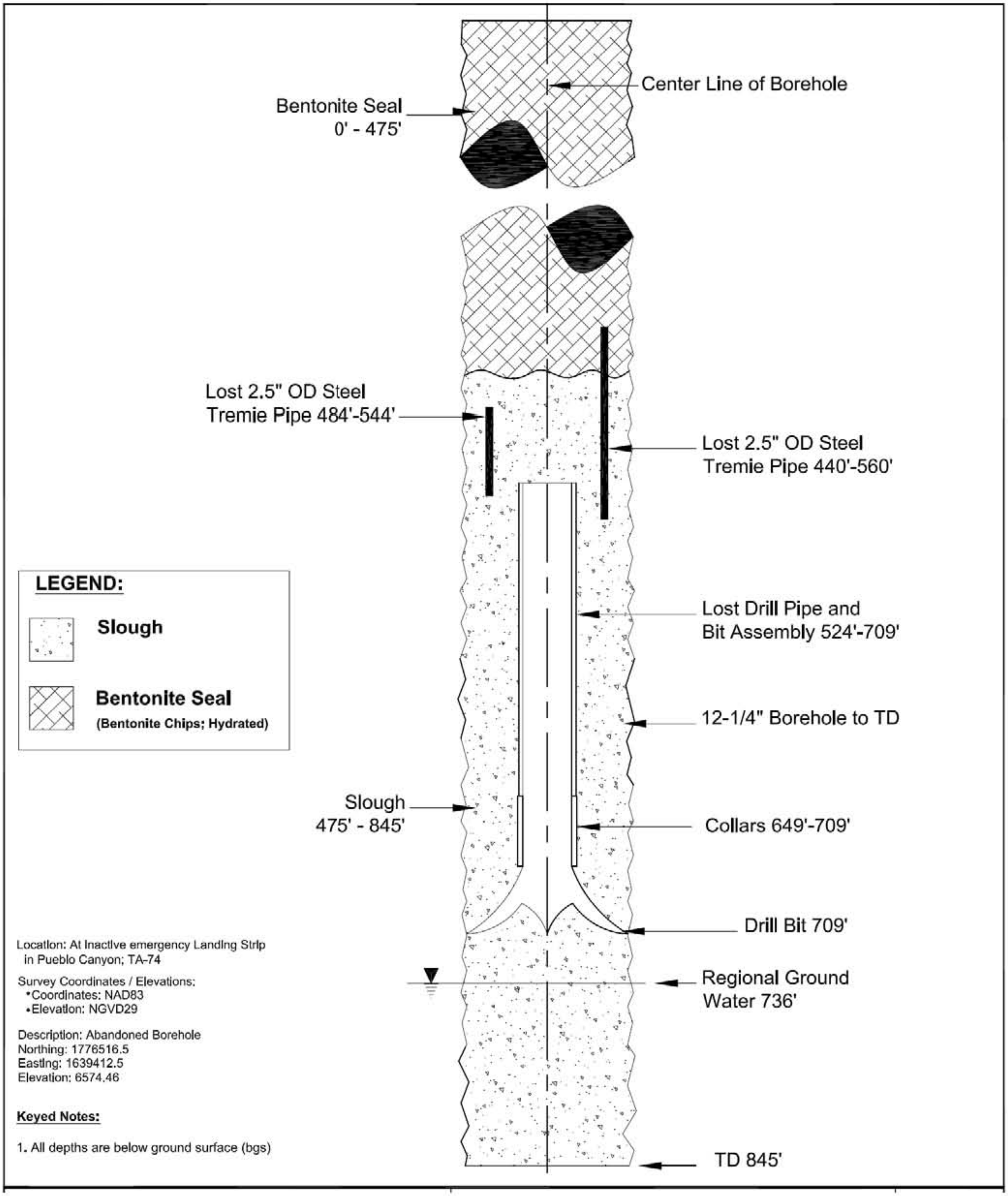


Figure 2 Plugged and abandoned hole at R-4

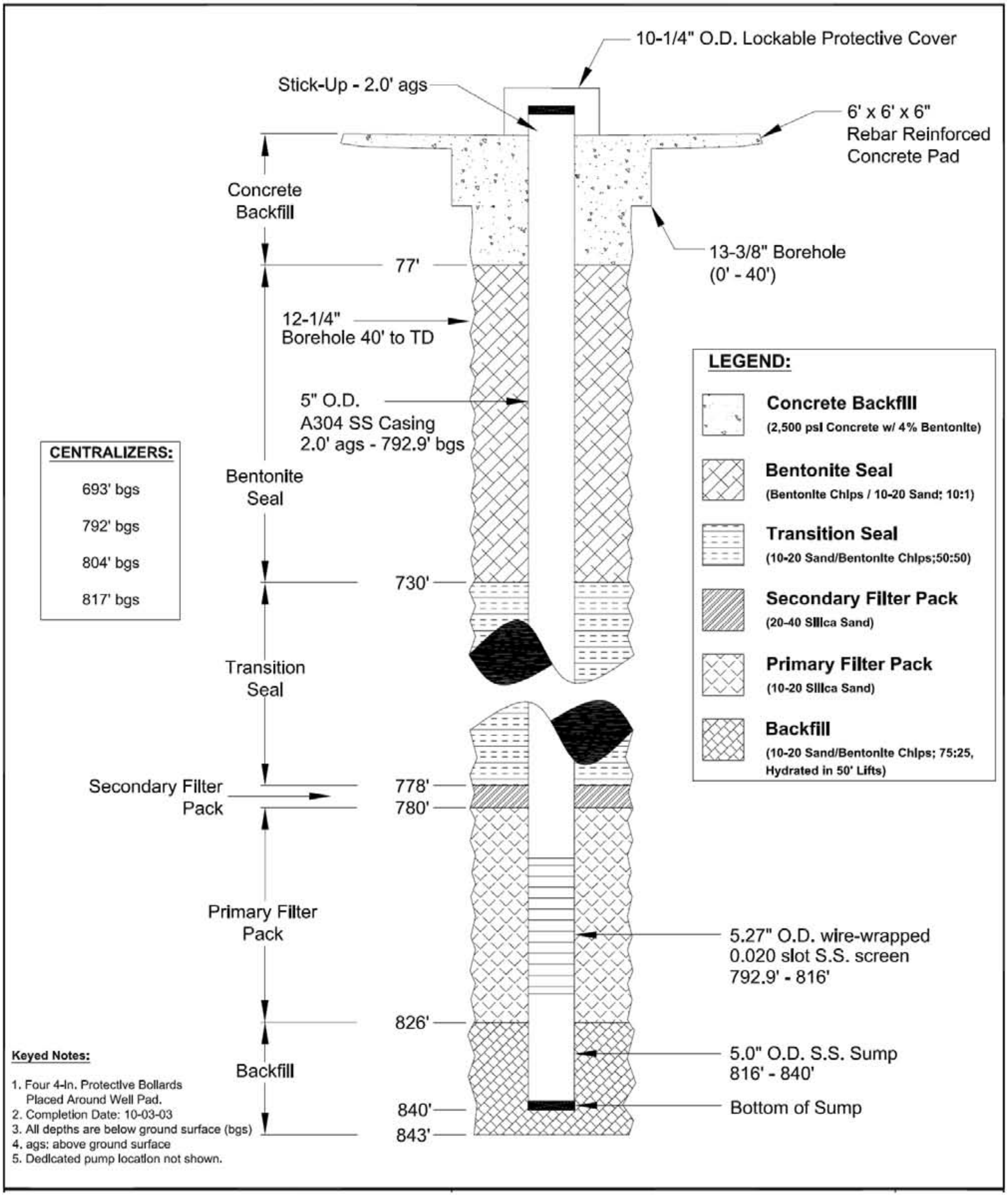


Figure 3 Well construction details for R-4

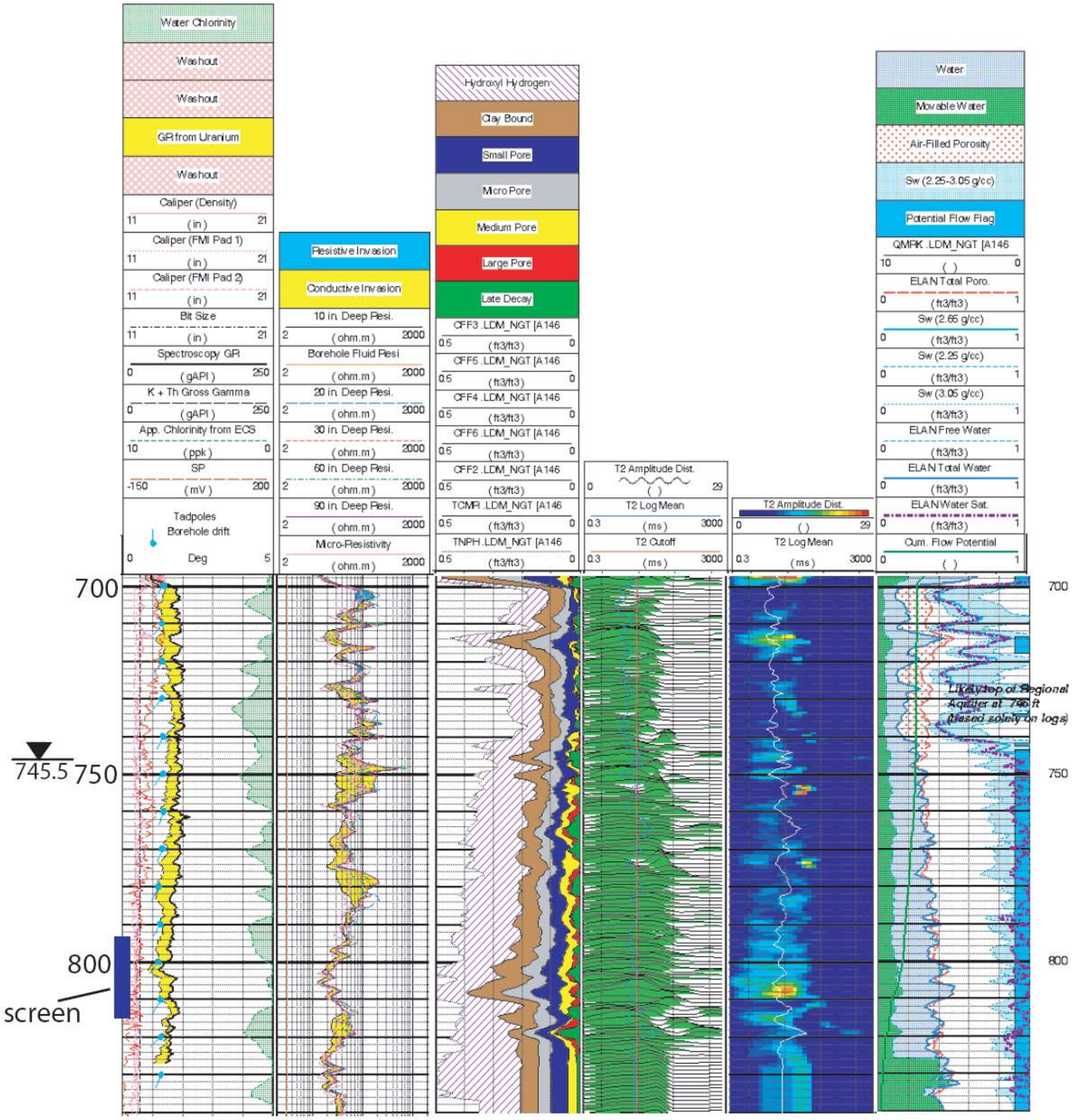


Figure 4 Summary of R-4 borehole geophysical logs for the regional aquifer

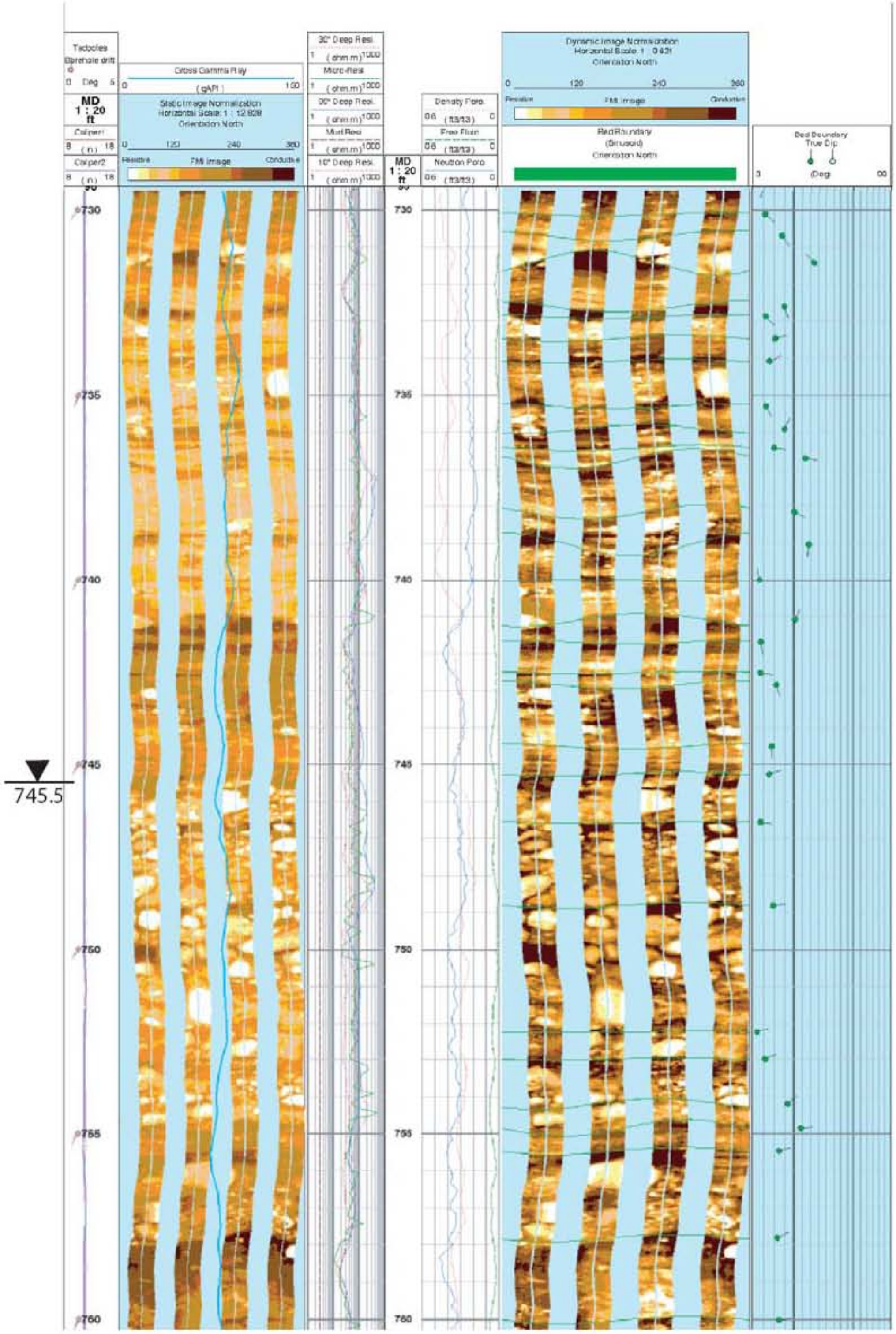


Figure 5a FMI log for R-4 (730 to 760 ft)

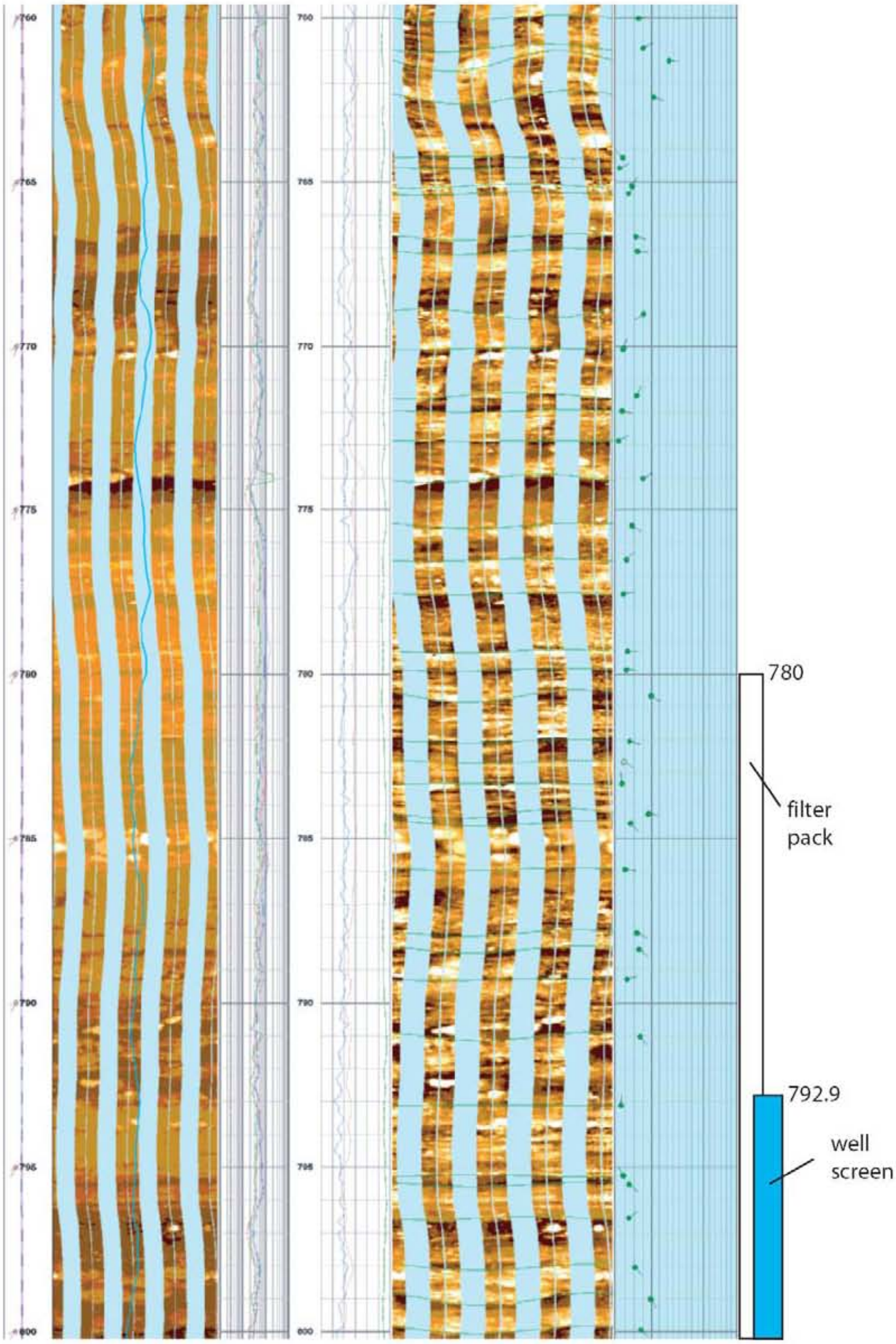


Figure 5b FMI log for R-4 (760 to 800 ft)

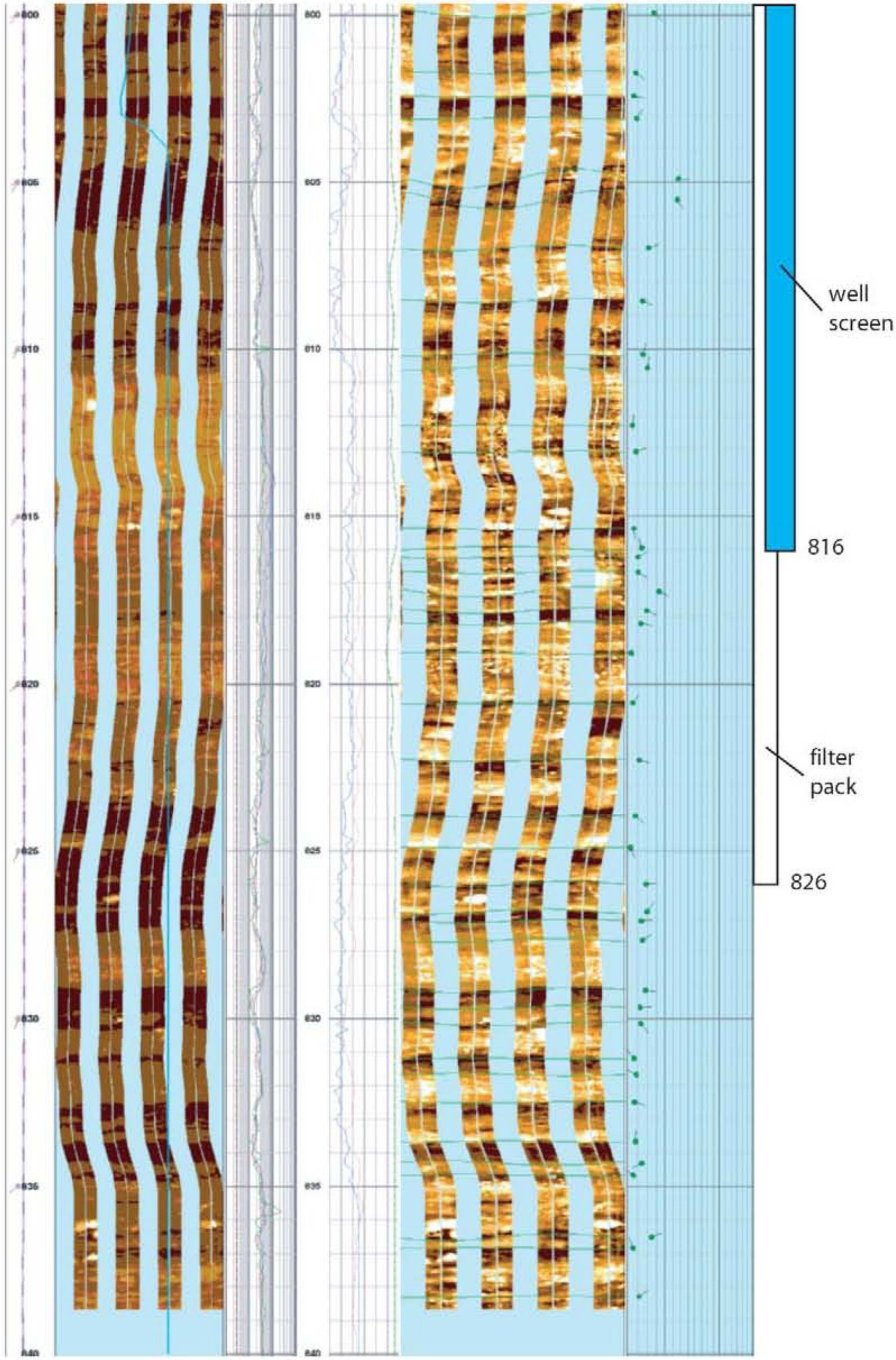


Figure 5c FMI log for R-4 (800 to 840 ft)

R-5 Well

R-5 Well

	Description	Evaluation
Drilling Method	R-5 was drilled using fluid-assisted air-rotary methods with casing advance to a TD of 902 ft.	R-5 was drilled using fluid-assisted air-rotary methods with casing advance. Drilling additives included air and municipal water mixed with QUIK-FOAM and EZ-MUD. Drilling additives can adversely affect the ability to collect representative water samples if not removed from the immediate vicinity of the well screen during well development or during purging before sample collection. Casing was first landed at 130-ft depth within Cerros del Rio lavas, followed by open-hole drilling through sediments (152–534 ft) to 547 ft in Miocene lavas. Formation instability prompted return to casing advance to 570 ft, where open-hole drilling then continued to 828 ft. Instability again required casing advance to 870 ft. Casing was then retracted to 850 ft, and the bit was advanced open hole to a TD of 902 ft. The hydrogeologic stratigraphy at R-5 is summarized in Figure 1.
General Well Characteristics	R-5 is a four-screen well constructed of 4.5-in.-I.D./5-in.-O.D. 304 stainless-steel casing.	The stainless-steel well materials are designed to prevent corrosion. The well design at R-5 is summarized in Figure 2.
Well Screen Construction	The pipe-based screens are constructed of 4.5-in.-I.D./5.56-in.-O.D. 304 perforated stainless-steel casing wrapped with stainless-steel wire wrap with 0.010-in. slots.	Pipe-based screens provide structural stability to well screens that might be damaged during well installation or by shifting geologic materials after well installation. Pipe-based screens were introduced after two well screens were damaged during installation of R-25 well. A drawback to pipe-based screens is that water surged into the filter pack and formation during development is less effective in those areas that are not adjacent to holes in the well casing. Also, the wire wrap on the R-5 well screen contains 0.010-in. slots. More recent wells contain 0.020-in. slots that facilitate the movement of water through the well screen when surging and pumping the well during development. The ability of 0.010-in. slot wire-wrapped pipe-based screen to develop properly must be judged on the quality of groundwater data collected from the wells. Evaluations of water-quality data from Screens 2 and 3 at R-5 do not reveal any residual effects of drilling products, whereas samples from the deepest screen (screen 4) reflect several residual effects, including persistent iron-reducing conditions (Appendix B; LANL 2007, 096330, Table 6-1). Screen 1 targeted an upper perched zone within the Puye Formation, indicated from borehole geophysical logs. However, this screen is, in fact, dry or only intermittently saturated.

	Description	Evaluation
Screen Length and Placement	Well screen 1 extends from 326.4 to 331.5 ft and has a length of 5.1 ft. This screen has remained dry since the well was constructed but has water in the sump (Allen and Koch 2007, 095268).	R-5 is designed to provide perched and regional sampling points and to improve knowledge of the perched and regional groundwater systems upstream of O-1. Specific goals for R-5 are as follows: • Characterize water quality in a perched system beneath Pueblo Canyon north of R-9i and determine whether the perched systems in Pueblo and Los Alamos Canyons are in communication. This goal is addressed by screen 2.
	Well screen 2 extends from 372.8 to 388.8 ft and has a length of 16 ft. Depth to perched water in screen 2 is currently 337.6 ft (Allen and Koch 2007, 095268). Well screen 3 extends from 676.9 to 720.3 ft and has a length of 43.4 ft. Depth to the regional aquifer at screen 3 is currently 707 ft (Allen and Koch 2007, 095268). Well screen 4 extends from 858.7 to 863.7 ft and has a length of 5 ft. Depth to the regional aquifer at screen 4 is currently 727.6 ft (Allen and Koch 2007, 095268).	• Place a screen at the water table that was estimated to be at 685-ft depth in the open borehole before well construction. The purpose of this screen is to detect maximum contaminant concentrations due to infiltration beneath this portion of Pueblo Canyon. This goal is addressed by screen 3. • Place another screen deeper in the aquifer to target a productive zone in the regional aquifer deeper than the screen across the top of regional saturation. This goal is addressed by screen 4. • Determine vertical hydraulic gradients in the regional groundwater system • Monitor water-level responses in the upper part of the regional aquifer to pumping from nearby water supply wells Schlumberger geophysical logs at R-5 were collected in a borehole that was cased to a depth of 850 ft (Figure 3). The two screens that targeted perched zones are in Puye Formation fanglomerate (screen 1) and in stream gravels that may be Totavi equivalents (screen 2). Screen 1 is in a zone where Schlumberger log analysis suggested that the available porosity is at or near saturation. Screen 2 targeted a zone where perched water (350 to 387 ft) was encountered and sampled during drilling. The two screens in the regional aquifer are sited in two very different units. Screen 3 is within a section of Santa Fe Group sands and gravels, extending from 670- to 720-ft depth, and sandwiched between two sequences of clay- and carbonate-altered Miocene lavas. The lower part of this zone (712–716 ft) is a washout zone in the Schlumberger logs. Screen 4 is within a deeper clay- and carbonate-altered Miocene lava (850- to 893-ft depth). Schlumberger logs indicate a density drop in this interval, and cuttings suggested a possible shear or rubble zone in the altered lavas. Water table maps for the Pajarito Plateau indicate that water levels measured in screen 3 are anomalously low compared with the surrounding wells (Appendix D-5.0). These data indicate that the location of the screen in sediments between Miocene basalts may not be hydrologically connected to other parts of the aquifer above the Miocene basalts.

	Description	Evaluation
Filter Pack Materials and Placement	The primary filter pack for Screen 1 consists of 20/40 sand from 316.5 to 331.5 ft. A secondary filter pack of 30/70 sand was placed above the primary filter pack from 314.4 to 316.5 ft. The primary filter pack for screen 2 consists of 20/40 sand from 364.5 to 369.5 ft, slough of river gravels from 369.5 to 386.7 ft, and 20/40 sand from 386.7 to 399.5 ft. A secondary filter pack of 30/70 sand was placed above the primary filter pack from 363.5 to 364.5 ft. The primary filter pack for screen 3 consists of 20/40 sand from 666.5 to 721.5 ft and slough of sand and gravel from 721.5 to 721.0 ft. Secondary filter packs of 30/70 sand are placed above the primary filter pack from 665.2 to 666.5 ft and below the slough, from 727.0 to 729.0 ft. The primary filter pack for screen 4 consists of 20/40 sand from 851.0 to 867.5 ft. There is no secondary filter pack of finer sand above the primary filter pack; below the primary filter pack from 867.5 to 902 ft (TD) is slough.	The primary filter pack for screen 1 covers the well screen, extending 9.9 ft above and 6.5 ft below. The primary filter pack for screen 2 extends 8.3 ft above and 10.7 ft below the well screen. However, most of the screened interval (the upper 87%, or 13.9 ft) is covered by slough composed dominantly of river sands and gravels, rather than the introduced 20/40 sand. The primary filter pack of 20/40 sand at screen 3 extends 10.4 ft above and 1.2 ft below the well screen, although there is another 5.5 ft of slough below the primary filter pack that may or may not be relatively transmissive. The upper section of transition sand extends farther than is common in current well design (~5 ft), but the extended filter pack is above the top of regional saturation and intersects the base of the upper section of Miocene lavas (at 670-ft depth), allowing possible collection of percolating water that might otherwise be diverted by clay zones along the base of that unit. The primary filter pack of 20/40 sand at screen 4 extends 7.7 ft above and 3.8 ft below the well screen. This filter pack is entirely within Miocene lava.

	Description	Evaluation
Sampling System	Westbay MP sampling system	Westbay is a low-flow sampling system that allows groundwater sampling of multiple well screens within a single well installation. Well screens are isolated by packers and sampled individually. Westbay is the only sampling system capable of sampling three or more screens in a multiscreen well. It is particularly effective for monitoring water levels at multiple depths within a well. Flow-through cells for measuring field parameters cannot be used at multiscreen wells containing the Westbay sampling system. Effective development and removal of residual drilling fluids are critical before installation of Westbay wells because groundwater is collected in proximity to the well due to low-flow sampling and the inability to purge the well before sampling. Samples collected from Westbay wells are particularly prone to water-quality problems that develop if residual drilling fluids are hydraulically connected to the screen interval. Screen 4 in particular is in a poorly transmissive lava and is therefore poorly developed, a likely cause of the iron-reducing conditions that persist at this screen (LANL 2007, 096330).
Other Issues That Could Affect the Performance of the Well	Slough at screen 3	Unstable borehole conditions resulted in slough filling the annulus next to the well casing behind screen 3 in the interval 369.5 to 386.7 ft during well construction as the drill casing was retracted. However, this slough consists predominantly of unconsolidated river sands and gravels very similar to the unconsolidated sands and gravels more distant from the screen. The impact on ability to characterize the top of regional saturation is likely minimal.
Additives Used During Drilling		Municipal water QUIK-FOAM EZ-MUD Fluid volume recovered: 14,230 gal. during well development: 3020 gal. by integral bailing, 1095 gal. pumped from screen 3, 985 gal. pumped from screen 4, and 9130 gal. pumped from the sump.
Annular Fill Other Than Filter and Transition Sands		6/9 sand:mixed with bentonite to bridge fracture and washout zones at 401- to 566-ft depth Holeplug: 0.375-in. angular and unrefined bentonite chips to provide borehole annular seal (17,700 lb) Pelplug: 0.25 in. by 0.375 in. refined elliptical bentonite pellets to provide a borehole annular seal below the water table (11,450 lb) Cement for annular support and surface seal (5076 lb) Benseal: high solids, multipurpose bentonite grout (100 lb)

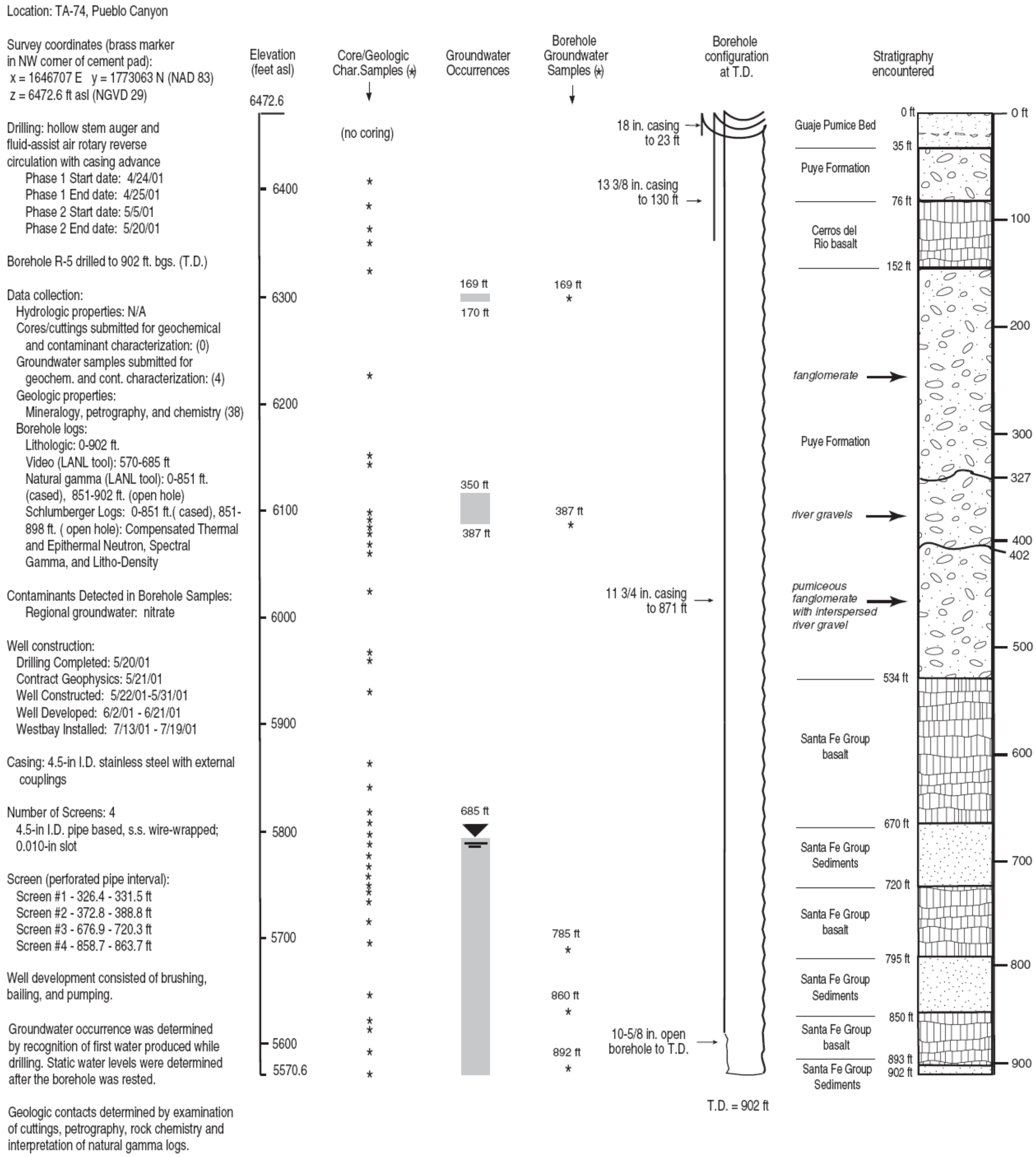
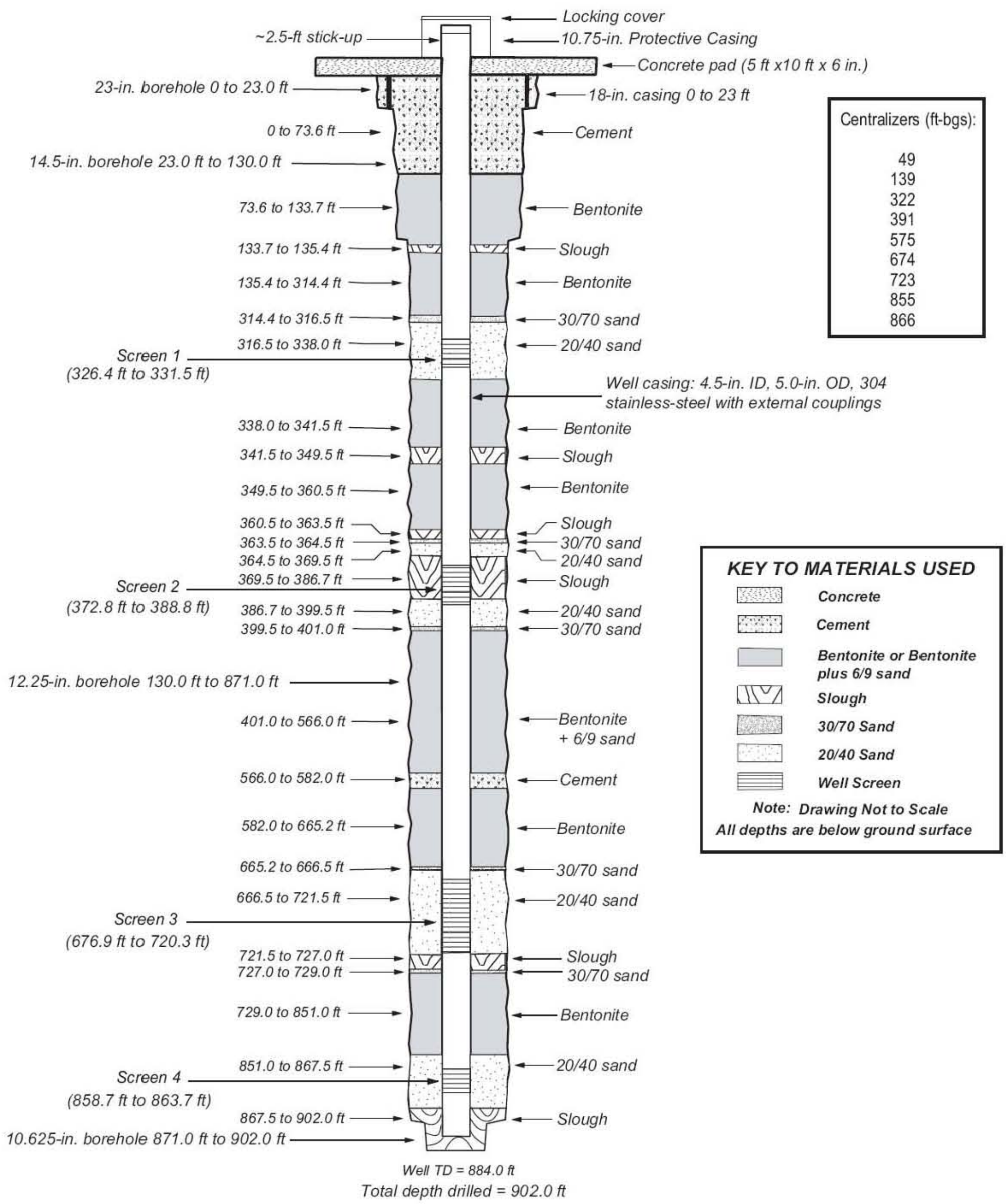


Figure 1 **Hydrogeologic stratigraphy at well R-5**



Notes: 1. The screen interval lists the footage of the pipe perforations, not the top and bottom of screen joints.
2. Pipe-based screen: 4.5-in. ID, 5.563-in. OD, 304 stainless-steel with s.s. wire wrap; 0.010-in. slots.
3. The top interval of slough consists of Cerros del Rio sediments. The intervals of slough around screen 2 consist of Puye river gravels. The slough intervals below screens 3 and 4 consist of Santa Fe Group sediments and/or basalt.
4. Westbay multiport sampling system (MP-55) casing not shown.

Figure 2 Well construction details at R-5

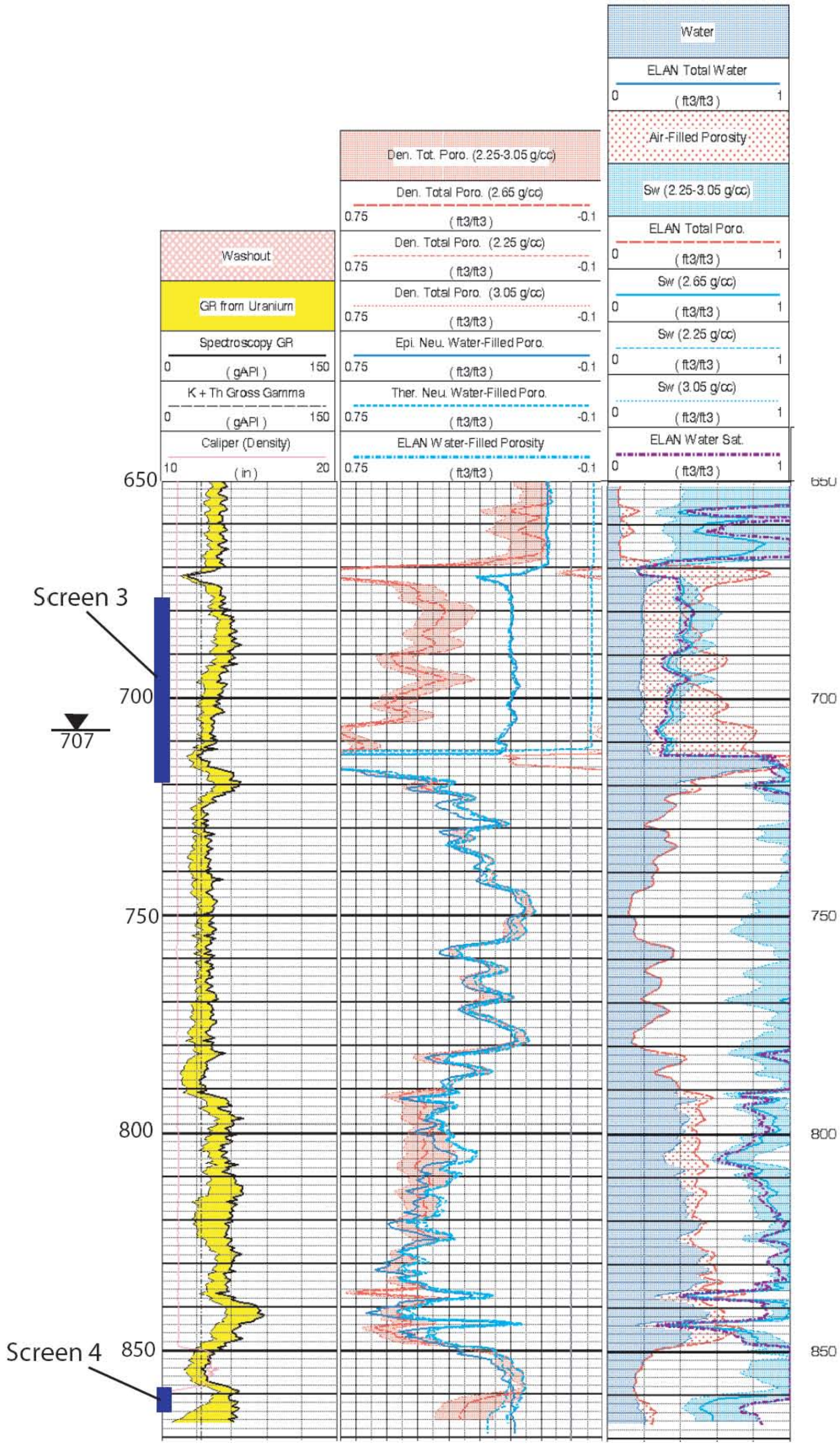


Figure 3 **Summary of R-5 borehole geophysical logs for the regional aquifer (11.75-in. casing to 850-ft depth)**

R-6 Well

R-6 Well

	Description	Evaluation
Drilling Method	R-6 was drilled using fluid-assisted air-rotary casing advance methods.	R-6 was initially drilled using a combination of conventional-circulation air-rotary and fluid-assisted air-rotary methods in open hole to 945-ft depth. Due to frequent episodes of lost circulation and clogging of the bits with gravel, the bottom part of the borehole was drilled to TD at 1303 ft by conventional-circulation mud-rotary drilling. There were significant problems with lost circulation and hole deviation during mud-rotary drilling, and eventually casing was set to 815-ft depth to isolate the upper part of the borehole. Finally, the bottom part of the borehole was drilled by open-hole mud-rotary drilling to TD at 1303 ft. Drilling additives included air and municipal water mixed with QUIK-FOAM, EZ-MUD in the upper part of the borehole, and municipal water mixed with bentonite (MAX-GEL and QUIK-GEL), N-SEAL, DRISPAC, and soda ash in the lower part. Drilling additives can adversely affect the ability to collect representative water samples if not removed from the immediate vicinity of the well screen during well development or during purging before sample collection.
General Well Characteristics	R-6 is a single-screen well constructed of 4.5-in.-I.D./5-in.-O.D. 304 stainless-steel casing.	The stainless-steel well materials are designed to prevent corrosion.
Well Screen Construction	The well screen is constructed of 4.46-in. I.D./5.27-in.-O.D. 304 stainless-steel wire wrap with 0.020-in. slots.	The R-6 well screen construction (0.020-wire-wrapped screen) is considered an optimum design that balances the need to prevent fine-grained material from entering the well and the need to promote the free flow of water during well development and sampling.
Screen Length and Placement	The well screen extends from 1205 to 1228 ft and has a length of 23 ft. The top of the screen is 48 ft below the water table (currently 1157 ft below the surface).	R-6 is designed to replace TW-3, and its screen length and placement were selected with the following goals in mind: • Provide upgradient monitoring for municipal water supply well Otowi-4 • Characterize water quality in the uppermost part of regional groundwater downgradient of TA-21 • Provide a monitoring point in a productive zone near the top of the regional aquifer to detect whether infiltration beneath Los Alamos Canyon has resulted in contamination of the regional groundwater system • Monitor water-level responses in the upper part of the regional aquifer to pumping from nearby water supply wells • Submerge the screen fully to facilitate well development. There were no direct measurements of depth to the regional water table because R-6 was drilled by mud-rotary techniques. The R-6 well design was based on a depth to water estimate of 1182 ft, based on mud log temperatures and Schlumberger's preliminary interpretation of the geophysical logs. However, water-level measurements in the completed well indicate that the depth to water was about 1157 ft, or about 25 ft higher than expected.

	Description	Evaluation
Screen Length and Placement (continued)		Reprocessing of geophysical logs after the well was installed indicated that strata from 1154 ft to the bottom of the log interval (1296 ft) is fully saturated and that the porosity across this interval mostly ranged from 26% to 34% of the total rock volume. A few tight zones with porosity as low as 10% were found in the uppermost part of the regional groundwater system at 1154 to 1156 ft, 1168 to 1172 ft, and 1173 to 1182 ft. Below 1182 ft, the strata are characterized by fairly uniform hydrogeologic properties, including high estimated effective porosity (17% to 24%). The well screen and filter pack span the upper part of this zone of uniform hydrogeologic properties. The strata consist of bedded Miocene (?) volcaniclastic sands and gravels that dip mostly <20 degrees toward the southwest and southeast. Individual beds are well stratified and range in thickness from a few inches to 2 ft.
Filter Pack Materials and Placement	The primary filter pack is made up of 10/20 sand from 1184 to 1257 ft. A secondary filter packs of 20/40 sand was placed above the primary filter pack from 1182 to 1184 ft.	The primary filter pack extends 21 ft above and 29 ft below the well screen. The well design called for the primary filter pack to extend 8 ft above and 5 ft below the well screen, and it is unclear from the completion report why the filter pack is so long. Emplacement of the filter pack through a column of mud may have hindered the accurate placement of materials in the annulus of the well. The long filter pack above the well screen may actually be advantageous because the water table was higher than planned for in the well design, and the excess filter pack allows water to be drawn into the well screen from strata closer to the water table. The longer-than-planned-for filter pack below the well screen could result in sampling of potential groundwater flow paths as deep as 100 ft below the water table. Because of uncertainties associated with flow pathways within heterogeneous aquifer materials, it is not clear whether the long filter pack aids or hinders detection of contamination.
Sampling System	Submersible pump	Submersible pumps installed in single completion wells allow groundwater to be purged from the well casing, well-filter pack, and to some degree, near-well formation materials. Water can pumped at a rate of 10–12 gal./min, greatly facilitating effective purging and efficient sampling. Conventional purging and sampling allow water to be drawn from more deeply within formation materials surrounding the well screen in comparison to low-flow systems, and there is a greater likelihood of obtaining water from zones beyond potential near-well drilling effects. Storage and disposal of purged water require additional resources relative to low-flow sampling systems. Water levels can be measured manually or by dedicated pressure transducers.
Other Issues That Could Affect the Performance of the Well	None	N/a

	Description	Evaluation
Additives Used During Drilling		Municipal water: 7485 gal. during air-rotary drilling, 80,000 gal. to regain circulation for mud drilling in open hole, and 3200 gal. for mud drilling after casing installed to 815 ft QUIK-FOAM: 110 gal. EZ-MUD: 45 gal. N-SEAL: 7140 lb Soda ash: 500 lb MAX-GEL: 2800 lb DRISPAC: 1100 lb QUIK-GEL: 37,700 lb Fluid volume recovered (48,359 gal.; includes drilling, well development, and hydrologic testing)
Annular Fill Other Than Filter and Transition Sands		Bentonite seal: bentonite chips and 10/20 silica sand (50:50) (640.4 ft^3) Cement slurry for surface seal (45.2 ft^3) Potable water (36,300 gal.)

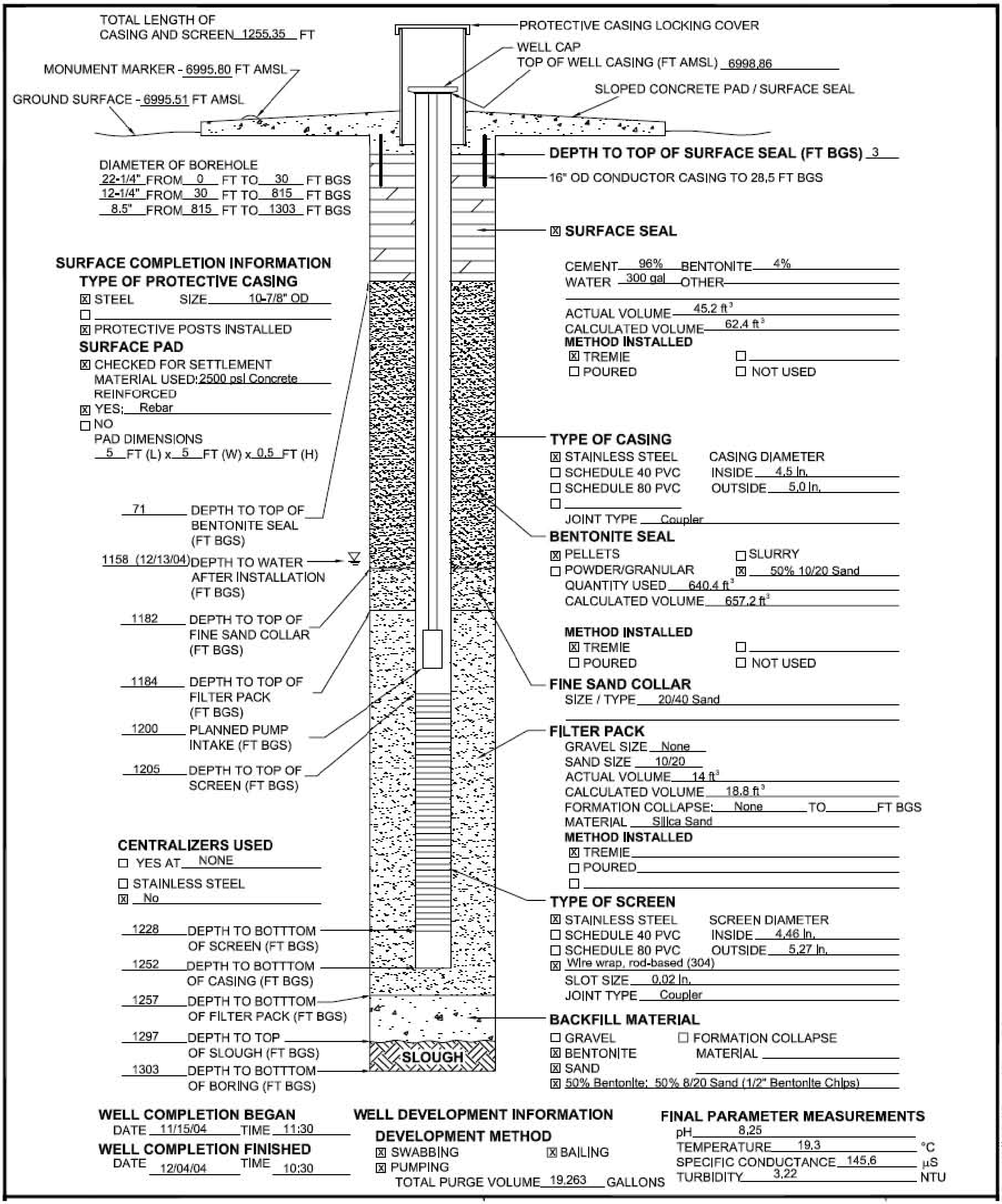


Figure 1 Well schematic for characterization well R-6

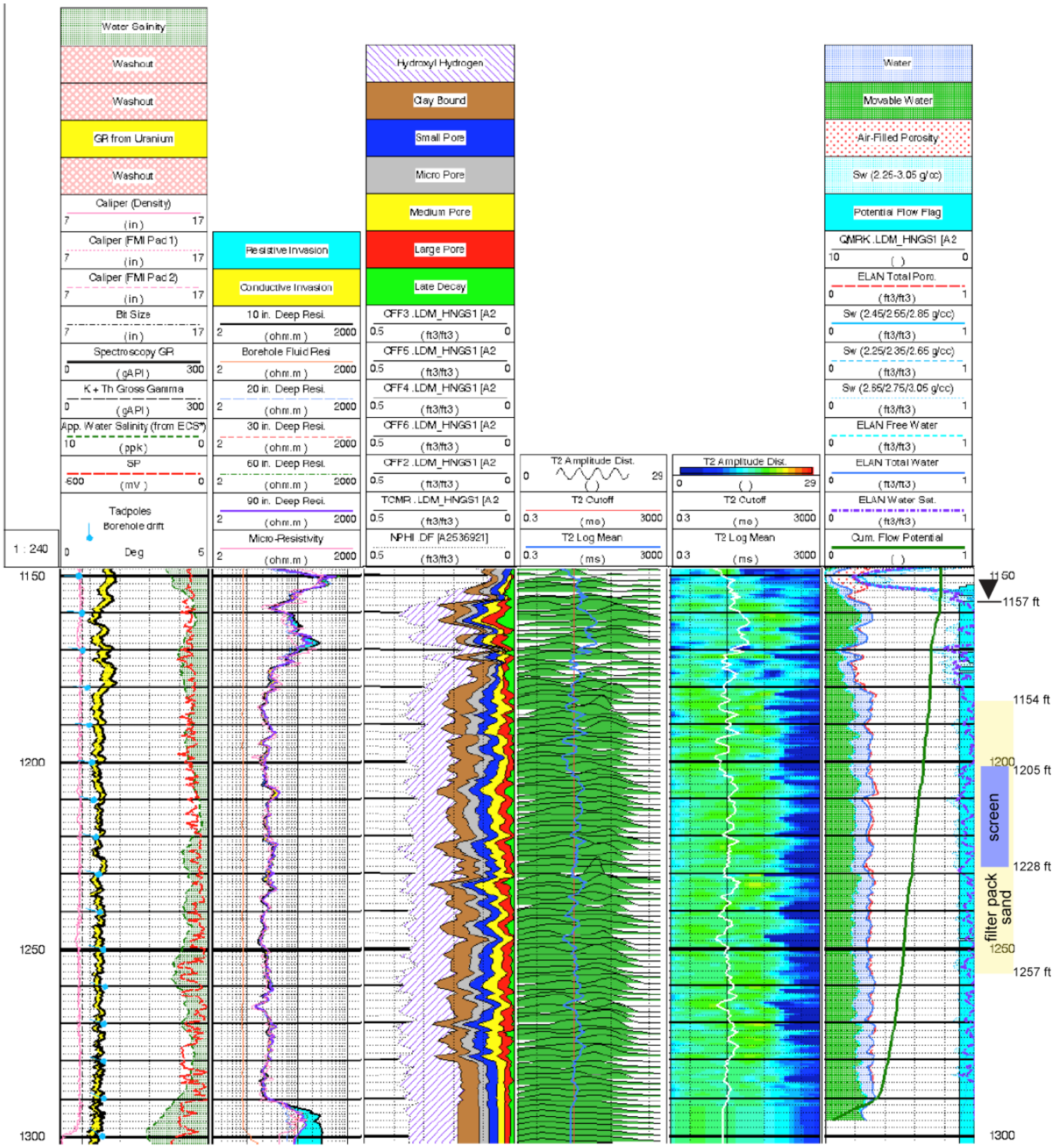


Figure 2 Summary of R-6 borehole geophysical logs for the regional aquifer

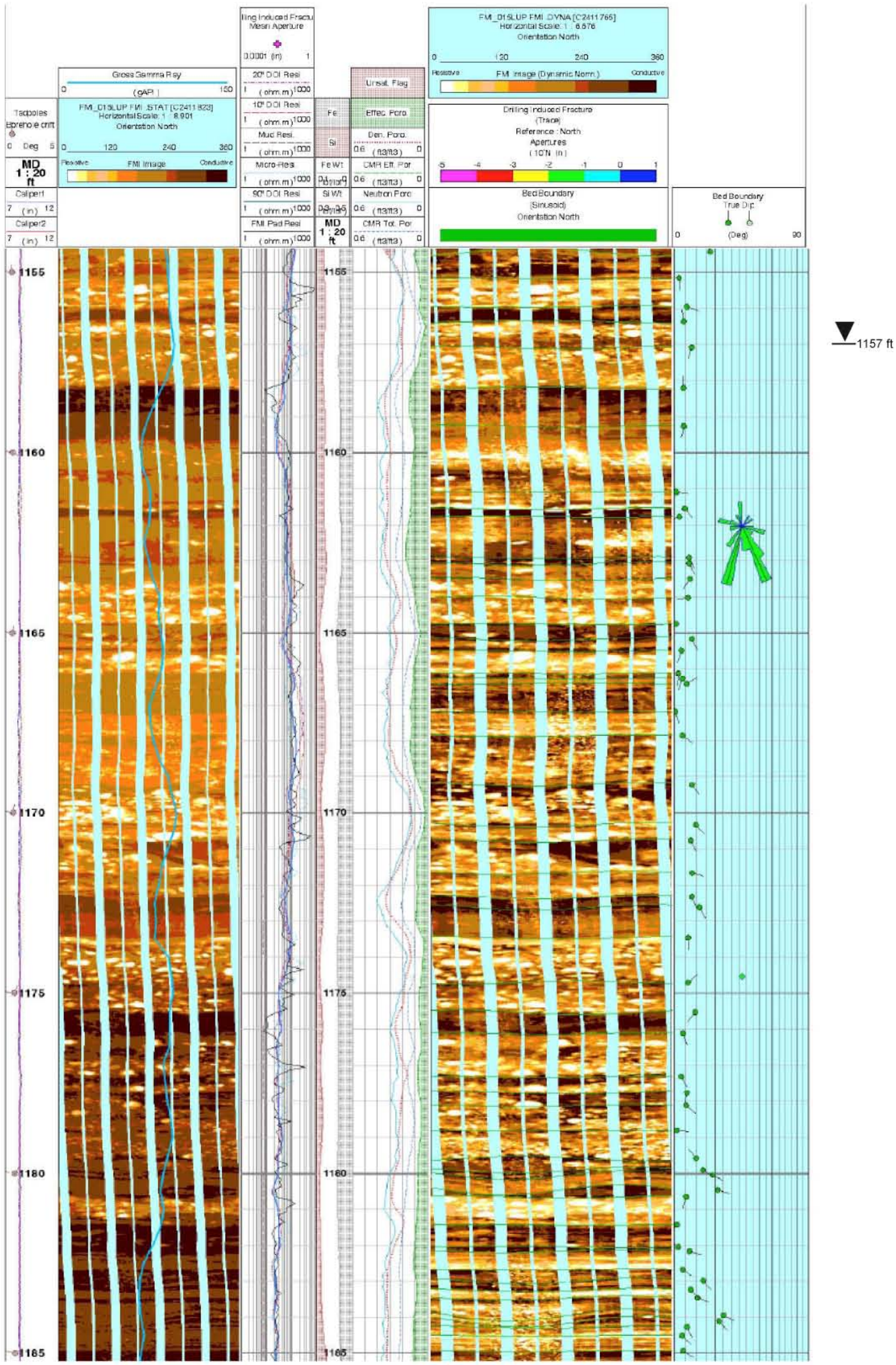


Figure 3 **FMI log for R-6**

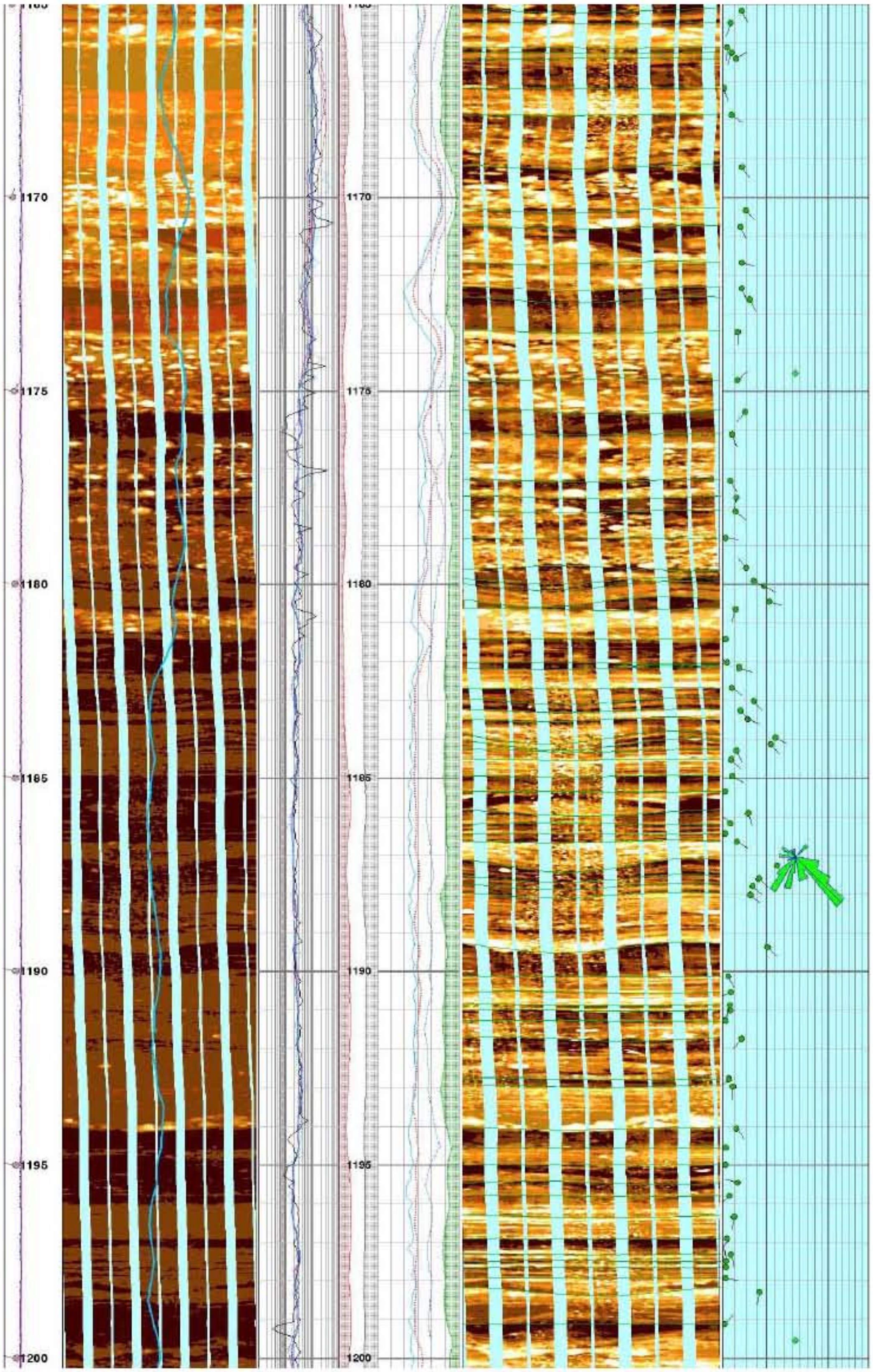


Figure 3 FMI log for R-6 (continued)

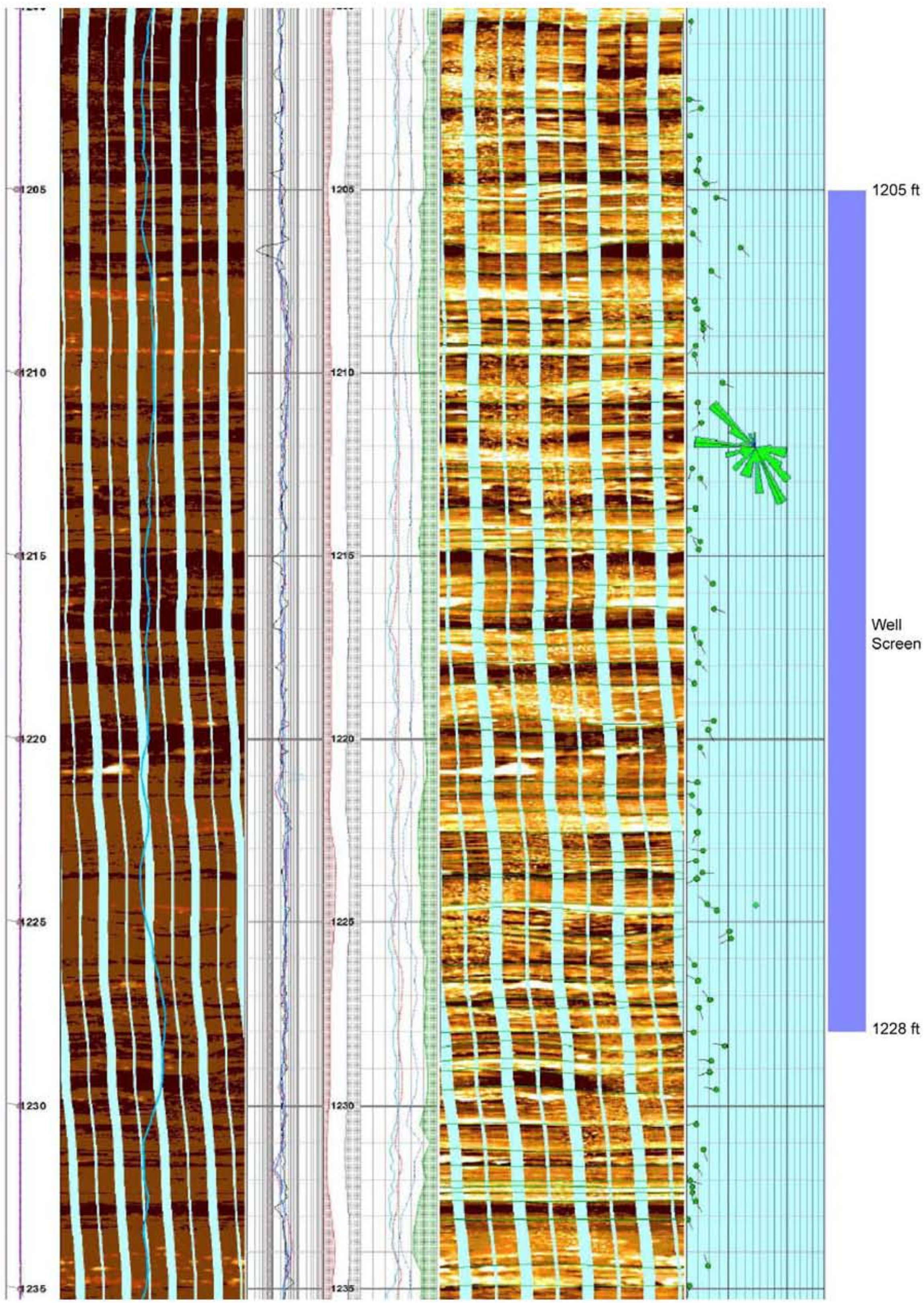


Figure 3 FMI log for R-6 (continued)

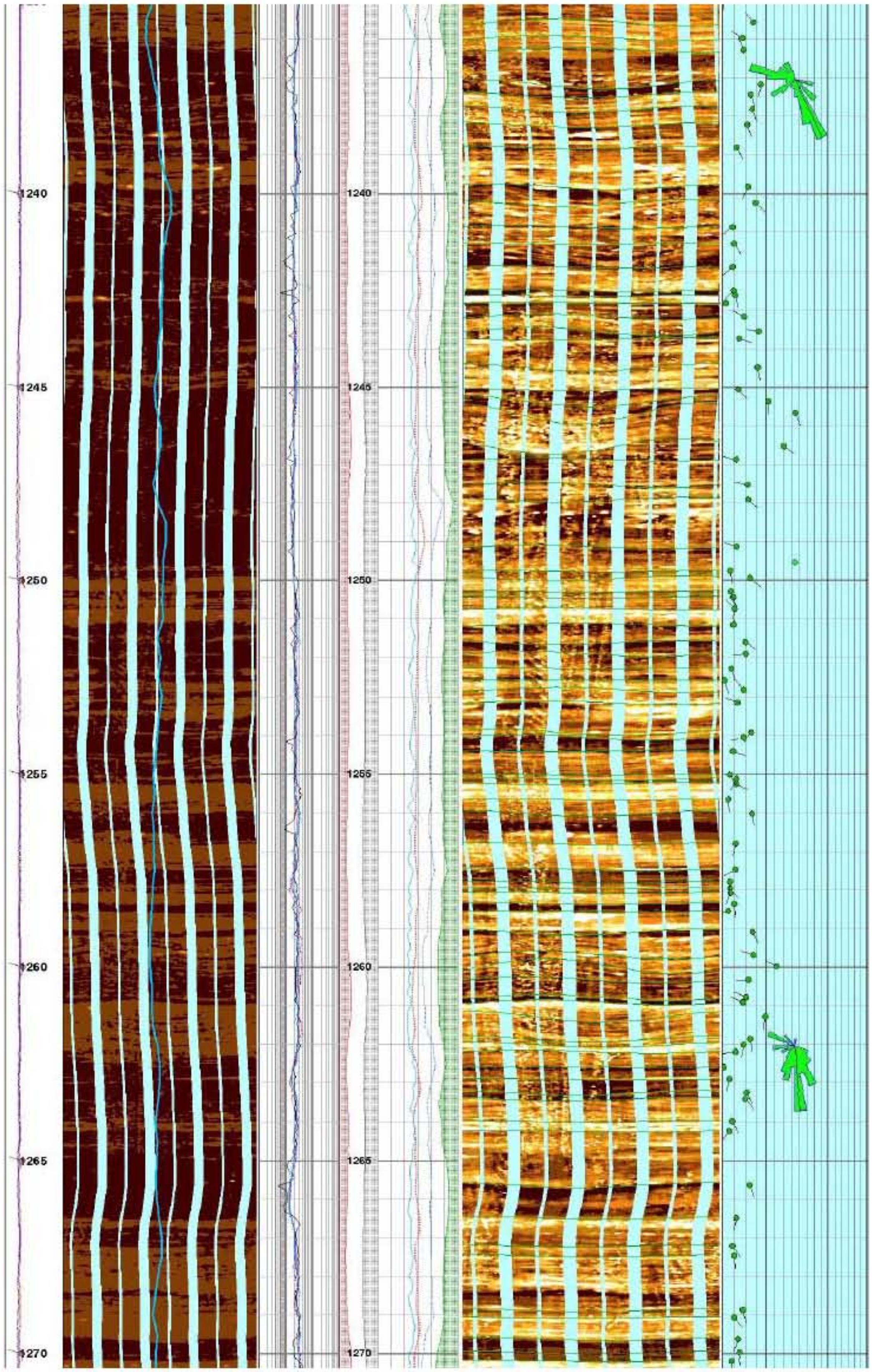


Figure 3 **FMI log for R-6 (continued)**

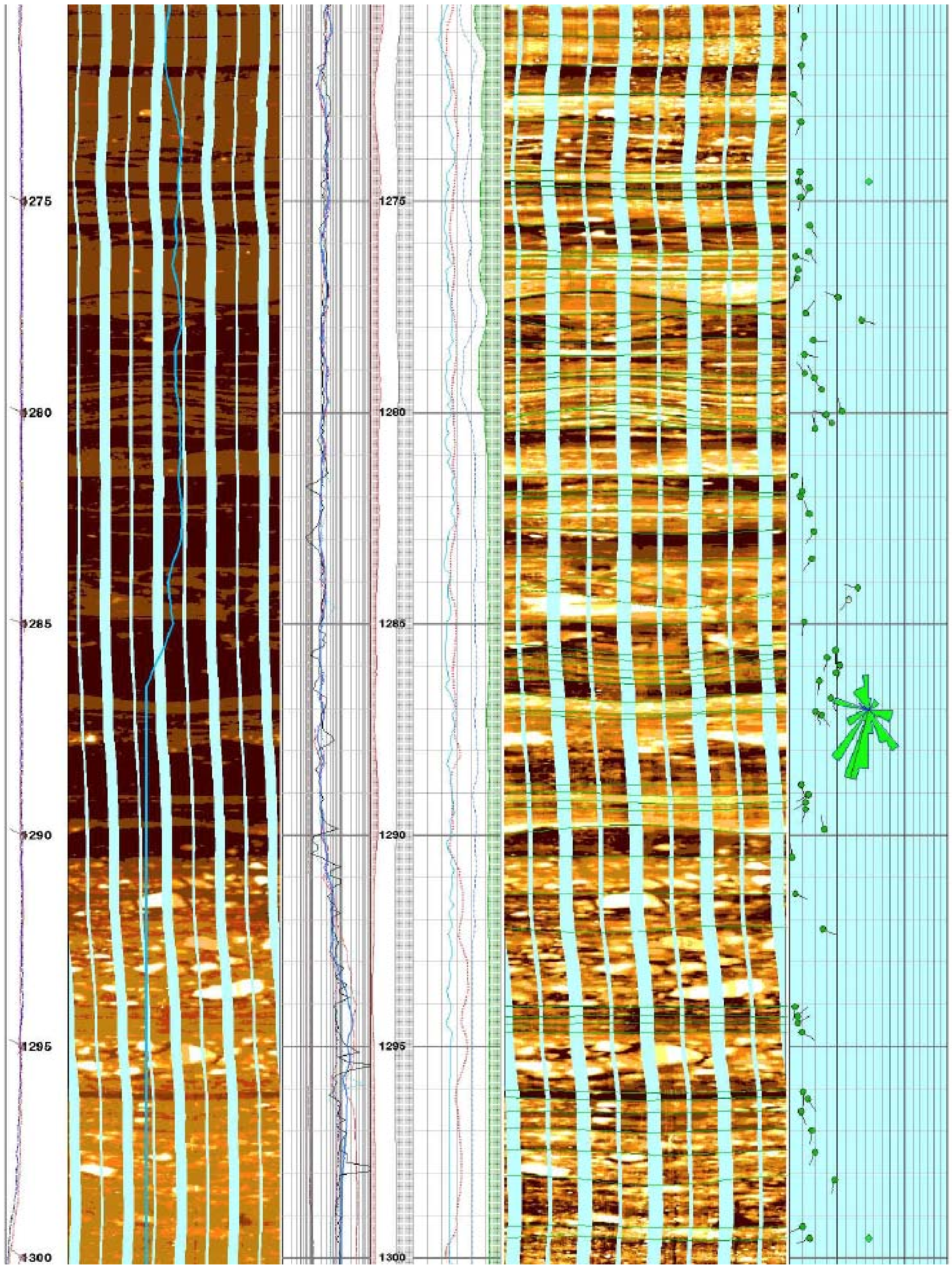


Figure 3 FMI log for R-6 (continued)

R-6i Well

R-6i Well

	Description	Evaluation
Drilling Method	R-6i was drilled using air-rotary and fluid-assisted air-rotary methods.	R-6i was drilled using conventional-circulation air-rotary and fluid-assisted air-rotary methods in open hole to 660-ft depth. Drilling additives included air and a mixture of municipal water mixed with QUIK-FOAM. Drilling additives can adversely affect the ability to collect representative water samples, and their use was minimized in the R-6i borehole.
General Well Characteristics	R-6i is a single-screen well constructed of 4.5-in.-I.D./5-in.-O.D. 304 stainless-steel casing.	The stainless-steel well materials are designed to prevent corrosion.
Well Screen Construction	The well screen is constructed of 4.46-in.-I.D./5.27-in.-O.D. 304 stainless-steel wire wrap with 0.020-in. slots.	The R-6i well screen construction (0.020-wire-wrapped screen) is considered an optimum design that balances the need to prevent fine-grained material from entering the well and the need to promote the free flow of water during well development and sampling.
Screen Length and Placement	The well screen extends from 602 to 612 ft and has a length of 10 ft. The top of the screen is 8.8 ft below the perched water table that is currently 593.2 ft below the ground surface (Allen and Koch 2007, 095268).	R-6i is designed to sample perched groundwater that was found while drilling regional well R-6, located about 20 ft to the northeast. The screen length and its placement were selected with the following goals in mind: • Monitor the water quality of perched intermediate groundwater near supply well Otowi-4 • Characterize water quality of perched intermediate groundwater in the vicinity of TA-21 • Monitor water levels to detect whether perched intermediate groundwater responds to seasonal infiltration beneath Los Alamos Canyon • Submerge the screen fully to facilitate well development Perched intermediate groundwater occurs in upper Puye Formation sedimentary deposits that are stratigraphically above Cerros del Rio basalt. The Puye Formation in this interval consists of dacitic gravels from 516- to 625-ft depth and silts and fine sands from 625 to 683 ft. A borehole video showed perched groundwater entering the R-6i borehole at about 604 ft, the same depth at which groundwater was seen entering the R-6 borehole. The interval between 615- and 625-ft depth appeared to be fairly tight and nonproductive, and an induction log showed a zone of markedly higher conductivity from 598 to 616 ft. The well screen targeted this zone of flowing water and elevated conductivity.
Filter Pack Materials and Placement	The primary filter pack is made up of 10/20 sand from 592 to 615 ft. A secondary filter packs of 20/40 sand was placed above the primary filter pack from 587 to 592 ft.	The primary filter pack extends 10 ft above and 3 ft below the well screen. The well screen and filter pack design are appropriate for sampling perched intermediate groundwater from this zone.

	Description	Evaluation
Sampling System	Submersible pump	Submersible pumps installed in single completion wells allow groundwater to be purged from the well casing, well-filter pack, and to some degree, near-well formation materials. Water can pumped at a rate of 10–12 gal./min, greatly facilitating effective purging and efficient sampling. Conventional purging and sampling allow water to be drawn from more deeply within formation materials surrounding the well screen in comparison to low-flow systems, and there is a greater likelihood of obtaining water from zones beyond potential near-well drilling effects. Storage and disposal of purged water require additional resources relative to low-flow sampling systems. Water levels can be measured manually or by dedicated pressure transducers.
Other Issues That Could Affect the Performance of the Well	None	N/a
Additives Used During Drilling		Municipal water (3530 gal. introduced during air-rotary drilling) QUIK-FOAM (56 gal.) Fluid volume recovered (3560 gal. during drilling and 5006 gal. during development and aquifer testing)
Annular Fill Other Than Filter and Transition Sands		Bentonite seal: bentonite chips (435.5 ft^3) Backfill: bentonite: 18.8 ft^3 Cement slurry for surface seal (81 ft^3) Potable water:1350 gal.

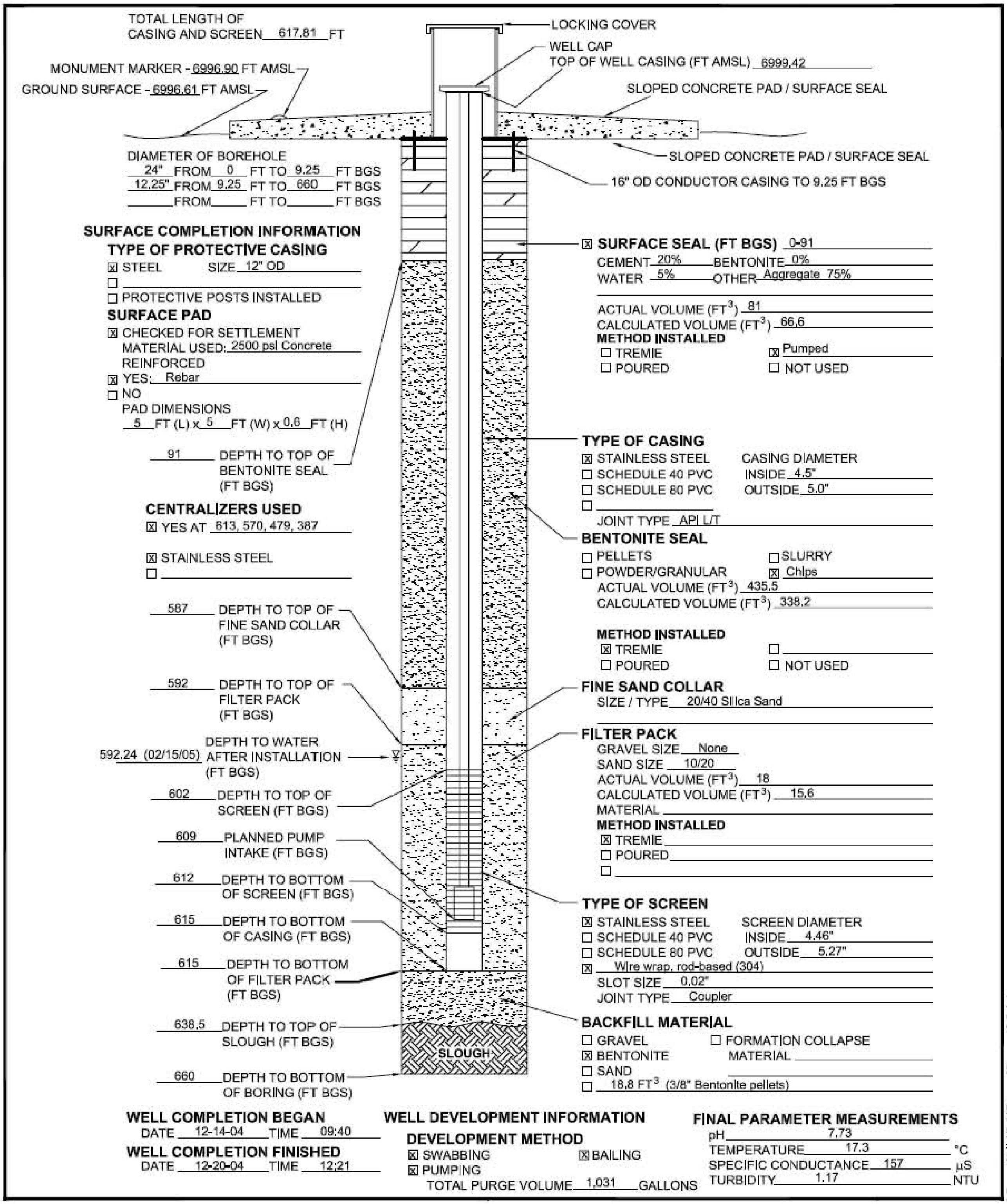


Figure 1 Well schematic for characterization well R-6i

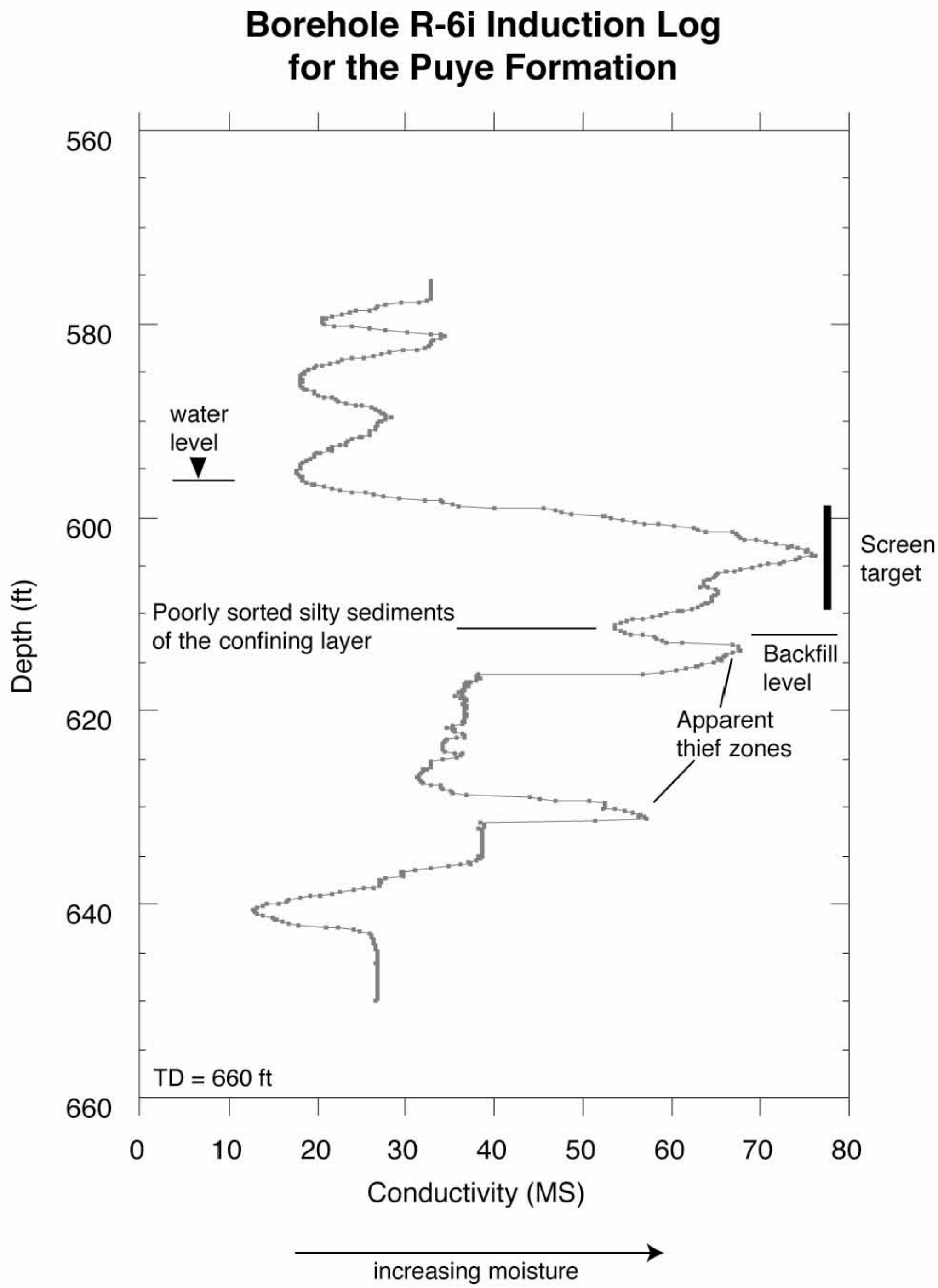


Figure 2 **R-6i borehole geophysical logs for the perched intermediate groundwater zone**

R-7 Well

R-7 Well

	Description	Evaluation
Drilling Method	R-7 was drilled using fluid-assisted air-rotary casing advance methods.	R-7 was drilled using a combination of reverse-circulation fluid-assisted air-rotary methods in open hole and with casing advance to 809 ft followed by reverse-circulation fluid-assisted air-rotary drilling in an open hole to TD at 880 ft. Circulation of cuttings was primarily accomplished using air and municipal water mixed with additives, including QUIK-FOAM and EZ-MUD. Drilling additives can adversely affect the ability to collect representative water samples.
General Well Characteristics	R-7 is a three-screen well constructed of 4.5-in.-I.D./5-in.-O.D. 304 stainless-steel casing.	The stainless-steel well materials are designed to prevent corrosion.
Well Screen Construction	The pipe-based screen is constructed of 4.5-in.-I.D./ 5.56-in.-O.D. 304 perforated stainless-steel casing wrapped with stainless-steel wire wrap with 0.010-in. slots.	Pipe-based screen provides structural stability to well screens that might be damaged during well installation or by shifting geologic materials after well installation. Pipe-based screen was used after two rod-based well screens were damaged during installation of well R-25. A drawback to pipe-based screens is that water surged into the filter pack and formation during development is less effective in those areas that are not adjacent to holes in the well casing. Also, the wire wrap on the R-7 well screen contains 0.010-in. slots. More recent wells contain 0.020-in. slots that facilitate the movement of water through the well screen when surging and pumping the well during development.
Screen Length and Placement	Screen 1 extends from 363.2 to 379.2 ft (length of 16 ft) and is submerged in perched water within the Puye Formation. Screen 2 extends from 730.4 to 746.4 ft (length of 16 ft); it targeted potential perched water at the contact between Puye Formation and Miocene pumiceous deposits but has been dry since installation.	The screen lengths and their placements were selected with the following goals in mind: • Characterize water quality in the uppermost part of regional groundwater approximately 3350 ft downgradient of TA-02 • Characterize water quality adjacent to TA-21, particularly in the vicinity of MDA B and MDA V • Monitor water-level responses in the upper part of the regional aquifer to pumping from nearby water supply wells • Characterize water quality of perched groundwater beneath Los Alamos Canyon • Monitor water levels to detect whether perched intermediate groundwater responds to seasonal infiltration beneath Los Alamos Canyon

	Description	Evaluation
Screen Length and Placement (continued)	Screen 3 extends from 895.5 to 937.4 ft (length of 41.9 ft), and it straddles the regional water table (currently 901 ft below the surface) within Miocene pumiceous sediments. The amount of submerged screen is 36.4 ft.	Screen 1 was placed in the uppermost interval of perched intermediate groundwater that was detected by borehole video near the top of the Puye Formation. The saturation occurred within fluvial sedimentary deposits between the depths of 362 and 382 ft bgs. The perching horizon is probably clay-rich sediments, extending from a depth of 382 to 397 ft. The top of the perched saturation was at a depth of 374 ft bgs at the time the well was installed, but over time the water level has declined to about 378 ft bgs, and currently the water level is about 1 ft above the bottom of the screen interval (Allen and Koch 2007, 095268). Screen 2 targeted a poorly defined zone of possible perched saturation above Miocene pumiceous sedimentary deposits. Borehole geophysics indicated relatively high moisture content above the regional water table, especially below 734 ft, where total and effective water-filled porosity averages about 20% and greater than 5%, respectively. Screen 2 has been dry since installation (Allen and Koch 2007, 095268). Screen 3 is designed to straddle the regional water table downgradient of TA-02 and adjacent to TA-21. The main goal for this screen was to determine if infiltration beneath Los Alamos Canyon results in contamination of regional groundwater. Thus, screen 3 was placed in the uppermost part of the regional groundwater system to detect the highest concentrations of contaminants before becoming diluted by mixing with uncontaminated groundwater. The screen is located within Miocene pumiceous sedimentary deposits that dip less than 10 degrees toward the west (dip azimuths vary between 230 and 310 degrees). The screen interval spans parts of two pumice-rich intervals that may include primary fall deposits. Total porosities within the screen interval range between 20% and 35%, and effective porosities range between 10% and 27%. The electrical resistivity image (FMI log) shows that these deposits consist of thinly laminated beds. The clay content of this interval is lower than deeper strata, and pumices from this interval are vitric, indicating bulk hydraulic properties are minimally affected by secondary alteration of volcanic glassy pyroclasts. However, the inability to pump water from screen 3 during development indicates that these deposits are poorly transmissive at this location. The placement of the three well screens at R-7 meets the characterization and monitoring goals for a well for this location.
Filter Pack Materials and Placement	The filter packs and their placements are discussed for the three well screens in the column to the right.	The primary filter pack for screen 1 is made up of 20/40 sand from 355.6 to 383.6 ft. A secondary filter pack of 30/70 sand was placed above the primary filter pack from 354.8 to 355.6 ft. The primary filter pack extends 7.6 ft above and 4.4 ft below the well screen. The combination of this filter pack with a 16-ft well screen allows groundwater to be drawn from throughout the perched groundwater interval where the distribution of water-producing beds is poorly known. The primary filter pack for screen 2 is made up of 20/40 sand from 725 to 754 ft. A secondary filter pack of 30/70 sand was placed above and below the primary filter pack from 722.8 to 725 ft and 754 to 756 ft, respectively. The primary filter pack extends 5.4 ft above and 7.6 ft below the well screen. Screen 2 has been dry since installation.

	Description	Evaluation
		The primary filter pack for screen 3 is made up of 20/40 sand from 880 to 946.8 ft. A secondary filter pack of 30/70 sand was placed above and below the primary filter pack from 879 to 880 ft and 946.8 to 949.8 ft, respectively. The primary filter pack extends 15.5 ft above and 9.4 ft below the well screen. This upper part of the filter pack length is above the water table and does not affect well performance. The lower part of the filter pack extends slightly farther below the well screen than current well designs (about 5 ft below the well screen). However, because the Miocene sedimentary deposits at this location are poorly transmissive, a slightly long filter pack allows groundwater to be drawn from a larger volume in rocks where the amount and location of water production are uncertain.
Sampling System	Westbay MP sampling system	Westbay is a low-flow sampling system that allows groundwater sampling of multiple well screens within a single well installation. Well screens are isolated by packers and sampled individually. Westbay is the only sampling system capable of sampling three or more screens in a multiscreen well. It is particularly effective for monitoring water levels at multiple depths within a well. Flow-through cells for measuring field parameters cannot be used at multiscreen wells containing the Westbay sampling system. Effective development and removal of residual drilling fluids are critical before installation of Westbay wells because groundwater is collected in proximity to the well due to low-flow sampling and the inability to purge the well before sampling. Samples collected from Westbay wells are particularly prone to water-quality problems that develop if residual drilling fluids are hydraulically connected to the screen interval. Screen 3 in particular is in poorly transmissive sedimentary deposits and is therefore poorly developed, a likely cause of the sulfate-reducing conditions that persist at this screen (Appendix B; LANL 2007, 096330).
Other Issues That Could Affect the Performance of the Well	Development was inhibited by poor water production from the three well screens.	The development strategy for R-7 called for two phases and three steps for each screened interval. The preliminary phase was to include wire-brushing followed by bailing. The final phase was to involve pumping until values for field parameters met goals or could not be improved. Development of screens 1 and 2 was not possible because of insufficient water production from these zones. Screen 3 was wire-brushed and bailed. However, it soon became apparent that productivity was also low in screen 3. It was not possible to develop screen 3 by pumping. Water rarely reached the surface, and the pump tripped off repeatedly because the pumping rate exceeded the production rate. As a result, R-7 was developed as much as possible by bailing. Field parameters were checked at the outset of bailing and checked periodically thereafter. The initial turbidity value was 237 NTUs. The withdrawal of 3000 gal. of water over a 1.5-d period improved this value to 21 NTUs. Development was terminated when turbidity values remain stable at 21 NTUs during approximately 10 h of bailing. However, this development appears to have been inadequate for removal of all residual drilling products from the well, based upon the persistent sulfate-reducing conditions in Screen 3 (LANL 2007, 096330).

