Drilling Work Plan for Los Alamos and Pueblo Canyons Groundwater Monitoring Wells

The "Drilling Work Plan for Los Alamos and Pueblo Canyons Groundwater Monitoring Wells" is composed of the set of well-specific work plans listed below. Each of the work plans is essentially a standalone document complete with figures and references. The work plans include the following:

1. Drilling Work Plan for Buckman Monitoring Well
2. Drilling Work Plan for Perched Intermediate Well at TA-53
3. Drilling Work Plan for Regional Well R-3 in Pueblo Canyon
4. Drilling Work Plan for TW-2A Replacement in Pueblo Canyon
5. Work Plan to Plug and Abandon Pueblo Canyon Wells TW-1, TW-1A, TW-2, and TW-2A

Drilling Work Plan for Buckman Monitoring Well

Primary Purpose	The installation of a Buckman monitoring well (temporary name) was recommended in the "Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations, Revision 1" (LANL 2008, 101330) and approved by the New Mexico Environment Department (NMED) in a letter dated March 28, 2008, "Approval with Direction Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations, Revision 1, Los Alamos National Laboratory" (NMED 2008, 101112). The primary purpose of this well is to monitor groundwater west of the Buckman well field for potential Los Alamos National Laboratory (Laboratory) contaminants originating in the Los Alamos and Pueblo Canyon Watersheds. The location of this regional well is not yet established, but it is likely to be sited off the Laboratory property proximal to the Buckman well field. A specific location will be selected in consultation with NMED and other landowners, as appropriate.
Conceptual Model	Possible contaminants in the Los Alamos and Pueblo Canyon Watersheds include radionuclide, organic, and inorganic constituents released from a variety of industrial outfalls, disposal sites, and sewage treatment plants. Infiltration of surface water has carried a portion of the mobile contaminants (bromide, perchlorate, nitrate, tritium, and uranium) through the vadose zone to the regional groundwater system (R-9, R-12 screen 3, and R-10a). The regional aquifer is a complex, heterogeneous system that includes confined and unconfined zones. The degree of hydraulic communication between these zones is unknown and believed to be spatially variable. The shallow portion of the regional aquifer (along the water table) is predominantly under phreatic (unconfined) conditions and has limited thickness (approximately 98–164 ft). Groundwater flow and contaminant transport directions in this zone are believed to generally follow the gradient of the regional water table; the flow is generally east-southeastward. The direction and gradient of groundwater 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 (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 pumping of municipal water-supply wells. Based on the available water-level data observed at multiscreen monitoring wells (e.g., R-10a/10, R-16r/16, R-35a/b, R-20, R-33, and R-19), the pumping appears to have a small impact on the flow directions in the phreatic zone because of poor hydraulic communication. As a result, the capture of contaminants transported along flow paths within the phreatic zone by the Buckman supply wells, which are screened deep within the regional aquifer, seems unlikely because of this poor vertical hydraulic communication. However, the poor hydraulic communication does not preclude the possibility that some contaminant migration may occur between the shallow and deep zones. Between the two zones, the hydraulic gradient has a downward vertical component due to water-supply pumping, which creates the possibility that downward contaminant transport may occur through "hydraulic windows." However, the hydraulic gradient might also have an upward vertical component near the Buckman well field (as seen in observation wells at the Buckman well field, e.g., SF-6) that can provide natural protection against the entry of contaminants from the phreatic zone into well screens. Installation of the Buckman monitoring well will test components of the conceptual model with respect to the fate and transport of mobile contaminants within the regional aquifer. The well will be completed with two screens. The upper well screen will be placed within the uppermost 100 ft of the regional groundwater system in the most productive zone encountered. Every effort will be made to place the screen near the regional water table. The lower screen will be placed at approximately the same elevation as the top of the well screens in the regional aquifer of the Buckman well field (B-1, B-2, and B-8). Final placement of both screens will depend upon the geology encountered. Water-level transducers will be placed in upper and lower well screens to evaluate hydraulic connections between shallow and deep parts of the aquifer and nearby water-supply wells.