	Description	Evaluation
Additives Used		Municipal water QUIK-FOAM EZ-MUD
Annular Fill Other Than Filter and Transition Sands		Benseal: high-solids multipurpose bentonite grout (2 bags) Holeplug: 0.375-in. angular and unrefined bentonite chips (391.5 bags) Pelplug bentonite: 0.25-in. by 0.375-in. refined elliptical pellets (166.5 buckets) Portland cement mixed with municipal water at a ratio of 5 gal. per bag (82 bags) Yard Art gravel was used to fill wash-out zones (250.5 bags).

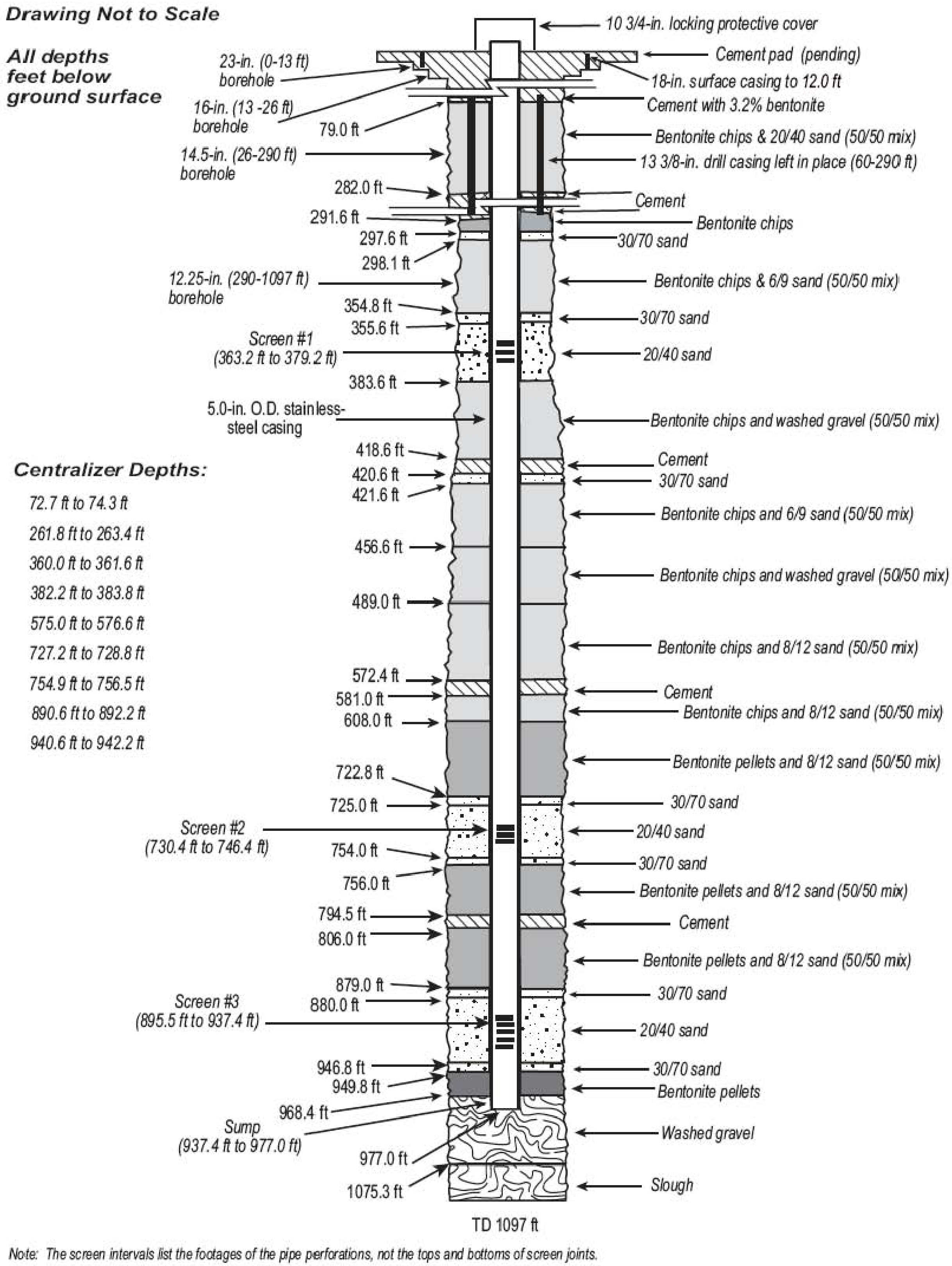


Figure 1 As-built well completion diagram for well R-7

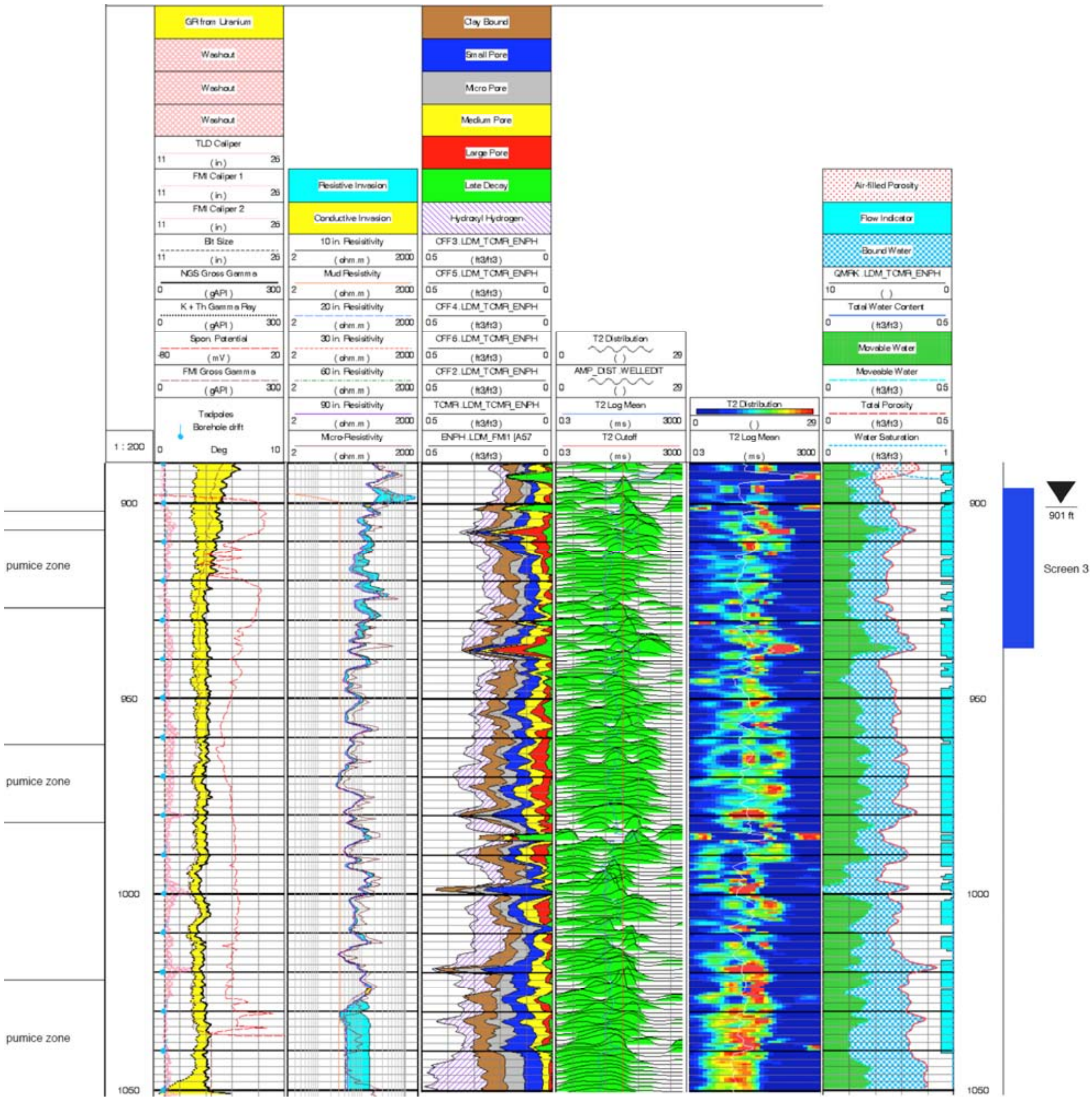


Figure 2 **Summary of R-7 borehole geophysical logs for the regional aquifer**

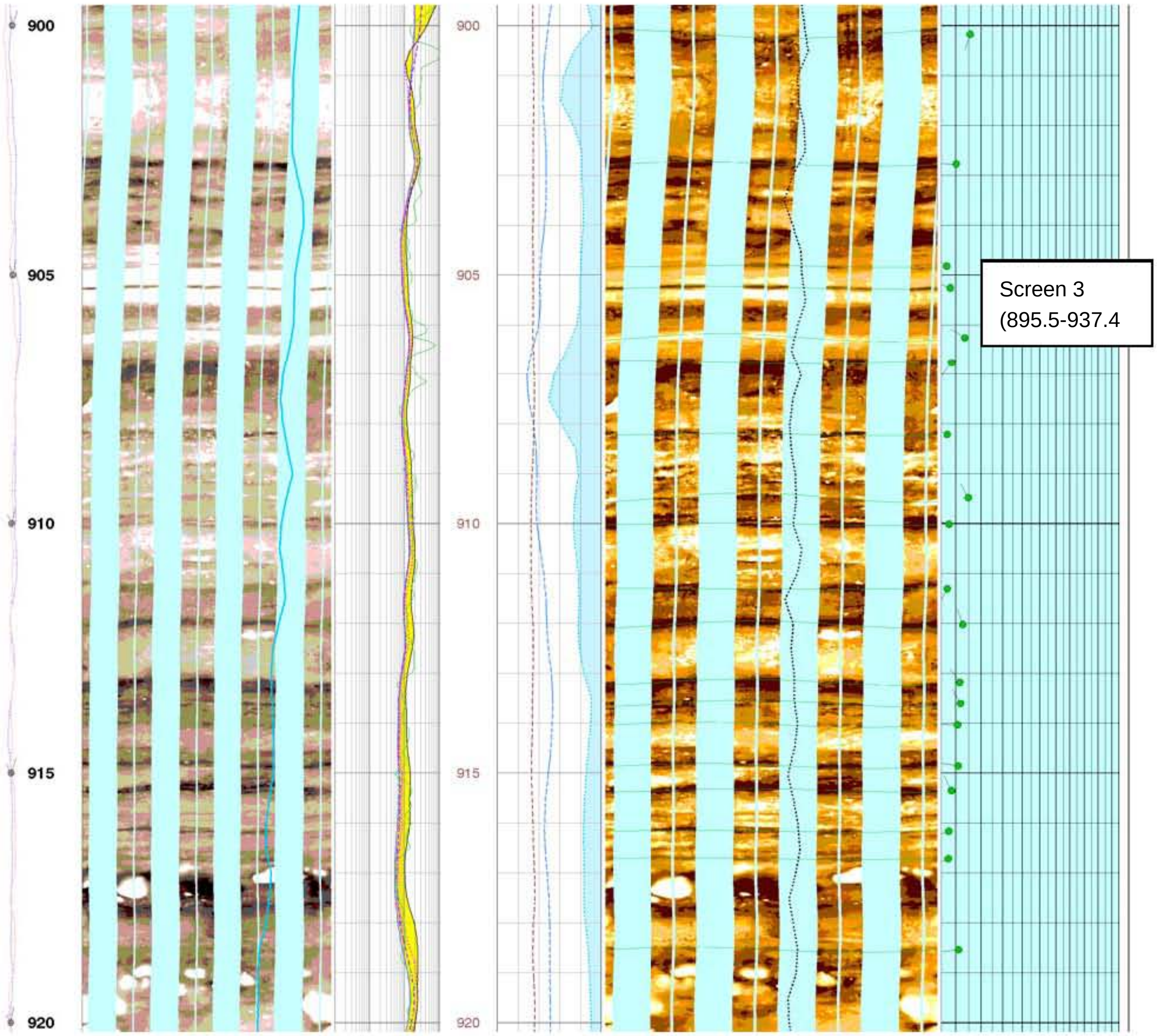


Figure 3 **FMI log for R-7**

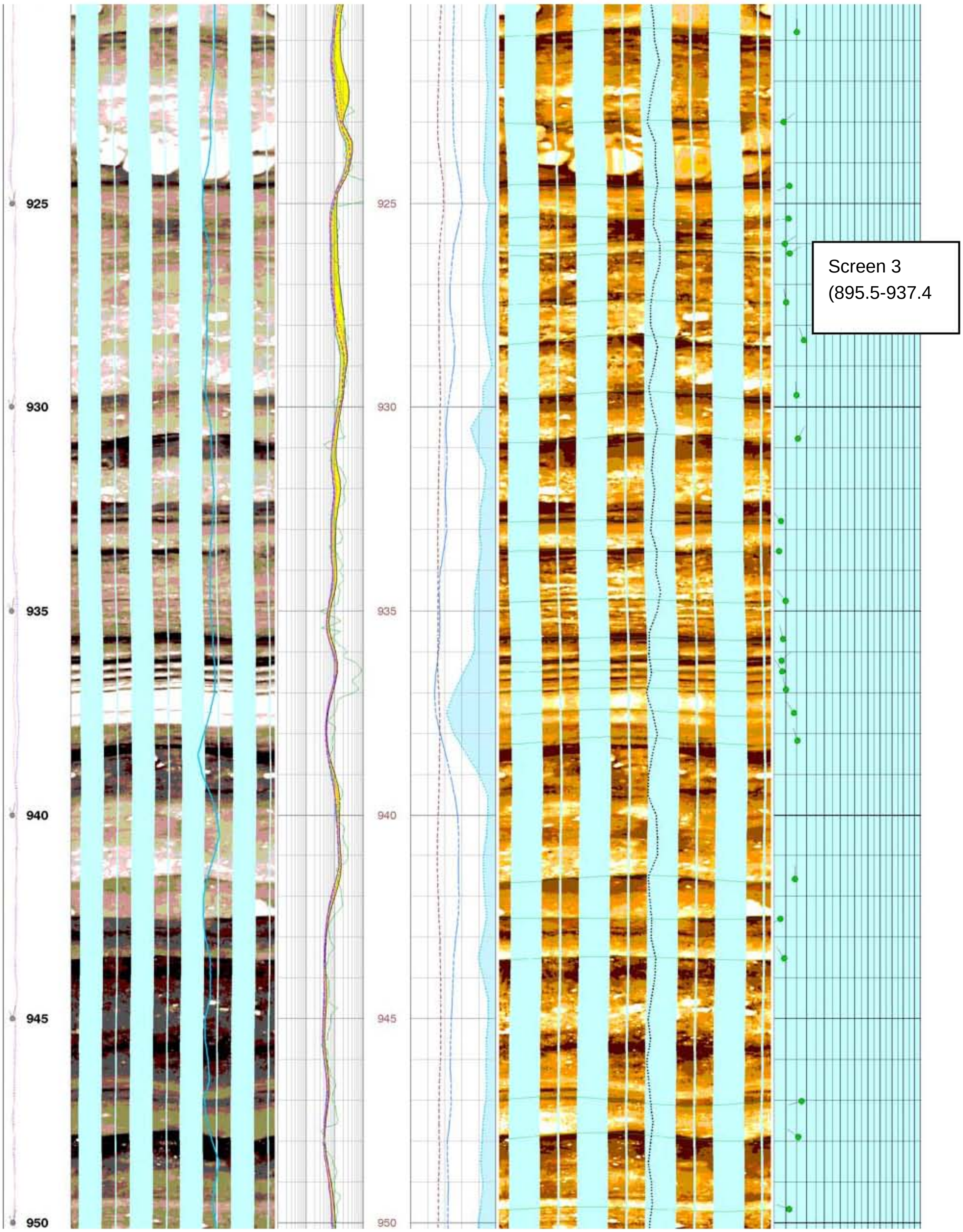


Figure 3 FMI log for R-7 (continued)

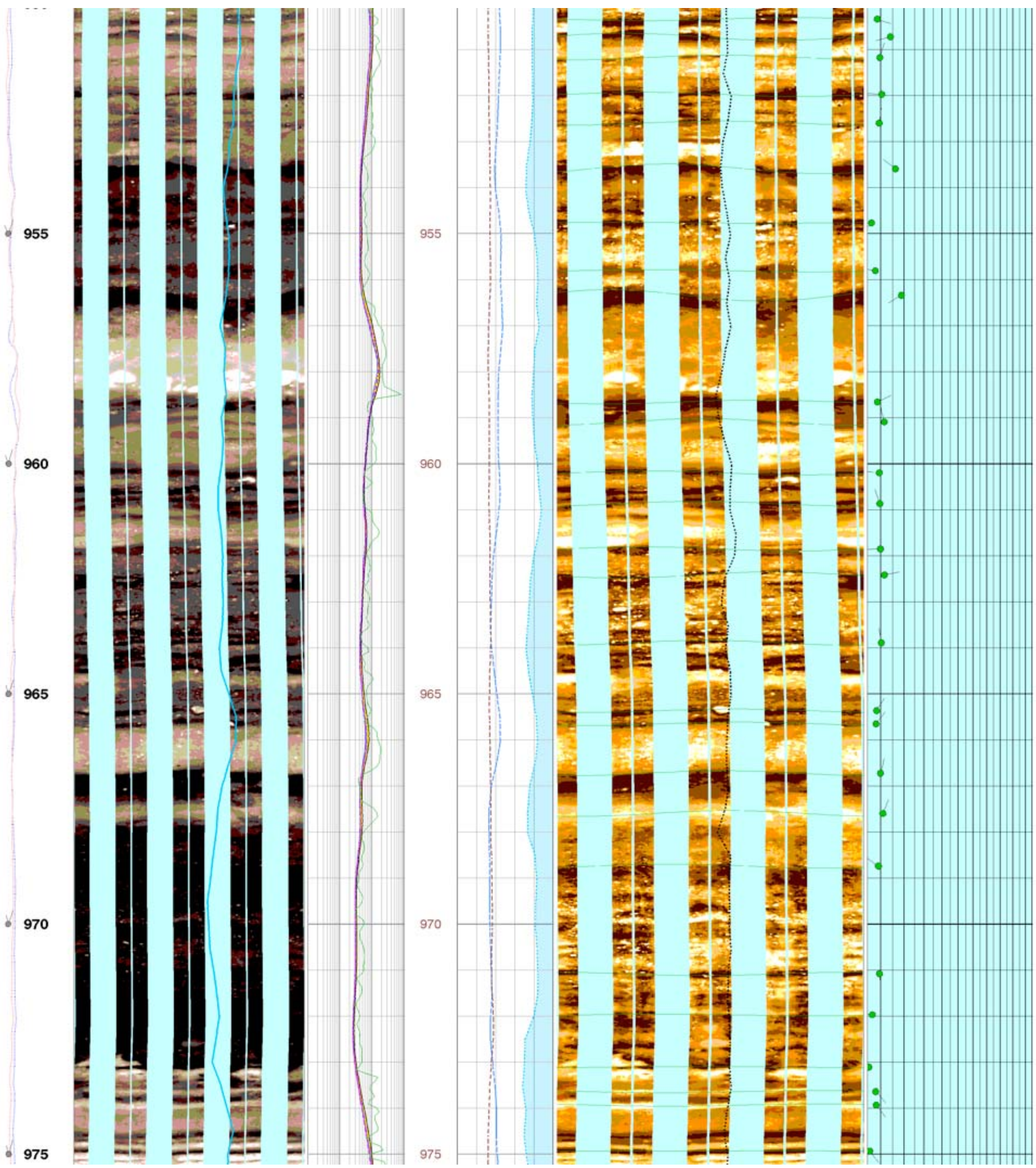


Figure 3 FMI log for R-7 (continued)

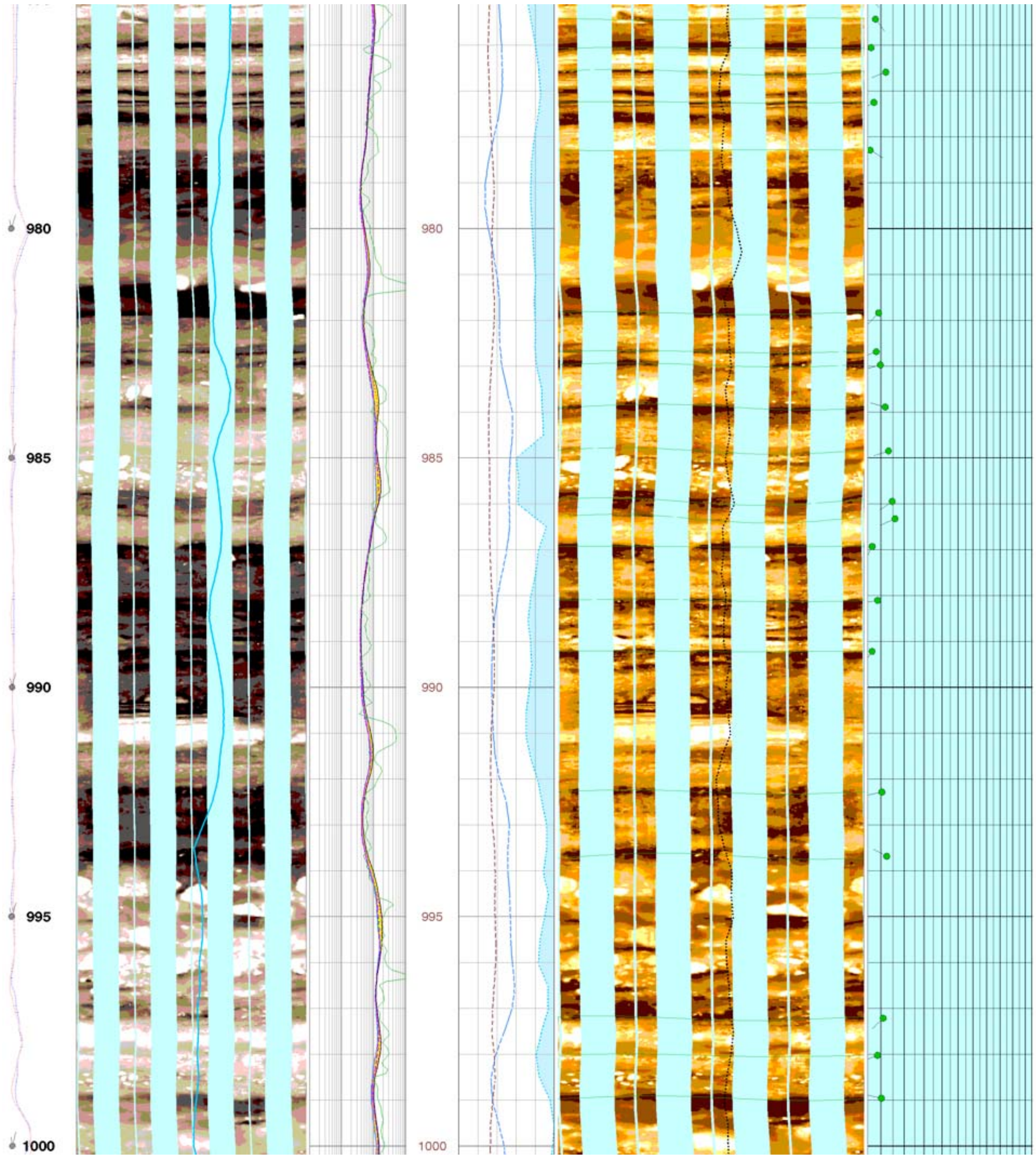


Figure 3 FMI log for R-7 (continued)

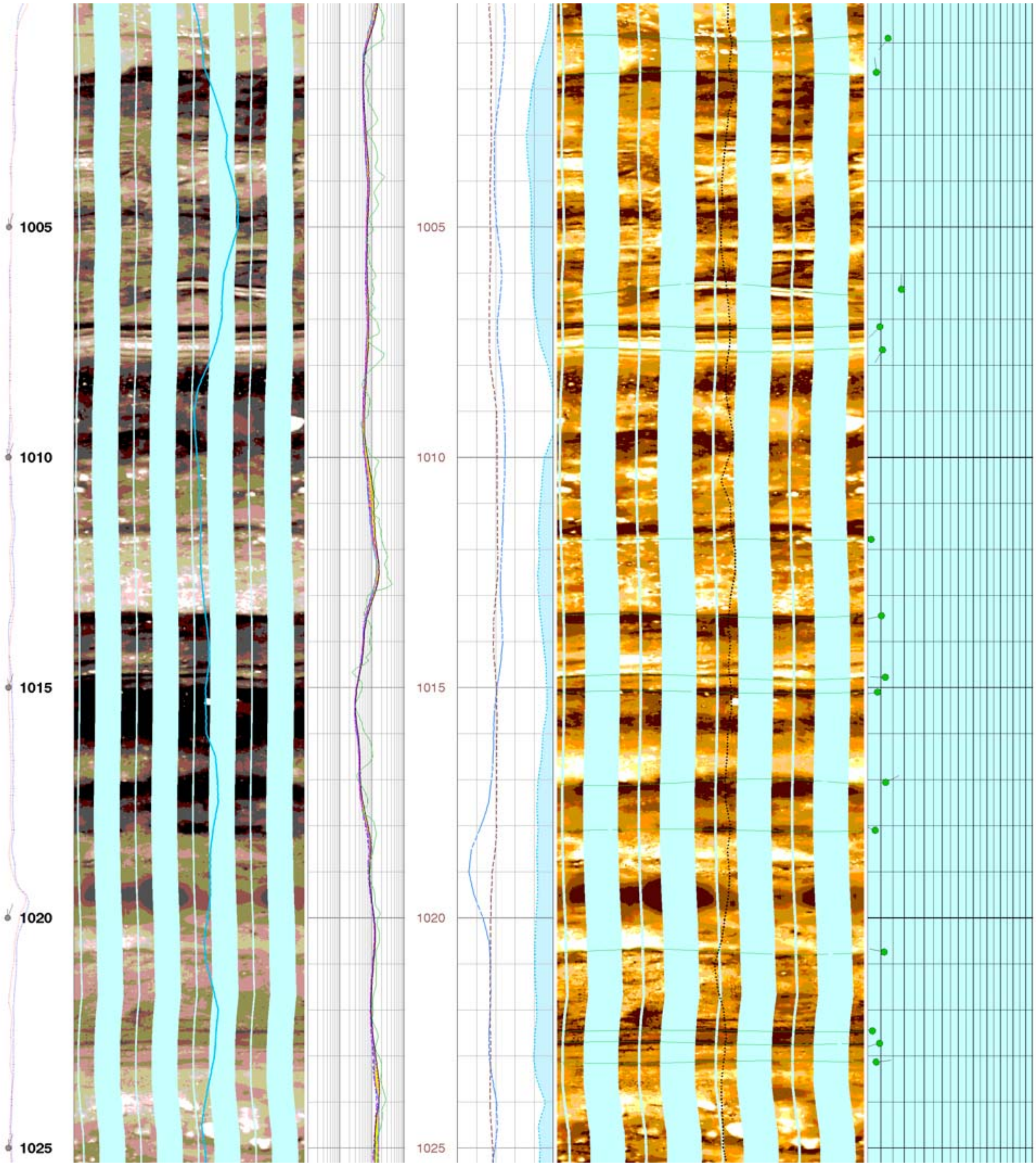


Figure 3 FMI log for R-7 (continued)

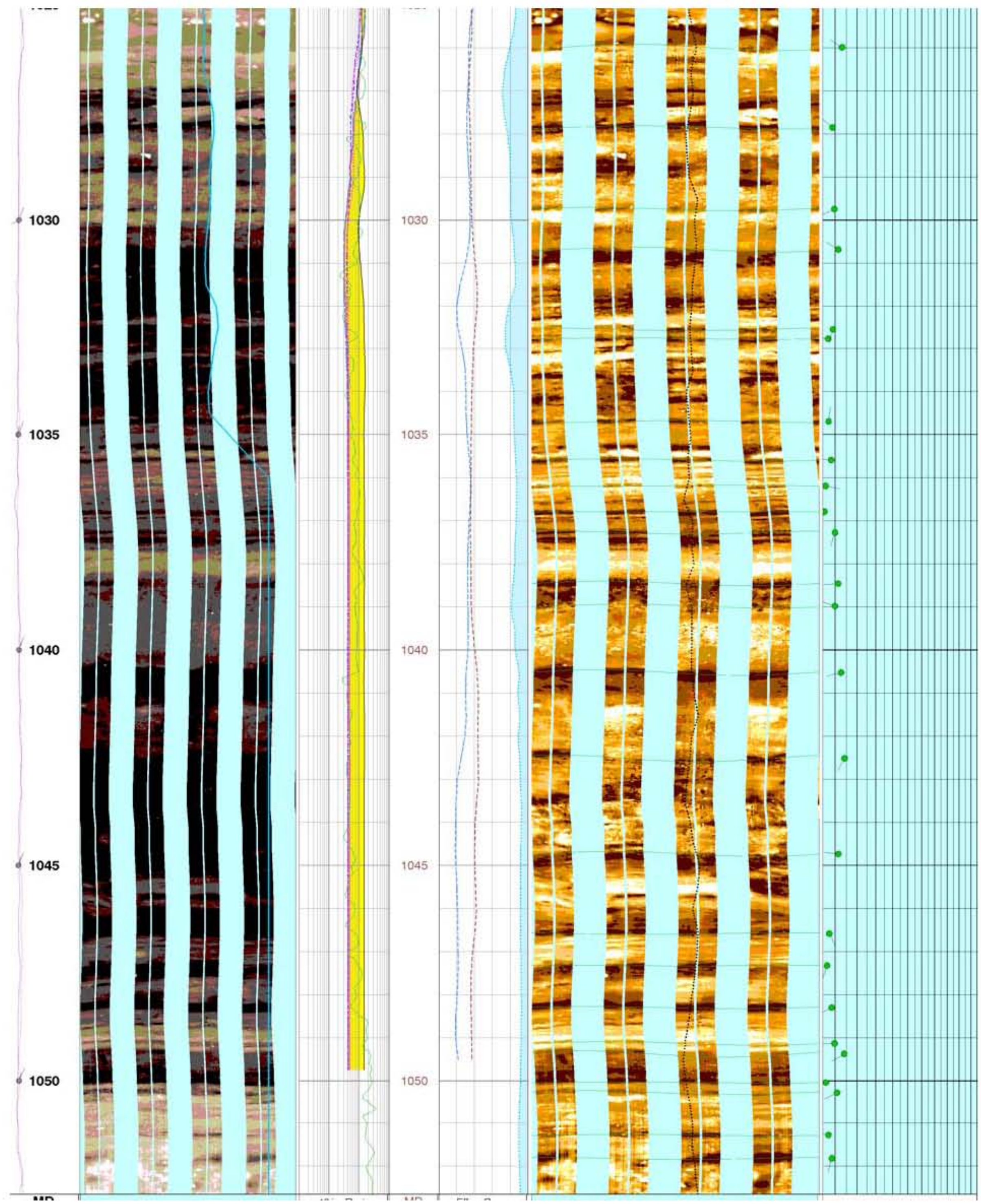


Figure 3 FMI log for R-7 (continued)

R-8 Well

R-8 Well

	Description	Evaluation
Drilling Method	R-8 was drilled using a combination of reverse-circulation fluid-assisted air-rotary methods in open hole and with casing advance to 809 ft followed by reverse-circulation fluid-assisted air-rotary drilling in an open hole to TD at 880 ft.	The first borehole (BH1) was cored to a depth of 261 ft and drilled to a depth of 1022 ft using air-rotary drilling methods. BH1 was plugged and abandoned after efforts to retrieve drilling equipment that became lodged in the borehole were unsuccessful. The installation of well R-8 was completed on February 14, 2002, in the second borehole (BH2) that was drilled to a depth of 880 ft. BH2 was drilled using reverse-circulation fluid-assisted air-rotary methods. Casing advance was used to stabilize the borehole to a depth of 809 ft, and an open hole was drilled from 809 to 880 ft. Drilling additives included air and municipal water mixed with QUIK-FOAM, EZ-MUD, and TORKease. Drilling additives can adversely affect the ability to collect representative water samples if not removed from the immediate vicinity of the well screen during well development or during purging before sample collection.
General Well Characteristics	R-8 is a two-screen well constructed of 4.5-in.-I.D./5-in.-O.D. 304 stainless-steel casing.	The stainless-steel well materials are designed to prevent corrosion.
Well Screen Construction	The pipe-based screen is constructed of 4.5-in.-I.D./ 5.56-in.-O.D. 304 perforated stainless-steel casing wrapped with stainless-steel wire wrap with 0.010-in. slots.	Pipe-based screen provides structural stability to well screens that might be damaged during well installation or by shifting geologic materials after well installation. Pipe-based screen was introduced after two well screens were damaged during installation of R-25 well. A drawback to pipe-based screens is that water surged into the filter pack and formation during development is less effective in those areas that are not adjacent to holes in the well casing. Also, the wire wrap on the R-8 well screen contains 0.010-in. slots. More recent wells contain 0.020-in. slots that facilitate the movement of water through the well screen when surging and pumping the well during development. The ability of 0.010-in. slot wire-wrapped pipe-based screen to develop properly must be judged on the quality of groundwater data collected from the wells. Evaluations of water-quality data from screens 1 and 2 at R-8 do not reveal any residual effects of drilling products (Appendix B).
Screen Length and Placement	Well screen 1 extends from 705.3 to 755.7 ft and has a length of 50.4 ft. The top of the screen is 15.3 ft below the water level that is currently 690 ft below the surface (Allen and Koch 2007, 095268).	

	Description	Evaluation
Screen Length and Placement	Well screen 2 extends from 821.3 to 828 ft and has a length of 6.7 ft. Depth to water in screen 2 is currently 709.7 ft (Allen and Koch 2007, 095268).	R-8 is designed to replace TW-3, and its screen length and placement were selected with the following goals in mind: • Characterize water quality in the uppermost part of regional groundwater downgradient of contaminant sources in Los Alamos Canyon, particularly TA-02 and -21 • Place screen 1 (705.3 to 755.7 ft) at the water table that was measured at 709-ft depth in the open borehole before well construction. The purpose of this screen is to detect maximum contaminant concentrations due to infiltration beneath Los Alamos Canyon. • Place screen 2 somewhat deeper in the aquifer (821.3 to 828 ft) to target the uppermost productive zone in the regional aquifer where the strata were expected to be more transmissive than those at the water table • Determine vertical hydraulic gradients in the regional groundwater system • Monitor water-level responses in the upper part of the regional aquifer to pumping from nearby water-supply wells Both well screens are sited in sedimentary deposits that are probably Miocene. In the vicinity of the regional water table, the interval from 622 to 787 ft bgs contains clay-rich volcaniclastic sands and gravels with clasts of porphyritic dacite, silicified dacite, and flow-banded rhyolite. These deposits also contain a component of Precambrian quartzite and metamorphosed granitic rocks, ranging from 5% to 15% by volume. The clay-rich nature of these strata, particularly between 680 and 750 ft, caused numerous drilling problems in both BH1 and BH2, including stuck drill casings and a twisted-off drill bit. Swelling clays plugged the open borehole at BH1, allowing collection of only limited borehole geophysical logs (0 to 761 ft in a cased hole and 761 to 764 ft in an open hole). Because the geophysical logs could not be collected at 764 ft, information for siting well screen 2 was limited to lithologic description of drill cuttings, water-level measurements, and driller's observations. R-8 was originally intended to be a single screen well targeting the top of the regional water table. However, the clay-rich nature of the strata straddling the water table caused the original well design to be modified to include a second well screen placed deeper in the aquifer in more transmissive rocks beneath clay-rich zones. Because of the clay-rich nature of the rocks near the water table, screen 1 was designed with a relatively long screen (50.4 ft) to allow groundwater from thin productive intervals to enter the well. Well screen 2 (821.3 to 828 ft) was sited within a lithologic interval from 762 to 842 ft bgs that is made up of fine sand to gravel layers with mixed varieties of volcanic clasts (dacite to basalt) and generally contains only a trace of quartzite clasts. The well screen is relatively short (6.7 ft), compared with other characterization wells, resulting in sampling of a more discrete zone within the regional aquifer.

	Description	Evaluation
Filter Pack Materials and Placement	The primary filter pack for screen 1 consists of 20/40 sand from 745.3 to 758.0 ft and slough from 694.3 to 745.3 ft. A secondary filter pack of 30/70 sand was placed above the primary filter pack from 687.4 to 694.3 ft. The primary filter pack for screen 2 consists of 20/40 sand from 812.3 to 832.4 ft. Secondary filter packs of 30/70 sand were placed above and below the primary filter pack from 810.2 to 812.3 ft and 832.4 to 838 ft, respectively.	The primary filter pack for screen 1 covers only the lower 10.4 ft of the well screen. During well construction, the borehole wall sloughed into the annulus next to the well screen as the drill casing was retracted from the borehole. The slough next to screen 1 is likely to contain clay-rich sands and gravels similar to those found in the cuttings for this interval. As a result, water drawn into the well during development, hydraulic testing, and groundwater sampling may come largely from the lower part of the well screen. The primary filter pack for screen 2 extends 9 ft above and 4.4 ft below the well screen. The length of filter pack above the well screen is slightly longer than current well designs of 5 ft. The longer filter pack is probably advantageous in this case because it allows groundwater from a slightly longer vertical profile to be drawn into a relatively short well screen, increasing the chance of capturing potential contaminant flow pathways within heterogeneous aquifer materials.
Sampling System	Westbay MP sampling system	Westbay is a low-flow sampling system that allows groundwater sampling of multiple well screens within a single well installation. Well screens are isolated by packers and sampled individually. Westbay is the only sampling system capable of sampling three or more screens in a multiscreen well. It is particularly effective for monitoring water levels at multiple depths within a well. Flow-through cells for measuring field parameters cannot be used at multiscreen wells containing the Westbay sampling system. Effective development and removal of residual drilling fluids are critical before installation of Westbay wells because groundwater is collected in proximity to the well due to low-flow sampling and the inability to purge the well before sampling. Samples collected from Westbay wells are particularly prone to water-quality problems that develop if residual drilling fluids are hydraulically connected to the screen interval.
Other Issues That Could Affect the Performance of the Well	Isolation of well screens	The well design specified that the annulus between the borehole wall and well casing be filled with bentonite to isolate the two well screens. However, unstable borehole conditions resulted in slough filling the annulus next to the well casing in the interval 758 to 796.8 ft during well construction as the drill casing was retracted. Fortunately, the field team was able to place 13.4 ft of bentonite in the interval 796.8 to 810.2 ft above the screen 2 secondary filter pack before slough filled the annulus. This amount of bentonite is apparently successful in isolating screens 1 and 2 because the water levels in these two screens differ by about 20 ft. Additionally, screen 2 shows a clear response to pumping of nearby municipal supply wells, and screen 1 shows little or no response.

	Description	Evaluation
Additives Used During Drilling		QUIK-FOAM EZ-MUD TORKease Fluid volume recovered (12,740 gal. during well development and hydrologic testing)
Annular Fill Other Than Filter and Transition Sands		Holeplug: 0.375-in. angular and unrefined bentonite chips to provide borehole annular seal (24,800 lb) Pelplug: 0.25 in. by 0.375 in. refined elliptical bentonite pellets to provide a borehole annular seal below the water table (23,000 lb) Cement for annular support and surface seal (6580 lb) Benseal: high solids, multipurpose bentonite grout (100 lb) Potable water: 5720 gal.

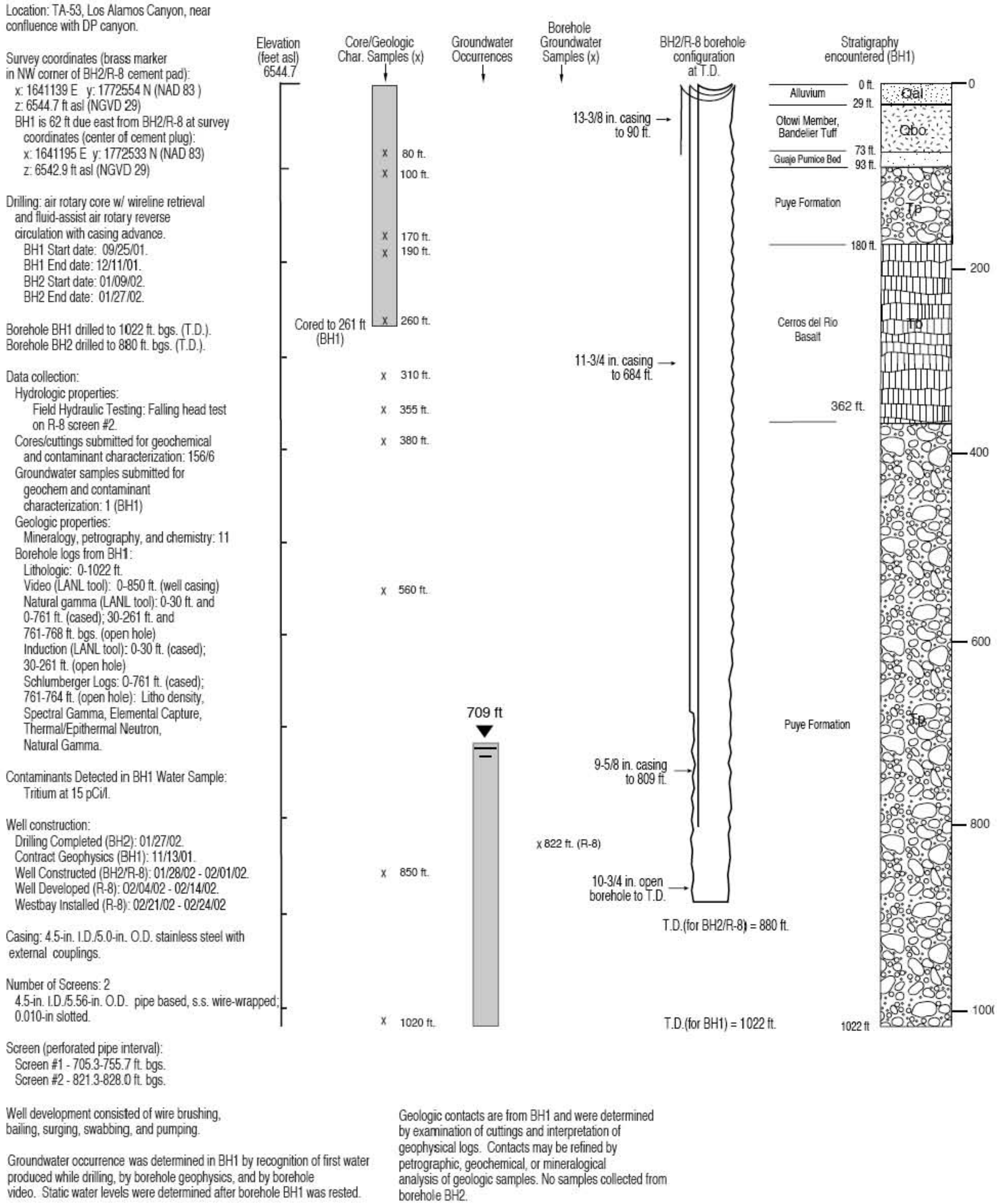
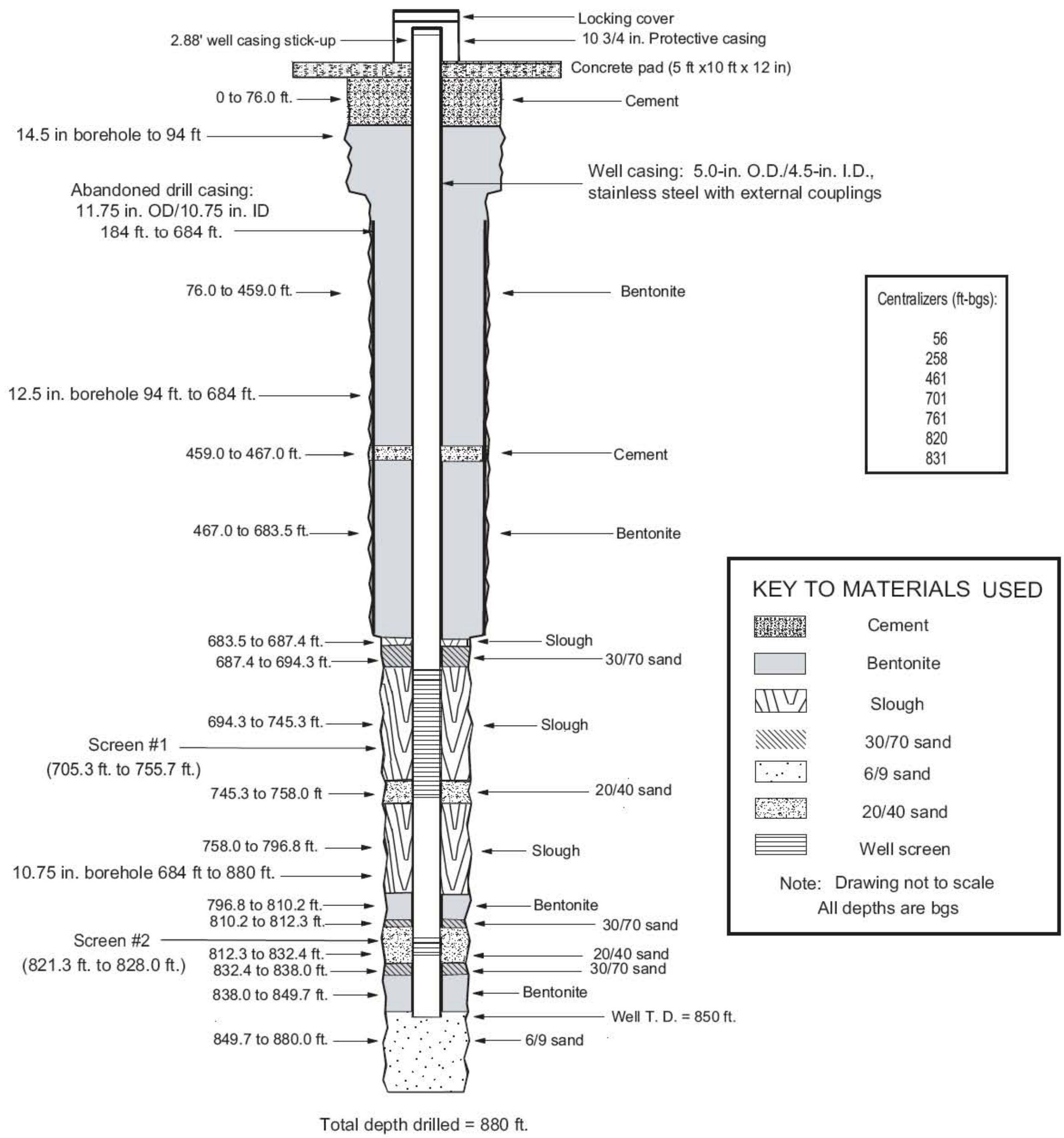


Figure 1 Well summary data for characterization well R-8



Notes: 1. The screen intervals list the footages of the pipe perforations, not the top and bottom of screen joints.
2. The formation slough around screen #1 consists of volcaniclastic sands and gravels.
3. Pipe-based screen: 5.56-in. O.D./ 4.5-in. I.D., 304 stainless steel with s.s. wire wrap; 0.010-in slots.

Figure 2 As-built configuration diagram of characterization well R-8 in BH2

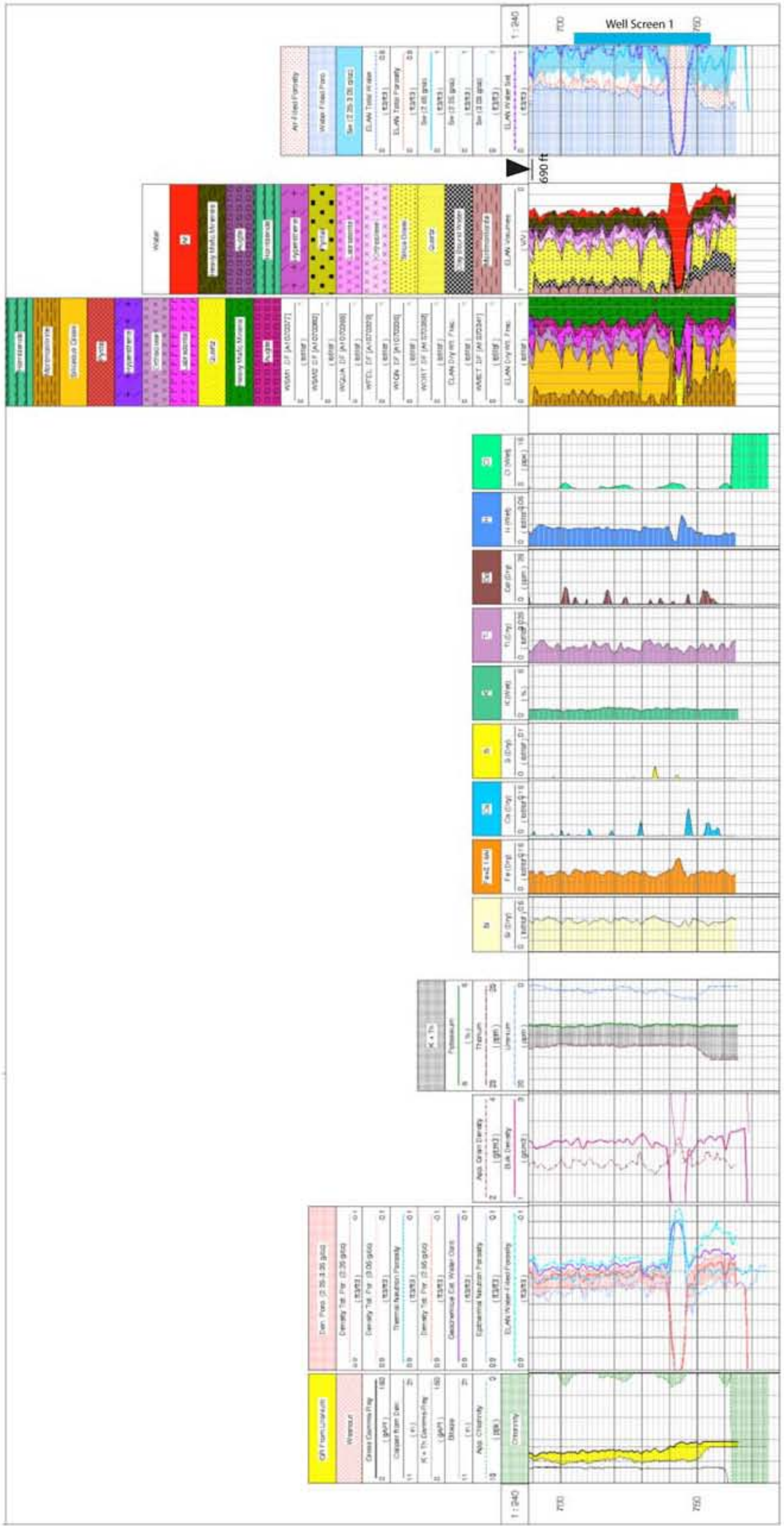


Figure 3 Geophysical logs for the top of regional saturation for well R-8

R-9 Well

R-9 Well

	Description	Evaluation
Drilling Method	R-9 was drilled using a combination of reverse-circulation air-rotary methods in open hole and with casing advance to 710 ft. followed by reverse-circulation fluid-assisted air-rotary drilling in an open hole to TD at 771 ft.	R-9 was initially drilled to 710-ft depth using combination of open-hole and casing-advance reverse-circulation air-rotary drilling methods with intervals of intermittent core collection. The casing-advance system was used to stabilize the borehole wall and to seal off as many as three discrete zones of perched groundwater that were encountered during drilling. A temporary PVC well was installed at a depth of 710 ft on February 3, 1998, because depth to the regional aquifer in R-9 could not be identified with certainty. Several discrete zones of saturation had been encountered in the lower part of the borehole, and it was unclear which, if any, of these zones represented regional groundwater. Work on R-9 was halted until R-12, located 1 km to the south, could be drilled and depth to the regional water table could be better constrained. Data collected from drilling activities at R-12 helped clarify groundwater conditions at R-9, and the final phase of drilling and installation of a permanent well at R-9 took place from September 22, 1999, to October 18, 1999. After removal of the temporary PVC well, the borehole was deepened by reverse-circulation fluid-assisted air-rotary drilling in an open hole from 710 to 771 ft. R-9 was deepened to find more productive zones within the Miocene basalt aquifer and to accommodate the desired length of well screen and sump. The R-9 borehole was drilled using air as the circulation fluid from the surface to 710 ft. Bentonite, mixed with municipal water, was introduced into the borehole in small amounts to create seals at the bottoms of drill casing strings landed at depths of 243.8 ft, 289 ft, and 679 ft; these drill casings were sealed with bentonite to prevent perched groundwater from entering the borehole as it advanced toward the regional aquifer. Drilling additives, including air and municipal water mixed with QUIK-FOAM and EZ-MUD, were used to deepen the borehole from 710 to 771 ft after the temporary PVC well was removed. These drilling additives can adversely affect the ability to collect representative water samples if not removed from the immediate vicinity of the well screen during well development or during purging before sample collection.
General Well Characteristics	R-9 is a single-screen well constructed of 4.5-in.-I.D./5-in.-O.D. schedule 40 low carbon-steel casing to a depth of 552.5 ft and 4.5-in.-I.D./5-in.-O.D. schedule 40 stainless-steel casing below 552.5 ft.	The low carbon-steel casing was used in the vadose zone and thus does not affect chemistry of the regional groundwater samples collected. Use of stainless-steel well materials below 552.5 ft is designed to prevent corrosion in the vicinity of the regional aquifer.

	Description	Evaluation
Well Screen Construction	The well screen is constructed of 304 stainless-steel wire wrap with 0.010-in. slots.	Wire-wrap screen is considered the optimum design for promoting the free flow of water during well development and sampling. The wire wrap on the R-9 well screen contains 0.010-in. slots. More recent wells contain 0.020-in. slots that facilitate the movement of water through the well screen when surging and pumping the well during development. The ability of 0.010-in. slot wire-wrapped screen to develop properly must be judged on the quality of groundwater data collected from the wells. R-9 consistently yields water samples considered representative of groundwater conditions in the regional aquifer at this location (see Appendix B). Field parameters, including turbidity, are consistently within acceptable limits. These data indicate that the well screen is properly designed, installed, and developed.
Screen Length and Placement	The R-9 well screen extends from 683 to 748.5 ft and has a length of 65.5 ft. The screen straddles the water table that is currently at a depth of 690.8-ft depth (Allen and Koch 2007, 095268). The top of the screen is 7.8 ft, above the water table, and 57.7 ft of the screen is submerged.	R-9 is designed to provide water-quality and water-level data for the regional aquifer near the Laboratory's eastern boundary, and its screen length and placement were selected with the following goals in mind: • Characterize water quality in the uppermost part of regional groundwater downgradient of contaminant sources in Los Alamos Canyon, particularly TA-02 and -21 • Place the well screen straddling the water table to detect maximum contaminant concentrations due to infiltration beneath Los Alamos Canyon • Collect water-level data for the regional aquifer • Monitor water-level responses in the upper part of the regional aquifer to pumping from nearby water supply wells The upper 3 ft of the well screen from 683 to 686 ft is within Miocene clay-rich volcanogenic sedimentary rocks; this portion of the well screen has always been above the water level. The remainder of the well screen is within Miocene basaltic rocks, with the main productive zones probably occurring within fractured basalt. A zone of soil development within the uppermost foot of the basalt is indicated by thick accumulations of clay and calcite with some drusy quartz in vesicles and fractures. Calcite veins extend downward in hairline fractures an additional 0.8 ft below this depth. Regional groundwater in R-9 appears to be unconfined. There was no measurable water-level rise after saturation was encountered in the basalt. The regional water level in R-9 (and in nearby R-12) is anomalously low compared with nearby water-supply wells PM-1 and Otowi-1 under nonpumping conditions. Water levels measured at R-9 are also anomalously low when compared with predictions based on regional water-table maps (see Figure O-2 in LANL 2006, 094161).

	Description	Evaluation
Screen Length and Placement (continued)		The screen length and placement are appropriate for the goals defined in the second, third, and fourth bullets above. However, the anomalously low water level in R-9 raises questions about how well regional groundwater in the Miocene basalt is in communication with other parts of the regional groundwater system, particularly to the west. Resolving this question is important for evaluating whether the current well location is appropriate for addressing the first bullet. A similar situation is present at R-12, and a replacement well (R-36) has been drilled west of the R-12 location so that groundwater can be monitored in the sedimentary deposits above the Miocene basalt. Water-level and water-quality results for R-36 and R-12 should be compared after the new well is installed to determine if there are significant differences in the monitoring data collected from the sedimentary deposits and the basalts. The location of R-9 as a monitoring well for contaminant sources in Los Alamos Canyon should be reevaluated based on the comparison of R-12 and R-36 data.
Filter Pack Materials and Placement	The primary filter pack consists of 20/40 sand from 675.5 to 748.5 ft. A secondary filter pack of 30/70 sand was placed above and below the primary filter pack from 669.5 to 675.5 ft and 748.5 to 755 ft, respectively.	The primary filter pack extends 7.5 ft above the well screen, and it extends to the bottom of the well screen. The filter pack above the well screen is slightly longer than the optimum design of 5 ft but has no effect on samples collected because the top of the well screen is above the water table.
Sampling System	Submersible pump	Submersible pumps installed in single completion wells allow groundwater to be purged from the well casing, well-filter pack, and to some degree, near-well formation materials. Water can pumped at a rate of 10–12 gal./min, greatly facilitating effective purging and efficient sampling. Conventional purging and sampling allow water to be drawn from more deeply within formation materials surrounding the well screen in comparison to low-flow systems, and there is a greater likelihood of obtaining water from zones beyond potential near-well drilling effects. Storage and disposal of purged water require additional resources relative to low-flow sampling systems. Water levels can be measured manually or by dedicated pressure transducers.

	Description	Evaluation
Other Issues That Could Affect the Performance of the Well	Abandoned drill casings	During well-construction operations, the 8-in. well casing was successfully pulled back in increments, while annular materials were placed around the well with a tremie line. The 8.62-in. casing was completely removed from the borehole, and the annular materials were installed to the bottom of the 10.75-in. drill casing. However, when attempts were made to pull back on the 10.75-in. drill casing, it was discovered that the 5-in. well casing had become locked to the drill casing. Attempts to decouple the 5-in. well casing from the 10.75-in. drill casing were unsuccessful. Because further attempts to pull back on the 10.75-in. drill casing could have caused severe damage to the well completion string, the decision was made to cement in place the 10.75-in. casing and the two other remaining drill casings. Cement between and outside the abandoned drill casings seals the regional aquifer from overlying perched groundwater. These abandoned drill casings do not affect the performance of R-9 as a monitoring well.
Additives Used During Drilling		QUIK-FOAM EZ-MUD
Annular Fill Other Than Filter and Transition Sands		Pelplug: 0.25 in. by 0.375 in. refined elliptical bentonite pellets to provide a borehole annular seal from 661.5 to 669.5 ft Cement for sealing off abandoned drill casing and surface seal Slough: Slough filled the well annulus between 622.5 and 661.5 ft when the 8.62-in. drill casing was retracted during well construction. The slough is sandwiched by cement above and bentonite below.

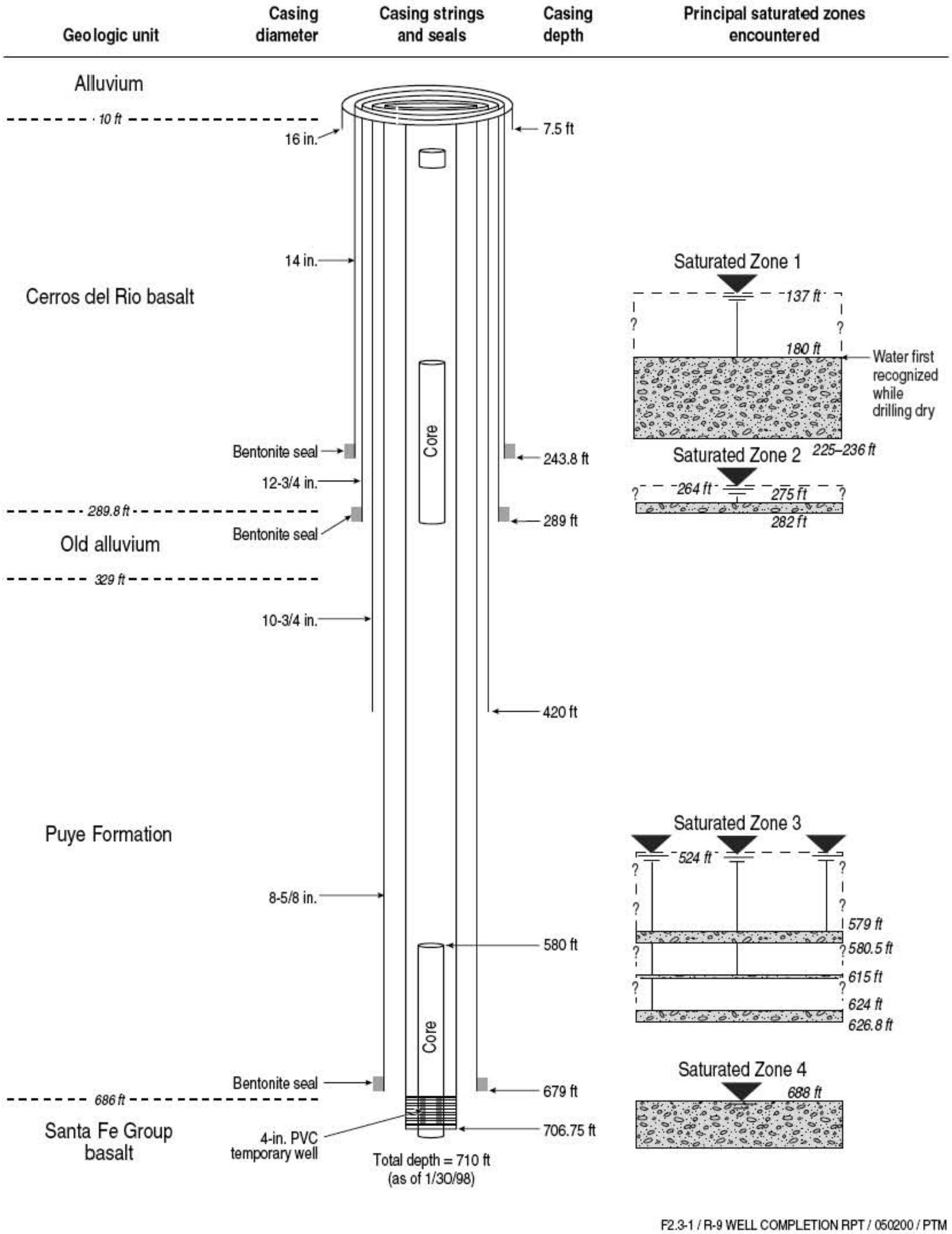


Figure 1 **Configuration of R-9 borehole as of January 30, 1998**

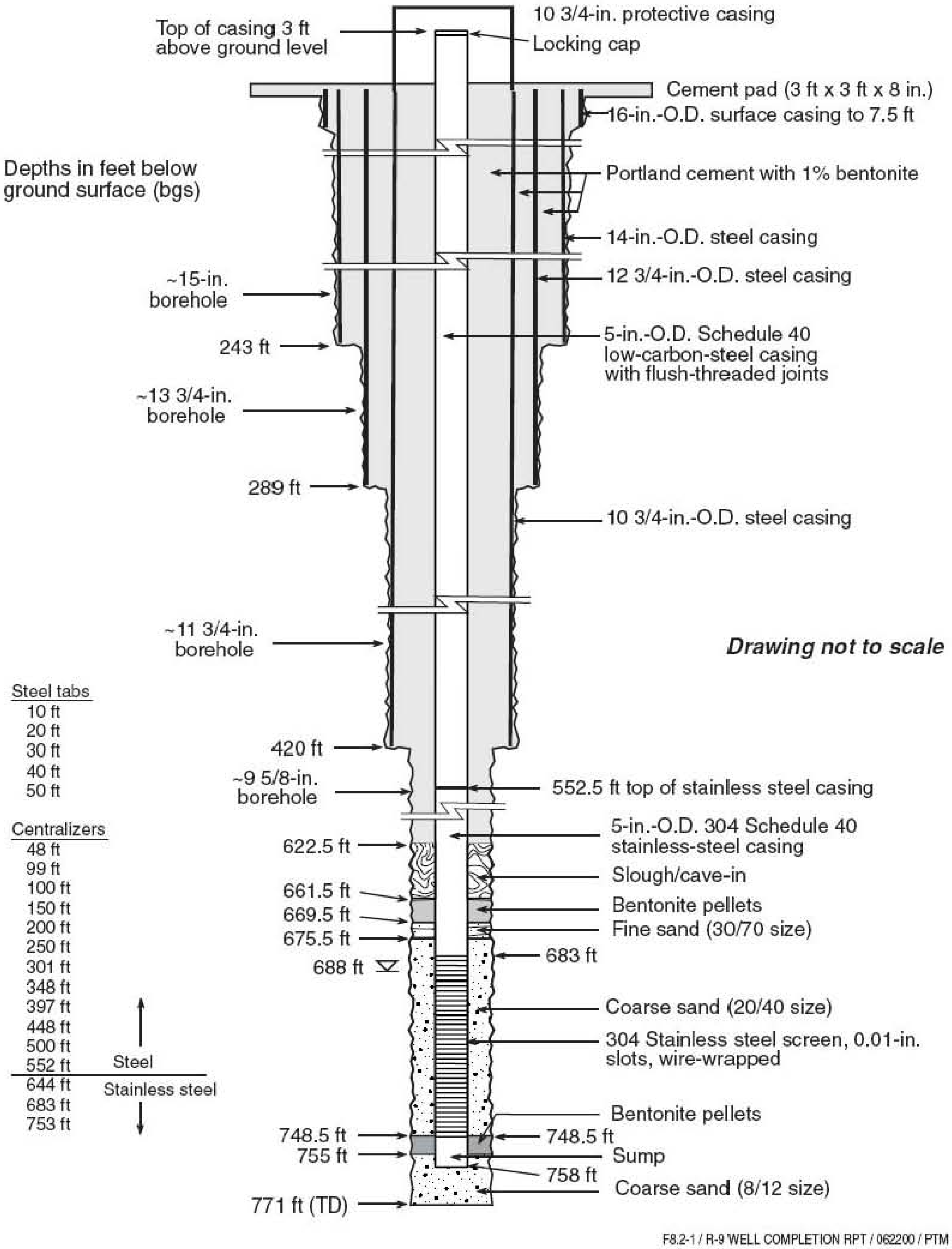


Figure 2 As-built completion diagram of well R-9

R-9i Well

R-9i Well

	Description	Evaluation
Drilling Method	R-9i was drilled using a combination of fluid-assisted reverse-circulation air-rotary methods in open hole and with casing advance.	R-9i is primarily designed to provide water-quality and water-level data for the two uppermost perched zones of saturation identified during the drilling of characterization well R-9. R-9i is located 35 ft west of R-9. R-9i was initially drilled to 18-ft depth using casing-advance reverse-circulation air-rotary drilling methods to install 13.375-in. surface casing. The remainder of the borehole (18 to 322 ft) was drilled using fluid-assisted reverse-circulation air-rotary methods in an open borehole. Air and municipal water mixed with EZ-MUD were used to circulate cuttings out of the borehole. Drilling additives such as EZ-MUD can adversely affect the ability to collect representative water samples if not removed from the immediate vicinity of the well screen during well development or during purging before sample collection.
General Well Characteristics	R-9i is a two-screen well constructed of 4.5-in.-I.D./5.56-in.-O.D. 304 stainless-steel casing.	The stainless-steel well materials are designed to prevent corrosion.
Well Screen Construction	The well screen is constructed of 5-in. I.D./5.5-in.-O.D. 304 stainless-steel wire wrap with 0.010-in. slots.	Wire-wrap screen is considered the optimum design for promoting the free flow of water during well development and sampling. The wire wrap on the R-9i well screen contains 0.010-in. slots. More recent wells contain 0.020-in. slots that facilitate the movement of water through the well screen when surging and pumping the well during development. The ability of 0.010-in. slot wire-wrapped screen to develop properly must be judged on the quality of groundwater data collected from the wells. Evaluations of water-quality data from the two screens in R-9i do not reveal any residual effects of drilling products in the most recent samples (Appendix B).
Screen Length and Placement	Well screen 1 extends from 189.1 to 199.5 ft and has a length of 10.4 ft. The screen is submerged within a perched zone that may be under confining conditions. The water level in screen 1 is currently at a depth of 146 ft below the surface (Allen and Koch 2007, 095268). The top of the screen is 43.1 ft below the water level.	R-9i is designed to provide water-quality and water-level data for the perched groundwater near the Laboratory's eastern boundary, and the screen lengths and placements were selected with the following goals in mind: • Characterize water quality in the uppermost perched groundwater zone located downgradient of contaminant sources in Los Alamos Canyon, particularly TA-02 and -21. This perched zone is located within the Cerros del Rio basalt and is one of the largest perched water zones encountered in the eastern part of the Laboratory. This goal was met by installation of screen 1. • Characterize water quality in the smaller perched groundwater zone located near the base of the Cerros del Rio basalt. This goal was met by installation of screen 2. • Monitor water levels to detect whether perched intermediate groundwater responds to seasonal infiltration beneath Los Alamos Canyon. This goal is met by water-level measurements in screens 1 and 2.

	Description	Evaluation
Screen Length and Placement (Continued)	Well screen 2 extends from 269.6 to 280.3 ft and has a length of 10.7 ft. The screen is submerged within a perched zone that may be under confining conditions. The water level in screen 2 is currently at a depth of 255 ft below the surface (Allen and Koch 2007, 095268). The top of the screen is 14.6 ft below the water level.	Two zones of perched saturation were encountered in R-9i, as expected from observations at adjacent regional well R-9. The upper perched water lies within the interior of the stack of Cerros del Rio basalt. The lower zone of perched saturation lies at the base of the Cerros del Rio basalt. The position of the top of the uppermost zone of perched saturation was not clearly understood at R-9. Thus, steps were taken at R-9i to resolve this uncertainty. Specifically, minimal amounts of drilling fluid were used to avoid plugging any productive zones, and operations were halted periodically to allow any formation water present to accumulate in the borehole. At such times, water injection was ceased, but circulation of compressed air was allowed to continue. Drilling was stopped at depths of 140 ft, 145 ft, 148 ft, 155 ft, 160 ft, 168 ft, 175 ft, 180 ft, and 188 ft. At all these depths, except 188 ft, the hole dried out within 5 min, suggesting significant saturation had not yet been encountered. At a depth of 184 ft, red-orange clay and red scoria and breccia showed up in the cuttings, and at 186 ft the driller noticed an increase in the penetration rate and ceased injecting water. The basalt flow beneath the breccia is highly fractured, and these fractures probably provide the permeability in this perched zone. While shut down at a depth of 188 ft, water was produced from the borehole. Based on these observations, the top of the uppermost saturation is believed to lie at a depth of 186 ft. Drilling was continued until a depth of 200 ft was reached. Then the bit was pulled back to a depth of 187 ft, leaving 12 ft of open hole. After 1.5 h, a composite water-level depth of 142 ft was obtained. At R-9i, information about the first occurrence of groundwater and the static water-level depth for the lower perched water could not be determined because the lower zone was flooded by water from the upper perched zone during open-hole drilling. However, the upper perched zone was sealed off by drill casing when nearby well R-9 was drilled. Observations during R-9 drilling indicate that the second perched zone was encountered in a breccia zone at the base of the Cerros del Rio lavas. Saturation was first recognized at a depth of 275 ft and water slowly rose to a static level of 264 ft. The basaltic breccia appears to constitute the permeable interval within the second perched zone. The perching layer occurs at a depth of 282 ft within fine-grained, highly stratified basaltic tephra. Hydraulic conductivity of the second perched zone appears to be significantly less than in the first perched zone, as evidenced by the slow recovery of water levels in the borehole after the samples were collected and the resistance to injection of water during hydraulic-property testing. The observations described above suggest that both perched zones at R-9i may be under confined conditions. Thus, the well screens target the zones where water was first produced during drilling rather the levels to which groundwater rose. The length and placement of the two screens in R-9i are appropriate for the conditions encountered at this location and meet the goals defined in the proceding bullets.

	Description	Evaluation
Filter Pack Materials and Placement	The screen 1 primary filter pack consists of 20/40 sand from 185.5 to 200.7 ft. A secondary filter pack of 30/70 sand was placed above and below the primary filter pack from 183.2 to 185.5 ft and 200.7 to 203.9 ft, respectively. The screen 2 primary filter pack consists of 20/40 sand from 266.4 to 282.1 ft. A secondary filter pack of 30/70 sand was placed above and below the primary filter pack from 264.3 to 266.4 ft and 282.1 to 282.8 ft, respectively.	The primary filter pack for screen 1 extends 3.6 ft above and 1.2 ft below the well screen, respectively. For screen 2, the primary filter pack extends 3.2 ft above and 1.8 ft below the well screen, respectively. Placement of the filter packs is within the optimum design for both well screens.
Sampling System	Westbay MP sampling system	Westbay is a low-flow sampling system that allows groundwater sampling of multiple well screens within a single well installation. Well screens are isolated by packers and sampled individually. Westbay is the only sampling system capable of sampling three or more screens in a multiscreen well. It is particularly effective for monitoring water levels at multiple depths within a well. Flow-through cells for measuring field parameters cannot be used at multiscreen wells containing the Westbay sampling system. Effective development and removal of residual drilling fluids are critical before installation of Westbay wells because groundwater is collected in proximity to the well due to low-flow sampling and the inability to purge the well before sampling. Samples collected from Westbay wells are particularly prone to water-quality problems that develop if residual drilling fluids are hydraulically connected to the screen interval.
Other Issues That Could Affect the Performance of the Well	The lower groundwater zone was flooded by upper perched zone water during open-hole drilling and in the completed well before installation of the Westbay sampling system.	The lower zone was flooded by water from the upper perched zone during open-hole drilling. In addition, the lower well screen was open to large amounts of water from screen 1 until isolation of the well screens was accomplished by installation of the Westbay system.

	Description	Evaluation
Additives Used During Drilling		Municipal water EZ-MUD
Annular Fill Other Than Filter and Transition Sands		Bentonite: 0.375-in. chips Pelplug: refined elliptical bentonite pellets to provide a borehole annular seal Portland Type I/II cement with 1% bentonite gel, by weight

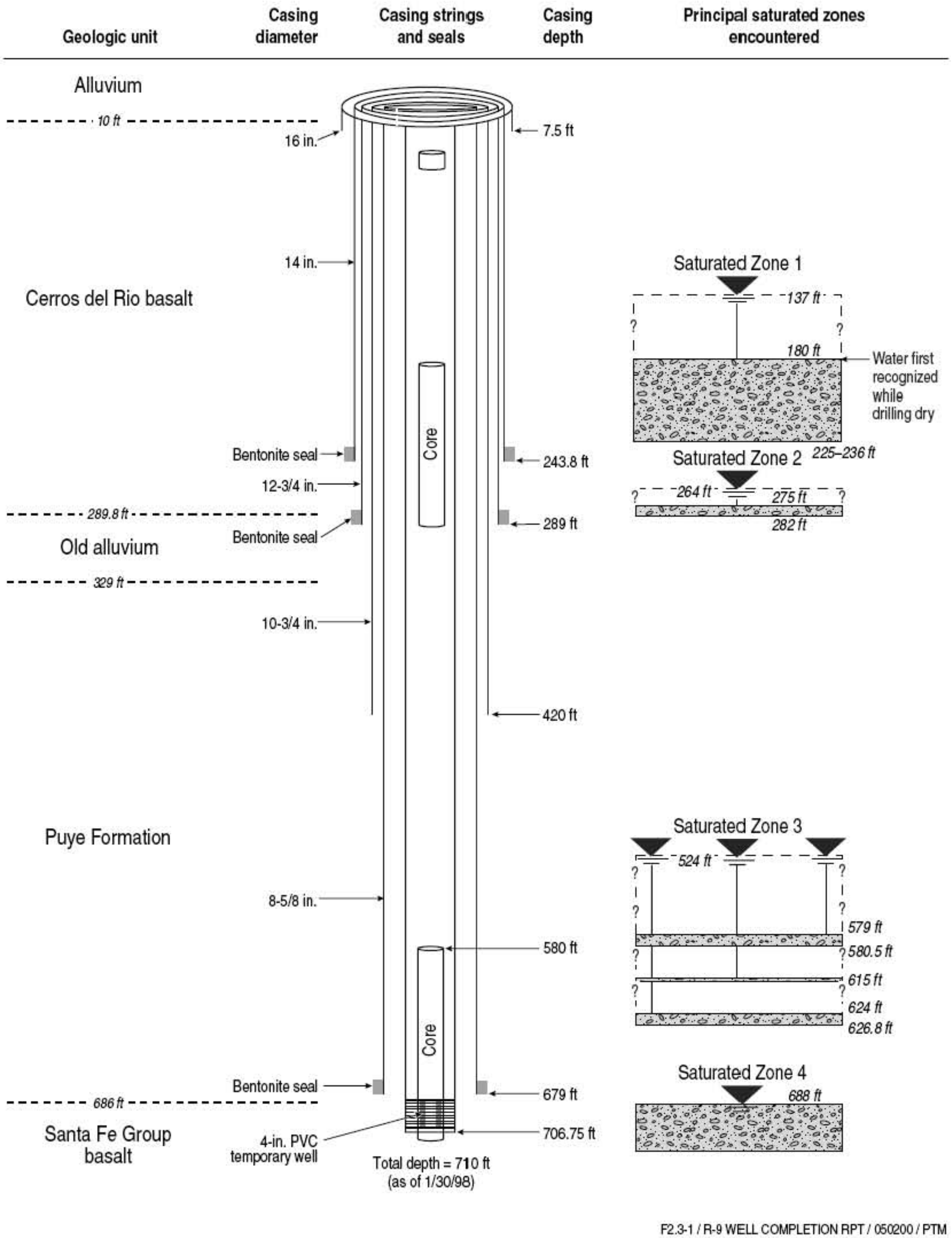


Figure 1 **Groundwater zones identified during drilling of nearby regional well R-9**

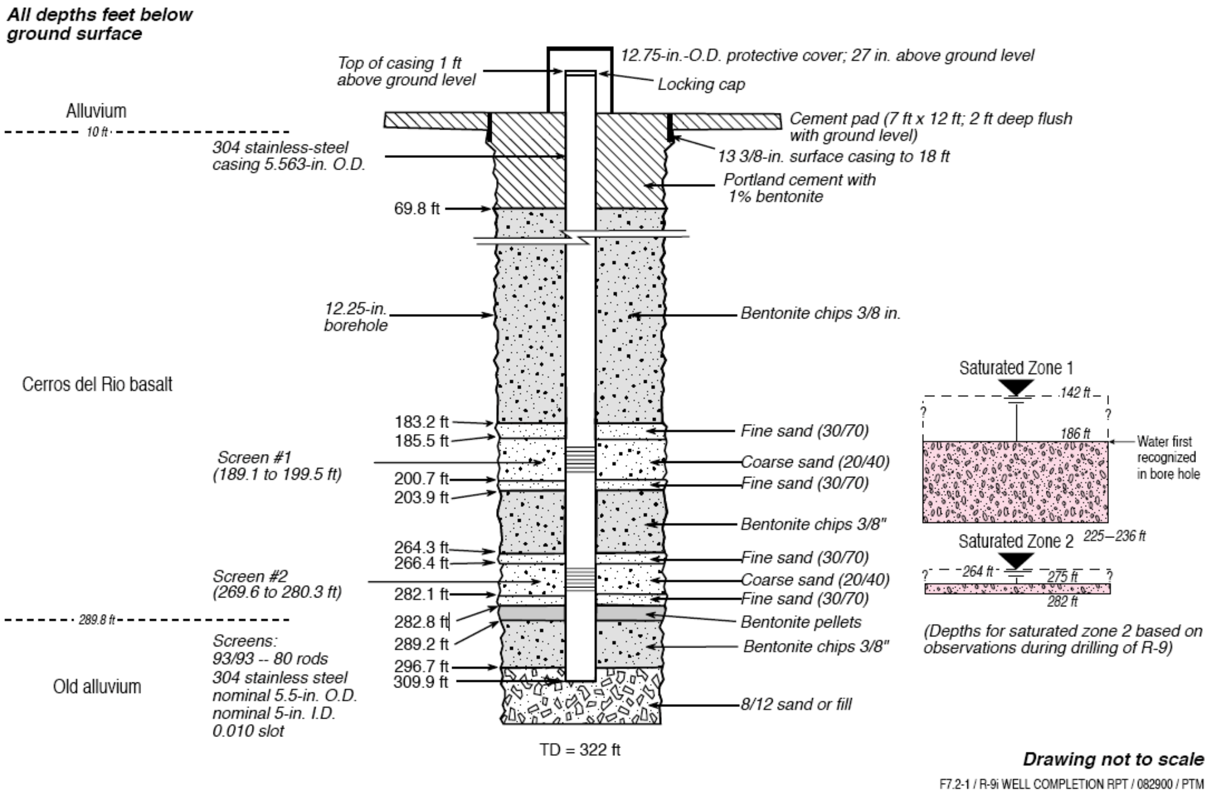


Figure 2 **As-built completion diagram of well 9i**

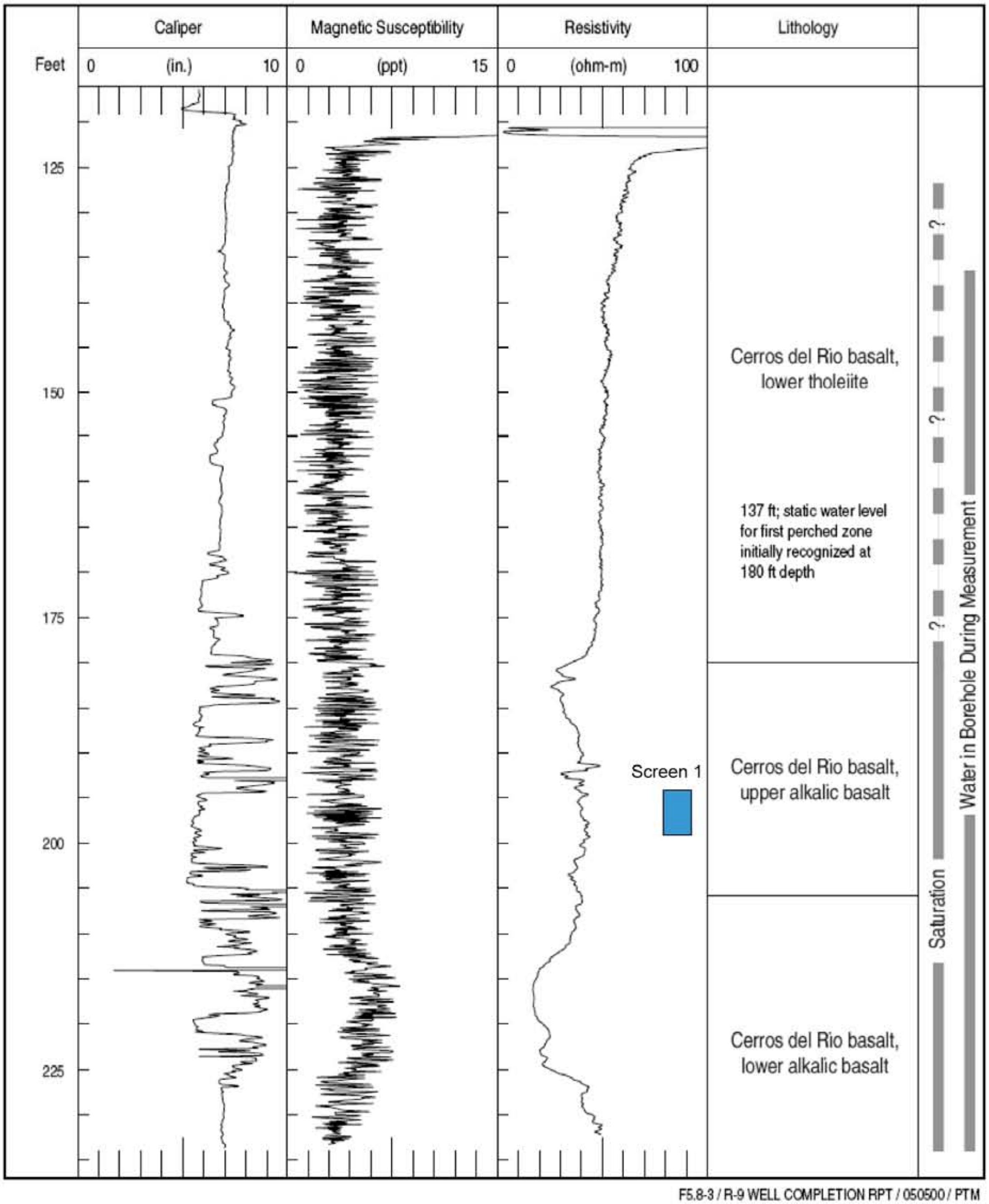


Figure 3 Position of R-9i well screen 1 relative to geophysical data collected in adjacent R-9 borehole

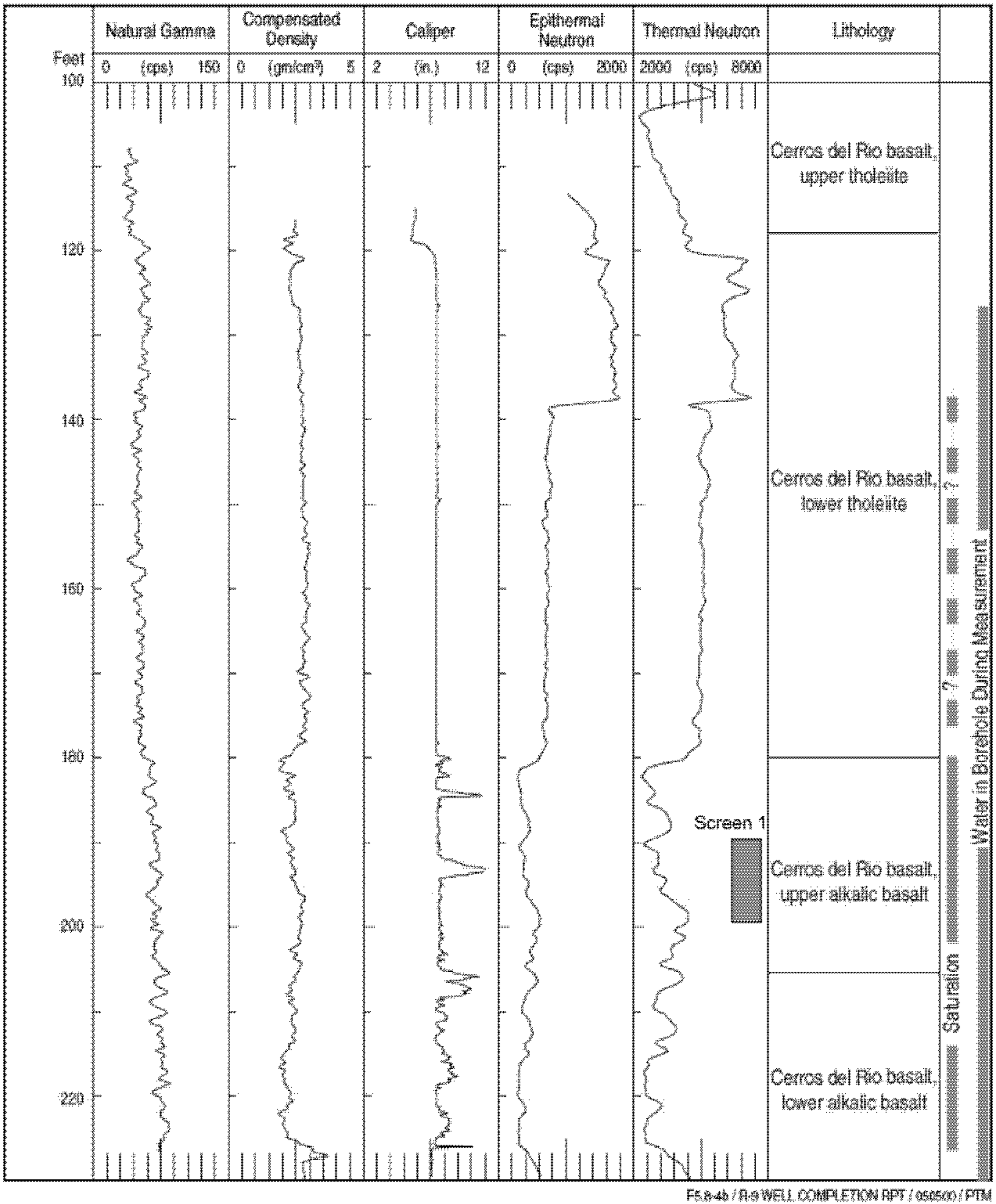


Figure 3 **Position of R-9i well screen 1 relative to geophysical data collected in adjacent R-9 borehole (continued)**

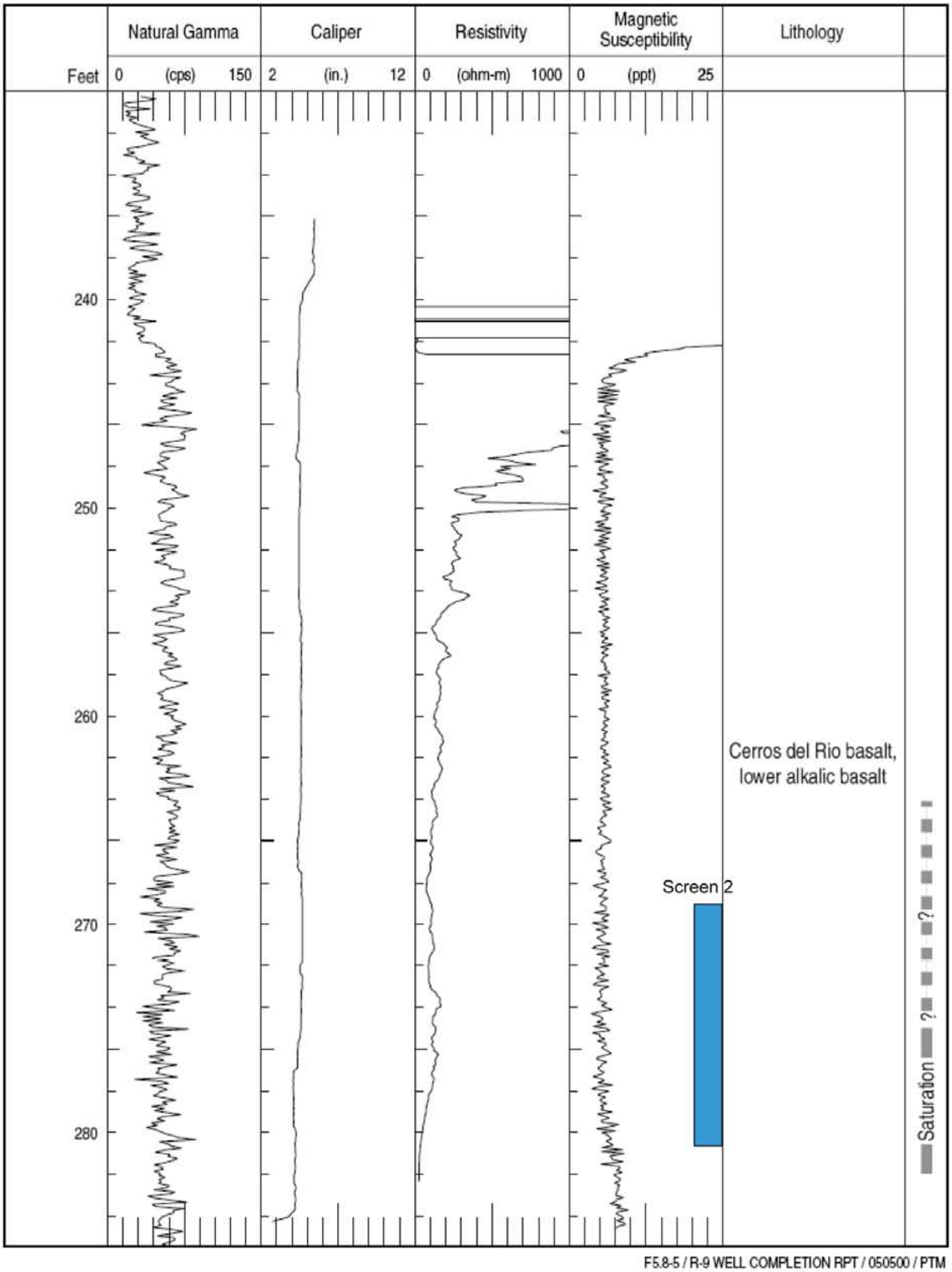


Figure 4 **Position of R-9i well screen 2 relative to geophysical data collected in adjacent R-9 borehole**

R-24 Well

R-24 Well

	Description	Evaluation
Drilling Method	R-24 was drilled in two phases. Phase I used wire-line coring methods to 213-ft depth to collect core. The coring target had been 300 ft, but coring was difficult and core recovery was intermittent. Phase II stepped aside and used fluid-assisted air-rotary methods to 881-ft depth. Only the second phase is discussed here because no well installation is associated with Phase I.	Phase II drilling at R-24 used fluid-assisted air-rotary methods to 881-ft depth. Circulation of cuttings was primarily accomplished using air and municipal water mixed with additives, including QUIK-FOAM and EZ-MUD. At 60-ft depth, loss of circulation required replacement of the 13.375-in. conductor casing with a 16-in. conductor casing, cemented in to a depth of 35.5 ft, and transition from a 12.25-in. tricone to a 15-in. bit. After drilling to 582 ft, an 11.75-in. casing was set at 100 ft. With further drilling, this casing was advanced to 610 ft and the bit was advanced to TD at 881 ft. Initial tag of regional saturation was at 715-ft depth. The hydrogeologic stratigraphy for R-24 is summarized in Figure 1.
General Well Characteristics	R-24 is a single-screen well constructed of 4.5-in.-I.D./5-in.-O.D. 304 stainless-steel casing.	The stainless-steel well materials are designed to prevent corrosion. The well design for R-24 is summarized in Figure 2.
Well Screen Construction	The rod-based wire-wrapped screen is constructed of 5.27-in.-O.D. 304 stainless steel with 0.020-in. slots.	Rod-based screen provides extensive, uniformly distributed openings for access to the filter pack during development. Also, the 0.020-in. slots in the R-24 screen allow greater water movement during development than 0.010-in. screen openings. The screen at R-24 was developed successfully using bailing, swabbing, and pumping. The screen at R-24 has produced water with moderately elevated uranium content. R-24 consistently yields water samples considered representative of groundwater conditions in the regional aquifer at this location (see Appendix B).
Screen Length and Placement	The screen at R-24 extends from 825 to 848 ft (length of 23 ft) and is submerged beneath the regional water table (currently 716.5 ft below the surface) within Santa Fe Group sediments that are sandwiched between two Miocene lavas. The top of the screen is currently 108.5 ft below the top of the regional aquifer.	This screen length and placement were selected with the following goals in mind: • Characterize water quality in Bayo Canyon northeast of the present wastewater treatment plant • Monitor the regional water table for seasonal fluctuations and long-term variation

	Description	Evaluation
Screen Length and Placement (continued)		The screen at R-24 is placed in the regional aquifer at a depth where submergence is sufficient to support aggressive development. The depth of over 100 ft below the top of regional saturation was necessary to avoid placing the screen in hydrologically tight Miocene lavas that extend to 810-ft depth (Figures 2 and 3). The screen is located within Santa Fe Group sediments that dip up to 15 degrees toward the south (dip azimuths are dominantly about 180 degrees). Total porosities within the screen interval range between 20% and 30%, with washout zones up to 58%, and highly variable effective porosities ranging between 2% and 35%. The electrical resistivity image (FMI log, Figure 4) shows that these deposits consist of thinly laminated beds with small channels. The screen at R-24 includes a zone of significant washout at about 842- to 845-ft depth (Figure 3). The placement of the well screen at R-24 meets the characterization goals for a well for this location, although screen placement deep below the top of regional saturation was dictated by thick and poorly transmissive Miocene lavas that contain the top of regional saturation.
Filter Pack Materials and Placement	The filter pack and its placement are discussed in the column to the right.	The primary filter pack is made up of 10/20 sand from 813 to 854 ft. A secondary filter pack of 20/40 sand was placed above the primary filter pack from 811 to 813 ft; beneath the primary filter pack is a backfill of ~50% bentonite plus ~50% 10/20 sand (854 to 872 ft) overlying slough from 872 ft to TD at 881 ft. The primary filter pack extends 12 ft above and 6 ft below the well screen. The top of the filter pack length is currently 108.5 ft below the water table. The upper part of the filter pack extends slightly farther above the well screen than current well designs (about 5 ft above the well screen). However, because the Santa Fe Group sediments at this location have highly variable transmissivity, a slightly long filter pack allows groundwater to be drawn from a larger volume in rocks where the amount and location of water production are uncertain.
Sampling System	Dedicated pump	Dedicated pumps allow relatively high-flow sampling. Flow-through cells for measuring field parameters can be used at single-screen wells with dedicated pumps installed. Effective development and removal of residual drilling fluids are critical, and the highest possible flow after development is desirable.
Other Issues That Could Affect the Performance of the Well	None	N/a
Additives Used		Municipal water QUIK-FOAM (above the regional aquifer) EZ-MUD (above the regional aquifer)
Annular Fill Other Than Filter and Transition Sands		Slough: at 872–881 ft Bentonite chips: 1453.5 ft3 Bentonite backfill below filter pack (~50:50 bentonite and 10/20 sand; 14.4 ft3) Cement slurry surface seal (135 ft3)

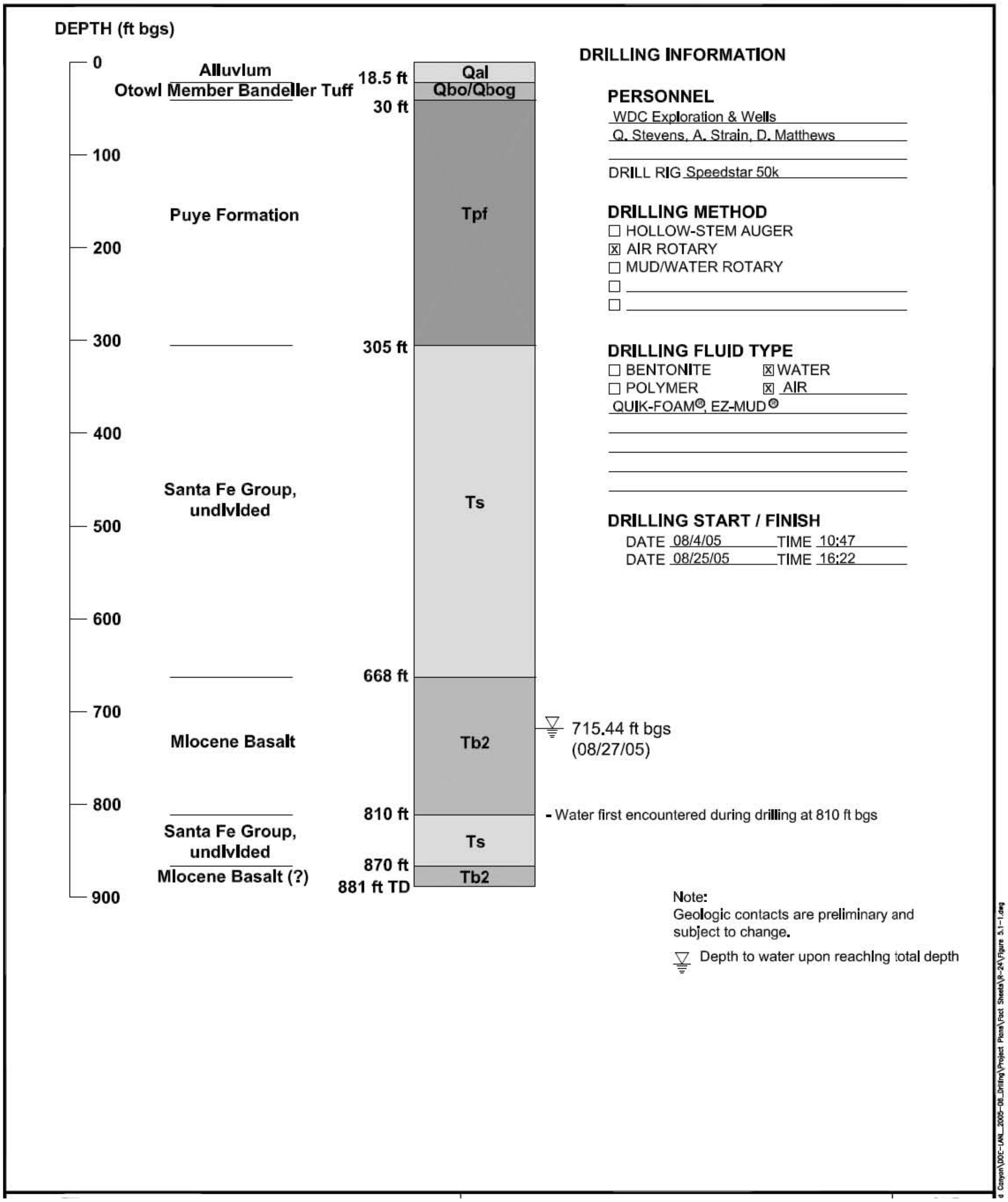


Figure 1 **Hydrogeologic stratigraphy for well R-24**

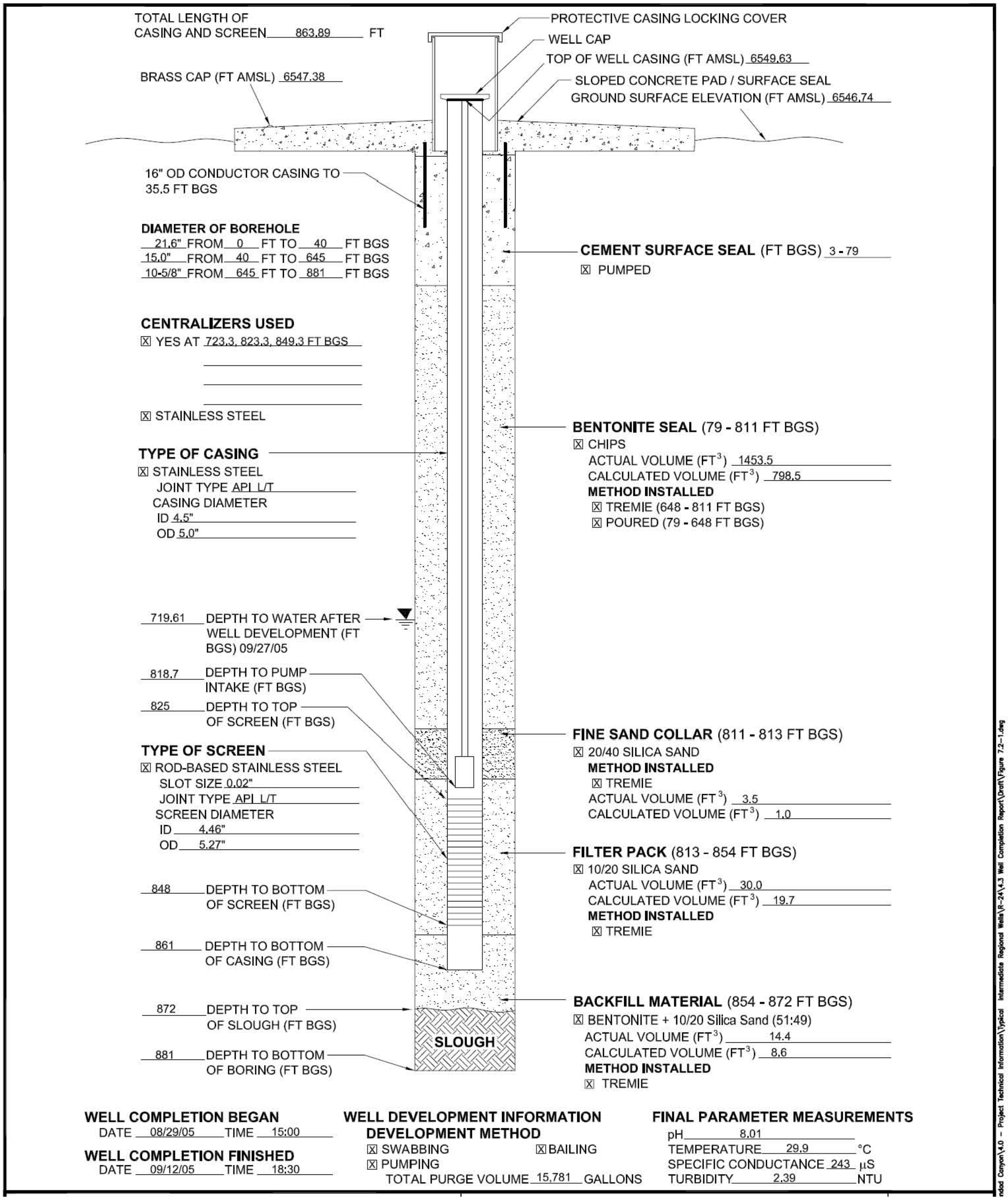


Figure 2 Well construction details for R-24

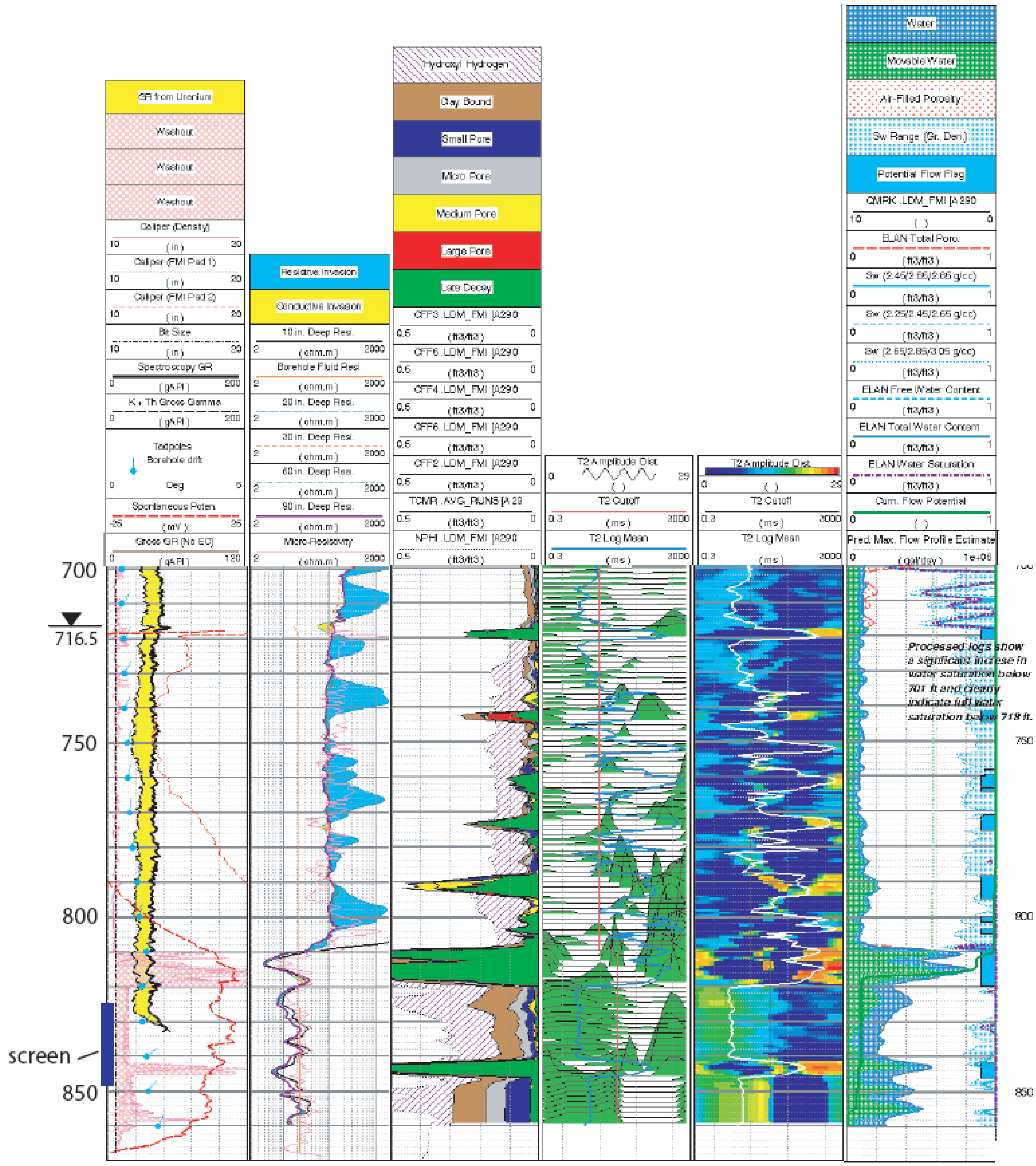


Figure 3 Summary of R-24 borehole geophysical logs for the regional aquifer

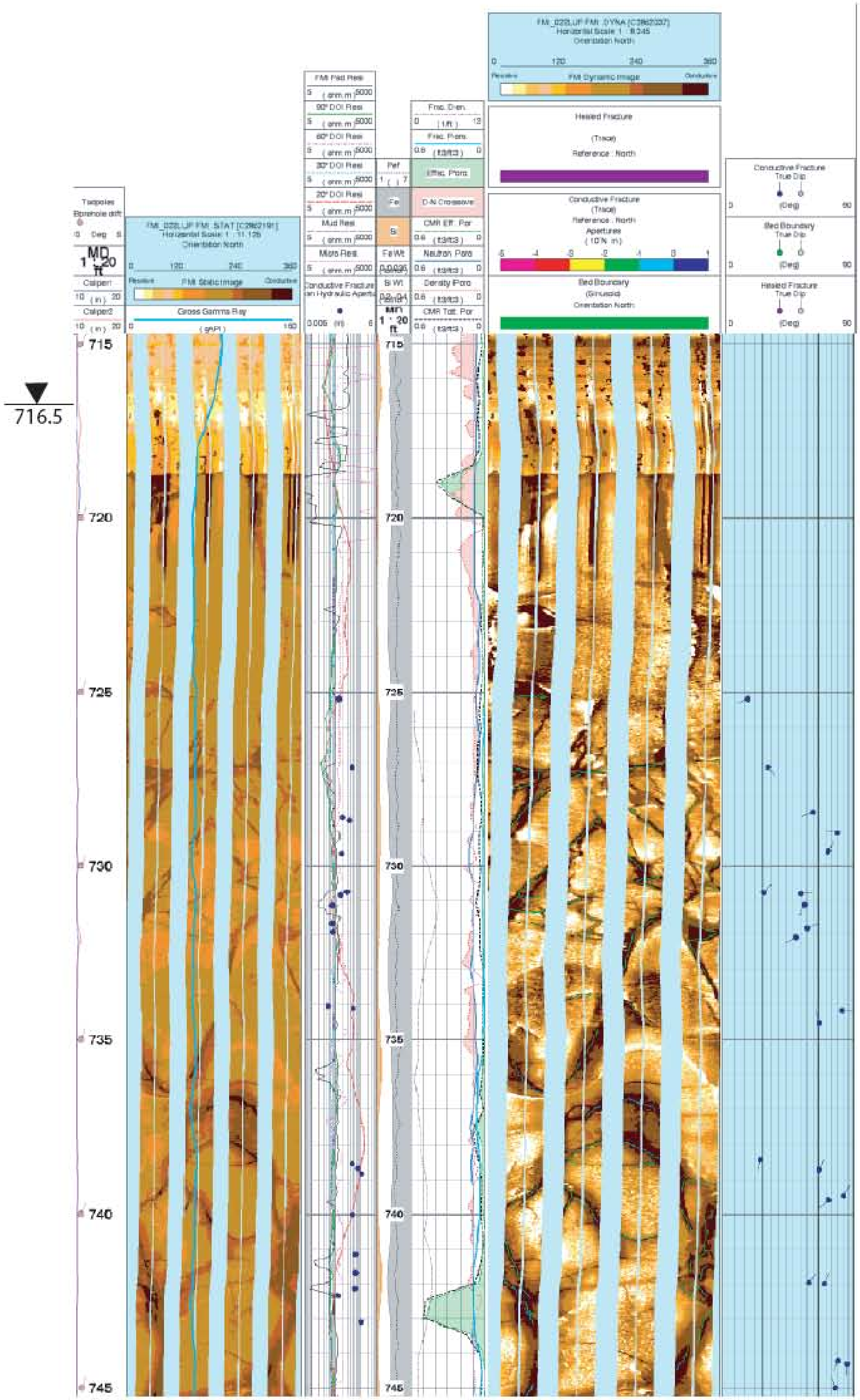


Figure 4a FMI log for R-24 (715 to 745 ft)

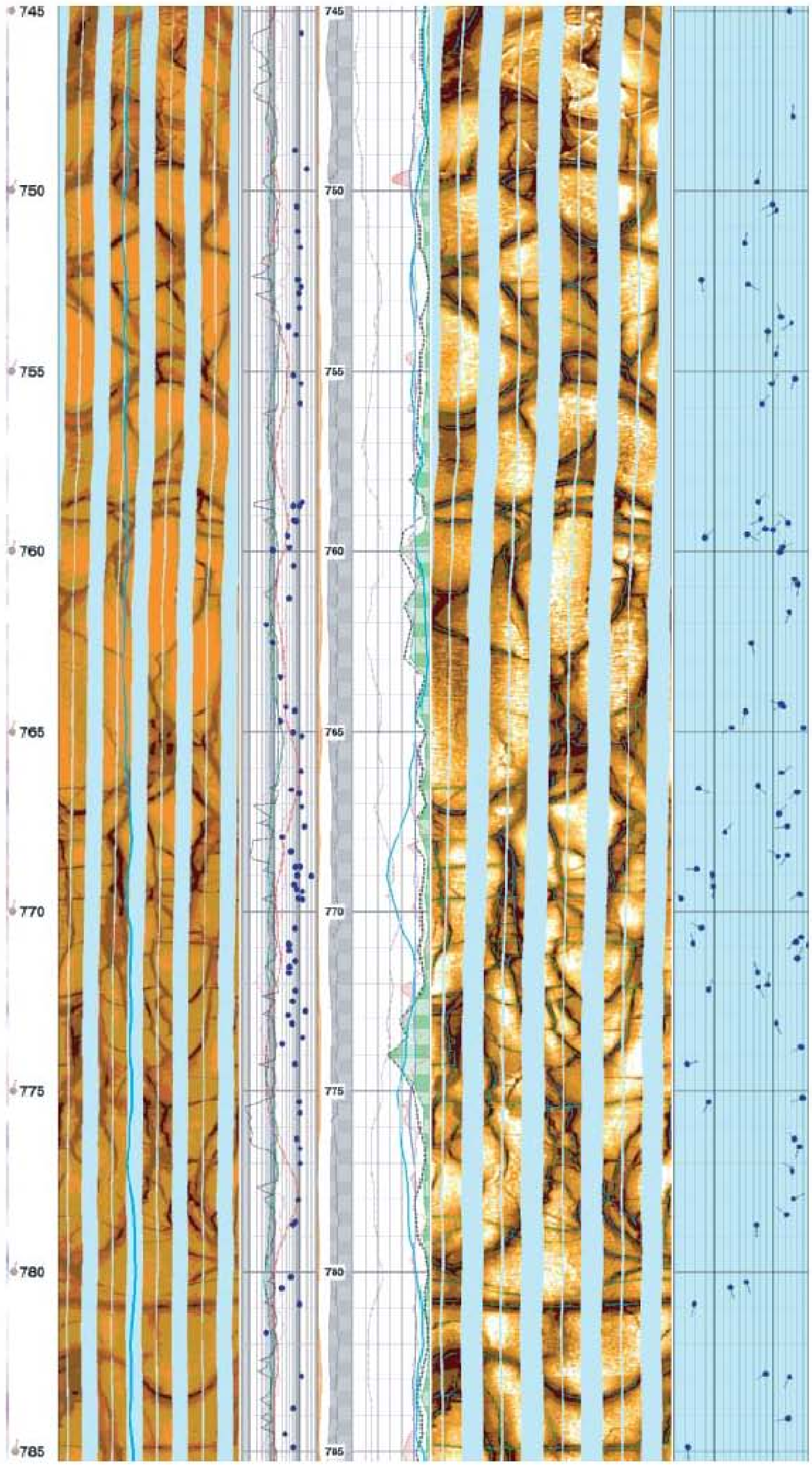


Figure 4b **FMI log for R-24 (745 to 785 ft)**

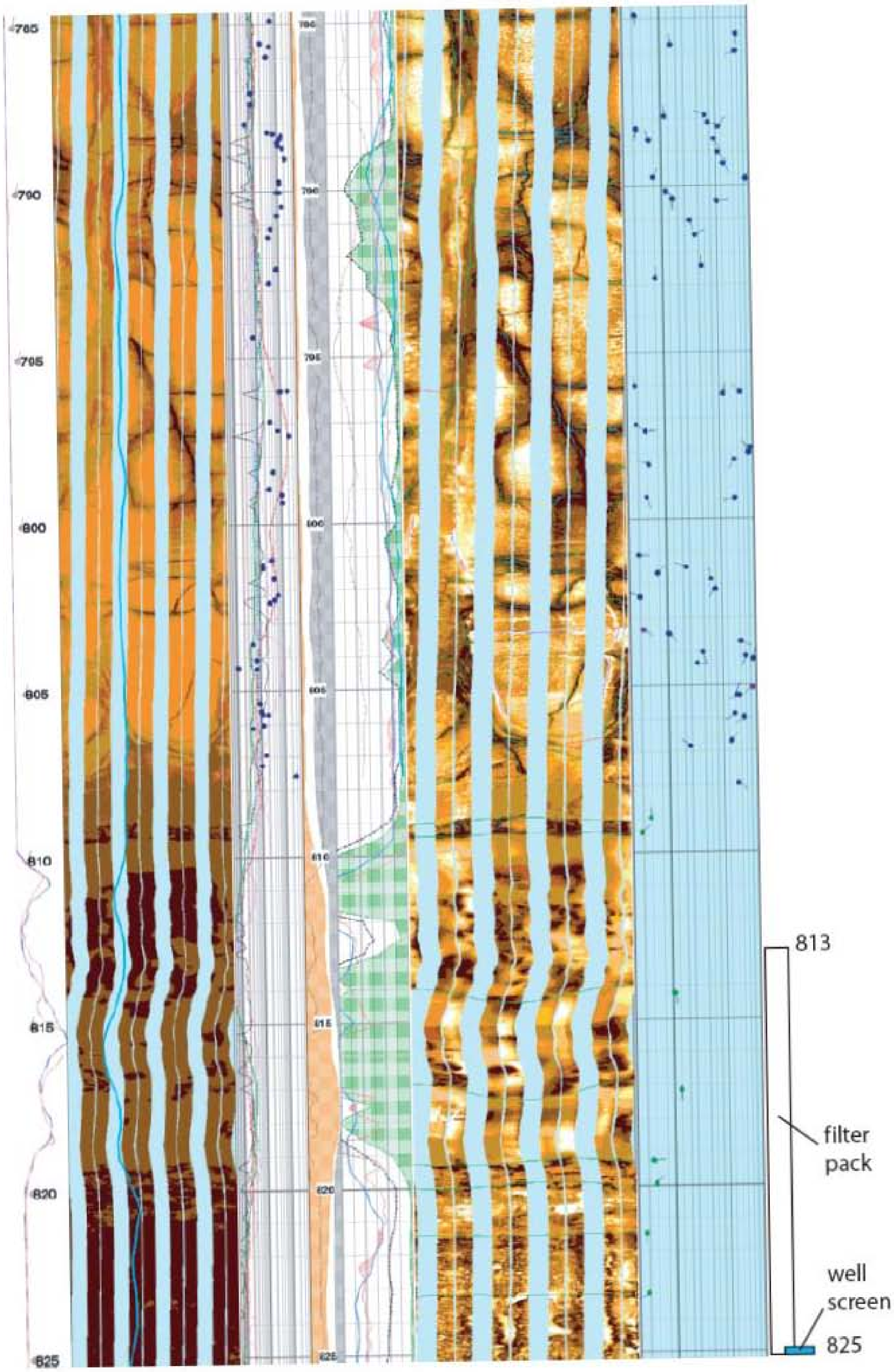


Figure 4c FMI log for R-24 (785 to 825 ft)

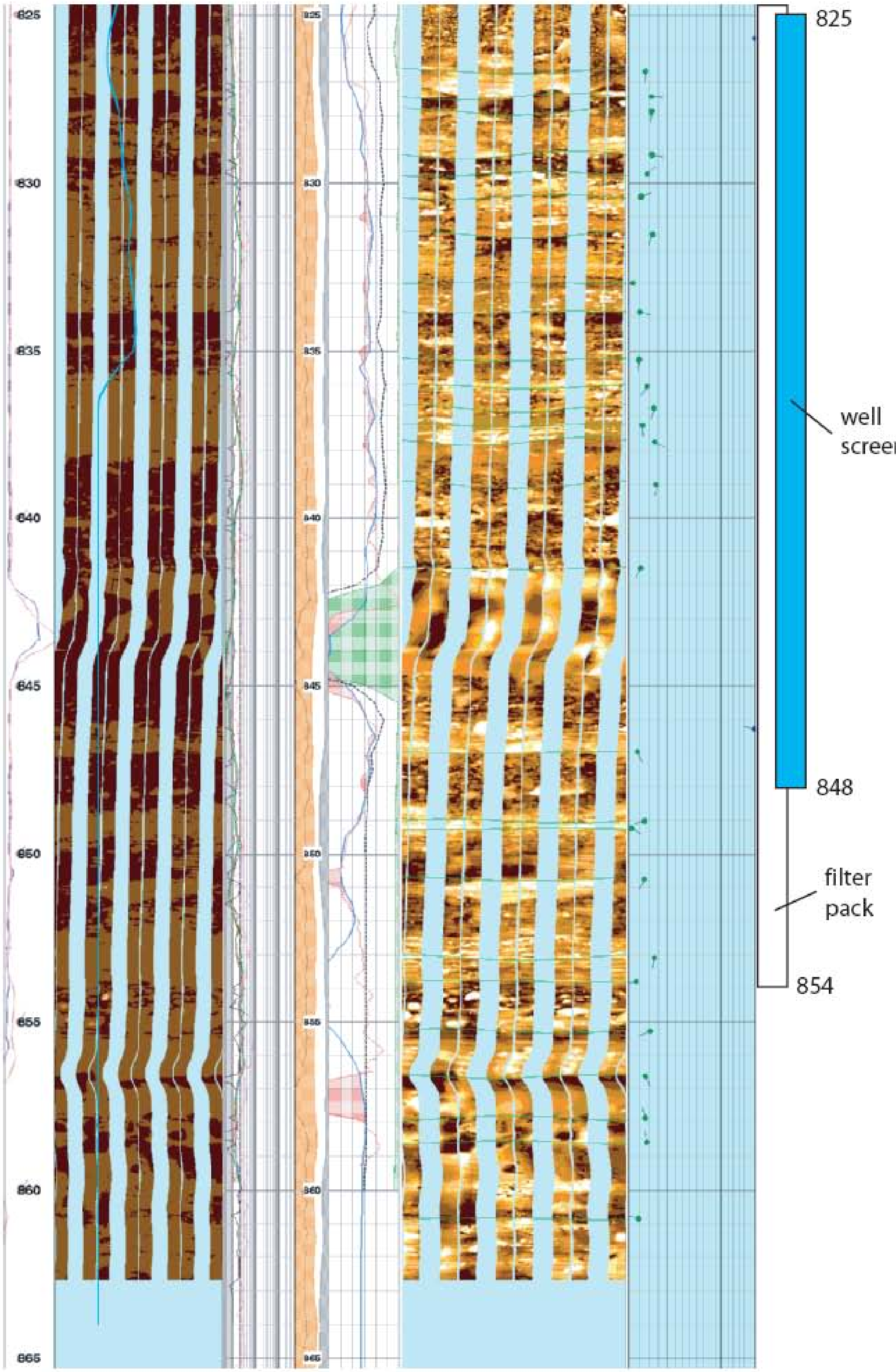


Figure 4d FMI log for R-24 (825 to 865 ft)

TW-1 Well

TW-1 Well

	Description	Evaluation
Drilling Method	TW-1 was drilled using a cable-tool method.	In 1950, TW-1 was drilled to a depth of 642 ft using the cable-tool method (Black and Veatch 1950, 008417; John et al. 1966, 008796; Purtymun 1995, 045344; Purtymun and Swanton 1998, 099096). The casing diameter is 16 in. (I.D.) to a depth of 52 ft, 12 in. to 241 ft, 8 in. to 627 ft, and 6 in. from 622 to 642 ft (Figure 1). Open hole was drilled from 627 to 642 ft. Current depth to water at TW-1 is about 510 ft.
General Well Characteristics	TW-1 is a single-screen well. A 16-in.-I.D. steel-surface casing was set to a depth of 52 ft to seal out surface water. Twelve-inch-I.D. steel casing was advanced inside the 16-in. casing to a depth of 241 ft; 8-in. casing was advanced inside the 12-in. to 627 ft. Open hole was drilled from 627 to 642 ft. Ten feet of 6-in.-I.D. blank steel casing was hung inside the 8-in. casing from 622 to 632 ft with a packer, making a seal between the two casings. Ten feet of 6-in. Layne Western, Inc., well screen was suspended from 632 to 642 ft beneath the blank 6-in. casing.	The types of well materials used to construct TW-1 are not specified in reports documenting its installation. Use of carbon-steel drive and well casings was common practice during the time this well was installed, and a well of this age is likely to be highly corroded. Below 627-ft depth, there is no annular fill outside the drive casings, although by nature cable-tool drilling usually results in a minimal annulus. From the surface to 241 ft, cement was added outside the 12-in. casing to seal off perched water encountered at 210- to 212-ft depth in a basalt interflow zone, extending from 210- to 225-ft depth. The lack of annular fill for most of the length of the well means that the annulus between the well and borehole could act as a preferential pathway for movement of perched groundwater to the regional aquifer. However, at the time of drilling, the placement of cement from surface to 241-ft depth appeared to seal off all perched sources. Contaminants detected in the regional aquifer at nearby production well O-1 include perchlorate, tritium, and nitrate.
Well Screen Construction	TW-1 was constructed with a bronze wire-wrapped well screen.	Wire-wrapped well screens are generally considered preferable to the pipe-based slotted screens for minimizing the amount of formation material drawn into the well during sampling. There is no information about the slot sizes of the well screen in reports describing the installation of this well. The 6-in. well screen is below the 8-in. casing, with 5 ft of blank 6-in. casing above the screen and below the bottom of the 8-in. casing.
Screen Length and Placement	The well screen extends from about 632 to 642 ft and has a length of 10 ft. The top of the well screen is submerged approximately 122 ft below the current water table (currently about 510 ft below the surface).	TW-1 was installed primarily to provide a monitoring point for the regional aquifer below Pueblo Canyon where contaminants derived from sources could be moving in the regional aquifer. Examples of these sources include Acid Canyon, sewage plants in Pueblo Canyon, and Manhattan-era buildings in the townsite. The regional aquifer-monitoring function of TW-1 will be superseded by the installation of well R-3 in this part of Pueblo Canyon.

	Description	Evaluation
Filter Pack Materials and Placement	There is no record of a filter pack being installed at TW-1.	Over time, the open hole occupied by the well screen probably filled in with formation materials. This natural filter pack likely helps to minimize the amount of formation material drawn into the well during sampling.
Sampling System	Submersible pump	Submersible pumps installed in single completion wells allow groundwater to be purged from the well casing, well-filter pack (either added or natural fill), and to some degree, near-well formation materials. Water can pumped at a rate of 10–12 gal./min, greatly facilitating effective purging and efficient sampling. Conventional purging and sampling allow water to be drawn from more deeply within formation materials surrounding the well screen in comparison to low-flow systems, and there is a greater likelihood of obtaining water from zones beyond potential near-well drilling effects. Storage and disposal of purged water require additional resources relative to low-flow sampling systems. Water levels can be measured manually or by dedicated pressure transducers.
Other Issues That Could Affect the Performance of the Well	Corrosion of carbon-steel casing	Corrosion of carbon-steel casing could reduce the structural stability of the well string and affect the quality of groundwater sampled by the well. The geochemical evaluation of groundwater is a means for assessing corrosion of well materials (see Appendix B).
Additives Used	Probably none	Cable-tool drilling does not introduce drilling additives, except for a small amount of municipal water.
Annular Fill Other Than Filter and Transition Sands	There is no record of annular fill being installed at TW-1.	Most likely, no annular materials were introduced outside the 16-in., 12-in., or 8-in. casings.

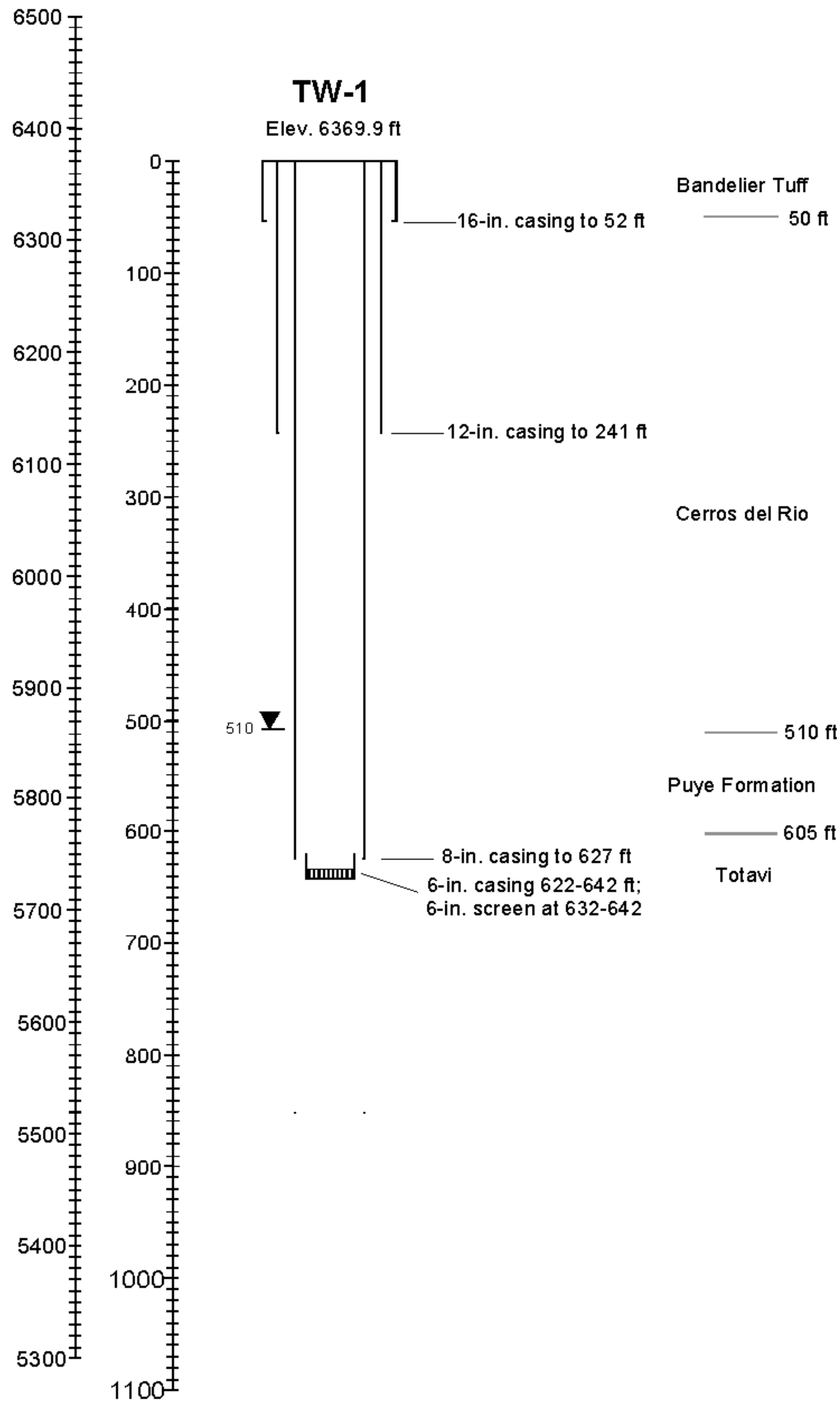


Figure 1 Well construction and stratigraphy at TW-1

TW-1A Well

TW-1A Well

	Description	Evaluation
Drilling Method	TW-1A was drilled using a cable-tool method.	In 1950, TW-1A was drilled to a depth of 225 ft using the cable-tool method (Black and Veatch 1950, 008417; John et al. 1966, 008796; Purtymun 1995, 045344; Purtymun and Swanton 1998, 099096). The casing diameter is 16 in. (I.D.) to a depth of 39 ft, 12 in. to 100 ft, and 6 in. to 223 ft. The method of installation of the 6-in. well casing is unclear, but it appears that a 6-in. drill casing was first driven to 225 ft then retracted from the borehole; 10 ft of 6-in. screen was then welded onto this or similar 6-in. casing and inserted to about 224-ft depth. There are discrepancies between various reports, and the bottom of the screen is between 223 and 225 ft. Current depth to water at TW-1A is about 182 ft.
General Well Characteristics	TW-1A is a single-screen intermediate well. A 16-in.-I.D. steel surface casing was set to a depth of 39 ft to seal out surface water. Twelve-inch-I.D. steel casing was advanced inside the 16-in. casing to a depth of 100 ft, and 6-in. casing was advanced inside the 12 in. to 225 ft. Ten feet of well screen was subsequently welded to the bottom of 214 ft of 6-in. casing and emplaced at a depth of about 214 to 224 ft (±1 ft).	The types of well materials used to construct TW-1A are not specified in reports documenting its installation. Use of carbon-steel drive and well casings was common practice during the time this well was installed, and a well of this age is likely to be highly corroded. There is no annular fill outside the drive casings, although by nature cable-tool drilling usually results in a minimal annulus. The lack of annular fill for most of the length of the well means that the annulus between the well and borehole could act as a preferential pathway for movement of surface or higher-level perched groundwater to the targeted perched zone, although at the time of drilling, there was no indication of any such sources. Contaminants detected at TW-1A include nitrate, phosphate, chloride, boron, and uranium.
Well Screen Construction	TW-1A was constructed with a well screen of unspecified nature.	There is no information about the fabrication or slot sizes of the well screen other than a notation that it was welded to the bottom of 6-in. casing.
Screen Length and Placement	The well screen extends from about 214 to 224 ft (±1 ft) and has a length of 10 ft. The top of the well screen is submerged approximately 32 ft below the top of the perched system (currently about 182 ft below the surface).	TW-1A was installed primarily to provide a monitoring point for a perched aquifer in a Cerros del Rio basalt interflow zone below Pueblo Canyon where contaminants derived from sources could be moving. Examples of these sources include Acid Canyon, sewage plants in Pueblo Canyon, and Manhattan-era buildings in the townsite. The perched aquifer monitoring function of TW-1A has been superseded by the installation of wells POI-4 and R-3i in this part of Pueblo Canyon. Wellhead equipment was removed from TW-1A in 2006 in preparation for plugging and abandonment.

	Description	Evaluation
Filter Pack Materials and Placement	There is no record of a filter pack being installed at TW-1A.	The hole behind the well screen has probably filled in with formation materials. This natural filter pack likely helps to minimize the amount of formation material drawn into the well during sampling.
Sampling System	Submersible pump	Submersible pumps installed in single completion wells allow groundwater to be purged from the well casing, well-filter pack (either added or natural fill), and to some degree, near-well formation materials. Water can pumped at a rate of 10–12 gal./min, greatly facilitating effective purging and efficient sampling. Conventional purging and sampling allow water to be drawn from more deeply within formation materials surrounding the well screen in comparison to low-flow systems, and there is a greater likelihood of obtaining water from zones beyond potential near-well drilling effects. Storage and disposal of purged water require additional resources relative to low-flow sampling systems. Water levels can be measured manually or by dedicated pressure transducers.
Other Issues That Could Affect the Performance of the Well	Corrosion of carbon-steel casing	Corrosion of carbon-steel casing could reduce the structural stability of the well string and affect the quality of groundwater sampled by the well. The geochemical evaluation of groundwater is a means for assessing corrosion of well materials (see Appendix B).
Additives Used	Probably none	Cable-tool drilling does not introduce drilling additives, except for a small amount of municipal water.
Annular Fill Other Than Filter and Transition Sands	There is no record of annular fill being installed at TW-1A.	Most likely, no annular materials were introduced outside or between the 12-in. and 6-in. casings.

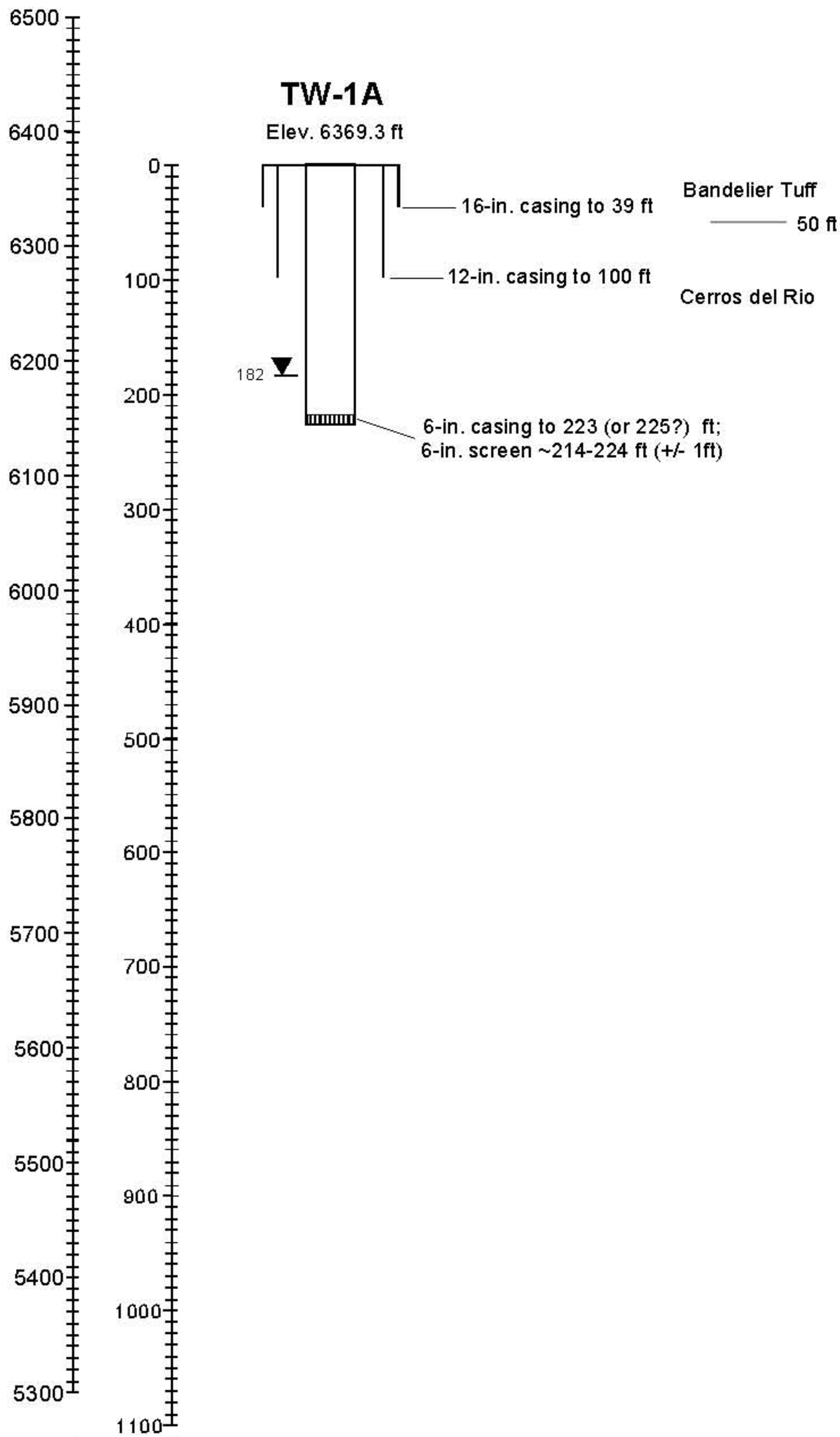


Figure 1 Well construction and stratigraphy at TW-1A

TW-2 Well

TW-2 Well

	Description	Evaluation
Drilling Method	TW-2 was drilled using a cable-tool method.	In 1949, TW-2 was drilled to a depth of 789 ft using the cable-tool method (Black and Veatch 1950, 008417; John et al. 1966, 008796; Purtymun 1995, 045344; Purtymun and Swanton 1998, 099096). The casing diameter is 16 in. (I.D.) to a depth of 57 ft, 12 in. to 197 ft, 10 in. to 519 ft, 8 in. to 778 ft, and 6 in. from 774 to 789 ft. Open hole was drilled from 778 to 789 ft (Figure 1). Original depth to top of saturation was 759 ft. Water levels at TW-2 have declined significantly. In 1990, the 15 ft of blank 6-in. casing and 6-in. screen were fished from the well, and the hole was redrilled by cable-tool methods to 834 ft through the 8-in. casing. A new 6-in. casing (possibly stainless steel) was set from surface to 834 ft with the lower section slotted from 774 to 824 ft (Purtymun and Swanton 1998, 099096), The last reliable measurement of depth to water was in 2000, with a measured depth to water of about 803 ft.
General Well Characteristics	TW-2 is a single-screen well. A 16-in.-I.D. steel-surface casing was set to a depth of 56 ft to seal out surface water. Twelve-inch-I.D. steel casing was advanced inside the 16-in. casing to a depth of 197 ft, 10-in. casing was advanced inside the 12-in. to 519 ft, and 8-in. casing was advanced inside the 10-in. to 778 ft. Open hole was drilled from 778 to 789 ft. Five feet of 6-in.-I.D. blank steel casing was hung inside the 8-in. casing from 774 to 779 ft, with a packer, making a seal between the two casings. Ten feet of 6-in. well screen was suspended from 779 to 789 ft beneath the blank 6-in. casing.	The types of well materials used to construct the initial well at TW-2 are not specified in reports documenting the installation of the well. Use of carbon-steel drive and well casings was common practice during the time this well was installed, and a well of this age is likely to be highly corroded. Below 778-ft depth, there is no annular fill outside the drive casings, although by nature cable-tool drilling usually results in a minimal annulus. The lack of annular fill for most of the length of the well means that the annulus between the well and borehole could act as a preferential pathway for movement of perched groundwater to the regional aquifer. Two perched zones were reported during the drilling of TW-2, one at 112 ft and another at 165 to 170 ft. Contaminants detected at regional aquifer well R-4 to the east include tritium and nitrate.

	Description	Evaluation
General Well Characteristics (continued)	In 1990, after water levels had dropped below the bottom of the original screen at TW-2, the 15 ft of blank 6-in. casing and 6-in. screen were fished from the well, and the hole was redrilled to 834 ft through the 8-in. casing. A new 6-in. casing was set from surface to 834 ft with the lower section slotted from 774 to 824 ft (Purtymun and Swanton 1998, 099096).	
Well Screen Construction	The original well at TW-2 was constructed with a bronze wire-wrapped well screen.	Wire-wrapped well screens are generally considered preferable to pipe-based slotted screens for minimizing the amount of formation material drawn into the well during sampling. There is no information about the slot sizes of the well screen in reports describing the installation of this well. The 6-in. well screen is below the 8-in. casing, with 5 ft of blank 6-in. casing above the screen and below the bottom of the 8-in. casing.
Screen Length and Placement	The current well screen extends from 774 to 824 and has a length of 50 ft. The top of the well screen is approximately 29 ft above the current water table (currently about 803 ft below the surface), leaving about 21 ft of screen within the regional aquifer.	TW-2 was installed primarily to provide a monitoring point for the regional aquifer below Pueblo Canyon where contaminants derived from sources could be moving in the regional aquifer. Examples of these sources include Acid Canyon, sewage plants in Pueblo Canyon, and Manhattan-era buildings in the townsite. The regional aquifer monitoring function of TW-2 has been superseded by the installation of wells R-2 and R-4 above and below TW-2, respectively, in this part of Pueblo Canyon.
Filter Pack Materials and Placement	There is no record of a filter pack being installed at TW-2.	Over time, the open hole occupied by the well screen probably filled in with formation materials. This natural filter pack likely helps to minimize the amount of formation material drawn into the well during sampling.

	Description	Evaluation
Sampling System	Submersible pump	Submersible pumps installed in single completion wells allow groundwater to be purged from the well casing, well-filter pack (either added or natural fill), and to some degree, near-well formation materials. Water can pumped at a rate of 10–12 gal./min, greatly facilitating effective purging and efficient sampling. Conventional purging and sampling allow water to be drawn from more deeply within formation materials surrounding the well screen in comparison to low-flow systems, and there is a greater likelihood of obtaining water from zones beyond potential near-well drilling effects. Storage and disposal of purged water require additional resources relative to low-flow sampling systems. Water levels can be measured manually or by dedicated pressure transducers.
Other Issues That Could Affect the Performance of the Well	Corrosion of carbon-steel casing	Corrosion of carbon-steel casing could reduce the structural stability of the well string and affect the quality of groundwater sampled by the well. The geochemical evaluation of groundwater is a means for assessing corrosion of well materials (see Appendix B).
Additives Used	Probably none	Cable-tool drilling does not introduce drilling additives, except for a small amount of municipal water.
Annular Fill Other Than Filter and Transition Sands	There is no record of annular fill being installed at TW-2.	Most likely, no annular materials were introduced outside or between the 16-in., 12-in., 10-in., 8-in., and 6-in. casings.

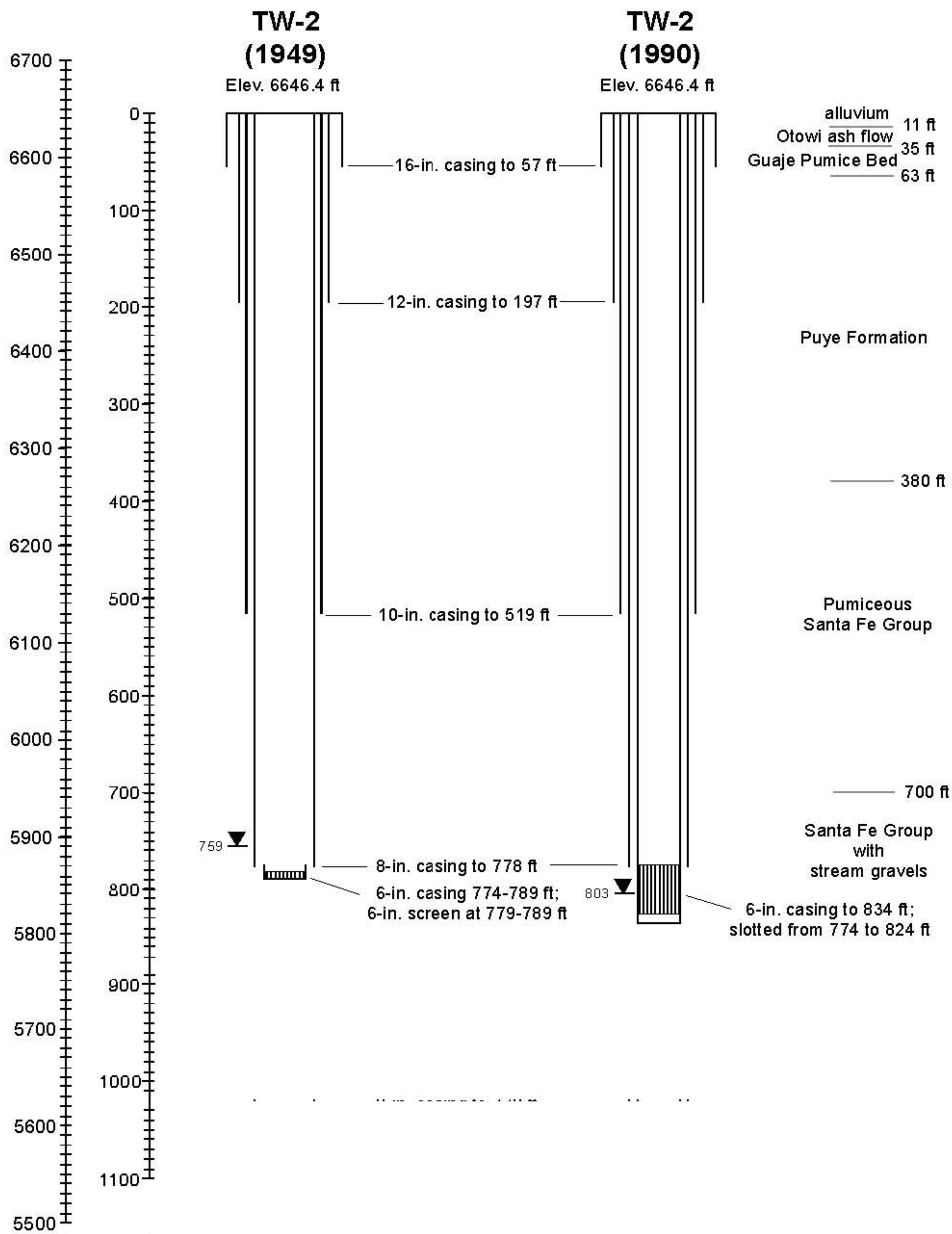


Figure 1 **Original and modified well construction at TW-2 with stratigraphy**

TW-2A Well

TW-2A Well

	Description	Evaluation
Drilling Method	TW-2A was drilled using a cable-tool method.	In 1950 (or 1949; documents are inconsistent), TW-2A was drilled to a depth of 133 ft using the cable-tool method (Black and Veatch 1950, 008417; John et al. 1966, 008796; Purtymun 1995, 045344; Purtymun and Swanton 1998, 099096). The casing diameter is 12 in. (I.D.) to a depth of 12 ft, 8 in. to 118 ft, and 6 in. from 113 to 133 ft (Figure 1). Open hole was drilled from 118 to 133 ft. Water levels at TW-2A declined until 2005 but have recently been rising; current depth to water is about 107 ft.
General Well Characteristics	TW-2A is a single-screen well. A 12-in.-I.D. steel-surface casing was set to a depth of 12 ft to seal out surface water. Eight-inch-I.D. steel casing was advanced inside the 12-in. casing to a depth of 118 ft. Open hole was drilled from 118 to 133 ft. Either 10 or 15 ft (depending on source document) of 6-in.-I.D. blank steel casing was hung inside the 8-in. casing from 113 to 123 ft (or 128 ft), with a lead packer, making a seal between the two casings at 113 ft. Ten feet (or 5 ft) of 6-in. well screen was suspended from 123 to 133 ft (or 128 to 133 ft) beneath the blank 6-in. casing.	The types of well materials used to construct the initial well at TW-2A are not specified in reports documenting its installation. Use of carbon-steel drive and well casings was common practice during the time this well was installed, and a well of this age is likely to be highly corroded. Below 118-ft depth, there is no annular fill outside the drive casings, although by nature cable-tool drilling usually results in a minimal annulus. The lack of annular fill for most of the length of the well means that the annulus between the well and borehole could act as a preferential pathway for movement of perched groundwater to the regional aquifer. Two perched zones were reported during the drilling of nearby regional well TW-2, one at 112 ft and another at 165 to 170 ft. TW-2A was drilled to target the zone at 165 ft but was instead designed to sample water encountered at a higher level. Contaminants that have been observed in TW-2A include tritium and nitrate. Two more attempts were made to install a well in the deeper zone at 165 ft depth, but both boreholes encountered dry conditions (Purtymun and Swanton 1998, 099096).
Well Screen Construction	Because it was installed by Layne-Western, Inc., the well at TW-2A is likely constructed with a bronze wire-wrapped well screen.	Wire-wrapped well screens are generally considered preferable to pipe-based slotted screens for minimizing the amount of formation material drawn into the well during sampling. There is no information about the slot sizes of the well screen in reports describing the installation of this well. Reports are inconsistent; the screen length is either 5 ft or 10 ft and is suspended beneath either 15 ft or 10 ft of blank casing, respectively.

	Description	Evaluation
Screen Length and Placement	The well screen extends from either 128 to 133 ft or 123 to 133 ft, depending on inconsistent sources. The screen is thus either 5 ft or 10 ft long. The top of the well screen (using the 123-ft depth) is submerged, approximately 16 ft below the current top of perched saturation (currently about 107 ft below the surface).	TW-2A was installed primarily to provide a monitoring point for a mid-canyon perched aquifer below Pueblo Canyon where contaminants derived from sources could be moving in the regional aquifer. Examples of sources include Acid Canyon, sewage plants in Pueblo Canyon, and Manhattan-era buildings in the townsite. To provide more modern wells capable of sampling this perched system, two 2-in.-O.D. PVC piezometers were installed near regional well R-4, one with a screen at 115–125 ft (west side of R-4) and another with a screen at 221–231 ft (east side of R-4). These piezometers are ~3100 ft east of TW-2A. The deeper piezometer has been dry since installation; the shallower one contained water at 114-ft depth (possibly from completion activities), right after completion, but has only had water in the sump since then.
Filter Pack Materials and Placement	There is no record of a filter pack being installed at TW-2A.	Over time, the open hole occupied by the well screen probably filled in with formation materials. This natural filter pack likely helps to minimize the amount of formation material drawn into the well during sampling.
Sampling System	Submersible pump	Submersible pumps installed in single completion wells allow groundwater to be purged from the well casing, well-filter pack (either added or natural fill), and to some degree, near-well formation materials. Water can pumped at a rate of 10–12 gal./min, greatly facilitating effective purging and efficient sampling. Conventional purging and sampling allow water to be drawn from more deeply within formation materials surrounding the well screen in comparison to low-flow systems, and there is a greater likelihood of obtaining water from zones beyond potential near-well drilling effects. Storage and disposal of purged water require additional resources relative to low-flow sampling systems. Water levels can be measured manually or by dedicated pressure transducers.
Other Issues That Could Affect the Performance of the Well	Corrosion of carbon-steel casing	Corrosion of carbon-steel casing could reduce the structural stability of the well string and affect the quality of groundwater sampled by the well. The geochemical evaluation of groundwater is a means for assessing corrosion of well materials (see Appendix B).
Additives Used	Probably none	Cable-tool drilling does not introduce drilling additives except for a small amount of municipal water.
Annular Fill Other Than Filter and Transition Sands	There is no record of annular fill being installed at TW-2A.	Most likely, no annular materials were introduced outside or between the 12-in., 8-in., and 6-in. casings.

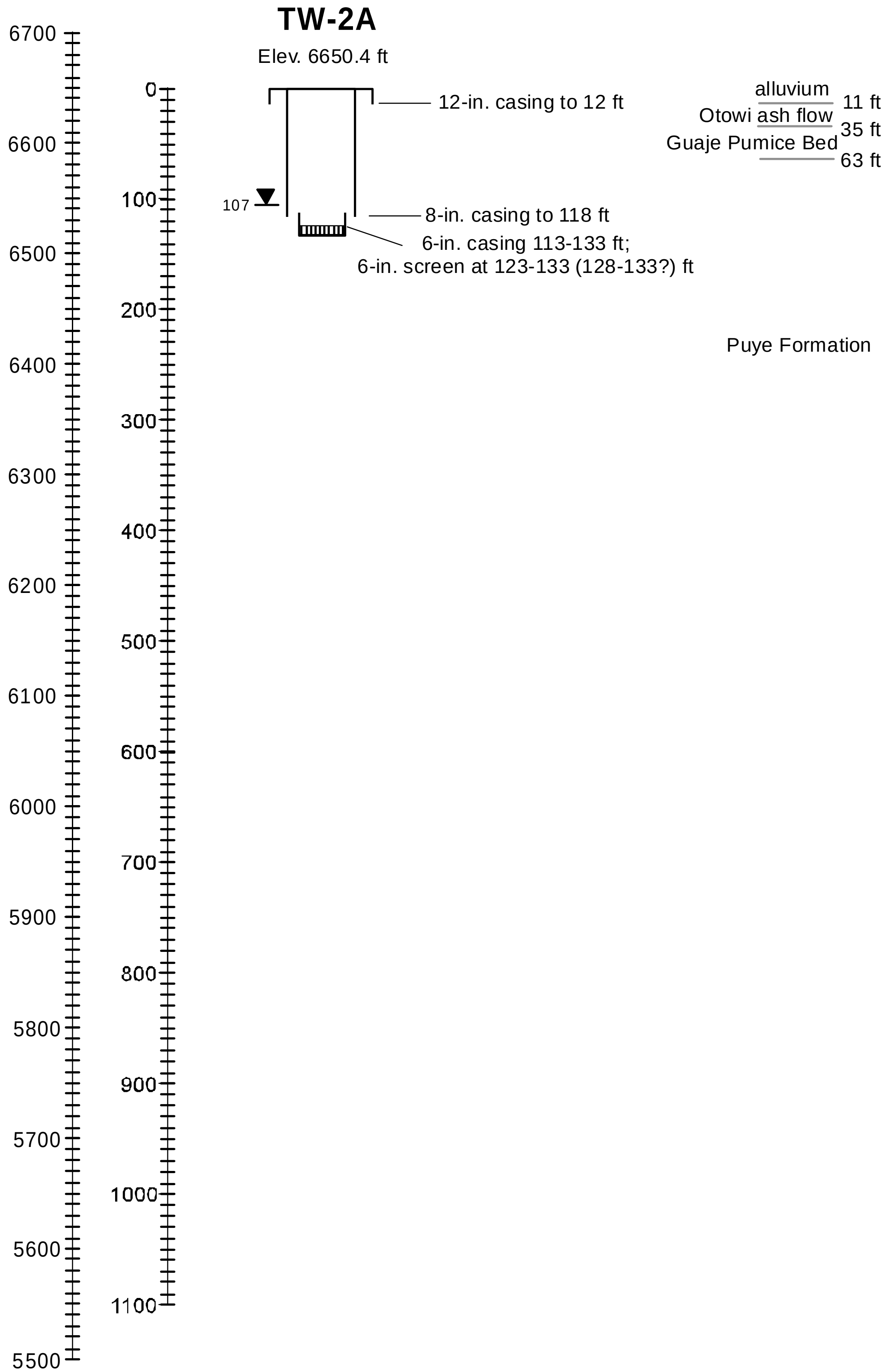


Figure 1 **Well construction and stratigraphy at TW-2A**

TW-3 Well

TW-3 Well

	Description	Evaluation
Drilling Method	TW-3 was drilled using a cable-tool method.	In 1949, TW-3 was drilled to a depth of 815 ft using the cable-tool method (Black and Veatch 1950, 008417; John et al. 1966, 008796; Purtymun 1995, 045344; Purtymun and Swanton 1998, 099096). The casing diameter is 16 in. to a depth of 33 ft and 10 in. from 33 to 811 ft. Open hole was drilled from 811 to 815 ft.
General Well Characteristics	TW-3 is a single-screen well. A 16-in.-casing was set to a depth of 33 ft to seal out surface water. A 10- in.-I.D. steel casing was advanced inside the 16-in. casing to a depth of 811 ft. Open hole was drilled from 811 to 815 ft. Ten feet of 6-in.-I.D. steel casing was hung inside the 10-in. casing from 795 to 805 ft with a packer making a seal between the two casings at 795 ft. Ten feet of 6-in. Layne Western, Inc., well screen was suspended from 805 to 815 ft beneath the 6-in casing.	The types of well materials used to construct TW-3 are not specified in reports documenting its installation. Use of carbon-steel drive and well casings was common practice during the time this was installed, and a well of this age is likely to be highly corroded. Furthermore, there is no annular fill outside the drive casings, although by nature cable-tool drilling usually results in a minimal annulus. The lack of annular fill for most of the length of the well means that the annulus between the well and borehole may act as a preferential pathway for movement of alluvial groundwater to the regional aquifer. Persistence of low-level tritium in groundwater from TW-3, coupled with the absence of contaminants in the properly constructed upgradient of well R-6, suggests that contaminants may be leaking from the surface to the regional aquifer through pathways associated with the annulus of TW-3. Although no perched water was noted in 1949 when TW-3 was drilled, new shallow wells LAOI-3.2 and LAOI-3.2a (completed in 2005) sample perching horizons in the Guaje Pumice Bed and in the upper Puye Formation that have elevated tritium content, providing a likely source for contaminant flow along the annulus of TW-3. Because of its age, construction, and possible contribution to contamination in the regional aquifer, TW-3 should be plugged and abandoned as soon as possible.
Well Screen Construction	TW-3 was constructed with a bronze wire-wrapped well screen.	Wire-wrapped well screens are generally considered preferable to the pipe-based slotted screens for minimizing the amount of formation material drawn into the well during sampling. There is no information about the slot sizes of the well screen in reports describing the installation of this well. The 6-in. well screen overlaps the bottom of the 10-in. casing, and 4 ft of the well screen extends into open borehole below the bottom of the 10-in. casing.
Screen Length and Placement	The well screen extends from about 805 to 815 ft and has a length of 10 ft. The top of the well screen where it exits the 10-in. casing (811 ft) is submerged, approximately 24 ft below the current water table (currently about 787 ft below the surface).	TW-3 was installed primarily to provide a monitoring point for the regional aquifer below Los Alamos Canyon where contaminants derived from such sources as TA-21 and Manhattan-era buildings in the townsite could be entering the regional aquifer. The regional aquifer-monitoring function of TW-3 is superseded by the installation of wells R-6 and R-8.

	Description	Evaluation
Filter Pack Materials and Placement	There is no record of a filter pack being installed at TW-3.	Over time, the open hole occupied by the well screen probably filled in with formation materials. This natural filter pack likely helps to minimize the amount of formation material drawn into the well during sampling.
Sampling System	Submersible pump	Submersible pumps installed in single completion wells allow groundwater to be purged from the well casing, well-filter pack, and to some degree, near-well formation materials. Water can pumped at a rate of 10–12 gal./min, greatly facilitating effective purging and efficient sampling. Conventional purging and sampling allow water to be drawn from more deeply within formation materials surrounding the well screen in comparison to low-flow systems, and there is a greater likelihood of obtaining water from zones beyond potential near-well drilling effects. Storage and disposal of purged water require additional resources relative to low-flow sampling systems. Water levels can be measured manually or by dedicated pressure transducers.
Other Issues That Could Affect the Performance of the Well	Corrosion of carbon-steel casing	Corrosion of carbon-steel casing could reduce the structural stability of the well string and affect the quality of groundwater sampled by the well. The geochemical evaluation of groundwater is a means for assessing corrosion of well materials (see Appendix B).
Additives Used	Probably none	Cable-tool drilling does not introduce drilling additives, except for a small amount of municipal water.
Annular Fill Other Than Filter and Transition Sands	There is no record of annular fill being installed at TW-3.	Most likely, no annular materials were introduced outside the 16-in. and 10-in. casings.

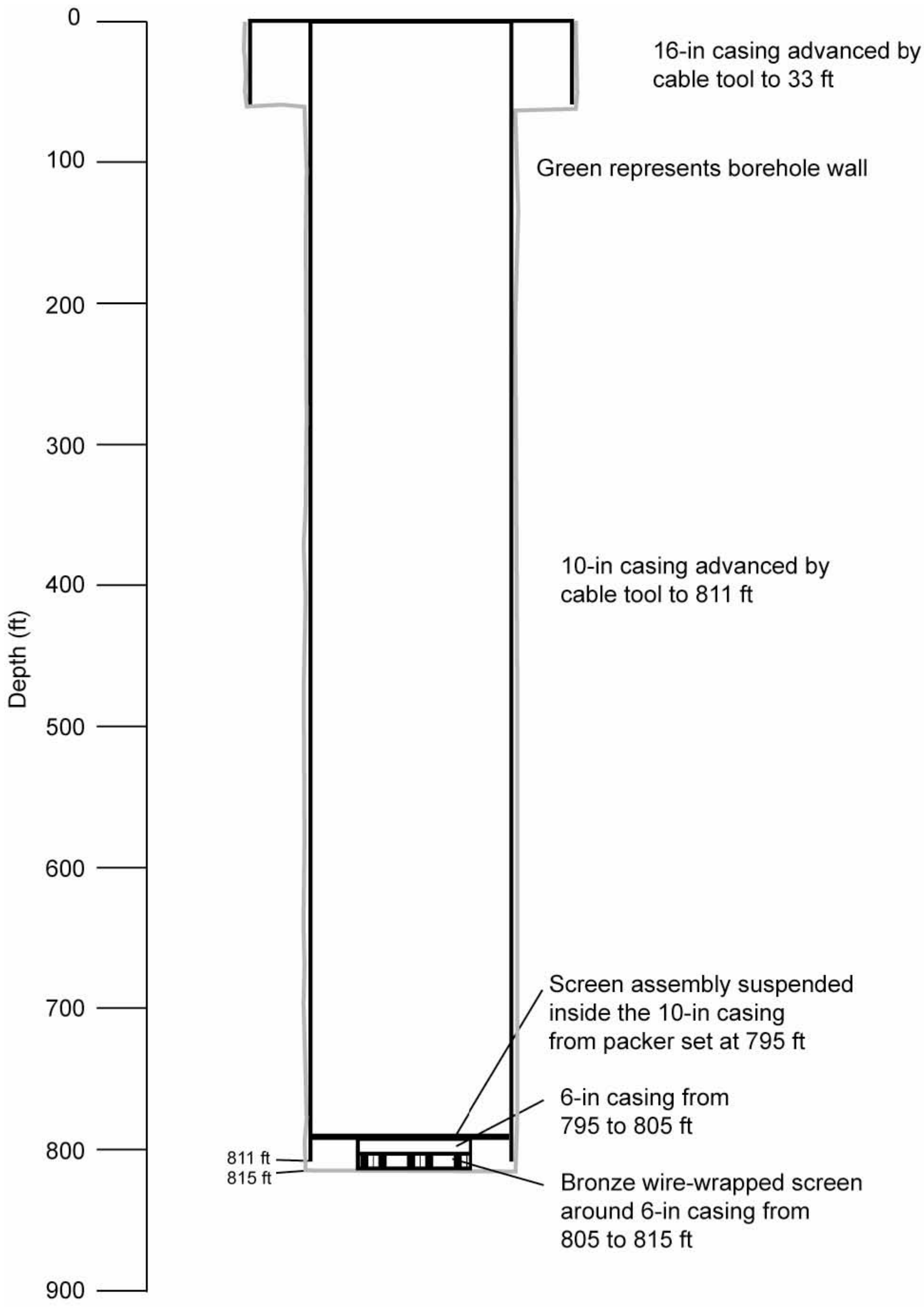


Figure 1 TW-3 well casing and screen construction

TW-4 Well

TW-4 Well

	Description	Evaluation
Drilling Method	TW-4 was drilled using a cable-tool method.	In 1950, TW-4 was drilled to a depth of 1205 ft using the cable-tool method (Black and Veatch 1950, 008417; John et al. 1966, 008796; Purtymun 1995, 045344; Purtymun and Swanton 1998, 099096). The casing diameter is 16 in. (I.D.) to a depth of 109 ft, 12 in. to 288 ft, 10 in. to either 633 ft or 734 ft (source documents differ), 6 in. to 1195 ft, and 4 in. from 1184 to 1205 ft. Open hole was drilled from 1195 to 1205 ft. Current depth to water in TW-4 is about 1173 ft.
General Well Characteristics	TW-4 is a single-screen well. A 16-in.-I.D. steel-surface casing was set to a depth of 109 ft to seal out surface and alluvial water. A 12 in.-I.D. steel casing was advanced inside the 16-in. casing to a depth of 288 ft, 10-in. casing was advanced inside the 12-in. to either 633 ft or 734 ft (source documents differ), and 6-in. casing was advanced inside the 10-in. to 1195 ft. Open hole was drilled from 1195 to 1205 ft. Eleven feet of blank 4-in.-I.D. steel casing was hung inside the 6-in casing from 1184 ft to 1195 ft with a lead packer making a seal between the two casings at 1183 ft. Ten feet of 4-in. well screen extends from 1195 to 1205 ft beneath the blank 4-in. casing.	The types of well materials used to construct the initial well at TW-4 are not specified in reports documenting its installation. Use of carbon-steel drive and well casings was common practice during the time this well was installed, and a well of this age is likely to be highly corroded. Below 1195-ft depth, there is no annular fill outside the drive casings, although by nature cable tool drilling usually results in a minimal annulus. The lack of annular fill for most of the length of the well means that the annulus between the well and borehole could act as a preferential pathway for movement of perched groundwater to the regional aquifer. Strong evidence of corrosion (e.g., high Fe content in sampled water) limits use of TW-4 for detecting contaminants. Well head equipment was removed in 2006 in preparation for plugging and abandonment.
Well Screen Construction	The well at TW-4 was constructed with a bronze wire-wrapped well screen.	Wire-wrapped well screens are generally considered preferable to pipe-based slotted screens for minimizing the amount of formation material drawn into the well during sampling. There is no information about the slot sizes of the well screen in reports describing the installation of this well. Ten feet of the 4-in. well screen is below the 6-in. casing, with 1 ft of screen and 11 ft of blank 4-in. casing within the 6-in. casing.

	Description	Evaluation
Screen Length and Placement	The current well screen extends from 1195 to 1205 ft and has a length of 10 ft (9 ft of which is exposed below the 6-in. casing). The top of the well screen is submerged approximately 22 ft below the current water table (currently about 1173 ft below the surface).	TW-4 was installed primarily to provide a monitoring point for the regional aquifer near the confluence of Acid and Pueblo Canyons where contaminants derived from sources such as Acid Canyon and Manhattan-era buildings in the townsite could be moving in the regional aquifer. The regional aquifer monitoring function of TW-4 has been superseded by the installation of wells R-2.
Filter Pack Materials and Placement	There is no record of a filter pack being installed at TW-4.	Over time, the open hole occupied by the well screen probably filled in with formation materials. This natural filter pack likely helps to minimize the amount of formation material drawn into the well during sampling.
Sampling System	Submersible pump	Submersible pumps installed in single completion wells allow groundwater to be purged from the well casing, well-filter pack (either added or natural fill), and to some degree, near-well formation materials. Water can pumped at a rate of 10–12 gal./min, greatly facilitating effective purging and efficient sampling. Conventional purging and sampling allow water to be drawn from more deeply within formation materials surrounding the well screen in comparison to low-flow systems, and there is a greater likelihood of obtaining water from zones beyond potential near-well drilling effects. Storage and disposal of purged water require additional resources relative to low-flow sampling systems. Water levels can be measured manually or by dedicated pressure transducers.
Other Issues That Could Affect the Performance of the Well	Corrosion of carbon-steel casing	Corrosion of carbon-steel casing could reduce the structural stability of the well string and affect the quality of groundwater sampled by the well. The geochemical evaluation of groundwater is a means for assessing corrosion of well materials (see Appendix B).
Additives Used	Probably none	Cable-tool drilling does not introduce drilling additives, except for a small amount of municipal water.
Annular Fill Other Than Filter and Transition Sands	There is no record of annular fill being installed at TW-4.	Most likely, no annular materials were introduced outside or between the 16-in., 12-in., 10-in., 6-in., and 4-in. casings.

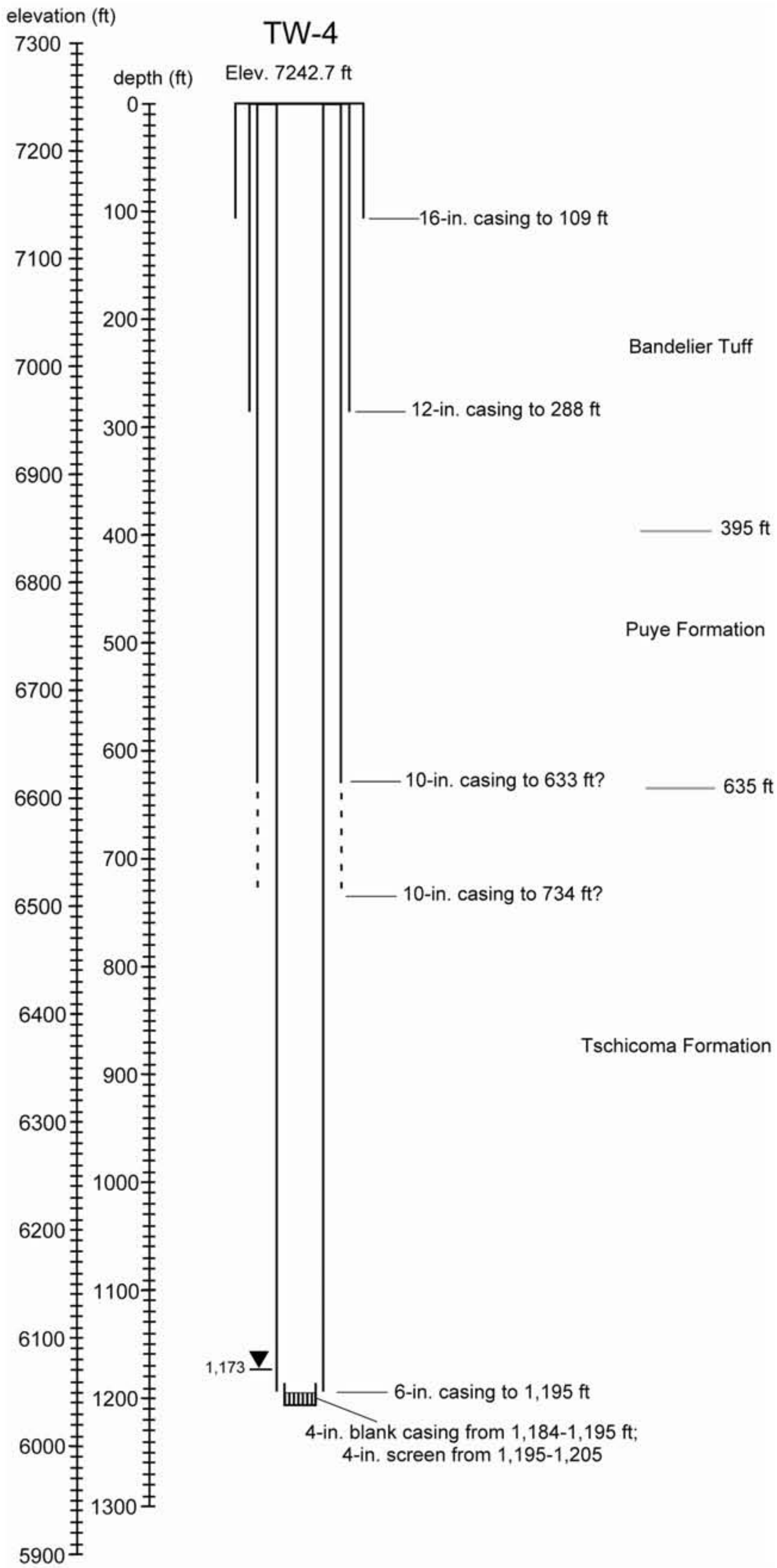


Figure 1 Well construction and stratigraphy at TW-4

A-2.0 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 number. This information is also included in text citations. ER ID numbers 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; the U.S. Department of Energy–Los Alamos Site Office; the U.S. Environmental Protection Agency, Region 6; 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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Purtymun, W.D., and A.S. Swanton, February 5, 1998. "Engineering, Geology, and Construction Data of Twenty-Five Test Holes and Test Wells on and Adjacent to the Pajarito Plateau," draft, Los Alamos National Laboratory, Los Alamos, New Mexico. (Purtymun and Swanton 1998, 099096)

Appendix B

Geochemical Performance of Network Wells

B-1.0 PURPOSE

This appendix presents the results obtained in the evaluation of the reliability and representativeness (R&R) of sample data collected from 23 candidate network monitoring wells for the Los Alamos Canyon and Pueblo Canyon monitoring network. These 23 wells contain 28 screened intervals that provide water samples for chemical analysis. The objective of the evaluation is to determine whether these intervals are capable of providing data that are R&R of predrilling conditions for chemicals of potential concern (COPCs) that meet the objectives for the Los Alamos Canyon and Pueblo Canyon monitoring network.

The evaluation is conducted following the approach outlined in the "Well Screen Analysis Report Revision 2" (hereafter, WSAR Rev. 2) (LANL 2007, 096330) using test indicators and test threshold values as implemented in EP-ERSS-SOP-5133, Analytical Data Qualification for Residual Effects of Drilling Products (draft dated 10-Dec-07). After summarizing the outcome of the evaluation in Section B-2.0 and Table B-1, the rest of the appendix outlines the steps of the process applied and documents the data used to derive the evaluation results.

B-2.0 RESULTS OF GEOCHEMICAL PERFORMANCE EVALUATION

The current capability of each screen to meet geochemical monitoring objectives is expressed by assignment of the screen to one of three categories:

- Meets geochemical monitoring objectives unconditionally—the evaluation does not reveal compelling evidence for any residual drilling effects, and the screen provides R&R samples for all COPCs
- Meets geochemical monitoring objectives conditionally—the evaluation indicates the presence of a residual drilling effect, but the screen currently provides R&R samples for some COPCs
- Does not meet geochemical monitoring objectives—the evaluation shows obvious geochemical effects related to drilling, such that the screen cannot provide R&R samples for any COPCs, and conditions do not show clear signs of improving within a reasonable time frame

Evaluation results are summarized below in terms of the present-day status of each screen interval with respect to its recovery from residual effects of drilling, based on an evaluation of the most recent sampling events. None of the sampling events used in this report were previously included in WSAR Rev. 2, either because the events occurred after December 2006 (the cutoff date for samples covered by WSAR Rev. 2), or because the wells were outside the scope of that report. Table B-1 tabulates the capability of each screen to provide water samples that are R&R for nine COPCs and other key analytes: tritium, boron (B), chloride (Cl), perchlorate (ClO_4), nitrate (NO_3), sulfate (SO_4), chromium (Cr), molybdenum (Mo), and uranium (U).

B-2.1 Evaluation of Regional Monitoring Wells

R-2 meets geochemical monitoring objectives unconditionally.

R-3i meets geochemical monitoring objectives unconditionally.

- Strontium concentrations in samples from this screen are consistently elevated above the upper test threshold value used for this indicator. Elevated strontium concentrations are also observed in two other perched intermediate wells that, like R-3i, are also screened in Cerros del Rio basalt: POI-4 (discussed later in this section) and MCOI-6 (LANL 2007, 099128). Based on this observation, in conjunction with the stability of strontium concentrations in these intervals, it is concluded that the elevated strontium is representative of the groundwater at this location and is not a residual effect of drilling. The elevated strontium could be is attributed to natural variations not captured by the limited set of groundwater types used to establish background ranges in the "Groundwater Background Investigation Report, Revision 3" (LANL 2007, 095817). In that report, the background concentration of strontium in perched intermediate groundwater was established at springs discharging within the Sierra de los Valles consisting of the Bandelier Tuff and Tschicoma Formation. Background water chemistry for the Cerros del Rio basalt in perched intermediate groundwater has not been established. Alternatively, the elevated strontium concentrations might be associated with the site-specific contamination at this location, reflecting water-rock interactions along the flowpath.

- Calcium, magnesium, sodium, and barium concentrations are also elevated above the upper test threshold values used for these indicators. The cause is unknown, but the stability of the elevated concentrations suggests that they are representative of the groundwater at this location and not related to drilling effects.
- COPCs presently detected in this screen that are above the upper threshold limits (UTLs) (or their equivalent) for background levels include tritium, B, Cl, ClO_4, NO_3, SO_4, and U.
- R-3i is considered capable of providing R&R data for all COPCs.

<u>R-4</u> meets geochemical monitoring objectives unconditionally.

- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include tritium, ClO_4, and NO_3.

<u>R-5 Screen 2</u> meets geochemical monitoring objectives unconditionally.

- Strontium, calcium, barium, and sodium concentrations are elevated above the upper test threshold values used for these indicators. The cause is uncertain, but the stability of the elevated concentrations suggests that they are representative of the groundwater at this location and not related to drilling effects.
- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include B, ClO_4, NO_3, U, and Cr. However, tritium has not been detected above 1 pCi/L in water samples from this screen, which suggests that these elevated concentrations may be natural in origin and not site-specific contaminants.
- R-5 Screen 2 is considered capable of providing R&R data for all COPCs.

<u>R-5 Screen 3</u> meets geochemical monitoring objectives unconditionally.

- Strontium and barium concentrations are slightly elevated above the upper test threshold values used for these indicators. The cause is uncertain, but the stability of the elevated concentrations suggests that they are representative of the groundwater at this location and not related to drilling effects.
- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include ClO_4, NO_3, SO_4, Cr, and U. However, tritium has not been detected above 1 pCi/L in water samples from this screen, which suggests that these elevated concentrations may be natural in origin and not contaminants.
- R-5 Screen 3 is considered capable of providing R&R data for all COPCs.

<u>R-5 Screen 4</u> does not meet geochemical monitoring objectives.

- Residual inorganic chemicals, iron-reducing conditions, and carbonate-mineral disequilibria are present in this interval, potentially affecting the R&R status of some COPCs.
- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include B, Cl, and Mo. However, concentrations of these analytes are suspect as a result of residual drilling effects. Tritium has not been detected above 1 pCi/L in water samples from this screen, other than a value of 3.5 pCi/L measured in the first characterization sample in November 2001.
- Of the COPCs listed in Table B-1, this screen is currently capable of providing R&R data for tritium. The most recent sample showed improved conditions relative to earlier ones. These conditions and the capability of the screen to provide R&R data for other COPCs will be reevaluated as additional data become available from future samples.

R-6 meets geochemical monitoring objectives unconditionally.

R-6i meets geochemical monitoring objectives unconditionally.

- Calcium, iron, and sodium concentrations are elevated above the upper test threshold values used for these indicators. The cause is uncertain, but the stability of the elevated concentrations suggests that they are representative of the groundwater at this location and not related to drilling effects.
- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include tritium, B, Cl, ClO_4, NO_3, and Cr.
- R-6i is considered capable of providing R&R data for all COPCs.

R-7 Screen 1 was not evaluated.

- The last water-sampling event was in August 2002, and the screen has been dry since then. No obvious drilling-related conditions were apparent in that water sample.
- COPCs detected in this screen in 2002 that are above the UTLs (or their equivalent) for background levels include Cr.

R-7 Screen 3 meets geochemical monitoring objectives conditionally.

- Sulfate-reducing conditions and carbonate-mineral disequilibria are present in this interval, potentially affecting the R&R status of some COPCs.
- Of the COPCs listed in Table B-1, this screen is currently capable of providing R&R data for tritium, B, and Cl. These conditions and the capability of the screen to provide R&R data for other COPCs will be reevaluated as additional data become available from future samples.

R-8 Screen 1 meets geochemical monitoring objectives conditionally.

- In the most recent sample from this screen (July 2007), NO_3 was detected at 0.12 mg/L as N, which is below its test threshold value (0.22 mg/L as N), implying the possible presence of nitrate-reducing conditions. However, all other redox indicators passed their respective tests, and all previous samples detected NO_3 (0.36–0.57 mg/L) above the mean background concentration for the regional aquifer (0.33 mg/L as N) and below the UTL (0.89 mg/L) (LANL 2007, 095817, Table 4.2-3). Thus, it is not clear at this time whether the recent nondetect condition is an aberration or the first indicator of nitrate-reducing conditions. This condition and the capability of the screen to provide R&R data for other COPCs will be reevaluated when additional data become available from future samples.

- R-8 Screen 1 is considered capable of providing R&R data for all COPCs other than NO_3.

<u>R-8 Screen 2</u> meets geochemical monitoring objectives unconditionally.

- Chloride and barium are elevated above the upper test threshold values used for these indicators. The cause of these trends is unknown but does not appear to be related to residual effects of drilling. Water samples from this screen consistently show elevated pH values (8.6 to 9.5), which likely affects the applicability of some test threshold values used to identify residual drilling effects.
- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include Cl. However, tritium has not been detected above 1 pCi/L in water samples from this screen, which suggests that this elevated concentration may be natural in origin and not a contaminant.
- R-8 Screen 2 is considered capable of providing R&R data for all COPCs. These trends and the capability of the screen to provide R&R data for COPCs will be reevaluated as additional data become available from future samples.

<u>R-9</u> meets geochemical monitoring objectives unconditionally.

- Barium and magnesium concentrations are elevated above the upper threshold values used for these indicators. The cause is uncertain, but the stability of the elevated concentrations suggests that they are representative of the groundwater at this location and not related to drilling effects.
- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include tritium, B, Cl, and ClO_4.
- R-9 is considered capable of providing R&R data for all COPCs.

<u>R-9i Screen 1</u> meets geochemical monitoring objectives unconditionally.

- Total organic carbon (TOC) concentrations (3.0–4.6 mg/L, September 2000 to April 2005) are consistently elevated above the test threshold value used for this indicator (1.1 mg/L), implying the possible presence of residual organic drilling products. However, all other residual organic indicators have passed their respective tests for the most recent samples, and the stability of the elevated TOC concentrations suggests that they are representative of the groundwater at this location and not related to drilling effects.
- Manganese-reducing conditions are present in this interval, a condition which may be related to the elevated TOC.

  Note: Reducing conditions for this screen have been slowly but consistently improving since sampling began in September 2000. Because NO_3 was not detected in the groundwater sample collected from this depth interval in the R-9 borehole during drilling, it is assumed that reducing conditions in this screen are representative of predrilling groundwater conditions and not an artifact of residual drilling products.
- Calcium and magnesium are slightly elevated above the upper test threshold values used for these indicators. The cause is uncertain, but the stability of the elevated concentrations suggests that they are representative of the groundwater at this location and not related to drilling effects.
- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include tritium, Cl, U, Cr, and Mo.

- Of the COPCs listed in Table B-1, this screen is currently capable of providing R&R data for all COPCs. Because of the groundwater's reducing condition at this location, concentrations of some redox-sensitive COPCs such as NO3 might fall below the range of natural background; such low concentrations and nondetects are nonetheless R&R data.

R-9i Screen 2 meets geochemical monitoring objectives unconditionally.

- Manganese-reducing conditions are present in this interval. NO_3 and ClO_4 were present at detectable concentrations in the most recent sample, although still below their minimum test thresholds.

  Note: Reducing conditions for this screen have been slowly but consistently improving since sampling began in September 2000. Reducing conditions at this location are likely to be representative of predrilling groundwater conditions and not an artifact of residual drilling products.

- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include tritium, Cl, ClO_4, U, and Mo.
- Of the COPCs listed in Table B-1, this screen is currently capable of providing R&R data for all COPCs. Because of the groundwater's reducing condition at this location, concentrations of some redox-sensitive COPCs such as NO_3 might fall below the range of natural background; such low concentrations and nondetects are nonetheless R&R data.

R-24 meets geochemical monitoring objectives unconditionally.

- Barium concentrations are elevated above the upper threshold limit reported for this element. The cause is uncertain, and it is possible that this condition is representative of the groundwater at this location and not related to drilling effects.
- Despite negative oxidation-reduction potential (ORP) readings and dissolved oxygen concentrations below 2 mg/L, both of which are indicators of reducing conditions, NO_3 and ClO_4 are nonetheless consistently detected above the lower test threshold values used for these indicators, near their median concentrations in regional groundwater.
- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include B, Cl, SO_4, and U.
- R-24 is considered capable of providing R&R data for all COPCs.

B-2.2 Evaluation of Observation and Investigation Wells

LADP-3 meets geochemical monitoring objectives unconditionally.

- Nitrate-reducing conditions are present in the most recent sample; both NO_3 and ClO_4 were detected in this sample but at concentrations below the minimum test threshold values used for these indicators. Alkalinity, sodium, and TOC are elevated above the maximum test threshold values used for these indicators. All of these conditions are assumed to be representative of predrilling groundwater and not an artifact of residual drilling products because no drilling products were used for this borehole. Air was the only fluid used to advance the borehole, which is constructed of polyvinyl chloride (PVC) well casing (Appendix A).

  Note: Reducing conditions for this screen have improved considerably since this well was completed in the mid-1990s. A water sample from 1995 indicated sulfate-reducing conditions.

- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include tritium, B, Cl, U, and Cr.
- LADP-3 is considered capable of providing R&R data for all COPCs.

<u>LAOI(a)-1.1</u> meets geochemical monitoring objectives unconditionally.

- Evaluation of water-quality samples from LAOI(a)-1.1 using the WSAR protocol does not reveal any obvious drilling-related conditions. Total iron concentration in the most recent sample exceeds the threshold value used to flag for steel corrosion, and iron concentrations from past samples are also consistently higher than typically observed in groundwater from the perched intermediate zone in the absence of drilling effects. However, this well is constructed of PVC casing (Appendix A), so indicators used to detect steel corrosion are not relevant. Samples from this well also show consistently elevated turbidities (8–20 nephelometric turbity units [NTUs]). These conditions are assumed to be representative of predrilling groundwater and not an artifact of residual drilling products because no drilling products were used for this borehole. Air was the only fluid used to advance the borehole (Appendix A).
- LAOI(a)-1.1 is considered capable of providing R&R data for all COPCs.
- <u>LAOI-3.2</u> meets geochemical monitoring objectives unconditionally.
- Manganese-reducing conditions have been present in this interval since the well's installation in the 1990s, steadily improving throughout this period. In the most recent sample, redox conditions appear to have been fully restored to oxidizing levels.
- In the most recent sample, phosphate was detected above its maximum test threshold and is an order of magnitude higher than in previous samples. However, the reliability of this analysis is uncertain.
- Calcium concentrations are above the upper test threshold value used for this indicator. The cause is uncertain, and it is likely that this condition is representative of the groundwater at this location and not related to drilling effects.
- The conditions described above are assumed to be representative of predrilling groundwater, and not an artifact of residual drilling products, because no drilling products were used for this borehole. Air was the only fluid used to advance the borehole (Appendix A).
- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include tritium, Cl, ClO_4, NO_3, and U.
- LAOI-3.2 is considered capable of providing R&R data for all COPCs.
- <u>LAOI-3.2a</u> meets geochemical monitoring objectives unconditionally.
- Calcium concentrations are slightly elevated above the upper test threshold value used for this indicator. The cause is uncertain, and it is likely that this condition is representative of the groundwater at this location and not related to drilling effects because no drilling products were used for this borehole. Air was the only fluid used to advance the borehole (Appendix A).
- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include tritium, Cl, ClO_4, NO_3, U, and Cr.
- LAOI-3.2a is considered capable of providing R&R data for all COPCs.
- <u>LAOI-7</u> meets geochemical monitoring objectives unconditionally.

- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include tritium, Cl, and ClO_4.
- LAOI-7 is considered capable of providing R&R data for all COPCs.

POI-4 meets geochemical monitoring objectives unconditionally.

- Barium, calcium, magnesium, and strontium concentrations are elevated above the upper test threshold values used for these indicators. The cause is uncertain, but the stability of the elevated concentrations suggests that they are representative of the groundwater at this location and not related to drilling effects.
- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include tritium, B, Cl, NO_3, and U.
- POI-4 is considered capable of providing R&R data for all COPCs.

B-2.3 Evaluation of Test Wells

TW-1 meets geochemical monitoring objectives conditionally.