Drilling Approach	The Buckman monitoring well will be installed using the following drilling methods. • A 16-in. surface casing will be advanced with fluid-assisted air-rotary methods through upper rock units (potentially including Bandelier Tuff, the Guaje Pumice Bed, and upper Puye Formation sediments) to the top of the Cerros del Rio basalt. • A 15-in. open borehole will be advanced with fluid-assisted air-rotary methods through the Cerros del Rio basalts and any associated perched water. • If perched water is present, bentonite will be tremied into the borehole, and a 12-in. casing will be lowered and sealed in place. • If no perched water is encountered, the 12-in. casing will be lowered into the open borehole and advanced to refusal. Introduction of drilling additives (e.g., foam) will stop 100 ft above the regional aquifer. • A 10-in. casing will be advanced deep enough to accommodate a range of possible two-screen well configurations. The casing will be advanced within the regional aquifer without the use of drilling fluid additives. Municipal water may be added to cool the drill bit and advance the borehole as needed.
Potential Drilling Fluids	The following fluids and additives have been characterized geochemically and are consistent with those previously used in the drilling program at the Laboratory: • potable water from the municipal water supply to cool the drill bit and to aid in delivering other drilling additives • QUIK-FOAM, a blend of alcohol ethoxy sulfates, to be used as a foaming agent • AQF-2, an anionic surfactant, to be used as a foaming agent
Potential Groundwater Occurrence and Detection	Depth to regional groundwater will depend on the location selected for the well. In general, the top of regional saturation near White Rock Canyon is expected to occur at an elevation similar to that found at R-16r (5693 ft). The drilling approach will allow identification of perched groundwater, if present. Methods for groundwater detection include driller's and on-site geologist's observations, water-level measurements, borehole video, and borehole geophysics.
Cuttings Collection	Cuttings will be collected at 5-ft increments for geologic characterization throughout both boreholes.
Groundwater-Screening Sampling	Groundwater-screening samples will be collected during drilling at any perched horizon producing sufficient water for sampling and at the regional water table. Screening samples of groundwater will be analyzed for dissolved cations/metals and anions by the Earth and Environmental Sciences Division (EES-6) chemistry laboratory. The screening samples collected from any perched horizon and the regional aquifer will be analyzed for tritium by the University of Miami.
Groundwater Characterization Sampling	Groundwater samples will be collected from the completed wells 10 to 60 d after well development in accordance with the Compliance Order on Consent Order. These samples will be analyzed for a suite of constituents, including radionuclides; target analyte list metals; general inorganic chemicals; total organic carbon (TOC); volatile and semivolatile organic compounds; hexavalent chromium (at EES-6); and stable isotopes of hydrogen, nitrogen, oxygen, and chromium. The geochemical data will be also applied to evaluate hydraulic separation between the screens. Subsequent groundwater samples will be collected as specified in the "2007 Interim Facility-Wide Groundwater Monitoring Plan" (LANL 2007, 096665).

Geophysical Testing of Wells	The suite and timing of geophysical logging will depend on borehole conditions. The borehole may be characterized numerous times with the Laboratory's natural gamma, induction (conductivity), caliper, and downhole video tools. Critical times for running these tools include after the open hole is advanced through the Cerros del Rio basalt but before the 12-in. casing is introduced, any time that perched groundwater is suspected, and any time that drilling operations allow access to the borehole. Upon reaching total drilling depth, borehole conditions permitting, the drill casing(s) will be pulled up above the regional aquifer, and a full suite of geophysical logs will be run in the open borehole. The logs will be collected by Schlumberger, Inc., and will include accelerator porosity sonde (neutron porosity), array induction, combined magnetic resonance, natural and spectral gamma, and Formation MicroImager logs. If the casing cannot be retracted for logging, the accelerator porosity sonde, elemental capture sonde, triple lithodensity, and natural and spectral gamma logs will be collected. These logs will be used to characterize the hydrogeologic properties of saturated rocks in the regional aquifer. The geophysical logs will also be used in conjunction with information from drill cuttings, driller's observations, and water-level measurements to select the well screen depths.
Well Completion Design	A 20-ft well screen will be placed in the most productive interval identified within the upper 100 ft of the regional aquifer. A deeper 10–20-ft screen will be placed at approximately the same elevation as the upper part of the well screens at the Buckman well field (B-1, B-2, and B-3). Depths of the screen intervals will be selected based on field observations of hydrology and stratigraphy during drilling. Well screens will be separated by packers and constructed in such a way to ensure isolation of each groundwater-bearing zone. A sampling system capable of effectively purging groundwater from the screened intervals will be installed in the well. A conceptual well design is shown in Figure 1.
Well Development	The wells will be developed by mechanical means, including swabbing, bailing, and pumping. The well screens will be isolated by packers during pumping development. Screening samples will be collected to guide adequacy of development. Target water-quality parameters used to evaluate development are turbidity (<5 nephelometric turbidity units), TOC <2 ppm, and stability of other field parameters.
Hydraulic Testing	Single-hole hydraulic testing will be considered if a significant water-producing horizon is encountered. The testing will address hydraulic communication between the screens. Long-term observation of water levels in both screens will be analyzed to evaluate hydraulic connections between shallow and deep parts of the aquifer and nearby water-supply wells.
Investigation-Derived Waste Management	All investigation-derived waste (IDW) generated during implementation of this work plan will be managed in accordance with applicable EP-ERSS and ENV-RCRA standard operating procedures (SOPs). These SOPs incorporate the requirements of all applicable U.S. Environmental Protection Agency (EPA) and NMED regulations, U.S. Department of Energy (DOE) orders, and Laboratory requirements. SOPs applicable to the characterization and management of IDW are the following: • EP-ERSS-SOP-5022, Characterization and Management of Environmental Restoration Project Waste (http://int.lanl.gov/environment/all/docs/qa/ep_qa/EP-ERSS-SOP-5022.pdf) • ENV-RCRA-SOP-010, Land Application of Groundwater (http://int.lanl.gov/orgs/env/rcra/qa.shtml?6), which implements the NMED-approved notice of intent (NOI) decision tree for drilling, development, rehabilitation, and sampling purge water

	• ENV-RCRA-SOP-011, Land Application of Drill Cuttings (http://int.lanl.gov/orgs/env/rcra/qa.shtml?6), which implements the NMED-approved NOI decision tree for IDW solids from construction of wells and boreholes The primary waste streams include drill cuttings, purge water generated during drilling, water generated during development of the well, contact waste, and decontamination water. Data from the existing wells indicate that the wastes generated should be nonhazardous and nonradioactive. Therefore, all wastes will initially be managed as nonhazardous. Drill cuttings and purge water will be characterized with direct sampling immediately following completion of drilling activities (i.e., date of generation) and waste determinations made from validated data. Drill cuttings and purge water will initially be stored in aboveground- or belowground-lined pits. If validated analytical data show these wastes are hazardous, they will be containerized in U.S. Department of Transportation-compliant containers and placed in a registered accumulation area for shipment to an authorized treatment, storage, and disposal facility within 90 d of generation. Contact waste will be characterized based on the waste determination of the drill cuttings and purge water. Decontamination water will be characterized by direct sampling of containerized waste.
Schedule	The Buckman monitoring well will be installed by December 31, 2009. The out-year date reflects the fact that other planned wells support more immediate corrective measures evaluation needs. The well is likely to be located on San Ildefonso land, and additional time will be required to negotiate an intergovernment agreement for its installation.

REFERENCES

The following list includes all documents cited in this plan. Parenthetical information following each reference provides the author(s), publication date, and ER ID 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.