- Iron corrosion products are present at TW-1. Although total iron concentrations do not exceed the upper test threshold value used to detect the possible presence of stainless-steel corrosion, the concentrations in TW-1 are nonetheless consistently higher than is typically observed in groundwater from the regional aquifer, as is also true for turbidity levels and zinc concentrations. These three indicators (iron, turbidity, zinc) are likely attributable to corrosion of carbon-steel well components. The type of steel used to construct this well is not known, but high zinc concentrations in the water samples would be consistent with the presence of hot-dip galvanized steel.
- Elevated manganese has also been present in this interval for at least the past decade. Although used as an indicator of reducing conditions, high manganese concentrations in water samples from TW-1 may also derive from steel corrosion. Consistent with this interpretation, NO_3 and ClO_4 have been consistently detected at concentrations well above background UTLs throughout this period.
- Barium, calcium, magnesium, and strontium concentrations are above the upper test threshold values used for these indicators. The cause is uncertain, but the stability of the elevated concentrations suggests that they are representative of the groundwater at this location and not related to drilling effects.
- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include tritium, B, Cl, ClO_4, NO_3, SO_4, and U.
- Of the COPCs listed in Table B-1, this screen is currently capable of providing R&R data for tritium, B, Cl, ClO_4, NO_3, SO_4, and U. Detections of trace metals that might be present as constituents of the well construction materials, such as Cr and Mo, are not R&R data.

TW-1a meets geochemical monitoring objectives conditionally.

- Iron corrosion products are present at TW-1a. Although total iron concentrations do not exceed the upper test threshold value used to detect the possible presence of stainless-steel corrosion, the concentrations in TW-1a are nonetheless consistently higher than is typically observed in groundwater from the perched intermediate zone, as is also true for turbidity levels and zinc concentrations. These three indicators (iron, turbidity, zinc) are likely attributable to corrosion of carbon-steel well components (Appendix A).

- Sulfate-reducing conditions are present in this interval.
- Several indicators used to detect residual inorganic and organic drilling products are also present above their test threshold values: sodium, phosphate, ammonia, and total Kjeldahl nitrogen (TKN). Because cable-tool drilling does not introduce drilling additives, except for a small amount of municipal water (Appendix A), these conditions are probably representative of predrilling groundwater conditions at this location and not artifacts of residual drilling effects.
- Barium, calcium, magnesium, and strontium concentrations are elevated above the upper test threshold values used for these indicators. The cause is uncertain, but the stability of the elevated concentrations suggests that they are representative of the groundwater at this location and not related to drilling effects.
- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include tritium, B, and Cl.
- Of the COPCs listed in Table B-1, this screen is currently capable of providing R&R data for tritium, B, and Cl. Data for redox-sensitive contaminants or for other trace metals that might be present as constituents of the well construction materials are not R&R data.

TW-2 does not meet geochemical monitoring objectives.

- Iron corrosion products are present at TW-2. Total iron concentrations consistently exceed the upper test threshold value used to detect the possible presence of steel corrosion. Zinc concentrations and turbidities are also consistently higher than is typically observed in groundwater from the regional aquifer. These three indicators (iron, turbidity, zinc) are likely attributable to corrosion of carbon-steel well components (Appendix A).
- Sulfate-reducing conditions have been present in this interval for at least the past decade and may still be present.
- Calcium and strontium concentrations are below the minimum threshold values used for these indicators. This condition is probably a consequence of sulfate-reducing conditions.
- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include tritium and B.
- Of the COPCs listed in Table B-1, this screen is currently capable of providing R&R data for tritium, B, and Cl. Data for redox-sensitive contaminants or for other trace metals that might be present as constituents of the well construction materials are not R&R data.

TW-2a meets geochemical monitoring objectives conditionally.

- Iron corrosion products are present at TW-2a. Although total iron concentrations do not exceed the upper test threshold value used to detect the possible presence of stainless-steel corrosion, the concentrations in TW-2a are nonetheless consistently higher than is typically observed in groundwater from the regional aquifer in the absence of drilling effects, as is also true for turbidity levels. These two indicators are likely attributable to corrosion of carbon-steel well components (Appendix A).
- Iron-reducing conditions have been present in this interval for at least the past decade and may still be present. It is conceivable that reducing conditions at this location are representative of predrilling groundwater conditions and not an artifact of residual drilling products.
- Calcium and strontium concentrations are above the maximum threshold values for background groundwater. The cause is uncertain, but the stability of the elevated concentrations suggests that they are representative of the groundwater at this location and not related to drilling effects.

- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include tritium, B, and Cl.
- Of the COPCs listed in Table B-1, this screen is currently capable of providing R&R data for tritium, B, and Cl. Data for redox-sensitive contaminants or for other trace metals that might be present as constituents of the well construction materials are not R&R data.

TW-3 does not meet geochemical monitoring objectives.

- Iron corrosion products are present at TW-3. Total iron concentrations consistently exceed the upper test threshold value used to detect the possible presence of steel corrosion. Zinc concentrations and turbidities are also higher than is typically observed in groundwater from the regional aquifer. These three indicators are likely attributable to corrosion of carbon-steel well components (Appendix A).
- Persistent sulfate-reducing conditions are present in this interval.
- COPCs presently detected in this screen that are above the UTLs (or their equivalent) for background levels include tritium.
- Of the COPCs listed in Table B-1, this screen is currently capable of providing R&R data for tritium, B, and Cl. Data for redox-sensitive contaminants or for other trace metals that might be present as constituents of the well construction materials are not R&R data.

TW-4 does not meet geochemical monitoring objectives.

- Iron corrosion products are present at TW-4. Total iron concentrations consistently exceed the threshold value used to detect the possible presence of steel corrosion. Zinc concentrations are also consistently higher than is typically observed in groundwater from the regional aquifer. These two indicators are likely attributable to corrosion of carbon-steel well components (Appendix A).
- Sulfate-reducing conditions are present in this interval.
- Of the COPCs listed in Table B-1, this screen is currently capable of providing R&R data for tritium, B, and Cl. Data for redox-sensitive contaminants or for other trace metals that might be present as constituents of the well construction materials are not R&R data.

B-3.0 APPROACH

The evaluation summarized above was conducted following the approach described in Section 4 of WSAR Rev. 2 (LANL 2007, 096330). Analytical data are compared against threshold levels for about 30 geochemical indicator species, which serve as test criteria for identifying the presence of residual drilling effects. The threshold levels are defined based on levels measured in background samples assumed to be representative of water quality in perched intermediate water or in the regional aquifer beneath the Pajarito Plateau, as reported in the “Groundwater Background Investigation Report, Revision 2” (LANL 2007, 094856). The test criteria are used to identify samples that appear not to be R&R of predrilling groundwater chemistry because of residual effects of drilling fluids. Site groundwater contamination for each well is also considered in this process. The residual effects are classified into seven categories (LANL 2007, 096330):

- Category A—Residual inorganic constituents from drilling, construction, and development products
- Category B—Residual organic components from drilling products
- Category C—Modification of in situ redox conditions

- Category D—Modification of surface-active mineral surfaces with the effect of enhancing adsorption, such as onto drilling clays
- Category E—Carbonate/sulfate-mineral disequilibria
- Category F—Corrosion of stainless-steel well components
- A seventh category includes general water-quality indicators: pH, alkalinity, and turbidity. Anomalous values for these constituents commonly accompany other indicators of residual drilling effects, but these excursions generally cannot be attributed with confidence to any single cause.

B-4.0 ANALYSIS OF RESIDUAL EFFECTS OF DRILLING

The results of each step of the geochemical performance evaluation are summarized in four tables, for which supporting details are documented in WSAR Rev. 2 (LANL 2007, 096330) and in additional tables at the end of this appendix.

- Table B-2 identifies test indicators that are not applicable for the R&R evaluation in specific sampling intervals because they are present as site-specific contaminants in that interval, which can bias the test outcome. In addition to tritium, the most common contaminants detected in the candidate monitoring wells at levels above the background UTLs are mobile anions—B, Cl, ClO_4, NO_3, SO_4, and U—one or more of which is present in 15 of the 28 intervals, 11 of which are in perched intermediate zones. Also present above background UTL but with much less frequency is Cr.
- Table B-3 summarizes the current status of each sampling interval for any residual effects of drilling, focusing on the results for the most recent samples. Most of these evaluations are not covered by WSAR Rev. 2 (LANL 2007, 096330), either because the data became available after that report had been prepared or because the wells did not fall within the scope of that report.
- Table B-4 lists the COPCs and identifies which residual drilling effects, if any, have the potential to impact the data reliability and representativeness. This table is based on information tabulated in WSAR Rev. 2 (LANL 2007, 096330, Appendix A).
- The result of the evaluation process was presented earlier as Table B-1, which summarizes the capability of each interval for producing R&R samples for each COPC. This table is constructed by combining the test outcomes (Table B-3) with the COPC list (Table B-4).

Details supporting the screen evaluations summarized in Table B-3 are documented in the following data tables. For each of the test indicators, column headings in these tables list the type of test.

- Table B-5, General Water-Quality Indicators and Field Parameters (tritium, pH, alkalinity, turbidity, oxygen-reduction potential, dissolved oxygen, sulfide)
- Table B-6, Organic Indicators (acetone, ammonia, TKN, TOC)
- Table B-7, Inorganic Nonmetal Indicators (barium, calcium, chloride, fluoride, magnesium, nitrate, perchlorate, phosphate, sodium, strontium, sulfate)
- Table B-8, Trace Metal Indicators (boron, chromium, iron, manganese, nickel, uranium, vanadium, zinc)

For each of the test indicators, column headings in Tables B-5 through B-8 provide the following information used for the evaluation. This information is taken from EP-ERSS-SOP-5133, Analytical Data Qualification for Residual Effects of Drilling Products (draft dated 10-Dec-07):

- Test number (e.g., Test A1)
- Type of test criterion, either >LL (data must be greater than or equal to the specified lower limit in order to pass) or <UL (data must be less than or equal to the specified upper limit in order to pass)
- Numerical threshold values used for the regional aquifer and the perched intermediate zone
- Laboratory qualifier codes (for selected analytes)

The final table in this appendix is Table B-9, Summary of Test Outcomes. This table provides a visual synopsis of the detailed data assessment tables in Tables B-5 through B-8. In this table, raw data and data qualifiers shown in the preceding tables have been stripped out, leaving only the Pass/Fail outcomes for each test. Tests are grouped by category of drilling effects; for example, all of the tests to evaluate redox conditions are grouped together in Category C. The identification of consistent outcomes for the different test categories is the basis for determining what residual drilling effects are present, as summarized in Table B-3.

B-5.0 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 number. This information is also included in text citations. ER ID numbers 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; the U.S. Department of Energy–Los Alamos Site Office; the U.S. Environmental Protection Agency, Region 6; 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)

LANL (Los Alamos National Laboratory), February 2007. "Groundwater Background Investigation Report, Revision 2," Los Alamos National Laboratory document LA-UR-07-0755, Los Alamos, New Mexico. (LANL 2007, 094856)

LANL (Los Alamos National Laboratory), May 2007. "Well Screen Analysis Report, Revision 2," Los Alamos National Laboratory document LA-UR-07-2852, Los Alamos, New Mexico. (LANL 2007, 096330)

LANL (Los Alamos National Laboratory), September 2007. "Mortandad Canyon Groundwater Monitoring Well Network Evaluation, Revision 1," Los Alamos National Laboratory document LA-UR-07-6435, Los Alamos, New Mexico. (LANL 2007, 099128)

LANL (Los Alamos National Laboratory), September 1997. "Work Plan for Mortandad Canyon," Los Alamos National Laboratory document LA-UR-97-3291, Los Alamos, New Mexico. (LANL 1997, 056835)

LANL (Los Alamos National Laboratory), October 2006. "Mortandad Canyon Investigation Report," Los Alamos National Laboratory document LA-UR-06-6752, Los Alamos, New Mexico. (LANL 2006, 094161)

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)

LANL (Los Alamos National Laboratory), February 2007. "Groundwater Background Investigation Report, Revision 2," Los Alamos National Laboratory document LA-UR-07-0755, Los Alamos, New Mexico. (LANL 2007, 094856)

LANL (Los Alamos National Laboratory), May 2007. "Well Screen Analysis Report, Revision 2," Los Alamos National Laboratory document LA-UR-07-2852, Los Alamos, New Mexico. (LANL 2007, 096330)

LANL (Los Alamos National Laboratory), September 2007. "Mortandad Canyon Groundwater Monitoring Well Network Evaluation, Revision 1," Los Alamos National Laboratory document LA-UR-07-6435, Los Alamos, New Mexico. (LANL 2007, 099128)

Longmire, P., M. Dale, D. Counce, A. Manning, T. Larson, K. Granzow, R. Gray, and B. Newman, July 2007. "Radiogenic and Stable Isotope and Hydrogeochemical Investigation of Groundwater, Pajarito Plateau and Surrounding Areas, New Mexico," Los Alamos National Laboratory report LA-14333, Los Alamos, New Mexico. (Longmire et al. 2007, 096660)

Table B-1
Capability of Screen to Provide Reliable and Representative Samples for Selected Chemicals of Potential Concern

Well	Port depth (ft)	Scr	3H	B	Cl	NO_3	ClO_4	SO_4	Cr	Mo	U
R-2	918	1	■[a]	■	■	■	■	■	■	■	■
R-3i	215	1	■	■	■	■	■	■	■	■	■
R-4	793	1	■	■	■	■	■	■	■	■	■
R-5	384	2	■	■	■	■	■	■	■	■	■
R-5	719	3	■	■	■	■	■	■	■	■	■
R-5	861	4	■	—[b]	—	—	—	—	—	—	—
R-6	1205	1	■	■	■	■	■	■	■	■	■
R-6i	602	1	■	■	■	■	■	■	■	■	■
R-7	378	1	■	■?[c]	■?	■?	■?	■?	■?	■?	■?
R-7	915	3	■	■	■	—	—	—	—	—	—
R-8	711	1	■	■	■	■–[d]	■	■	■	■	■
R-8	825	2	■	■	■	■	■	■	■	■	■
R-9	684	1	■	■	■	■	■	■	■	■	■
R-9i	199	1	■	■	■	■	■	■	■	■	■
R-9i	279	2	■	■	■	■	■	■	■	■	■
R-24	825	1	■	■	■	■	■	■	■	■	■
LADP-3	316	1	■	■	■	■	■	■	■	■	■
LAOI(a)-1.1	295	1	■	■	■	■	■	■	■	■	■
LAOI-3.2	153	1	■	■	■	■	■	■	■	■	■
LAOI-3.2a	181	1	■	■	■	■	■	■	■	■	■
LAOI-7	240	1	■	■	■	■	■	■	■	■	■
POI-4	159	1	■	■	■	■	■	■	■	■	■
TW-1	632	1	■	■	■	■	■	■	—	—	■
TW-1A	215	1	■	■	■	—	—	—	—	—	—
TW-2	768	1	■	■	■	—	—	—	—	—	—
TW-2A	123	1	■	■	■	—	—	—	—	—	—
TW-3	805	1	■	■	■	—	—	—	—	—	—
TW-4	1195	1	■	■	■	—	—	—	—	—	—

Source: Derived from Tables B-3 and B-4, modified as documented in Section B-2 and supporting tables.

[a] ■ = Screen can provide reliable and representative sample for this COPC.

[b] — = Screen cannot provide reliable and representative sample for this COPC.

[c] ■? = Screen probably can provide reliable and representative sample for this COPC, but there is uncertainty associated with this judgment.

[d] ■– = Screen has provided one or more recent samples in which this analyte was detected, but measured concentrations may be biased low due to residual effects of drilling.

Table B-2
Indicators That May Not be Applicable Due to Presence as a Site-Specific Contaminant

Well	Port Depth (ft)	Scr #	Watershed	Site-specific Contamination[a]	Site-specific Contaminants Present in Screened Intervals[c]							
					^3H[b]	B	Cl	ClO_4	Cr	NO_3	SO_4	U
R-2	918	1	Pueblo	None	—	—	—	—	—	—	—	—
R-3i	215	1	Pueblo	Present	Yes	■	■	■	—	■	■	■
R-4	793	1	Pueblo	Present	Yes	—	■	■	—	■	—	—
R-5	384	2	Pueblo	Present?	—	■?	—	■?	■?	■?	—	■?
R-5	719	3	Pueblo	Present?	—	■?	—	■?	■?	■?	■?	—
R-5	861	4	Pueblo	None	—	—	—	—	—	—	—	—
R-6	1205	1	Los Alamos	None	—	—	—	—	—	—	—	—
R-6i	602	1	Los Alamos	Present	Yes	■	■	■	—	■	■	—
R-7	378	1	Los Alamos	None	—	—	—	—	—	—	—	—
R-7	915	3	Los Alamos	None	—	—	—	—	—	—	—	—
R-8	711	1	Los Alamos	None	—	—	—	—	—	—	—	—
R-8	825	2	Los Alamos	None	—	—	—	—	—	—	—	—
R-9	684	1	Los Alamos	Present	Yes	■	■	■	—	—	—	■
R-9i	199	1	Los Alamos	Present	Yes	—	■	—	■	—	■	■
R-9i	279	2	Los Alamos	Present	Yes	—	■	—	—	—	■	■
R-24	825	1	Bayo	None?	—	—?	—?	—	—	—	—?	—?
LADP-3	316	1	Los Alamos	Present	Yes	■	■	—	■	—	■	■?
LAOI(a)-1.1	295	1	Los Alamos	None	—	—	—	—	—	—	—	—
LAOI-3.2	153	1	Los Alamos	Present	Yes	—	■	■	—	■	—	■
LAOI-3.2a	181	1	Los Alamos	Present	Yes	—	■	■	—?	■	■	■
LAOI-7	240	1	Los Alamos	Present	Yes	—	■	■	—	—	■	—
POI-4	159	1	Pueblo	Present	Yes	■	■	—	—	■	■	■
TW-1	632	1	Pueblo	Present	Yes	■	■	■	—	■	■	■
TW-1A	215	1	Pueblo	Present	Yes	■	■	—	—	—	—	—
TW-2	768	1	Pueblo	None?	—?	—	—	—	—	—	—	—
TW-2A	123	1	Pueblo	Present	Yes	■	■	—	—	■	■	—
TW-3	805	1	Los Alamos	None?	—?	—?	—	—	—	—	—	—
TW-4	1195	1	Pueblo	None?	—	—?	—	—	—	—	—	—

Sources: Identification of site-specific contaminants is based on WSAR Revision 2 (LANL 2007, 096330, Table 2-1) and the "Los Alamos/Pueblo Canyon Investigation Report" (LANL 2006, 094161, Section 7.2.2), updated with more recent data and expanded to include indicator species that were also present in canyon discharges, based on information presented in the "Work Plan for Mortandad Canyon" (LANL 1997, 056835, Section 3.8.1). Shaded table cells for regional wells indicate evaluations that differ from those presented in WSAR Rev. 2 (LANL 2007, 096330, Table 2-1). Thresholds for identifying the presence of tritium as a site-specific contaminant in perched intermediate aquifers and the regional aquifer are described in footnote b.

[a] Present = One or more contaminants are recognized as being present in this screen interval. Present? = One or more contaminants may be present in this screen interval but there is uncertainty about this interpretation. None = No contaminant is known with certainty to be present in this screen interval. None? = No contaminant is known to be present in this screen interval but there is uncertainty about this interpretation.

[b] Yes = Tritium (^3H) is present as a potential contaminant. Threshold values of 17 pCi/L for perched groundwater, and 1 pCi/L for regional groundwater, are based on Longmire et al. (2007, 096660). — = ^3H is not present above the threshold value. —? = ^3H may not be present above the threshold value because there is uncertainty about this interpretation.

[c] ■ = Constituent is recognized as being present as a contaminant in the screened interval. ■? = Constituent is probably present as a contaminant, but there is uncertainty about this interpretation. — = Constituent is not present as a contaminant. —? = Constituent is probably not present as a contaminant but there is uncertainty about this interpretation.

Table B-3
Summary of Evaluation Outcomes for Most Recent Sample

Well Screen			Conditions Present in Screen Interval									
Well	Port depth (ft)	Screen number	Modern Water	Contaminant	Outside pH-Alk Range	Residual Inorganics	Residual Organics	Redox Stage	Enhanced Adsorption	Iron Mineralogy	Carbonate Mineralogy	Steel Corrosion
R-2	918	1	■[a]	—[b]	—	—	—	Oxic	—	—	—	—
R-3i	215	1	■	■	■	—?[c]	—	Oxic	—	—	—	—
R-4	793	1	■	■	—	—	—	Oxic	—	—	—	—
R-5	384	2	—	—?	■?[d]	—?	—	Oxic	—	—	—?	—
R-5	719	3	—	—?	■	—	—	Oxic	—	—	—?	—
R-5	861	4	—	—	■?	—	—	Fe	—	—	—?	—
R-6	1205	1	—	—	—	—	—	Oxic	—	—	—	—
R-6i	602	1	■	■	—	—	—	Oxic	—	—	—	—
R-7	378	1	■	—	—	—	—	Oxic?	—	—	—	—
R-7	915	3	—	—	■?	—	■?	SO_4	—	—	—	—
R-8	711	1	—	—	—	—	—?	Oxic?	—	—	—	—
R-8	825	2	—	—	■	—?	—	Oxic	—	—	—?	—
R-9	684	1	■	■	■?	—	—	Oxic	—	—	—?	—
R-9i	199	1	■	■	■?	—	—	Fe?	—	—	—?	—
R-9i	279	2	■	■	■?	—	—	Mn	—	—	—?	—
R-24	825	1	—	■	—	—?	—	NO_3	—	—	—?	—
LADP-3	316	1	■	■	—	—	—	NO_3	—	—	—	—
LAOI(a)-1.1	295	1	■	—	■?	—	—	Oxic	—	—	—	—
LAOI-3.2	153	1	■	■	■?	—	—	Oxic	—	—	—?	—
LAOI-3.2a	181	1	■	■	■?	—	—	Oxic	—	—	—?	—
LAOI-7	240	1	■	■	—	—	—	Mn	—	—	—	—
POI-4	159	1	■	■	■	—	—	Oxic	—	—	—?	—
TW-1	632	1	■	■	■	—	—	Oxic?	—	—	—?	■
TW-1A	215	1	■	■	■	—	—?	SO_4	—	■?	—?	■
TW-2	768	1	■?	—?	—	—	—	SO_4?	—	■?	—?	■
TW-2A	123	1	■	■	■	—	—	Fe	—	■?	—?	■
TW-3	805	1	■?	—?	—	—	—?	SO_4	—	■?	—	■
TW-4	1195	1	—?	—?	—	—	—	SO_4	—	■?	—?	■

Source: Test outcomes are based on the detailed evaluations in Tables B-5 through B-10.

[a] ■ = This residual effect of drilling is inferred as likely to be present in the screen interval. The criteria for designating a condition as being present are summarized in WSAR Rev. 2 (LANL 2007, 096330, Table 6-1 footnotes).

[b] — = This residual effect of drilling does not appear to be present in the screen interval.

[c] —? = This residual effect of drilling is probably not present in the screen interval, but uncertainty associated with this interpretation is described in Section B-2 of this report.

[d] ■? = This residual effect of drilling is possibly present in the screen interval, but uncertainty associated with this interpretation is described in Section B-4 of this report.

Table B-4
Effects of Residual Drilling Impacts on Selected Chemicals of Potential Concern

Analyte	Relevance to this Evaluation		Outside Range of Background pH or Alkalinity[a]	Category of Residual Drilling Effects												
				A	B	C				D					E	F
	COPC	Test Indicator		Residual Inorganics	Residual Organics	SO_4- reducing	Fe-reducing	Mn-reducing	NO_3 reducing	Sr sorption	U sorption	Ba sorption	Zn sorption	None[b]	Carbonate-Sulfate Mineral Equilibria	Steel Corrosion
Tritium	■[c]	■	—[d]	—	—	—	—	—	—	—	—	—	—	—	—	—
Boron	■	■	—	■	—	—	—	—	—	—	—	—	—	—	—?[e]	—
Chloride	■	■	—	■	—	—	—	—	—	—	—	—	—	—	—	—
Chromium	■	■	—	■	—	■	■	■	—	—	—	—	—	—	—	■ (CP)
Molybdenum	■	—	—	■	—	■	■	—	—	—	—	—	—	—	■?[f]	■ (CP)[g]
Nitrate	■	■	—	■	—	■	■	■	■	—	—	—	—	—	—	—
Perchlorate	■	■	—	—	—	■	■	■	—	—	—	—	—	—	—	—
Sulfate	■	■	—	■	—	■	—	—	—	—	—	—	—	—	■	—
Uranium	■	■	■	■	—	■	■	—	—	—	■	—	—	—	■	—

Source: Compiled from WSAR Rev. 2 (LANL 2007, 096330, Tables 603, A-1, A-2, and A-8), modified as noted above.

[a] An entry in this column signifies only that the analyte's speciation may differ significantly from that expected under pH and alkalinity conditions that are characteristic of native groundwater, such that assumptions about the analyte's behavior in the presence of a residual drilling effect from drilling may not be valid.

[b] An entry in this column signifies that the analyte may adsorb onto residual bentonite but that it does not have a suitable indicator species to evaluate whether this effect is present.

[c] ■ = Analytical data for this analyte may not be reliable or representative of predrilling groundwater if this condition is present as a residual effect of drilling.

[d] — = The reliability or representativeness of this analyte is not affected by this residual effect of drilling.

[e] — ? = The reliability or representativeness of this analyte is probably not affected by this residual effect of drilling but there is uncertainty associated with this judgment.

[f] ■? =. Analytical data for this analyte is probably not reliable or representative of predrilling groundwater if this condition is present as a residual effect of drilling but there is uncertainty associated with this judgment.

[g] CP = corrosion product.

Table B-5
General Water-Quality Indicators and Field Parameters

Well	Port Depth (ft)	Screen #	Sample Collection Date Regional > Perched >	Tritium (pCi/L)	Modern Water? >UL 1 1	Field pH	Low pH test >LL 6.94 6.73	High pH test <UL 8.65 8.80	Test Gen-1	Alkalinity (mg/L $CaCO_3$)[a]	Test Gen-2 <UL 105 52	Turbidity (NTU[b])	Test Gen-3 <UL 5 5	ORP[c] mV	Test C3 >LL 0 0	DO[d] mg/L	Test C12 >LL 2 2	Sulfide mg/L	Test C2 <UL 0.01 0.01
R-2	918	1	17-Apr-07	0.22	No	7.50	Yes	Yes	P	63 CL	P	4.7	P	37	P	4.0	P	—	ND
R-2	918	1	16-Jul-07	-0.3	No	7.51	Yes	Yes	P	64 CL	P	4.11	P	280	P	3.2	P	—	ND
R-3i	215	1	9-Apr-07	71	Yes	7.52	Yes	Yes	P	162 CL	Fail	1.4	P	258	P	7.3	P	—	ND
R-3i	215	1	20-Jul-07	69	Yes	7.43	Yes	Yes	P	153 CL	Fail	4.6	P	234	P	5.1	P	—	ND
R-4	793	1	17-Apr-07	43	Yes	7.88	Yes	Yes	P	71 CL	P	0.32	P	-56	Fail	2.5	P	—	ND
R-4	793	1	18-Jul-07	53	Yes	7.85	Yes	Yes	P	63 CL	P	0.27	P	199	P	3.2	P	—	ND
R-5	384	2	17-Apr-07	0.19	No	8.04	Yes	Yes	P	93 CL	Fail	0.21	P	—	ND	—	ND	—	ND
R-5	384	2	16-Jul-07	0.319	No	8.03	Yes	Yes	P	95 CL	Fail	0.28	P	—	ND	—	ND	—	ND
R-5	719	3	18-Apr-07	0.42	No	8.15	Yes	Yes	P	93 CL	P	0.3	P	—	ND	—	ND	—	ND
R-5	719	3	17-Jul-07	—	ND	8.13	Yes	Yes	P	88 CL	P	0.24	P	—	ND	—	ND	—	ND
R-5	861	4	17-Apr-07	0.22	No	7.80	Yes	Yes	P	—	ND	0.21	P	—	ND	—	ND	—	ND
R-5	861	4	16-Jul-07	0.287	No	8.08	Yes	Yes	P	—	ND	0.48	P	—	ND	—	ND	—	ND
R-6	1205	1	12-Apr-07	0.32	No	8.27	Yes	Yes	P	80 CL	P	0.67	P	198	P	4.0	P	—	ND
R-6	1205	1	17-Jul-07	-0.1	No	8.36	Yes	Yes	P	68 Fld	P	0.8	P	284	P	3.1	P	—	ND
R-6i	602	1	12-Apr-07	4230	Yes	7.34	Yes	Yes	P	56 CL	Fail	1.48	P	158	P	4.3	P	—	ND
R-6i	602	1	17-Jul-07	4060	Yes	7.29	Yes	Yes	P	69 CL	Fail	0.81	P	157	P	3.8	P	—	ND
R-7	378	1	19-Feb-02	3.3	Yes	7.43	Yes	Yes	P	21 CL	P	0.56	P	—	ND	6.1	P	—	ND
R-7	378	1	5-Aug-02	2.3	Yes	7.30	Yes	Yes	P	35 CL	P	0.83	P	—	ND	5.7	P	—	ND
R-7	915	3	13-Apr-07	0.35	No	6.55	No	Yes	Fail	67 E6	P	2.64	P	—	ND	—	ND	0.003	P
R-7	915	3	31-Jul-07	0.192	No	6.87	No	Yes	Fail	68 E6	P	0.4	P	—	ND	—	ND	0.005	P
R-8	711	1	10-Apr-07	0.16	No	8.19	Yes	Yes	P	76 CL	P	0.17	P	—	ND	—	ND	—	ND

Table B-5 (continued)

Well	Port Depth (ft)	Screen #	Sample Collection Date Regional > Perched >	Tritium (pCi/L)	Modern Water? >UL 1 1	Field pH	Low pH test >LL 6.94 6.73	High pH test <UL 8.65 8.80	Test Gen-1	Alkalinity (mg/L $CaCO_3$)[a]		Test Gen-2 <UL 105 52	Turbidity (NTU[b])	Test Gen-3 <UL 5 5	ORP[c] mV	Test C3 >LL 0 0	DO[d] mg/L	Test C12 >LL 2 2	Sulfide mg/L	Test C2 <UL 0.01 0.01
R-8	711	1	24-Jul-07	0.128	No	8.35	Yes	Yes	P	66	CL	P	0.28	P	—	ND	—	ND	—	ND
R-8	825	2	10-Apr-07	0.26	No	8.63	Yes	Yes	P	92	E6	P	0.17	P	—	ND	—	ND	<0.003	P
R-8	825	2	25-Jul-07	0.096	No	9.03	Yes	No	Fail	82	E6	P	0.4	P	—	ND	—	ND	<0.003	P
R-9	684	1	10-Apr-07	9.2	Yes	8.06	Yes	Yes	P	118	CL	Fail	2.28	P	272	P	4.5	P	—	ND
R-9	684	1	19-Jul-07	9.6	Yes	8.08	Yes	Yes	P	107	CL	Fail	0.2	P	235	P	3.1	P	—	ND
R-9i	199	1	9-Apr-07	155	Yes	7.35	Yes	Yes	P	80	E6	Fail	—	ND	—	ND	—	ND	<0.003	P
R-9i	199	1	27-Jul-07	111	Yes	7.86	Yes	Yes	P	83	E6	Fail	1.46	P	—	ND	—	ND	<0.003	P
R-9i	279	2	9-Apr-07	111	Yes	8.25	Yes	Yes	P	73	E6	Fail	—	ND	—	ND	—	ND	<0.003	P
R-9i	279	2	27-Jul-07	109	Yes	7.96	Yes	Yes	P	80	E6	Fail	0.34	P	—	ND	—	ND	0.005	P
R-24	825	1	16-Apr-07	0.67	No	7.70	Yes	Yes	P	129	CL	Fail	0.55	P	-115	Fail	1.8	Fail	—	ND
R-24	825	1	18-Jul-07	0.16	No	7.90	Yes	Yes	P	106	CL	P	0.58	P	219	P	1.5	Fail	—	ND
LADP-3	316	1	26-Apr-07	—	ND	8.14	Yes	Yes	P	59		Fail	2	P	281	P	0.5	Fail	—	ND
LAOI(a)-1.1	295	1	25-Apr-07	3.0	Yes	9.70	Yes	No	Fail	74	CL	Fail	7.8	Fail	124	P	8.9	P	—	ND
LAOI(a)-1.1	295	1	31-Jul-07	—	ND	6.97	Yes	Yes	P	39	CL	P	9.83	Fail	408	P	5.3	P	—	ND
LAOI-3.2	153	1	19-Apr-07	2990	Yes	6.70	Yes	Yes	P	82	CL	Fail	0.77	P	211	P	9.9	P	—	ND
LAOI-3.2	153	1	26-Jul-07	3990	Yes	6.70	Yes	Yes	P	78	CL	Fail	1.82	P	250	P	4.3	P	—	ND
LAOI-3.2A	181	1	25-Apr-07	2700	Yes	6.80	Yes	Yes	P	73	CL	Fail	0.2	P	502	P	7.0	P	—	ND
LAOI-3.2A	181	1	30-Jul-07	2740	Yes	6.73	Yes	Yes	P	67	CL	Fail	1.06	P	5	P	5.8	P	—	ND
LAOI-7	240	1	18-Apr-07	1130	Yes	7.22	Yes	Yes	P	53	CL	Fail	1.74	P	71	P	6.7	P	—	ND
LAOI-7	240	1	19-Jul-07	892	Yes	7.23	Yes	Yes	P	52	CL	Fail	1.03	P	64	P	4.5	P	—	ND
POI-4	159	1	25-Apr-07	17.8	Yes	7.11	Yes	Yes	P	179	CL	Fail	1.61	P	560	P	5.9	P	—	ND
POI-4	159	1	2-Aug-07	19.5	Yes	7.55	Yes	Yes	P	151	CL	Fail	12.6	Fail	392	P	0.5	Fail	—	ND
TW-1	632	1	20-Dec-05	99	Yes	8.8	Yes	No	Fail	120	CL	Fail	6.96	Fail	222	P	5.7	P	—	ND

Table B-5 (continued)

Well	Port Depth (ft)	Screen #	Sample Collection Date Regional > Perched >	Tritium (pCi/L)	Modern Water? >UL 1 1	Field pH	Low pH test >LL 6.94 6.73	High pH test <UL 8.65 8.80	Test Gen-1	Alkalinity (mg/L $CaCO_3$)[a]	Test Gen-2 <UL 105 52	Turbidity (NTU[b])	Test Gen-3 <UL 5 5	ORP[c] mV	Test C3 >LL 0 0	DO[d] mg/L	Test C12 >LL 2 2	Sulfide mg/L	Test C2 <UL 0.01 0.01
TW-1A	215	1	20-Dec-05	34	Yes	8.1	Yes	Yes	P	115 CL	Fail	6.65	Fail	243	P	3.97	P	—	ND
TW-2	768	1	22-Mar-05	—	ND	—	—	—	ND	51 E6	P	—	ND	—	ND	2.07	P	—	ND
TW-2A	123	1	27-May-99	1320	Yes	8.03	Yes	Yes	P	98	Fail	—	ND	—	ND	—	ND	—	ND
TW-2A	123	1	30-Jul-01	1110	Yes	—	—	—	ND	—	ND	—	ND	—	ND	—	ND	—	ND
TW-2A	123	1	16-May-05	944	Yes	6.76	Yes	Yes	P	—	ND	9.74	Fail	—	ND	1.45	Fail	—	ND
TW-3	805	1	19-Jan-06	15.4	Yes	7.73	Yes	Yes	P	77 CL	P	9.2	Fail	-152	Fail	0.08	Fail	—	ND
TW-4	1195	1	19-Dec-05	0.13	No	8.88	Yes	No	Fail	49 CL	P	0.38	P	-632	Err	3.61	P	—	ND

Sources: Water Quality Data Base (WQDB) and Geochemistry and Geomaterials Research Laboratory (GGRL) data base.

Notes: The following abbreviations and color codings apply throughout this table:

- Types of test criteria: LL = Lower limit; UL = upper limit.
- Test outcomes: P = Pass; P and blue shading both indicate that the data pass the test criterion. Fail and pink shading both indicate that the data do not pass the test criterion. ND = No data.
- Data column entries: — = No data.

[a] Entries signifying how alkalinity data were obtained: CL = contract analytical laboratory; E6 = EES-6 analysis (GGRL); Fld = field analysis.

[b] NTU = Nephelometric turbidity units.

[c] ORP = Oxidation reduction potential.

[d] DO = Dissolved oxygen.

Table B-6
Organic Indicators

Well	Port Depth (ft)	Screen #	Sample Collection Date Regional > Perched >	Acetone (µg/L)	Test B1 <UL 5 5	NH_3-N (mg/L)	Test B2 <UL 0.05 0.05	TKN[a] (mg/L)	Test B3 <UL 0.28 0.28	TOC[b] (mg/L)	Test B4 <UL 1.1 1.1
R-2	918	1	17-Apr-07	< 5	P	< 0.03	P	< 0.029	P	1.10	P
R-2	918	1	16-Jul-07	1.6	P	< 0.03	P	< 0.058	P	0.41	P
R-3i	215	1	9-Apr-07	< 5	P	< 0.03	P	0.056	P	0.84	P
R-3i	215	1	20-Jul-07	< 5	P	< 0.03	P	< 0.057	P	1.07	P
R-4	793	1	17-Apr-07	< 5	P	< 0.03	P	< 0.029	P	0.76	P
R-4	793	1	18-Jul-07	< 5	P	< 0.03	P	< 0.029	P	0.52	P
R-5	384	2	17-Apr-07	< 5	P	< 0.03	P	< 0.029	P	0.62	P
R-5	384	2	16-Jul-07	1.6	P	< 0.03	P	< 0.029	P	0.54	P
R-5	719	3	18-Apr-07	< 5	P	< 0.03	P	< 0.058	P	0.87	P
R-5	719	3	17-Jul-07	< 5	P	< 0.03	P	< 0.145	P	0.36	P
R-5	861	4	17-Apr-07	—	ND	—	ND	—	ND	—	ND
R-5	861	4	16-Jul-07	—	ND	—	ND	—	ND	—	ND
R-6	1205	1	12-Apr-07	< 5	P	< 0.03	P	< 0.029	P	0.62	P
R-6	1205	1	17-Jul-07	1.4	P	< 0.03	P	< 0.145	P	< 0.33	P
R-6i	602	1	12-Apr-07	< 5	P	< 0.03	P	0.064	P	< 1.07	P
R-6i	602	1	17-Jul-07	< 2.0	P	< 0.03	P	< 0.029	P	< 0.97	P
R-7	378	1	19-Feb-02	< 5	P	< 0.05	P	< 0.1	P	0.67	P
R-7	378	1	5-Aug-02	< 5	P	< 0.024	P	—	ND	< 0.37	P
R-7	915	3	13-Apr-07	—	ND	—	ND	—	ND	—	ND
R-7	915	3	31-Jul-07	—	ND	—	ND	—	ND	—	ND
R-8	711	1	10-Apr-07	< 5	P	< 0.03	P	0.029	P	< 0.33	P
R-8	711	1	24-Jul-07	< 5	P	< 0.15	DL[c]	0.03	P	< 0.33	P
R-8	825	2	10-Apr-07	—	ND	—	ND	—	ND	—	ND
R-8	825	2	25-Jul-07	—	ND	—	ND	—	ND	—	ND
R-9	684	1	10-Apr-07	< 5	P	< 0.03	P	< 0.029	P	0.41	P
R-9	684	1	19-Jul-07	< 5	P	< 0.03	P	< 0.029	P	0.44	P
R-9i	199	1	9-Apr-07	—	ND	—	ND	—	ND	—	ND
R-9i	199	1	27-Jul-07	—	ND	—	ND	—	ND	—	ND
R-9i	279	2	9-Apr-07	—	ND	—	ND	—	ND	—	ND
R-9i	279	2	27-Jul-07	—	ND	—	ND	—	ND	—	ND
R-24	825	1	16-Apr-07	< 5	P	< 0.03	P	< 0.029	P	< 1.17	Fail
R-24	825	1	18-Jul-07	< 5	P	< 0.03	P	< 0.145	P	< 0.74	P

Table B-6 (continued)

Well	Port Depth (ft)	Screen #	Sample Collection Date Regional > Perched >		Acetone (µg/L)	Test B1 <UL 5 5		NH_3-N (mg/L)	Test B2 <UL 0.05 0.05		TKN[a] (mg/L)	Test B3 <UL 0.28 0.28		TOC[b] (mg/L)	Test B4 <UL 1.1 1.1
LADP-3	316	1	26-Apr-07	<	5	P	<	0.03	P	<	0.029	P	<	1.56	DL
LAOI(a)-1.1	295	1	25-Apr-07	<	5	P	<	0.03	P	<	0.029	P		0.69	P
LAOI(a)-1.1	295	1	31-Jul-07	<	5	P	<	0.03	P	<	0.029	P		1.16	Fail
LAOI-3.2	153	1	19-Apr-07	<	5	P	<	0.03	P	<	0.029	P		1.18	Fail
LAOI-3.2	153	1	26-Jul-07	<	5	P	<	0.03	P	<	0.029	P		0.80	P
LAOI-3.2A	181	1	25-Apr-07	<	5	P	<	0.03	P	<	0.029	P		1.09	P
LAOI-3.2A	181	1	30-Jul-07	<	5	P	<	0.03	P	<	0.029	P		1.30	Fail
LAOI-7	240	1	18-Apr-07	<	5	P	<	0.03	P	<	0.029	P		1.09	P
LAOI-7	240	1	19-Jul-07	<	5	P	<	0.15	DL	<	0.029	P		1.19	Fail
POI-4	159	1	25-Apr-07	<	5	P	<	0.03	P		0.207	P		1.73	Fail
POI-4	159	1	2-Aug-07		1.98	P	<	0.073	DL		0.245	P		1.48	Fail
TW-1	632	1	20-Dec-05	<	5	P	<	0.01	P	<	0.01	P		—	ND
TW-1A	215	1	20-Dec-05		14.2	Fail		7.1	Fail		7.85	Fail		—	ND
TW-2	768	1	22-Mar-05		—	ND		—	ND		—	ND		—	ND
TW-2A	123	1	27-May-99		—	ND		—	ND		—	ND		—	ND
TW-2A	123	1	30-Jul-01	<	5	P		—	ND		—	ND		—	ND
TW-2A	123	1	16-May-05		—	ND		—	ND		—	ND		—	ND
TW-3	805	1	19-Jan-06	<	5	P		0.607	Fail		0.742	Fail		—	ND
TW-4	1195	1	19-Dec-05	<	5	P	<	0.01	P	<	0.01	P		—	ND

Sources: WQDB and GGRL data base.

Notes: The following abbreviations and color codings apply throughout this table:

- Types of test criteria: LL = Lower limit; UL = upper limit.
- Test outcomes: P = Pass; P and blue shading both indicate that the data pass the test criterion. Fail and pink shading both indicate that the data do not pass the test criterion. ND = No data. DL = Indeterminate outcome due to inadequate detection limit.
- Data column entries: — = No data.

[a] TKN = Total Kjeldahl nitrogen.

[b] TOC = Total organic carbon.

Table B-7a
Inorganic Nonmetal Indicators

Well	Port Depth (ft)	Scr #	Sample Collection Date Regional > Perched >	Ba µg/L	Test D3 µg/L >LL 4.6 1.4	Test E2 µg/L <UL 70 72	Ca mg/L	Test E1a mg/L >LL 9.3 4.6	Test E1b mg/L <UL 25 18	Test E1 (within Range)	Cl mg/L	Test A1 mg/L <UL 3.8 3.6	F mg/L	Test A2 Mg/L <UL 0.53 0.23	Mg mg/L	Test E4 mg/L <UL 4.9 6.2		NO_3 mg/L as N	LQC	Test C11 mg/L >LL 0.15 0.22
R-2	918	1	17-Apr-07	15.1	P	P	10.6	Yes	Yes	P	2.21	P	0.27	P	2.9	P		0.44		P
R-2	918	1	16-Jul-07	15.4	P	P	10.9	Yes	Yes	P	2.17	P	0.28	P	3.0	P		0.42		P
R-3i	215	1	9-Apr-07	95.2	P	Fail	54.8	Yes	No	Fail	39.3	Ctmt	0.31	Ctmt	15.2	Fail		4.30		P
R-3i	215	1	20-Jul-07	101.0	P	Fail	58.1	Yes	No	Fail	35.1	Ctmt	0.31	Ctmt	16.1	Fail		4.04		P
R-4	793	1	17-Apr-07	38.8	P	P	18.2	Yes	Yes	P	4.86	Ctmt	0.71	Ctmt	3.5	P		1.06		P
R-4	793	1	18-Jul-07	35.3	P	P	16.6	Yes	Yes	P	5.15	Ctmt	0.70	Ctmt	3.2	P		1.76		P
R-5	384	2	17-Apr-07	198	P	Fail	30.8	Yes	No	Fail	7.36	Ctmt	1.05	Ctmt	2.9	P		2.93		P
R-5	384	2	16-Jul-07	187	P	Fail	27.9	Yes	No	Fail	7.47	Ctmt	1.07	Ctmt	2.7	P		3.02		P
R-5	719	3	18-Apr-07	87.9	P	Fail	24.0	Yes	Yes	P	7.36	Ctmt	0.66	Ctmt	4.1	P		2.39		P
R-5	719	3	17-Jul-07	95.5	P	Fail	25.0	Yes	Yes	P	7.66	Ctmt	0.61	Ctmt	4.2	P		2.11		P
R-5	861	4	17-Apr-07	—	ND	ND	—	—	—	ND	7.76	Fail	—	ND	4.1	P		—		ND
R-5	861	4	16-Jul-07	—	ND	ND	—	—	—	ND	—	ND	—	ND	—	ND		—		ND
R-6	1205	1	12-Apr-07	21.3	P	P	13.0	Yes	Yes	P	2.24	P	0.38	P	3.5	P		0.35		P
R-6	1205	1	17-Jul-07	20.7	P	P	12.6	Yes	Yes	P	2.09	P	0.53	P	3.3	P		0.34		P
R-6i	602	1	12-Apr-07	24.8	P	P	24.4	Yes	No	Fail	18	Ctmt	0.63	Ctmt	4.4	P		4.74		P
R-6i	602	1	17-Jul-07	26.3	P	P	24.3	Yes	No	Fail	17	Ctmt	0.61	Ctmt	4.4	P		4.78		P
R-7	378	1	19-Feb-02	56.0	P	P	7.2	Yes	Yes	P	1.56	P	0.08	P	1.4	P		0.27		P
R-7	378	1	5-Aug-02	46.0	P	P	7.0	Yes	Yes	P	1.42	P	0.16	P	1.4	P		0.22		P
R-7	915	3	13-Apr-07	77.7	P	Fail	7.9	No	Yes	Fail	2.23	P	0.51	P	3.0	P		0.008		Fail
R-7	915	3	31-Jul-07	82.8	P	Fail	7.5	No	Yes	Fail	2.18	P	0.51	P	2.9	P	<	0.002	U	Fail
R-8	711	1	10-Apr-07	23.0	P	P	15.3	Yes	Yes	P	1.43	P	0.54	Fail	2.4	P		0.57		P
R-8	711	1	24-Jul-07	23.3	P	P	16.2	Yes	Yes	P	1.65	P	0.53	P	2.5	P		0.12		Fail

Table B-7a (continued)

Well	Port Depth (ft)	Scr #	Sample Collection Date Regional > Perched >	Ba µg/L	Test D3 µg/L >LL 4.6 1.4	Test E2 µg/L <UL 70 72	Ca mg/L	Test E1a mg/L >LL 9.3 4.6	Test E1b mg/L <UL 25 18	Test E1 (within Range)	Cl mg/L	Test A1 mg/L <UL 3.8 3.6	F mg/L	Test A2 Mg/L <UL 0.53 0.23	Mg mg/L	Test E4 mg/L <UL 4.9 6.2	NO_3 mg/L as N	LQC	Test C11 mg/L >LL 0.15 0.22
R-8	825	2	10-Apr-07	154.6	P	Fail	12.6	Yes	Yes	P	6.67	Fail	0.60	Fail	4.6	P	0.59		P
R-8	825	2	25-Jul-07	161.2	P	Fail	9.9	Yes	Yes	P	4.7	Fail	0.44	P	3.7	P	0.50		P
R-9	684	1	10-Apr-07	206.0	P	Fail	23.2	Yes	Yes	P	6.06	Ctmt	0.31	P	6.8	Fail	0.61		P
R-9	684	1	19-Jul-07	190.0	P	Fail	21.8	Yes	Yes	P	5.72	Ctmt	0.33	P	6.3	Fail	0.76		P
R-9i	199	1	9-Apr-07	54.6	P	P	19.4	Yes	No	Fail	43.2	Ctmt	0.55	Ctmt	6.7	Fail	0.330		P
R-9i	199	1	27-Jul-07	53.5	P	P	17.9	Yes	Yes	P	43.3	Ctmt	0.33	Ctmt	6.7	Fail	< 0.002	U	Fail
R-9i	279	2	9-Apr-07	25.3	P	P	16.5	Yes	Yes	P	23.3	Ctmt	0.36	Ctmt	5.4	P	0.45		P
R-9i	279	2	27-Jul-07	28.3	P	P	15.1	Yes	Yes	P	13.9	Ctmt	0.24	Ctmt	5.4	P	< 0.002	U	Fail
R-24	825	1	16-Apr-07	104.0	P	Fail	22.2	Yes	Yes	P	7.31	Fail	0.32	P	4.1	P	0.23		P
R-24	825	1	18-Jul-07	163.0	P	Fail	19.6	Yes	Yes	P	7.22	Fail	0.32	P	3.5	P	0.35		P
LADP-3	316	1	26-Apr-07	27.6	P	P	15.2	Yes	Yes	P	35.8	Ctmt	0.27	Ctmt	4.8	P	0.20		Fail
LAOI(a)-1.1	295	1	25-Apr-07	12.2	P	P	4.3	No	Yes	Fail	1.38	P	0.18	P	0.9	P	0.71		P
LAOI(a)-1.1	295	1	31-Jul-07	9.2	P	P	6.2	Yes	Yes	P	1.2	P	0.18	P	1.7	P	0.42		P
LAOI-3.2	153	1	19-Apr-07	47.1	P	P	22.4	Yes	No	Fail	17.4	Ctmt	0.14	P	5.1	P	3.71		P
LAOI-3.2	153	1	26-Jul-07	49.1	P	P	22.2	Yes	No	Fail	19	Ctmt	0.14	P	5.4	P	3.88		P
LAOI-3.2A	181	1	25-Apr-07	17.6	P	P	22.0	Yes	No	Fail	20	Ctmt	0.15	P	4.7	P	2.84	J[c]	P
LAOI-3.2A	181	1	30-Jul-07	18.2	P	P	22.2	Yes	No	Fail	19.9	Ctmt	0.14	P	4.8	P	2.27	J	P
LAOI-7	240	1	18-Apr-07	20.7	P	P	13.5	Yes	Yes	P	18.4	Ctmt	0.22	P	6.1	P	0.28	J	P
LAOI-7	240	1	19-Jul-07	26.2	P	P	16.3	Yes	Yes	P	24.8	Ctmt	0.21	P	7.3	Fail	0.08		Fail
POI-4	159	1	25-Apr-07	108	P	Fail	47.1	Yes	No	Fail	45.3	Ctmt	0.33	Ctmt	12.1	Fail	7.48		P
POI-4	159	1	2-Aug-07	106	P	Fail	48.2	Yes	No	Fail	42.5	Ctmt	0.30	Ctmt	12.4	Fail	6.68		P
TW-1	632	1	20-Dec-05	30.2	P	P	6.84	No	Yes	Fail	38.8	Ctmt	0.34	P	3.37	P	5.25		P

Table B-7a (continued)

Well	Port Depth (ft)	Scr #	Sample Collection Date Regional > Perched >	Ba µg/L	Test D3 µg/L >LL 4.6 1.4	Test E2 µg/L <UL 70 72	Ca mg/L	Test E1a mg/L >LL 9.3 4.6	Test E1b mg/L <UL 25 18	Test E1 (within Range)	Cl mg/L	Test A1 mg/L <UL 3.8 3.6	F mg/L	Test A2 Mg/L <UL 0.53 0.23	Mg mg/L	Test E4 mg/L <UL 4.9 6.2	NO_3 mg/L as N	LQC	Test C11 mg/L >LL 0.15 0.22
TW-1A	215	1	20-Dec-05	277	P	Fail	34.6	Yes	No	Fail	76.5	Ctmt	0.27	Ctmt	10.2	Fail	0.042		Fail
TW-2	768	1	22-Mar-05	24	P	P	5.2	No	Yes	Fail	2.24	P	0.59	Fail	1.2	P	0.003		Fail
TW-2A	123	1	27-May-99	50.0	P	P	41.2	Yes	No	Fail	46.2	Ctmt	0.17	P	7.4	Fail	0.38		P
TW-2A	123	1	30-Jul-01	63.4	P	P	34.8	Yes	No	Fail	—	ND	—	ND	—	ND	0.007		Fail
TW-2A	123	1	16-May-05	—	ND	ND	—	—	—	ND	—	ND	—	ND	—	ND	—		ND
TW-3	805	1	19-Jan-06	29.0	P	P	14.2	Yes	Yes	P	3.17	P	0.38	P	4.63	P	< 0.017	U	Fail
TW-4	1195	1	19-Dec-05	85.5	P	Fail	53.5	Yes	No	Fail	2.01	P	0.16	P	10.5	Fail	< 0.017	U	Fail

Sources: WQDB and GGRL data base.

Notes: The following abbreviations and color codings apply throughout this table:

- Types of test criteria: LL = Lower limit; UL = upper limit.
- Test outcomes: P = Pass; P and blue shading both indicate that the data pass the test criterion. Fail and pink shading both indicate that the data do not pass the test criterion. ND = No data. Ctmt = Indeterminate outcome because of presence of the indicator as a site-specific contaminant at this location.
- Data column entries: — = No data.
- LQC = Laboratory qualifier code. U = The analyte was not detected above the level of the associated numeric value. J = The associated numerical value is an estimated quantity.

Table B-7b
Inorganic Nonmetal Indicators

Well	Port Depth (ft)	Scr #	Sample Collection Date Regional > Perched >		ClO_4 µg/L		Test C6 µg/L >LL 0.22 0.22		PO_4 mg/L as P	LQC	Test A3 mg/L <UL 0.09 0.08	Na mg/L	Test A4 mg/L <UL 29 13	Sr µg/L	Test D1 µg/L >LL 44 19	Test E3 µg/L <UL 180 155	SO_4 mg/L	Test C1 mg/L >LL 1.7 1.1	Test A4 mg/L <UL
R-2	918	1	17-Apr-07		0.347		P	<	0.064		P	15.6	P	50.4	P	P	2.8	P	P
R-2	918	1	16-Jul-07		0.373		P	<	0.062		P	13.9	P	51.9	P	P	2.6	P	P
R-3i	215	1	9-Apr-07		2.6		P	<	0.046	J	P	19.0	Fail	267	P	Fail	22.2	P	Ctmt
R-3i	215	1	20-Jul-07		2.18		P		0.035	J	P	19.9	Fail	281	P	Fail	20.3	P	Ctmt
R-4	793	1	17-Apr-07		2.54		P	<	0.041	J	P	12.9	P	87.3	P	P	4.1	P	P
R-4	793	1	18-Jul-07		4.31		P	<	0.024	U	P	11.8	P	78.3	P	P	4.3	P	P
R-5	384	2	17-Apr-07		1.33		P	<	0.041	J	P	15.6	Fail	309	P	Fail	8.5	P	Ctmt
R-5	384	2	16-Jul-07		1.38		P	<	0.039	J	P	13.6	Fail	294	P	Fail	8.2	P	Ctmt
R-5	719	3	18-Apr-07		1.19		P	<	0.068		P	21.5	P	182	P	Fail	16.3	P	Ctmt
R-5	719	3	17-Jul-07		1.19		P	<	0.036	J	P	20.3	P	193	P	Fail	15.5	P	Ctmt
R-5	861	4	17-Apr-07		0.27		P		—		ND	—	ND	—	ND	ND	—	ND	ND
R-5	861	4	16-Jul-07		0.246		P		—		ND	—	ND	—	ND	ND	—	ND	ND
R-6	1205	1	12-Apr-07		0.345		P	<	0.042	J	P	16.8	P	53.3	P	P	2.6	P	P
R-6	1205	1	17-Jul-07		0.349		P	<	0.043	J	P	12.4	P	52.9	P	P	2.7	P	P
R-6i	602	1	12-Apr-07		7.04		P	<	0.089		Fail	21.3	Fail	113	P	P	9.7	P	Ctmt
R-6i	602	1	17-Jul-07		6.87		P	<	0.074		P	20.3	Fail	116	P	P	9.1	P	Ctmt
R-7	378	1	19-Feb-02	<	4	U	DL	<	0.05	U	P	6.3	P	37.8	P	P	2.3	P	P
R-7	378	1	5-Aug-02	<	1.45	U	DL	<	0.05		P	6.6	P	37.4	P	P	2.0	P	P
R-7	915	3	13-Apr-07	<	2	U	DL		0.005		P	8.9	P	36.9	Red	P	1.1	Fail	P
R-7	915	3	31-Jul-07	<	1	U	DL	<	0.003	U	P	8.1	P	41.7	Red	P	1.1	Fail	P
R-8	711	1	10-Apr-07		0.289		P	<	0.024	U	P	8.8	P	82.8	P	P	2.1	P	P
R-8	711	1	24-Jul-07		0.284		P	<	0.024	U	P	9.7	P	90.6	P	P	2.1	P	P

Table B-7b (continued)

Well	Port Depth (ft)	Scr #	Sample Collection Date Regional > Perched >	ClO_4 µg/L	Test C6 µg/L >LL 0.22 0.22	PO_4 mg/L as P	LQC	Test A3 mg/L <UL 0.09 0.08	Na mg/L	Test A4 mg/L <UL 29 13	Sr µg/L	Test D1 µg/L >LL 44 19	Test E3 µg/L <UL 180 155	SO_4 mg/L	Test C1 mg/L >LL 1.7 1.1	Test A4 mg/L <UL
R-8	825	2	10-Apr-07	< 2 U	DL	< 0.003	U	P	18.8	P	142	P	P	6.2	P	P
R-8	825	2	25-Jul-07	< 2 U	DL	0.017		P	17.0	P	185	P	Fail	4.5	P	P
R-9	684	1	10-Apr-07	0.886	P	< 0.024	U	P	18.5	P	184	P	Red	5.9	P	P
R-9	684	1	19-Jul-07	0.986	P	< 0.024	U	P	17.1	P	171	P	P	5.6	P	P
R-9i	199	1	9-Apr-07	< 2 U	DL	0.046		P	19.9	Fail	109	P	P	23.3	P	Ctmt
R-9i	199	1	27-Jul-07	< 2 U	DL	0.029		P	23.8	Fail	118	P	P	16.7	P	Ctmt
R-9i	279	2	9-Apr-07	< 2 U	DL	0.183		Fail	9.7	P	100	P	P	17.9	P	Ctmt
R-9i	279	2	27-Jul-07	< 2 U	DL	0.062		P	9.4	P	93.6	P	P	15.7	P	Ctmt
R-24	825	1	16-Apr-07	0.209	Fail	< 0.044	J	P	34.8	Fail	130	P	P	12.5	P	Fail
R-24	825	1	18-Jul-07	0.31	P	< 0.024	U	P	26.8	P	114	P	P	8.2	P	Fail
LADP-3	316	1	26-Apr-07	0.139 J	Fail	< 0.096		Fail	26.7	Ctmt	112	P	P	8.3	P	Ctmt
LAOI(a)-1.1	295	1	25-Apr-07	0.167 J	Fail	< 0.049	J	P	19.1	Fail	89.1	P	P	4.1	P	P
LAOI(a)-1.1	295	1	31-Jul-07	0.171 J	Fail	< 0.024	U	P	8.3	P	53	P	P	3.0	P	P
LAOI-3.2	153	1	19-Apr-07	6.65	P	< 0.059		P	17.7	Ctmt	135	P	P	4.0	P	P
LAOI-3.2	153	1	26-Jul-07	7.3	P	0.467		Ctmt	17.6	Ctmt	133	P	P	4.5	P	Ctmt
LAOI-3.2A	181	1	25-Apr-07	3.52	P	< 0.046	J	P	16.2	Ctmt	136	P	P	8.8	P	Ctmt
LAOI-3.2A	181	1	30-Jul-07	3.4	P	< 0.024	U	P	15.0	Ctmt	140	P	P	8.5	P	Ctmt
LAOI-7	240	1	18-Apr-07	0.757	P	< 0.058		P	10.2	P	75.4	P	P	8.8	P	Ctmt
LAOI-7	240	1	19-Jul-07	0.535	P	< 0.065		P	11.0	P	92.4	P	P	9.8	P	Ctmt
POI-4	159	1	25-Apr-07	0.234	P	1.08		Ctmt	51.1	Ctmt	243	P	Fail	23.6	P	Ctmt
POI-4	159	1	2-Aug-07	0.234	P	1.14		Ctmt	48.3	Ctmt	237	P	Fail	22.5	P	Ctmt
TW-1	632	1	20-Dec-05	1.87	P	0.069		P	10.4	P	31.8	Fail	P	22.7	P	Ctmt
TW-1A	215	1	20-Dec-05	< 0.05 U	Fail	0.511		Ctmt	35.9	Ctmt	256	P	Red	< 0.057	Fail	P

Table B-7b (continued)

Well	Port Depth (ft)	Scr #	Sample Collection Date Regional > Perched >	ClO_4 µg/L		Test C6 µg/L >LL 0.22 0.22	PO_4 mg/L as P	LQC	Test A3 mg/L <UL 0.09 0.08	Na mg/L	Test A4 mg/L <UL 29 13	Sr µg/L	Test D1 µg/L >LL 44 19	Test E3 µg/L <UL 180 155	SO_4 mg/L	Test C1 mg/L >LL 1.7 1.1	Test A4 mg/L <UL
TW-2	768	1	22-Mar-05	< 5E-04	U	Fail	0.033		P	15.3	P	28	Red	P	0.3	Fail	P
TW-2A	123	1	27-May-99	—		ND	< 0.03	UL	P	22.5	Ctmt	219	P	Red	24.8	P	Ctmt
TW-2A	123	1	30-Jul-01	< 0.958	U	DL	< 0.019	U	P	—	ND	203	P	Red	—	ND	ND
TW-2A	123	1	16-May-05	< 0.05	U	Fail	—		ND	—	ND	—	ND	ND	—	ND	ND
TW-3	805	1	19-Jan-06	< 0.05	U	Fail	< 0.038	UH	P	10.6	P	64	P	P	0.8	Fail	P
TW-4	1195	1	19-Dec-05	< 0.05	U	Fail	0.085		P	21.2	P	300	P	Red	< 0.1	Fail	P

Sources: WQDB; and GGRL data base

Notes: The following abbreviations and color codings apply throughout this table:

- Types of test criteria: LL = Lower limit; UL = upper limit.
- Test outcomes: P = Pass (P and blue shading both indicate that the data pass the test criterion). Fail and pink shading both indicate that the data do not pass the test criterion. ND = No data. Bkgd = Indeterminate outcome because of uncertainty about the representativeness of the groundwater background data set for this location or geologic formation. Ctmt = Indeterminate outcome because of presence of the indicator as a site-specific contaminant at this location. DL = Indeterminate outcome because of an inadequate detection limit. Red = Indeterminate outcome because this test is not reliable if reducing conditions are present.
- Data column entries: — = No data.
- LQC = Laboratory qualifier code. U = The analyte was not detected above the level of the associated numeric value. J = The associated numerical value is an estimated quantity. UL = The analyte was not detected above the level of the associated numeric value. UH = The analyte was not detected above the level of the associated numeric value.

Table B-8a
Trace Metal Indicators

Well	Port Depth (ft)	Scr #	Sample Collection Date Regional > Perched >	B µg/L	LQC	Test A1| µg/L <UL 42| 16	Cr (F[a]) µg/L	LQC		Test C10| µg/L >LL 0.9 0.5	Cr (UF[b]) µg/L	LQC	Test F3 µg/L <UL 10 10	Ratio Cr (UF/F)	Test F4 Ratio <UL 5 5	V µg/L	LQC	Test C4 µg/L >LL 3.8 0.5
R-2	918	1	17-Apr-07	13.4	J	P	5.1	J		P	10.1	J	Fail	2.0	P	—		ND
R-2	918	1	16-Jul-07	17.5	J	P	4.4			P	5.4		P	1.2	NA	8.5		P
R-3i	215	1	9-Apr-07	95.3		Ctmt	< 1.0	U		DL	< 1	U	P	—	NA	3.7	J	P
R-3i	215	1	20-Jul-07	108		Ctmt	< 1.0	U		DL	< 1	U	P	—	NA	3.9	J	P
R-4	793	1	17-Apr-07	23	J	P	< 5.0	U		DL	< 5	U	P	—	NA	7.3		P
R-4	793	1	18-Jul-07	27	J	P	< 5.0			P	< 4.9		P	1.0	NA	7.2		P
R-5	384	2	17-Apr-07	21.3	J	Ctmt	3.7			P	7	J	P	1.9	NA	8.4		P
R-5	384	2	16-Jul-07	< 27.4	J	Ctmt	3.8			P	7.6		P	2.0	NA	8.1		P
R-5	719	3	18-Apr-07	31.2	J	P	7.1			P	17.1		Ctmt	2.4	P	9.4		P
R-5	719	3	17-Jul-07	36.4	J	P	7.3			P	12.9		Ctmt	1.8	P	9.4		P
R-5	861	4	17-Apr-07	—		ND	—			ND	—		ND	—	ND	—		ND
R-5	861	4	16-Jul-07	—		ND	—			ND	—		ND	—	ND	—		ND
R-6	1205	1	12-Apr-07	21.2	J	P	4.1			P	4.8		P	1.2	NA	8.1		P
R-6	1205	1	17-Jul-07	< 26.9	J	P	3.2			P	3.3		P	1.0	NA	9.1		P
R-6i	602	1	12-Apr-07	21.8	J	Fail	3.0			P	2.9	J	P	1.0	NA	2.1	J	P
R-6i	602	1	17-Jul-07	< 22	J	Fail	1.7	J		P	1.9	J	P	1.1	NA	< 1	U	DL
R-7	378	1	19-Feb-02	< 50	U	DL	2.9			P	48.8		Fail	16.8	Fail	< 5	U	DL
R-7	378	1	5-Aug-02	< 4.88	U	P	2.0	B	UF	P	2.01	B	P	—	NA	0.82	B	P
R-7	915	3	13-Apr-07	< 2	U	P	< 1.0	U		DL	< 1	U	P	—	NA	< 1	U	Fail
R-7	915	3	31-Jul-07	15.8	U	P	< 1.0	U		DL	1.4		P	—	NA	< 1	U	Fail
R-8	711	1	10-Apr-07	17.5	J	P	3.4			P	3.6		P	1.1	NA	12		P
R-8	711	1	24-Jul-07	18.7	J	P	4.8			P	5.1		P	1.1	NA	12.4		P

Table B-8a (continued)

Well	Port Depth (ft)	Scr #	Sample Collection Date Regional > Perched >	B µg/L	LQC	Test A1| µg/L <UL 42| 16	Cr (F[a]) µg/L	LQC	Test C10| µg/L >LL 0.9 0.5	Cr (UF[b]) µg/L	LQC	Test F3 µg/L <UL 10 10	Ratio Cr (UF/F)	Test F4 Ratio <UL 5 5	V µg/L	LQC	Test C4 µg/L >LL 3.8 0.5
R-8	825	2	10-Apr-07	6.1		P	4.0		P	4		P	1.0	NA	10.7		P
R-8	825	2	25-Jul-07	22.9		P	4.4		P	4.3		P	1.0	NA	12.9		P
R-9	684	1	10-Apr-07	49.9	J	Ctmt	2.3	J	P	2.2	J	P	1.0	NA	11.4		P
R-9	684	1	19-Jul-07	45.7	J	Ctmt	< 3.3		P	< 3.3		P	1.0	NA	10.9		P
R-9i	199	1	9-Apr-07	< 2	U	P	3.0		P	3.6		P	1.2	NA	1.1		P
R-9i	199	1	27-Jul-07	8.9		P	3.8		P	9.5		P	2.5	NA	1.1		P
R-9i	279	2	9-Apr-07	< 2	U	P	1.7		P	1.9		P	1.1	NA	2.8		P
R-9i	279	2	27-Jul-07	15.1		P	< 1.0	U	DL	1.2		P	—	NA	1.9		P
R-24	825	1	16-Apr-07	60.4		Fail	2.1	J	P	3.3		P	1.6	NA	9.9		P
R-24	825	1	18-Jul-07	54.5		Fail	< 3.6		P	< 3.1		P	0.9	NA	17.5		P
LADP-3	316	1	26-Apr-07	18.9		Fail	8.8		P	9.8		P	1.1	NA	1.8	J	P
LAOI(a)-1.1	295	1	25-Apr-07	11.8	J	P	< 1.0	U	DL	1	J	P	—	NA	1.7	J	P
LAOI(a)-1.1	295	1	31-Jul-07	< 10.9	J	P	1.9	J	P	2.1	J	P	1.1	NA	< 1	U	DL
LAOI-3.2	153	1	19-Apr-07	< 10	U	P	< 1.0	U	DL	< 1.0	U	P	—	NA	< 1	U	DL
LAOI-3.2	153	1	26-Jul-07	11.3	J	P	< 2.0	J	P	< 2.0	J	P	1.0	NA	< 1	U	DL
LAOI-3.2A	181	1	25-Apr-07	10.5	J	P	2.8	J	P	2.8	J	P	1.0	NA	< 1	U	DL
LAOI-3.2A	181	1	30-Jul-07	< 11.6	J	P	3.5		P	3.7		P	1.1	NA	< 1	U	DL
LAOI-7	240	1	18-Apr-07	13.7	J	P	1.0	J	P	4.3		P	4.3	NA	1.8	J	P
LAOI-7	240	1	19-Jul-07	15.9	J	P	1.2	J	P	2.4	J	P	2.0	NA	1.2	J	P
POI-4	159	1	25-Apr-07	223		Ctmt	1.3	J	P	1.5	J	P	1.2	NA	4	J	P
POI-4	159	1	2-Aug-07	230		Ctmt	1.6	J	P	3.7		P	2.3	NA	2.3	J	P
TW-1	632	1	20-Dec-05	< 10	U	Rej	< 1	U UF	DL	< 1	U	P	—	NA	< 1	U	Fail
TW-1A	215	1	20-Dec-05	155		Ctmt	< 1	U UF	DL	< 1.0	U	P	—	NA	< 1	U	DL

Table B-8a (continued)

Well	Port Depth (ft)	Scr #	Sample Collection Date Regional > Perched >	B µg/L	LQC	Test A1| µg/L <UL 42| 16	Cr (F[a]) µg/L	LQC		Test C10| µg/L >LL 0.9 0.5	Cr (UF[b]) µg/L	LQC	Test F3 µg/L <UL 10 10	Ratio Cr (UF/F)	Test F4 Ratio <UL 5 5	V µg/L	LQC	Test C4 µg/L >LL 3.8 0.5
TW-2	768	1	22-Mar-05	17		P	1.4			P	—		ND	—	ND	< 1	U	Fail
TW-2A	123	1	27-May-99	80		Ctmt	< 5	UL	UF	DL	< 5	UL	P	—	NA	< 7	UL	DL
TW-2A	123	1	30-Jul-01	78		Ctmt	< 0.57	U	UF	DL	< 0.57	U	P	—	NA	< 0.48	U	Fail
TW-2A	123	1	16-May-05	—		ND	—			ND	—		ND	—	ND	—		ND
TW-3	805	1	19-Jan-06	31	J	P	< 1	U		DL	2.4	J	P	—	NA	< 1	U	Fail
TW-4	1195	1	19-Dec-05	84.6		Fail	< 1	U	UF	DL	< 1	U	P	—	NA	1.9	J	Fail

Sources: WQDB and GGRL data base.

Notes: The following abbreviations and color codings apply throughout this table:

- Types of test criteria: LL = Lower limit; UL = upper limit.
- Test outcomes: P = Pass (P and blue shading both indicate that the data pass the test criterion). Fail and pink shading both indicate that the data do not pass the test criterion. ND = no data. Ctmt = Indeterminate outcome because of presence of the indicator as a site-specific contaminant at this location. DL = Indeterminate outcome because of an inadequate detection limit. Red = Indeterminate outcome because this test is not reliable if reducing conditions are present. Rej = Indeterminate outcome because these data are rejected for this test.
- Data column entries: — = No data.
- LQC = Laboratory qualifier code. U = The analyte was not detected above the level of the associated numeric value. J = The associated numerical value is an estimated quantity. UL = The analyte was not detected above the level of the associated numeric value. UH = The analyte was not detected above the level of the associated numeric value. B = The reported value was obtained from a reading that was less than the contract-required detection limit (CRDL) but greater than or equal to the instrument detection limit (IDL).
- NA = This test is not applicable for this sample.

[a] F = Filtered.

[b] UF = Unfiltered.

Table B-8b
Trace Metal Indicators

Well	Port Depth (ft)	Scr #	Sample Collection Date Regional > Perched >	Mn µg/L	LQC	Test C6 µg/L <UL 14 14	Fe (F[a]) µg/L	LQC	Test C5 µg/L >LL 103 103	Fe (UF[b]) µg/L	LQC	Test F1| µg/L <UL 500 500	Ratio Fe (UF/F)	Test F2 Ratio <UL 10 10	Ni µg/L	LQC	Test F5 µg/L <UL 50 50
R-2	918	1	17-Apr-07	10.5		P[a]	< 18	U	P	383		Yes	—	NA	< 2.5	U	P
R-2	918	1	16-Jul-07	2.3	J	P	< 25	U	P	154		Yes	6.16	NA	1.1	J	P
R-3i	215	1	9-Apr-07	< 2	U	P	< 18	U	P	25.6	J	Yes	1.42	NA	9.6		P
R-3i	215	1	20-Jul-07	< 2	U	P	< 25	U	P	< 25	U	Yes	—	NA	8.7		P
R-4	793	1	17-Apr-07	22.1		Fail	< 18	U	P	< 18	U	Yes	—	NA	5.9	J	P
R-4	793	1	18-Jul-07	< 2	U	P	42.8	J	P	94.3	J	Yes	2.2	NA	3.1		P
R-5	384	2	17-Apr-07	< 2	U	P	< 18	U	P	< 18	U	Yes	—	NA	0.77	J	P
R-5	384	2	16-Jul-07	< 2	U	P	< 25	U	P	< 25	U	Yes	—	NA	0.63	J	P
R-5	719	3	18-Apr-07	< 2	U	P	< 18	U	P	< 18	U	Yes	—	NA	2		P
R-5	719	3	17-Jul-07	< 2	U	P	< 25	U	P	27.3	J	Yes	1.09	NA	1.6	J	P
R-5	861	4	17-Apr-07	—		ND	—		ND	—		ND	—	ND	—		ND
R-5	861	4	16-Jul-07	—		ND	—		ND	—		ND	—	ND	—		ND
R-6	1205	1	12-Apr-07	14.2		Fail	52	J	P	74.6	J	Yes	1.43	NA	0.64	J	P
R-6	1205	1	17-Jul-07	< 2	U	P	< 25	U	P	43.4	J	Yes	1.74	NA	< 0.5	U	P
R-6i	602	1	12-Apr-07	2.2	J	P	111		Fail	127		Yes	1.14	NA	1.5	J	P
R-6i	602	1	17-Jul-07	2.2	J	P	169		Fail	148		Yes	0.88	NA	1.1		P
R-7	378	1	19-Feb-02	50.1		Fail	< 50	U	P	184		Yes	3.68	NA	< 5	U	P
R-7	378	1	5-Aug-02	35.7		Fail	21.9	B* UF	P	21.9	B*	Yes	—	NA	< 0.69	U	P
R-7	915	3	13-Apr-07	675		Fail	1585		Fail	2007		No	1.27	P	2.6		P
R-7	915	3	31-Jul-07	575		Fail	1273		Fail	1628		No	1.28	P	1.6		P
R-8	711	1	10-Apr-07	< 2	U	P	< 18	U	P	136		Yes	7.56	NA	< 0.5	U	P
R-8	711	1	24-Jul-07	—		ND	< 25	U	P	< 25	U	Yes	—	NA	< 2	U	P

Table B-8b (continued)

Well	Port Depth (ft)	Scr #	Sample Collection Date Regional > Perched >	Mn µg/L	LQC	Test C6 µg/L <UL 14 14	Fe (F[a]) µg/L	LQC	Test C5 µg/L >LL 103 103	Fe (UF[b]) µg/L	LQC	Test F1| µg/L <UL 500 500	Ratio Fe (UF/F)	Test F2 Ratio <UL 10 10	Ni µg/L	LQC	Test F5 µg/L <UL 50 50
R-8	825	2	10-Apr-07	< 1	U	P	< 10	U	P	17.8		Yes	—	NA	< 1	U	P
R-8	825	2	25-Jul-07	7		P	< 10	U	P	< 10	U	Yes	—	NA	1.7		P
R-9	684	1	10-Apr-07	16		Fail	< 18	U	P	18.1	J	Yes	—	NA	1.3	J	P
R-9	684	1	19-Jul-07	10.5		P	36.2	J	P	60.2	J	Yes	1.66	NA	1.6	J	P
R-9i	199	1	9-Apr-07	211		Fail	11		P	11.2		Yes	1.02	NA	215		Fail
R-9i	199	1	27-Jul-07	109		Fail	238		Fail	343		Yes	1.44	NA	121		Fail
R-9i	279	2	9-Apr-07	34		Fail	< 10	U	P	13		Yes	—	NA	21.9		P
R-9i	279	2	27-Jul-07	37		Fail	< 10	U	P	< 10	U	Yes	—	NA	21		P
R-24	825	1	16-Apr-07	68.9		Fail	< 18	U	P	< 18	U	Yes	—	NA	1.1	J	P
R-24	825	1	18-Jul-07	3.4	J	P	< 25	U	P	50.7	J	Yes	2.03	NA	1.4	J	P
LADP-3	316	1	26-Apr-07	< 2	U	P	20	J	P	< 18	U	Yes	—	NA	< 0.5	U	P
LAOI(a)-1.1	295	1	25-Apr-07	< 2	U	P	< 18	U	P	189		Yes	—	NA	0.57	J	P
LAOI(a)-1.1	295	1	31-Jul-07	< 2	U	P	< 25	U	P	743		No	—	DL	< 0.5	U	P
LAOI-3.2	153	1	19-Apr-07	15.8		Fail	< 18	U	P	47.1	J	Yes	—	NA	0.78	J	P
LAOI-3.2	153	1	26-Jul-07	11.2		P	< 25	U	P	< 25	U	Yes	—	NA	< 0.5	U	P
LAOI-3.2A	181	1	25-Apr-07	< 2	U	P	< 18	U	P	< 18	U	Yes	—	NA	0.57	J	P
LAOI-3.2A	181	1	30-Jul-07	< 2	U	P	< 25	U	P	< 25	U	Yes	—	NA	0.76	J	P
LAOI-7	240	1	18-Apr-07	< 2	U	P	< 18	U	P	38.8	J	Yes	2.16	NA	1.1	J	P
LAOI-7	240	1	19-Jul-07	4.1	J	P	47.8	J	P	287		Yes	6	NA	6.1		P
POI-4	159	1	25-Apr-07	2.7	J	P	27.8	J	P	57.6	J	Yes	2.07	NA	10.1		P
POI-4	159	1	2-Aug-07	< 2	U	P	31.5	J	P	3650		No	116	Fail	10.1		P
TW-1	632	1	20-Dec-05	10.8		P	33.3	J UF	P	33.3		Yes	—	NA	5.3		P
TW-1A	215	1	20-Dec-05	271		Fail	2810	UF	Fail	2810		No	—	ND	4.1		P

Table B-8b (continued)

Well	Port Depth (ft)	Scr #	Sample Collection Date Regional > Perched >	Mn µg/L	LQC	Test C6 µg/L <UL 14 14	Fe (F[a]) µg/L	LQC	Test C5 µg/L >LL 103 103	Fe (UF[b]) µg/L	LQC	Test F1| µg/L <UL 500 500	Ratio Fe (UF/F)	Test F2 Ratio <UL 10 10	Ni µg/L	LQC	Test F5 µg/L <UL 50 50
TW-2	768	1	22-Mar-05	73		Fail	40		P	—		ND	—	ND	1.1		P
TW-2A	123	1	27-May-99	127		Fail	1892	UF	Fail	1892		No	—	ND	< 20	UL	P
TW-2A	123	1	30-Jul-01	514		Fail	4610	UF	Fail	4610		No	—	ND	1.8	B	P
TW-2A	123	1	16-May-05	—		ND	—		ND	—		ND	—	ND	—		ND
TW-3	805	1	19-Jan-06	175		Fail	440		Fail	6130		No	13.9	Fail	0.64	J	P
TW-4	1195	1	19-Dec-05	44.6		Fail	963	UF	Fail	963		No	—	ND	< 0.5	U	P

Sources: WQDB and GGRL data base.

Notes: The following abbreviations and color codings apply throughout this table:

- Types of test criteria: LL = Lower limit; UL = upper limit.
- Test outcomes: P = pass (P and blue shading both indicate that the data pass the test criterion). Fail and pink shading both indicate that the data do not pass the test criterion. ND = No data. Ctmt = Indeterminate outcome because of presence of the indicator as a site-specific contaminant at this location. DL = Indeterminate outcome because of an inadequate detection limit. Red = Indeterminate outcome because this test is not reliable if reducing conditions are present. Rej = Indeterminate outcome because these data are rejected for this test
- Data column entries: — = No data.
- LQC = Laboratory qualifier code. U = The analyte was not detected above the level of the associated numeric value. J = The associated numerical value is an estimated quantity. UL = The analyte was not detected above the level of the associated numeric value. UH = The analyte was not detected above the level of the associated numeric value. B = The reported value was obtained from a reading that was less than the CRDL but greater than or equal to the IDL. B* = The reported value was obtained from a reading that was less than the CRDL but greater than or equal to the IDL.
- NA = This test is not applicable for this sample.

[a] F = Filtered.

[b] UF =Unfiltered.

Table B-8c
Trace Metal Indicators

Well	Port Depth (ft)	Scr #	Sample Collection Date Regional > Perched >		U (µg/L)	LQC	Test C7 >LL 0.16 0.1	Test D2 >LL 0.16 0.1	Test E5 <UL 1.6 0.72		Zn (µg/L)	LQC	Test Gen-5 >LL 0.6 0.5	Test Gen-6 <UL 40 40
R-2	918	1	17-Apr-07		0.57		P	P	P		6	J	P	P
R-2	918	1	16-Jul-07		0.58		P	P	P		6.8	J	P	P
R-3i	215	1	9-Apr-07		8.5		P	P	Ctmt	<	3.1	J	P	P
R-3i	215	1	20-Jul-07		10		P	P	Ctmt	<	2	U	DL	P
R-4	793	1	17-Apr-07		1		P	P	P	<	2	U	DL	P
R-4	793	1	18-Jul-07		0.64		P	P	P	<	2	U	DL	P
R-5	384	2	17-Apr-07		2.9		P	P	Ctmt	<	2	U	DL	P
R-5	384	2	16-Jul-07		2.8		P	P	Ctmt		2.9		P	P
R-5	719	3	18-Apr-07		1.7		P	P	Fail	<	2	U	DL	P
R-5	719	3	17-Jul-07		1.7		P	P	Fail	<	2	U	DL	P
R-5	861	4	17-Apr-07		—		ND	ND	ND		—		ND	ND
R-5	861	4	16-Jul-07		—		ND	ND	ND		—		ND	ND
R-6	1205	1	12-Apr-07		0.39		P	P	P	<	2	U	DL	P
R-6	1205	1	17-Jul-07		0.45		P	P	P		2.4	J	P	P
R-6i	602	1	12-Apr-07		0.54		P	P	P		14.3		P	P
R-6i	602	1	17-Jul-07		0.6		P	P	P		6	J	P	P
R-7	378	1	19-Feb-02	<	0.2	U	DL	DL	P		13.6		P	P
R-7	378	1	5-Aug-02	<	15.6	U	DL	DL	DL		12.3	UF[a]	UF	P
R-7	915	3	13-Apr-07	<	0.2	U	DL	DL	P		19.1		P	P
R-7	915	3	31-Jul-07	<	0.2	U	DL	DL	P		19.3		P	P
R-8	711	1	10-Apr-07		0.28		P	P	P	<	2	U	DL	P
R-8	711	1	24-Jul-07	<	0.24		P	P	P	<	2	U	DL	P
R-8	825	2	10-Apr-07		0.9		P	P	P		2.4		P	P
R-8	825	2	25-Jul-07		0.7		P	P	P	<	1	U	DL	P
R-9	684	1	10-Apr-07		1.8		P	P	Ctmt	<	2	U	DL	P
R-9	684	1	19-Jul-07		1.7		P	P	Ctmt	<	2	U	DL	P
R-9i	199	1	9-Apr-07		1.2		P	P	Fail		36.3		P	P
R-9i	199	1	27-Jul-07		0.9		P	P	Fail		8.3		P	P
R-9i	279	2	9-Apr-07		1.5		P	P	Fail		3.7		P	P
R-9i	279	2	27-Jul-07		1.5		P	P	Fail		3.2		P	P
R-24	825	1	16-Apr-07		2.5		P	P	Fail		12		P	P
R-24	825	1	18-Jul-07		1.9		P	P	Fail		18.9		P	P
LADP-3	316	1	26-Apr-07		0.9		P	P	Fail	<	4.3	J	P	P

Table B-8c (continued)

Well	Port Depth (ft)	Scr #	Sample Collection Date Regional > Perched >		U (µg/L)	LQC	Test C7 >LL 0.16 0.1	Test D2 >LL 0.16 0.1	Test E5 <UL 1.6 0.72		Zn (µg/L)	LQC		Test Gen-5 >LL 0.6 0.5	Test Gen-6 <UL 40 40
LAOI(a)-1.1	295	1	25-Apr-07		0.47		P	P	P	<	2	U		DL	P
LAOI(a)-1.1	295	1	31-Jul-07		0.18	J	P	P	P		11.3			P	P
LAOI-3.2	153	1	19-Apr-07		1.3		P	P	Ctmt	<	2	U		DL	P
LAOI-3.2	153	1	26-Jul-07		1.5		P	P	Ctmt		3.5	J		P	P
LAOI-3.2A	181	1	25-Apr-07		1.3		P	P	Ctmt	<	2	U		DL	P
LAOI-3.2A	181	1	30-Jul-07		1.5		P	P	Ctmt	<	2	U		DL	P
LAOI-7	240	1	18-Apr-07		0.57		P	P	P		3.1	J		P	P
LAOI-7	240	1	19-Jul-07		0.61		P	P	P		6.8	J		P	P
POI-4	159	1	25-Apr-07		3		P	P	Ctmt	<	2	U		DL	P
POI-4	159	1	2-Aug-07		3.1		P	P	Ctmt		2.4	J		P	P
TW-1	632	1	20-Dec-05		3.6		P	P	Ctmt		184		UF	UF	UF
TW-1A	215	1	20-Dec-05		0.13	J	P	P	P		901		UF	UF	UF
TW-2	768	1	22-Mar-05	<	0.2	U	DL	DL	P		1540			NA	Fail
TW-2A	123	1	27-May-99		0.18		P	P	P		4981		UF	UF	UF
TW-2A	123	1	30-Jul-01		—		ND	ND	ND		20800		UF	UF	UF
TW-2A	123	1	16-May-05		—		ND	ND	ND		—			ND	ND
TW-3	805	1	19-Jan-06	<	0.05	U	Fail	Red	P		64			NA	Fail
TW-4	1195	1	19-Dec-05	<	0.05	U	Fail	Red	P		913		UF	UF	UF

Sources: WQDB and GGRL data base.

Notes: The following abbreviations and color codings apply throughout this table:

- Types of test criteria: LL = lower limit; UL = upper limit.
- Test outcomes: P = Pass (P and blue shading both indicate that the data pass the test criterion). Fail and pink shading both indicate that the data do not pass the test criterion. ND = No data. Ctmt = Indeterminate outcome because of presence of the indicator as a site-specific contaminant at this location. DL = Indeterminate outcome because of an inadequate detection limit. Red = Indeterminate outcome because this test is not reliable if reducing conditions are present. Rej = Indeterminate outcome because these data are rejected for this test.
- Data column entries: — = No data.
- LQC = Laboratory qualifier code. .U = The analyte was not detected above the level of the associated numeric value.
  J = The associated numerical value is an estimated quantity. UL = The analyte was not detected above the level of the associated numeric value. UH = The analyte was not detected above the level of the associated numeric value.
  B = The reported value was obtained from a reading that was less than the CRDLbut greater than or equal to the IDL.

[a] UF = Unfiltered.