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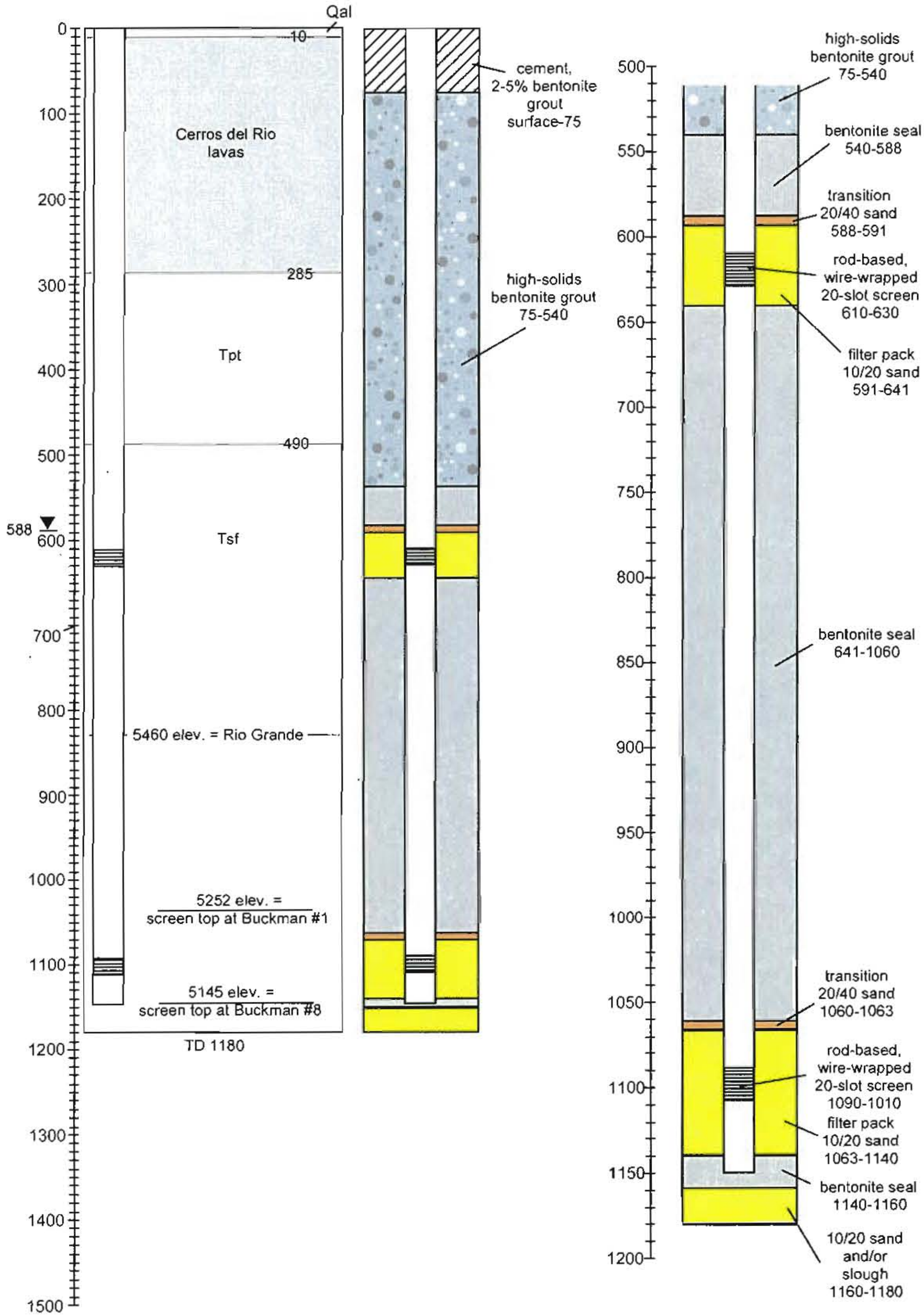
LANL (Los Alamos National Laboratory), May 2007. "2007 Interim Facility-Wide Groundwater Monitoring Plan," Los Alamos National Laboratory document LA-UR-07-3271, Los Alamos, New Mexico. (LANL 2007, 096665)

LANL (Los Alamos National Laboratory), February 2008. "Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations, Revision 1," Los Alamos National Laboratory document LA-UR-08-1105, Los Alamos, New Mexico. (LANL 2008, 101330)

NMED (New Mexico Environment Department), March 28, 2008. "Approval with Direction, Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations, Revision 1," New Mexico Environment Department letter to D. Gregory (DOE-LASO) and D. McInroy (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2008, 101112)



Note: All depths and elevations are shown in feet.

Figure 1 Conceptual well design for the Buckman monitoring well

Drilling Work Plan for Perched Intermediate Well at TA-53

Primary Purpose	A perched intermediate monitoring well is being installed at Technical Area 53 (TA-53) to meet a requirement of the New Mexico Environment Department (NMED) letter dated January 18, 2008, "Notice of Disapproval, Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations" (NMED 2008, 099818) to investigate possible perched saturation in or near the Guaje Pumice Bed that may provide a contaminant pathway between Los Alamos and Sandia Canyons. A perched intermediate well is also recommended in the "Los Alamos and Pueblo Canyons Monitoring Well Network Evaluation and Recommendations, Revision 1" (LANL 2008, 101330). The unnamed intermediate well, located on the mesa between Los Alamos and Sandia Canyons (Figure 1) within TA-53, will be installed to intersect possible perched saturation between these canyons and south of the perched saturation as observed in R-6i and LAOI-3.2/3.2a (Figure 1), which have elevated levels of Los Alamos National Laboratory- (Laboratory-) derived contaminants (e.g., tritium, nitrate, perchlorate, and uranium). A well will be installed at this location only if perched groundwater is encountered during drilling. This well is designed with a single 20-ft well screen to evaluate water quality and measure water levels within the potential perched groundwater system (Figure 2). The depth of the screen interval will be selected based on field observations of hydrology and stratigraphy during drilling, and a sampling system capable of effectively purging groundwater from the screened interval will be installed. The intermediate well will be deep enough to collect representative samples from any perched groundwater above the Cerros del Rio basalt in this area. The target depth for this intermediate well is approximately 610 ft. The borehole will be plugged and abandoned if no perched intermediate groundwater is encountered.
Conceptual Model	The current conceptual model for perched saturation beneath Los Alamos and Sandia Canyons includes significant cross-canyon communication to the east near R-9/R-9i and R-12 screens 1 and 2 but not as far to the west as the location of this intermediate borehole at TA-53 (Figure 1). The cross-canyon communication to the east occurs in a perched zone within Cerros del Rio basalt. Near TA-53, perched saturation is observed at levels above the Cerros del Rio lavas, in the Guaje Pumice Bed—LAOI(A)-1.1, LADP-3, and LAOI-3.2—or in the Puye Formation above the Cerros del Rio basalt (LAOI-3.2a and R-6i). The specific concern in the NMED letter referenced above is to address whether the higher zone of perched saturation observed in these boreholes extends beneath the mesa and/or communicates with a comparable level of perched saturation observed to the south in Sandia Canyon (e.g., well SCI-1). If equivalent perched saturation is found beneath the mesa separating these wells, an intermediate well will be installed to sample and monitor this zone. Such monitoring will help to define the extent of contamination within the perched intermediate groundwater observed in Los Alamos Canyon at LADP-3, LAOI-3.2, LAOI-3.2a, and R-6i. Defining the nature and extent of perched groundwater is important for identifying potential groundwater pathways to the regional aquifer and could affect the design of the groundwater-monitoring network, particularly near municipal supply well Otowi-4.

Drilling Approach	The intermediate well at TA-53 will be installed using the following drilling methods. • A 12-in. surface casing will be advanced with fluid-assisted air-rotary methods through the Tshirege Member of the Bandelier Tuff, the Cerro Toledo Formation, the Otowi Member ash flows of the Bandelier Tuff, the Guaje Pumice Bed, and upper Puye Formation sediments to the top of the Cerros del Rio basalt. • Introduction of drilling additives (e.g., foam) will stop at 400 ft below ground surface within the Otowi Member. Municipal water may be added to cool the drill bit as needed to advance the borehole to the Cerros del Rio basalt. • If no perched water is encountered, the borehole will be plugged and abandoned. • If perched water is present, a well will be installed and completed with a single screen. The screen will be set within the perched zone. Final placement will be dependent upon the hydrology and stratigraphy encountered, the identification of the perching horizon, and the thickness of the perched interval. Lifts of bentonite fill may be used in the borehole to determine the interval in which a stable level of depth to perched saturation is maintained.
Potential Drilling Fluids	The following fluids and additives have been characterized geochemically and are consistent with those previously used in the drilling program at the Laboratory: • potable water from the municipal water supply to cool the drill bit and to aid in delivery of other drilling additives • QUIK-FOAM, a blend of alcohol ethoxy sulfates, to be used as a foaming agent • AQF-2, an anionic surfactant, to be used as a foaming agent
Potential Groundwater Occurrence and Detection	Perched groundwater may occur in either the Guaje Pumice Bed at ~528–548-ft depth or in underlying Puye sediments at ~548–610-ft depth (Figure 2). Methods for perched water detection may include driller's and on-site geologist's observations, water-level measurements, borehole video, and borehole geophysics.
Cuttings Sampling	Cuttings will be collected at 5-ft increments for geologic characterization throughout the borehole.
Cuttings Analysis	Cuttings or core will not be collected for geochemical analysis because the submesa unsaturated zone is not expected to be a zone of contaminant transport.
Groundwater-Screening Sampling	Groundwater-screening samples will be collected during drilling at any perched horizon producing sufficient water for sampling. Screening samples of groundwater will be analyzed for dissolved cations/metals and anions by the Earth and Environmental Sciences Division (EES-6) chemistry laboratory. The screening samples collected from any perched horizon will be analyzed for tritium by the University of Miami.
Groundwater Characterization Sampling	If present, groundwater samples will be collected from the completed wells 10 to 60 d after well development in accordance with the Compliance Order on Consent. These samples will be analyzed for a suite of constituents, including radionuclides; target analyte list metals; general inorganic chemicals; total organic carbon (TOC); volatile and semivolatile organic compounds; hexavalent chromium (at EES-6); and stable isotopes of hydrogen, nitrogen, oxygen, and chromium. Subsequent groundwater samples will be collected as specified in the "2007 Interim Facility-Wide Groundwater Monitoring Plan" (LANL 2008, 096665).