Table B-9
Summary of Test Outcomes

				General Indicators				Category A Residual Inorganics						Category A Residual Organics				Category C1 SO_4-Reducing		
Well	Port Depth (ft)	Scr #	Sample Collection Date	Mod ^3H?	Gen-1 pH	Gen-2 Alk	Gen-3 Turb	A1 B	A2 Cl	A3 Na	A4 SO_4	A5 F	A6 PO_4	B1 Ace-tone	B2 NH_3	B3 TKN	B4 TOC	C1 SO_4	C2 S	C3 ORP
R-2	918	1	17-Apr-07	No	P[a]	P	P	P	P	P	P	P	P	P	P	P	P	P	ND	P
R-2	918	1	16-Jul-07	No	P	P	P	P	P	P	P	P	P	P	P	P	P	P	ND	P
R-3i	215	1	9-Apr-07	Ctmt	P	Fail[c]	P	Ctmt	Ctmt	Fail	Ctmt	Ctmt	P	P	P	P	P	P	ND	P
R-3i	215	1	20-Jul-07	Ctmt	P	Fail	P	Ctmt	Ctmt	Fail	Ctmt	Ctmt	P	P	P	P	P	P	ND	P
R-4	793	1	17-Apr-07	Ctmt	P	P	P	P	Ctmt	P	P	Ctmt	P	P	P	P	P	P	ND	Fail
R-4	793	1	18-Jul-07	Ctmt	P	P	P	P	Ctmt	P	P	Ctmt	P	P	P	P	P	P	ND	P
R-5	384	2	17-Apr-07	No	P	Fail	P	Ctmt	Ctmt	Fail	Ctmt	Ctmt	P	P	P	P	P	P	ND	ND
R-5	384	2	16-Jul-07	No	P	Fail	P	Ctmt	Ctmt	Fail	Ctmt	Ctmt	P	P	P	P	P	P	ND	ND
R-5	719	3	18-Apr-07	No	P	P	P	P	Ctmt	P	Ctmt	Ctmt	P	P	P	P	P	P	ND	ND
R-5	719	3	17-Jul-07	ND	P	P	P	P	Ctmt	P	Ctmt	Ctmt	P	P	P	P	P	P	ND	ND
R-5	861	4	17-Apr-07	No	P	ND	P	ND	Fail	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
R-5	861	4	16-Jul-07	No	P	ND	P	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
R-6	1205	1	12-Apr-07	No	P	P	P	P	P	P	P	P	P	P	P	P	P	P	ND	P
R-6	1205	1	17-Jul-07	No	P	P	P	P	P	P	P	P	P	P	P	P	P	P	ND	P
R-6i	602	1	12-Apr-07	Ctmt	P	Fail	P	Fail	Ctmt	Fail	Ctmt	Ctmt	Fail	P	P	P	P	P	ND	P
R-6i	602	1	17-Jul-07	Ctmt	P	Fail	P	Fail	Ctmt	Fail	Ctmt	Ctmt	P	P	P	P	P	P	ND	P
R-7	378	1	19-Feb-02	No	P	P	P	DL	P	P	P	P	P	P	P	P	P	P	ND	ND
R-7	378	1	5-Aug-02	No	P	P	P	P	P	P	P	P	P	P	P	ND	P	P	ND	ND
R-7	915	3	13-Apr-07	No	Fail	P	P	P	P	P	P	P	P	ND	ND	ND	ND	Fail	P	ND
R-7	915	3	31-Jul-07	No	Fail	P	P	P	P	P	P	P	P	ND	ND	ND	ND	Fail	P	ND
R-8	711	1	10-Apr-07	No	P	P	P	P	P	P	P	Fail	P	P	P	P	P	P	ND	ND
R-8	711	1	24-Jul-07	No	P	P	P	P	P	P	P	P	P	P	DL	P	P	P	ND	ND

Table B-9 (continued)

Well	Port Depth (ft)	Scr #	Sample Collection Date	General Indicators				Category A Residual Inorganics						Category A Residual Organics				Category C1 SO_4-Reducing		
				Mod ^3H?	Gen-1 pH	Gen-2 Alk	Gen-3 Turb	A1 B	A2 Cl	A3 Na	A4 SO_4	A5 F	A6 PO_4	B1 Acetone	B2 NH_3	B3 TKN	B4 TOC	C1 SO_4	C2 S	C3 ORP
R-8	825	2	10-Apr-07	No	P	P	P	P	Fail	P	P	Fail	P	ND	ND	ND	ND	P	P	ND
R-8	825	2	25-Jul-07	No	Fail	P	P	P	Fail	P	P	P	P	ND	ND	ND	ND	P	P	ND
R-9	684	1	10-Apr-07	No	P	Fail	P	Ctmt	Ctmt	P	P	P	P	P	P	P	P	P	ND	P
R-9	684	1	19-Jul-07	No	P	Fail	P	Ctmt	Ctmt	P	P	P	P	P	P	P	P	P	ND	P
R-9i	199	1	9-Apr-07	Ctmt	P	Fail	ND	P	Ctmt	Fail	Ctmt	Ctmt	P	ND	ND	ND	ND	P	P	ND
R-9i	199	1	27-Jul-07	Ctmt	P	Fail	P	P	Ctmt	Fail	Ctmt	Ctmt	P	ND	ND	ND	ND	P	P	ND
R-9i	279	2	9-Apr-07	Ctmt	P	Fail	ND	P	Ctmt	P	Ctmt	Ctmt	Fail	ND	ND	ND	ND	P	P	ND
R-9i	279	2	27-Jul-07	Ctmt	P	Fail	P	P	Ctmt	P	Ctmt	Ctmt	P	ND	ND	ND	ND	P	P	ND
R-24	825	1	16-Apr-07	No	P	Fail	P	Fail	Fail	Fail	Fail	P	P	P	P	P	Fail	P	ND	Fail
R-24	825	1	18-Jul-07	No	P	P	P	Fail	Fail	P	Fail	P	P	P	P	P	P	P	ND	P
LADP-3	316	1	26-Apr-07	ND	P	Fail	P	Fail	Ctmt	Ctmt	Ctmt	Ctmt	Fail	P	P	P	DL	P	ND	P
LAOI(a)-1.1	295	1	25-Apr-07	No	Fail	Fail	Fail	P	P	Fail	P	P	P	P	P	P	P	P	ND	P
LAOI(a)-1.1	295	1	31-Jul-07	ND	P	P	Fail	P	P	P	P	P	P	P	P	P	Fail	P	ND	P
LAOI-3.2	153	1	19-Apr-07	Ctmt	P	Fail	P	P	Ctmt	Ctmt	P	P	P	P	P	P	Fail	P	ND	P
LAOI-3.2	153	1	26-Jul-07	Ctmt	P	Fail	P	P	Ctmt	Ctmt	Ctmt	P	Ctmt	P	P	P	P	P	ND	P
LAOI-3.2A	181	1	25-Apr-07	Ctmt	P	Fail	P	P	Ctmt	Ctmt	Ctmt	P	P	P	P	P	P	P	ND	P
LAOI-3.2A	181	1	30-Jul-07	Ctmt	P	Fail	P	P	Ctmt	Ctmt	Ctmt	P	P	P	P	P	Fail	P	ND	P
LAOI-7	240	1	18-Apr-07	Ctmt	P	Fail	P	P	Ctmt	P	Ctmt	P	P	P	P	P	P	P	ND	P
LAOI-7	240	1	19-Jul-07	Ctmt	P	Fail	P	P	Ctmt	P	Ctmt	P	P	P	DL	P	Fail	P	ND	P
POI-4	159	1	25-Apr-07	Yes	P	Fail	P	Ctmt	Ctmt	Ctmt	Ctmt	Ctmt	Ctmt	P	P	P	Fail	P	ND	P
POI-4	159	1	2-Aug-07	Yes	P	Fail	Fail	Ctmt	Ctmt	Ctmt	Ctmt	Ctmt	Ctmt	P	DL	P	Fail	P	ND	P
TW-1	632	1	20-Dec-05	Ctmt	Fail	Fail	Fail	Rej	Ctmt	P	Ctmt	P	P	P	P	P	ND	P	ND	P
TW-1A	215	1	20-Dec-05	Ctmt	P	Fail	Fail	Ctmt	Ctmt	Ctmt	P	Ctmt	Ctmt	Fail	Fail	Fail	ND	Fail	ND	P

Table B-9 (continued)

Well	Port Depth (ft)	Scr #	Sample Collection Date	General Indicators				Category A Residual Inorganics						Category A Residual Organics				Category C1 SO_4-Reducing		
				Mod ^3H?	Gen-1 pH	Gen-2 Alk	Gen-3 Turb	A1 B	A2 Cl	A3 Na	A4 SO_4	A5 F	A6 PO_4	B1 Ace-tone	B2 NH_3	B3 TKN	B4 TOC	C1 SO_4	C2 S	C3 ORP
TW-2	768	1	22-Mar-05	ND	ND	P	ND	P	P	P	P	Fail	P	ND	ND	ND	ND	Fail	ND	ND
TW-2A	123	1	27-May-99	Ctmt	P	Fail	ND	Ctmt	Ctmt	Ctmt	Ctmt	P	P	ND	ND	ND	ND	P	ND	ND
TW-2A	123	1	30-Jul-01	Ctmt	ND	ND	ND	Ctmt	ND	ND	ND	ND	P	P	ND	ND	ND	ND	ND	ND
TW-2A	123	1	16-May-05	Ctmt	P	ND	Fail	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TW-3	805	1	19-Jan-06	No	P	P	Fail	P	P	P	P	P	P	P	Fail	Fail	ND	Fail	ND	Fail
TW-4	1195	1	19-Dec-05	No	Fail	P	P	Fail	P	P	P	P	P	P	P	P	ND	Fail	ND	Err

Table B-9 (continued)

Well	Port depth (ft)	Scr #	Sample Collection Date	Category C2 Fe/Mn-Reducing						Category C3 NO3-Reducing		Category D Enhanced Adsorption				Category E Carbonate/Sulfate Mineralogy				
				C4 V	C5 Fe	C6 Mn	C7 U	C8 ClO4	C9 Cr	C10 NO3	C11 DO	D1 Sr	D2 U	D3 Ba	D4 Zn	E1 Ca	E2 Ba	E3 Sr	E4 Mg	E5 U
R-2	918	1	17-Apr-07	ND	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
R-2	918	1	16-Jul-07	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
R-3i	215	1	9-Apr-07	P	P	P	P	P	DL	P	P	P	P	P	P	Fail	Fail	Fail	Fail	Ctmt
R-3i	215	1	20-Jul-07	P	P	P	P	P	DL	P	P	P	P	P	DL	Fail	Fail	Fail	Fail	Ctmt
R-4	793	1	17-Apr-07	P	P	Fail	P	P	DL	P	P	P	P	P	DL	P	P	P	P	P
R-4	793	1	18-Jul-07	P	P	P	P	P	P	P	P	P	P	P	DL	P	P	P	P	P
R-5	384	2	17-Apr-07	P	P	P	P	P	P	P	ND	P	P	P	DL	Fail	Fail	Fail	P	Ctmt
R-5	384	2	16-Jul-07	P	P	P	P	P	P	P	ND	P	P	P	P	Fail	Fail	Fail	P	Ctmt
R-5	719	3	18-Apr-07	P	P	P	P	P	P	P	ND	P	P	P	DL	P	Fail	Fail	P	Fail
R-5	719	3	17-Jul-07	P	P	P	P	P	P	P	ND	P	P	P	DL	P	Fail	Fail	P	Fail
R-5	861	4	17-Apr-07	ND	ND	ND	ND	P	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	P	ND
R-5	861	4	16-Jul-07	ND	ND	ND	ND	P	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
R-6	1205	1	12-Apr-07	P	P	Fail	P	P	P	P	P	P	P	P	DL	P	P	P	P	P
R-6	1205	1	17-Jul-07	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
R-6i	602	1	12-Apr-07	P	Fail	P	P	P	P	P	P	P	P	P	P	Fail	P	P	P	P
R-6i	602	1	17-Jul-07	DL	Fail	P	P	P	P	P	P	P	P	P	P	Fail	P	P	P	P
R-7	378	1	19-Feb-02	DL	P	Fail	DL	DL	P	P	P	P	DL	P	P	P	P	P	P	P
R-7	378	1	5-Aug-02	P	P	Fail	DL	DL	P	P	P	P	DL	P	UF	P	P	P	P	DL
R-7	915	3	13-Apr-07	Fail	Fail	Fail	DL	DL	DL	Fail	ND	Red	DL	P	P	Fail	Fail	P	P	P
R-7	915	3	31-Jul-07	Fail	Fail	Fail	DL	DL	DL	Fail	ND	Red	DL	P	P	Fail	Fail	P	P	P
R-8	711	1	10-Apr-07	P	P	P	P	P	P	P	ND	P	P	P	DL	P	P	P	P	P
R-8	711	1	24-Jul-07	P	P	ND	P	P	P	Fail	ND	P	P	P	DL	P	P	P	P	P
R-8	825	2	10-Apr-07	P	P	P	P	DL	P	P	ND	P	P	P	P	P	Fail	P	P	P

Table B-9 (continued)

Well	Port depth (ft)	Scr #	Sample Collection Date	Category C2 Fe/Mn-Reducing						Category C3 NO3-Reducing		Category D Enhanced Adsorption				Category E Carbonate/Sulfate Mineralogy				
				C4 V	C5 Fe	C6 Mn	C7 U	C8 ClO4	C9 Cr	C10 NO3	C11 DO	D1 Sr	D2 U	D3 Ba	D4 Zn	E1 Ca	E2 Ba	E3 Sr	E4 Mg	E5 U
R-8	825	2	25-Jul-07	P	P	P	P	DL	P	P	ND	P	P	P	DL	P	Fail	Fail	P	P
R-9	684	1	10-Apr-07	P	P	Fail	P	P	P	P	P	P	P	P	DL	P	Fail	Red	Fail	Ctmt
R-9	684	1	19-Jul-07	P	P	P	P	P	P	P	P	P	P	P	DL	P	Fail	P	Fail	Ctmt
R-9i	199	1	9-Apr-07	P	P	Fail	P	DL	P	P	ND	P	P	P	P	Fail	P	P	Fail	Fail
R-9i	199	1	27-Jul-07	P	Fail	Fail	P	DL	P	Fail	ND	P	P	P	P	P	P	P	Fail	Fail
R-9i	279	2	9-Apr-07	P	P	Fail	P	DL	P	P	ND	P	P	P	P	P	P	P	P	Fail
R-9i	279	2	27-Jul-07	P	P	Fail	P	DL	DL	Fail	ND	P	P	P	P	P	P	P	P	Fail
R-24	825	1	16-Apr-07	P	P	Fail	P	Fail	P	P	Fail	P	P	P	P	P	Fail	P	P	Fail
R-24	825	1	18-Jul-07	P	P	P	P	P	P	P	Fail	P	P	P	P	P	Fail	P	P	Fail
LADP-3	316	1	26-Apr-07	P	P	P	P	Fail	P	Fail	Fail	P	P	P	P	P	P	P	P	Fail
LAOI(a)-1.1	295	1	25-Apr-07	P	P	P	P	Fail	DL	P	P	P	P	P	DL	Fail	P	P	P	P
LAOI(a)-1.1	295	1	31-Jul-07	DL	P	P	P	Fail	P	P	P	P	P	P	P	P	P	P	P	P
LAOI-3.2	153	1	19-Apr-07	DL	P	Fail	P	P	DL	P	P	P	P	P	DL	Fail	P	P	P	Ctmt
LAOI-3.2	153	1	26-Jul-07	DL	P	P	P	P	P	P	P	P	P	P	P	Fail	P	P	P	Ctmt
LAOI-3.2A	181	1	25-Apr-07	DL	P	P	P	P	P	P	P	P	P	P	DL	Fail	P	P	P	Ctmt
LAOI-3.2A	181	1	30-Jul-07	DL	P	P	P	P	P	P	P	P	P	P	DL	Fail	P	P	P	Ctmt
LAOI-7	240	1	18-Apr-07	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
LAOI-7	240	1	19-Jul-07	P	P	P	P	P	P	Fail	P	P	P	P	P	P	P	P	Fail	P
POI-4	159	1	25-Apr-07	P	P	P	P	P	P	P	P	P	P	P	DL	Fail	Fail	Fail	Fail	Ctmt
POI-4	159	1	2-Aug-07	P	P	P	P	P	P	P	Fail	P	P	P	P	Fail	Fail	Fail	Fail	Ctmt
TW-1	632	1	20-Dec-05	Fail	P	P	P	P	DL	P	P	Fail	P	P	UF	Fail	P	P	P	Ctmt
TW-1A	215	1	20-Dec-05	DL	Fail	Fail	P	Fail	DL	Fail	P	P	P	P	UF	Fail	Fail	Red	Fail	P

Table B-9 (continued)

Well	Port depth (ft)	Scr #	Sample Collection Date	Category C2 Fe/Mn-Reducing						Category C3 NO3- Reducing		Category D Enhanced Adsorption				Category E Carbonate/Sulfate Mineralogy				
				C4 V	C5 Fe	C6 Mn	C7 U	C8 ClO4	C9 Cr	C10 NO3	C11 DO	D1 Sr	D2 U	D3 Ba	D4 Zn	E1 Ca	E2 Ba	E3 Sr	E4 Mg	E5 U
TW-2	768	1	22-Mar-05	Fail	P	Fail	DL	Fail	P	Fail	P	Red	DL	P	NA	Fail	P	P	P	P
TW-2A	123	1	27-May-99	DL	Fail	Fail	P	ND	DL	P	ND	P	P	P	UF	Fail	P	Red	Fail	P
TW-2A	123	1	30-Jul-01	Fail	Fail	Fail	ND	DL	DL	Fail	ND	P	ND	P	UF	Fail	P	Red	ND	ND
TW-2A	123	1	16-May-05	ND	ND	ND	ND	Fail	ND	ND	Fail	ND	ND	ND	ND	ND	ND	ND	ND	ND
TW-3	805	1	19-Jan-06	Fail	Fail	Fail	Fail	Fail	DL	Fail	Fail	P	Red	P	NA	P	P	P	P	P
TW-4	1195	1	19-Dec-05	Fail	Fail	Fail	Fail	Fail	DL	Fail	P	P	Red	P	UF	Fail	Fail	Red	Fail	P

Table B-9 (continued)

Well	Port depth (ft)	Scr #	Sample Collection Date	Category F Steel Corrosion						Summary of Test Outcomes				
				F1 Fe	F2 Fe ratio	F3 Cr	F4 Cr ratio	F5 Ni	F6 Zn	Pass	Fail	Indeter-minate	Total tests with Pass/Fail Outcome	% Pass
R-2	918	1	17-Apr-07	Yes	NA	Fail	P	P	P	38	1	0	39	97
R-2	918	1	16-Jul-07	Yes	NA	P	NA	P	P	39	0	0	39	100
R-3i	215	1	9-Apr-07	Yes	NA	DL	NA	P	P	25	6	8	31	81
R-3i	215	1	20-Jul-07	Yes	NA	DL	NA	P	P	24	6	9	30	80
R-4	793	1	17-Apr-07	Yes	NA	DL	NA	P	P	31	2	6	33	94
R-4	793	1	18-Jul-07	Yes	NA	P	NA	P	P	34	0	5	34	100
R-5	384	2	17-Apr-07	Yes	NA	P	NA	P	P	23	5	9	28	82
R-5	384	2	16-Jul-07	Yes	NA	P	NA	P	P	24	5	8	29	83
R-5	719	3	18-Apr-07	Yes	NA	P	P	P	P	27	3	8	30	90
R-5	719	3	17-Jul-07	Yes	NA	P	P	P	P	27	3	8	30	90
R-5	861	4	17-Apr-07	ND	ND	ND	ND	ND	ND	5	1	0	6	83
R-5	861	4	16-Jul-07	ND	ND	ND	ND	ND	ND	4	0	0	4	100
R-6	1205	1	12-Apr-07	Yes	NA	P	NA	P	P	37	1	1	38	97
R-6	1205	1	17-Jul-07	Yes	NA	P	NA	P	P	39	0	0	39	100
R-6i	602	1	12-Apr-07	Yes	NA	P	NA	P	P	27	6	6	33	82
R-6i	602	1	17-Jul-07	Yes	NA	P	NA	P	P	28	5	6	33	85
R-7	378	1	19-Feb-02	Yes	NA	P	Fail	P	P	29	4	6	33	88
R-7	378	1	5-Aug-02	Yes	NA	P	NA	P	P	30	1	6	31	97
R-7	915	3	13-Apr-07	No	P	DL	NA	P	P	21	8	5	29	72
R-7	915	3	31-Jul-07	No	P	DL	NA	P	P	21	8	5	29	72
R-8	711	1	10-Apr-07	Yes	NA	P	NA	P	P	35	1	1	36	97
R-8	711	1	24-Jul-07	Yes	NA	P	NA	P	P	33	1	2	34	97
R-8	825	2	10-Apr-07	Yes	NA	P	NA	P	P	29	3	2	32	91

Table B-9 (continued)

Well	Port depth (ft)	Scr #	Sample Collection Date	Category F Steel Corrosion: F1 Fe	F2 Fe ratio	F3 Cr	F4 Cr ratio	F5 Ni	F6 Zn	Summary of Test Outcomes: Pass	Fail	Indeter-minate	Total tests with Pass/Fail Outcome	% Pass
R-8	825	2	25-Jul-07	Yes	NA	P	NA	P	P	27	4	3	31	87
R-9	684	1	10-Apr-07	Yes	NA	P	NA	P	P	29	4	5	33	88
R-9	684	1	19-Jul-07	Yes	NA	P	NA	P	P	31	3	5	34	91
R-9i	199	1	9-Apr-07	Yes	NA	P	NA	Fail	P	20	7	6	27	74
R-9i	199	1	27-Jul-07	Yes	NA	P	NA	Fail	P	20	8	6	28	71
R-9i	279	2	9-Apr-07	Yes	NA	P	NA	P	P	24	4	5	28	86
R-9i	279	2	27-Jul-07	Yes	NA	DL	NA	P	P	24	4	6	28	86
R-24	825	1	16-Apr-07	Yes	NA	P	NA	P	P	27	12	0	39	69
R-24	825	1	18-Jul-07	Yes	NA	P	NA	P	P	33	6	0	39	85
LADP-3	316	1	26-Apr-07	Yes	NA	P	NA	P	P	26	8	5	34	76
LAOI(a)-1.1	295	1	25-Apr-07	Yes	NA	DL	NA	P	P	31	6	2	37	84
LAOI(a)-1.1	295	1	31-Jul-07	No	DL	P	NA	P	P	35	3	2	38	92
LAOI-3.2	153	1	19-Apr-07	Yes	NA	DL	NA	P	P	27	4	8	31	87
LAOI-3.2	153	1	26-Jul-07	Yes	NA	P	NA	P	P	29	2	8	31	94
LAOI-3.2A	181	1	25-Apr-07	Yes	NA	P	NA	P	P	28	2	9	30	93
LAOI-3.2A	181	1	30-Jul-07	Yes	NA	P	NA	P	P	28	3	8	31	90
LAOI-7	240	1	18-Apr-07	Yes	NA	P	NA	P	P	35	1	3	36	97
LAOI-7	240	1	19-Jul-07	Yes	NA	P	NA	P	P	31	4	4	35	89
POI-4	159	1	25-Apr-07	Yes	NA	P	NA	P	P	24	6	9	30	80
POI-4	159	1	2-Aug-07	No	Fail	P	NA	P	P	22	10	8	32	69
TW-1	632	1	20-Dec-05	Yes	NA	DL	NA	P	UF	22	7	9	29	76
TW-1A	215	1	20-Dec-05	No	ND	DL	NA	P	UF	14	14	9	28	50
TW-2	768	1	22-Mar-05	ND	ND	P	ND	P	Fail	18	9	2	27	67
TW-2A	123	1	27-May-99	No	ND	DL	NA	P	UF	14	6	9	20	70

Table B-9 (continued)

Well	Port depth (ft)	Scr #	Sample Collection Date	Category F Steel Corrosion						Summary of Test Outcomes				
				F1 Fe	F2 Fe ratio	F3 Cr	F4 Cr ratio	F5 Ni	F6 Zn	Pass	Fail	Indeter-minate	Total tests with Pass/Fail Outcome	% Pass
TW-2A	123	1	30-Jul-01	No	ND	DL	NA	P	UF	9	6	6	15	60
TW-2A	123	1	16-May-05	ND	ND	ND	ND	ND	ND	2	3	0	5	40
TW-3	805	1	19-Jan-06	No	Fail	DL	NA	P	Fail	22	14	1	36	61
TW-4	1195	1	19-Dec-05	No	ND	DL	NA	P	UF	19	13	4	32	59

Source: Tables B-4 to B-8.

Notes: The following abbreviations and color codings for test outcomes apply throughout this table:

- P = pass (P and blue shading both indicate that the data pass the test criterion).
- Fail and pink shading both indicate that the data do not pass the test criterion.
- ND = No data.
- Bkgd = Indeterminate outcome because of uncertainty about the representativeness of the groundwater background data set for this location or geologic formation.
- Ctmt = Indeterminate outcome because of presence of the indicator as a site-specific contaminant at this location.
- Ctmt* = Indeterminate outcome because the concentration of this indicator is likely to have affected by the presence of site-specific contamination.
- DL = Indeterminate outcome because of an inadequate detection limit.
- Err = Indeterminate outcome because the reported data appear to be erroroneous.
- Red = Indeterminate outcome because this test is not reliable if reducing conditions are present.
- Rej = Indeterminate outcome because these data are rejected as unreliable for this test.
- UF = Indeterminate outcome because a failure of this test is not applicable using data for an unfiltered sample.
- NA = This test is not applicable for this sample.

Appendix C

Evaluation of Existing Monitoring Well Locations for the Purpose of Detecting Contaminants from the Los Alamos and Pueblo Watersheds

C-1.0 INTRODUCTION

This appendix describes an assessment of the regional monitoring well network's ability to detect contaminant plumes from potential contaminant sources within the Los Alamos and Pueblo Watersheds. The network consists of the existing monitoring wells.

Contaminant transport through the vadose zone is not explicitly considered in the applied numerical models. Instead, potential contaminants are assumed to migrate from their original source locations before reaching the regional aquifer. The time required for transport through the vadose zone is not taken into account; thus, modeling of contaminant transport begins at the regional water table.

C-2.0 MONITORING WELL NETWORK EVALUATION

A major objective of the numerical simulations is to analyze flow and contaminant transport directions near potential sources in the regional aquifer beneath the canyons and Technical Area (TA) 21. Uncertainties in the flow directions are estimated as well. Through this analysis, monitoring wells important for detecting plume migration in the regional aquifer are identified.

Contaminant transport in the regional aquifer is modeled from 19 potential breakthrough locations (Figures C-1 and 2.0-1 in the main text). The breakthrough locations are defined as approximate projections of the areas where either (1) contaminants may have already reached or may potentially reach the regional aquifer, or (2) contaminants are disposed of in the subsurface at a mesa-top location. The first case represents effluent releases to canyons for which considerable near-surface migration down the canyon floor with surface water and alluvial groundwater occurs, and the resulting breakthrough areas at the regional aquifer are elongated along the length of the canyon. The second case represents mesa-top disposal at TA-21, and the sources projected onto the regional water table are assumed to be located vertically below the disposal units. Note that to make the analyses more comprehensive and to address potential uncertainties, the 19 potential breakthrough locations cover much of the length of the canyons. Subdivision into multiple breakthrough locations also allows for a less conservative approach for analysis of monitoring network detection efficiencies. The simulated plumes migrate in the regional aquifer from these breakthrough locations. The analyses incorporate all the production wells on the Pajarito Plateau, including LA-5. The Buckman well field is not explicitly simulated in the model and technically is outside the computational grid. In the present analyses, it is explored in terms of the potential for contaminates to migrate without detection through the phreatic zone toward the Rio Grande springs near the Buckman well field. It should also be noted that due to vertical stratification of the regional aquifer, the pumping of the deep portions of the regional aquifer at the Buckman well field is not expected to propagate to the shallow phreatic portion of the regional aquifer. This assumption is supported by various field observations and conceptual considerations (Vesselinov 2005, 090040).

The site-scale model domain used for these analyses is shown in Figure C-1. Laterally, the grid extends from the flanks of the Sierra de los Valles on the west to the Rio Grande on the east. The entire Laboratory lies within the boundaries of this domain, as do all of the Los Alamos County water-supply wells. The top of the grid is defined by the shape of the regional water table. The computational grid is uniform (structured) with horizontal grid spacing of 25 m × 25 m (82 ft × 82 ft).

The explicit simulation of the phreatic zone in the numerical model generally requires a complex representation of both the saturated and unsaturated zones in a single three-dimensional numerical model. However, because the water-table elevations do not exhibit pronounced transients, and the flow directions in the phreatic zone are almost at steady state (LANL 2006, 094161), the development of such a complex model is not necessary in this case. A simpler approach is used to simulate contaminant transport in the shallow phreatic zone. It is assumed that the water-table gradients are known and defined by two alternative maps of the water table in Figures D.5-1 and D.5-2 (Appendix D). It also is assumed that limited vertical mixing of contaminants occurs below the phreatic zone, and therefore, the model is reduced to a relatively thin zone along the water table. As a result, the two-dimensional model becomes pseudo–three-dimensional, with a uniform thickness of 100 m (328 ft).

Flow directions and magnitudes that control contaminant transport in the aquifer are generally dictated by the shape of the regional water table (Freeze and Cherry 1979, 088742, Chapter 5; Vesselinov 2005, 090040). Transport velocities are a function of the hydraulic gradients and the permeability and porosity of the hydrostratigraphic units. Permeability and porosity values of the hydrostratigraphic units are uncertain and represented as random variables, as defined in Table C-1; theoretical probability distribution functions are presented in Figures C-2 and C-3. The permeability ranges are based on site-specific field hydraulic tests reported in McLin (2006, 093670) and literature data (Freeze and Cherry 1979, 088742). The ranges of porosity values for the regional aquifer units are defined based on data from the literature (Freeze and Cherry 1979, 088742). The only site-specific data available are for the Cerros del Rio basalt (Tb 4) and Puye Fanglomerate (Tpf), and these data are considered in developing the distributions for those two units (Keating et al. 2001, 095399). The parameter ranges include high-permeability values and low-porosity values that are expected to occur in the case of fracture flow.

To represent the dispersion of the contaminant plumes, an axisymmetric form of the dispersion tensor is used (cf., Lichtner et al. 2002, 095397); the longitudinal and transverse dispersivities are defined to characterize the tensor. It is assumed that longitudinal and transverse dispersivities are random variables with statistical parameters presented in Table C-2. Site-specific data supporting these values are not available. Based on data from literature, the selected range of values is reasonable for the spatial scale of simulated contaminant transport (on the order of kilometers, (Neuman 1990, 090184) and the properties of the flow medium.

To estimate uncertainty in the model predictions, a Monte Carlo analysis is performed. A set of 1000 uncorrelated, equally probable random realizations are generated using a Latin Hypercube sampling technique with the software Crystal Ball. Each realization includes 26 random variables, representing various model parameters that include the permeability and the porosity of the hydrostratigraphic units and the longitudinal and transverse dispersivities. It should be noted that the units are assumed to be uniform, and the dispersivities are the same for all of the hydrostratigraphic units. Because the parameter range includes high-permeability values and low-porosity values characteristic of fracture flow, a fraction (about one-tenth) of the realizations simulate fast preferential flow paths. Therefore, the probability that contaminant plumes might be affected by fracture flow is accounted for.

The numerical simulation of contaminant transport in the regional aquifer is performed using random-walk particle-tracking techniques (Lichtner et al. 2002, 095397). For each realization, a series of particles are released within areas at the top of the regional aquifer within the 19 potential source areas, as shown in Figure C-1. The results consist of 1000 possible contaminant plume distributions in the regional aquifer for each of the 19 breakthrough windows. The number of particles is selected to be large enough for sufficient characterization of contaminant dispersion in the numerical model. The particles' movement is tracked through the model domain to estimate potential spatial migration of contaminants. The numerical simulations are performed using particle-tracking capabilities of FEHM (Zyvoloski et al. 1996, 054421) and specially developed codes for numerical convolution (PointConvolute, PlumeConvolute, PlumeStat). The saturated-zone analyses are computationally very intensive and produce a huge amount of output data. The analyses are achieved efficiently through parallelization using the Laboratory's supercomputers. The code MPRUN is used, which efficiently executes a series of Monte Carlo runs in a parallel environment. Because of the independent nature of the individual Monte Carlo runs, the parallelization efficiency scales well with the number of applied processors.

It is important to note that the numerical convolution of a given source to compute the breakthrough curves at the wells requires uniform time steps. In these analyses, breakthrough relative concentrations are computed at the wells using 0.25-yr time steps.

The hydraulic gradients in the model are constrained based on the water-table maps (Figures D.5-1 and D.5-2). As a result, it is possible that the permeability variation in the 1000 stochastic runs might produce groundwater flow (Darcy) velocities that exceed ranges expected based on previous information about the total amount of water flowing through the regional aquifer. Groundwater velocity is equal to hydraulic gradient times permeability, but the velocity can also be computed by dividing the total groundwater flow rate by the flow area (Freeze and Cherry 1979, 088742, Chapter 5). However, the transport velocities simulated in the model are considered to be characteristic only of the fraction of the groundwater flow medium where a dominant portion of contaminant transport occurs. As a result, the total amount of groundwater flowing through the aquifer will be consistent with existing hydrogeological information. Therefore, the simulations target potential uncertainties associated with contaminant transport velocities rather than groundwater flow velocities.

The shape of the water table presented in Figures D.5-1 and D.5-2 is not expected to be affected by water-supply pumping at depth. However, the potential effects of pumping on contaminant transport are simulated by mimicking a cone of depression around each pumping well. In the simulations, the node that represents a particular pumping well is assigned a low pressure head consistent with water levels measured during pumping, and it is assigned a much higher permeability than the surrounding medium. This yields a gradient toward the pumping well, and the extent of the gradient varies in size depending on the permeability of the surrounding medium for a given realization. The pumping-well node is also defined as a sink that removes particles from the simulation domain and counts them as arriving at the water-supply well. Thus, while the hydraulic effects of pumping are not explicitly stated in this model, the potential for pumping wells to capture nearby plumes is included.

In the numerical simulations, the properties of various hydrostratigraphic units are assumed to be spatially uniform. In reality, the aquifer is expected to be highly heterogeneous. This heterogeneity is a major constraint regarding the generality of the simulation results. Real contaminant plumes are expected to be more spatially heterogeneous than currently represented in the model. Therefore, spatial heterogeneity might affect the ability of any monitoring network to detect potential contaminant plumes.

Simulated plumes are based on a unit concentration released at each of the two source areas. Therefore, the model produces concentrations relative to the original source concentration at monitoring and production wells. The movement of a nonsorbing conservative tracer is simulated. No analytical detection limit or regulatory limits are used in this analysis because the predicted concentrations are relative, not absolute concentrations. Therefore, the modeling results do not indicate whether any of the plumes are associated with concentrations that exceed regulatory standards or detection limits. However, the simulations yield information about flow directions and about relative magnitudes of concentrations at pumping and monitoring wells that can be used to define the efficiency of the network.

C-3.0 MONITORING METRICS

An efficient monitoring location must intercept a contaminant plume before arrival at the production wells or before crossing the Los Alamos National Laboratory (the Laboratory) boundary. There are a number of possible scenarios for each simulation (or plume).

- *Successful detections* are plumes that are detected at a monitoring well.
- *Successful protections* are plumes that are first detected at a monitoring well and after that reach, a production well or the Laboratory boundary.
- *Failed protections* are plumes that first reach a production well or the Laboratory boundary and then later arrive at a monitoring well.
- *Nondetects* are plumes that reach either a production well or the Laboratory boundary but are not detected by any monitoring well.
- *False-positive detections* are plumes that are detected by the monitoring wells but never reach either a production well or the Laboratory boundary.
- *Detected plumes* are plumes that arrive at the monitoring wells. They include successful detections and failed detections.
- *Plumes of concern* are plumes that reach either a production well or the Laboratory boundary.

Finally, detection efficiency is computed as the number of detected plumes divided by the number of simulated plumes (1000 plumes). Protection efficiency is computed as the number of successful detections divided by the number of plumes of concern (in general, the number of plumes of concern can be different for each source).

To estimate successful protection, the model-predicted contaminant travel times from the source area to the monitoring wells are compared with travel times to the water-supply wells and the Laboratory boundary. If the contaminant arrives first at a monitoring well, it is considered that the monitoring well provides successful protection.

There are multiple approaches that can be applied to estimate the travel times to the wells. For example, they can be based on the (1) first-particle arrival, (2) peak-mass arrival, or (3) arrival of some fraction of the released contaminant mass. As described above, a particle-tracking technique is used to simulate contaminant transport. Arrival of the first particle in such simulations is sporadic and often not statistically significant. To resolve this problem, a test that compares the arrival times for the first 10% of the peak contaminant (relative) concentration arriving at the locations of interest was previously applied in similar network efficiency analyses (LANL 2007, 098548; LANL 2007, 099128). This approach allows for better definition of the rising limb of a breakthrough curve at a given location and proved to be a successful test for this assessment. However, the results presented in previous reports using this metric seem to be conservative. This is because the comparisons are performed only in terms of whether the travel times are faster or slower to the monitoring wells when compared, for example, with the production wells. To better asses the network efficiency, the analyses are expanded to estimate statistical significance of differences in the travel times. In this case, the number of particles detected by the wells and the variance in the particle-travel times are also considered. The statistical comparison is based on standard t-test, which takes into account statistical properties of the particle-travel times associated with the compared wells. A comprehensive review of the application of t-test and related equations is given by Ruxton (2006, 099109). In this case, if the particles' travel times to a given production well are statistically smaller with 95% confidence from the travel times to a given monitoring well, then it is considered that the monitoring well does not provide successful protection. This approach provides more adequate estimation of protection efficiency. Still, the major limitation of this approach is that it assumes that analyzed random variables (log-transformed particle travel times) are normally distributed. This assumption is generally valid. To make the statistical analyses more general, other more complicated statistical tests may be implemented in future monitoring network evaluations.

C-4.0 RESULTS

The protection efficiency (%) of the regional monitoring network to detect potential plumes originating at all the 19 breakthrough windows before their arrival at production wells is shown in Tables C-3 and C-4. The two tables present protection efficiency values associated with alternative conceptual water-table maps #1 and #2, respectively (see Appendix D). The differences in the results between the two tables show that the uncertainty in the regional aquifer flow directions is important for plumes originating from some of the breakthrough windows. For example, P8, P9, L4, and L5 breakthrough windows may produce plumes that are detected by the monitoring network with probabilities less than 95% (using 95% confidence levels, as discussed above) before affecting O-1 in the case of water-table map #1, but only P7 and P8 may affect O-1 before being successfully detected (with probability greater than 95%) by the monitoring network in the case of water-table map #2. The production well O-1 is currently not used for municipal drinking water supply and already contains detectable contamination. Nonetheless, the detection efficiencies for this well illustrate the uncertainties associated with using alternative water-table maps. O-4 may be affected by either L2A or 21-3 breakthrough windows, depending on the applied water-table map before successful (with probability greater than 95%) detection by the monitoring network. However, existing hydrogeologic data suggest that O-4 is not at risk from contamination in the shallow part of the aquifer because its pumping does not seem to cause clearly defined drawdown at any of the monitoring wells, except for R-35a. It is important to note that based on the results in these tables, all the other production wells on the Pajarito Plateau, including LA-5, are protected by the regional monitoring network.

The analyses are further expanded to include the Rio Grande springs near Buckman. The pumping of the deep portions of the regional aquifer at Buckman well field is not expected to propagate to the shallow phreatic portion of the regional aquifer. This assumption is supported by various field observations and conceptual considerations (Vesselinov 2005, 090040). The Rio Grande springs near Buckman may be impacted by plumes originating from L5 that are detected by the monitoring network with probability less than 95% (87.3) in the case of water-table map #2 only. However, in the case of map #1, the detection efficiency of the network is 100%.

The detection efficiencies (probability of detection in %) of the individual monitoring wells as well as the entire regional monitoring network to detect potential plumes from each of the 19 breakthrough locations are shown in Tables C-5 and C-6 for conceptual water-table maps #1 and #2, respectively. Regardless of the applied water-table map, the monitoring network provides detection efficiency above 95% for all potential source areas, except source L5 which is downgradient of most monitoring wells. The detection efficiency of potential plumes originating at L5 is 93.5% for the case of water-table map #2. TW-1, R-5, R-10a, R-12, and R-35 are wells with high detection efficiencies. As discussed in Appendix D, there is uncertainty associated with the structure of flow in the phreatic zone near R-5, R-9, and R-12, which is represented by the two alternative water-table maps. Nevertheless, the location of these wells is important because they lie along probable flow paths of potential plumes originating along Los Alamos and Pueblo Canyons.

C-5.0 REFERENCES

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Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau; the U.S. Department of Energy–Los Alamos Site Office; the U.S. Environmental Protection Agency, Region 6; 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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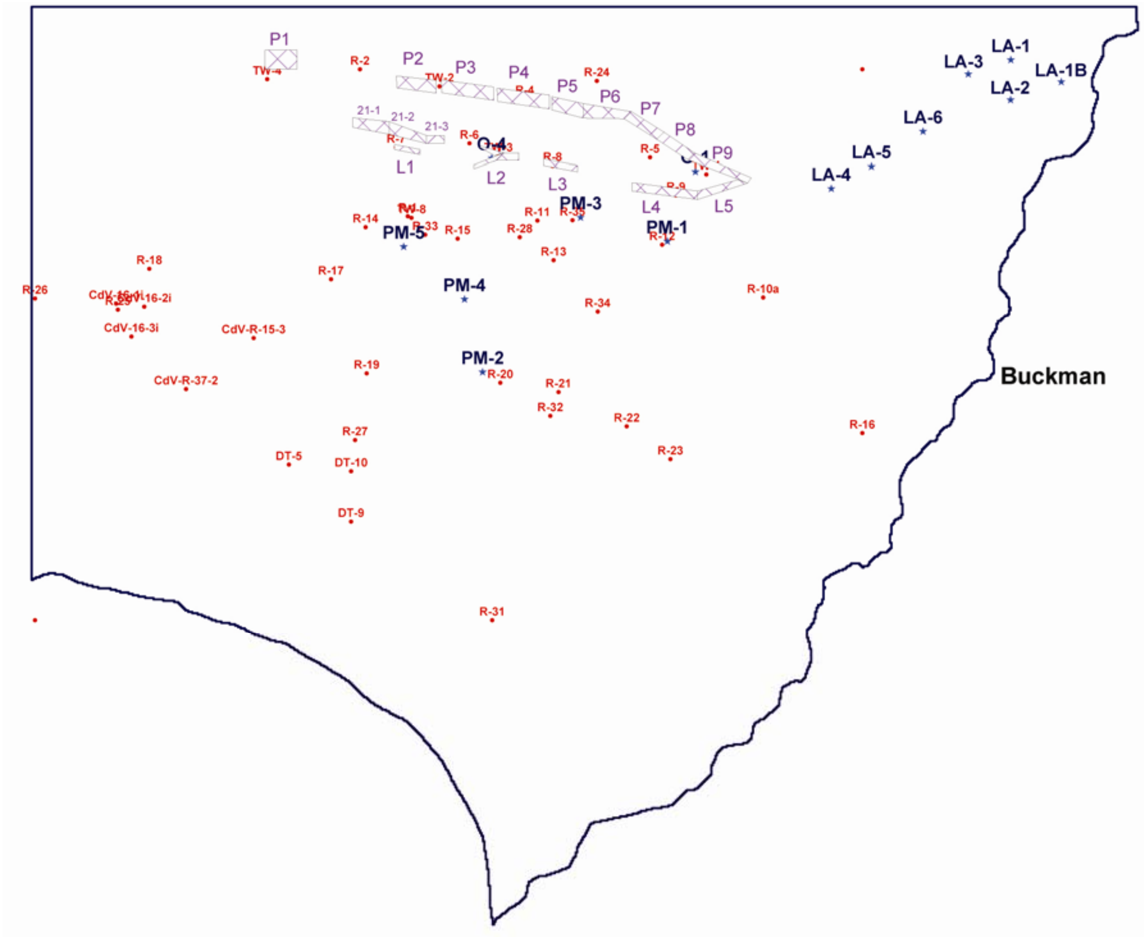
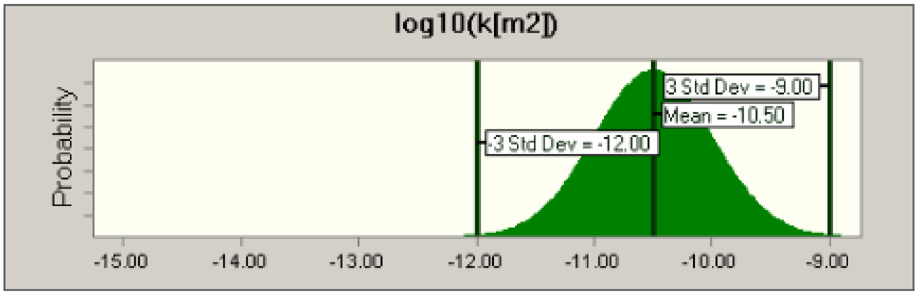
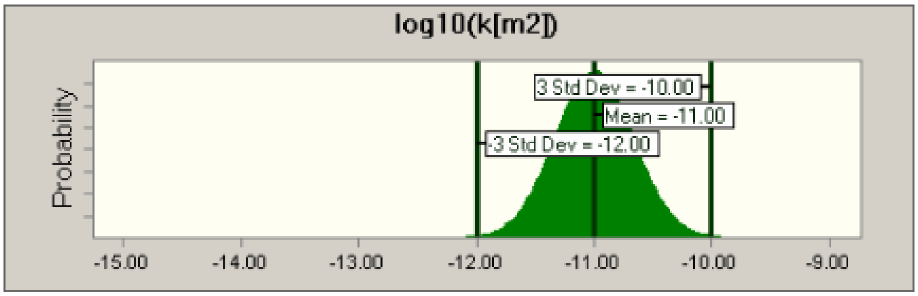


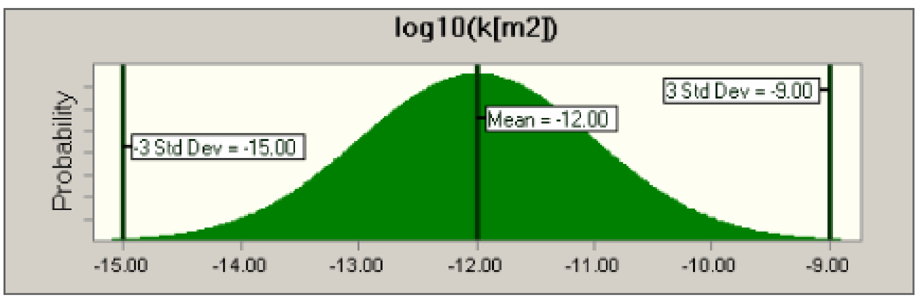
Figure C-1 **Model domain (blue polygon) and potential breakthrough windows along Los Alamos and Pueblo Canyons (purple polygons). Regional monitoring wells are shown as red dots and productions wells are shown as blue stars.**



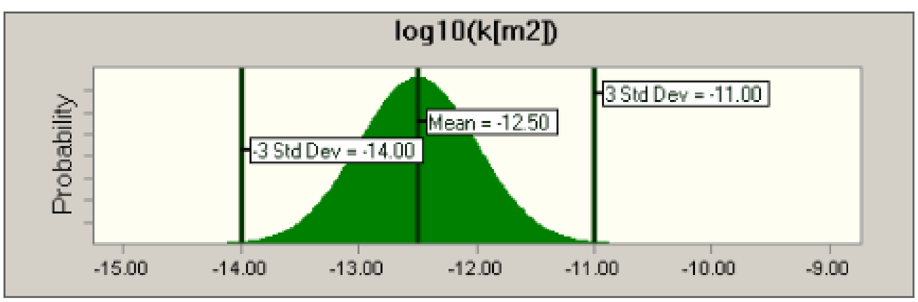
(a)



(b)

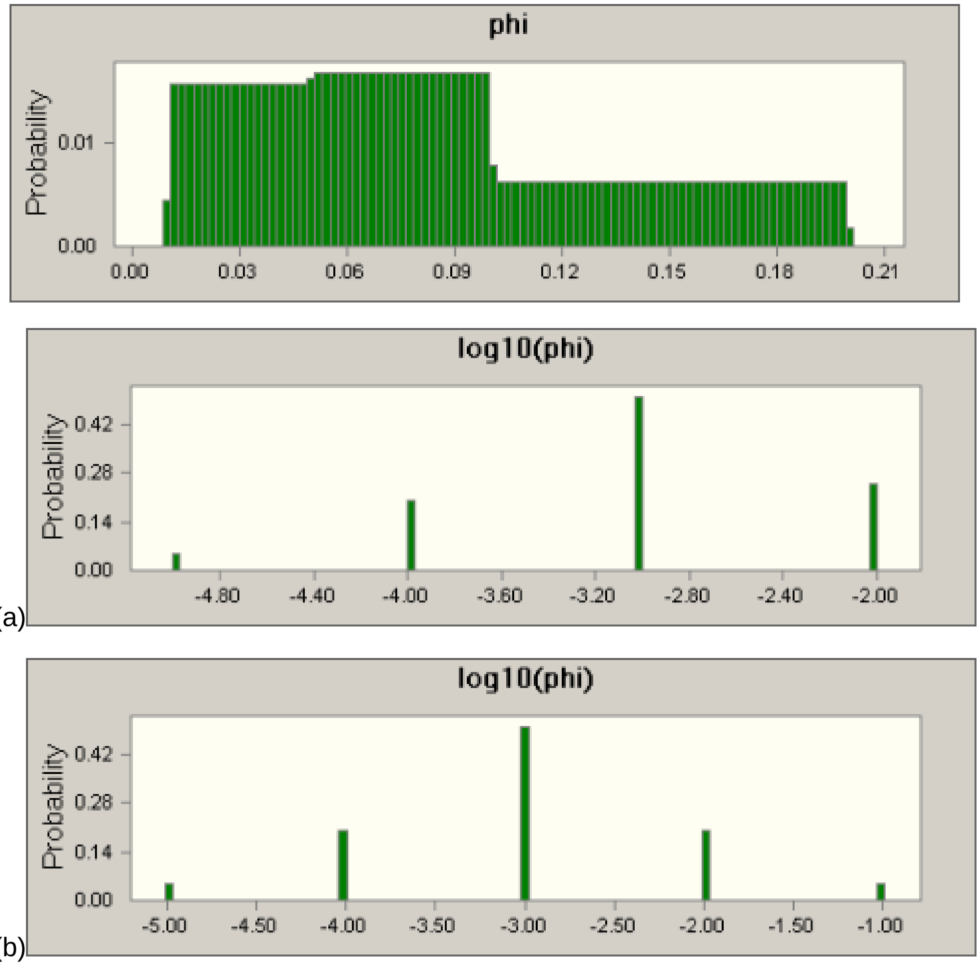


(c)



(d)

Figure C-2 Probability distributions of permeability for different hydrostratigraphic units: (a) Tschicoma, Keres group; (b) Totavi Lentil; (c) Cerros del Rio basalt, Bayo Canyon basalt; (d) pumiceous Puye, Puye fanglomerate, Santa Fe fanglomerate, and Santa Fe silt and sands



(a)

(b)

(c)

Figure C-3 Probability distributions of effective porosity for different hydrostratigraphic units: (a) Totavi Lentil, pumiceous Puye, Puye fanglomerate, Santa Fe fanglomerate, Santa Fe silt and sands; (b) Tschicoma, Keres group; and (c) Cerros del Rio basalt, Bayo Canyon basalt

Table C-1
Characteristics of Hydrostratigraphic Units Represented in the Model

				Permeability			Porosity		
Unit	Name	Number of Nodes	Percentage in the Model	Distribution Type	Mean	Standard Deviation	Distribution Type	Min	Max
Tschicoma	Tt	73049	10.5%	Log normal	-10.5	0.50	Discrete	1.E-05	1.E-02
Keres Group	Tk	2865	0.4%	Log normal	-10.5	0.50	Discrete	1.E-05	1.E-02
Cerros del Rio Basalt	Tb4	97099	14.0%	Log normal	-12.0	1.00	Discrete	1.E-05	1.E-01
Bayo Canyon Basalt	Tb2	24007	3.5%	Log normal	-12.0	1.00	Discrete	1.E-05	1.E-01
Totavi Lentil	Tpt	22543	3.2%	Log normal	-11.0	0.33	Discrete	1.E-02	2.E-01
Pumiceous Puye	Tpp	29116	4.2%	Log normal	-12.5	0.50	Discrete	1.E-02	2.E-01
Puye Fanglomerate	Tpf	152808	22.0%	Log normal	-12.5	0.50	Discrete	1.E-02	2.E-01
Santa Fe Fanglomerate	Tf	78269	11.3%	Log normal	-12.5	0.50	Discrete	1.E-02	2.E-01
Santa Fe Silt and Sands	Ts	214192	30.9%	Log normal	-12.5	0.50	Discrete	1.E-02	2.E-01

Table C-2
Statistical Properties of Dispersivities

	Distribution Type	Min	Max
Longitudinal dispersivity	Uniform	100	200
Transverse dispersivity	Uniform	10	20

Table C-3
Protection Efficiency of the Production Wells
of the Entire Network for Conceptual Model Water-Table #1

Sources	O-1	O-4	PM-1	PM-2	PM-3	PM-4	PM-5	LA-5	Rio Grande Springs Near Buckman
P1	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
P2	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
P3	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
P4	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
P5	99.9%	99.8%	99.9%	100.0%	99.7%	100.0%	100.0%	100.0%	100.0%
P6	99.4%	100.0%	99.9%	100.0%	99.9%	100.0%	100.0%	100.0%	100.0%
P7	99.3%	100.0%	99.8%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
P8	80.3%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
P9	75.1%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
L1	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
L2a	100.0%	99.8%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
L2b	100.0%	96.3%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
L2c	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
L3	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
L4	83.9%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
L5	78.7%	100.0%	95.4%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
21-1	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	99.9%	100.0%	100.0%
21-2	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
21-3	100.0%	87.4%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Note: Network efficiency values below 95% are marked in red. Protection efficiency values between 95 and 100% are marked in blue.

Table C-4
Protection Efficiency of the Production Wells
by the Entire Network for Conceptual Model Water-Table #2

Sources	O-1	O-4	PM-1	PM-2	PM-3	PM-4	PM-5	LA-5	Rio Grande Springs Near Buckman
P1	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
P2	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
P3	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
P4	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
P5	99.6%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
P6	96.8%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
P7	85.2%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	99.9%	99.7%
P8	81.9%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
P9	95.5%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	99.9%
L1	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
L2a	100.0%	71.6%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
L2b	100.0%	99.8%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
L2c	100.0%	99.8%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
L3	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
L4	99.8%	100.0%	99.9%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
L5	99.2%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	87.4%
21-1	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
21-2	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
21-3	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Note: Network efficiency values below 95% are marked in red. Protection efficiency values between 95 and 100% are marked in blue.

Table C-5
Detection Efficiency of Individual Monitoring Wells and the Entire Network with Respect to Each of the 19 Assumed Breakthrough Locations: Estimates Are Based on Conceptual Model Water-Table Map#1

Monitoring wells	Breakthrough Location																	
	P1	P2	P3	P4	P5	P6	P7	P8	P9	L1	L2a	L2b	L2c	L3	L4	L5	21-1	21-2	21-3
R-02	100.0%	37.9%	24.4%	0.6%	0.1%	0.0%	0.0%	0.0%	0.0%	7.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	52.0%	22.5%	4.9%
R-04	98.5%	99.3%	100.0%	100.0%	83.0%	54.3%	40.0%	29.0%	1.3%	99.0%	26.8%	22.7%	44.0%	70.7%	8.6%	0.4%	99.2%	99.3%	98.8%
R-05	88.3%	91.4%	93.6%	96.6%	96.1%	95.7%	97.7%	99.7%	72.9%	87.1%	12.0%	7.3%	27.1%	99.3%	99.0%	41.0%	89.4%	91.1%	88.3%
R-06	53.6%	57.8%	59.1%	34.4%	5.5%	2.1%	1.2%	0.9%	0.0%	88.7%	71.0%	71.1%	58.5%	9.3%	0.6%	0.0%	59.3%	71.9%	86.7%
R-07	28.4%	29.8%	25.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	67.8%	88.3%	44.9%
R-08	50.7%	52.7%	59.7%	61.3%	54.4%	49.0%	39.2%	29.9%	1.9%	37.8%	6.6%	3.2%	15.7%	100.0%	14.6%	0.7%	49.6%	51.8%	39.3%
R-09	64.1%	66.4%	73.4%	79.6%	77.3%	81.2%	81.7%	94.7%	83.4%	46.1%	0.4%	0.5%	2.4%	67.4%	100.0%	80.6%	61.6%	66.6%	49.1%
R-10a	31.0%	32.9%	38.7%	40.5%	37.2%	43.2%	43.0%	62.6%	99.7%	14.9%	0.1%	0.0%	0.5%	20.7%	100.0%	100.0%	27.0%	28.6%	14.2%
R-11	12.2%	13.2%	18.7%	22.6%	16.5%	15.5%	9.0%	4.9%	0.2%	4.4%	1.5%	0.5%	3.0%	59.6%	2.6%	0.1%	11.9%	11.7%	5.6%
R-12	70.4%	73.3%	78.2%	82.6%	83.3%	84.0%	85.5%	95.3%	60.5%	54.1%	1.7%	0.6%	2.8%	93.6%	100.0%	97.3%	68.0%	71.4%	57.3%
R-13	3.5%	3.8%	6.1%	6.8%	6.1%	5.5%	4.4%	3.8%	0.2%	1.5%	0.3%	0.2%	0.8%	11.7%	1.7%	0.1%	2.4%	3.4%	1.5%
R-16	4.8%	4.4%	6.3%	6.4%	5.7%	7.7%	6.5%	11.9%	86.1%	1.2%	0.1%	0.0%	0.0%	2.3%	71.9%	92.3%	1.7%	3.3%	1.1%
R-24	85.1%	87.3%	90.3%	92.1%	90.9%	90.4%	84.0%	79.0%	19.4%	82.5%	18.5%	14.5%	38.2%	81.0%	61.6%	5.8%	86.1%	87.1%	83.1%
R-28	2.7%	1.6%	2.8%	4.7%	3.2%	2.3%	1.4%	0.4%	0.0%	0.8%	0.6%	0.3%	0.6%	13.4%	0.2%	0.0%	1.9%	1.6%	0.7%
R-35	52.5%	55.5%	61.6%	66.5%	59.4%	57.3%	50.9%	42.3%	3.9%	40.3%	12.3%	6.4%	21.6%	100.0%	29.7%	1.1%	52.0%	53.9%	42.2%
R-36	9.9%	9.6%	13.0%	16.5%	15.1%	14.9%	12.7%	9.4%	1.6%	3.6%	0.8%	0.2%	1.1%	33.1%	21.2%	2.8%	6.8%	8.7%	2.9%
TW-1	44.8%	48.6%	55.0%	61.7%	58.2%	61.3%	59.8%	90.5%	100.0%	23.8%	0.4%	0.3%	1.4%	26.4%	85.3%	88.8%	42.7%	43.8%	27.7%
TW-2	100.0%	100.0%	100.0%	37.8%	3.0%	1.4%	0.2%	0.2%	0.0%	98.7%	2.2%	0.2%	1.7%	0.4%	0.0%	0.0%	100.0%	100.0%	90.3%
TW-3	67.4%	67.9%	72.1%	69.6%	51.6%	38.5%	25.9%	15.8%	0.5%	70.0%	100.0%	100.0%	100.0%	96.7%	5.6%	0.0%	66.9%	70.8%	74.1%
TW-4	82.9%	5.4%	2.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.3%	2.8%	0.6%
Entire Network	100.0%	100.0%	100.0%	100.0%	98.7%	97.9%	97.8%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Notes: The analysis is based on 1000 simulated plumes. Network efficiency values below 95% are marked in red. Otherwise, detection efficiency values in blue range between 95% and 100%. For individual monitoring wells, values in green range between 50% and 94.9%, and values in black are less than 50%.

Table C-6
Detection Efficiency of Individual Monitoring Wells and the Entire Network for Each of the 19 Assumed Breakthrough Locations: Estimates Are Based on Conceptual Model Water-Table Map #2

Monitoring wells	Breakthrough Location																		
	P1	P2	P3	P4	P5	P6	P7	P8	P9	L1	L2a	L2b	L2c	L3	L4	L5	21-1	21-2	21-3
R-02	100.0%	51.0%	11.7%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	9.8%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	60.3%	30.6%	2.4%
R-04	99.9%	99.9%	100.0%	100.0%	78.4%	30.6%	3.1%	0.4%	0.0%	47.5%	42.8%	46.9%	51.6%	20.0%	0.4%	0.0%	82.9%	76.2%	58.5%
R-05	98.9%	99.2%	99.3%	99.7%	99.7%	97.5%	74.8%	64.6%	26.1%	91.2%	93.5%	98.8%	99.5%	98.7%	66.9%	23.8%	97.7%	97.6%	98.0%
R-06	83.4%	73.6%	43.9%	11.2%	2.2%	1.2%	0.0%	0.0%	0.0%	99.7%	63.0%	92.2%	52.0%	6.9%	0.0%	0.0%	99.4%	100.0%	100.0%
R-07	59.6%	28.0%	6.5%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	100.0%	2.0%	2.9%	0.7%	0.0%	0.0%	0.0%	99.0%	96.0%	67.5%
R-08	71.9%	73.5%	68.4%	55.4%	43.0%	25.5%	4.0%	1.2%	0.1%	77.1%	86.4%	88.6%	95.6%	100.0%	20.5%	0.4%	91.3%	93.5%	89.5%
R-09	95.6%	97.2%	96.2%	89.7%	81.2%	66.9%	39.5%	31.5%	20.8%	80.0%	89.3%	93.1%	98.5%	100.0%	100.0%	57.3%	93.2%	95.1%	93.4%
R-10a	76.0%	77.0%	73.5%	70.2%	60.6%	54.5%	41.2%	42.6%	43.2%	89.8%	99.1%	95.5%	98.7%	99.6%	97.0%	66.2%	90.1%	93.7%	95.0%
R-11	39.9%	30.8%	20.0%	9.9%	3.7%	0.9%	0.0%	0.0%	0.0%	94.3%	99.0%	70.9%	79.0%	34.7%	2.3%	0.0%	84.2%	89.0%	86.6%
R-12	71.1%	67.7%	55.3%	38.9%	23.8%	12.6%	2.7%	1.8%	1.2%	95.0%	99.8%	99.3%	100.0%	99.9%	62.0%	2.8%	93.8%	96.5%	98.7%
R-13	22.4%	18.1%	11.3%	7.3%	3.2%	0.7%	0.1%	0.0%	0.0%	60.4%	67.0%	34.9%	42.7%	27.8%	2.0%	0.0%	55.1%	57.1%	47.9%
R-16	63.3%	64.3%	62.2%	57.0%	47.4%	41.8%	29.3%	29.4%	33.0%	83.0%	95.5%	90.0%	94.7%	96.3%	91.6%	59.4%	82.0%	86.4%	87.4%
R-24	90.7%	82.9%	87.0%	90.5%	81.8%	66.8%	29.5%	2.9%	0.1%	29.7%	29.3%	33.1%	38.5%	19.9%	1.0%	0.0%	63.2%	53.8%	36.0%
R-28	11.2%	6.9%	4.4%	1.5%	0.6%	0.2%	0.0%	0.0%	0.0%	56.7%	59.8%	20.3%	25.3%	5.6%	0.2%	0.0%	49.9%	51.9%	34.5%
R-35	70.2%	67.1%	50.2%	32.7%	15.6%	6.5%	0.6%	0.5%	0.1%	98.0%	100.0%	99.9%	100.0%	88.5%	10.4%	0.4%	96.3%	98.7%	99.4%
R-36	58.8%	54.8%	38.6%	23.6%	9.5%	3.4%	0.4%	0.2%	0.2%	96.6%	99.9%	94.7%	97.7%	78.0%	12.5%	0.2%	94.3%	97.5%	97.8%
TW-1	98.5%	98.5%	98.6%	99.6%	99.6%	99.6%	99.7%	100.0%	99.9%	79.7%	82.2%	91.4%	95.1%	92.3%	81.8%	91.8%	95.9%	96.8%	94.9%
TW-2	100.0%	100.0%	100.0%	30.2%	2.0%	0.4%	0.0%	0.0%	0.0%	26.3%	2.2%	3.0%	3.4%	0.4%	0.0%	0.0%	78.3%	58.8%	20.4%
TW-3	81.4%	76.4%	59.7%	32.5%	9.3%	3.3%	0.2%	0.1%	0.0%	99.5%	100.0%	100.0%	100.0%	40.1%	0.6%	0.0%	98.8%	100.0%	100.0%
TW-4	84.5%	5.0%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	24.6%	10.5%	0.1%
Entire Network	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	99.7%	100.0%	99.9%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	93.5%	100.0%	100.0%	100.0%

Notes: The analysis is based on 1000 simulated plumes. Network efficiency values below 95% are marked in red. Otherwise, detection efficiency values in blue range between 95% and 100%. For individual monitoring wells, values in green range between 50% and 94.9%, and values in black are less than 50%.

Appendix D

Hydrologic Observations

D-1.0 VADOSE-ZONE MOISTURE PROFILES

Moisture data for samples from Pueblo and Los Alamos canyons are summarized in figures D.1.0-1 (Pueblo and Bayo Canyons) and D-1.0-2 (Los Alamos and DP Canyons). These figures show moisture data plotted against depth and stratigraphic interval, with borehole profiles adjusted to elevation. In each figure the presence of perched saturation zones is indicated by blue shading. All moisture data were collected from core samples, with the exception of data below 573 ft depth in LADP-4 where moisture data were collected from cuttings. These data were collected using American Society for Testing and Materials (ASTM) method D2216-90 and are reported as gravimetric weight percent (percentage weight water over weight dry material). Tabulated values are provided in Appendix F-2-1, Vadose Zone Moisture.

Moisture content in these samples is influenced by borehole location (particularly whether the borehole is in a wet or dry canyon), hydrostratigraphic unit, and location along the canyon flow system.

In both the Pueblo/Bayo Canyon system and the Los Alamos/DP Canyon system there are indications of specific horizons where moisture content is likely to be elevated. Alluvial fill is first among these, but the amount of saturation in the alluvium is strongly dependent on location; few of the data from core described here include many sample data for the alluvial system, but where such data are present the moisture contents support the canyon hydrology concept presented in this report (Sections 2.1.2 and 2.2.2) and in many of the findings in studies that focus on the streamflow/alluvium system (e.g., LANL, 2004, 087390). In Los Alamos Canyon the differences in alluvial moisture content between LADP-3 (high moisture content, to ~40%) and R-8 (low moisture content, <~20%) coincide with zones where flow is persistent to seasonal (LADP-3) or reduced to seasonal or ephemeral (R-8) (Figure 1.0-1). The common suballuvial unit along most of Pueblo Canyon and of the section of Los Alamos Canyon considered here consists of Otowi Member ash flows of the Bandelier Tuff (Qbo), with canyon incision into the Guaje Pumice Bed down-section to the east and ultimately into thin deposits of Puye Formation and underlying Cerros del Rio basaltic lavas, as shown in Figures 2.0-1 and 2.0-2. Among these suballuvial units, the most common horizon of elevated moisture content is the Guaje Pumice Bed (Qbog). This horizon may or may not support perched saturation (Figure D-1.0-2), but the Guaje Pumice Bed generally has significantly elevated moisture content even where perched saturation does not occur, as beneath much of the Pueblo/Bayo Canyon system (Figure D-1.0-1). This observation supports the inference that water and contaminant movement may be focused along this horizon (see Figure 2.0-1).

Two of the core moisture profiles shown in Figure D-1.0-2, LADP-4 and LADP-5, were collected at the relatively dry DP Canyon. These profiles show exceptionally low moisture content in the devitrified Tshirege Member of the Bandelier Tuff (units Qbt 1v and higher), particularly at LADP-4. This may in part be due to lower porosity as a result of devitrification and of welding that both reduce void space; in both of these holes the moisture content rises with transition into the vitric nonwelded unit Qbt 1g. However, there are other indications that the much lower infiltration in dry versus wet canyon locations is more significant in determining the diminished moisture content beneath DP Canyon. Comparison of the relatively uniform Otowi ash flows between LADP-3 (wet canyon bottom) and LADP-4 (dry canyon bottom) shows that moisture content is significantly higher for the wet canyon bottom versus the dry canyon environment (averages of 14 ±3% versus 8 ±3%). In addition, there is little indication of lateral moisture movement within the Guaje Pumice Bed from the saturation observed at LADP-3 to under the mesa toward LADP-4, where this unit is not saturated. In LADP-3 the moisture content in Qbog is elevated above that in the overlying Qbo ash flows, but at LADP-4 there is no such change in saturation.

Groundwater migration beneath the Bandelier Tuff into the underlying Puye Formation (Tpf) must occur to account for perched saturation within the Puye, as observed at R-7 (see Figure 2.0-1) and at TW-2/2a (see Figure 2.0-2). As with the Otowi ash flows, comparison of moisture profiles between wet canyon

(R-8, LAOI-3.2/3.2a) and dry canyon (LADP-4) indicates that the dry canyon Puye Formation has very low moisture content (5 ±2%) compared to Puye beneath the wet canyon (18 ±6%). However, this comparison does not account for location relative to streamflow regimes or for the fact that the Puye moisture data at LADP-4 are from cuttings that may have lost some moisture during collection. Moreover, the Puye Formation at R-9 above the perched saturation zone at 524-627 ft depth is beneath the wet canyon but also has very low moisture content (5 ±1%). These results suggest that groundwater movement within the Puye Formation varies locally along the length of Los Alamos Canyon. Where perched saturation is observed within the Puye Formation, as at R-9 from 524-626.8 ft depth (Figure D-1.0-2), the core moisture content (11 ±6%) is not significantly different from the Puye average at R-8 (18 ±6%). This suggests that much of the Puye where high moisture content occurs may be near saturation and may periodically support groundwater movement. There are fewer moisture data for the Puye Formation beneath Pueblo Canyon (Figure D.1.0-1) but those available also suggest local variation in Puye moisture content, with significant vertical variation at R-24 that may reflect infiltration effects from proximity to the Bayo Waste Water Treatment Facility, which was active when that well was installed (Section 2.2.1 and Figure 1.0-1).

The most significant perching horizon for both the Pueblo/Bayo Canyon system and the Los Alamos/ DP Canyon system is within the Cerros del Rio lavas. Moisture data from the Cerros del Rio lavas is strongly influenced by whether the sample collected is from a relatively nonporous flow or porous interflow location. In most cases, sampling of massive flow interiors is avoided because of the poor data obtained from such samples. Nevertheless, where closely space samples of reasonable validity can be collected, the moisture data can reveal some details about the basalt-system hydrology. This is seen at R-9 (Figure D-1.0-2) where samples from the productive saturated zone at 137-225 ft depth have high moisture content, yet those above 180 ft within this system have very low moisture content. When R-9 was drilled, this perched zone was first recognized by production of water below 180-ft depth, with water only rising later to 137 ft. The lower moisture contents above 180 ft reflect the relatively poor hydrologic communication of this interval.

D-2.0 OBSERVATIONS OF PERCHED INTERMEDIATE WATER

This appendix summarizes the observed occurrences of intermediate perched water and interprets, where possible, the cause of the perching. Table D-2.0-1 lists 14 occurrences of intermediate perched groundwater detected for boreholes in Los Alamos Canyon and 5 occurrences of intermediate perched groundwater in Pueblo Canyon. The occurrence of perched groundwater in Los Alamos Canyon probably reflects infiltration of surface water derived from snowmelt and seasonal rainfall in a large watershed with headwaters high in the Jemez Mountains. The source of perched water in the western part of Pueblo Canyon includes snowmelt and storm runoff; this was augmented by effluent released from the Pueblo Canyon wastewater treatment plant from 1951 to 1991 and the central wastewater treatment plant (WWTP) from 1947 to 1961. Perched water in eastern Pueblo Canyon includes contributions of effluent infiltration from the Bayo WWTP. The perched zones described in the text and table in this appendix are schematically shown on the conceptual cross section, Figures 2.0-1 and 2.0-2, in the main text.

Perched intermediate groundwater occurs beneath Los Alamos Canyon at depths of 26 to 450 ft within the basal ash-flow tuffs of the Otowi Member, the Guaje Pumice Bed, and the underlying Puye Formation fanglomerate (Figure 2.0-1). Saturated thicknesses for these occurrences range from about 9 ft at LADP-3 to more than 31 ft at LAOI-3.2a. Groundwater occurrences in this stratigraphic interval may represent a connected groundwater system because of their similar geologic and geographic settings. If connected, the east-west extent of perched groundwater in this zone is about 3.7 mi. Little is known about how far perched groundwater extends beneath the adjacent mesas, but paired canyon/mesa boreholes suggest that saturation does not extend northward beneath TA-21. The perched groundwater is free of Laboratory contamination at well LAO(I)A-1.1, but it contains tritium at LADP-3 and nitrate, perchlorate, and chloride at LAOI-3.2a. The movement of groundwater in this interval may be controlled by paleotopography on top of the Puye Formation. Structure contours indicate that the downdip direction for the top of the Puye Formation beneath Los Alamos Canyon is toward the east-southeast as far downcanyon as the area between LADP-3 and Otowi-4, where the dip direction swings to the south following the axis of a paleocanyon.

Units of the Bandelier Tuff, including the Guaje Pumice Bed, pinch out eastward beneath the floor of Los Alamos Canyon, and the perched zones to the east are found in stratigraphically lower geologic units (Figure 2.0-1). These eastern perched zones tend to become thicker and occur at multiple depths. For example, at well R-9, three perched systems were encountered: (1) in the central part of a thick sequence of Cerros del Rio basalts, (2) in the basal part of the Cerros del Rio basalts, and (3) in clay-rich, pumiceous deposits in volcanogenic sediments above Miocene basalt. Saturated thicknesses for the top and bottom zones at R-9 range from about 45 to 103 ft, and the middle zone was about 7 ft thick. The top and middle perched zones at R-9 in basaltic lavas are also present within similar lavas at well LAWS-1, located 1300 ft to the east (Figure 2.0-3). At well LAOI-7, saturated intervals are dispersed in a zone up to 138 ft thick in fractures of the Cerros del Rio basalt. The occurrence of thicker perched zones in the eastern part of Los Alamos Canyon may be due to enhanced infiltration where the canyon floor is underlain by Puye fanglomerate and Cerros del Rio basalts rather than by Bandelier Tuff. Tritium activities of 69 to 246 pCi/L for these eastern perched groundwaters are elevated relative to the cosmogenic baseline of 1 pCi/L, suggesting that these zones contain a component of young water that postdates the advent of atmospheric nuclear testing 60 yr ago.

In Pueblo Canyon, perched intermediate water occurs within Pliocene and Miocene volcanogenic sediments and has a saturated thickness of >23 ft at well TW-2a and a saturated thickness of about 49 ft at R-5 (Figure 2.0-2). Depth to water is 110 ft at TW-2a and about 338 ft at R-5. These perched zones probably represent relatively small, unrelated water bodies because of their distance from one another (2.5 mi), the lateral heterogeneity of volcanogenic sediments, and their varying depths beneath the canyon floor.

Wells TW-1a, R-3i, and POI-4 encountered perched water within Cerros del Rio basalts at depths between 160 and 191 ft (Figure 2.0-2). The saturated thickness of these zones is more than 21 ft and may be as much as 68 ft. Saturation is associated with fractures and interflow breccias. The perched intermediate groundwater in these three wells is probably part of an interconnected groundwater system based on the close spacing of the wells and based on the similarities in geologic setting, depth to saturation, and contaminants (Table D-2.0-1).

D-3.0 REGIONAL WATER-LEVEL OBSERVATIONS AND RESPONSES TO PUMPING

D-3.1 Introduction

This section provides regional groundwater level observations and a description of monitoring well responses to pumping of water-supply wells in the northern part of the Laboratory in the area of Los Alamos and Pueblo Canyons. Data presented in this section are included on the data CD (Appendix F, Section F.1) that is attached to this report.

Figure D-3.1-1 shows the regional aquifer monitoring wells and the supply wells that could potentially impact groundwater levels and flow regimes in the northern part of the Laboratory near Los Alamos and Pueblo Canyons. The water-table contours and flow lines at the top of the regional aquifer are discussed in Appendix Section D-4. The supply wells that may impact Los Alamos and Pueblo Canyons are O-1 in lower Pueblo Canyon, O-4 in Los Alamos Canyon, PM-3 and PM-1 in Sandia Canyon, and the Guaje well field in Guaje Canyon. Water-level data from monitoring well G-3 in the Guaje well field are used to evaluate water-level responses from the Guaje well field.

In the present analyses, the predominant focus was on groundwater-level data collected in 2005 and 2006. For this period there is a reliable data record for most of the monitoring wells and some of the water-supply wells in the area. For some of the wells, there is also a presentation and discussion of data collected before 2005 and in 2007 that provide insight into groundwater level responses.

D-3.2 Water Levels and Pumping Rates of Water-Supply Wells

The Guaje well field is located north of Pueblo Canyon and typically produces 20 to 30% of the water for Los Alamos County (Koch and Rogers 2003, 088425). The best producing well in the Guaje well field is typically G-2A, which produced about 44% of the well field total in 2005 and 39% in 2006.

Supply well O-4 in Los Alamos Canyon produces about 20% of the water for Los Alamos County, nearly equal to the entire production of the Guaje well field. Supply well O-1 in lower Pueblo Canyon is used as a reserve well and has not been routinely used for water production. Figure D-3.2-1 summarizes the monthly water production from the Guaje and Otowi wells in 2005 and 2006 and includes wells PM-1, PM-3, and PM-5. These Pajarito mesa wells are located south of Los Alamos Canyon and potentially influence monitoring wells in Los Alamos and Pueblo Canyons. Supply wells PM-1, PM-3, and PM-5 each produce 10%–15% of the water for Los Alamos annually.

The seasonal nature of water production is evident in Figure D-3.2-1. The month of maximum water production for the wells shown was in July in both 2005 and 2006; in 2005, June and July were the highest months of production; in 2006, May, June, and July were the highest months of production.

The Los Alamos County water-supply wells, except for PM-4, have electric pump motors that are usually operated at night and on weekends when electric rates are lower. Because the supply wells are typically cycled on and off daily, the wells exhibit a range of drawdown characteristics. Drawdown characteristics of the water-supply wells were summarized by Koch and Rogers (2003, 088425). In this section and in the text below, there is a discussion of sets of data extracted for the water-supply wells that are called nonpumping water levels, which here are defined as the highest water-level observed daily. "Nonpumping" water-levels may not be available for all days if the pumping continued for more than a day. Nonpumping water-levels may also be affected by the pumping at other nearby supply wells.

Figure D-3.2-2 summarizes the daily production history and hourly water levels for Guaje well G-2A and the mean daily water levels for monitoring well G-3. Supply well G-2A has a daily drawdown of about 40 ft when cycled on and off, while monitoring well G-3 shows a daily water-level fluctuation of about 5 ft in response to operation of G-2A and the other Guaje wells. Thus, the mean daily water level at G-3 is used in the following analyses to evaluate the water-level responses in monitoring wells to pumping of the Guaje well field.

Figure D-3.2-3 shows the nonpumping water levels for supply wells in the Guaje well field for 2006 and 2007. The seasonal water-level fluctuations due to pumping were over 60 ft at G-3 in 2006 and about 50 ft in 2007. Additional information about the Guaje well field and an evaluation of aquifer characteristics in the Guaje well field was provided by McLin (2006, 093672).

To the south of Los Alamos Canyon, water-supply wells PM-1 and PM-3 have a daily drawdown of about 30 ft when in operation. A transducer was installed in PM-3 in October 2006 and in PM-1 in December 2006; thus, data are not available for 2005 and most of 2006 for these wells. The recent data for PM-3 indicate that when not pumping, PM-3 shows about 1 ft of water-level change in response to pumping O-4 (LANL 2007, 098129, p. E-10), but PM-3 does not show an apparent response to pumping PM-1. Similarly, recent data for PM-1 indicate that PM-1 does not show an apparent response to pumping at PM-3.

Supply well O-1 in lower Pueblo Canyon was used only occasionally during 2005 and 2006, usually when samples were collected from the well and in January 2006 for a few days during a pump test of the well (David Schafer & Associates 2006, 094699). Continuous water-level data are not available for O-1 in 2005 and 2006; a transducer was installed in 2007 that shows a response at O-1 of about 1 ft to pumping PM-1. Water-level data are not currently available for supply well O-4 in Los Alamos Canyon and G-1A in Guaje Canyon due to the construction of the wells.

For a given supply well, water levels are affected not only by the pumping at the well but also by the other water-supply wells in the vicinity; thus, there is not full recovery of the water levels in the supply wells. In the following analyses, the water-level responses in regional aquifer monitoring wells are compared with the available nonpumping water levels for water-supply wells to determine if responses are attributable to pumping effects in order to investigate the potential hydraulic connection between the deep confined zone and shallower sections of the regional aquifer. The shallower portions of the aquifer are expected to be less confined and more phreatic in hydrogeologic behavior (Vesselinov 2005, 089753; Vesselinov 2005, 090040).

D-3.3 Monitoring Well Hydrologic Characteristics

Monitoring well construction information is provided in Appendix A. Table D-3.3-1 summarizes general characteristics of monitoring well screens located at or near the top of the regional aquifer in the Los Alamos and Pueblo Canyon area.

Screens in wells R-5 and R-7 (shown in green) straddle the water table, but screens in other area wells are located at varying depths below the water table. Screens at R-2 and R-8 are within about 30 ft of the water table (shown in yellow), but screens at R-4, R-6, and R-24 are much deeper than 30 ft below the water table. Screens located significantly below the water table (e.g., R-4 and R-24) may not provide representative data for water-table elevations.

Table D-3.3-2 summarizes hydraulic conductivity data available for regional aquifer screens in the Los Alamos and Pueblo Canyon area. The highest hydraulic conductivity values are from the deeper screens in the Puye Formation at R-4 and R-7 (6 to 10 ft/d). The lowest hydraulic conductivity values are from R-24 in the Tesuque Formation, which was estimated to have a value of 0.39 ft/d.

No aquifer parameter data are available for R-5 screen 3, R-7 screen 3, R-8 screen 1, and R-9 at the top of the regional aquifer because testing was not possible at the time of well completion.

D-3.4 Monitoring Well Water Levels

The groundwater level responses of monitoring wells in the Los Alamos and Pueblo Canyon area are compared with the production and water levels of nearby water-supply wells to determine the source of the water-level fluctuations. In addition, the water levels of monitoring wells are analyzed to evaluate potential impacts of regional infiltration recharge on the flow regime in the regional aquifer. The groundwater level monitoring program and groundwater level data have been summarized by Allen and Koch (2006, 093652) and Allen and Koch (2007, 095268).

Groundwater-level data in monitoring wells and water-supply wells are obtained using pressure transducers according to the Laboratory's Environmental Programs standard operating procedures. Multiple completion wells that have the Westbay sampling system have packers that isolate each screen interval from atmospheric pressure effects; thus, barometric efficiency for these wells and screens is not applicable as for wells that are open to the atmosphere.

The accuracy of groundwater level measurements using transducers is typically 0.1% of the full scale of the transducer. Accuracy ranges from 0.07 to 1.16 ft, depending on the pressure rating of the transducer required for a specific well screen. Transducers installed in most single completion wells are 30 psi-rated and have an accuracy of 0.07 ft. The resolution of transducer measurements is typically 0.005% of the full-scale measurement or better or about 0.003 ft for a 30 psi transducer.

The following discussion of transient responses in monitoring wells first discusses the wells in Pueblo Canyon and then the wells in Los Alamos Canyon.

D-3.4-1 R-2

R-2 is a single completion well completed in October 2003 (Kleinfelder 2004, 090046); the pump and transducers were installed in April 2005. R-2 is located in middle Pueblo Canyon midway between older wells TW-4 and TW-2. The nearest production well is O-4 in Los Alamos Canyon, about 1.8 mi to the southeast; the Guaje well field is about 4 mi to the east-northeast. The top of the R-2 screen is within 10 ft of the top of the regional aquifer.

Figure D-3.4-1 shows the mean daily water level at R-2 (corrected for atmospheric pressure) compared with the daily production at O-4 and the mean daily water level at G-3. The water level at R-2 shows a steady decline of about 1 ft in 2 yr, for a decline rate of about 0.5 ft/yr. The water level does not show an apparent influence to the Guaje well field or to pumping at O-4. However, the decline at R-2 is probably related to long-term water withdrawals from the regional aquifer.

D-3.4.2 R-4

R-4 is a single completion well completed in October 2003 (Kleinfelder 2005, 099132); the pump and transducers were installed in April 2005. R-4 is located in middle Pueblo Canyon upstream of the Bayo Sewage Treatment Plant. The nearest production well is O-4 in Los Alamos Canyon about 0.76 mi to the southwest; the Guaje well field is about 2.5 mi to the northeast, and PM-3 is 1.47 mi to the southeast. The top of the R-4 screen is about 50 ft below the top of the regional aquifer.

Figure D-3.4-2 shows the mean daily water level at R-4 (corrected for atmospheric pressure) compared with the daily production at O-4 and the mean daily water level at G-3 for 2005 and 2006, and the nonpumping water level at PM-3 for 2006 and 2007. The water level at R-4 shows a seasonal decline and recovery of about 2 ft in 2005 and a decline of about 2.6 ft in 2007, with about 0.6 ft recovery. The R-4 water level appears to respond more closely to the nonpumping water level at PM-3 than to the water level at G-3 in the Guaje well field. The R-4 water-level responses may also coincide with production at O-4, but without water-level data from O-4, the correlation is tenuous. When O-1 was pumped in January 2006, no apparent response was observed at R-4.

D-3.4.3 R-5

Multiscreen monitoring well R-5 was completed in May 2001 (LANL 2003, 080925) and transducers were most recently installed in April 2005. There are two screens in the regional aquifer, screens 3 and 4; screen 1 is dry and screen 2 is located in an intermediate zone with a head that is just below screen 1. R-5 is located in lower Pueblo Canyon, about 0.53 mi west-northwest of O-1, about 1.77 mi east of O-4, and about 2.6 mi south of the Guaje well field. Screen 3 has a relatively stable water level of about 6767 ft, while screen 4 has a water level that fluctuates 5 to 10 ft seasonally with an average of about 5750 ft.

Figure D-3.4-3 shows the water level at screens 3 and 4 compared with the water level at G-3 in the Guaje well field. Screens 3 and 4 do not show an apparent response to pumping of the Guaje well field. Screen 3 shows a slow gradual water-level decline of about 0.6 ft/yr but does not indicate an apparent response to pumping of any individual supply well. Figure D-3.4-3 also shows the water level at R-5 screen 4 and the nonpumping water level at supply well PM-1. The R-5 screen 4 water level apparently rose about 7 ft in the summer of 2007 in response to resting PM-1 when the PM-1 water level recovered about 10 ft.

Figure D-3.4-4 shows the hourly water-level data for R-5 screen 4 and PM-1 during July and August 2007. The R-5 screen 4 water-level responds to each pumping operation at PM-4. Figure D-3.4-4 also shows the hourly water-level data for R-5 screen 4 and O-1 for a 2-wk period in July 2007 when O-1 was operated for about 1 h for a sampling event. The water level at R-5 showed no apparent response to the short-term pumping of O-1. During the O-1 aquifer test in January 2006, the water level at R-5 screen responded primarily to pump cycling at PM-1, with a possible slight response to pumping at O-1; additional data and monitoring are needed to evaluate transient responses at R-5 to pumping at O-1.

D-3.4.4 R-24

R-24 is a single completion well completed in September 2005 (Kleinfelder 2006, 092489); the pump and transducers were installed in March 2006. R-24 is located in middle Bayo Canyon north of the Bayo Sewage Treatment Plant. The nearest production well is O-4 in Los Alamos Canyon, about 1.46 mi to the southwest, O-1 in lower Pueblo Canyon is 1.5 mi to the southeast, PM-3 is 1.54 mi to the south, and the Guaje well field is about 2 mi to the north and northeast. The top of the R-24 screen is about 110 ft below the top of the regional aquifer.

Figure D-3.4-5 shows the mean daily water level at R-24 (corrected for atmospheric pressure) compared with the daily production at O-4, the mean daily water level at G-3, and the nonpumping water level at PM-3 for 2006 and 2007. The water level at R-24 shows a seasonal decline of about 7 ft in 2006 with a recovery of about 5 ft. At times, the R-24 water-level trends appear to respond to the Guaje well field, but the data indicate that R-24 responds more closely to the production characteristics at O-4 than to the water level at G-3 in the Guaje well field. The water-level trends and the sharp water-level decline in August 2007 at R-24 coincides with the nonpumping water level of supply well PM-3 in Sandia Canyon. Thus it appears that the primary response at R-24 is to PM-3, with possible lesser responses to O-4 and Guaje wells.

D-3.4.5 TW-1

TW-1 is a single completion well completed in 1950 (Purtymun 1995, 045344); a transducer was most recently installed in 2000 but was removed in February 2006 in preparation for plugging the well. TW-1 is located in lower Pueblo Canyon, about 1.2 mi downstream of the Bayo Sewage Treatment Plant. The nearest production well is O-1, about 0.13 mi to the west; PM-1 is 0.87 mi to the southwest; and the Guaje well field is about 3 mi to the north and northwest. The top of the TW-1 screen is over 100 ft below the water level. Recent water levels have been erratic and 40 to 90 ft higher than in the 1950s and 1960s (Koch and Rogers 2003, 088425).

Figure D-3.4-6 shows the mean daily water level at TW-1 (corrected for atmospheric pressure) compared with the daily production at O-1 and the production at PM-1. There is no apparent response at TW-1 to production in the Guaje well field or at the nearby supply wells.

D-3.4.6 TW-2

TW-2 is single completion well originally completed in 1950. The well was recompleted in 1990 (Purtymun 1995, 045344); a transducer was most recently installed in 2000 but equipment problems have limited the usefulness of the data (Allen and Koch 2007, 095268). TW-2 is located in middle Pueblo Canyon, about midway between R-2 and R-4. The nearest production well is O-4, about 1 mi to the south-southeast; the Guaje well field is about 3 mi to the northeast. The top of the TW-2 screen is about 80 ft below the water level.

The available water-level data indicate a seasonal water-level fluctuation of 2 to 5 ft, but because of transducer equipment problems at this well, sufficient data for a transient analysis are not available.

D-3.4.7 TW-4

TW-4 is a single completion well completed in 1950 (Purtymun 1995, 045344); a transducer was most recently installed in 2001 but was removed in February 2006 in preparation for plugging the well. TW-4 is located in upper Pueblo Canyon. The nearest production well is O-4, about 2.6 mi to the southeast; the Guaje well field is about 4.5 mi to the northeast. The top of the TW-4 screen is about 20 ft below the water level.

Figure D-3.4-7 shows the mean daily water level at TW-4 (corrected for atmospheric pressure) compared with the G-3 water level and the daily production at O-4. There is no apparent response at TW-4 to production in the Guaje well field or at O-4.

D-3.4.8 R-6

R-6 is a single completion well completed in November 2004 (Kleinfelder 2005, 091693); a transducer was installed in October 2005. R-6 is located at the east end of DP mesa between Los Alamos Canyon and DP Canyon. The nearest production well is O-4, which is 0.30 mi to the southeast, PM-5 is 1.37 mi to the southwest, and PM-3 is 1.49 mi to the southeast. The top of the R-6 screen is about 49 ft below the top of the regional aquifer.

Figure D-3.4-8 shows the water level at R-6 (corrected for atmospheric pressure) and the G-3 water level, the daily production at O-4, and the nonpumping water levels at PM-3 and PM-5 from October 2005 to October 2007. The R-6 water-level trends have similarities with the Guaje well field that are probably associated with the similar operating characteristics of the well fields. It appears that the water-level responses at R-6 may be primarily influenced by pumping at PM-3 and possibly O-4, but current data are not sufficient for a precise determination. The R-6 water level does not appear to be influenced significantly by pumping at PM-5.

D-3.4.9 R-7

Multiscreen monitoring well R-7 was completed in January 2001 (Stone et al. 2002, 072717) and transducers were most recently installed in April 2005. There is one screen in the regional aquifer, screen 3; screens 1 and 2 are dry intermediate screens. R-7 is located in middle Los Alamos Canyon, about 1.1 mi west and upstream of O-4 and about 1.2 mi north of PM-5. Screen 3 has a slowly declining water level at about 5879 ft in early 2005 to about 5878 ft in late 2006, for a decline rate of about 0.5 ft/yr.

Figure D-3.4-9 shows the mean daily water level at R-7 screen 3 compared with the G-3 water level, the daily production at O-4 and the nonpumping water levels at PM-5 and PM-3. There is no apparent response at R-7 screen 3 to production at these nearby supply wells.

D-3.4.10 R-8

Multiscreen monitoring well R-8 was completed in January 2002 (LANL 2003, 079594) and transducers were most recently installed in April 2005. There are two screens in the regional aquifer. R-8 is located in middle Los Alamos Canyon, about 0.64 mi north-northwest of PM-3 and about 0.72 mi east and downstream of O-4. Screen 1 is about 16 ft below the top of the regional aquifer, which at screen 1 is about 5855 ft, while the water level at screen 2 is about 20 ft lower than screen 1, at about 5835 ft.

The water levels at both R-8 screens respond to pumping at supply well PM-3. Figure D-3.4-10 shows the water level at both R-8 screens and the daily production at PM-3 during 2005 and 2006, and the R-8 screen 2 water levels, compared with the PM-3 nonpumping water level from October 2006 to October 2007. The water-level responses at screen 1 are about 40% of the responses at screen 2. R-8 screen 2 responds nearly 1:1, with the nonpumping water level at PM-3, but the water-level data indicate another influence on the R-8 water levels.

Figure D-3.4-10 also shows the R-8 screen 2 mean daily water level compared with O-4 daily production from April 2005 to April 2007. At times when PM-3 is not operating, it appears that there is a small response to pumping O-4. Additional monitoring is needed to determine the pumping responses at R-8.

D-3.4.11 R-9

R-9 is a single completion well completed in 1999 (Broxton et al. 2001, 071250); a transducer most recently installed in April 2005. R-9 is located in Los Alamos Canyon near the eastern Laboratory boundary. The nearest production wells are O-1, about 0.34 mi to the north, and PM-1, about 0.53 mi to the south. PM-3 is about 1.1 mi to the southwest. The top of the R-9 screen straddles a “deep” regional aquifer in the Miocene basalt.

Figure D-3.4-11 shows the R-9 water-level data compared with the G-3 water level and O-1 daily production in 2005 and 2006 and the PM-1 nonpumping water levels for December 2006 to August 2007. The water level at R-9 shows a gradual decline of about 0.4 ft/yr, but there are no apparent responses to pumping of the water-supply wells.

D-3.4.12 TW-3

TW-3 is a single completion well completed in 1949 (Purtymun 1995, 045344); a transducer was most recently installed in April 2005 but was removed in February 2006 in preparation for plugging and abandoning the well. TW-3 is located in Los Alamos Canyon near the confluence with DP Canyon. The nearest production well is O-4, which is about 400 ft to the west, PM-3 is 1.15 mi to the southeast, and PM-5 is 1.47 mi to the southwest. The top of the TW-3 screen is about 18 ft below the top of the regional aquifer.

TW-3 has an intermittent record of transducer water-level data from 1992 to 2006 that shows a gradual water-level decline and a seasonal response to transient pumping of about 0.1 to 0.2 ft (Allen and Koch 2007, 095268). The water-level decline from 1992 to 2006 was about 11.4 ft for an average decline rate of about 0.8 ft/yr for the period. Figure D-3.4-12 shows the recent water-level data from April 2005 to February 2006 compared with the water level at G-3, the daily production at nearby supply well O-4, and the nonpumping water level at PM-5. Although the water-level trends at TW-3 follow seasonal trends, data are insufficient to attribute the response to any particular supply well.

D-3.5 Summary

Analyses of transient responses observed in regional aquifer monitoring wells in the Los Alamos and Pueblo Canyon area were performed to determine what influences might be affecting water levels in the monitoring wells.

Table D-3.5-1 summarizes the transient responses observed in the monitoring wells. None of the regional aquifer monitoring wells evaluated exhibited a sole response to pumping of the Guaje well field. Although wells R-4 and R-24 may have some influence from the Guaje well field, the primary response, especially at R-24 in Bayo Canyon, was to pumping of supply well PM-3 in Sandia Canyon. Other wells that exhibit responses to PM-3 pumping include R-4, R-6, and R-8.

Monitoring wells TW-4 and R-2 in upper Pueblo Canyon do not show an apparent response to supply well pumping; TW-4 shows a seasonal fluctuation that does not correlate with seasonal supply well pumping, while R-2 shows a gradual decline but no seasonal fluctuations.

Evaluation of the pumping effects associated with supply well O-4 in Los Alamos Canyon are made more difficult because water-level data are not available for this well, only daily production records. However, wells that possibly respond to pumping at O-4 include R-4, R-6, R-8, and possibly R-24. The water level at supply well PM-3 in Sandia Canyon responds immediately to pumping at O-4.

Supply well O-1 in lower Pueblo Canyon is rarely pumped, and when pumped for sampling events, it is only operated for a short time; thus, transient responses to this well are ephemeral and difficult to assess. The nearby monitoring well R-5 has two screens in the regional aquifer. Screen 3 at the top of the regional aquifer shows no apparent response to supply well pumping, while R-5 screen 4, deeper within the regional aquifer, responds to pumping at PM-1 but shows no significant response to pumping at nearby O-1 or to the Guaje well field.

Monitoring well R-7 in Los Alamos Canyon shows a gradual water-level decline but does not indicate a seasonal response to supply well pumping or any response to nearby supply wells.

Both regional aquifer screens in R-8 in Los Alamos Canyon respond to pumping at PM-3, but screen 1 shows a muted response that is about 40% of the response shown at screen 2.

TW-3 and R-9 in Los Alamos Canyon exhibit a seasonal response to supply well pumping and a gradual water-level decline, but these wells do not appear to respond to pumping at any particular supply well.

D-4.0 ALTERNATIVE CONTOUR MAPS OF THE REGIONAL WATER TABLE

The regional aquifer beneath the Laboratory is a complex hydrogeological system. The top of the aquifer is predominantly under phreatic (water-table) conditions, but there are zones of local confinement as well. The shape of the regional water table is predominantly controlled by the areas of regional recharge to the west (flanks of Sierra de los Valles) and discharge to the east (the Rio Grande and the White Rock Canyon Springs). The structure of the phreatic flow is also impacted by (1) infiltration zones (predominantly along western faults and canyons), (2) medium heterogeneity, and (3) discharge zones (e.g., springs and water-supply wells). Information about the elevation of the top of the regional aquifer (regional water table) is provided by existing data from monitoring wells and some of the springs (discharge elevations). Predominantly, well data are used to define the water table; spring data are used only in the vicinity of White Rock Canyon. Water-table elevation data shown in Figure D-4.0-1 are representative for monthly average water levels in January 2006. The data are analyzed to create two alternative water-table maps by making different conceptual model assumptions important for phreatic flow near Los Alamos and Pueblo Canyons. In addition to the January 2006 data, the recent data were collected at the newly drilled wells R-35 and R-36 to support some of the conceptual assumptions.

The analyses demonstrate water-level data from wells R-5, R-9, and R-12 have been excluded. The top regional aquifer screens of R-5, R-9, and R-12 are either within the Miocene basalt (R-9 and R-12) or in sedimentary units sandwiched between Miocene basalts (R-5). In the vicinity of these wells, the Miocene basalts do not appear to be hydraulically well connected to the rest of the regional aquifer. The water levels at R-5, R-9, and R-12 are substantially lower than at nearby wells. Lack of any water-level responses at R-5 screen 3, R-9, and R-12 to barometric, seasonal, or pumping (there are production wells close by) influences suggests that the heads at R-5, R-9, and R-12 are not representative of the elevation of the regional water table. The regional aquifer water table is expected to be at elevations higher than the levels observed at R-5, R-9, and R-12. The water table may not have been detected during drilling of these wells due to very low hydraulic properties of the units above the top regional aquifer screens of R-5, R-9, and R-12. For example, the pumiceous sediments above the Miocene basalts at R-5 (402- to 534-ft depth) are fully clay altered (up to 90 wt% smectite and more; Appendix A). The low water levels at the top regional aquifer screens of R-5, R-9, and R-12 may characterize a compartmentalization of the regional aquifer associated with the Miocene basalts.

Sufficient water-level data are not available to characterize the water-table elevation to the north of the Pueblo Canyon. Based on all the available data, R-4 and R-24 appear to be tapping a confined portion of the regional aquifer that may not be representative of the regional water-table elevation; however, the water-level data from these wells are used in the contouring of the regional water table. In addition, data from monitoring well G-3 in the Guaje well field are used to constrain the uncertainty in the water-table elevation farther to the north. G-3 is a deep well previously used for water-supply production. Due to its proximity to the Guaje well field and its long and deep screens, the well responds to pumping of the Guaje supply wells and may not provide adequate information about the water-table elevation. Nevertheless, these data are also used in map contouring due to the lack of any other measurements in this area.

Figures D-4.0-1 and D-4.0-2 show two alternative maps of water-table elevation. The maps differ in the interpretation of TW-1 data. The first map assumes that the water level at TW-1 defines a local mounding of the regional water table, potentially associated with the enhanced infiltration along the Pueblo Canyon from the Bayo wastewater treatment plant; available water-level data around TW-1 do not provide good constraint on the spatial extent of the mound. Alternatively, it can be assumed that the elevated TW-1 water levels are due to vertical discharge of alluvial water into the regional aquifer through the borehole annulus. This is also supported by hydrogeochemical analyses that suggest that the water at TW-1 is very young (approximately 2 yr is the travel time of infiltrated water to reach the regional aquifer at TW-1) (Longmire et al. 2007, 096660). In this case, the artificially created infiltration pathway along TW-1 might still produce local mounding in the regional aquifer. The second map represents an alternative case of no mounding near TW-1. (TW-1 data are excluded in the contouring process.) The two alternative maps of water-table elevation represent two end members of the possible mounding near TW-1. Both maps are considered feasible and equally likely. The first map (Figure D-4.0-1) is a result of manually contouring of the water-level data. The second map is obtained using combining manual and automated contouring techniques.

It is important to note that based on the water-table maps, it is expected that the regional aquifer flow beneath the Los Alamos and Pueblo Canyons is expected to be to the east toward the Rio Grande and the White Rock Springs. In these terms, the uncertainty in the water-table elevation near TW-1, R-5, R-9, and R-12 causes uncertainty in the magnitude and direction of groundwater flow near and to the east (downgradient) of these wells. The resulting flow uncertainty can be expected to have an important impact on the model predictions of potential contaminant transport.

Hydrostratigraphy along the water table is presented in Figure D-4.0-3. The figure is based on the fiscal year (FY) 2005 sitewide 3D geologic model and the alternative water-table map #1 in this report (Figure D.4.0-1).