Geophysical Testing of Wells	The suite and timing of geophysical logging will depend on borehole conditions. The borehole may be characterized with the Laboratory's natural gamma, induction (conductivity), caliper, and downhole video tools. Critical times for running these tools may include after any perched saturation is encountered and the casing is retracted to allow use of video and contact tools. The gamma ray tool may be run through the casing and/or in open hole. The geophysical logs will be used in conjunction with information from drill cuttings, driller's observations, and water-level measurements to select the well screen depth.
Well Completion Design	For any well, the screen will be placed in the most productive interval identified within the perched zone. A conceptual well design is shown in Figure 2.
Well Development	The well will be developed by mechanical means, including swabbing, bailing, and pumping. Screening samples will be collected to guide adequacy of development. Target water-quality parameters used to evaluate development are turbidity (<5 nephelometric turbidity units), TOC <2 ppm, and stability of other field parameters.
Hydraulic Testing	Hydraulic testing will be considered if a significant perched zone is encountered. However, it is anticipated that any submesa perched zone will not have volume or transmissivity sufficient for hydrologic testing.
Investigation-Derived Waste Management	All investigation-derived waste (IDW) generated during implementation of this work plan will be managed in accordance with applicable EP-ERSS and ENV-RCRA standard operating procedures (SOPs). These SOPs incorporate the requirements of all applicable U.S. Environmental Protection Agency (EPA) and NMED regulations, U.S. Department of Energy (DOE) orders, and Laboratory requirements. SOPs applicable to the characterization and management of IDW are the following: • EP-ERSS-SOP-5022, Characterization and Management of Environmental Restoration Project Waste (http://int.lanl.gov/environment/all/docs/qa/ep_qa/EP-ERSS-SOP-5022.pdf) • ENV-RCRA-SOP-010, Land Application of Groundwater (http://int.lanl.gov/orgs/env/rcra/qa.shtml?6), which implements the NMED-approved notice of intent (NOI) decision tree for drilling, development, rehabilitation, and sampling purge water • ENV-RCRA-SOP-011, Land Application of Drill Cuttings (http://int.lanl.gov/orgs/env/rcra/qa.shtml?6), which implements the NMED-approved NOI decision tree for IDW solids from construction of wells and boreholes The primary waste streams include drill cuttings, purge water generated during drilling, water generated during development of the well, contact waste, and decontamination water. Data from the existing wells indicate that the wastes generated should be nonhazardous and nonradioactive. Therefore, all wastes will initially be managed as nonhazardous. Drill cuttings and purge water will be characterized with direct sampling immediately following completion of drilling activities (i.e., date of generation) and waste determinations made from validated data. Drill cuttings and purge water will initially be stored in aboveground- or belowground-lined pits. If validated analytical data show these wastes are hazardous, they will be containerized in U.S. Department of Transportation-compliant containers and placed in a registered accumulation area for shipment to an authorized treatment, storage, and disposal facility within 90 d of generation. Contact waste will be characterized based on the waste determination of the drill cuttings and purge water. Decontamination water will be characterized by direct sampling of containerized waste.

Schedule	The TA-53 borehole will be drilled by March 30, 2009. A well will be installed if perched groundwater is encountered. Installation of this well is given a high priority because it will help define the extent of perched intermediate groundwater near TA-21 and because it provides information useful for corrective measures evaluation decisions for the material disposal areas at that site.