D-5.0 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 number. This information is also included in text citations. ER ID numbers 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; the U.S. Department of Energy–Los Alamos Site Office; the U.S. Environmental Protection Agency, Region 6; 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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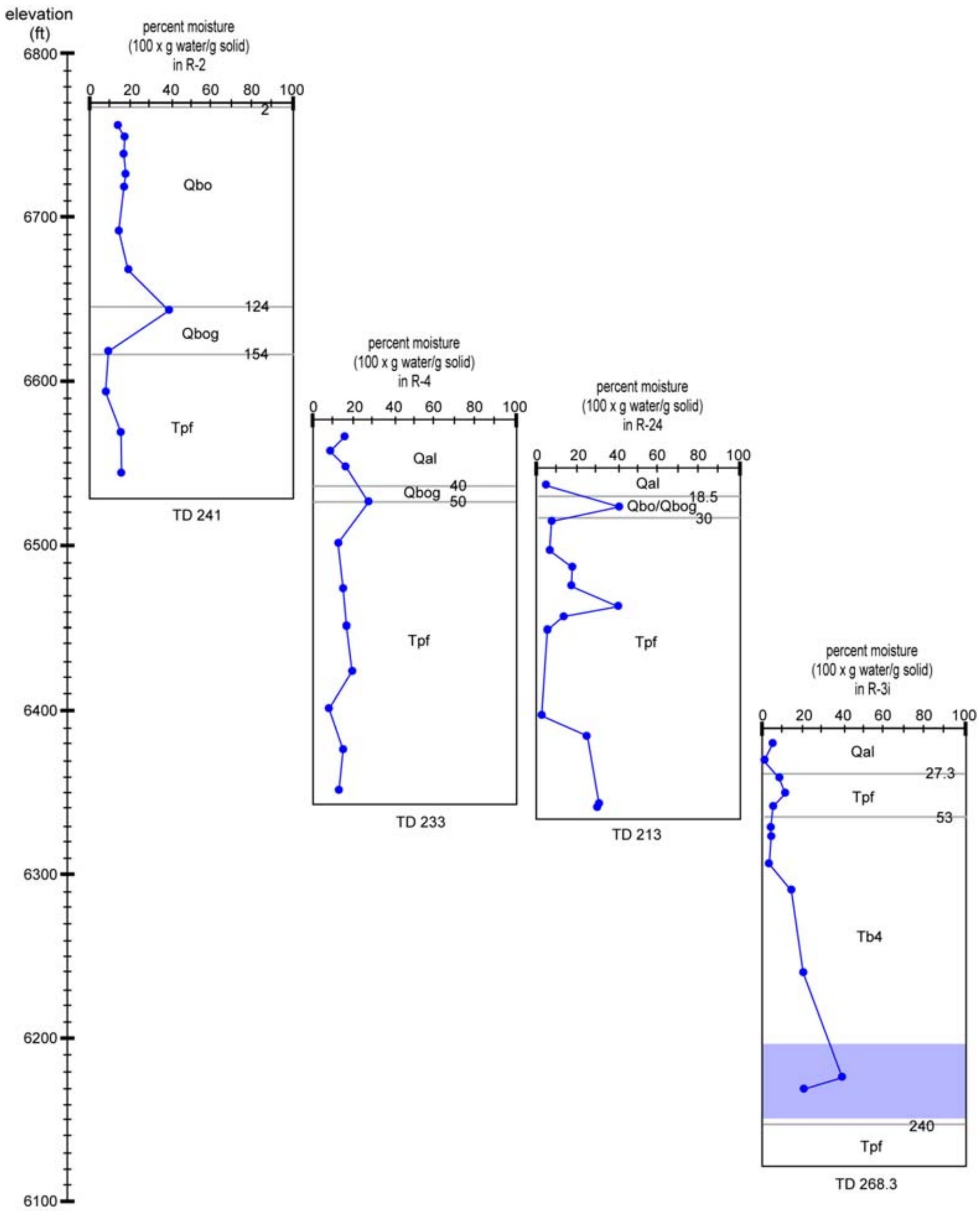


Figure D-1.0-1 Moisture profiles for four core holes in the Pueblo/Bayo Canyon system. Core hole profiles are adjusted for elevation. Moisture content is plotted as gravimetric weight percent (percentage weight water over weight dry material). The zone of perched saturation at R-3i is shown in blue. Hydrostratigraphic unit designations are alluvium (Qal), ash flows of the Otowi Member of the Bandelier Tuff (Qbo), Guaje Pumice Bed (Qbog), Puye Formation (Tpf), and Cerros del Rio lavas (Tb 4).

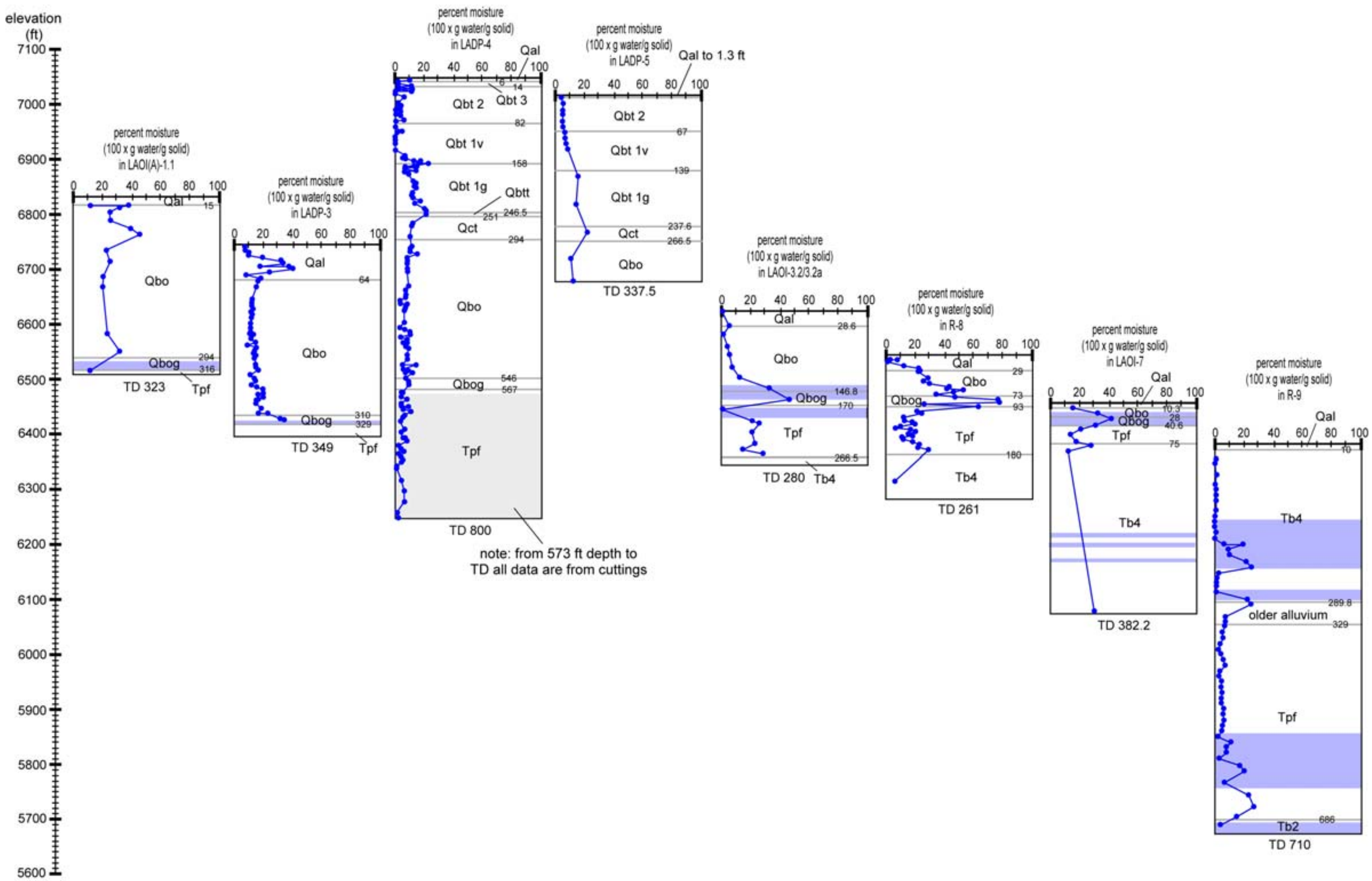


Figure D-1.0-2 Moisture profiles for eight core holes in the Los Alamos/DP Canyon system. Core hole profiles are adjusted for elevation. Moisture content is plotted as gravimetric weight percent (percentage weight water over weight dry material). Zones of saturation are shown in blue. Hydrostratigraphic unit designations are alluvium (Qal), subunits of the Tshirege Member of the Bandelier Tuff (Qbt 3, Qbt 2, Qbt 1v, and Qbt 1g), Tsankawi Pumice Bed (Qbtt), Cerro Toledi Interval (Qct), ash flows of the Otowi Member of the Bandelier Tuff (Qbo), Guaje pumice Bed (Qbog), Puye Formation (Tpf), Cerros del Rio lavas (Tb 4), and Miocene basalt (Tb 2).

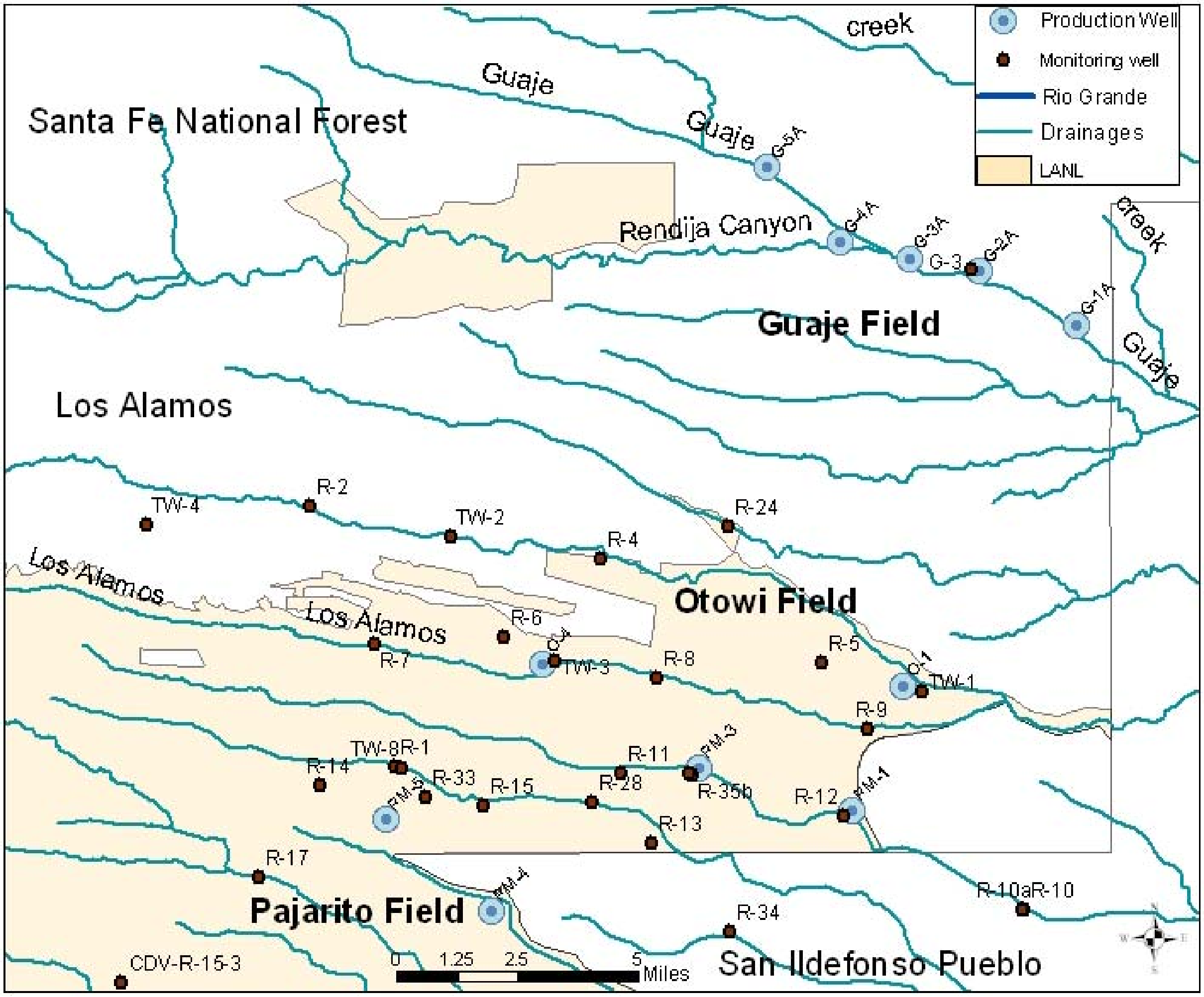


Figure D-3.1-1 Water supply wells and regional monitoring wells in the vicinity of Los Alamos and Pueblo Canyons

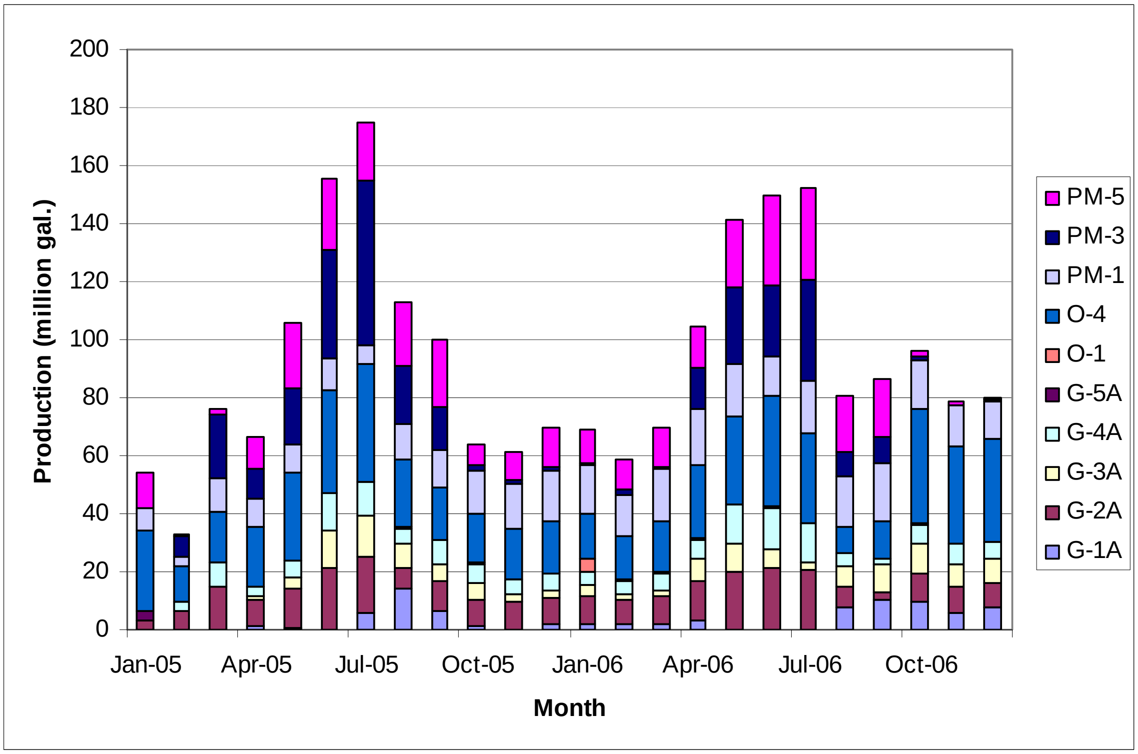


Figure D-3.2-1 Summary of production from the supply wells near Los Alamos and Pueblo Canyons in 2005 and 2006 (excluding PM-2 and PM-4 production)

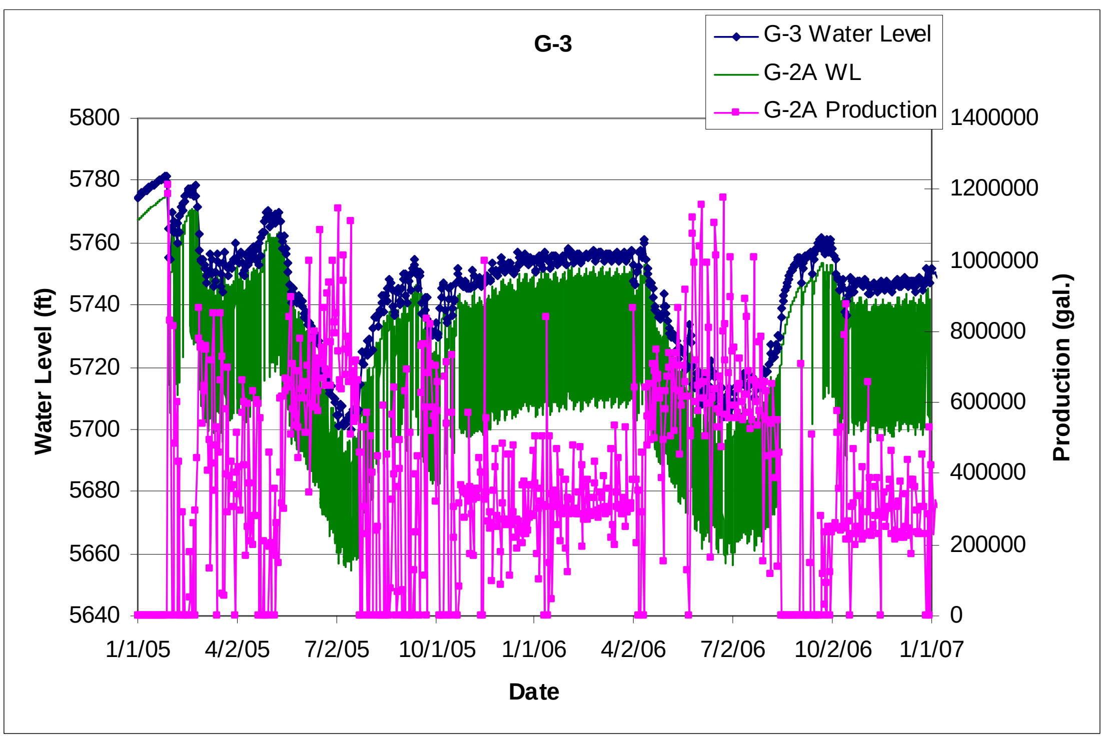


Figure D-3.2-2 Summary of daily production and hourly water levels for supply well G-2A and the mean daily water level of monitoring well G-3 in the Guaje well field

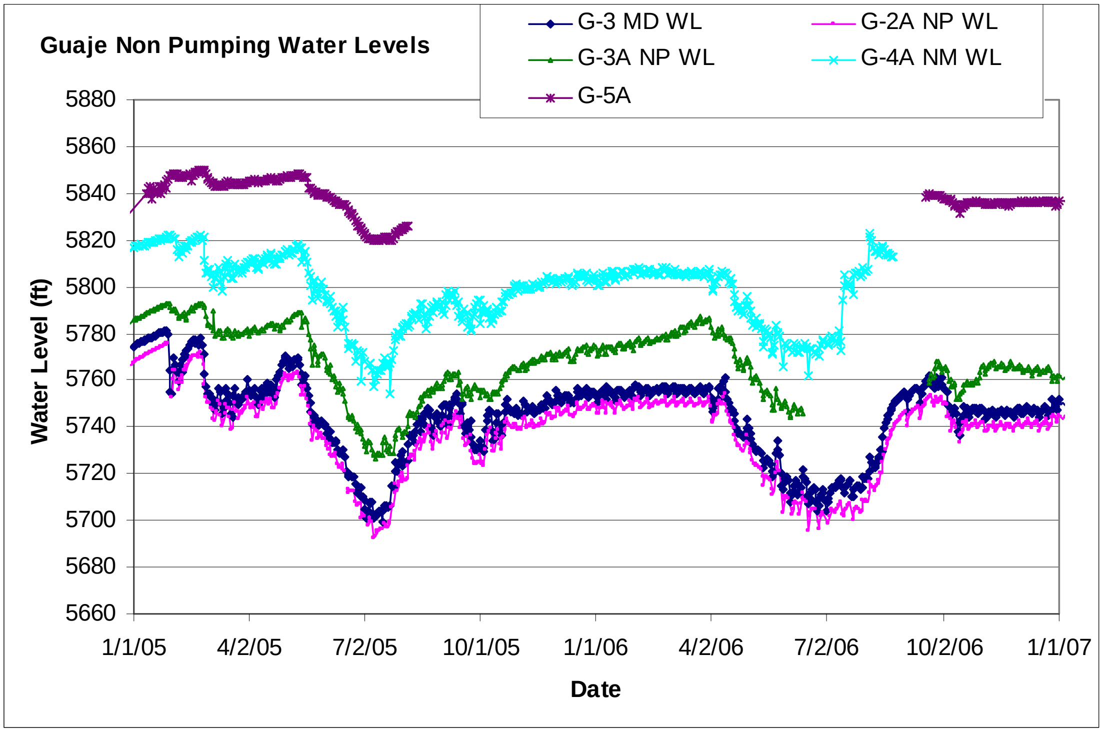


Figure D-3.2-3 Nonpumping water levels of supply wells in the Guaje well field during 2006 and 2007

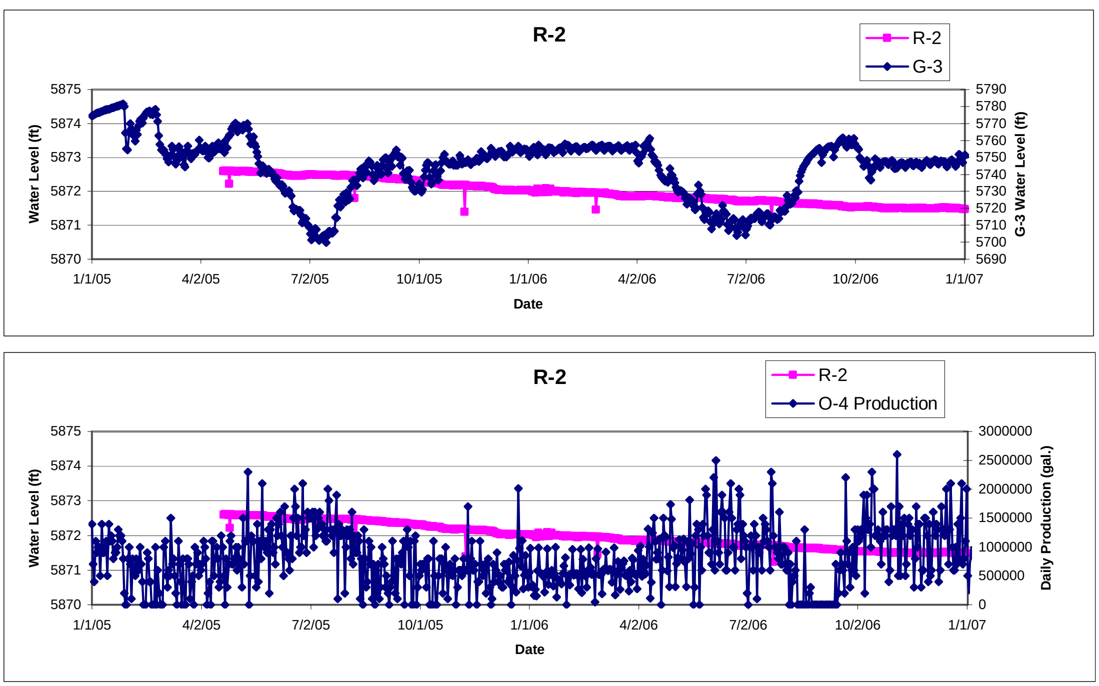


Figure D-3.4-1 R-2 water level compared with G-3 water level and the daily production at O-4 for 2005 and 2006

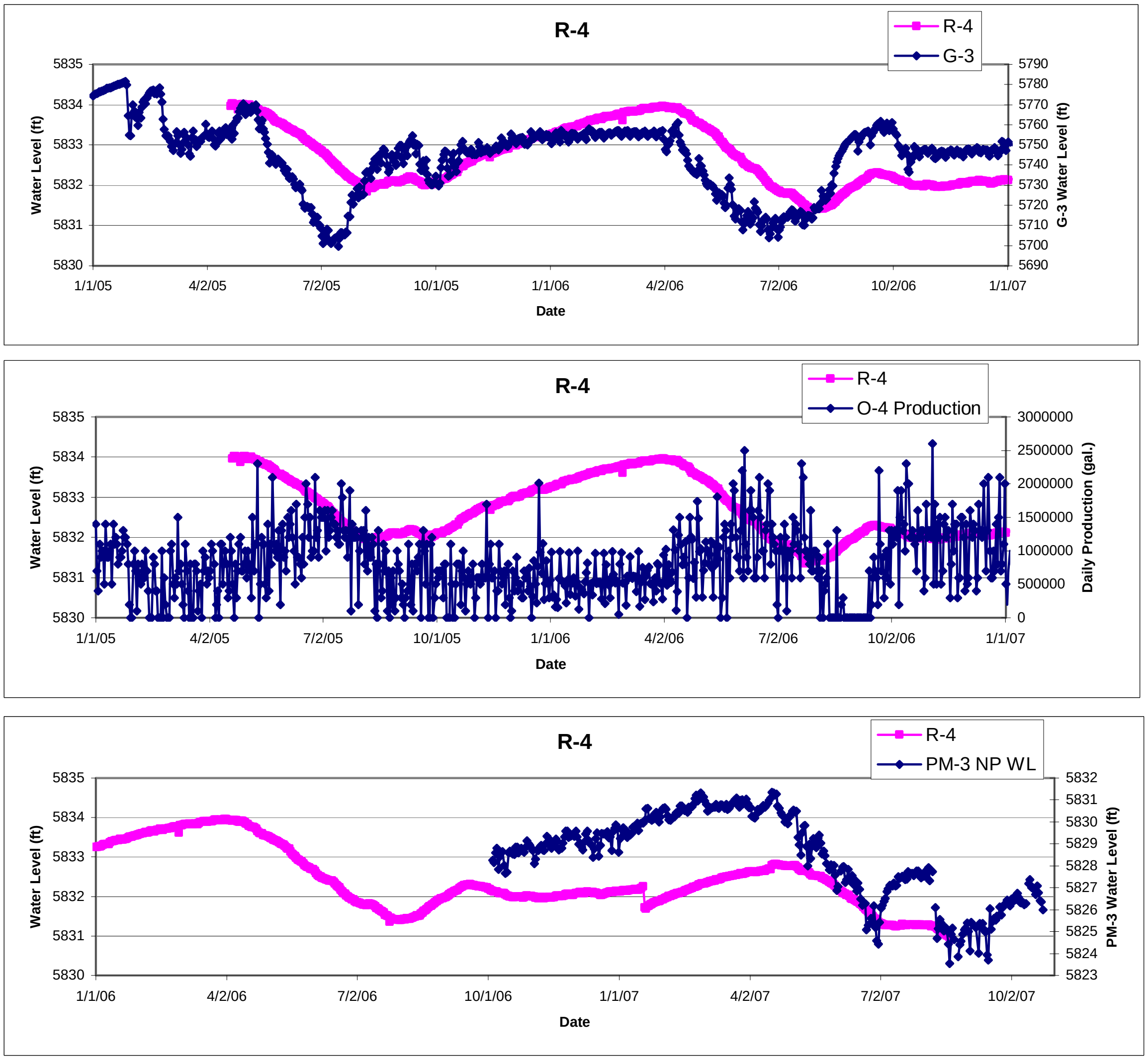


Figure D-3.4-2 R-4 water level compared with G-3 water level and the daily production at O-4 for 2005 and 2006 and the PM-3 nonpumping water level for 2006 and 2007

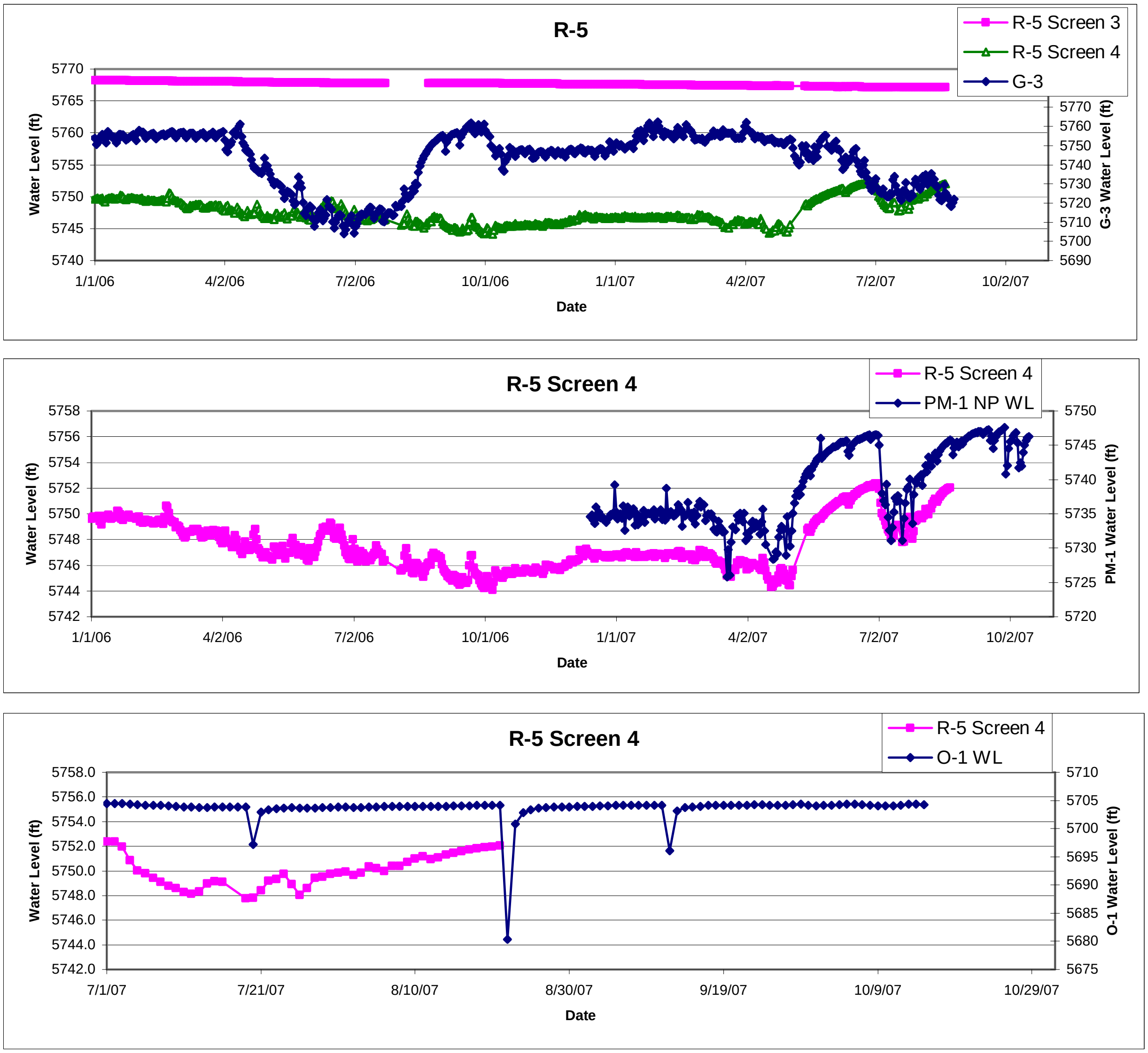
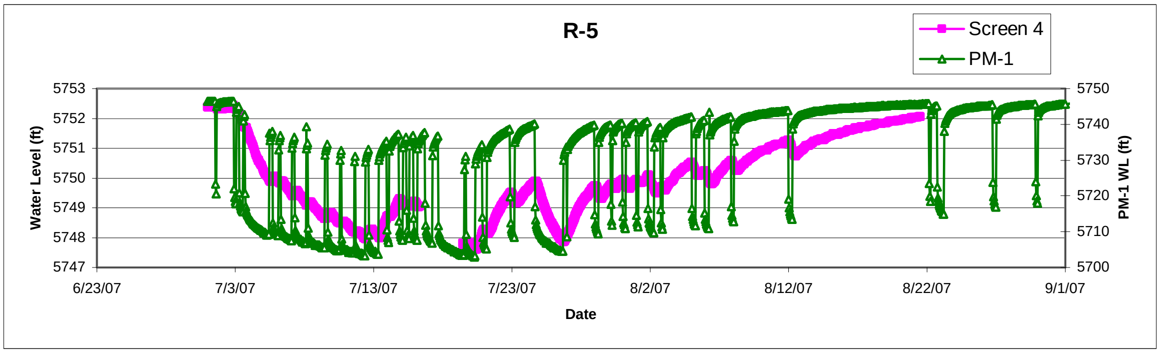


Figure D-3.4-3 R-5 Screens 3 and 4 water levels compared with G-3 water level for 2006 and 2007; R-5 Screen 4 mean daily water levels compared with PM-1 nonpumping water levels for 2006 and 2007; and R-5 Screen 4 hourly water levels compared with PM-1 hourly water levels in July and August 2007



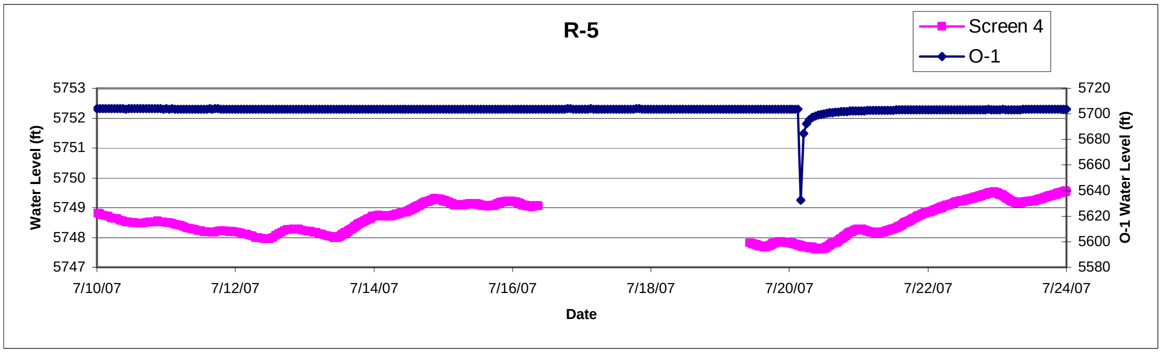


Figure D-3.4-4 R-5 Screen 4 hourly water levels compared with PM-1 hourly water levels in July and August 2007 and R-5 screen 4 hourly water levels compared with O-1 hourly water levels in July 2007

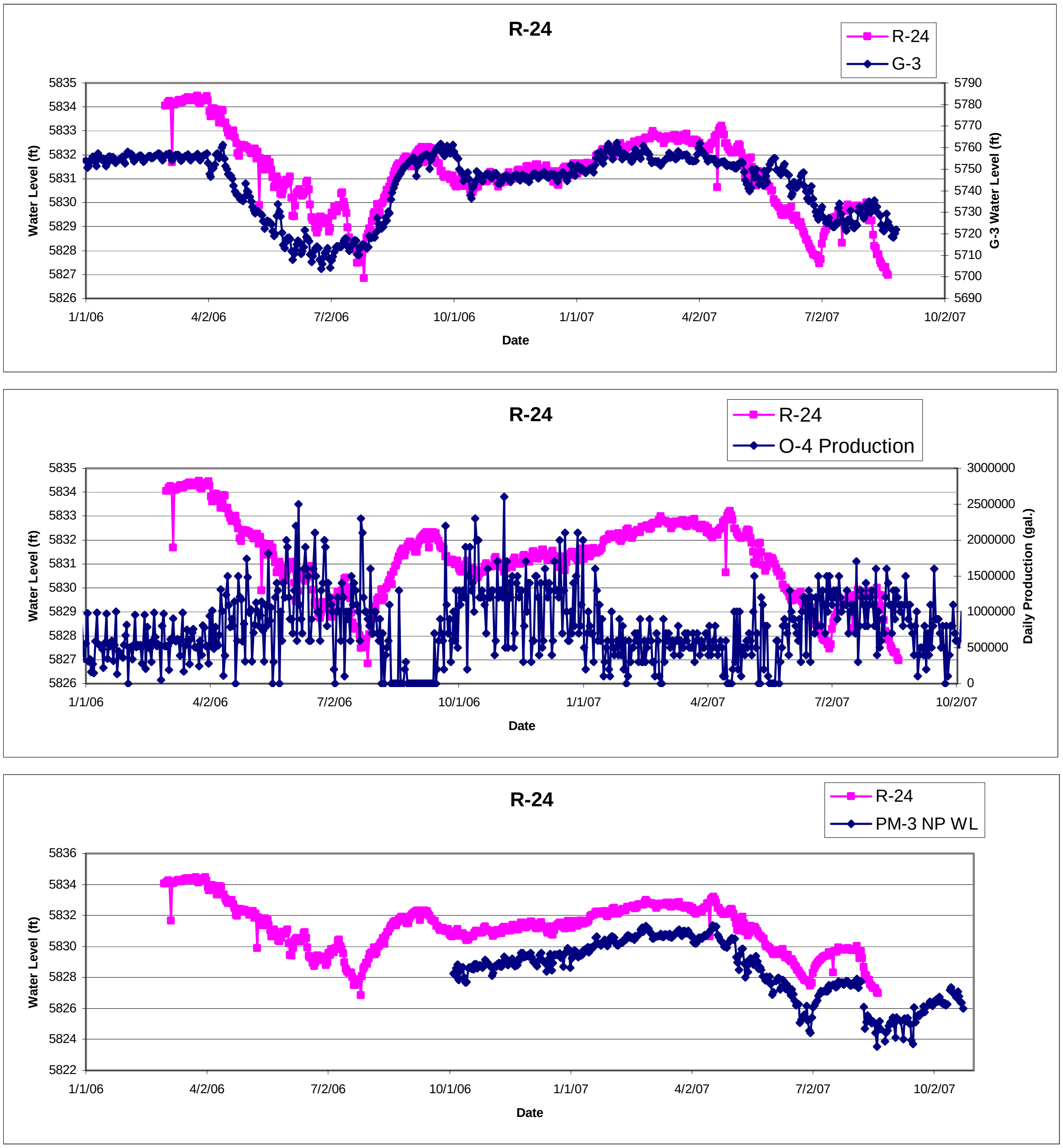


Figure D-3.4-5 R-24 water level compared with G-3 water level, the daily production at O-4, and the nonpumping water level at PM-3 for 2006 and 2007

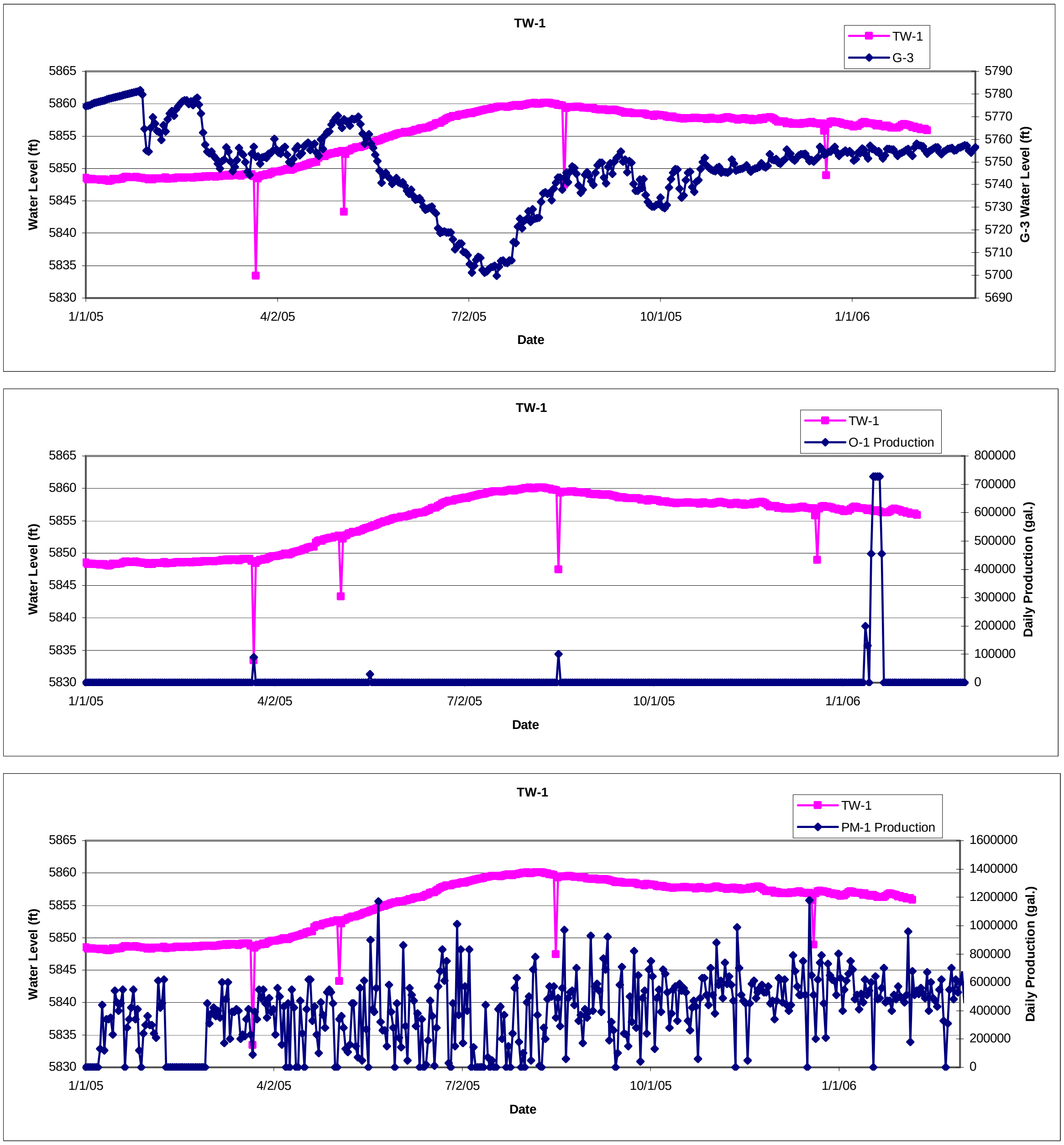


Figure D-3.4-6 TW-1 mean daily water level compared with the G-3 water level and daily production at O-1 and PM-1 in 2005 and early 2006

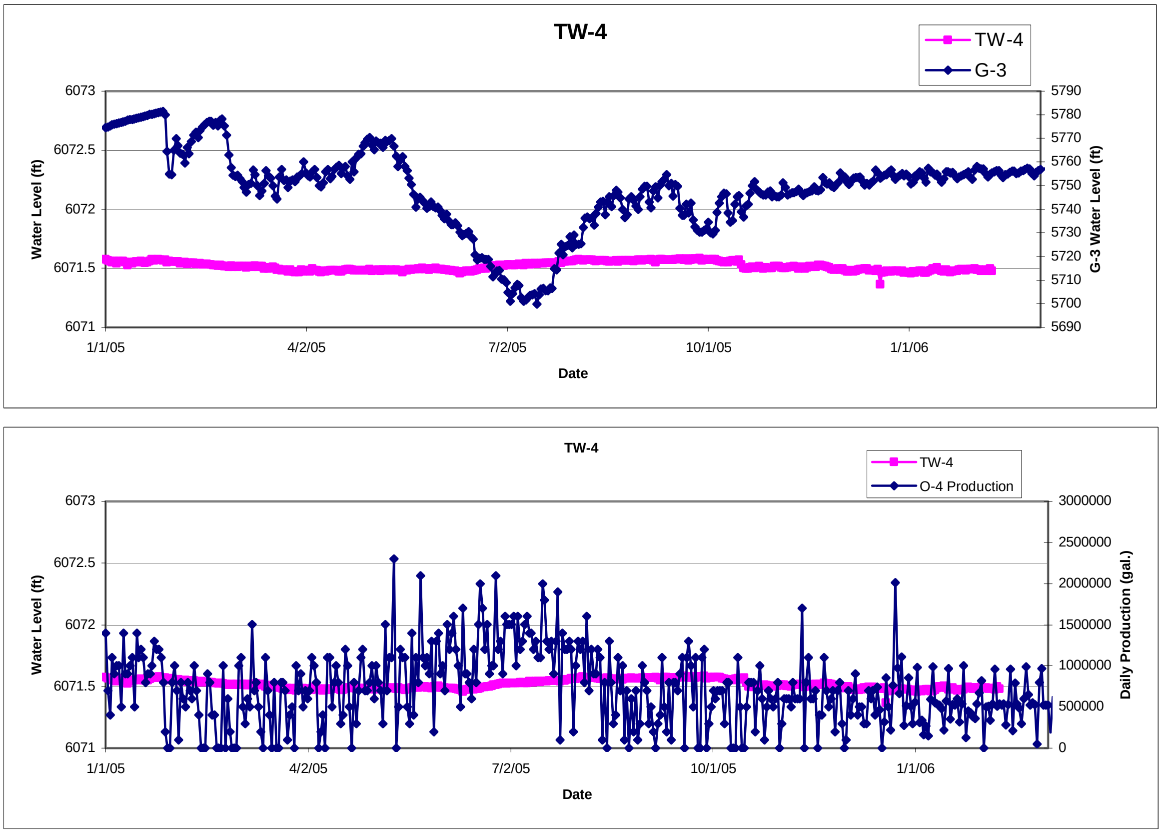


Figure D-3.4-7 TW-4 mean daily water level compared with the G-3 water level and daily production at O-4 in 2005 and early 2006

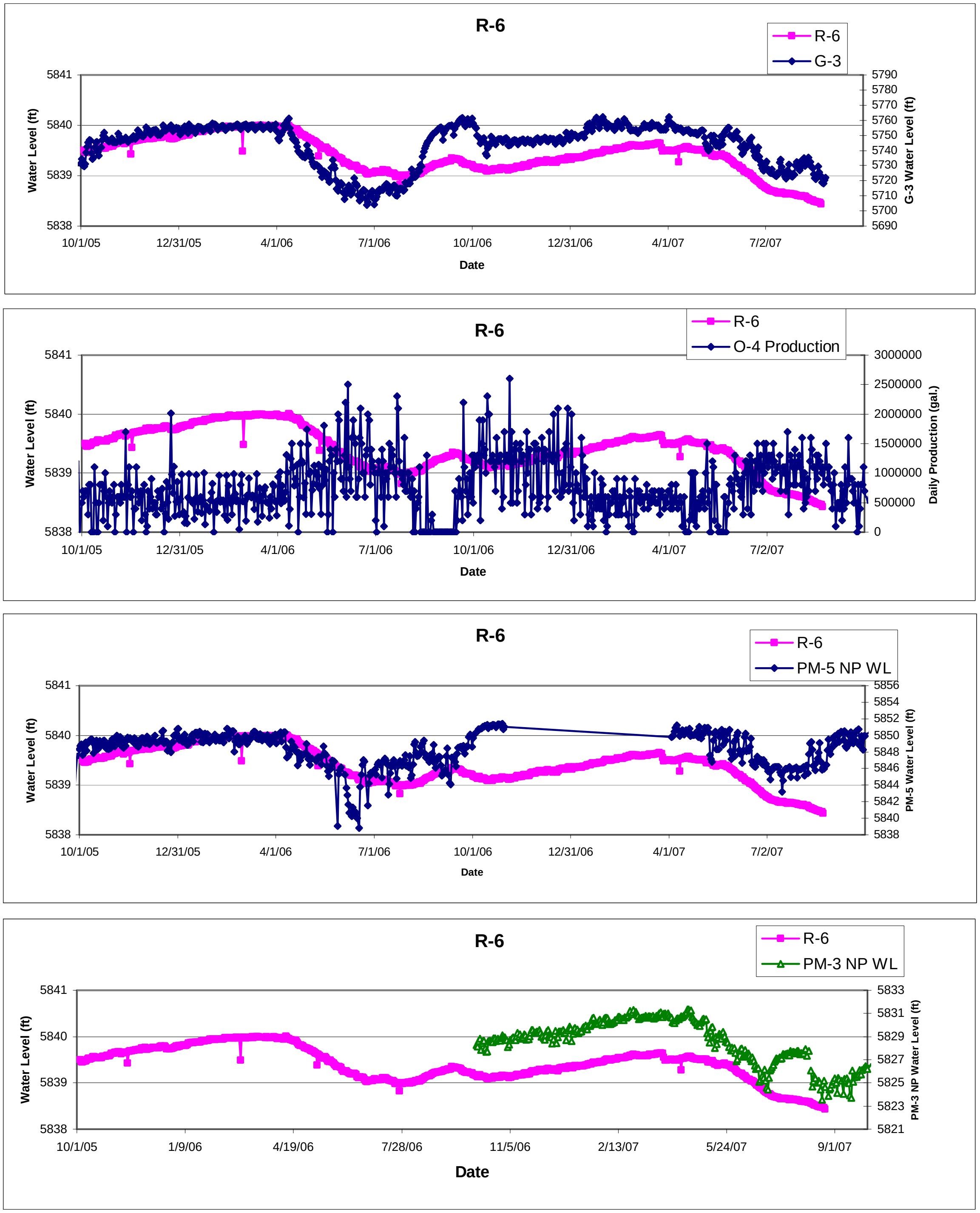


Figure D-3.4-8 R-6 mean daily water level compared with the G-3 water level, O-4 daily production and PM-5 and PM-3 nonpumping water levels for in 2005 and 2006

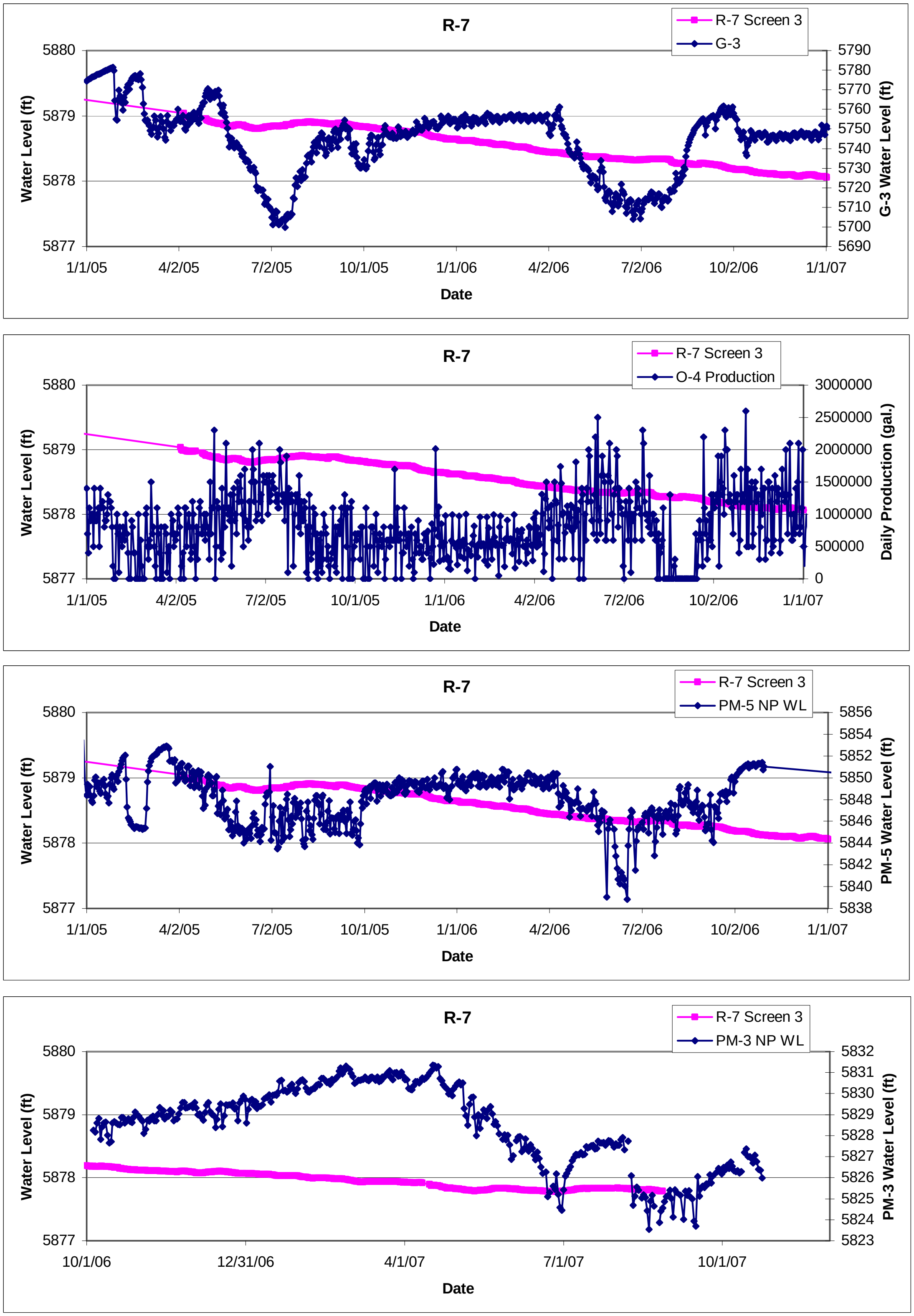


Figure D-3.4-9 R-7 Screen 3 mean daily water level compared with G-3 water level, O-4 production, and the nonpumping water level at PM-5 in 2005 and 2006 and the nonpumping water level at PM-3 in 2007

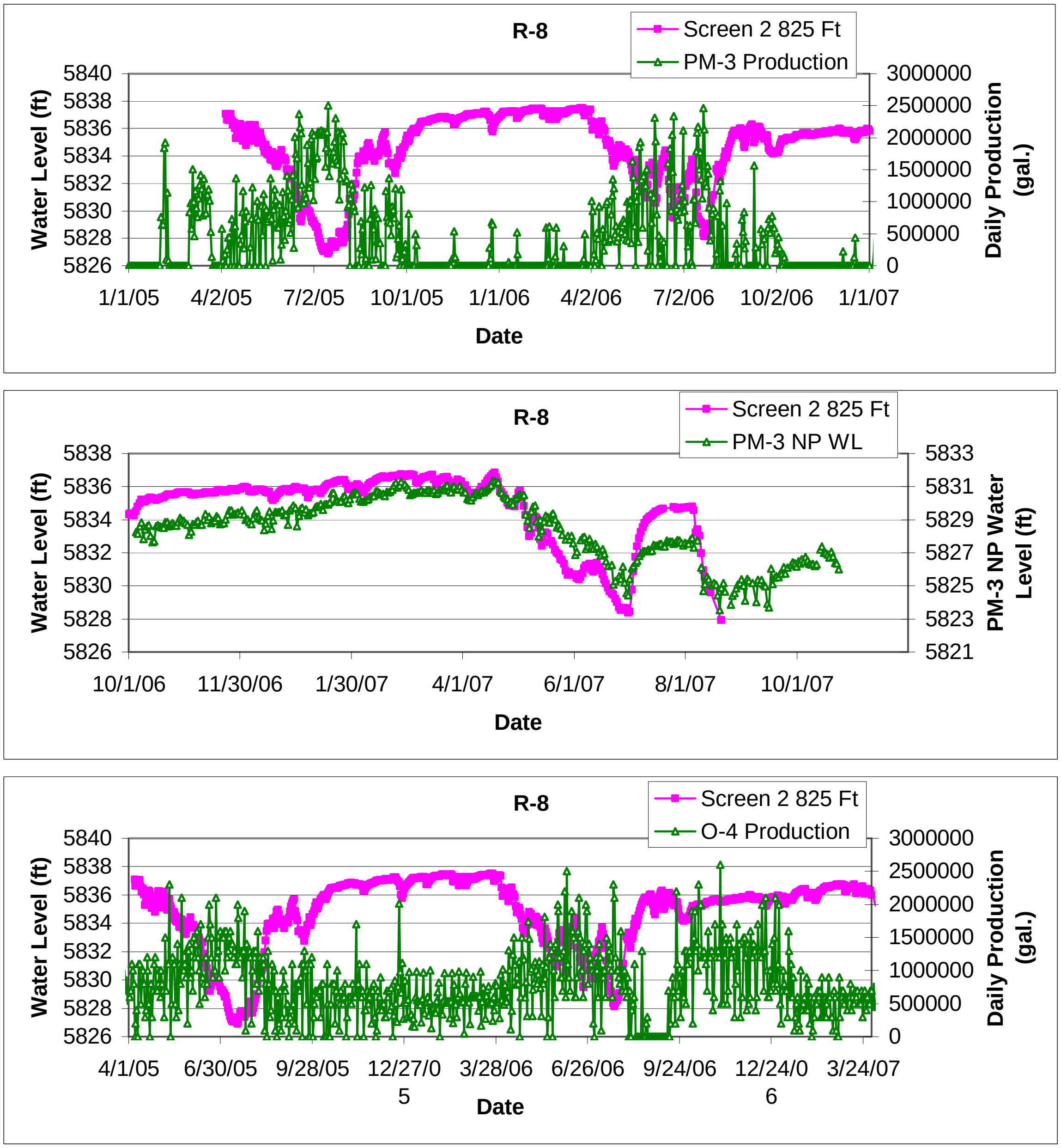


Figure D-3.4-10 R-8 Screens 1 and 2 mean daily water levels compared with PM-3 daily production in 2005 and 2006. Screen 2 mean daily water level compared with PM-3 nonpumping water from October 2006 to October 2007, and R-8 Screen 2 mean daily water level compared with O-4 daily production from April 2005 to April 2007.

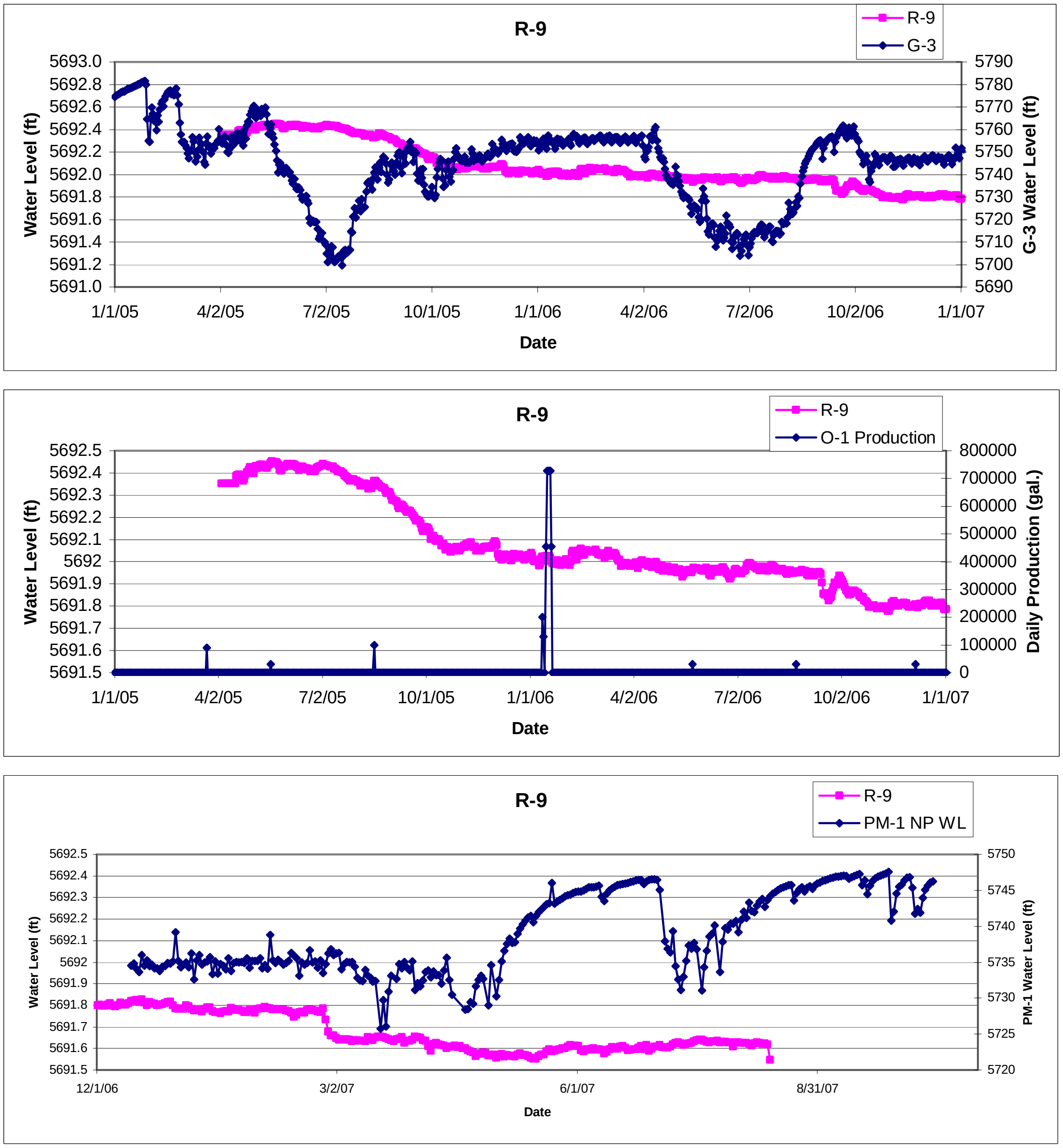


Figure D-3.4-11 R-9 mean daily water level compared with the G-3 water level, O-1 daily production in 2005 and 2006, and the PM-1 nonpumping water levels for December 2006 to August 2007

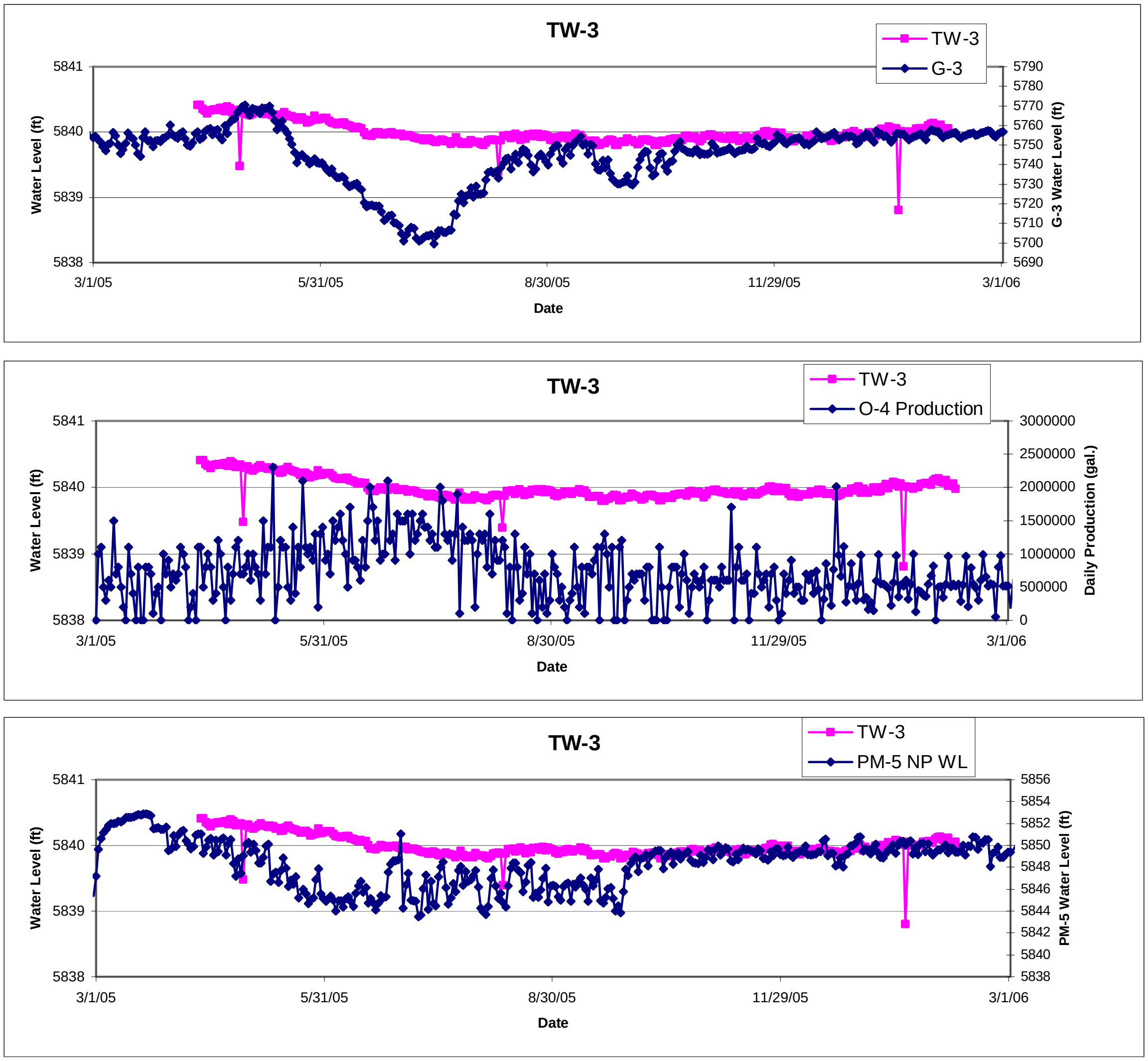


Figure D-3.4-12 TW-3 mean daily water level compared with the G-3 water level, O-4 daily production and PM-5 nonpumping water levels for April 2005 to February 2006

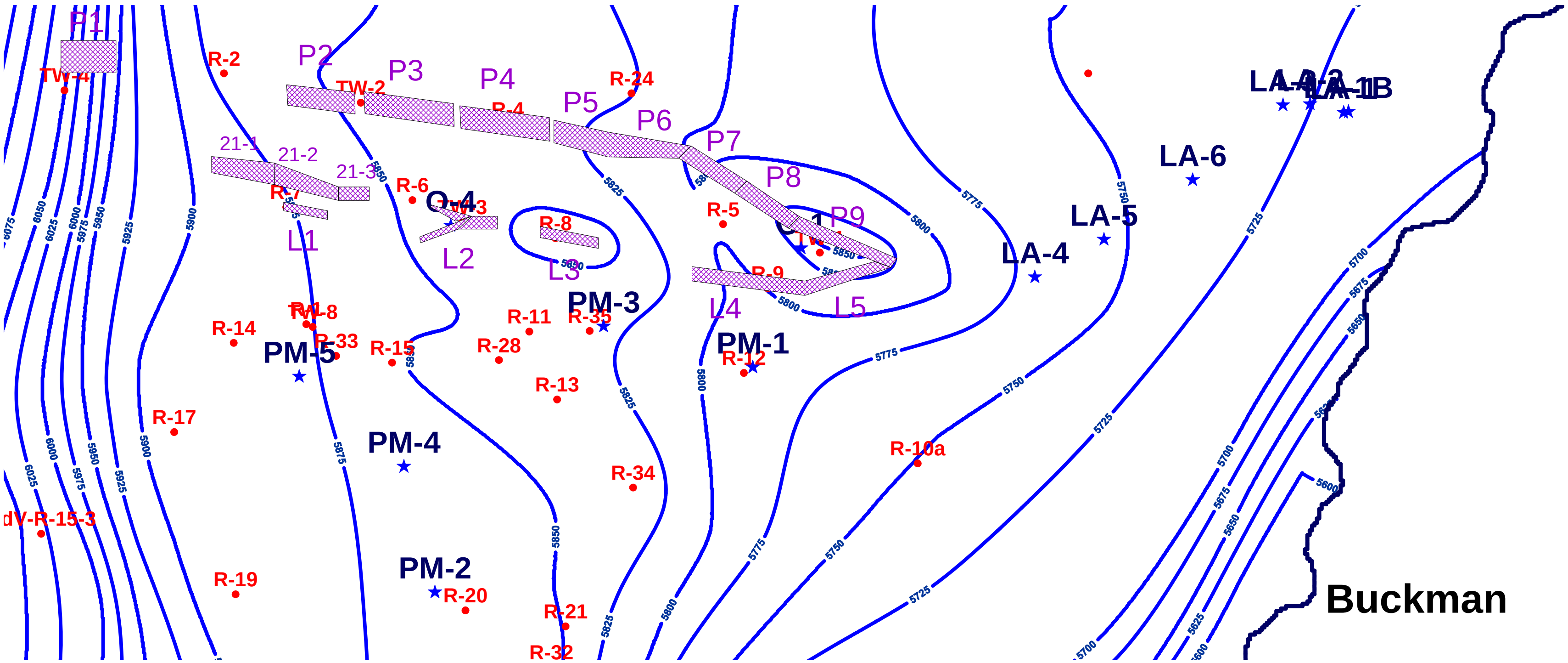


Figure D-4.0-1   Alternative water-table map #1

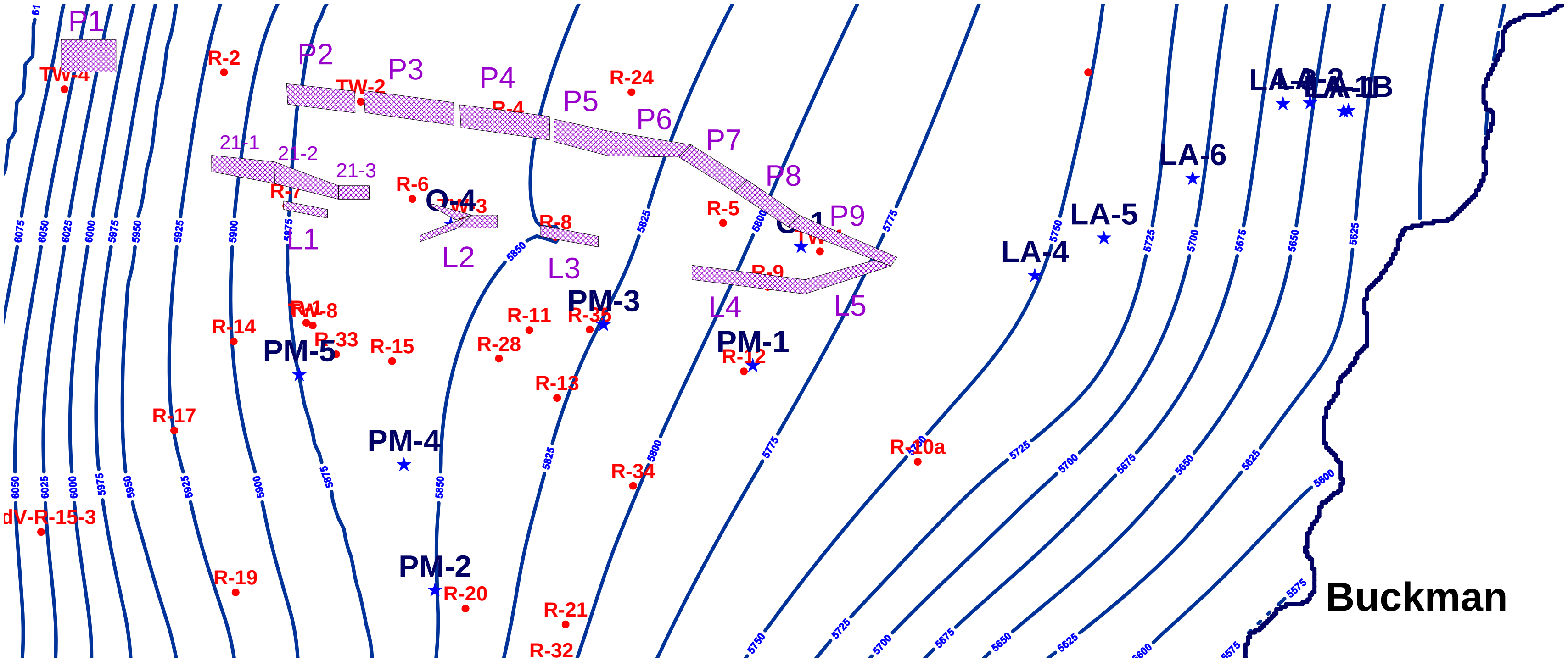


Figure D-4.0-2 Alternative water-table map #2

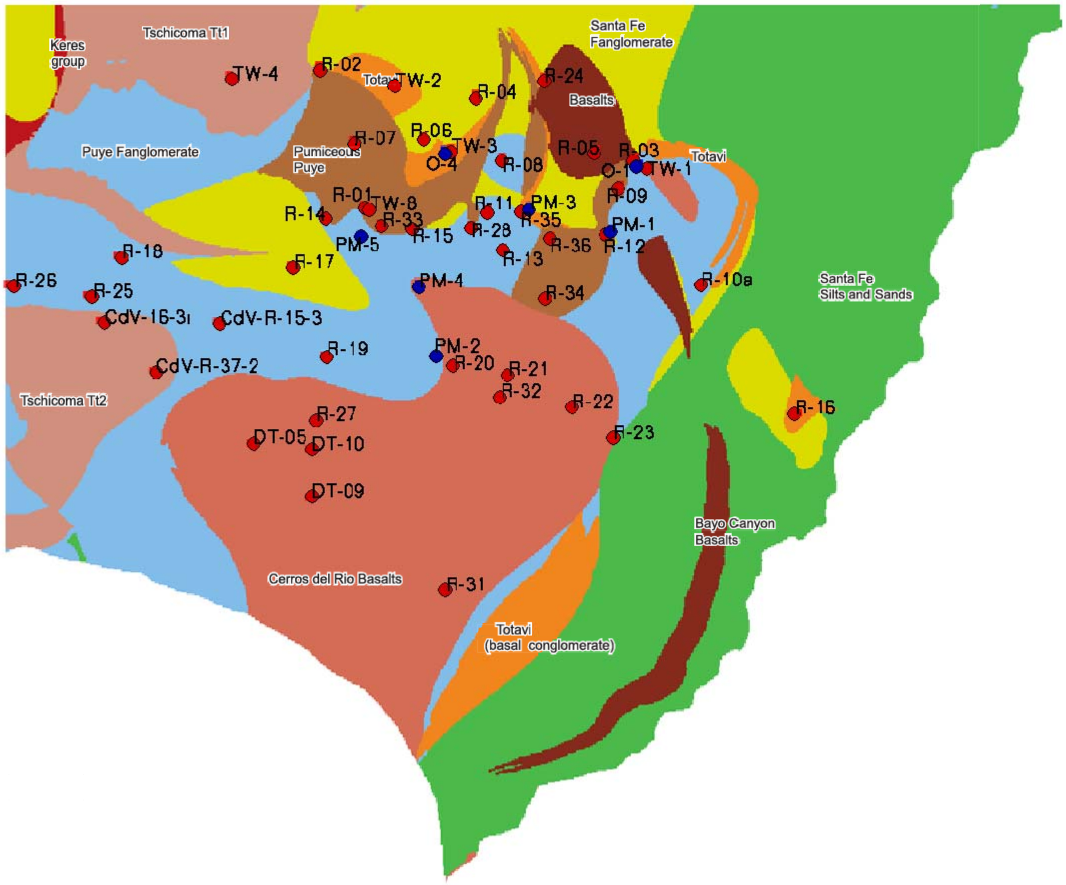


Figure D-4.0-3 Hydrostratigraphy along the water table from the FY05 sitewide 3D geologic model. The water table is based on alternative map #1 in this report (Figure D-4.1).

Table D-2.0-1
Perched Intermediate Groundwater in Pueblo and Los Alamos Canyons

Watershed	Well Name, Borehole Depth (ft), Surface Elev. (ft)	Depth to Water (ft)	Saturated Thickness (ft)	Groundwater Host Rock	Nature of Perching Layer	Anthropogenic Chemicals Detected	Comments
Pueblo Canyon	TW-2a 133 6646	110	>23	Puye Formation fanglomerate	Within Puye Formation fanglomerate; perching lithology not known	Tritium and nitrate	A single-screen well was installed in this zone (Griggs and Hem 1964, 092516; Purtymun 1995, 045344).
Pueblo Canyon	R-5 902 6473	338	~49	Miocene/Pliocene dacitic sands and gravels mixed with 5%–15% rounded quartzite and granite river gravels	Within Pliocene/Miocene sediments; perching lithology not known	Nitrate, fluoride, chloride, uranium, and sulphate	A canyon-floor well was installed with four isolated screens (LANL 2003, 080925). Screen 1 is dry. Screen 2 is completed in this perched zone. The vertical extent of this zone is poorly known. Screens 3 and 4 are in regional groundwater.
Pueblo Canyon	R-3i 268 6390	191	Uncertain, multiple zone of saturation detected in cores and borehole camera logs between 192- and 260-ft depth.	Cerros del Rio fractured basalt	Multiple confining layers within the Cerros del Rio basalt. Lowermost perching horizon appears to be maar deposits at the base of the basalt; core from the underlying Puye Formation was dry.	Nitrate, fluoride, chloride, uranium, sulphate, perchlorate, and uranium	This is a complex zone with saturation occurring at several horizons in the interval between 192 and 240 ft. The saturated horizons seem to be poorly connected because multiple water levels were measured as the cased core hole was advanced. Water production is associated with zones of highly fractured basalt. A well screen was installed between 215.5 and 220.0 ft.

Table D-2.0-1 (continued)

Watershed	Well Name, Borehole Depth (ft), Surface Elev. (ft)	Depth to Water (ft)	Saturated Thickness (ft)	Groundwater Host Rock	Nature of Perching Layer	Anthropogenic Chemicals Detected	Comments
Pueblo Canyon	POI-4 181 6372	160	>21	Cerros del Rio fractured basalt	Confining layer not penetrated	Nitrate, phosphate, chloride, and boron,	Groundwater occurs in massive basalt cut by high-angle fractures. A single-screen well was installed in this zone.
Pueblo Canyon	TW-1a 225 6370	184	±37 (?)	Interflow breccia and siltstone in Cerros del Rio basalt	Possibly nonfractured massive basalt	Nitrate, phosphate, chloride, boron, and uranium	Groundwater was first encountered near the top of Cerros del Rio basalts in a zone from 212- to 215-ft-depth (John et al. 1966, 008796). Groundwater may be confined because the water level stabilized at 188 ft (Purtymun 1995, 045344). Well screen was placed from 215- to 225-ft depth.
Los Alamos Canyon	H-19 2000 7172	450	22	Porous, well-bedded and well-sorted fall deposits of the Guaje Pumice Bed	Tschicoma Formation lava flow top	Not sampled	Saturation in this zone was noted while drilling to reach the regional aquifer (Griggs and Hem 1964, 092516). The perched zone was not screened, and the regional well was later abandoned.
Los Alamos Canyon	LAOI(A)1.1 323 6833	289	27	Porous, well-bedded and well-sorted fall deposits of the Guaje Pumice Bed	Top of Puye Formation; possible clay-rich soil horizon —see description for well LADP-3	None	A single-screen well was installed in this zone.

Table D-2.0-1 (continued)

Watershed	Well Name, Borehole Depth (ft), Surface Elev. (ft)	Depth to Water (ft)	Saturated Thickness (ft)	Groundwater Host Rock	Nature of Perching Layer	Anthropogenic Chemicals Detected	Comments
Los Alamos Canyon	R-7 1097 6779	373	9	Puye Formation silty, clayey, and sandy gravels	Clay-rich gravels from 382- to 397-ft depth in the Puye Formation	None	A canyon-floor well was installed with three isolated screens (Stone et al. 2002, 072717). Screen 1 in well R-7 is completed in this perched zone.
Los Alamos Canyon	R-7 1097 6779	744	~23	Pliocene/Miocene. sandy gravel with abundant pumice clasts	Possible perching layer from 767 to 772 ft in silty pebble gravel or from 772 to 777 ft in clayey pumiceous sands	None	Screen 2 in well R-7 is completed in this zone. Geophysical logs and borehole videos suggest additional perched groundwater zones were encountered when the R-7 borehole was drilled.
Los Alamos Canyon	LADP-3 349 6756	320	9	Porous, well-bedded and well-sorted fall deposits of the Guaje Pumice Bed	Smectite- and kaolinite-rich soil a few inches thick at top of Puye Formation	Tritium	Soil development occurs at top of the Puye Formation in outcrops and in boreholes elsewhere. A single-screen well was installed in this zone (Broxton et al. 1995, 050119).
Los Alamos Canyon	R-6i 660 6997	592	23	Puye Formation gravels	Poorly sorted fanglomerate with a silty matrix	Nitrate and perchlorate	This zone occurs at the same elevation and may be related to the perched zone identified by borehole video in nearby supply well Otowi 4 during drilling. A single-screen well was installed in this zone.

Table D-2.0-1 (continued)

Watershed	Well Name, Borehole Depth (ft), Surface Elev. (ft)	Depth to Water (ft)	Saturated Thickness (ft)	Groundwater Host Rock	Nature of Perching Layer	Anthropogenic Chemicals Detected	Comments
Los Alamos Canyon	Otowi 4 2806 6639	~253	Not known	Puye Formation gravels	Within Puye Formation fanglomerate; perching lithology not known	Not sampled	Saturation in this zone was noted while drilling to install a municipal supply well in the regional aquifer (Stoker et al. 1992, 058718). The geologic log notes, “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.” This perched zone is not accessed by a well screen in Otowi 4.
Los Alamos Canyon	LAOI-3.2 165.5 6623	134	>31	Basal ash-flow tuffs of the Otowi Member and porous, well-bedded and well-sorted fall deposits of the Guaje Pumice Bed	The perched zone was not fully penetrated during drilling; perching lithology not known.	Nitrate, perchlorate, and chloride	Perched groundwater was detected while coring through the lowermost part of the Bandelier Tuff. The bottom of saturation was not penetrated by the borehole. A single-screen well was installed in this zone.
Los Alamos Canyon	LAOI-3.2a 266.9 6624	175	~20 ft	Puye Formation gravels	The perching horizon appears to be a stratified sequence of brown homogeneous silts, fine-grained sands, with subordinate clay in the interval from 195 to 266.5 ft.	Nitrate, perchlorate, and chlorate	LAOI-3.2 and LAOI-3.2a are located about 50 ft apart with LAOI-3.2 screened in the Guaje Pumice Bed and LAOI-3.2a screened in the upper Puye Formation. The differences in depth to water in these two wells suggest two separate water-bearing zones occur at that location.

Table D-2.0-1 (continued)

Watershed	Well Name, Borehole Depth (ft), Surface Elev. (ft)	Depth to Water (ft)	Saturated Thickness (ft)	Groundwater Host Rock	Nature of Perching Layer	Anthropogenic Chemicals Detected	Comments
Los Alamos Canyon	LAOI-7 380 6458	26	See comments.	Basal ash-flow tuffs of the Otowi Member and porous, well-bedded and well-sorted fall deposits of the Guaje Pumice Bed	The perching horizon is uncertain but may be silty sediments of the Puye Formation.	Nitrate and mercury	Perched groundwater was detected in the lower part of the Otowi Member during coring. The base of the perched water is uncertain because of incomplete core recovery, but most likely it extends to the top of dry silt-rich sediments comprising Puye deposits that overlie the Cerros del Rio basalt in this area.
Los Alamos Canyon	LAOI-7 380 6458	222	Groundwater dispersed in fractures over an interval of about 138 ft	Cerros del Rio basalt, in portions of lava flows cut by high-angle fractures and in interflow breccias separating basalt flows.	Perching appears to occur above those sections of massive basalt flows where fractures are rare to absent. The lowermost perching horizon is not known with certainty but may be layered maar deposits between 360 and 363.4 ft at the base of the basalt sequence.	Mercury	This is a complex zone with saturation occurring at several horizons in the interval between 237.2 and 286.8 ft. The saturated horizons seem to be interconnected via high-angle fractures because the saturated zones yielded similar water levels. Water was first noted in the core barrel after drilling the 237.2- to 242.2-ft interval. Coring was halted and the water level stabilized at 221.6 ft. Fractures below 234.3 ft contain common clay; clay is much less abundant above this depth. Additional zones of saturation in core occurred between depths of 256.8 and 262.2 ft in a basalt rubble zone and between depths of 282.2 and 286.8 ft in a vesicular basalt.

Table D-2.0-1 (continued)

Watershed	Well Name, Borehole Depth (ft), Surface Elev. (ft)	Depth to Water (ft)	Saturated Thickness (ft)	Groundwater Host Rock	Nature of Perching Layer	Anthropogenic Chemicals Detected	Comments
Los Alamos Canyon	R-9i 322 6383 and LAWS-01 281.5 6305	137	45–99	Cerros del Rio basalt interflow breccia and highly fractured basalt	Massive basalt with few fractures	Tritium	Groundwater was first encountered at a depth of 180 ft, but the water level quickly rose to 137 ft, indicating possible confinement. At R-9i a canyon-floor well was installed with two isolated screens (Broxton et al. 2001, 071251). Screen 1 of R-9i is completed in this zone. In LAWS-01, this zone is sampled via a flexible liner with sampling ports (Stone and Newell 2002, 099125).
Los Alamos Canyon	R-9i 322 6383 and LAWS-01 281.5 6305	275	7	Cerros del Rio basalt brecciated flow base	Clay-rich, stratified, basaltic tephra (maar deposits) from 282 to 289.8 ft	Tritium	Water was first encountered at 275 ft. The water level stabilized at 264 ft and may be confined (Broxton et al. 2001, 071251). Screen 2 in well R-9i is completed in this zone. In LAWS-01, this zone is sampled via a flexible liner with sampling ports (Stone and Newell 2002, 099125).

Table D-2.0-1 (continued)

Watershed	Well Name, Borehole Depth (ft), Surface Elev. (ft)	Depth to Water (ft)	Saturated Thickness (ft)	Groundwater Host Rock	Nature of Perching Layer	Anthropogenic Chemicals Detected	Comments
Los Alamos Canyon	R-9 771 6383	524	48–103	Pliocene/Micene volcanogenic sands and gravels	Clay-rich tuffaceous sands and gravels	Tritium	Three stringers of sands and gravels at 579–580.5 ft, 615 ft, and 624–626.8 ft produced perched groundwater (Broxton et al. 2001, 071250). These occurrences probably constitute a single saturated zone because, when isolated, each yielded the same depth to water of 524 ft. The water-bearing stringers are enclosed by clay-rich tuffaceous sands and gravels that may be confining units or may simply be unproductive. No well screens were installed in this saturated zone.

Table D-3.3-1
Monitoring Well Screens at The Top of The Regional Aquifer

Well	Screen	Avg March 2006 Water Level (ft)	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Screen Length (ft)	Geologic Unit	Screen Top Elev (ft)	Top of Screen from Water Table (ft)	Comment
G-3	Single	5761.0	560.0	1100.0	540.0	Tsf	5579.0	-182.0	Former supply well converted to monitoring
R-2	Single	5871.9	906.5	929.6	23.1	Tpf	5863.9	-7.9	
R-4	Single	5833.9	792.9	816.0	23.1	Tp	5784.6	-49.3	Screen monitors potential confined zone
R-5	3	5768.0	676.9	720.3	43.4	Tsf/Tsfb	5795.7	27.7	Long screen at top of regional aquifer
R-6	Single	5839.9	1205.0	1228.0	23.0	Tf	5790.8	-49.1	Screen significantly below water table
R-7	3	5878.5	895.5	937.4	41.9	Tp	5883.7	5.2	Screen straddles water table
R-8	1	5855.6	705.3	755.7	50.4	Tp	5839.4	-16.2	Screen below water table, no filter pack
R-9	Single	5692.0	683.0	748.5	65.5	Tsfb	5699.8	7.8	Screen straddles "deep" water table
R-24	Single	5834.2	825.0	848.0	23.0	Tsf	5722.4	-111.8	Screen monitors confined zone
TW-1	Single	5855.4	632.0	642.0	10.0	Tp	5737.2	-118.2	Water level erratic
TW-2	Single	5838.0	768.0	824.0	56.0	Tp	5880.1	42.1	Screen significantly below water table
TW-3	Single	5840.0	805.0	815.0	10.0	Tp	5821.9	-18.1	Screen below water table
TW-4	Single	6071.5	1195.0	1205.0	10.0	Tt	6049.6	-21.9	Screen below water table

Table D-3.3-2
Summary of Well Hydraulic Conductivity and Sampling Characteristics

Well	Screen	Screen Length (ft)	Geologic Unit	Hydraulic Conductivity (ft/day)	Sampling Drawdown (ft)	Screen Sampling Characteristics
G-3	Single	540	Tsf	6.3	NA	Well not sampled
R-2	Single	23	Tpf	5.7	6	Immediate recovery after sampling
R-4	Single	23	Tp	10.1	2	Immediate recovery after sampling
R-5	3	43	Tsf/Tsfb	Not Available	10	Significant drawdown during low flow sampling
R-6	Single	23	Tf	6.1	6	Immediate recovery after sampling
R-7	3	42	Tp	Not Available	0	No drawdown during low flow sampling
R-8	1	50	Tp	Not Available	0	No drawdown during low flow sampling
R-9	Single	66	Tsfb	Not Available	0.25	Immediate recovery after sampling
R-24	Single	23	Tsf	0.39	25	Immediate recovery after sampling
TW-1	Single	10	Tp	0.7	35	Immediate recovery after sampling
TW-2	Single	56	Tp	2.7	20	Immediate recovery after sampling
TW-3	Single	10	Tp	6.3	10	Immediate recovery after sampling
TW-4	Single	10	Tt	8.2	10	Immediate recovery after sampling

Note: Hydraulic data are from McLin (2006, 093672).

Table D-3.5-1
Summary of Transient Aquifer Responses in Los Alamos and Pueblo Canyon Regional Aquifer Screens

Well	Screen	Seasonal	Guaje	Otowi 1	Otowi 4	PM-1	PM-3	PM-5	Comment
R-2	Single	No	No	NE	No	NE*	NE	NE	Gradual decline of abut 0.5 ft/yr
R-4	Single	Yes	Possible	No	Possible	NE	Yes	NE	Seasonal fluctuations associated with supply pumping
R-5	3	No	No	No	No	No	No	NE	Gradual decline of abut 0.6 ft/yr
R-5	4	Yes	No	Possible	No	Yes	No	NE	Seasonal fluctuations associated with supply pumping
R-6	Single	Yes	No	No	Possible	NE	Yes	No	Seasonal fluctuations associated with supply pumping
R-7	3	No	No	No	No	NE	No	NE	Gradual decline of abut 0.5 ft/yr
R-8	1	Yes	No	NE	Possible	No	Yes	NE	Responds primarily to pumping at PM-3
R-8	2	Yes	No	NE	Possible	No	Yes	NE	Responds primarily to pumping at PM-3
R-9	Single	Yes	No	No	NE	No	No	NE	Gradual decline of about 0.4 ft/yr
R-24	Single	Yes	Possible	No	Possible	No	Yes	NE	Responds primarily to pumping at PM-3
TW-1	Single	No	No	No	NE	No	NE	NE	Water level apparently impacted by surface water near well
TW-2	Single	Yes	NE	NE	NE	NE	NE	NE	No recent valid water level data
TW-3	Single	Yes	No	NE	No	NE	No	NE	Gradual decline of about 0.8 ft/yr
TW-4	Single	Yes	No	NE	No	NE	NE	NE	Seasonal fluctuations not related to supply well pumping

*NE = Not evaluated.

Appendix E

Contaminant Observations

E-1.0 FREQUENCY OF DETECT TABLES FOR REGIONAL AND INTERMEDIATE WELLS

Tables E-1.0-1 (a–g) and Table E-1.0-2 (a–g) summarize frequency of detects for metals and cations, organic compounds, radioactive elements, and general inorganic chemicals for regional wells and perched intermediate wells, respectively, in the Los Alamos and Pueblo Canyons watersheds. These tables are primarily used to identify potential contaminants of concern in the two watersheds. These tables also identify wells with one or more occurrences of constituents above background. Appendix B evaluates the present-day ability of each of the wells to provide reliable and representative data for a suite of nine key indicators discussed in section E-2.0 that are used to define nature and extent of canyon-specific contaminants.

E-2.0 ASSESSMENT OF RELIABABILITY OF REGIONAL AND INTERMEDIATE GROUNDWATER SAMPLES USING KEY INDICATORS

Table E-2.0-1 and Table E-2.0-2 summarize the presence or absence of nine constituents above background concentrations in each of the 28 well screens in the Los Alamos and Pueblo Canyons watershed. These nine constituents were selected as key indicators because they are highly mobile and are characteristic of one or more of the contaminant sources in these watersheds. In the two tables, the detection status for each indicator in each screen is categorized as either background, indeterminate, or present; if present, an approximate maximum observed concentration is given. These tabulations provide the primary basis for defining nature and extent of canyon-specific contaminants (Section 2).

The maximum concentrations listed in Tables E-2.0-1 and E-2.0-2 are shown in figures that illustrate temporal and spatial trends for key indicators in each watershed. Figures E-2.0-1 through E-2.0-11 plot trends for the nine key indicators as well as for two trace metals (iron and manganese) commonly used to assess redox conditions in the screened intervals. Because the sole purpose of these figures is to show general trends, the plotted data represent a subset of those available. Data validation status was not considered. Data were excluded if they did not appear to be reliable, e.g., due to an inadequate detection limit. Although data for filtered samples for general inorganics or trace metals were generally preferred (other than for total iron, Figure E-2.0-5), data for a nonfiltered sample was nonetheless included in the plots if no data were available for a filtered sample. Except for the chromium plot (Figure E-2.0-4), the use of nonfiltered sample data is not labeled as such because this substitution generally made less difference in the overall trends. The period of time covered by the data for each screen is highly variable, as indicated in Tables E-2.0-1 and E-2.0-2. Finally, several data points plotted below the associated background limits are actually nondetects, but this data qualification is also not shown in the plots because it also makes little difference for establishing overall trends.

E-3.0 VADOSE-ZONE PROFILES

E-3.1 Nitrate, Perchlorate, and Chlorate Profiles

Concentration profiles for deionized (DI) water leachates using core or cuttings samples are summarized in Figures E-3.1-1 (Pueblo and Bayo Canyons) and E-3.1-2 (Los Alamos and DP Canyons). These figures show concentrations of nitrate (NO_3), perchlorate (ClO_4), and chlorate (ClO_3) plotted against depth and stratigraphic interval, with borehole profiles adjusted to elevation (note however that the inset ClO_3 figure for LADP-4 in Figure E-3.1-2 is displaced from true elevation). In each figure the presence of perched saturation zones is indicated by blue shading. All leachate data were collected from core samples, with the exception of data below 573 ft depth in LADP-4 where leachate data were collected from cuttings. The leachate abundance scales for each analyte are the same for all boreholes with the exception of LADP-4, where exceptionally high concentrations of both nitrate and perchlorate require an expanded scale and the appearance of abundant chlorate (very rare elsewhere) requires addition of an inset figure. Tabulated values are provided in Appendix F-2.2, Vadose Zone DI-Leach Nitrate, Perchlorate, and Chlorate Data.

In Pueblo Canyon (Figure E-3.1-1), core from hole R-2 contains the only observed perchlorate occurrences in core from this canyon. These perchlorate occurrences within R-2 are distributed throughout the core at R-2, peaking in the Guaje Pumice Bed (Qbog) but extending down into the underlying Puye Formation (Tpf). In contrast, nitrate occurs only in the uppermost vadose zone at R-2 whereas nitrate occurrences are more pervasive throughout the vadose zone down-canyon. This distribution of perchlorate and nitrate reflects the localization of perchlorate sources up-canyon and the more distributed sewage input along the canyon over time. The perchlorate and nitrate data provide some insight into relative contaminant distribution within hydrostratigraphic units; the increase in perchlorate content at the Guaje Pumice Bed in R-2 and the increased nitrate content at this horizon in R-4 and R-24 is in accord with moisture profiles showing increased vadose water content in Qbog (Appendix D, Figure D-1.0-1). Elevated nitrate also occurs in the perched zone at the base of the Cerros del Rio lavas in R-3i. Chlorate is not observed in any of the Pueblo Canyon core leachate data, but this contaminant is locally abundant in Los Alamos Canyon.

In Los Alamos Canyon (Figure E-3.1-2), the extensive input of nitrate, perchlorate, and chlorate at TA-21 requires a shift in scale for adequate representation of the contaminant profiles in borehole LADP-4. All other core profiles shown in this figure have the same abundance scale for nitrate (0-50 mg/L) and perchlorate (0-50 μg/L) as used in the figure for Pueblo Canyon (Figure E-3.1-1), but the abundance scales must be expanded 50x to show the profiles at LADP-4. In addition, an inset figure has been added to show the chlorate profile at LADP-4 (note that the scale for chlorate in this hole is in mg/L rather than μg/L; maximum ClO_3 abundance at LADP-4 is ~25x maximum ClO_4 abundance). The chlorate occurrences throughout LADP-4 provide a unique tracer and the widespread lack of chlorate detection in leachates from other coreholes suggests limitations in vadose-zone migration of this contaminant. Notably the only other DI-leach occurrences of chlorate are in two samples above the Cerros del Rio lavas in R-8, where two adjacent samples have very small amounts of this contaminant. It is also notable that although both nitrate and perchlorate are highly elevated in the upper portion of LADP-4, in devitrified Tshirege Member units Qbt 1v and higher, the chlorate distribution peaks in both this upper horizon and in a broad zone from the middle of the Otowi Member (Qbo) down to the deepest samples collected in the Puye Formation (Tpf).

In broader perspective, the nitrate and perchlorate data show the dominant influence of TA-21, with no detections occurring up-canyon (LAOI(A)-1.1) but localized detections of perchlorate and widely distributed detections of nitrate down-canyon as far as LAOI-7. Perchlorate is not detected down-canyon in core leachates from R-9, and nitrate detection in this corehole is largely limited to samples in or near zones of perched saturation.

E-3.2 Chromium and Molybdenum Profiles

This section discusses the spatial distribution of pore-water chromium and molybdenum and acid-leachable chromium in Los Alamos Canyon because of interest in identifying potential sources of chromium contamination found in regional groundwater at monitoring wells R-11 and R-28 in canyons south of Los Alamos Canyon. Chromium was discharged to Los Alamos Canyon from the Technical Area (TA) 02 Omega West site after use to control corrosion of cooling system (see section 2.2.1 in the main text). Molybdenum was released from cooling towers at TA-53. These contaminants mixed with surface water and alluvial groundwater before infiltrating into the deeper vadose zone farther downcanyon.

E-3.2.1 Occurrences above Background

Selected archival core samples from Los Alamos Canyon were analyzed to determine the nature and extent of chromium contamination in the upper vadose zone and to identify potential infiltration pathways. Core samples were selected for analysis at nominal 20-ft intervals for each core hole. Locations of the core holes sampled are shown on the location map in Figure 1.0-1 in the main text.

Core samples were analyzed for chromium and other constituents using both deionized water leaching and the U.S. Environmental Protection Agency (EPA) 3050 Digestion Method, which is referred to as the acid-soluble (digested) fraction. Pore-water concentrations of analytes are reported in units of milligrams per liters, which is considered to be equivalent to parts per million (ppm) for solutions having a total dissolved solids content less than 1000 and a solution density of 1 gal./mL, or 1 gal./cm^3. Core samples leached with deionized water provide pore-water concentrations of soluble or dissolved chromium and other solutes. Analytical results for pore-water solutes are provided in Appendix F-2 of this report. Analytical results for core samples digested by the EPA 3050 Method are given in units of milligrams per kilogram and were previously reported in Appendix C-3 of the "Interim Measures Investigation Report for Chromium Contamination in Groundwater" (LANL 2006, 094431).

E-3.2.2 Pore-Water Chromium

Figure E-3.2-1 shows chromium and molybdenum concentrations for deionized water leachates as a function of depth and stratigraphy for boreholes LAOI-3.2/3.2a, R-8, LAOI-7, and R-9. Dissolved chromium concentrations in pore water from cores collected in Los Alamos Canyon are generally low and generally similar to concentrations found in pore water from Sandia Canyon (LANL 2006, 094431). These low concentrations suggest that much of the soluble chromium (probably as CrVI) was flushed from the vadose zone by decades of recharge. LAOI-3.2 and LAOI-3.2a contain elevated residual chromium concentrations in the alluvium and upper part of the Otowi Member. Dissolved chromium concentrations generally decrease with depth, except for a single elevated value at a depth of about 180 ft in the Puye Formation between two intermediate perched groundwater zones. Farther downcanyon, R-8 and LAOI-7 cores are characterized by generally lower dissolved chromium concentrations. Slightly elevated chromium is associated with the alluvium at R-8.

Pore waters from R-9 cores generally contain greater concentrations of dissolved chromium in comparison to upcanyon boreholes, such as LAOI-3.2, LAOI-3.2a, R-8, and LAOI-7. However, comparison of R-9 to upcanyon locations is complicated by lithological differences between the core holes. The rocks at R-9 consist mostly of chromium-rich Cerros del Rio basalt (~200 ± 80 ppm) and moderately chromium-rich dacitic (~50 ppm) sedimentary rocks of the lower Puye Formation. In contrast, the rocks penetrated at LAOI-3.2, LAOI-3.2a, R-8, and LAOI-7 are primarily chromium-poor rhyolitic tuff (~1–6 ppm) and fine-grained sedimentary rocks of the upper Puye Formation. Because of these lithological differences, it is not possible to determine how much of the elevated pore-water chromium concentrations at R-9 is the result of residual chromium contamination and how much is due to elevated background values of naturally occurring chromium. Nonetheless, it appears likely that a portion of the chromium in R-9 is anthropogenic, as discussed below.

At R-9, the highest water-soluble chromium concentrations occur in two main zones. The upper zone extends from near the surface to a depth of about 180 ft within the Cerros del Rio basalt. The zone coincides with an interval of elevated pore-water phosphate, oxalate, sulfate, and chloride as described in the "Characterization Well R-9 Completion Report" (Broxton et al. 2001, 071250, section 5.3). This combination of soluble constituents likely represents residual contamination derived from former Laboratory operations located upcanyon. The abrupt lower boundary of elevated pore-water concentrations for all constituents coincides with a geologic contact separating tholeiitic basalts above from alkalic basalts below; this contact represents the base of the confining layer for the pressurized uppermost intermediate perched groundwater zone at R-9.

The lower zone of elevated water-soluble chromium concentrations at R-9 occurs in clay-rich tuffaceous sedimentary deposits in the lower Puye Formation. Chromium concentrations up to 0.5 mg/L, which peak at a depth of about 600 ft, are among the highest water-soluble chromium concentrations measured in cores from Los Alamos Canyon. Elevated pore-water nitrate also overlaps in part with this zone (Broxton et al. 2001, 071250, section 5.3). The occurrence of the greatest chromium concentrations in the Puye Formation is unexpected because whole-rock samples from the overlying Cerros del Rio basalt contain significantly more naturally occurring chromium (148 to 267 ppm) than does the lower Puye Formation (29–62 ppm) (Broxton et al. 2001, 071250, Table 3.0-1; Broxton et al. 2001, 071254). This lower zone of elevated pore-water chromium and nitrate corresponds with the lowermost perched intermediate groundwater zone encountered at R-9 and may represent residual contamination along a contaminant pathway.

E-3.2.3 Pore-Water Molybdenum

In Los Alamos Canyon, the greatest molybdenum pore-water concentrations occur in cores collected from alluvium and the upper part of the Otowi Member in borehole LAOI-3.2/3.2a (Figure E-3.2-1). In addition, a single sample collected at a depth of about 180 ft from the Puye Formation contains elevated dissolved molybdenum. This sample, which is associated with the lower of two perched zones in this area, also had elevated dissolved chromium as described above. Farther downcanyon, R-8 and LAOI-7 cores are characterized by generally low dissolved molybdenum concentrations. Slightly elevated molybdenum is associated with the alluvium at R-8.

At R-9 pore-water molybdenum concentrations closely mimic pore-water chromium concentrations through the Cerros del Rio basalt (Figure E-3.2-1). Pore-water molybdenum concentrations are generally elevated throughout the Puye Formation, with the greatest concentrations occurring near the base of the unit where chromium concentrations are also elevated. The peak pore-water molybdenum concentration of 4.1 mg/kg occurs at a depth of about 615 ft, near the base of the lowermost intermediate perched groundwater zone encountered in R-9.

E-3.2.4 Acid-Soluble Chromium

Figure E-3.2-2 presents plots of acid-soluble chromium in boreholes LAOI(A)-1.1, LADP-3, LAOI-3.2, LAOI-3.2a, R-8, LAOI-7, and R-9. The background upper tolerance limit (UTL) for chromium is 10.5 mg/kg in sediments, including the alluvium in Los Alamos Canyon. A single background UTL was established for acid-soluble chromium in Tshirege Member unit Qbt 1g, Cerro Toledo deposits, and the Otowi Member because of the geochemical similarity of these units (LANL 1998, 059730). These combined units have a mean background concentration of 0.9 mg/kg, a median of 0.81 mg/kg, and a UTL of 2.6 mg/kg. A background UTL has not been established for the Puye Formation and the Cerros del Rio basalt.

Potential anthropogenic chromium was identified at concentrations exceeding the background UTL for the Otowi Member at LAOI(A)-1.1, LADP-3, LAOI-3.2, LAOI-3.2a, R-8, and LAOI-7. Core samples from LAOI-3.2 and LAOI-3.2a contained the highest acid-soluble chromium concentrations for the Otowi Member in Los Alamos Canyon (Figure E-3.2-2). The maximum acid-soluble chromium concentration in LAOI-3.2and LAOI-3.2a was 41 mg/kg, and it occurred at a depth of 80 ft in the central part of the Otowi Member. In general, acid-soluble chromium concentrations in the Otowi Member increase downcanyon from LAOI(A)1.1 to LAOI-3.2 and LAOI-3.2a, and then they decrease farther downcanyon to LAOI-7. These results suggest that chromium-bearing water infiltrated the upper vadose zone beneath much of the canyon between LAOI(A)1.1 and LAOI-7, but the zone of maximum infiltration was located in the vicinity of the Los Alamos and DP Canyon confluence near LAOI-3.2 and LAOI-3.2a.

Where penetrated, the Puye Formation and Cerros del Rio basalt contain relatively greater concentrations of acid-soluble chromium compared with the overlying Otowi Member, except for LAOI-3.2 and LAOI-3.2a (Figure E-3.2-2). Although higher concentrations of naturally occurring acid-soluble chromium are expected in these dacitic and basaltic rocks, identification of natural versus anthropogenic chromium cannot be determined because background values for deeper rock units have not been established. This is a topic of current study. The greatest acid-soluble chromium concentrations for rocks of the Puye Formation and Cerros del Rio basalt occur in R-9 and are associated with the perched zone in basalt with a water level of 264-ft depth. Two samples from this zone contain 25 to 34 mg/kg acid-soluble chromium, whereas the common range is 5 to 20 mg/kg for basalts in Los Alamos Canyon.

In summary, pore-water chromium and molybdenum and acid soluble chromium in cores suggest that chromium-bearing water infiltrated the upper vadose zone beneath much of Los Alamos Canyon between LAOI(A)1.1 and R-9. The confluence of Los Alamos and DP Canyons near LAOI-3.2 and LAOI-3.2a appears to be the area of maximum infiltration. Pore-water chromium and molybdenum in conjunction with other anions (see Broxton et al. 2001, 071250) indicate that infiltration was also important in the vicinity of R-9.

E-4.0 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 number. This information is also included in text citations. ER ID numbers 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; the U.S. Department of Energy–Los Alamos Site Office; the U.S. Environmental Protection Agency, Region 6; 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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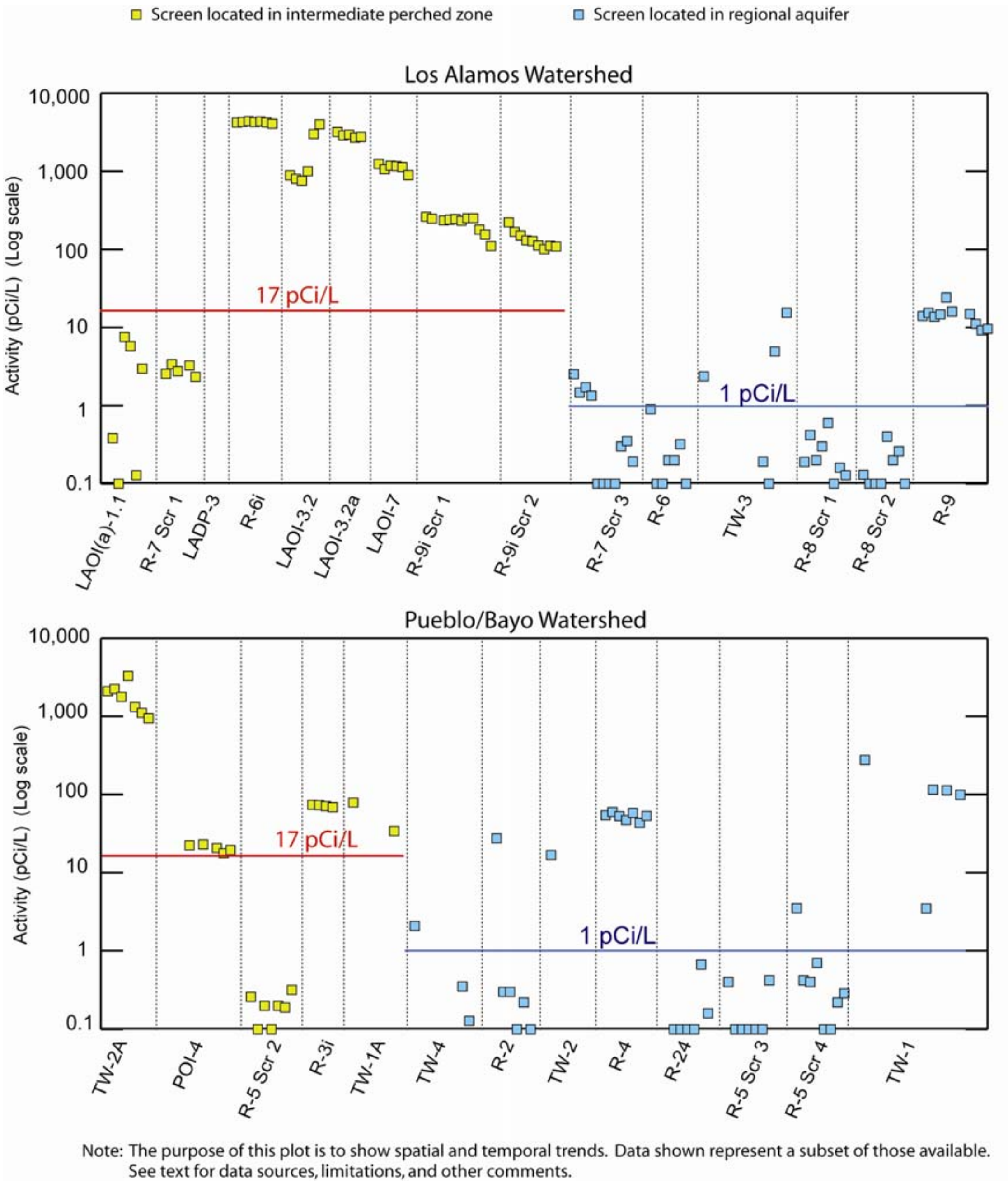

Figure E-2.0-1 Comparison of tritium data against tritium activities in background groundwater

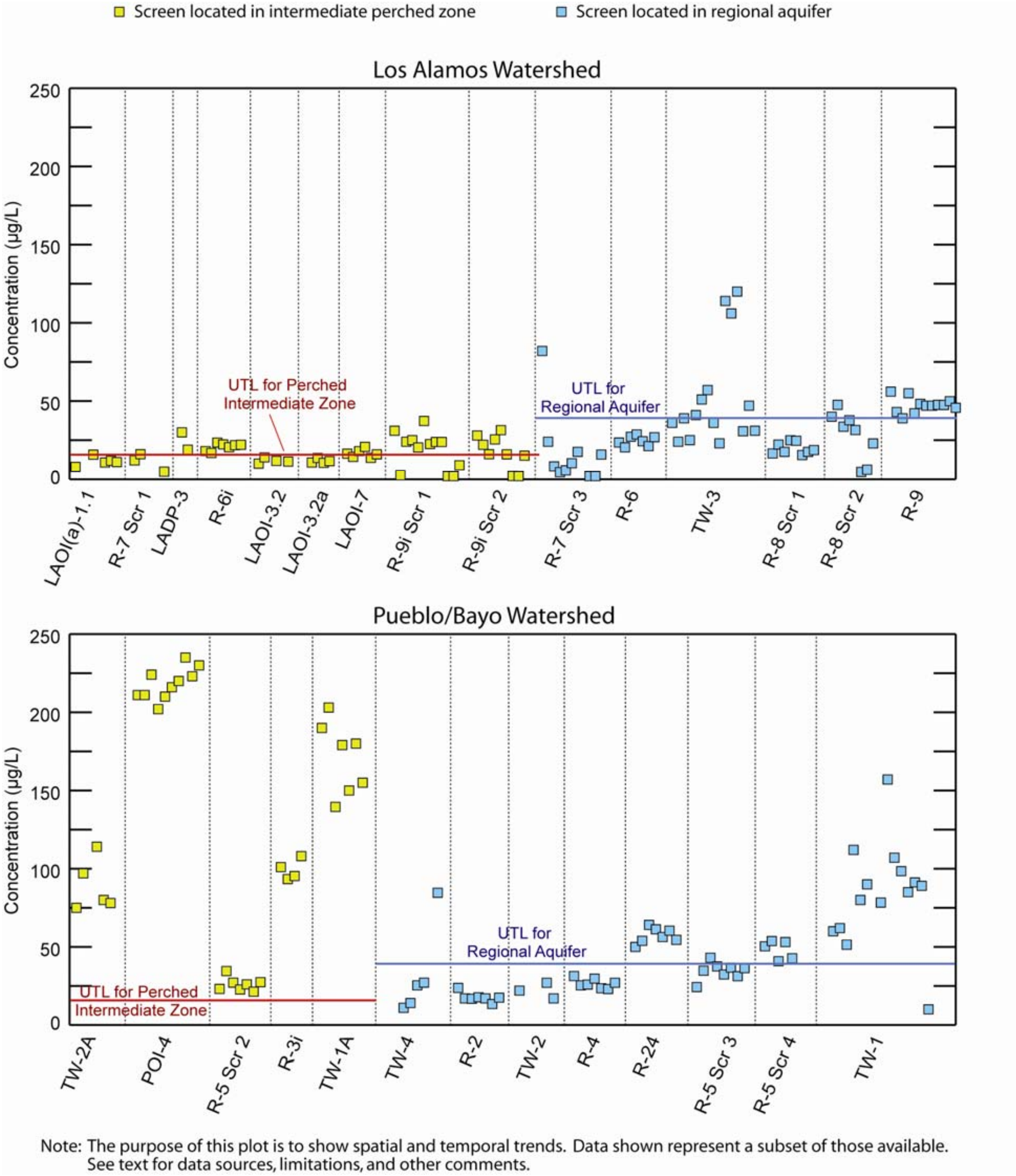

Figure E-2.0-2 Comparison of water-quality data against UTLs for background groundwater: boron

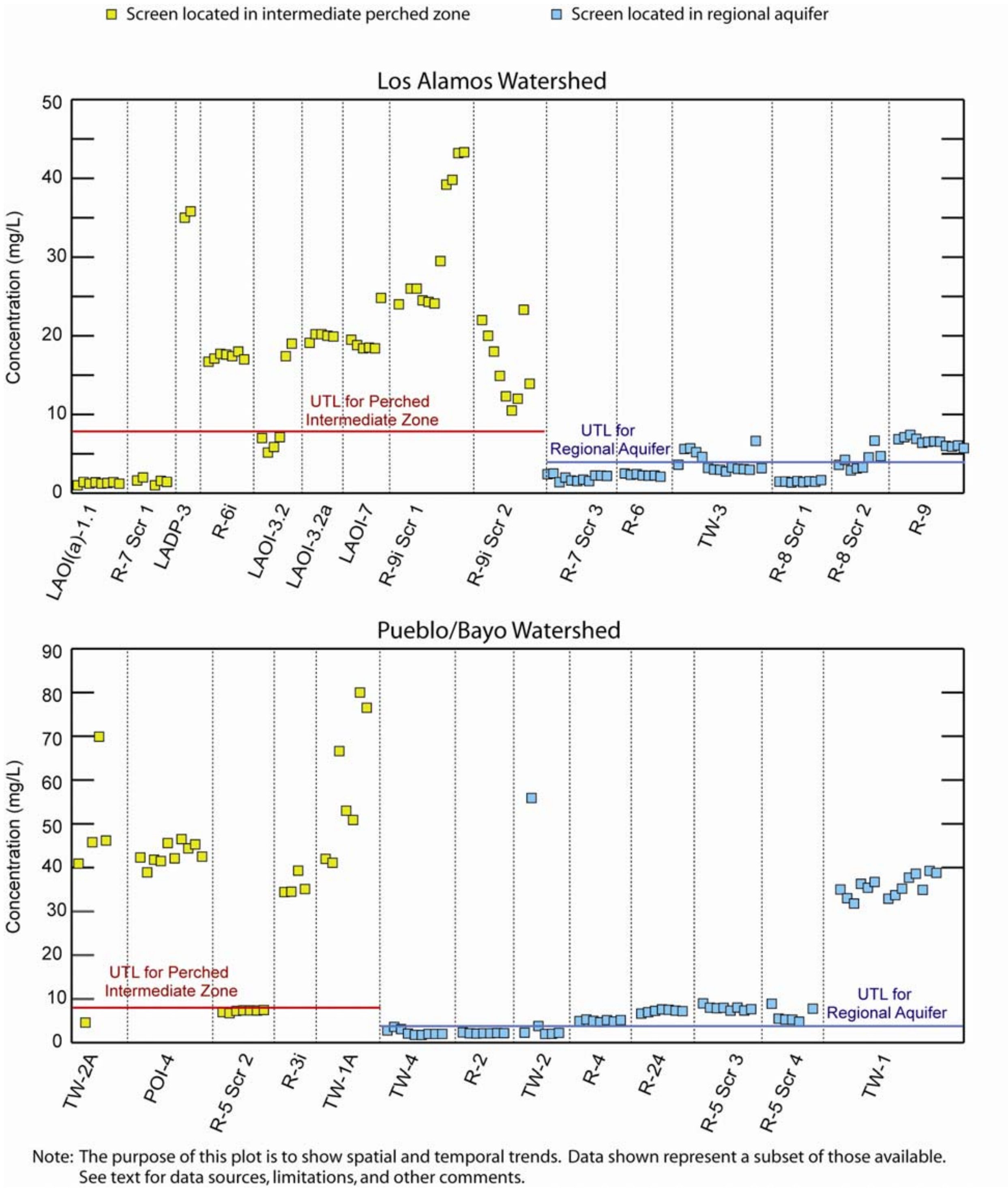

Figure E-2.0-3 Comparison of water-quality data against UTLs for background groundwater: chloride

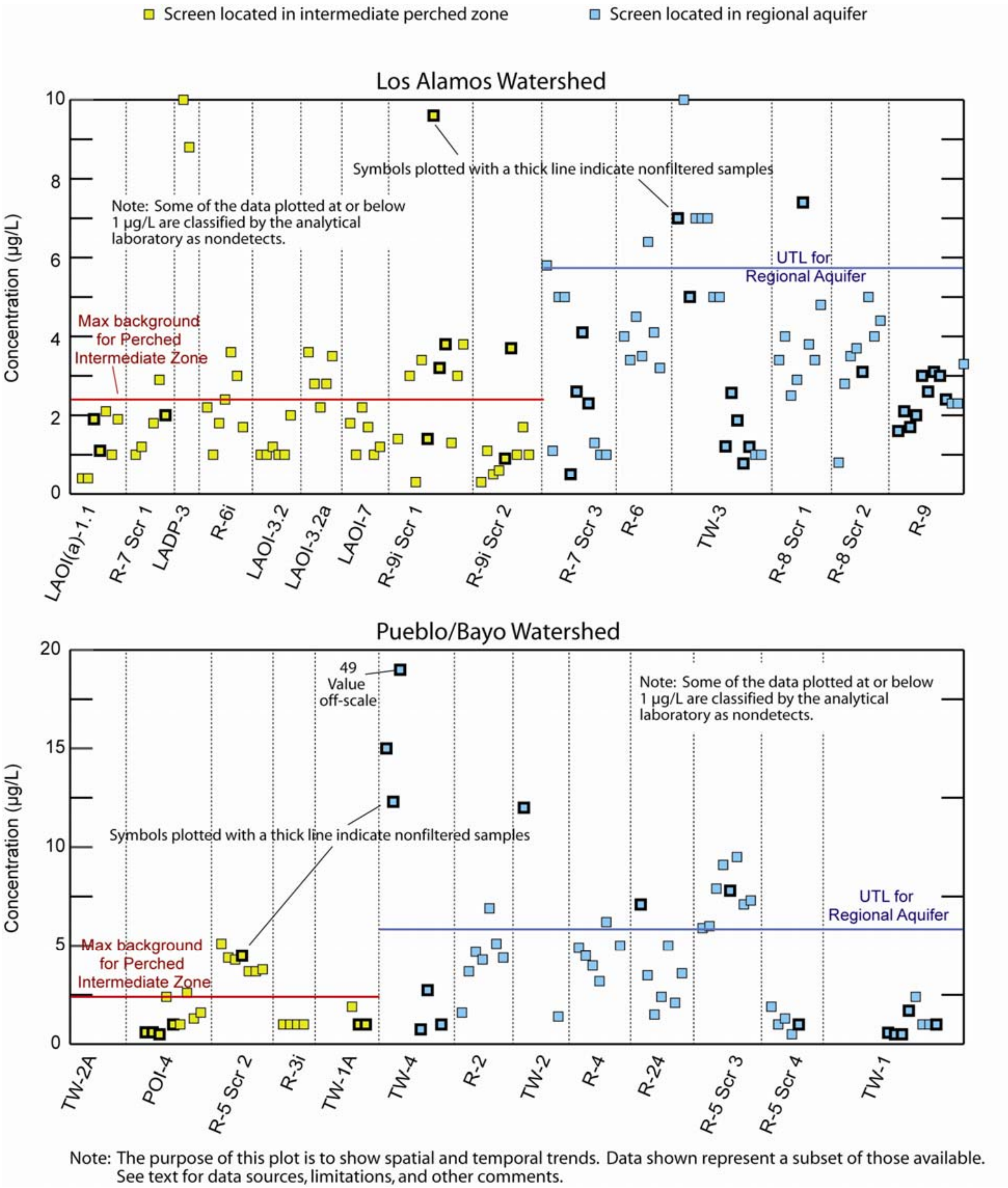

Figure E-2.0-4 Comparison of water-quality data against UTLs for background groundwater: chromium

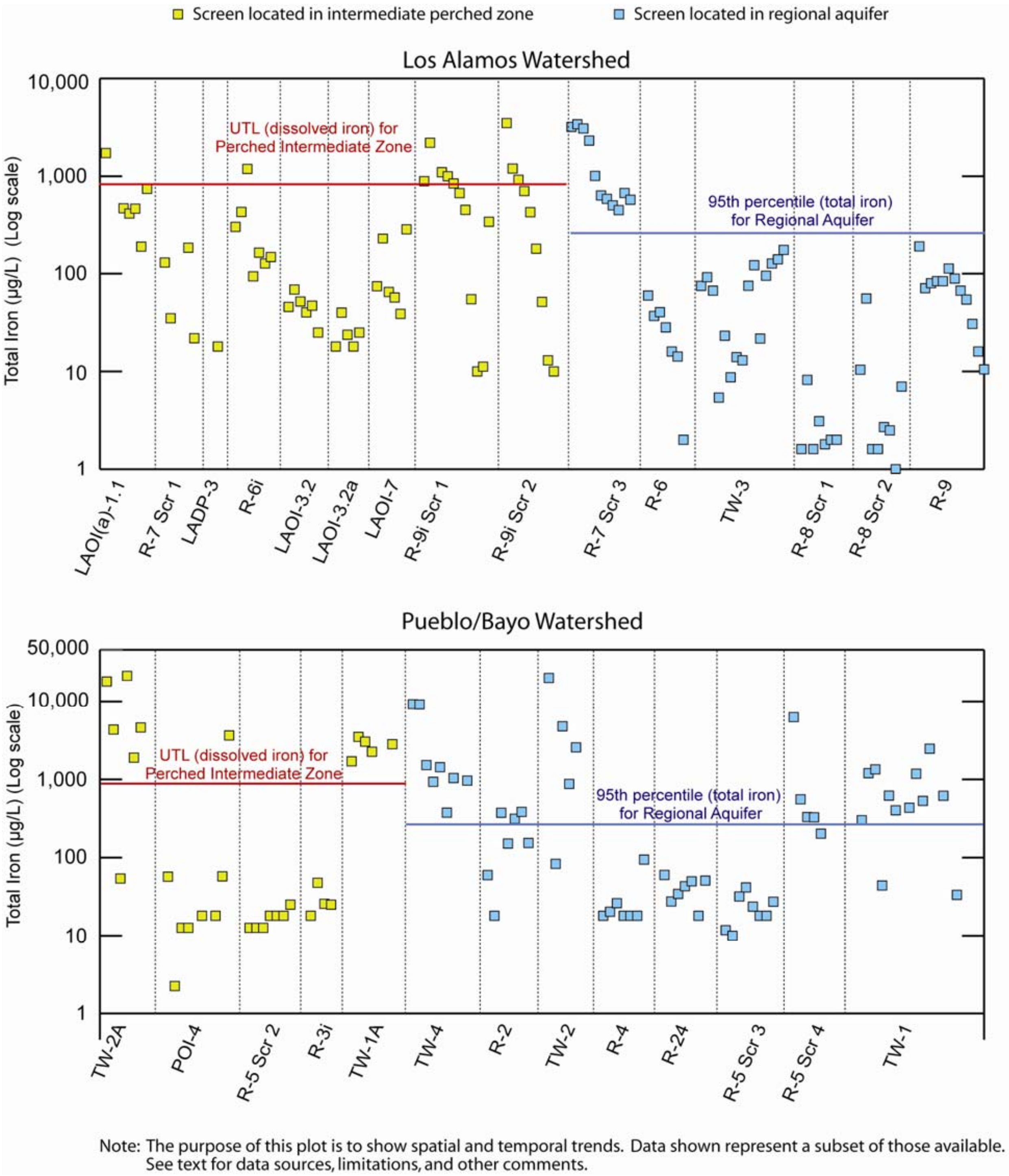

Figure E-2.0-5 Comparison of water-quality data against UTLs for background groundwater: iron (total)

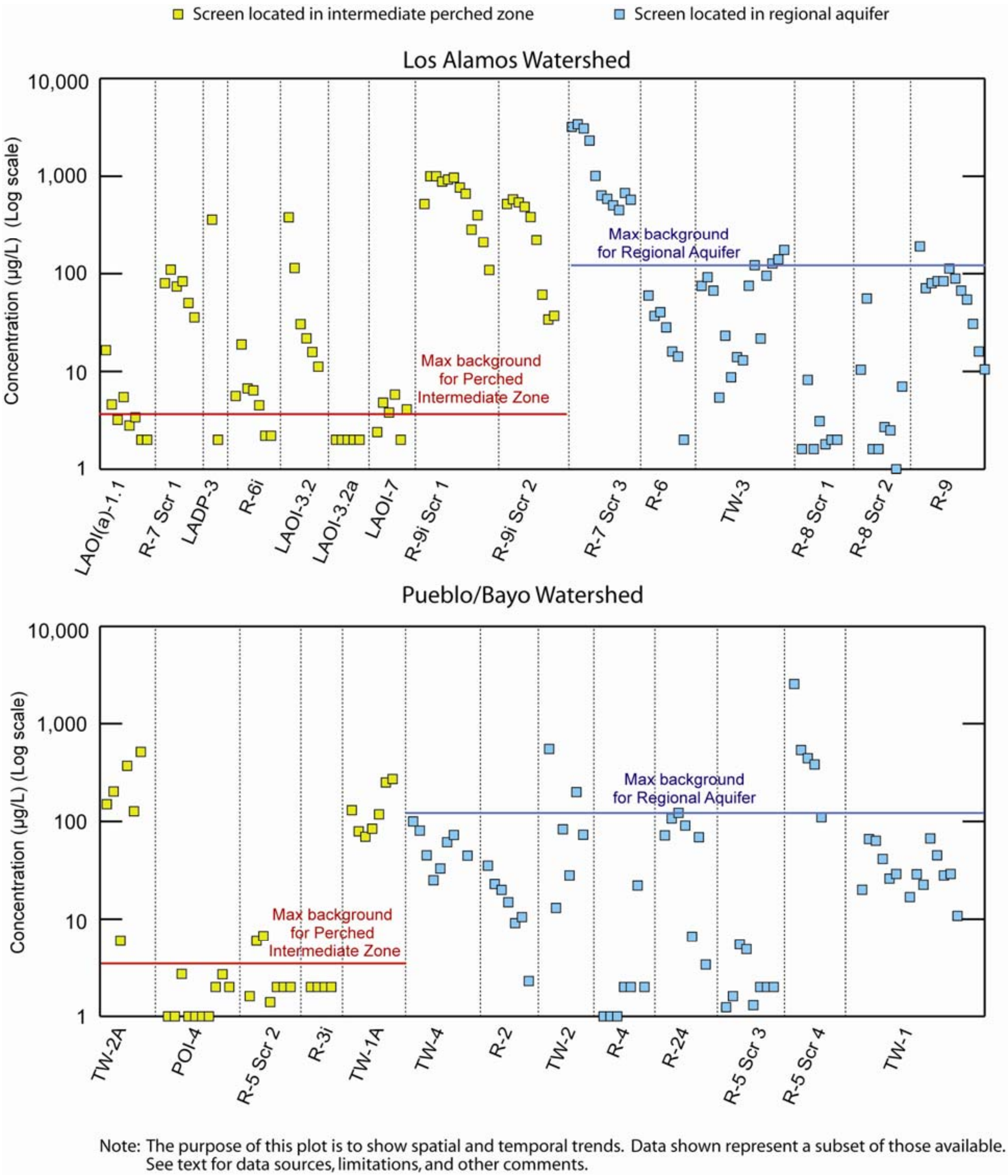

Figure E-2.0-6 Comparison of water-quality data against UTLs for background groundwater: manganese

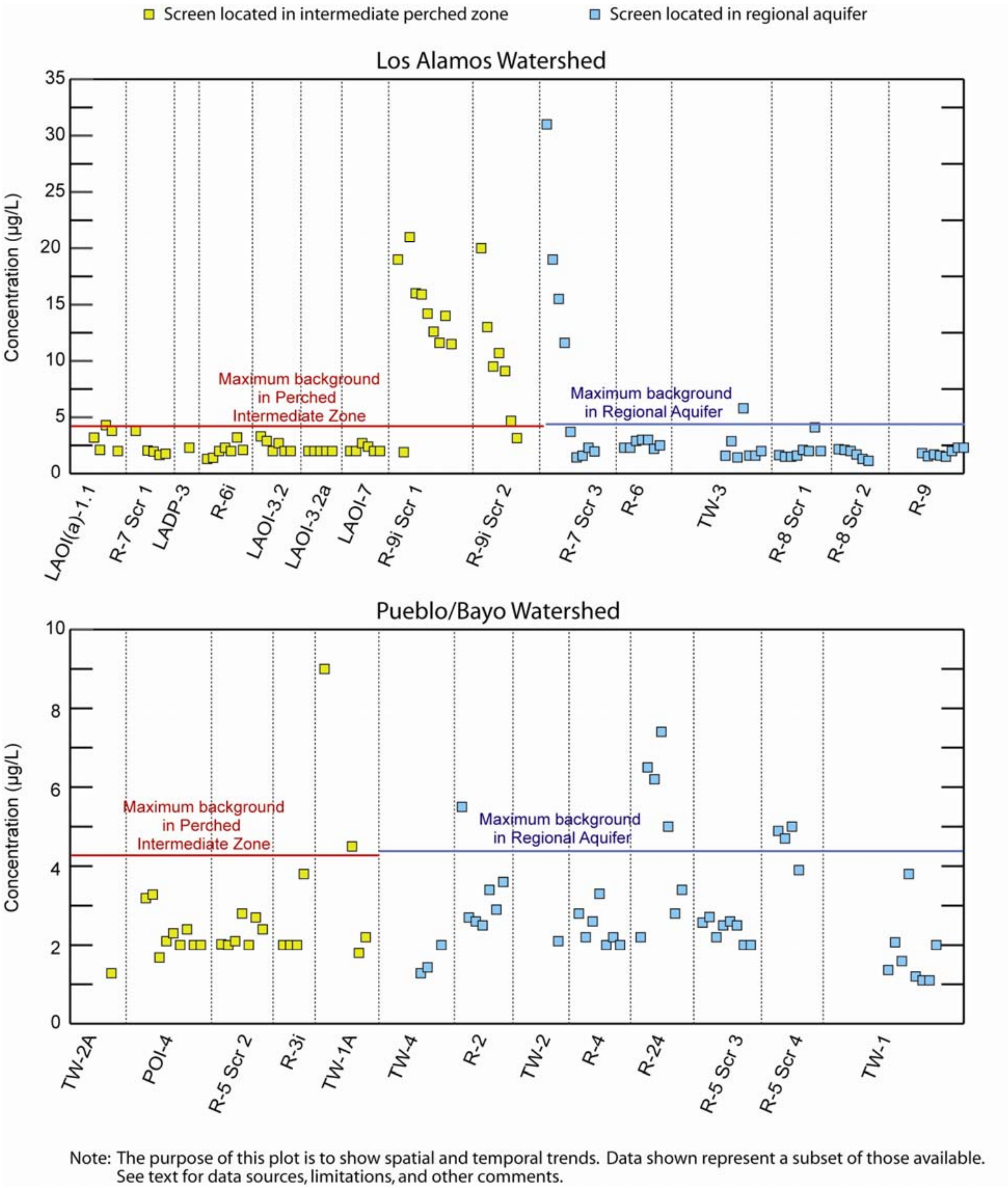

Figure E-2.0-7 Comparison of water-quality data against UTLs for background groundwater: molybdenum

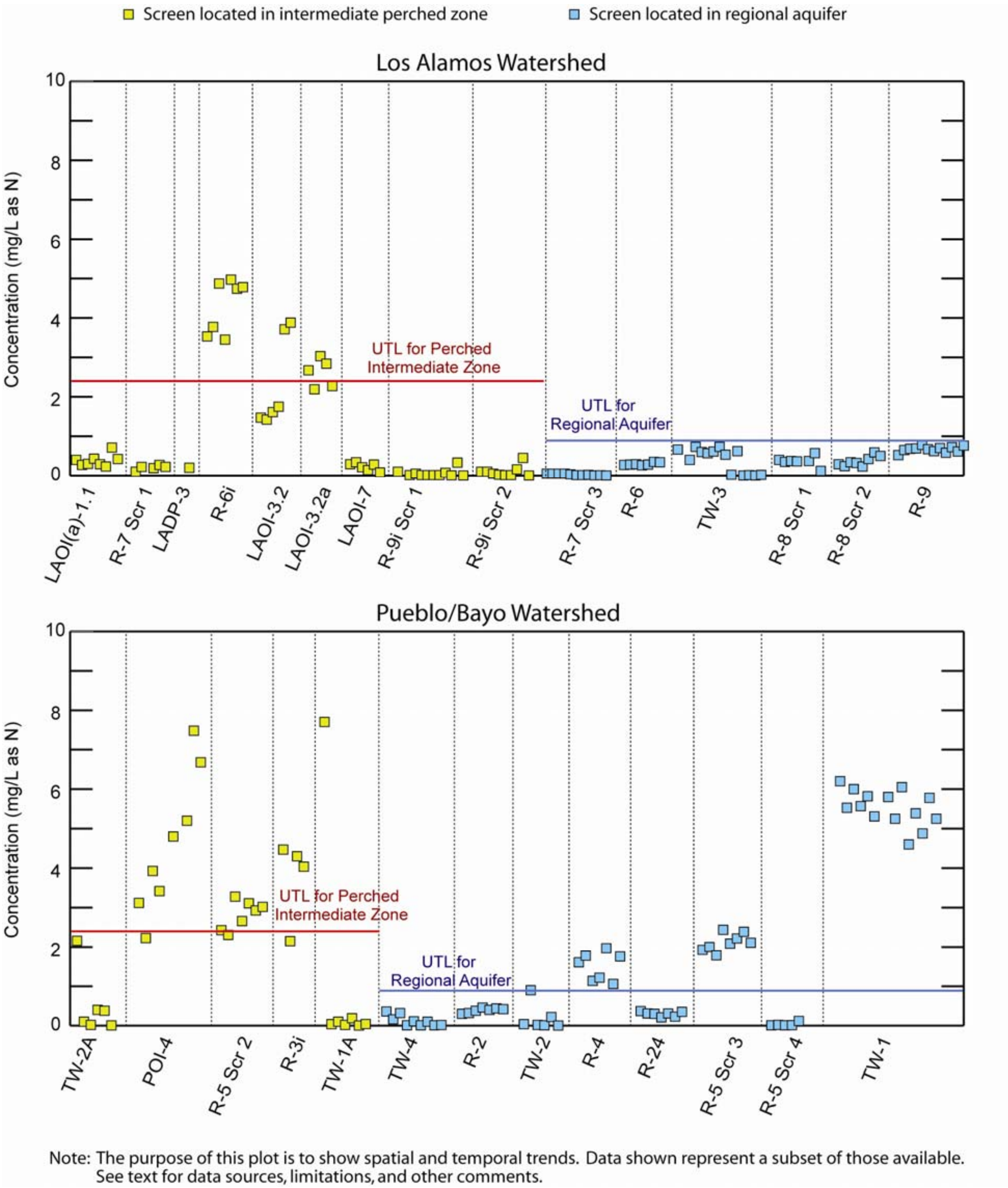

Figure E-2.0-8 Comparison of water-quality data against UTLs for background groundwater: nitrate

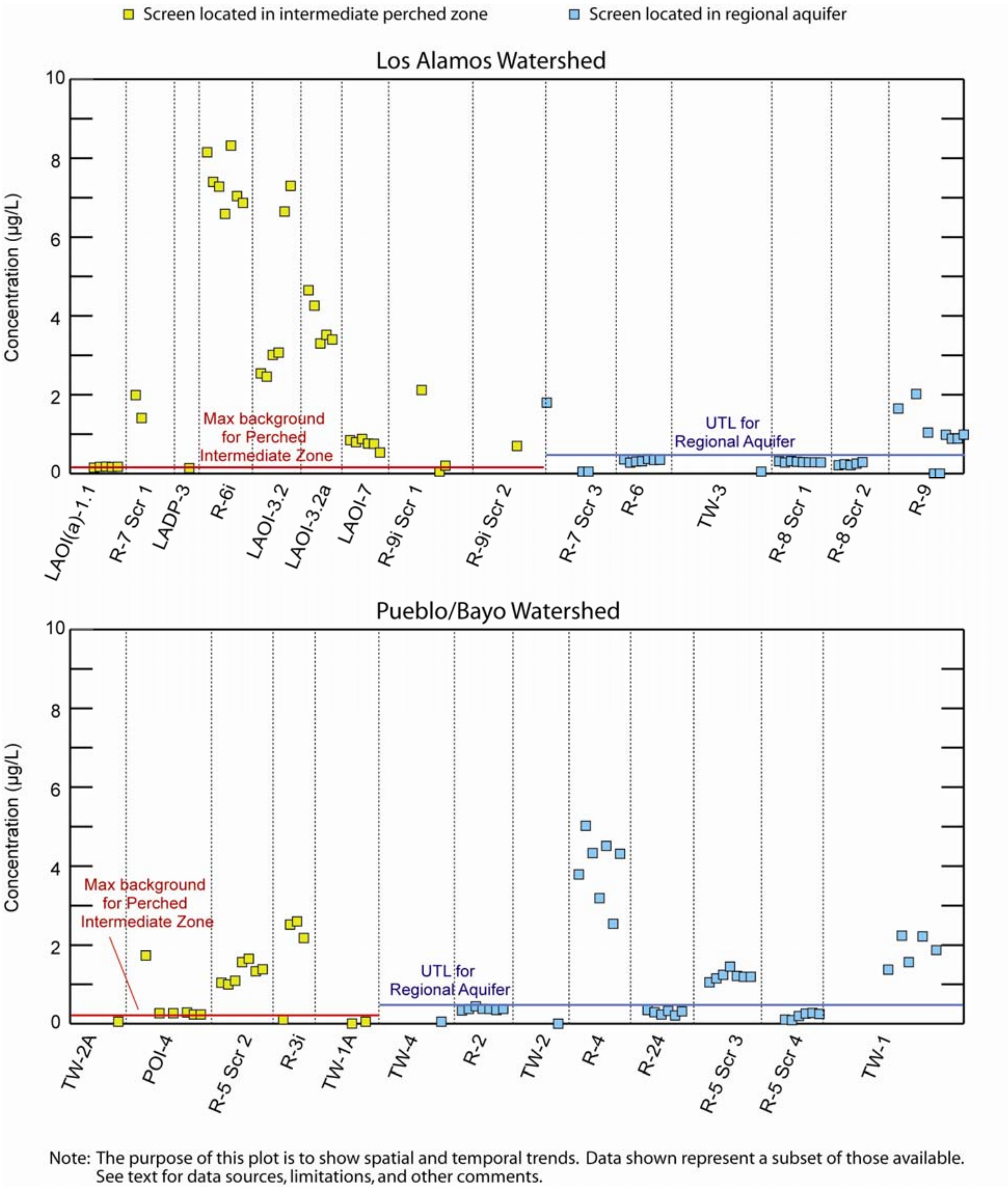

Figure E-2.0-9 Comparison of water-quality data against UTLs for background groundwater: perchlorate

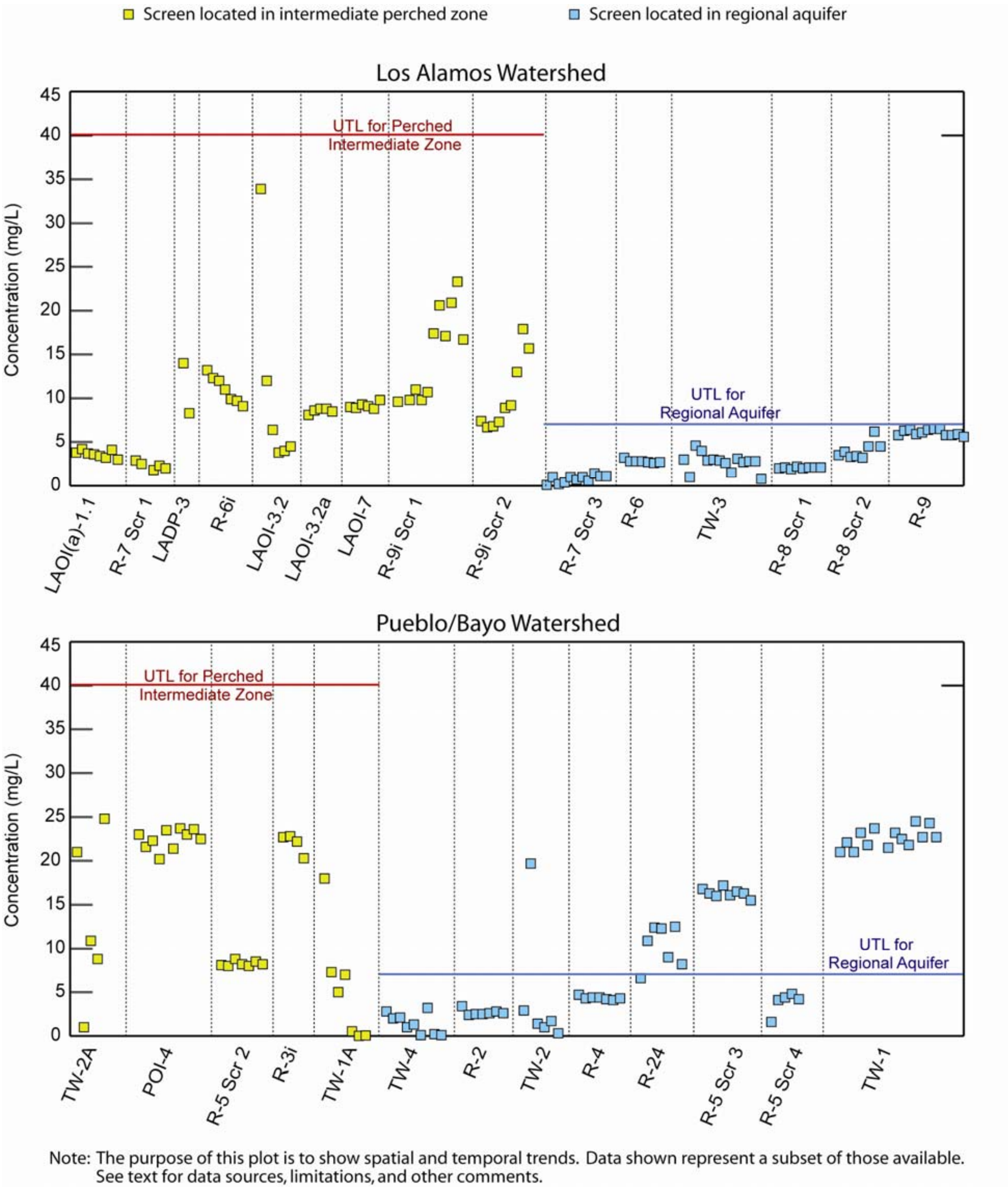

Figure E-2.0-10 Comparison of water-quality data against UTLs for background groundwater: sulfate

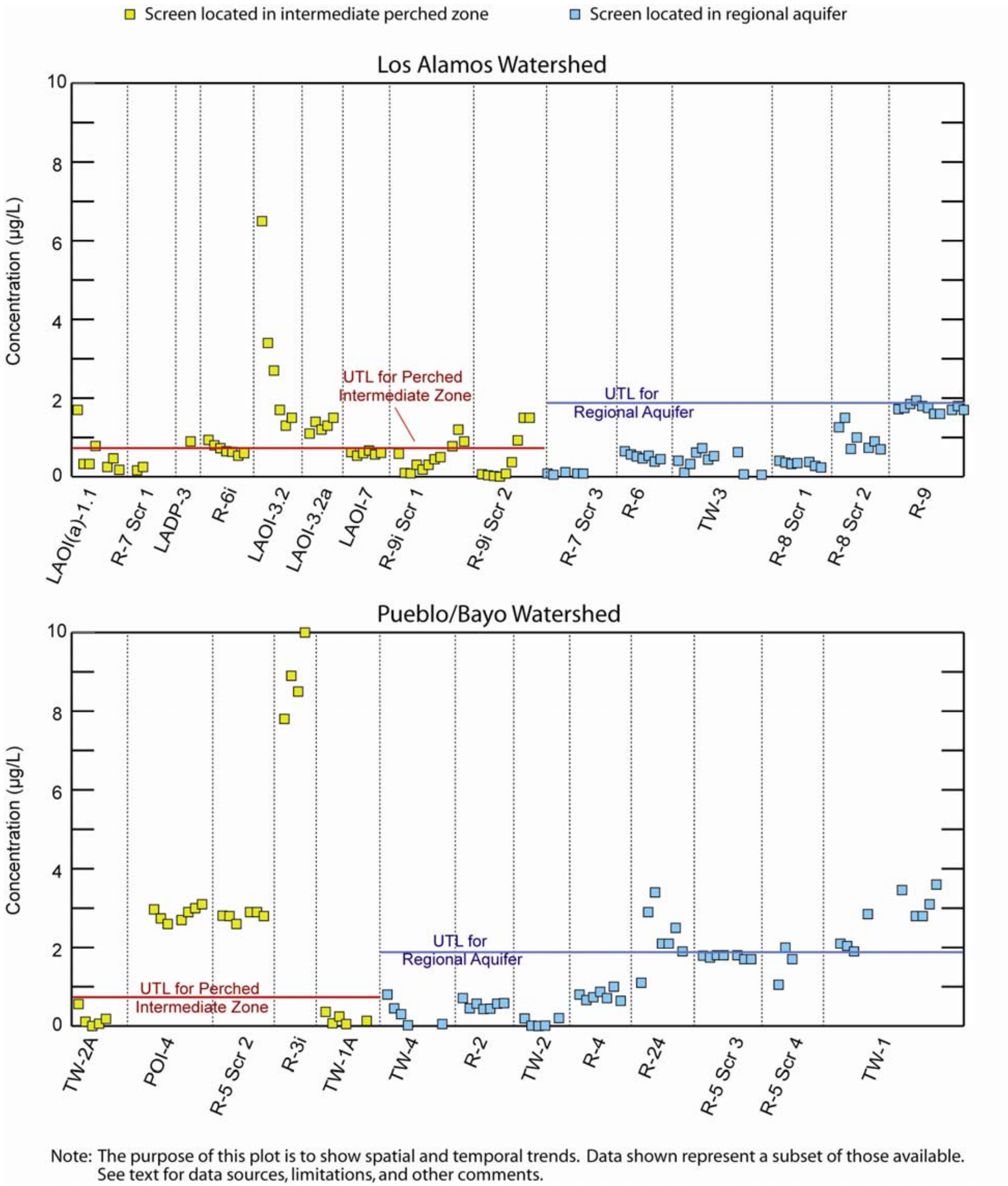

Figure E-2.0-11 Comparison of water-quality data against UTLs for background groundwater: uranium

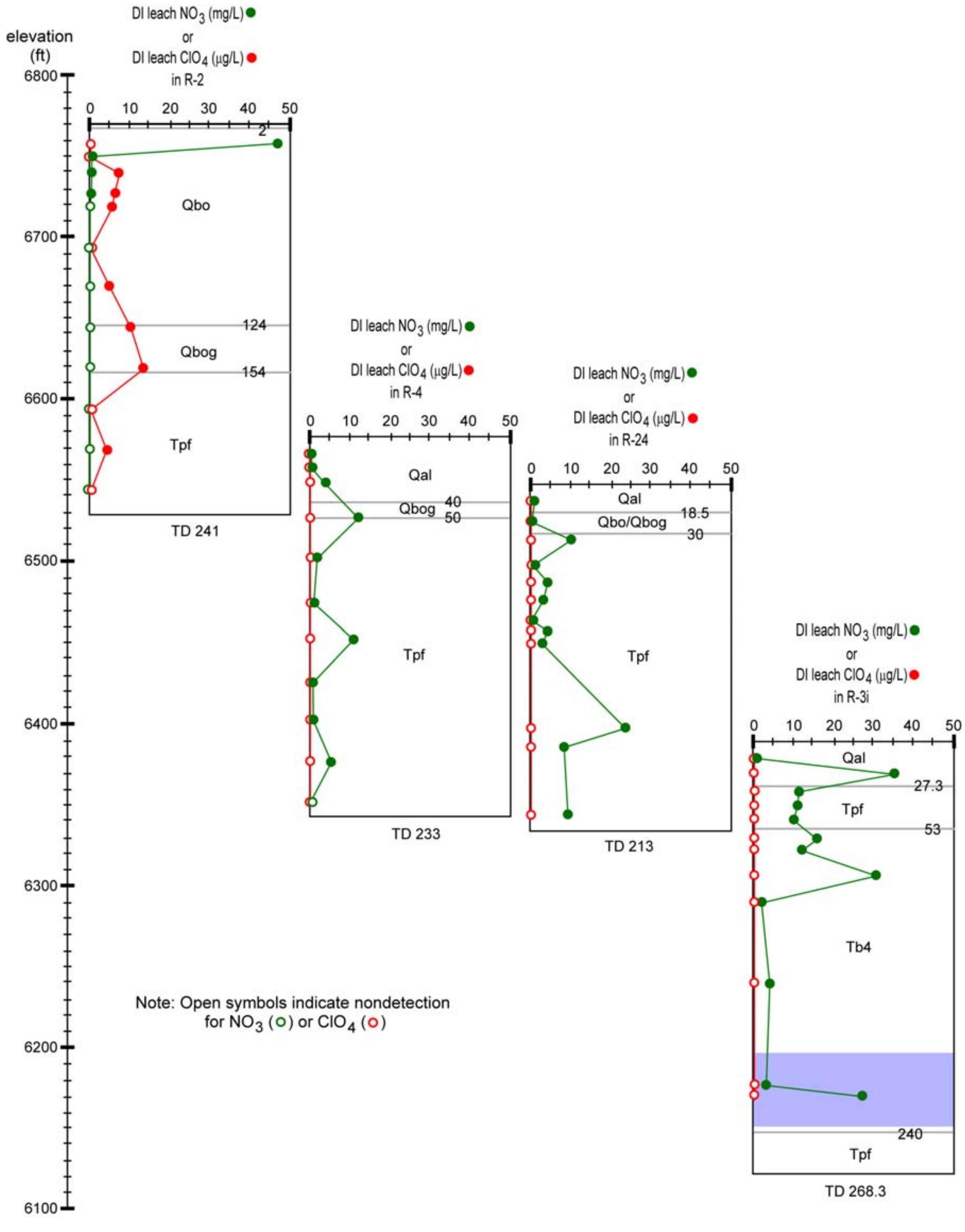

Figure E-3.1-1 DI-leach nitrate and perchlorate profiles for four coreholes in the Pueblo/Bayo Canyon system. Corehole profiles are adjusted for elevation. The abundance scales are constant for all boreholes (0-50 mg/L for nitrate and 0-50 µg/L for perchlorate). The zone of perched saturation at R-3i is shown in blue. Hydrostratigraphic unit designations are alluvium (Qal), ash flows of the Otowi Member of the Bandelier Tuff (Qbo), Guaje Pumice Bed (Qbog), Puye Formation (Tpf), and Cerros del Rio lavas (Tb4).

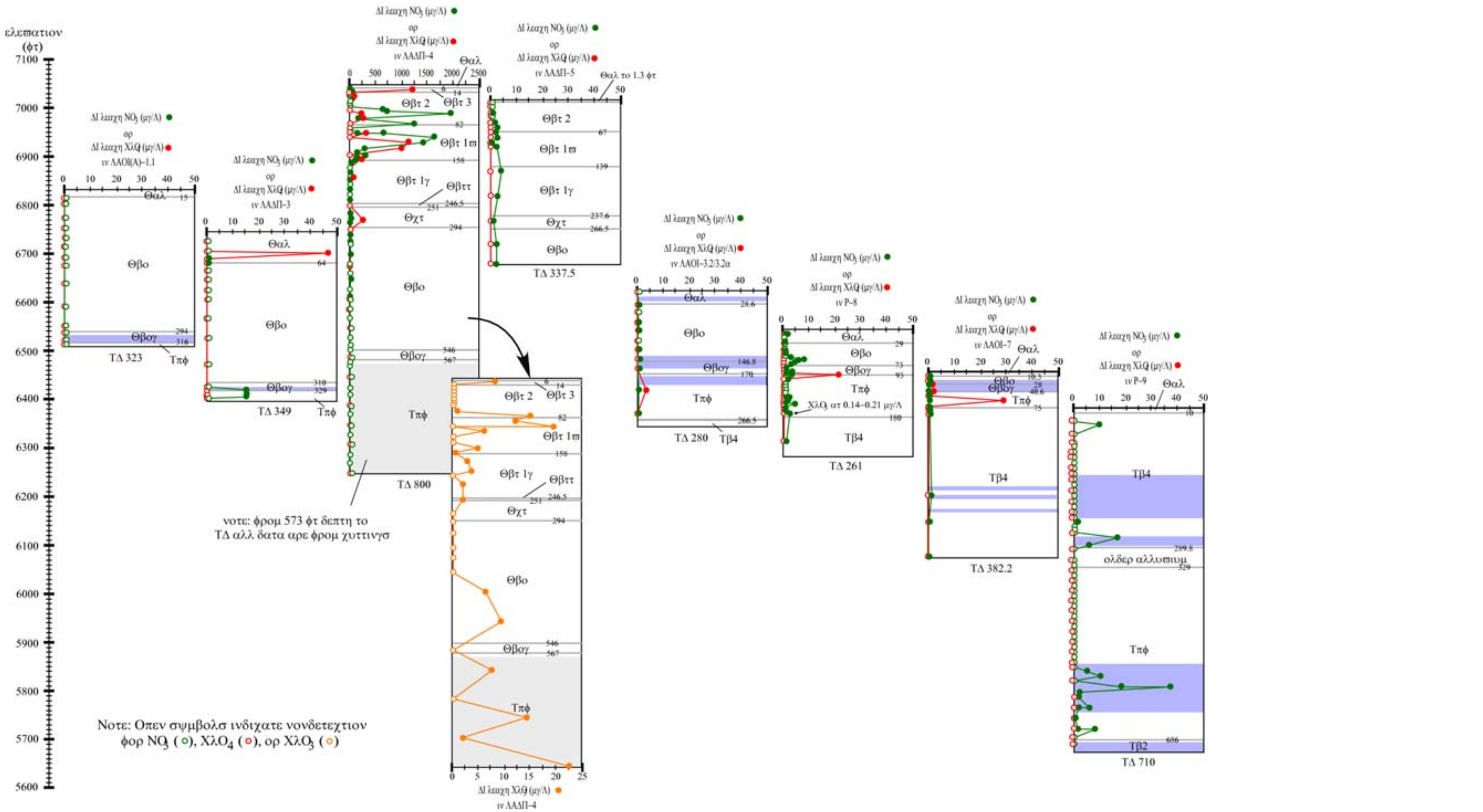

Figure E-3.1-2 **DI-leach nitrate and perchlorate profiles for eight coreholes in the Los Alamos/DP Canyon system, plus an inset plot of chlorate abundance at LADP-4. Corehole profiles are adjusted for elevation. For all boreholes except LADP-4 the abundance scales are constant and the same as those in Figure E-3.1-1 (0-50 mg/L for nitrate and 0-50 μg/L for perchlorate); this scale is significantly expanded at LADP-4 and a separate scale is added for the inset figure of chlorate abundance. Zones of saturation are shown in blue. Hydrostratigraphic unit designations are alluvium (Qal), subunits of the Tshirege Member of the Bandelier Tuff (Qbt 3, Qbt 2, Qbt 1v, and Qbt 1g), Tsankawi Pumice Bed (Qbtt), Cerro Toledi Interval (Qct), ash flows of the Otowi Member of the Bandelier Tuff (Qbo), Guaje Pumice Bed (Qbog), Puye Formation (Tpf), Cerros del Rio lavas (Tb4), and Miocene basalt (Tb2).**

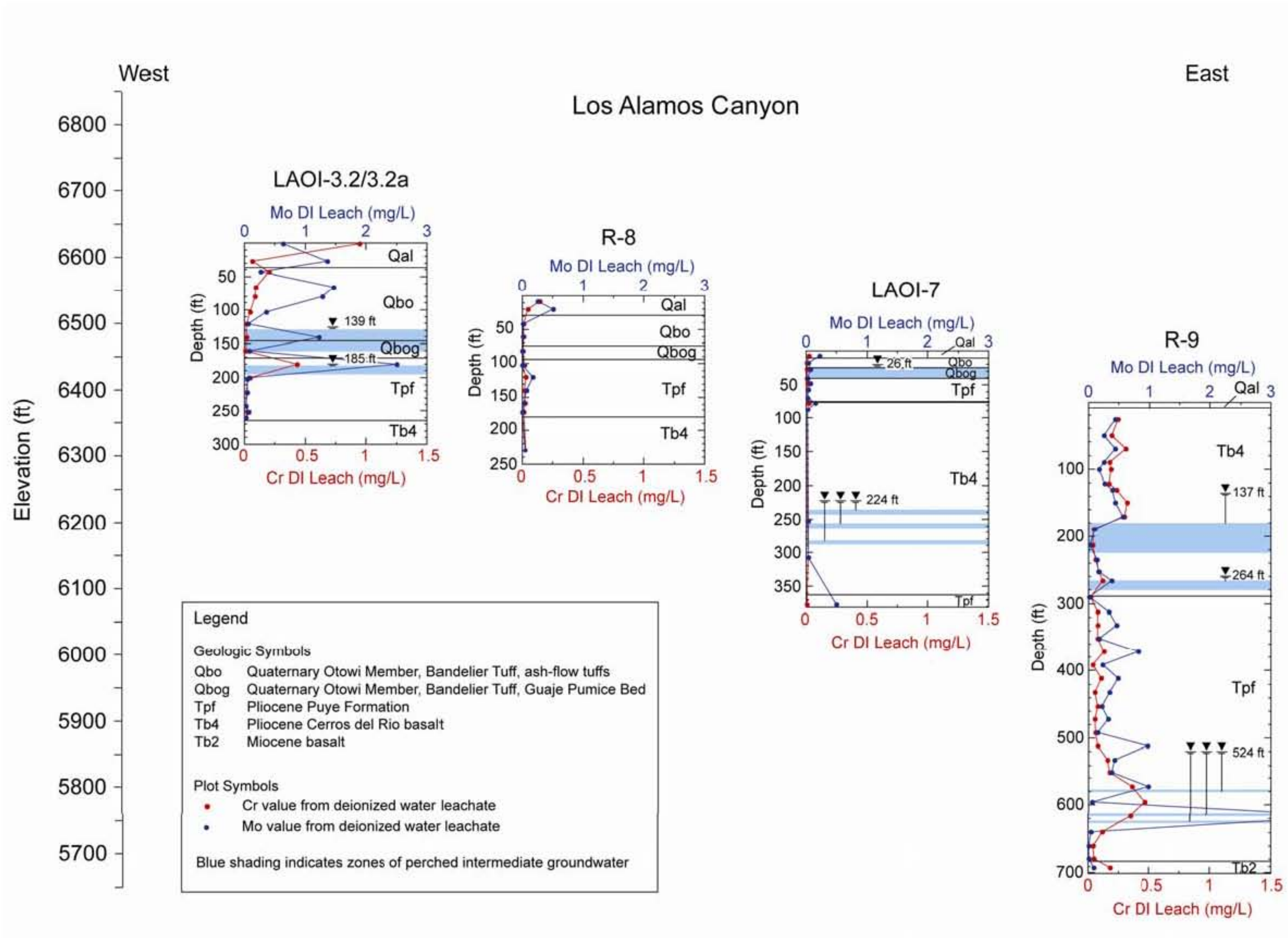

Figure E-3.2-1 **Depth-concentration profiles showing the distribution of deionized-water leached chromium and molybdenum in cores collected from boreholes in Los Alamos Canyon Table E-2.1 Highest Representative Concentrations of Site-Specific Contaminants in Laboratory Monitoring Wells in the Los Alamos Watershed**

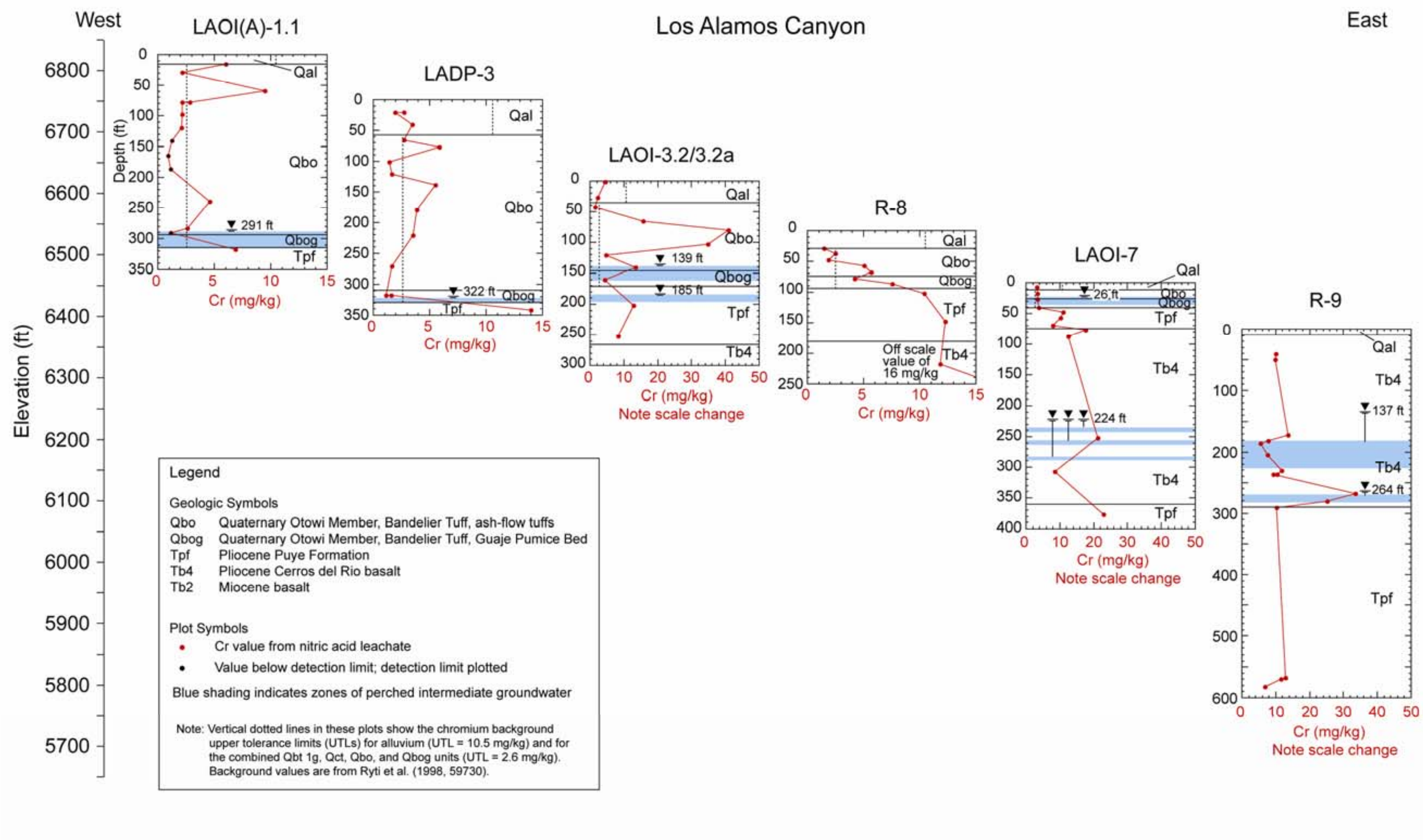

Figure E-3.2-2 Depth-concentration profiles showing the distribution of nitric-acid leached chromium in cores collected from boreholes in Los Alamos Canyon

Table E-1.0-1a
Screening Table for Los Alamos Watershed Metals in Intermediate (Perched Zone) Groundwater Filtered (F) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd (number of	D>Bkgd	D>Std (number of	D>Std
Metals	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)	locations)	station List[c]	locations)	station List[c]
Aluminum	ug/L	76	13	17.1	4.1	12.73	85.6	0	0	1065.84	5000	NMGSF	14	0		0	
Antimony	ug/L	79	4	5.06	0.22	0.2695	0.65	1	0	0.5	6	MCL	14	1	5	0	
Arsenic	ug/L	79	19	24.1	0.3057	1.6	4.6	1	0	4.32	10	MCL	14	1	6	0	
Barium	ug/L	79	78	98.7	7.1	43.35	620	28	0	71.83	1000	NMGSF	14	7	6, 7, 8, 9, 11, 12, 14	0	
Beryllium	ug/L	79	6	7.59	0.01	0.014	0.138	0	0	0.5	4	MCL	14	0		0	
Boron	ug/L	79	53	67.1	2.09	21.3	235	38	0	15.12	750	NMGSF	14	10	1, 5, 6, 7, 8, 9, 10, 12, 13, 14	0	
Cadmium	ug/L	79	4	5.06	0.04	0.143	2	1	0	0.5	5	MCL	14	1	14	0	
Cesium	ug/L	12	1	8.33	1.6	1.6	1.6	n/a	n/a	na	na	n/a	9	n/a		n/a	
Chromium	ug/L	79	55	69.6	0.4	2.2	9.5	26	0	2.4	50	NMGSF	14	8	1, 3, 4, 8, 9, 10, 11, 12	0	
Chromium hexavalent ion	ug/L	3	3	100	0.3	0.3	1.6	n/a	0	na	50	NMGSF	3	n/a		0	
Cobalt	ug/L	79	18	22.8	1.1	1.8	5.447	17	0	1.2	50	NMGSF	14	8	3, 6, 7, 8, 9, 10, 12, 13	0	
Copper	ug/L	71	14	19.7	1.3	2.969	9.394	3	0	5.32	1000	NMGSF	13	3	6, 12, 14	0	
Iron	ug/L	79	29	36.7	11	52.8	2300	7	4	839.99	1000	NMGSF	14	2	12, 13	2	12, 13
Lead	ug/L	79	6	7.59	0.037	0.129	186.6	1	1	0.3	15	MCL	14	1	14	1	14
Lithium	ug/L	12	12	100	4	8.05	41	0	0	61.25	730	Reg6	9	0		0	
Manganese	ug/L	79	53	67.1	1.115	6.7	1000	40	11	3.63	200	NMGSF	14	10	2, 3, 5, 8, 9, 10, 11, 12, 13, 14	4	3, 12, 13, 14
Mercury	ug/L	78	0	0	n/a	n/a	n/a	0	0	0.03	2	MCL	14	0		0	
Molybdenum	ug/L	77	41	53.2	1.3	2.5	21	11	0	4.3	1000	NMGSF	14	3	12, 13, 14	0	
Nickel	ug/L	79	63	79.7	0.55	1.7	140	5	3	29	100	MCL	14	2	12, 13	2	12, 13
Selenium	ug/L	77	1	1.3	3.72	3.72	3.72	1	0	1.25	50	NMGSF	14	1	12	0	
Silicon	ug/L	13	13	100	14000	16000	32000	n/a	n/a	na	na	n/a	5	n/a		n/a	
Silver	ug/L	79	0	0	n/a	n/a	n/a	0	0	0.5	50	NMGSF	14	0		0	
Strontium	ug/L	77	77	100	33.7	132	329	26	0	154.76	21900	Reg6	14	6	3, 6, 7, 8, 9, 14	0	
Thallium	ug/L	79	18	22.8	0.103	0.435	0.952	7	0	0.5	2	MCL	14	5	2, 7, 8, 11, 13	0	
Tin	ug/L	56	2	3.57	2.6	2.75	2.9	2	0	1.25	21900	Reg6	13	2	9, 10	0	
Titanium	ug/L	12	1	8.33	2	2	2	0	n/a	8.96	na	n/a	9	0		n/a	
Uranium	ug/L	79	72	91.1	0.02	1.051	10	43	0	0.72	30	NMGSF	14	10	1, 3, 4, 6, 7, 8, 9, 10, 12, 13	0	
Vadium	ug/L	79	50	63.3	0.39	2.1	10.4	13	0	4.91	182.5	Reg6	14	3	6, 8, 9	0	
Zinc	ug/L	77	35	45.5	1.156	6.45	9150	9	0	19	10000	NMGSF	14	4	10, 11, 13, 14	0	

n/a=not applicable
na = not available (no published value)

[c] Station List (codes)

1=LADP-3	9=R-5, Screen 2
2=LAOI(a)-1.1	10=R-6i
3=LAOI-3.2	11=R-7, Screen 1
4=LAOI-3.2a	12=R-9i, Screen 1
5=LAOI-7	13=R-9i, Screen 2
6=POI-4	14=Test Well 1A
7=R-3i	15=Test Well 2A
8=R-5, Screen 1	

[a]GW Bkgd upper tolerance level (UTL) or maximum detect for Intermediate Groundwater filtered samples
LANL, 2007. Groundwater Background Investigation, Rev 3.

[b]Screening Standard

Std Type	Standard (Source and Name)
MCL	EPA Maximum Contaminant Level (MCL)
Reg6	EPA Region 6 Tap Water Screening Level
NMGSF	NMAC 20.6.2, Groundwater Standards (Filtered)

Table E-1.0-1b

Screening Table for Los Alamos Watershed Organic Constituents in Intermediate (Perched Zone) Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd (number of locations)	D>Bkgd station List[c]	D>Std (number of locations)	D>Std station List[c]
Metals	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)				
Aluminum	ug/L	99	43	43.4	1.3	27	4750	n/a	0	na	36500	Reg6	15	n/a		0	
Antimony	ug/L	103	2	1.94	0.16	0.615	1.07	n/a	0	na	6	MCL	15	n/a		0	
Arsenic	ug/L	103	32	31.1	0.3	1.45	4.9	n/a	0	na	10	MCL	15	n/a		0	
Barium	ug/L	103	102	99	11.2	48.65	360	n/a	0	na	2000	MCL	15	n/a		0	
Beryllium	ug/L	100	5	5	0.007	0.015	0.503	n/a	0	na	4	MCL	15	n/a		0	
Boron	ug/L	102	77	75.5	2.6	23.8	252	n/a	0	na	7300	Reg6	15	n/a		0	
Cadmium	ug/L	103	8	7.77	0.05	0.169	0.43	n/a	0	na	5	MCL	15	n/a		0	
Cesium	ug/L	20	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	9	n/a		n/a	
Chromium	ug/L	103	74	71.8	0.36	3.7	48.8	n/a	0	na	100	MCL	15	n/a		0	
Chromium hexavalent ion	ug/L	3	3	100	0.3	0.4	1.7	n/a	0	na	100	MCL	3	n/a		0	
Cobalt	ug/L	103	16	15.5	0.83	2.25	9.27	n/a	0	na	730	Reg6	15	n/a		0	
Copper	ug/L	98	39	39.8	1.2	2.91	73	n/a	0	na	1300	MCL	15	n/a		0	
Iron	ug/L	103	66	64.1	10	118.5	4610	n/a	0	na	25550	Reg6	15	n/a		0	
Lead	ug/L	103	28	27.2	0.072	0.675	21	n/a	1	na	15	Reg6	15	n/a		1	14
Lithium	ug/L	20	20	100	4.107	10.94	60	n/a	0	na	730	Reg6	9	n/a		0	
Manganese	ug/L	103	79	76.7	1.018	10.4	1000	n/a	0	na	1703.09	Reg6	15	n/a		0	
Mercury	ug/L	102	4	3.92	0.06	0.064	2.3	4	1	0.04	2	NMGSU	15	4	5, 8, 10, 13	1	5
Molybdenum	ug/L	103	65	63.1	0.7	2.6	22	n/a	0	na	182.5	Reg6	15	n/a		0	
Nickel	ug/L	103	80	77.7	0.52	2.9	140	n/a	3	na	100	MCL	15	n/a		2	12, 13
Selenium	ug/L	103	8	7.77	1	1.25	8.5	1	0	8.5	50	MCL	15	0		0	
Silicon	ug/L	12	12	100	15000	16000	57000	n/a	n/a	na	na	n/a	5	n/a		n/a	
Silver	ug/L	103	0	0	n/a	n/a	n/a	0	0	0.5	182.5	Reg6	15	0		0	
Strontium	ug/L	103	103	100	36.6	130	390	n/a	0	na	21900	Reg6	15	n/a		0	
Thallium	ug/L	103	14	13.6	0.039	0.164	0.838	n/a	0	na	2	MCL	15	n/a		0	
Tin	ug/L	82	0	0	n/a	n/a	n/a	n/a	0	na	21900	Reg6	15	n/a		0	
Titanium	ug/L	21	4	19	4	16.5	32	n/a	n/a	na	na	n/a	10	n/a		n/a	
Uranium	ug/L	94	88	93.6	0.022	1.15	9.8	n/a	0	na	30	MCL	14	n/a		0	
Vadium	ug/L	103	62	60.2	0.49	3.1	10.8	n/a	0	na	182.5	Reg6	15	n/a		0	
Zinc	ug/L	101	67	66.3	1.42	8.4	20800	n/a	1	na	10950	Reg6	15	n/a		1	15

n/a=not applicable
na = not available (no published value)

[c] Station List (codes)

1=LADP-3	9=R-5, Screen 2
2=LAOI(a)-1.1	10=R-6i
3=LAOI-3.2	11=R-7, Screen 1
4=LAOI-3.2a	12=R-9i, Screen 1
5=LAOI-7	13=R-9i, Screen 2
6=POI-4	14=Test Well 1A
7=R-3i	15=Test Well 2A
8=R-5, Screen 1	

[a]GW Bkgd upper tolerance level (UTL) or maximum detect for Intermediate Groundwater unfiltered samples
LANL, 2007. Groundwater Background Investigation, Rev 3.

[b]Screening Standard

Std Type	Standard (Source and Name)
MCL	EPA Maximum Contaminant Level (MCL)
Reg6	EPA Region 6 Tap Water Screening Level
NMGSU	NMAC 20.6.2, Groundwater Standards (Unfiltered)

Table E-1.0-1c

Screening Table for Los Alamos Watershed Organic Constituents in Intermediate (Perched Zone) Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data (number)	D>Bkgd (number of locations)	D>Bkgd station List[c]	D>Std (number of locations)	D>Std station List[c]
Organics	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type					
2,4-Diamino-6-nitrotoluene	ug/L	10	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	4	n/a		n/a	
2,6-Diamino-4-nitrotoluene	ug/L	10	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	4	n/a		n/a	
3,5-Dinitroaniline	ug/L	10	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	4	n/a		n/a	
Acenaphthene	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	365	Reg6	15	n/a		0	
Acenaphthylene	ug/L	71	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Acetone	ug/L	71	10	14.1	1.46	2.31	14.2	n/a	0	na	5475	Reg6	15	n/a		0	
Acetonitrile	ug/L	49	0	0	n/a	n/a	n/a	n/a	0	na	124.1	Reg6	12	n/a		0	
Acetophenone	ug/L	1	0	0	n/a	n/a	n/a	n/a	0	na	608.33	Reg6	1	n/a		0	
Acrolein	ug/L	56	0	0	n/a	n/a	n/a	n/a	0	na	0.0416	Reg6	13	n/a		0	
Acrylonitrile	ug/L	58	0	0	n/a	n/a	n/a	n/a	0	na	1.237	Reg6	14	n/a		0	
Aldrin	ug/L	68	1	1.47	0.0056	0.0056	0.0056	n/a	0	na	0.0395	Reg6	14	n/a		0	
Amino-2,6-dinitrotoluene[4-]	ug/L	36	2	5.56	2.3	2.45	2.6	n/a	n/a	na	na	n/a	12	n/a		n/a	
Amino-4,6-dinitrotoluene[2-]	ug/L	36	1	2.78	0.15	0.15	0.15	n/a	n/a	na	na	n/a	12	n/a		n/a	
Aniline	ug/L	70	0	0	n/a	n/a	n/a	n/a	0	na	117.95	Reg6	15	n/a		0	
Anthracene	ug/L	68	0	0	n/a	n/a	n/a	n/a	0	na	1825	Reg6	15	n/a		0	
Aroclor-1016	ug/L	52	0	0	n/a	n/a	n/a	n/a	0	na	0.5	MCL	13	n/a		0	
Aroclor-1221	ug/L	52	0	0	n/a	n/a	n/a	n/a	0	na	0.5	MCL	13	n/a		0	
Aroclor-1232	ug/L	52	0	0	n/a	n/a	n/a	n/a	0	na	0.5	MCL	13	n/a		0	
Aroclor-1242	ug/L	52	0	0	n/a	n/a	n/a	n/a	0	na	0.5	MCL	13	n/a		0	
Aroclor-1248	ug/L	52	0	0	n/a	n/a	n/a	n/a	0	na	0.5	MCL	13	n/a		0	
Aroclor-1254	ug/L	52	0	0	n/a	n/a	n/a	n/a	0	na	0.5	MCL	13	n/a		0	
Aroclor-1260	ug/L	52	0	0	n/a	n/a	n/a	n/a	0	na	0.5	MCL	13	n/a		0	
Aroclor-1262	ug/L	34	0	0	n/a	n/a	n/a	n/a	0	na	0.5	MCL	11	n/a		0	
Atrazine	ug/L	47	0	0	n/a	n/a	n/a	n/a	0	na	3	MCL	11	n/a		0	
Azobenzene	ug/L	63	0	0	n/a	n/a	n/a	n/a	0	na	6.112	Reg6	14	n/a		0	
BHC[alpha-]	ug/L	68	1	1.47	0.0056	0.0056	0.0056	n/a	0	na	0.1067	Reg6	14	n/a		0	
BHC[beta-]	ug/L	68	1	1.47	0.0091	0.0091	0.0091	n/a	0	na	0.3735	Reg6	14	n/a		0	
BHC[delta-]	ug/L	68	1	1.47	0.0058	0.0058	0.0058	n/a	n/a	na	na	n/a	14	n/a		n/a	
BHC[gamma-]	ug/L	68	1	1.47	0.0055	0.0055	0.0055	n/a	0	na	0.2	MCL	14	n/a		0	
Benzene	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	15	n/a		0	
Benzidine	ug/L	45	0	0	n/a	n/a	n/a	n/a	0	na	0.0009363	Reg6	15	n/a		0	
Benzo(a)anthracene	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	0.29499	Reg6	15	n/a		0	
Benzo(a)pyrene	ug/L	70	0	0	n/a	n/a	n/a	n/a	0	na	0.2	MCL	15	n/a		0	
Benzo(b)fluoranthene	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	0.29499	Reg6	15	n/a		0	
Benzo(g,h,i)perylene	ug/L	69	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Benzo(k)fluoranthene	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	2.9499	Reg6	15	n/a		0	
Benzoic Acid	ug/L	64	3	4.69	8.73	9.11	17.6	n/a	0	na	146000	Reg6	15	n/a		0	
Benzyl Alcohol	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	10950	Reg6	15	n/a		0	
Bis(2-chloroethoxy)methane	ug/L	68	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Bis(2-chloroethyl)ether	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	0.60216	Reg6	15	n/a		0	
Bis(2-ethylhexyl)phthalate	ug/L	71	6	8.45	2.6	4.03	483	n/a	2	na	6	MCL	15	n/a		2	6, 11
Bromobenzene	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	23.25	Reg6	15	n/a		0	
Bromochloromethane	ug/L	77	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Bromodichloromethane	ug/L	77	1	1.3	0.93	0.93	0.93	n/a	0	na	10.69	Reg6	15	n/a		0	
Bromoform	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	85.1	Reg6	15	n/a		0	
Bromomethane	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	8.661	Reg6	15	n/a		0	

Table E-1.0-1c
Screening Table for Los Alamos Watershed Organic Constituents in Intermediate (Perched Zone) Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]						
Organics	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	Locations with data (number)	D>Bkgd (number of locations)	D>Bkgd station List[c]	D>Std (number of locations)	D>Std station List[c]
Bromophenyl-phenylether[4-]	ug/L	71	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Butanol[1-]	ug/L	10	0	0	n/a	n/a	n/a	n/a	0	na	3650	Reg6	9	n/a		0	
Butanone[2-]	ug/L	77	1	1.3	1.65	1.65	1.65	n/a	0	na	7064.52	Reg6	15	n/a		0	
Butylbenzene[n-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	60.83	Reg6	15	n/a		0	
Butylbenzene[sec-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	60.83	Reg6	15	n/a		0	
Butylbenzene[tert-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	60.83	Reg6	15	n/a		0	
Butylbenzylphthalate	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	7300	Reg6	15	n/a		0	
Carbazole	ug/L	6	0	0	n/a	n/a	n/a	n/a	0	na	33.616	Reg6	4	n/a		0	
Carbon Disulfide	ug/L	75	1	1.33	1.81	1.81	1.81	n/a	0	na	1042.86	Reg6	15	n/a		0	
Carbon Tetrachloride	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	15	n/a		0	
Chlordane[alpha-]	ug/L	68	1	1.47	0.0067	0.0067	0.0067	n/a	n/a	na	na	n/a	14	n/a		n/a	
Chlordane[gamma-]	ug/L	68	1	1.47	0.0063	0.0063	0.0063	n/a	n/a	na	na	n/a	14	n/a		n/a	
Chloro-1,3-butadiene[2-]	ug/L	51	0	0	n/a	n/a	n/a	n/a	0	na	14.3137	Reg6	12	n/a		0	
Chloro-1-propene[3-]	ug/L	51	0	0	n/a	n/a	n/a	n/a	0	na	1825	Reg6	12	n/a		0	
Chloro-3-methylphenol[4-]	ug/L	70	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Chloroaniline[4-]	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	146	Reg6	15	n/a		0	
Chlorobenzene	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	100	MCL	15	n/a		0	
Chlorodibromomethane	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	7.891	Reg6	15	n/a		0	
Chloroethane	ug/L	77	1	1.3	4.7	4.7	4.7	n/a	0	na	228.57	Reg6	15	n/a		0	
Chloroethyl vinyl ether[2-]	ug/L	10	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	8	n/a		n/a	
Chloroform	ug/L	77	6	7.79	0.264	0.291	3.1	n/a	0	na	60	MCL	15	n/a		0	
Chloromethane	ug/L	77	1	1.3	0.84	0.84	0.84	n/a	0	na	21.345	Reg6	15	n/a		0	
Chloronaphthalene[2-]	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	486.67	Reg6	15	n/a		0	
Chlorophenol[2-]	ug/L	70	0	0	n/a	n/a	n/a	n/a	0	na	30.417	Reg6	15	n/a		0	
Chlorophenyl-phenyl[4-] Ether	ug/L	71	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Chlorotoluene[2-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	121.67	Reg6	15	n/a		0	
Chlorotoluene[4-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Chrysene	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	0.2	MCL	15	n/a		0	
DB[2,4-]	ug/L	11	0	0	n/a	n/a	n/a	n/a	0	na	292	Reg6	11	n/a		0	
DDD[4,4'-]	ug/L	68	1	1.47	0.018	0.018	0.018	n/a	0	na	2.801	Reg6	14	n/a		0	
DDE[4,4'-]	ug/L	67	3	4.48	0.0051	0.0167	0.017	n/a	0	na	1.977	Reg6	14	n/a		0	
DDT[4,4'-]	ug/L	68	5	7.35	0.014	0.0208	0.0353	n/a	0	na	1.977	Reg6	14	n/a		0	
DNX	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	3	n/a		n/a	
D[2,4-]	ug/L	11	0	0	n/a	n/a	n/a	n/a	0	na	70	MCL	11	n/a		0	
Dalapon	ug/L	11	0	0	n/a	n/a	n/a	n/a	0	na	200	MCL	11	n/a		0	
Di-n-butylphthalate	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	3650	Reg6	15	n/a		0	
Di-n-octylphthalate	ug/L	71	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Dibenz(a,h)anthracene	ug/L	70	0	0	n/a	n/a	n/a	n/a	0	na	0.029499	Reg6	15	n/a		0	
Dibenzofuran	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	12.167	Reg6	15	n/a		0	
Dibromo-3-Chloropropane[1,2-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	0.2	MCL	15	n/a		0	
Dibromoethane[1,2-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	0.05	MCL	15	n/a		0	
Dibromomethane	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	60.83	Reg6	15	n/a		0	
Dicamba	ug/L	11	0	0	n/a	n/a	n/a	n/a	0	na	1095	Reg6	11	n/a		0	
Dichlorobenzene[1,2-]	ug/L	148	0	0	n/a	n/a	n/a	n/a	0	na	600	MCL	15	n/a		0	
Dichlorobenzene[1,3-]	ug/L	148	0	0	n/a	n/a	n/a	n/a	0	na	600	MCL	15	n/a		0	
Dichlorobenzene[1,4-]	ug/L	148	0	0	n/a	n/a	n/a	n/a	0	na	75	MCL	15	n/a		0	

Table E-1.0-1c
Screening Table for Los Alamos Watershed Organic Constituents in Intermediate (Perched Zone) Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd (number of locations)	D>Bkgd station List[c]	D>Std (number of locations)	D>Std station List[c]
Organics	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)				
Dichlorobenzidine[3,3'-]	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	1.494	Reg6	15	n/a		0	
Dichlorodifluoromethane	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	394.59	Reg6	15	n/a		0	
Dichloroethane[1,1-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	25	NMGSU	15	n/a		0	
Dichloroethane[1,2-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	15	n/a		0	
Dichloroethene[1,1-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	5	NMGSU	15	n/a		0	
Dichloroethene[cis-1,2-]	ug/L	70	0	0	n/a	n/a	n/a	n/a	0	na	70	MCL	14	n/a		0	
Dichloroethene[cis/trans-1,2-]	ug/L	1	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Dichloroethene[trans-1,2-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	100	MCL	15	n/a		0	
Dichlorophenol[2,4-]	ug/L	70	0	0	n/a	n/a	n/a	n/a	0	na	109.5	Reg6	15	n/a		0	
Dichloropropane[1,2-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	15	n/a		0	
Dichloropropane[1,3-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Dichloropropane[2,2-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Dichloropropene[1,1-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Dichloropropene[cis-1,3-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Dichloropropene[cis/trans-1,3-]	ug/L	8	0	0	n/a	n/a	n/a	n/a	0	na	6.7097	Reg6	7	n/a		0	
Dichloropropene[trans-1,3-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Dichlorprop	ug/L	11	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	11	n/a		n/a	
Dieldrin	ug/L	68	1	1.47	0.013	0.013	0.013	n/a	0	na	0.04202	Reg6	14	n/a		0	
Diesel Range Organics	ug/L	4	2	50	17.4	19.6	21.8	n/a	n/a	na	na	n/a	2	n/a		n/a	
Diethyl Ether	ug/L	11	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	9	n/a		n/a	
Diethylphthalate	ug/L	71	1	1.41	6.2	6.2	6.2	n/a	0	na	29200	Reg6	15	n/a		0	
Dimethyl Phthalate	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	365000	Reg6	15	n/a		0	
Dimethylphenol[2,4-]	ug/L	70	0	0	n/a	n/a	n/a	n/a	0	na	730	Reg6	15	n/a		0	
Dinitro-2-methylphenol[4,6-]	ug/L	71	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Dinitrobenzene[1,3-]	ug/L	36	0	0	n/a	n/a	n/a	n/a	0	na	3.65	Reg6	12	n/a		0	
Dinitrophenol[2,4-]	ug/L	70	0	0	n/a	n/a	n/a	n/a	0	na	73	Reg6	15	n/a		0	
Dinitrotoluene[2,4-]	ug/L	107	1	0.935	0.5	0.5	0.5	n/a	0	na	73	Reg6	15	n/a		0	
Dinitrotoluene[2,6-]	ug/L	107	0	0	n/a	n/a	n/a	n/a	0	na	36.5	Reg6	15	n/a		0	
Dinoseb	ug/L	58	0	0	n/a	n/a	n/a	n/a	0	na	7	MCL	13	n/a		0	
Dioxane[1,4-]	ug/L	47	3	6.38	1.13	2.66	4.07	n/a	0	na	61.12	Reg6	11	n/a		0	
Diphenylamine	ug/L	64	0	0	n/a	n/a	n/a	n/a	0	na	912.5	Reg6	14	n/a		0	
Diphenylhydrazine[1,2-]	ug/L	3	0	0	n/a	n/a	n/a	n/a	0	na	0.8404	Reg6	3	n/a		0	
Endosulfan I	ug/L	68	1	1.47	0.0053	0.0053	0.0053	n/a	n/a	na	na	n/a	14	n/a		n/a	
Endosulfan II	ug/L	67	1	1.49	0.0088	0.0088	0.0088	n/a	n/a	na	na	n/a	14	n/a		n/a	
Endosulfan Sulfate	ug/L	68	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	14	n/a		n/a	
Endrin	ug/L	68	1	1.47	0.017	0.017	0.017	n/a	0	na	2	MCL	14	n/a		0	
Endrin Aldehyde	ug/L	67	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	14	n/a		n/a	
Endrin Ketone	ug/L	68	1	1.47	0.0091	0.0091	0.0091	n/a	n/a	na	na	n/a	14	n/a		n/a	
Ethyl Methacrylate	ug/L	51	0	0	n/a	n/a	n/a	n/a	0	na	547.5	Reg6	12	n/a		0	
Ethylbenzene	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	700	MCL	15	n/a		0	
Fluoranthene	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	1460	Reg6	15	n/a		0	
Fluorene	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	243.3	Reg6	15	n/a		0	
HMX	ug/L	36	0	0	n/a	n/a	n/a	n/a	0	na	1825	Reg6	12	n/a		0	
Heptachlor	ug/L	68	1	1.47	0.0066	0.0066	0.0066	n/a	0	na	0.4	MCL	14	n/a		0	
Heptachlor Epoxide	ug/L	68	1	1.47	0.0056	0.0056	0.0056	n/a	0	na	0.2	MCL	14	n/a		0	
Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	

Table E-1.0-1c

Screening Table for Los Alamos Watershed Organic Constituents in Intermediate (Perched Zone) Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd (number of locations)	D>Bkgd station List[c]	D>Std (number of locations)	D>Std station List[c]
Organics	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)				
Heptachlorodibenzodioxins (Total)	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	ug/L	5	1	20	1E-05	1.1E-05	1E-05	n/a	n/a	na	na	n/a	2	n/a		n/a	
Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Heptachlorodibenzofurans (Total)	ug/L	5	1	20	1E-05	1.1E-05	1E-05	n/a	n/a	na	na	n/a	2	n/a		n/a	
Hexachlorobenzene	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	1	MCL	15	n/a		0	
Hexachlorobutadiene	ug/L	134	0	0	n/a	n/a	n/a	n/a	0	na	8.619	Reg6	15	n/a		0	
Hexachlorocyclopentadiene	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	50	MCL	15	n/a		0	
Hexachlorodibenzodioxin[1,2,3,4,7,8-]	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Hexachlorodibenzodioxin[1,2,3,6,7,8-]	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Hexachlorodibenzodioxin[1,2,3,7,8,9-]	ug/L	5	0	0	n/a	n/a	n/a	n/a	0	na	0.0001084	Reg6	2	n/a		0	
Hexachlorodibenzodioxins (Total)	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Hexachlorodibenzofuran[1,2,3,4,7,8-]	ug/L	5	1	20	3E-06	3.4E-06	3E-06	n/a	n/a	na	na	n/a	2	n/a		n/a	
Hexachlorodibenzofuran[1,2,3,6,7,8-]	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Hexachlorodibenzofuran[1,2,3,7,8,9-]	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Hexachlorodibenzofuran[2,3,4,6,7,8-]	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Hexachlorodibenzofurans (Total)	ug/L	5	1	20	8E-06	8.2E-06	8E-06	n/a	n/a	na	na	n/a	2	n/a		n/a	
Hexachloroethane	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	48.0225	Reg6	15	n/a		0	
Hexanone[2-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Indeno(1,2,3-cd)pyrene	ug/L	70	0	0	n/a	n/a	n/a	n/a	0	na	0.29499	Reg6	15	n/a		0	
Iodomethane	ug/L	77	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Isobutyl alcohol	ug/L	45	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	12	n/a		n/a	
Isophorone	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	707.7	Reg6	15	n/a		0	
Isopropylbenzene	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	658.2	Reg6	15	n/a		0	
Isopropyltoluene[4-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
MCPA	ug/L	11	0	0	n/a	n/a	n/a	n/a	0	na	18.25	Reg6	11	n/a		0	
MCPP	ug/L	11	0	0	n/a	n/a	n/a	n/a	0	na	36.5	Reg6	11	n/a		0	
MNX	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	3	n/a		n/a	
Methacrylonitrile	ug/L	51	0	0	n/a	n/a	n/a	n/a	0	na	1.043	Reg6	12	n/a		0	
Methoxychlor[4,4'-]	ug/L	67	0	0	n/a	n/a	n/a	n/a	0	na	40	MCL	13	n/a		0	
Methyl Methacrylate	ug/L	51	0	0	n/a	n/a	n/a	n/a	0	na	1419.4	Reg6	12	n/a		0	
Methyl tert-Butyl Ether	ug/L	11	0	0	n/a	n/a	n/a	n/a	0	na	370.83	Reg6	9	n/a		0	
Methyl-2-pentanone[4-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	1990.91	Reg6	15	n/a		0	
Methylene Chloride	ug/L	77	2	2.6	1.9	3.15	4.4	n/a	0	na	5	MCL	15	n/a		0	
Methylnaphthalene[1-]	ug/L	47	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	11	n/a		n/a	
Methylnaphthalene[2-]	ug/L	68	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Methylphenol[2-]	ug/L	70	2	2.86	5.03	5.305	5.58	n/a	0	na	1825	Reg6	15	n/a		0	
Methylphenol[3-,4-]	ug/L	48	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	11	n/a		n/a	
Methylphenol[4-]	ug/L	22	0	0	n/a	n/a	n/a	n/a	0	na	182.5	Reg6	7	n/a		0	
Methylpyridine[2-]	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	3	n/a		n/a	
Naphthalene	ug/L	128	1	0.781	0.343	0.343	0.343	n/a	0	na	30	NMGSU	15	n/a		0	
Nitroaniline[2-]	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	109.5	Reg6	15	n/a		0	
Nitroaniline[3-]	ug/L	71	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Nitroaniline[4-]	ug/L	71	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Nitrobenzene	ug/L	107	0	0	n/a	n/a	n/a	n/a	0	na	3.395	Reg6	15	n/a		0	
Nitrophenol[2-]	ug/L	66	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	15	n/a		n/a	
Nitrophenol[4-]	ug/L	70	0	0	n/a	n/a	n/a	n/a	0	na	292	Reg6	15	n/a		0	

Table E-1.0-1c

Screening Table for Los Alamos Watershed Organic Constituents in Intermediate (Perched Zone) Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd (number of locations)	D>Bkgd station List[c]	D>Std (number of locations)	D>Std station List[c]
Organics	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)				
Nitroso-di-n-butylamine[N-]	ug/L	47	0	0	n/a	n/a	n/a	n/a	0	na	0.1227	Reg6	11	n/a		0	
Nitroso-di-n-propylamine[N-]	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	0.096045	Reg6	15	n/a		0	
Nitrosodiethylamine[N-]	ug/L	47	0	0	n/a	n/a	n/a	n/a	0	na	0.0014356	Reg6	11	n/a		0	
Nitrosodimethylamine[N-]	ug/L	67	0	0	n/a	n/a	n/a	n/a	0	na	0.004222	Reg6	15	n/a		0	
Nitrosodiphenylamine[N-]	ug/L	7	0	0	n/a	n/a	n/a	n/a	0	na	137.207	Reg6	4	n/a		0	
Nitrosopyrrolidine[N-]	ug/L	47	0	0	n/a	n/a	n/a	n/a	0	na	0.32015	Reg6	11	n/a		0	
Nitrotoluene[2-]	ug/L	36	0	0	n/a	n/a	n/a	n/a	0	na	2.9231	Reg6	12	n/a		0	
Nitrotoluene[3-]	ug/L	36	1	2.78	0.15	0.15	0.15	n/a	0	na	121.67	Reg6	12	n/a		0	
Nitrotoluene[4-]	ug/L	36	0	0	n/a	n/a	n/a	n/a	0	na	39.548	Reg6	12	n/a		0	
Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	ug/L	5	1	20	1E-05	1.2E-05	1E-05	n/a	n/a	na	na	n/a	2	n/a		n/a	
Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	ug/L	5	1	20	3E-06	3.1E-06	3E-06	n/a	n/a	na	na	n/a	2	n/a		n/a	
Oxybis(1-chloropropane)[2,2'-]	ug/L	70	0	0	n/a	n/a	n/a	n/a	0	na	9.5364	Reg6	15	n/a		0	
PETN	ug/L	10	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	4	n/a		n/a	
Pentachlorobenzene	ug/L	47	0	0	n/a	n/a	n/a	n/a	0	na	29.2	Reg6	11	n/a		0	
Pentachlorodibenzodioxin[1,2,3,7,8-]	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Pentachlorodibenzodioxins (Total)	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Pentachlorodibenzofuran[1,2,3,7,8-]	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Pentachlorodibenzofuran[2,3,4,7,8-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Pentachlorodibenzofurans (Totals)	ug/L	5	1	20	7E-06	6.8E-06	7E-06	n/a	n/a	na	na	n/a	2	n/a		n/a	
Pentachlorophenol	ug/L	70	0	0	n/a	n/a	n/a	n/a	0	na	1	MCL	15	n/a		0	
Phenanthrene	ug/L	57	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	14	n/a		n/a	
Phenol	ug/L	70	1	1.43	14.8	14.8	14.8	n/a	1	na	5	NMGSU	15	n/a		1	14
Propionitrile	ug/L	51	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	12	n/a		n/a	
Propylbenzene[1-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	60.83	Reg6	15	n/a		0	
Pyrene	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	182.5	Reg6	15	n/a		0	
Pyridine	ug/L	23	0	0	n/a	n/a	n/a	n/a	0	na	36.5	Reg6	13	n/a		0	
RDX	ug/L	35	1	2.86	0.49	0.49	0.49	n/a	0	na	6.11196	Reg6	12	n/a		0	
Styrene	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	100	MCL	15	n/a		0	
TATB	ug/L	10	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	4	n/a		n/a	
TNX	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	3	n/a		n/a	
TP[2,4,5-]	ug/L	11	0	0	n/a	n/a	n/a	n/a	0	na	50	MCL	11	n/a		0	
T[2,4,5-]	ug/L	11	0	0	n/a	n/a	n/a	n/a	0	na	365	Reg6	11	n/a		0	
Tetrachlorobenzene[1,2,4,5]	ug/L	46	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	11	n/a		n/a	
Tetrachlorodibenzodioxin[2,3,7,8-]	ug/L	5	0	0	n/a	n/a	n/a	n/a	0	na	3.00E-05	MCL	2	n/a		0	
Tetrachlorodibenzodioxins (Total)	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Tetrachlorodibenzofuran[2,3,7,8-]	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Tetrachlorodibenzofurans (Totals)	ug/L	5	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Tetrachloroethane[1,1,1,2-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	25.4955	Reg6	15	n/a		0	
Tetrachloroethane[1,1,2,2-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	10	NMGSU	15	n/a		0	
Tetrachloroethene	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	15	n/a		0	
Tetrachlorophenol[2,3,4,6-]	ug/L	47	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	11	n/a		0	
Tetryl	ug/L	35	1	2.86	2.3	2.3	2.3	n/a	0	na	146	Reg6	12	n/a		0	
Toluene	ug/L	77	14	18.2	0.261	29.5	112	n/a	0	na	750	NMGSU	15	n/a		0	
Toxaphene (Technical Grade)	ug/L	68	0	0	n/a	n/a	n/a	n/a	0	na	3	MCL	14	n/a		0	
Trichloro-1,2,2-trifluoroethane[1,1,2-]	ug/L	73	0	0	n/a	n/a	n/a	n/a	0	na	59179.86	Reg6	15	n/a		0	
Trichlorobenzene[1,2,3-]	ug/L	54	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	14	n/a		n/a	

Table E-1.0-1c

Screening Table for Los Alamos Watershed Organic Constituents in Intermediate (Perched Zone) Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]						
Organics	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	Locations with data (number)	D>Bkgd (number of locations)	D>Bkgd station List[c]	D>Std (number of locations)	D>Std station List[c]
Trichlorobenzene[1,2,4-]	ug/L	127	0	0	n/a	n/a	n/a	n/a	0	na	70	MCL	15	n/a		0	
Trichloroethane[1,1,1-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	60	NMGSU	15	n/a		0	
Trichloroethane[1,1,2-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	15	n/a		0	
Trichloroethene	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	15	n/a		0	
Trichlorofluoromethane	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	15	n/a		0	
Trichlorophenol[2,4,5-]	ug/L	70	0	0	n/a	n/a	n/a	n/a	0	na	3650	Reg6	15	n/a		0	
Trichlorophenol[2,4,6-]	ug/L	70	0	0	n/a	n/a	n/a	n/a	0	na	6.11196	Reg6	15	n/a		0	
Trichloropropane[1,2,3-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	0.09469	Reg6	15	n/a		0	
Trimethylbenzene[1,2,4-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	12.429	Reg6	15	n/a		0	
Trimethylbenzene[1,3,5-]	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	12.3262	Reg6	15	n/a		0	
Trinitrobenzene[1,3,5-]	ug/L	36	0	0	n/a	n/a	n/a	n/a	0	na	1095	Reg6	12	n/a		0	
Trinitrotoluene[2,4,6-]	ug/L	36	0	0	n/a	n/a	n/a	n/a	0	na	22.4105	Reg6	12	n/a		0	
Tris (o-cresyl) phosphate	ug/L	8	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	3	n/a		n/a	
Vinyl Chloride	ug/L	77	0	0	n/a	n/a	n/a	n/a	0	na	1	NMGSU	15	n/a		0	
Vinyl acetate	ug/L	44	0	0	n/a	n/a	n/a	n/a	0	na	412.429	Reg6	12	n/a		0	
Xylene (Total)	ug/L	27	0	0	n/a	n/a	n/a	n/a	0	na	10000	MCL	9	n/a		0	
Xylene[1,2-]	ug/L	68	0	0	n/a	n/a	n/a	n/a	0	na	1431.37	Reg6	15	n/a		0	
Xylene[1,3-]+Xylene[1,4-]	ug/L	62	1	1.61	0.287	0.287	0.287	n/a	n/a	na	na	n/a	14	n/a		n/a	

n/a=not applicable
na = not available (no published value)

[c] Station List (codes)

1=LADP-3	9=R-5, Screen 2
2=LAOI(a)-1.1	10=R-6i
3=LAOI-3.2	11=R-7, Screen 1
4=LAOI-3.2a	12=R-9i, Screen 1
5=LAOI-7	13=R-9i, Screen 2
6=POI-4	14=Test Well 1A
7=R-3i	15=Test Well 2A
8=R-5, Screen 1	

[a]GW Bkgd upper tolerance level (UTL) or maximum detect for Intermediate Groundwater unfiltered samples
LANL, 2007. Groundwater Background Investigation, Rev 3.
[b]Screening Standard

Std Type	Standard (Source and Name)
MCL	EPA Maximum Contaminant Level (MCL)
Reg6	EPA Region 6 Tap Water Screening Level
NMGSU	NMAC 20.6.2, Groundwater Standards (Unfiltered)

Table E-1.0-1d
Screening Table for Los Alamos Watershed Radioactive Constituents in Intermediate (Perched Zone) Groundwater Filtered (F) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]						
Radionuclides	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	Locations with data (number)	D>Bkgd (number of locations)	D>Bkgd station List[c]	D>Std (number of locations)	D>Std station List[c]
Americium-241	pCi/L	41	4	9.76	0.0223	0.0348	0.049	0	0	0.11	20	NMRPS	12	0		0	
Cesium-137	pCi/L	38	0	0	n/a	n/a	n/a	0	0	0.76	1000	NMRPS	12	0		0	
Cobalt-60	pCi/L	38	0	0	n/a	n/a	n/a	n/a	0	na	3000	NMRPS	12	n/a		0	
Gross alpha	pCi/L	31	7	22.6	1.53	3.96	6.25	n/a	0	na	15	MCL	11	n/a		0	
Gross beta	pCi/L	31	28	90.3	2.7	5.16	10.6	n/a	0	na	50	SMCL	11	n/a		0	
Gross gamma	pCi/L	31	2	6.45	21	90	159	n/a	n/a	na	na	n/a	11	n/a		n/a	
Iodine-129	pCi/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Neptunium-237	pCi/L	34	0	0	n/a	n/a	n/a	n/a	0	na	20	NMRPS	12	n/a		0	
Plutonium-238	pCi/L	41	1	2.44	0.0358	0.0358	0.0358	1	0	0.01	20	NMRPS	12	1	5	0	
Plutonium-239/240	pCi/L	41	0	0	n/a	n/a	n/a	n/a	0	na	20	NMRPS	12	n/a		0	
Potassium-40	pCi/L	35	0	0	n/a	n/a	n/a	n/a	0	na	4000	NMRPS	12	n/a		0	
Sodium-22	pCi/L	37	0	0	n/a	n/a	n/a	n/a	0	na	6000	NMRPS	12	n/a		0	
Strontium-90	pCi/L	41	0	0	n/a	n/a	n/a	0	0	0.05	8	MCL	12	0		0	
Technetium-99	pCi/L	4	0	0	n/a	n/a	n/a	n/a	0	na	4000	DCG	2	n/a		0	
Thorium-228	pCi/L	2	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Thorium-230	pCi/L	2	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Thorium-232	pCi/L	2	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Uranium-234	pCi/L	41	37	90.2	0.0191	0.476	4.55	26	0	0.26	300	NMRPS	12	9	3, 4, 5, 6, 7, 8, 9, 10, 12	0	
Uranium-235/Uranium-236	pCi/L	41	12	29.3	0.0347	0.06055	0.234	n/a	n/a	na	na	n/a	12	n/a		n/a	
Uranium-238	pCi/L	41	33	80.5	0.021	0.371	2.96	24	0	0.2	300	NMRPS	12	9	3, 4, 5, 6, 7, 8, 9, 10, 12	0	

n/a=not applicable
na = not available (no published value)

[c] Station List (codes)

1=LADP-3	9=R-5, Screen 2
2=LAOI(a)-1.1	10=R-6i
3=LAOI-3.2	11=R-7, Screen 1
4=LAOI-3.2a	12=R-9i, Screen 1
5=LAOI-7	13=R-9i, Screen 2
6=POI-4	14=Test Well 1A
7=R-3i	15=Test Well 2A
8=R-5, Screen 1	

[a]GW Bkgd upper tolerance level (UTL) or maximum detect for Intermediate Groundwater filtered samples
LANL, 2007. Groundwater Background Investigation, Rev 3.
[b]Screening Standard

Std Type	Standard (Source and Name)
MCL	EPA Maximum Contaminant Level (MCL)
Reg6	EPA Region 6 Tap Water Screening Level
NMGSF	NMAC 20.6.2, Groundwater Standards (Filtered)

Table E-1.0-1e
Screening Table for Los Alamos Watershed Radioactive Constituents in Intermediate (Perched Zone) Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data (number)	D>Bkgd (number of locations)	D>Bkgd station List[c]	D>Std (number of locations)	D>Std station List[c]
Radionuclides	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type					
Americium-241	pCi/L	69	5	7.25	0.00224	0.0105	0.107	n/a	0	na	20	NMRPS	14	n/a		0	
Cesium-137	pCi/L	64	2	3.13	-0.9	2.84	6.58	n/a	0	na	1000	NMRPS	14	n/a		0	
Cobalt-60	pCi/L	64	1	1.56	0.79	0.79	0.79	n/a	0	na	3000	NMRPS	14	n/a		0	
Gross alpha	pCi/L	61	25	41	0.664	2.62	12.2	n/a	0	na	15	MCL	14	n/a		0	
Gross alpha/beta	pCi/L	3	1	33.3	1.5	1.5	1.5	n/a	n/a	na	na	n/a	2	n/a		n/a	
Gross beta	pCi/L	64	59	92.2	1.94	4.85	23.9	n/a	0	na	50	SMCL	14	n/a		0	
Gross gamma	pCi/L	64	6	9.38	44.3	162.5	306	n/a	n/a	na	na	n/a	13	n/a		n/a	
Iodine-129	pCi/L	17	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	7	n/a		n/a	
Neptunium-237	pCi/L	53	0	0	n/a	n/a	n/a	n/a	0	na	20	NMRPS	14	n/a		0	
Plutonium-238	pCi/L	69	4	5.8	-1.76E-09	0.002145	0.0098	n/a	0	na	20	NMRPS	14	n/a		0	
Plutonium-239/240	pCi/L	68	5	7.35	-0.00181	0.00553	0.0204	n/a	0	na	20	NMRPS	14	n/a		0	
Potassium-40	pCi/L	64	1	1.56	55.6	55.6	55.6	n/a	0	na	4000	NMRPS	13	n/a		0	
Radium-226	pCi/L	14	3	21.4	0.532	0.543	0.592	n/a	0	na	5	MCL	7	n/a		0	
Sodium-22	pCi/L	66	1	1.52	0.31	0.31	0.31	n/a	0	na	6000	NMRPS	14	n/a		0	
Strontium-90	pCi/L	69	2	2.9	-0.01	0.261	0.532	n/a	0	na	8	MCL	14	n/a		0	
Technetium-99	pCi/L	23	0	0	n/a	n/a	n/a	n/a	0	na	4000	DCG	8	n/a		0	
Thorium-228	pCi/L	9	2	22.2	0.0376	0.1223	0.207	n/a	n/a	na	na	n/a	5	n/a		n/a	
Thorium-230	pCi/L	9	3	33.3	0.0215	0.0341	0.197	n/a	n/a	na	na	n/a	5	n/a		n/a	
Thorium-232	pCi/L	9	2	22.2	0.0065	0.08125	0.156	n/a	n/a	na	na	n/a	5	n/a		n/a	
Tritium	pCi/L	106	80	75.5	-0.2554	236.8	4365	68	0	7.54	20000	MCL	15	11	7, 10, 12, 13, 14, 15	0	
Uranium-234	pCi/L	69	65	94.2	0.0463	0.58	4.43	n/a	0	na	300	NMRPS	14	n/a		0	
Uranium-235/Uranium-236	pCi/L	69	29	42	0.0184	0.071	0.218	n/a	n/a	na	na	n/a	14	n/a		n/a	
Uranium-238	pCi/L	69	62	89.9	0.0276	0.4575	3.09	n/a	0	na	300	NMRPS	14	n/a		0	

n/a=not applicable
na = not available (no published value)

[c] Station List (codes)

1=LADP-3	9=R-5, Screen 2
2=LAOI(a)-1.1	10=R-6i
3=LAOI-3.2	11=R-7, Screen 1
4=LAOI-3.2a	12=R-9i, Screen 1
5=LAOI-7	13=R-9i, Screen 2
6=POI-4	14=Test Well 1A
7=R-3i	15=Test Well 2A
8=R-5, Screen 1	

[a]GW Bkgd upper tolerance level (UTL) or maximum detect for Intermediate Groundwater unfiltered samples
LANL, 2007. Groundwater Background Investigation, Rev 3.
[b]Screening Standard

Std Type	Standard (Source and Name)
MCL	EPA Maximum Contaminant Level (MCL)
Reg6	EPA Region 6 Tap Water Screening Level
NMGSU	NMAC 20.6.2, Groundwater Standards (Unfiltered)

Table E-1.0-1f
Screening Table for Los Alamos Watershed General Chemistry Constituents in Intermediate (Perched Zone) Groundwater Filtered (F) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd		D>Std	
General Inorganics	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)	(number of locations)	D>Bkgd station List[c]	(number of locations)	D>Std station List[c]
Alkalinity-CO3	ug/L	51	16	31.4	750	869.5	14100	n/a	n/a	na	na	n/a	12	n/a		n/a	
Alkalinity-CO3+HCO3	ug/L	72	72	100	57	75830	296000	60	n/a	52000	na	n/a	14	14	7, 8, 9, 10, 11, 12, 13, 14	n/a	
Alkalinity-HCO3	ug/L	5	5	100	68000	77000	88800	n/a	n/a	na	na	n/a	4	n/a		n/a	
Ammonia	ug/L	15	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	5	n/a		n/a	
Ammonia as Nitrogen	ug/L	46	3	6.52	59	74	154	2	0	70	208.5714286	Reg6	10	2	2, 7	0	
Bromide	ug/L	78	42	53.8	10	146.5	315	40	n/a	30	na	n/a	14	11	3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14	n/a	
Calcium	ug/L	79	79	100	4260	21520	58100	48	n/a	17310	na	n/a	14	9	3, 4, 6, 7, 8, 9, 10, 12, 14	n/a	
Carbote	ug/L	9	0	0	n/a	n/a	n/a	0	n/a	500	na	n/a	7	0		n/a	
Chloride	ug/L	79	79	100	998	18400	80000	57	0	7780	250000	NMGSF	14	11	1, 3, 4, 5, 6, 7, 9, 10, 12, 13, 14	0	
Cyanide (Total)	ug/L	19	1	5.26	2.09	2.09	2.09	n/a	0	na	200	NMGSF	9	n/a		0	
Fluoride	ug/L	79	73	92.4	76	290	1120	44	0	230	1600	NMGSF	14	10	1, 5, 6, 7, 8, 9, 10, 12, 13, 14	0	
Hardness	ug/L	44	44	100	14200	75850	212000	n/a	n/a	na	na	n/a	10	n/a		n/a	
Humic Substances, Hydrophilic Acids	ug/L	7	7	100	0	1300	2900	n/a	n/a	na	na	n/a	4	n/a		n/a	
Humic Substances, Hydrophilic Bases	ug/L	7	7	100	0	200	600	n/a	n/a	na	na	n/a	4	n/a		n/a	
Humic Substances, Hydrophilic Neutrals	ug/L	7	7	100	100	300	800	n/a	n/a	na	na	n/a	4	n/a		n/a	
Humic Substances, Hydrophilic Total	ug/L	7	7	100	700	1600	3700	n/a	n/a	na	na	n/a	4	n/a		n/a	
Humic Substances, Hydrophobic Acids	ug/L	7	7	100	500	900	1600	n/a	n/a	na	na	n/a	4	n/a		n/a	
Humic Substances, Hydrophobic Bases	ug/L	7	7	100	0	0	0	n/a	n/a	na	na	n/a	4	n/a		n/a	
Humic Substances, Hydrophobic Neutrals	ug/L	7	7	100	400	800	1900	n/a	n/a	na	na	n/a	4	n/a		n/a	
Humic Substances, Hydrophobic Total	ug/L	7	7	100	1300	1700	3500	n/a	n/a	na	na	n/a	4	n/a		n/a	
Magnesium	ug/L	79	79	100	862	4790	16100	20	n/a	6120	na	n/a	14	5	5, 6, 7, 12, 14	n/a	
Nitrate as Nitrogen	ug/L	15	15	100	4	1860	4540	5	0	2410	10000	MCL	11	4	6, 7, 8, 10	0	
Nitrate-Nitrite as Nitrogen	ug/L	72	65	90.3	20	2110	7480	n/a	n/a	na	na	n/a	13	n/a		n/a	
Nitrite as Nitrogen	ug/L	13	2	15.4	12	72.04	132.1	2	0	0	1000	MCL	9	2	3, 4	0	
Oxalate	ug/L	21	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	12	n/a		n/a	
Perchlorate	ug/L	106	59	55.7	0.104	2.12	9	54	0	0.18	24.5	Reg6	15	11	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13	0	
Phosphorus, Orthophosphate (Expressed as PO4	ug/L	7	4	57.1	20	106.8	334.5	n/a	n/a	na	na	n/a	4	n/a		n/a	
Potassium	ug/L	79	79	100	607	4750	21900	1	n/a	10030	na	n/a	14	1	2	n/a	
Silicon Dioxide	ug/L	66	66	100	1410	55000	73800	45	n/a	50720	na	n/a	14	9	1, 2, 3, 4, 5, 6, 7, 8, 10	n/a	
Sodium	ug/L	79	79	100	5700	17000	51100	58	n/a	12190	na	n/a	14	12	1, 2, 3, 4, 6, 7, 8, 9, 10, 12, 13, 14	n/a	
Sulfate	ug/L	79	78	98.7	530	9100	33900	0	0	40030	600000	NMGSF	14	0		0	
Total Kjeldahl Nitrogen	ug/L	62	30	48.4	34	198	450	15	n/a	200	na	n/a	13	6	6, 8, 9, 11, 12, 13	n/a	
Total Phosphate as Phosphorus	ug/L	66	24	36.4	4	37.5	1340	9	n/a	80	na	n/a	14	4	3, 6, 9, 14	n/a	
Total Phosphorus	ug/L	9	2	22.2	56	56	56	n/a	2	na	0.73	Reg6	4	n/a		2	12, 13

n/a=not applicable
na = not available (no published value)

[c] Station List (codes)

1=LADP-3	9=R-5, Screen 2
2=LAOI(a)-1.1	10=R-6i
3=LAOI-3.2	11=R-7, Screen 1
4=LAOI-3.2a	12=R-9i, Screen 1
5=LAOI-7	13=R-9i, Screen 2
6=POI-4	14=Test Well 1A
7=R-3i	15=Test Well 2A
8=R-5, Screen 1	

[a]GW Bkgd upper tolerance level (UTL) or maximum detect for Intermediate Groundwater filtered samples
LANL, 2007. Groundwater Background Investigation, Rev 3.
[b]Screening Standard

Std Type	Standard (Source and Name)
MCL	EPA Maximum Contaminant Level (MCL)
Reg6	EPA Region 6 Tap Water Screening Level
NMGSF	NMAC 20.6.2, Groundwater Standards (Filtered)

Table E-1.0-1g

Screening Table for Los Alamos Watershed General Chemistry Constituents in Intermediate (Perched Zone) Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd (number of locations)	D>Bkgd station List[c]	D>Std (number of locations)	D>Std station List[c]
General Inorganics	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)				
Alkalinity-CO3	ug/L	31	2	6.45	2520	5975	9430	n/a	n/a	na	na	n/a	11	n/a		n/a	
Alkalinity-CO3+HCO3	ug/L	46	45	97.8	34700	78000	1610000	n/a	n/a	na	na	n/a	12	n/a		n/a	
Alkalinity-HCO3	ug/L	17	17	100	34600	79600	1610000	n/a	n/a	na	na	n/a	6	n/a		n/a	
Ammonia	ug/L	2	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Ammonia as Nitrogen	ug/L	25	4	16	63	158	7100	n/a	1	na	208.5714286	Reg6	10	n/a		1	14
Bromide	ug/L	37	24	64.9	20	80	217	n/a	n/a	na	na	n/a	11	n/a		n/a	
Calcium	ug/L	103	103	100	4570	21800	58300	n/a	n/a	na	na	n/a	15	n/a		n/a	
Carbote	ug/L	17	4	23.5	1000	6400	8600	n/a	n/a	na	na	n/a	8	n/a		n/a	
Chloride	ug/L	49	49	100	1220	18100	76500	n/a	n/a	na	na	n/a	12	n/a		n/a	
Cyanide (Total)	ug/L	74	5	6.76	2.18	3	4.54	n/a	0	na	200	MCL	14	n/a		0	
Fluoride	ug/L	49	45	91.8	80	300	1120	n/a	0	na	4000	MCL	12	n/a		0	
Hardness	ug/L	61	61	100	15500	77500	212000	n/a	n/a	na	na	n/a	14	n/a		n/a	
Magnesium	ug/L	102	102	100	995	4750	16200	n/a	n/a	na	na	n/a	14	n/a		n/a	
Nitrate as Nitrogen	ug/L	16	16	100	330	2630	5510	n/a	0	na	10000	Reg6	7	n/a		0	
Nitrate-Nitrite as Nitrogen	ug/L	38	29	76.3	55.4	2230	5060	n/a	n/a	na	na	n/a	12	n/a		n/a	
Nitrite as Nitrogen	ug/L	15	0	0	n/a	n/a	n/a	n/a	0	na	1000	Reg6	6	n/a		0	
Oxalate	ug/L	15	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	6	n/a		n/a	
Perchlorate	ug/L	74	36	48.6	0.151	1.475	9.48	34	0	0.17	24.5	Reg6	13	8	3, 4, 5, 6, 8, 9, 10, 12	0	
Potassium	ug/L	102	102	100	572	4480	27700	n/a	n/a	na	na	n/a	14	n/a		n/a	
Silicon Dioxide	ug/L	61	61	100	3000	49100	73900	n/a	n/a	na	na	n/a	13	n/a		n/a	
Sodium	ug/L	102	102	100	5800	17200	53700	n/a	n/a	na	na	n/a	14	n/a		n/a	
Sulfate	ug/L	49	48	98	1970	10000	39500	n/a	n/a	na	na	n/a	12	n/a		n/a	
Total Kjeldahl Nitrogen	ug/L	53	20	37.7	15	174.5	7850	n/a	n/a	na	na	n/a	14	n/a		n/a	
Total Phosphate as Phosphorus	ug/L	48	21	43.8	6.52	53	1240	n/a	n/a	na	na	n/a	13	n/a		n/a	
Total Phosphorus	ug/L	2	2	100	80	81	82	n/a	2	na	0.73	Reg6	2	n/a		2	12, 13

n/a=not applicable

na = not available (no published value)

[c] Station List (codes)

1=LADP-3	9=R-5, Screen 2
2=LAOI(a)-1.1	10=R-6i
3=LAOI-3.2	11=R-7, Screen 1
4=LAOI-3.2a	12=R-9i, Screen 1
5=LAOI-7	13=R-9i, Screen 2
6=POI-4	14=Test Well 1A
7=R-3i	15=Test Well 2A
8=R-5, Screen 1	

[a]GW Bkgd upper tolerance level (UTL) or maximum detect for Intermediate Groundwater unfiltered samples LANL, 2007. Groundwater Background Investigation, Rev 3.

[b]Screening Standard

Std Type	Standard (Source and Name)
MCL	EPA Maximum Contaminant Level (MCL)
Reg6	EPA Region 6 Tap Water Screening Level
NMGSU	NMAC 20.6.2, Groundwater Standards (Unfiltered)

Table E-1.0-2a
Screening Table for Los Alamos Watershed Metals in Regional Groundwater Filtered (F) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd (number of locations)	D>Bkgd	D>Std (number of locations)	D>Std
Metals	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)		station List[c]		station List[c]
Aluminum	ug/L	70	10	14.3	3.355	8.627	115	1	0	73.5	5000	NMGSF	13	1	1	0	
Antimony	ug/L	76	4	5.26	0.297	0.445	1.2	1	0	1	6	MCL	13	1	11	0	
Arsenic	ug/L	76	20	26.3	0.1	1.816	5.79	0	0	12	10	MCL	13	0		0	
Barium	ug/L	76	75	98.7	12.5	74.05	545	39	0	56.83	1000	NMGSF	13	8	2, 4, 5, 7, 9, 10, 11, 13	0	
Beryllium	ug/L	76	5	6.58	0.011	0.031	0.09	0	0	0.5	4	MCL	13	0		0	
Boron	ug/L	76	68	89.5	4.51	30.5	96	30	0	38.77	750	NMGSF	13	7	2, 5, 7, 9, 10, 11, 13	0	
Cadmium	ug/L	76	3	3.95	0.143	1.6	2.2	2	0	0.5	5	MCL	13	2	12, 13	0	
Cesium	ug/L	12	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	7	n/a		n/a	
Chromium	ug/L	76	56	73.7	0.8	3.5	6.9	4	0	5.75	50	NMGSF	13	3	1, 6, 7	0	
Cobalt	ug/L	76	13	17.1	0.52	3.28	14	3	0	7	50	NMGSF	13	2	7, 8	0	
Copper	ug/L	68	18	26.5	0.88	3.75	22	6	0	5	1000	NMGSF	13	4	2, 11, 12, 13	0	
Iron	ug/L	76	31	40.8	10	110	17000	14	8	147	1000	NMGSF	13	3	5, 7, 13	3	5, 7, 13
Lead	ug/L	76	10	13.2	0.058	6.65	44.9	6	1	2.9	15	MCL	13	4	8, 11, 12, 13	1	12
Lithium	ug/L	12	12	100	16.73	25	34	4	0	27.4	730	Reg6	7	2	10, 11	0	
Manganese	ug/L	76	60	78.9	2.3	37.45	3400	13	9	124	200	NMGSF	13	4	5, 7, 10, 13	2	5, 7
Mercury	ug/L	75	4	5.33	0.068	0.15	0.22	0	0	0.26	2	MCL	13	0		0	
Molybdenum	ug/L	76	54	71.1	1.1	2.35	31	13	0	4.4	1000	NMGSF	13	4	1, 2, 5, 7	0	
Nickel	ug/L	76	56	73.7	0.64	1.45	210	2	2	50	100	MCL	13	1	7	1	7
Selenium	ug/L	76	1	1.32	6.9	6.9	6.9	1	0	3.93	50	NMGSF	13	1	1	0	
Silicon	ug/L	6	6	100	21000	33500	35000	n/a	n/a	na	na	n/a	2	n/a		n/a	
Silver	ug/L	76	0	0	n/a	n/a	n/a	0	0	2.5	50	NMGSF	13	0		0	
Strontium	ug/L	76	76	100	28	96.75	467	0	0	540	21900	Reg6	13	0		0	
Thallium	ug/L	76	15	19.7	0.204	0.53	1	2	0	0.83	2	MCL	13	2	1, 8	0	
Tin	ug/L	46	3	6.52	1.5	2.6	3	0	0	3.6	21900	Reg6	11	0		0	
Titanium	ug/L	12	3	25	1	1	2	3	n/a	1	na	n/a	7	1	11	n/a	
Uranium	ug/L	76	65	85.5	0.051	0.8	3.4	15	0	1.9	30	NMGSF	13	5	2, 4, 5, 10, 11	0	
Vadium	ug/L	76	61	80.3	1	9.2	22.9	7	0	13.41	182.5	Reg6	13	2	2, 8	0	
Zinc	ug/L	76	41	53.9	1.17	12	1540	12	0	32	10000	NMGSF	13	5	2, 7, 11, 12, 13	0	

n/a=not applicable
na = not available (no published value)

[c] Station List (codes)

1=R-2	8=R-8, Screen 1
2=R-24	9=R-8, Screen 2
3=R-4	10=R-9
4=R-5, Screen 3	11=Test Well 1
5=R-5, Screen 4	12=Test Well 2
6=R-6	13=Test Well 3
7=R-7, Screen 3	14=Test Well 4

[a]GW Bkgd upper tolerance level (UTL) or maximum detect for Regional Groundwater filtered samples
LANL, 2007. Groundwater Background Investigation, Rev 3.
[b]Screening Standard

Std Type	Standard (Source and Name)
MCL	EPA Maximum Contaminant Level (MCL)
Reg6	EPA Region 6 Tap Water Screening Level
NMGSF	NMAC 20.6.2, Groundwater Standards (Filtered)

Table E-1.0-2b
Screening Table for Los Alamos Watershed Metals in Regional Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd (number of	D>Bkgd	D>Std (number of	D>Std
Metals	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)	locations)	station List[c]	locations)	station List[c]
Aluminum	ug/L	126	55	43.7	2.7	22.5	1270	n/a	0	na	36500	Reg6	14	n/a		0	
Antimony	ug/L	133	13	9.77	0.1	0.7	4.2	n/a	0	na	6	MCL	14	n/a		0	
Arsenic	ug/L	133	51	38.3	0.5028	1.8	8.12	n/a	0	na	10	MCL	14	n/a		0	
Barium	ug/L	133	132	99.2	11	79.45	549	n/a	0	na	2000	MCL	14	n/a		0	
Beryllium	ug/L	131	3	2.29	0.018	0.244	3	n/a	0	na	4	MCL	14	n/a		0	
Boron	ug/L	133	118	88.7	5.24	37.4	157	n/a	0	na	7300	Reg6	14	n/a		0	
Cadmium	ug/L	133	18	13.5	0.045	0.264	1.02	n/a	0	na	5	MCL	14	n/a		0	
Cesium	ug/L	37	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	9	n/a		n/a	
Chromium	ug/L	133	102	76.7	0.78	3.265	18	n/a	0	na	100	MCL	14	n/a		0	
Chromium hexavalent ion	ug/L	4	4	100	3.4	3.55	4.4	n/a	0	na	100	MCL	3	n/a		0	
Cobalt	ug/L	133	11	8.27	0.638	8	15	n/a	0	na	730	Reg6	14	n/a		0	
Copper	ug/L	125	64	51.2	1	3.19	65	n/a	0	na	1300	MCL	14	n/a		0	
Iron	ug/L	133	97	72.9	10	151	21000	n/a	0	na	25550	Reg6	14	n/a		0	
Lead	ug/L	133	49	36.8	0.1	1.1	47.9	n/a	10	na	15	Reg6	14	n/a		4	11, 12, 13, 14
Lithium	ug/L	37	37	100	16.86	27	41	n/a	0	na	730	Reg6	9	n/a		0	
Manganese	ug/L	133	108	81.2	1.24	38.65	3500	n/a	5	na	1703.09	Reg6	14	n/a		2	5, 7
Mercury	ug/L	133	14	10.5	0.05	0.08	0.2	0	0	0.24	2	NMGSU	14	0		0	
Molybdenum	ug/L	133	96	72.2	1.1	2.45	26	n/a	0	na	182.5	Reg6	14	n/a		0	
Nickel	ug/L	133	85	63.9	0.56	1.9	220	n/a	2	na	100	MCL	14	n/a		1	7
Selenium	ug/L	134	12	8.96	2	4.525	7.2	6	0	4.99	50	MCL	14	4	4, 9, 10, 13	0	
Silicon	ug/L	11	11	100	19000	34000	83000	n/a	n/a	na	na	n/a	6	n/a		n/a	
Silver	ug/L	133	2	1.5	0.3	0.495	0.69	0	0	2.5	182.5	Reg6	14	0		0	
Strontium	ug/L	133	133	100	31.8	95	461	n/a	0	na	21900	Reg6	14	n/a		0	
Thallium	ug/L	133	13	9.77	0.02	0.273	3.9	n/a	1	na	2	MCL	14	n/a		1	10
Tin	ug/L	103	1	0.971	3.7	3.7	3.7	n/a	0	na	21900	Reg6	13	n/a		0	
Titanium	ug/L	43	4	9.3	1	14.5	24	n/a	n/a	na	na	n/a	13	n/a		n/a	
Uranium	ug/L	110	104	94.5	0.063	0.79	3.6	n/a	0	na	30	MCL	13	n/a		0	
Vadium	ug/L	133	107	80.5	0.5	8.4	26	n/a	0	na	182.5	Reg6	14	n/a		0	
Zinc	ug/L	133	91	68.4	1	16.7	1080	n/a	0	na	10950	Reg6	14	n/a		0	

n/a=not applicable
na = not available (no published value)

[c] Station List (codes)

1=R-2	8=R-8, Screen 1
2=R-24	9=R-8, Screen 2
3=R-4	10=R-9
4=R-5, Screen 3	11=Test Well 1
5=R-5, Screen 4	12=Test Well 2
6=R-6	13=Test Well 3
7=R-7, Screen 3	14=Test Well 4

[a]GW Bkgd upper tolerance level (UTL) or maximum detect for Regional Groundwater unfiltered samples
LANL, 2007. Groundwater Background Investigation, Rev 3.

[b]Screening Standard

Std Type	Standard (Source and Name)
MCL	EPA Maximum Contaminant Level (MCL)
Reg6	EPA Region 6 Tap Water Screening Level
NMGSU	NMAC 20.6.2, Groundwater Standards (Unfiltered)

Table E-1.0-2c
Screening Table for Los Alamos Watershed Organic Constituents in Regional Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd		D>Std	
Organics	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)	(number of locations)	D>Bkgd station List[c]	(number of locations)	D>Std station List[c]
2,4-Diamino-6-nitrotoluene	ug/L	8	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
2,6-Diamino-4-nitrotoluene	ug/L	8	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
3,5-Dinitroaniline	ug/L	8	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Acenaphthene	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	365	Reg6	13	n/a		0	
Acenaphthylene	ug/L	76	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Acetone	ug/L	84	7	8.33	1.35	12	51	n/a	0	na	5475	Reg6	13	n/a		0	
Acetonitrile	ug/L	44	0	0	n/a	n/a	n/a	n/a	0	na	124.1	Reg6	12	n/a		0	
Acrolein	ug/L	53	1	1.89	7.18	7.18	7.18	n/a	1	na	0.0416	Reg6	12	n/a		1	3
Acrylonitrile	ug/L	53	0	0	n/a	n/a	n/a	n/a	0	na	1.237	Reg6	12	n/a		0	
Aldrin	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	0.0395	Reg6	13	n/a		0	
Amino-2,6-dinitrotoluene[4-]	ug/L	50	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	14	n/a		n/a	
Amino-4,6-dinitrotoluene[2-]	ug/L	50	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	14	n/a		n/a	
Aniline	ug/L	71	0	0	n/a	n/a	n/a	n/a	0	na	117.95	Reg6	13	n/a		0	
Anthracene	ug/L	75	1	1.33	0.236	0.236	0.236	n/a	0	na	1825	Reg6	13	n/a		0	
Aroclor-1016	ug/L	72	0	0	n/a	n/a	n/a	n/a	0	na	0.5	MCL	13	n/a		0	
Aroclor-1221	ug/L	72	0	0	n/a	n/a	n/a	n/a	0	na	0.5	MCL	13	n/a		0	
Aroclor-1232	ug/L	72	0	0	n/a	n/a	n/a	n/a	0	na	0.5	MCL	13	n/a		0	
Aroclor-1242	ug/L	72	0	0	n/a	n/a	n/a	n/a	0	na	0.5	MCL	13	n/a		0	
Aroclor-1248	ug/L	72	0	0	n/a	n/a	n/a	n/a	0	na	0.5	MCL	13	n/a		0	
Aroclor-1254	ug/L	72	1	1.39	0.059	0.059	0.059	n/a	0	na	0.5	MCL	13	n/a		0	
Aroclor-1260	ug/L	72	1	1.39	0.53	0.53	0.53	n/a	1	na	0.5	MCL	13	n/a		1	14
Aroclor-1262	ug/L	38	0	0	n/a	n/a	n/a	n/a	0	na	0.5	MCL	12	n/a		0	
Atrazine	ug/L	36	0	0	n/a	n/a	n/a	n/a	0	na	3	MCL	9	n/a		0	
Azobenzene	ug/L	70	0	0	n/a	n/a	n/a	n/a	0	na	6.112	Reg6	13	n/a		0	
BHC[alpha-]	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	0.1067	Reg6	13	n/a		0	
BHC[beta-]	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	0.3735	Reg6	13	n/a		0	
BHC[delta-]	ug/L	76	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
BHC[gamma-]	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	0.2	MCL	13	n/a		0	
Benzene	ug/L	88	2	2.27	0.3	1.1	1.9	n/a	0	na	5	MCL	13	n/a		0	
Benzidine	ug/L	35	0	0	n/a	n/a	n/a	n/a	0	na	0.0009363	Reg6	10	n/a		0	
Benzo(a)anthracene	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	0.29499	Reg6	13	n/a		0	
Benzo(a)pyrene	ug/L	76	1	1.32	1.1	1.1	1.1	n/a	1	na	0.2	MCL	13	n/a		1	1
Benzo(b)fluoranthene	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	0.29499	Reg6	13	n/a		0	
Benzo(g,h,i)perylene	ug/L	74	1	1.35	3.43	3.43	3.43	n/a	n/a	na	na	n/a	13	n/a		n/a	
Benzo(k)fluoranthene	ug/L	74	1	1.35	0.235	0.235	0.235	n/a	0	na	2.9499	Reg6	13	n/a		0	
Benzoic Acid	ug/L	70	2	2.86	9	11	13	n/a	0	na	146000	Reg6	13	n/a		0	
Benzyl Alcohol	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	10950	Reg6	13	n/a		0	
Bis(2-chloroethoxy)methane	ug/L	76	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Bis(2-chloroethyl)ether	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	0.60216	Reg6	13	n/a		0	
Bis(2-ethylhexyl)phthalate	ug/L	76	4	5.26	1.4	2.18	3.2	n/a	0	na	6	MCL	13	n/a		0	
Bromobenzene	ug/L	85	0	0	n/a	n/a	n/a	n/a	0	na	23.25	Reg6	13	n/a		0	
Bromochloromethane	ug/L	85	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Bromodichloromethane	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	10.69	Reg6	13	n/a		0	
Bromoform	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	85.1	Reg6	13	n/a		0	
Bromomethane	ug/L	82	0	0	n/a	n/a	n/a	n/a	0	na	8.661	Reg6	13	n/a		0	
Bromophenyl-phenylether[4-]	ug/L	76	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Butanol[1-]	ug/L	7	0	0	n/a	n/a	n/a	n/a	0	na	3650	Reg6	4	n/a		0	
Butanone[2-]	ug/L	89	2	2.25	1.73	6.865	12	n/a	0	na	7064.52	Reg6	13	n/a		0	

Table E-1.0-2c
Screening Table for Los Alamos Watershed Organic Constituents in Regional Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd (number of	D>Bkgd	D>Std (number of	D>Std
Organics	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)	locations)	station List[c]	locations)	station List[c]
Butylbenzene[n-]	ug/L	85	0	0	n/a	n/a	n/a	n/a	0	na	60.83	Reg6	13	n/a		0	
Butylbenzene[sec-]	ug/L	85	0	0	n/a	n/a	n/a	n/a	0	na	60.83	Reg6	13	n/a		0	
Butylbenzene[tert-]	ug/L	85	0	0	n/a	n/a	n/a	n/a	0	na	60.83	Reg6	13	n/a		0	
Butylbenzylphthalate	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	7300	Reg6	13	n/a		0	
Carbazole	ug/L	4	0	0	n/a	n/a	n/a	n/a	0	na	33.616	Reg6	2	n/a		0	
Carbon Disulfide	ug/L	89	1	1.12	3.8	3.8	3.8	n/a	0	na	1042.86	Reg6	13	n/a		0	
Carbon Tetrachloride	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	13	n/a		0	
Chlordane[alpha-]	ug/L	76	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Chlordane[gamma-]	ug/L	76	1	1.32	0.00613	0.00613	0.00613	n/a	n/a	na	na	n/a	13	n/a		n/a	
Chloro-1,3-butadiene[2-]	ug/L	44	0	0	n/a	n/a	n/a	n/a	0	na	14.3137	Reg6	12	n/a		0	
Chloro-1-propene[3-]	ug/L	44	0	0	n/a	n/a	n/a	n/a	0	na	1825	Reg6	12	n/a		0	
Chloro-3-methylphenol[4-]	ug/L	73	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Chloroaniline[4-]	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	146	Reg6	13	n/a		0	
Chlorobenzene	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	100	MCL	13	n/a		0	
Chlorodibromomethane	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	7.891	Reg6	13	n/a		0	
Chloroethane	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	228.57	Reg6	13	n/a		0	
Chloroethyl vinyl ether[2-]	ug/L	10	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	7	n/a		n/a	
Chloroform	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	60	MCL	13	n/a		0	
Chloromethane	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	21.345	Reg6	13	n/a		0	
Chloronaphthalene[2-]	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	486.67	Reg6	13	n/a		0	
Chlorophenol[2-]	ug/L	73	0	0	n/a	n/a	n/a	n/a	0	na	30.417	Reg6	13	n/a		0	
Chlorophenyl-phenyl[4-] Ether	ug/L	76	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Chlorotoluene[2-]	ug/L	85	0	0	n/a	n/a	n/a	n/a	0	na	121.67	Reg6	13	n/a		0	
Chlorotoluene[4-]	ug/L	85	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Chrysene	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	0.2	MCL	13	n/a		0	
DB[2,4-]	ug/L	10	0	0	n/a	n/a	n/a	n/a	0	na	292	Reg6	9	n/a		0	
DDD[4,4'-]	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	2.801	Reg6	13	n/a		0	
DDE[4,4'-]	ug/L	75	2	2.67	0.0204	0.02305	0.0257	n/a	0	na	1.977	Reg6	13	n/a		0	
DDT[4,4'-]	ug/L	75	3	4	0.0077	0.0119	0.0415	n/a	0	na	1.977	Reg6	13	n/a		0	
DNX	ug/L	1	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
D[2,4-]	ug/L	10	0	0	n/a	n/a	n/a	n/a	0	na	70	MCL	9	n/a		0	
Dalapon	ug/L	10	0	0	n/a	n/a	n/a	n/a	0	na	200	MCL	9	n/a		0	
Di-n-butylphthalate	ug/L	74	1	1.35	1.4	1.4	1.4	n/a	0	na	3650	Reg6	13	n/a		0	
Di-n-octylphthalate	ug/L	76	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Dibenz(a,h)anthracene	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	0.029499	Reg6	13	n/a		0	
Dibenzofuran	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	12.167	Reg6	13	n/a		0	
Dibromo-3-Chloropropane[1,2-]	ug/L	84	0	0	n/a	n/a	n/a	n/a	0	na	0.2	MCL	13	n/a		0	
Dibromoethane[1,2-]	ug/L	85	0	0	n/a	n/a	n/a	n/a	0	na	0.05	MCL	13	n/a		0	
Dibromomethane	ug/L	85	0	0	n/a	n/a	n/a	n/a	0	na	60.83	Reg6	13	n/a		0	
Dicamba	ug/L	10	0	0	n/a	n/a	n/a	n/a	0	na	1095	Reg6	9	n/a		0	
Dichlorobenzene[1,2-]	ug/L	161	0	0	n/a	n/a	n/a	n/a	0	na	600	MCL	13	n/a		0	
Dichlorobenzene[1,3-]	ug/L	161	0	0	n/a	n/a	n/a	n/a	0	na	600	MCL	13	n/a		0	
Dichlorobenzene[1,4-]	ug/L	161	0	0	n/a	n/a	n/a	n/a	0	na	75	MCL	13	n/a		0	
Dichlorobenzidine[3,3'-]	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	1.494	Reg6	13	n/a		0	
Dichlorodifluoromethane	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	394.59	Reg6	13	n/a		0	
Dichloroethane[1,1-]	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	25	NMGSU	13	n/a		0	
Dichloroethane[1,2-]	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	13	n/a		0	
Dichloroethene[1,1-]	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	5	NMGSU	13	n/a		0	

Table E-1.0-2c
Screening Table for Los Alamos Watershed Organic Constituents in Regional Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd (number of locations)	D>Bkgd station List[c]	D>Std (number of locations)	D>Std station List[c]
Organics	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)				
Dichloroethene[cis-1,2-]	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	70	MCL	13	n/a		0	
Dichloroethene[cis/trans-1,2-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	3	n/a		n/a	
Dichloroethene[trans-1,2-]	ug/L	85	0	0	n/a	n/a	n/a	n/a	0	na	100	MCL	13	n/a		0	
Dichlorophenol[2,4-]	ug/L	73	0	0	n/a	n/a	n/a	n/a	0	na	109.5	Reg6	13	n/a		0	
Dichloropropane[1,2-]	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	13	n/a		0	
Dichloropropane[1,3-]	ug/L	85	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Dichloropropane[2,2-]	ug/L	85	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Dichloropropene[1,1-]	ug/L	85	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Dichloropropene[cis-1,3-]	ug/L	89	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Dichloropropene[cis/trans-1,3-]	ug/L	8	0	0	n/a	n/a	n/a	n/a	0	na	6.7097	Reg6	5	n/a		0	
Dichloropropene[trans-1,3-]	ug/L	89	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Dichlorprop	ug/L	10	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	9	n/a		n/a	
Dieldrin	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	0.04202	Reg6	13	n/a		0	
Diethyl Ether	ug/L	8	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	5	n/a		n/a	
Diethylphthalate	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	29200	Reg6	13	n/a		0	
Dimethyl Phthalate	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	365000	Reg6	13	n/a		0	
Dimethylphenol[2,4-]	ug/L	73	0	0	n/a	n/a	n/a	n/a	0	na	730	Reg6	13	n/a		0	
Dinitro-2-methylphenol[4,6-]	ug/L	73	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Dinitrobenzene[1,3-]	ug/L	50	0	0	n/a	n/a	n/a	n/a	0	na	3.65	Reg6	14	n/a		0	
Dinitrophenol[2,4-]	ug/L	73	0	0	n/a	n/a	n/a	n/a	0	na	73	Reg6	13	n/a		0	
Dinitrotoluene[2,4-]	ug/L	126	0	0	n/a	n/a	n/a	n/a	0	na	73	Reg6	14	n/a		0	
Dinitrotoluene[2,6-]	ug/L	126	0	0	n/a	n/a	n/a	n/a	0	na	36.5	Reg6	14	n/a		0	
Dinoseb	ug/L	45	0	0	n/a	n/a	n/a	n/a	0	na	7	MCL	12	n/a		0	
Dioxane[1,4-]	ug/L	30	0	0	n/a	n/a	n/a	n/a	0	na	61.12	Reg6	7	n/a		0	
Diphenylamine	ug/L	67	0	0	n/a	n/a	n/a	n/a	0	na	912.5	Reg6	13	n/a		0	
Diphenylhydrazine[1,2-]	ug/L	2	0	0	n/a	n/a	n/a	n/a	0	na	0.8404	Reg6	1	n/a		0	
Endosulfan I	ug/L	76	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Endosulfan II	ug/L	74	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Endosulfan Sulfate	ug/L	76	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Endrin	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	2	MCL	13	n/a		0	
Endrin Aldehyde	ug/L	74	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Endrin Ketone	ug/L	76	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Ethyl Methacrylate	ug/L	44	0	0	n/a	n/a	n/a	n/a	0	na	547.5	Reg6	12	n/a		0	
Ethylbenzene	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	700	MCL	13	n/a		0	
Fluoranthene	ug/L	76	1	1.32	0.295	0.295	0.295	n/a	0	na	1460	Reg6	13	n/a		0	
Fluorene	ug/L	74	0	0	n/a	n/a	n/a	n/a	0	na	243.3	Reg6	13	n/a		0	
HMX	ug/L	50	0	0	n/a	n/a	n/a	n/a	0	na	1825	Reg6	14	n/a		0	
Heptachlor	ug/L	75	0	0	n/a	n/a	n/a	n/a	0	na	0.4	MCL	13	n/a		0	
Heptachlor Epoxide	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	0.2	MCL	13	n/a		0	
Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	ug/L	4	2	50	1.65E-06	1.82E-06	1.99E-06	n/a	n/a	na	na	n/a	1	n/a		n/a	
Heptachlorodibenzodioxins (Total)	ug/L	4	2	50	1.65E-06	1.82E-06	1.99E-06	n/a	n/a	na	na	n/a	1	n/a		n/a	
Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Heptachlorodibenzofurans (Total)	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Hexachlorobenzene	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	1	MCL	13	n/a		0	
Hexachlorobutadiene	ug/L	134	0	0	n/a	n/a	n/a	n/a	0	na	8.619	Reg6	13	n/a		0	
Hexachlorocyclopentadiene	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	50	MCL	13	n/a		0	
Hexachlorodibenzodioxin[1,2,3,4,7,8-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	

Table E-1.0-2c
Screening Table for Los Alamos Watershed Organic Constituents in Regional Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd (number of locations)	D>Bkgd station List[c]	D>Std (number of locations)	D>Std station List[c]
Organics	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)				
Hexachlorodibenzodioxin[1,2,3,6,7,8-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Hexachlorodibenzodioxin[1,2,3,7,8,9-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	0	na	0.0001084	Reg6	1	n/a		0	
Hexachlorodibenzodioxins (Total)	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Hexachlorodibenzofuran[1,2,3,4,7,8-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Hexachlorodibenzofuran[1,2,3,6,7,8-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Hexachlorodibenzofuran[1,2,3,7,8,9-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Hexachlorodibenzofuran[2,3,4,6,7,8-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Hexachlorodibenzofurans (Total)	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Hexachloroethane	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	48.0225	Reg6	13	n/a		0	
Hexanone[2-]	ug/L	89	1	1.12	1.34	1.34	1.34	n/a	n/a	na	na	n/a	13	n/a		n/a	
Indeno(1,2,3-cd)pyrene	ug/L	75	0	0	n/a	n/a	n/a	n/a	0	na	0.29499	Reg6	13	n/a		0	
Iodomethane	ug/L	85	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Isobutyl alcohol	ug/L	41	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	11	n/a		n/a	
Isophorone	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	707.7	Reg6	13	n/a		0	
Isopropylbenzene	ug/L	85	4	4.71	0.299	0.48	0.94	n/a	0	na	658.2	Reg6	13	n/a		0	
Isopropyltoluene[4-]	ug/L	85	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
MCPA	ug/L	10	0	0	n/a	n/a	n/a	n/a	0	na	18.25	Reg6	9	n/a		0	
MCPP	ug/L	10	0	0	n/a	n/a	n/a	n/a	0	na	36.5	Reg6	9	n/a		0	
MNX	ug/L	1	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Methacrylonitrile	ug/L	43	0	0	n/a	n/a	n/a	n/a	0	na	1.043	Reg6	11	n/a		0	
Methoxychlor[4,4'-]	ug/L	74	0	0	n/a	n/a	n/a	n/a	0	na	40	MCL	12	n/a		0	
Methyl Methacrylate	ug/L	44	0	0	n/a	n/a	n/a	n/a	0	na	1419.4	Reg6	12	n/a		0	
Methyl tert-Butyl Ether	ug/L	8	0	0	n/a	n/a	n/a	n/a	0	na	370.83	Reg6	5	n/a		0	
Methyl-2-pentanone[4-]	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	1990.91	Reg6	13	n/a		0	
Methylene Chloride	ug/L	89	1	1.12	0.73	0.73	0.73	n/a	0	na	5	MCL	13	n/a		0	
Methylnaphthalene[1-]	ug/L	36	1	2.78	0.325	0.325	0.325	n/a	n/a	na	na	n/a	9	n/a		n/a	
Methylnaphthalene[2-]	ug/L	74	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Methylphenol[2-]	ug/L	73	0	0	n/a	n/a	n/a	n/a	0	na	1825	Reg6	13	n/a		0	
Methylphenol[3-,4-]	ug/L	40	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	9	n/a		n/a	
Methylphenol[4-]	ug/L	29	3	10.3	1.2	1.8	58	n/a	0	na	182.5	Reg6	12	n/a		0	
Methylpyridine[2-]	ug/L	6	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	4	n/a		n/a	
Naphthalene	ug/L	133	0	0	n/a	n/a	n/a	n/a	0	na	30	NMGSU	13	n/a		0	
Nitroaniline[2-]	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	109.5	Reg6	13	n/a		0	
Nitroaniline[3-]	ug/L	76	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Nitroaniline[4-]	ug/L	76	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Nitrobenzene	ug/L	126	0	0	n/a	n/a	n/a	n/a	0	na	3.395	Reg6	14	n/a		0	
Nitrophenol[2-]	ug/L	71	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	
Nitrophenol[4-]	ug/L	74	0	0	n/a	n/a	n/a	n/a	0	na	292	Reg6	13	n/a		0	
Nitroso-di-n-butylamine[N-]	ug/L	36	0	0	n/a	n/a	n/a	n/a	0	na	0.1227	Reg6	9	n/a		0	
Nitroso-di-n-propylamine[N-]	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	0.096045	Reg6	13	n/a		0	
Nitrosodiethylamine[N-]	ug/L	36	0	0	n/a	n/a	n/a	n/a	0	na	0.0014356	Reg6	9	n/a		0	
Nitrosodimethylamine[N-]	ug/L	72	0	0	n/a	n/a	n/a	n/a	0	na	0.004222	Reg6	13	n/a		0	
Nitrosodiphenylamine[N-]	ug/L	9	1	11.1	9.6	9.6	9.6	n/a	0	na	137.207	Reg6	5	n/a		0	
Nitrosopyrrolidine[N-]	ug/L	36	0	0	n/a	n/a	n/a	n/a	0	na	0.32015	Reg6	9	n/a		0	
Nitrotoluene[2-]	ug/L	50	0	0	n/a	n/a	n/a	n/a	0	na	2.9231	Reg6	14	n/a		0	
Nitrotoluene[3-]	ug/L	50	0	0	n/a	n/a	n/a	n/a	0	na	121.67	Reg6	14	n/a		0	
Nitrotoluene[4-]	ug/L	50	1	2	0.18	0.18	0.18	n/a	0	na	39.548	Reg6	14	n/a		0	
Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	

Table E-1.0-2c
Screening Table for Los Alamos Watershed Organic Constituents in Regional Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]						
Organics	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	Locations with data (number)	D>Bkgd (number of locations)	D>Bkgd station List[c]	D>Std (number of locations)	D>Std station List[c]
Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Oxybis(1-chloropropane)[2,2'-]	ug/L	73	0	0	n/a	n/a	n/a	n/a	0	na	9.5364	Reg6	13	n/a		0	
PETN	ug/L	8	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Pentachlorobenzene	ug/L	36	0	0	n/a	n/a	n/a	n/a	0	na	29.2	Reg6	9	n/a		0	
Pentachlorodibenzodioxin[1,2,3,7,8-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Pentachlorodibenzodioxins (Total)	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Pentachlorodibenzofuran[1,2,3,7,8-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Pentachlorodibenzofuran[2,3,4,7,8-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Pentachlorodibenzofurans (Totals)	ug/L	4	1	25	7.50E-07	7.50E-07	7.50E-07	n/a	n/a	na	na	n/a	1	n/a		n/a	
Pentachlorophenol	ug/L	73	0	0	n/a	n/a	n/a	n/a	0	na	1	MCL	13	n/a		0	
Phenanthrene	ug/L	72	1	1.39	0.279	0.279	0.279	n/a	n/a	na	na	n/a	13	n/a		n/a	
Phenol	ug/L	73	1	1.37	11	11	11	n/a	1	na	5	NMGSU	13	n/a		1	7
Propionitrile	ug/L	44	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	12	n/a		n/a	
Propylbenzene[1-]	ug/L	85	0	0	n/a	n/a	n/a	n/a	0	na	60.83	Reg6	13	n/a		0	
Pyrene	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	182.5	Reg6	13	n/a		0	
Pyridine	ug/L	21	0	0	n/a	n/a	n/a	n/a	0	na	36.5	Reg6	12	n/a		0	
RDX	ug/L	49	0	0	n/a	n/a	n/a	n/a	0	na	6.11196	Reg6	14	n/a		0	
Styrene	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	100	MCL	13	n/a		0	
TATB	ug/L	8	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
TNX	ug/L	1	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
TP[2,4,5-]	ug/L	10	0	0	n/a	n/a	n/a	n/a	0	na	50	MCL	9	n/a		0	
T[2,4,5-]	ug/L	10	0	0	n/a	n/a	n/a	n/a	0	na	365	Reg6	9	n/a		0	
Tetrachlorobenzene[1,2,4,5]	ug/L	36	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	9	n/a		n/a	
Tetrachlorodibenzodioxin[2,3,7,8-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	0	na	3.00E-05	MCL	1	n/a		0	
Tetrachlorodibenzodioxins (Total)	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Tetrachlorodibenzofuran[2,3,7,8-]	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Tetrachlorodibenzofurans (Totals)	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Tetrachloroethane[1,1,1,2-]	ug/L	83	0	0	n/a	n/a	n/a	n/a	0	na	25.4955	Reg6	13	n/a		0	
Tetrachloroethane[1,1,2,2-]	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	10	NMGSU	13	n/a		0	
Tetrachloroethene	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	13	n/a		0	
Tetrachlorophenol[2,3,4,6-]	ug/L	35	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	9	n/a		0	
Tetryl	ug/L	49	0	0	n/a	n/a	n/a	n/a	0	na	146	Reg6	14	n/a		0	
Toluene	ug/L	89	8	8.99	0.18	1.05	12	n/a	0	na	750	NMGSU	13	n/a		0	
Toxaphene (Technical Grade)	ug/L	76	0	0	n/a	n/a	n/a	n/a	0	na	3	MCL	13	n/a		0	
Trichloro-1,2,2-trifluoroethane[1,1,2-]	ug/L	75	0	0	n/a	n/a	n/a	n/a	0	na	59179.86	Reg6	13	n/a		0	
Trichlorobenzene[1,2,3-]	ug/L	51	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	12	n/a		n/a	
Trichlorobenzene[1,2,4-]	ug/L	125	0	0	n/a	n/a	n/a	n/a	0	na	70	MCL	13	n/a		0	
Trichloroethane[1,1,1-]	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	60	NMGSU	13	n/a		0	
Trichloroethane[1,1,2-]	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	13	n/a		0	
Trichloroethene	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	13	n/a		0	
Trichlorofluoromethane	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	5	MCL	13	n/a		0	
Trichlorophenol[2,4,5-]	ug/L	73	0	0	n/a	n/a	n/a	n/a	0	na	3650	Reg6	13	n/a		0	
Trichlorophenol[2,4,6-]	ug/L	73	0	0	n/a	n/a	n/a	n/a	0	na	6.11196	Reg6	13	n/a		0	
Trichloropropane[1,2,3-]	ug/L	85	0	0	n/a	n/a	n/a	n/a	0	na	0.09469	Reg6	13	n/a		0	
Trimethylbenzene[1,2,4-]	ug/L	85	0	0	n/a	n/a	n/a	n/a	0	na	12.429	Reg6	13	n/a		0	
Trimethylbenzene[1,3,5-]	ug/L	85	0	0	n/a	n/a	n/a	n/a	0	na	12.3262	Reg6	13	n/a		0	
Trinitrobenzene[1,3,5-]	ug/L	50	0	0	n/a	n/a	n/a	n/a	0	na	1095	Reg6	14	n/a		0	

Table E-1.0-2c
Screening Table for Los Alamos Watershed Organic Constituents in Regional Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd	D>Bkgd	D>Std	D>Std
Organics	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)	(number of locations)	station List[c]	(number of locations)	station List[c]
Trinitrotoluene[2,4,6-]	ug/L	50	0	0	n/a	n/a	n/a	n/a	0	na	22.4105	Reg6	14	n/a		0	
Tris (o-cresyl) phosphate	ug/L	8	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	2	n/a		n/a	
Vinyl Chloride	ug/L	89	0	0	n/a	n/a	n/a	n/a	0	na	1	NMGSU	13	n/a		0	
Vinyl acetate	ug/L	41	0	0	n/a	n/a	n/a	n/a	0	na	412.429	Reg6	12	n/a		0	
Xylene (Total)	ug/L	48	0	0	n/a	n/a	n/a	n/a	0	na	10000	MCL	11	n/a		0	
Xylene[1,2-]	ug/L	69	0	0	n/a	n/a	n/a	n/a	0	na	1431.37	Reg6	13	n/a		0	
Xylene[1,3-]+Xylene[1,4-]	ug/L	62	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	13	n/a		n/a	

n/a=not applicable
na = not available (no published value)

[c] Station List (codes)

1=R-2	8=R-8, Screen 1
2=R-24	9=R-8, Screen 2
3=R-4	10=R-9
4=R-5, Screen 3	11=Test Well 1
5=R-5, Screen 4	12=Test Well 2
6=R-6	13=Test Well 3
7=R-7, Screen 3	14=Test Well 4

[a]GW Bkgd upper tolerance level (UTL) or maximum detect for Regional Groundwater unfiltered samples
LANL, 2007. Groundwater Background Investigation, Rev 3.
[b]Screening Standard

Std Type	Standard (Source and Name)
MCL	EPA Maximum Contaminant Level (MCL)
Reg6	EPA Region 6 Tap Water Screening Level
NMGSU	NMAC 20.6.2, Groundwater Standards (Unfiltered)

Table E-1.0-2d

Screening Table for Los Alamos Watershed Radioactive Constituents in Regional Groundwater Filtered (F) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd (number of locations)	D>Bkgd station List[c]	(number of locations)	D>Std station List[c]
Radionuclides	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)				
Americium-241	pCi/L	30	1	3.33	0.0221	0.0221	0.0221	0	0	0.032	20	NMRPS	10	0		0	
Cesium-137	pCi/L	28	0	0	n/a	n/a	n/a	0	0	4.45	1000	NMRPS	10	0		0	
Cobalt-60	pCi/L	27	0	0	n/a	n/a	n/a	n/a	0	na	3000	NMRPS	10	n/a		0	
Gross alpha	pCi/L	23	9	39.1	1.4	1.99	3.01	2	0	2.54	15	MCL	7	2	2, 6	0	
Gross beta	pCi/L	23	12	52.2	1.72	4.15	5.27	0	0	14.1	50	SMCL	7	0		0	
Gross gamma	pCi/L	23	2	8.7	132	140.5	149	2	n/a	123	na	n/a	7	1	10	n/a	
Neptunium-237	pCi/L	24	0	0	n/a	n/a	n/a	n/a	0	na	20	NMRPS	8	n/a		0	
Plutonium-238	pCi/L	30	1	3.33	0.0377	0.0377	0.0377	1	0	0.025	20	NMRPS	10	1	13	0	
Plutonium-239/240	pCi/L	29	0	0	n/a	n/a	n/a	n/a	0	na	20	NMRPS	10	n/a		0	
Potassium-40	pCi/L	26	0	0	n/a	n/a	n/a	n/a	0	na	4000	NMRPS	10	n/a		0	
Sodium-22	pCi/L	27	0	0	n/a	n/a	n/a	n/a	0	na	6000	NMRPS	9	n/a		0	
Strontium-90	pCi/L	30	0	0	n/a	n/a	n/a	0	0	4.49	8	MCL	10	0		0	
Uranium-234	pCi/L	30	28	93.3	0.0602	0.799	1.43	0	0	2.17	300	NMRPS	10	0		0	
Uranium-235/Uranium-236	pCi/L	30	10	33.3	0.0219	0.04755	0.103	n/a	n/a	na	na	n/a	10	n/a		n/a	
Uranium-238	pCi/L	30	26	86.7	0.0956	0.539	0.864	0	0	1.2	300	NMRPS	10	0		0	

n/a=not applicable
na = not available (no published value)

[c] Station List (codes)

1=R-2	8=R-8, Screen 1
2=R-24	9=R-8, Screen 2
3=R-4	10=R-9
4=R-5, Screen 3	11=Test Well 1
5=R-5, Screen 4	12=Test Well 2
6=R-6	13=Test Well 3
7=R-7, Screen 3	14=Test Well 4

[a]GW Bkgd upper tolerance level (UTL) or maximum detect for Regional Groundwater filtered samples
LANL, 2007. Groundwater Background Investigation, Rev 3.

[b]Screening Standard

Std Type	Standard (Source and Name)
MCL	EPA Maximum Contaminant Level (MCL)
Reg6	EPA Region 6 Tap Water Screening Level
NMGSF	NMAC 20.6.2, Groundwater Standards (Filtered)

Table E-1.0-2e

Screening Table for Los Alamos Watershed Radioactive Constituents in Regional Groundwater Unfiltered (UF) Sample

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd (number of locations)	D>Bkgd	D>Std (number of locations)	D>Std
Radionuclides	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)		station List[c]		station List[c]
Americium-241	pCi/L	94	13	13.8	-0.0077	0.0185	0.0522	n/a	0	na	20	NMRPS	14	n/a		0	
Cesium-137	pCi/L	92	7	7.61	-0.43	0.15	9.47	n/a	0	na	1000	NMRPS	14	n/a		0	
Cobalt-60	pCi/L	86	5	5.81	-0.36	0	5.52	n/a	0	na	3000	NMRPS	14	n/a		0	
Gross alpha	pCi/L	69	29	42	0.06	2.21	13.5	n/a	0	na	15	MCL	13	n/a		0	
Gross alpha/beta	pCi/L	4	2	50	1.61	1.965	2.32	n/a	n/a	na	na	n/a	3	n/a		n/a	
Gross beta	pCi/L	73	54	74	0.98	3.745	6.79	n/a	0	na	50	SMCL	14	n/a		0	
Gross gamma	pCi/L	71	11	15.5	45.1	108	237	n/a	n/a	na	na	n/a	14	n/a		n/a	
Iodine-129	pCi/L	28	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	7	n/a		n/a	
Neptunium-237	pCi/L	62	0	0	n/a	n/a	n/a	n/a	0	na	20	NMRPS	12	n/a		0	
Plutonium-238	pCi/L	94	6	6.38	-0.00212	0.01555	0.0634	n/a	0	na	20	NMRPS	14	n/a		0	
Plutonium-239/240	pCi/L	94	8	8.51	0	0.01745	0.0556	n/a	0	na	20	NMRPS	14	n/a		0	
Potassium-40	pCi/L	80	9	11.3	-46.3	24.6	65.6	n/a	0	na	4000	NMRPS	14	n/a		0	
Radium-226	pCi/L	22	7	31.8	0.274	0.571	1.17	n/a	0	na	5	MCL	8	n/a		0	
Sodium-22	pCi/L	91	5	5.49	-6.76	-0.63	1.16	n/a	0	na	6000	NMRPS	14	n/a		0	
Strontium-90	pCi/L	118	6	5.08	0.01	0.03	0.88	n/a	0	na	8	MCL	14	n/a		0	
Technetium-99	pCi/L	31	0	0	n/a	n/a	n/a	n/a	0	na	4000	DCG	8	n/a		0	
Thorium-228	pCi/L	10	1	10	0.0432	0.0432	0.0432	n/a	n/a	na	na	n/a	5	n/a		n/a	
Thorium-230	pCi/L	10	4	40	0.0451	0.06165	0.172	n/a	n/a	na	na	n/a	5	n/a		n/a	
Thorium-232	pCi/L	10	1	10	0.00645	0.00645	0.00645	n/a	n/a	na	na	n/a	5	n/a		n/a	
Tritium	pCi/L	131	62	47.3	-40	10.98	199	30	0	11.43	20000	MCL	14	7	1, 3, 10, 11, 12, 13	0	
Uranium-234	pCi/L	94	86	91.5	0.0324	0.5474	2.14	n/a	0	na	300	NMRPS	14	n/a		0	
Uranium-235/Uranium-236	pCi/L	94	36	38.3	-0.0118	0.06115	0.181	n/a	n/a	na	na	n/a	14	n/a		n/a	
Uranium-238	pCi/L	94	85	90.4	0.0201	0.269	1.18	n/a	0	na	300	NMRPS	14	n/a		0	

n/a=not applicable

na = not available (no published value)

[c] Station List (codes)

1=R-2	8=R-8, Screen 1
2=R-24	9=R-8, Screen 2
3=R-4	10=R-9
4=R-5, Screen 3	11=Test Well 1
5=R-5, Screen 4	12=Test Well 2
6=R-6	13=Test Well 3
7=R-7, Screen 3	14=Test Well 4

[a]GW Bkgd upper tolerance level (UTL) or maximum detect for Regional Groundwater unfiltered samples
LANL, 2007. Groundwater Background Investigation, Rev 3.

[b]Screening Standard

Std Type	Standard (Source and Name)
MCL	EPA Maximum Contaminant Level (MCL)
Reg6	EPA Region 6 Tap Water Screening Level
NMGSU	NMAC 20.6.2, Groundwater Standards (Unfiltered)

Table E-1.0-2f
Screening Table for Los Alamos Watershed General Chemistry Constituents in Regional Groundwater Filtered (F) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd (number of locations)	D>Bkgd station List[c]	D>Std (number of locations)	D>Std station List[c]
General Inorganics	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)				
Alkalinity-CO3	ug/L	45	28	62.2	786	1090	19400	n/a	n/a	na	na	n/a	10	n/a		n/a	
Alkalinity-CO3+HCO3	ug/L	71	71	100	51400	77670	153000	0	n/a	156600	na	n/a	13	0		n/a	
Alkalinity-HCO3	ug/L	10	10	100	64000	68600	120000	n/a	n/a	na	na	n/a	6	n/a		n/a	
Ammonia	ug/L	10	5	50	380	450	710	n/a	n/a	na	na	n/a	4	n/a		n/a	
Ammonia as Nitrogen	ug/L	43	3	6.98	66	117	607	1	1	250	208.57	Reg6	8	1	13	1	13
Bromide	ug/L	75	22	29.3	21.08	71.5	241	2	n/a	180	na	n/a	13	1	10	n/a	
Calcium	ug/L	76	76	100	5230	17050	51500	13	n/a	24880	na	n/a	13	5	4, 5, 7, 10, 11	n/a	
Carbote	ug/L	10	0	0	n/a	n/a	n/a	0	n/a	7200	na	n/a	4	0		n/a	
Chloride	ug/L	75	74	98.7	1380	4690	39240	41	0	3570	250000	NMGSF	13	8	2, 3, 4, 5, 9, 10, 11, 13	0	
Cyanide (Total)	ug/L	18	0	0	n/a	n/a	n/a	n/a	0	na	200	NMGSF	7	n/a		0	
Fluoride	ug/L	75	74	98.7	203	396.5	1250	12	0	570	1600	NMGSF	13	4	3, 4, 8, 12	0	
Hardness	ug/L	34	34	100	36700	56950	91100	n/a	n/a	na	na	n/a	7	n/a		n/a	
Humic Substances, Hydrophilic Acids	ug/L	8	8	100	200	800	2300	n/a	n/a	na	na	n/a	4	n/a		n/a	
Humic Substances, Hydrophilic Bases	ug/L	8	8	100	0	100	400	n/a	n/a	na	na	n/a	4	n/a		n/a	
Humic Substances, Hydrophilic Neutrals	ug/L	8	8	100	100	300	1900	n/a	n/a	na	na	n/a	4	n/a		n/a	
Humic Substances, Hydrophilic Total	ug/L	8	8	100	500	1350	4100	n/a	n/a	na	na	n/a	4	n/a		n/a	
Humic Substances, Hydrophobic Acids	ug/L	8	8	100	400	750	2500	n/a	n/a	na	na	n/a	4	n/a		n/a	
Humic Substances, Hydrophobic Bases	ug/L	7	7	100	0	0	200	n/a	n/a	na	na	n/a	3	n/a		n/a	
Humic Substances, Hydrophobic Neutrals	ug/L	8	8	100	300	850	1600	n/a	n/a	na	na	n/a	4	n/a		n/a	
Humic Substances, Hydrophobic Total	ug/L	8	8	100	800	1700	4200	n/a	n/a	na	na	n/a	4	n/a		n/a	
Magnesium	ug/L	76	76	100	1210	3670	10100	26	n/a	4150	na	n/a	13	6	5, 7, 9, 10, 11, 13	n/a	
Nitrate as Nitrogen	ug/L	16	13	81.3	3	398	5780	4	0	530	10000	MCL	9	2	10, 11	0	
Nitrate-Nitrite as Nitrogen	ug/L	71	63	88.7	10	367	4880	12	n/a	890	na	n/a	12	3	3, 4, 11	n/a	
Nitrite as Nitrogen	ug/L	13	1	7.69	22	22	22	1	0	0	1000	MCL	8	1	2	0	
Oxalate	ug/L	24	1	4.17	70	70	70	n/a	n/a	na	na	n/a	10	n/a		n/a	
Perchlorate	ug/L	82	35	42.7	0.202	0.373	4.65	16	0	0.46	24.5	Reg6	13	4	3, 4, 10, 11	0	
Phosphorus, Orthophosphate (Expressed as PO4)	ug/L	4	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	4	n/a		n/a	
Potassium	ug/L	76	76	100	1050	2640	5530	40	n/a	2630	na	n/a	13	8	2, 3, 4, 5, 7, 9, 10, 11	n/a	
Silicon Dioxide	ug/L	70	70	100	1070	58200	92100	1	n/a	88500	na	n/a	13	1	1	n/a	
Sodium	ug/L	76	76	100	8700	15600	37900	11	n/a	24500	na	n/a	13	2	2, 9	n/a	
Sulfate	ug/L	75	72	96	340	3970	24500	13	0	7200	600000	NMGSF	13	3	2, 4, 11	0	
Total Kjeldahl Nitrogen	ug/L	58	25	43.1	29	240	1600	4	n/a	1000	na	n/a	12	2	5, 7	n/a	
Total Phosphate as Phosphorus	ug/L	70	18	25.7	3.26	26.5	148	0	n/a	340	na	n/a	13	0		n/a	
Total Phosphorus	ug/L	5	1	20	51	51	51	n/a	1	na	0.73	Reg6	2	n/a		1	10

n/a=not applicable
na = not available (no published value)

[c] Station List (codes)

1=R-2	8=R-8, Screen 1
2=R-24	9=R-8, Screen 2
3=R-4	10=R-9
4=R-5, Screen 3	11=Test Well 1
5=R-5, Screen 4	12=Test Well 2
6=R-6	13=Test Well 3
7=R-7, Screen 3	14=Test Well 4

[a]GW Bkgd upper tolerance level (UTL) or maximum detect for Regional Groundwater filtered samples
LANL, 2007. Groundwater Background Investigation, Rev 3.
[b]Screening Standard

Std Type	Standard (Source and Name)
MCL	EPA Maximum Contaminant Level (MCL)
Reg6	EPA Region 6 Tap Water Screening Level
NMGSF	NMAC 20.6.2, Groundwater Standards (Filtered)

Table E-1.0-2g
Screening Table for Los Alamos Watershed General Chemistry Constituents in Regional Groundwater Unfiltered (UF) Samples

Constituent		Summary by Sample								Screening Values			Location Summary				
			detects (D)					exceedances		GW Bkgd[a]	Screening Standard[b]		Locations with data	D>Bkgd		D>Std	
General Inorganics	Units	total	number	rate (%)	Min.	Median	Max.	D>Bkgd (number)	D>Std (number)	Level	Level	Std Type	(number)	(number of locations)	D>Bkgd station List[c]	(number of locations)	D>Std station List[c]
Alkalinity-CO3	ug/L	42	6	14.3	784	889	6510	n/a	n/a	na	na	n/a	13	n/a		n/a	
Alkalinity-CO3+HCO3	ug/L	73	73	100	38000	78100	135000	n/a	n/a	na	na	n/a	13	n/a		n/a	
Alkalinity-HCO3	ug/L	26	26	100	38000	87500	134000	n/a	n/a	na	na	n/a	7	n/a		n/a	
Ammonia	ug/L	2	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	1	n/a		n/a	
Ammonia as Nitrogen	ug/L	28	2	7.14	62	86	110	n/a	0	na	208.57	Reg6	8	n/a		0	
Bromide	ug/L	58	35	60.3	10	40	162	n/a	n/a	na	na	n/a	12	n/a		n/a	
Calcium	ug/L	133	133	100	6840	16900	53500	n/a	n/a	na	na	n/a	14	n/a		n/a	
Carbote	ug/L	35	12	34.3	5480	7310	28100	n/a	n/a	na	na	n/a	8	n/a		n/a	
Chloride	ug/L	79	79	100	1320	3610	38800	n/a	n/a	na	na	n/a	13	n/a		n/a	
Cyanide (Total)	ug/L	96	6	6.25	2.2	4.23	30	n/a	0	na	200	MCL	14	n/a		0	
Fluoride	ug/L	79	79	100	158	358	880	n/a	0	na	4000	MCL	13	n/a		0	
Hardness	ug/L	66	66	100	30800	58650	177000	n/a	n/a	na	na	n/a	13	n/a		n/a	
Magnesium	ug/L	133	133	100	1850	3720	10600	n/a	n/a	na	na	n/a	14	n/a		n/a	
Nitrate as Nitrogen	ug/L	39	39	100	50	420	5310	n/a	0	na	10000	Reg6	12	n/a		0	
Nitrate-Nitrite as Nitrogen	ug/L	53	48	90.6	10	364	6050	n/a	n/a	na	na	n/a	13	n/a		n/a	
Nitrite as Nitrogen	ug/L	34	0	0	n/a	n/a	n/a	n/a	0	na	1000	Reg6	8	n/a		0	
Oxalate	ug/L	36	0	0	n/a	n/a	n/a	n/a	n/a	na	na	n/a	8	n/a		n/a	
Perchlorate	ug/L	146	54	37	0.0912	0.47	5.02	28	0	0.44	24.5	Reg6	13	4	1, 3, 10, 11	0	
Potassium	ug/L	133	133	100	659	2590	5320	n/a	n/a	na	na	n/a	14	n/a		n/a	
Silicon Dioxide	ug/L	104	104	100	2000	43950	91900	n/a	n/a	na	na	n/a	14	n/a		n/a	
Sodium	ug/L	133	133	100	7880	16100	1950000	n/a	n/a	na	na	n/a	14	n/a		n/a	
Sulfate	ug/L	79	76	96.2	596	3880	23700	n/a	n/a	na	na	n/a	13	n/a		n/a	
Total Kjeldahl Nitrogen	ug/L	61	22	36.1	49	267	1710	n/a	n/a	na	na	n/a	12	n/a		n/a	
Total Phosphate as Phosphorus	ug/L	83	33	39.8	0	19.56	1150	n/a	n/a	na	na	n/a	13	n/a		n/a	
Total Phosphorus	ug/L	2	1	50	52	52	52	n/a	1	na	0.73	Reg6	1	n/a		1	10

n/a=not applicable
na = not available (no published value)

[c] Station List (codes)

1=R-2	8=R-8, Screen 1
2=R-24	9=R-8, Screen 2
3=R-4	10=R-9
4=R-5, Screen 3	11=Test Well 1
5=R-5, Screen 4	12=Test Well 2
6=R-6	13=Test Well 3
7=R-7, Screen 3	14=Test Well 4

[a]GW Bkgd upper tolerance level (UTL) or maximum detect for Regional Groundwater unfiltered samples
LANL, 2007. Groundwater Background Investigation, Rev 3.
[b]Screening Standard

Std Type	Standard (Source and Name)
MCL	EPA Maximum Contaminant Level (MCL)
Reg6	EPA Region 6 Tap Water Screening Level
NMGSU	NMAC 20.6.2, Groundwater Standards (Unfiltered)

Table E-2.0-1
Highest Representative Concentrations of Site-Specific Contaminants in Laboratory Monitoring Wells in Los Alamos Watershed

Well	Screen Depth (ft)	Period of Water-Quality Record Examined	^3H pCi/L	Cl mg/L	NO_3 mg/L as N	ClO_4 µg/L	SO_4 mg/L	U µg/L	Cr µg/L	B µg/L	Mo µg/L
Well screens completed in the intermediate perched zone (listed in order of distance downgradient)											
Upper Background Limit[a]			17	7.78	0.54	0.46	40	0.72	2.4	15	4.3
LAOI(a)-1.1	295	1995—2007	Bkgd[a]	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd
R-7	378	2001—2002	Bkgd	Bkgd	Bkgd	Indeter (D)[b]	Bkgd	Indeter (D)	Bkgd	Indeter (D)	Bkgd
LADP-3	316	1995—2007	1500	36	Bkgd	Indeter (D)	14	Indeter (D)	10	20	Bkgd
R-6i	602	2005—2007	4400	18	5	8	13	Bkgd	Bkgd	22	Bkgd
LAOI-3.2	153	2005—2007	4000	19	4	7	Bkgd	2	Indeter	Bkgd	Bkgd
LAOI-3.2(a)	181	2006—2007	2900	20	3	5	9	1.5	Indeter	Bkgd	Bkgd
LAOI-7	240	2006—2007	1200	25	Bkgd	1	9	Bkgd	Bkgd	Indeter (D)	Bkgd
R-9i	199	2000—2007	250	43	Indeter (W,R)[c, d]	Indeter (W,R)	23	1	3	Indeter (D)	20
R-9i	279	2000—2007	150	23	Indeter (W,R)	Indeter (W,R)	18	1	Indeter (R)	Indeter (D)	Indeter (W)

Table E-2.0-1 (continued)

Well	Screen Depth (ft)	Period of Water-Quality Record Examined	^3H pCi/L	Cl mg/L	NO_3 mg/L as N	ClO_4 µg/L	SO_4 mg/L	U µg/L	Cr µg/L	B µg/L	Mo µg/L
Well screens completed in the regional aquifer (listed in order of distance downgradient)											
Upper Background Limit			1	3.57	0.89	0.46	7.2	1.9	5.75	39	4.4
R-7	915	2001—2007	Dead[e]	Bkgd	Indeter (R)	Indeter (R)	Indeter (R)	Indeter (R)	Indeter (R)	Indeter	Indeter (W)
R-6	1205	2005—2007	Dead	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd
TW-3	805	1995—2006	15	Bkgd	1	Indeter (R)	Bkgd	Indeter (C)[f]	Indeter (R,C)	110	Bkgd
R-8	711	2004—2007	Dead	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd
R-8	825	2004—2007	Dead	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd
R-9	684	2000—2007	16	7	1	1	Bkgd	2	Bkgd	49	Bkgd

Note: Yellow highlight indicates constituent is present in well above background concentrations.

[a] Bkgd = Not detected above groundwater background levels. Upper background limits for tritium of 17 pCi/L for intermediate perched groundwater and 1 pCi/L for regional groundwater are based on Longmire et al. (2007, 096660). Upper background values for other constituents are taken from "Groundwater Background Investigation Report Revision 3" (LANL 2007, 095817, Tables 4.2-2 and 4.2-3).

[b] Indeter (D) = Indeterminate due to inadequacies of data record, such as sampling frequency, detection limits, variability, or data quality.

[c] Indeter (W) = Indeterminate due to residual effects of drilling.

[d] Indeter (R = Indeterminate due to reducing conditions that are unrelated to residual effects of drilling or well construction.

[e] Dead = Tritium is not detected above 1 pCi/L.

[f] Indeter (C) = Indeterminate due to metal corrosion.

Table E-2.0-2
Highest Representative Concentrations of Site-Specific Contaminants in Laboratory Monitoring Wells in the Pueblo/Bayo Watershed

Well	Screen Depth (ft)	Period of Water-Quality Record Examined	^3H pCi/L	Cl mg/L	NO_3 mg/L as N	ClO_4 µg/L	SO_4 mg/L	U µg/L	Cr µg/L	B µg/L	Mo µg/L
Well screens completed in the intermediate perched zone (listed in order of distance downgradient)											
Upper Background Limit[a]			17	7.78	0.54	0.46	40	0.72	2.4	15	4.3
TW-2a	123	1995—2005	3300	70	2	Indeter (R)[b]	25	Indeter (R)	Indeter	80	Indeter
POI-4	159	2000—2007	23	46	7	Bkgd[a]	24	3	Bkgd	230	Bkgd
R-5	384	2004—2007	Dead[c]	Bkgd	3	2	Bkgd	3	4	24	Bkgd
R-3i	215	2006—2007	74	39	4	3	23	10	Bkgd	95	Bkgd
TW-1A	215	1995—2005	80	80	Indeter (D,R,C)[d, e]	Indeter (D,R,C)	Indeter (D,R,C)	Indeter (D,R,C)	Indeter	180	Indeter (D,R,C)
Well screens completed in the regional aquifer (listed in order of distance downgradient)											
Upper Background Limit			1	3.57	0.89	0.46	7.2	1.9	5.75	39	4.4
TW-4	1195	1995—2005	Bkgd	Bkgd	Indeter (D,R)	Indeter (D,R)	Indeter (D,R)	Indeter (D,R)	Indeter (D,C,R)	Indeter	Bkgd
R-2	918	2005—2007	Dead	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd
TW-2	768	1995—2005	Bkgd	Bkgd	Indeter (D,R,W)[f]	Indeter (D,R,W)	Indeter (D,R,W)	Indeter (D,R,W)	Indeter Reducing	Bkgd	Bkgd
R-4	793	2005—2007	60	Bkgd	2	5	Bkgd	Bkgd	Bkgd	Bkgd	Bkgd

Table E-2.0-2 (continued)

Well	Screen Depth (ft)	Period of Water-Quality Record Examined	^3H pCi/L	Cl mg/L	NO_3 mg/L as N	ClO_4 µg/L	SO_4 mg/L	U µg/L	Cr µg/L	B µg/L	Mo µg/L
R-24	825	2005—2007	Dead	Bkgd	Bkgd	Bkgd	Indeter (W)	Indeter (W)	Bkgd	Indeter	Indeter (W)
R-5	719	2001—2007	Dead	Bkgd	2	1	17	Indeter (B)[g]	8	35	Bkgd
R-5	861	2001—2007	Dead	Bkgd	Indeter (D,R)	Bkgd	Bkgd	Indeter (D,R)	Indeter (R)	Indeter (W)	Indeter (D,W)
TW-1	632	1995—2005	280	40	6	2	24	3	Indeter (C,R)	90	Bkgd

Note: Yellow highlight indicates constituent is present in well above background concentrations.

[a] Bkgd = Not detected above groundwater background levels. Upper background limits for tritium of 17 pCi/L for intermediate perched groundwater and 1 pCi/L for regional groundwater are based on Longmire et al. (2007, 096660). Upper background values for other constituents are taken from "Groundwater Background Investigation Report Revision 3" (LANL 2007, 095817, Tables 4.2-2 and 4.2-3).

[b] Indeter (R) = Indeterminate due to reducing conditions that are unrelated to residual effects of drilling or well construction.

[c] Dead = Tritium is not detected above 1 pCi/L.

[d] Indeter (D) = Indeterminate due to inadequacies of data record, such as sampling frequency, detection limits, or data quality.

[e] Indeter (C) = Indeterminate due to metal corrosion.

[f] Indeter (W) = Indeterminate due to residual effects of drilling.

[g] Indeter (B) = Indeterminate due to uncertainty in representativeness of background data set for this location.

Appendix F

Hydrologic and Geochemical Data Files Specific to the Los Alamos and Pueblo Canyon Watersheds (on CD included with this document)

Data files that include hydrologic and chemical data used for analyses of the Los Alamos and Pueblo Canyon Watersheds presented in this report are included on the data CD that accompanies this document.

Section F-1 contains the water-level data that are presented in Appendix D, Section D-4.0.

Section F-2 contains vadose-zone data collected from core samples. Specifically included are nitrate and perchlorate concentrations measured in deionized water leachate of rock core to obtain concentration profiles as functions of depth, as presented in Appendix E, Section E-3.1. Also included are moisture content profiles as functions of depth, as presented in Appendix D, Section D-2.0.

Section F-3 presents groundwater chemistry data for the intermediate and regional wells located in the watersheds from 2000 to the present. These data were used to develop the screening tables presented in Appendix E, Section E-1.0.