REFERENCES

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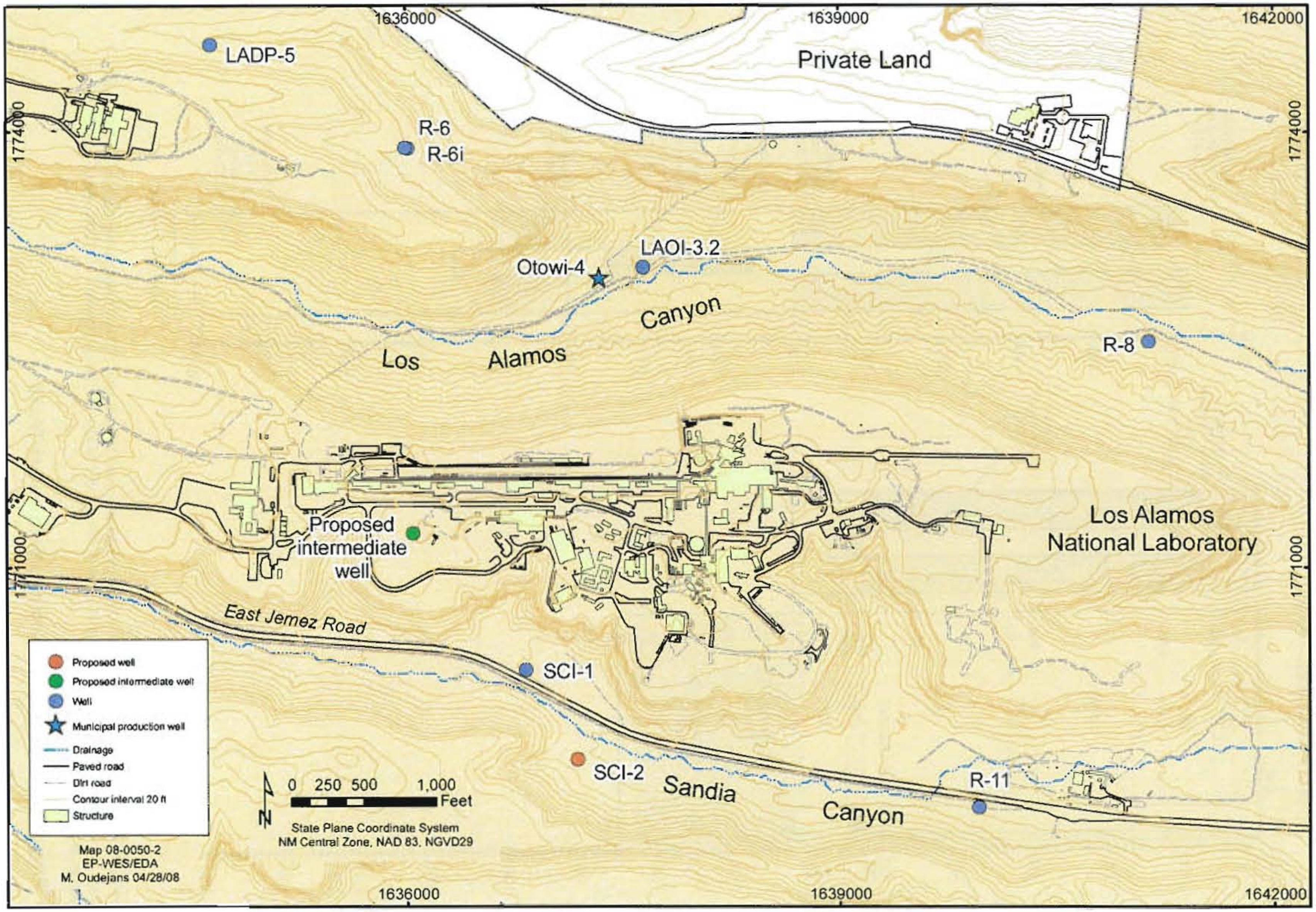
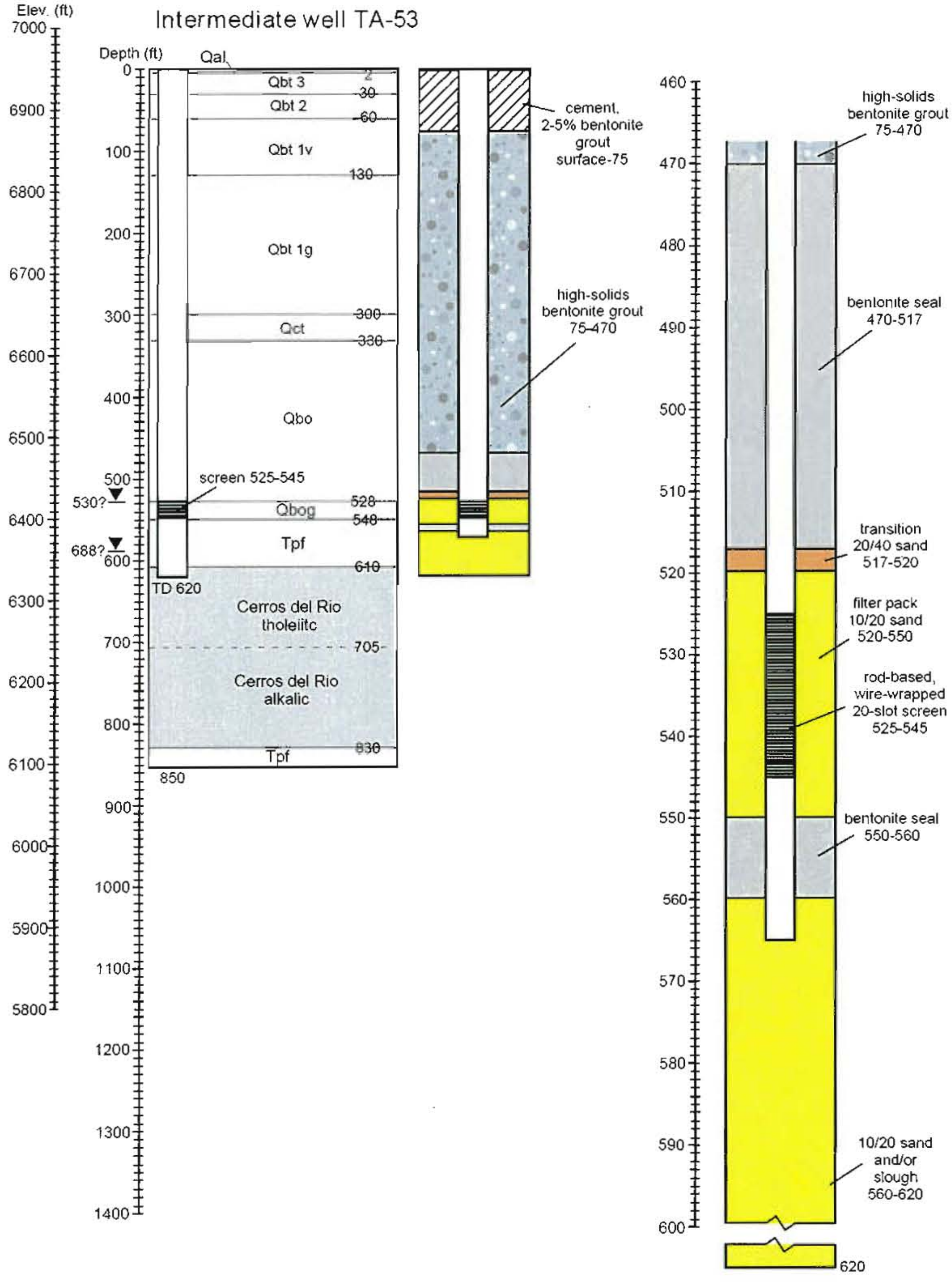


Figure 1 **Locations of existing monitoring wells, planned monitoring well SCI-2, production well Otowi-4, and proposed intermediate well at TA-53**



Notes: All depths and elevations are shown in feet. Abbreviations are used for subunits of the Tshirege Member of the Bandelier Tuff (Qbt), the Cerro Toledo Interval (Qct), ash flows of the Otowi Member of the Bandelier Tuff (Qbo), the Guaje Pumice Bed (Qbog), and the Puye Formation (Tpf).

Figure 2 Proposed well design for intermediate well at TA-53

Drilling Work Plan for Regional Well R-3 in Pueblo Canyon

Primary Purpose	Regional monitoring well R-3 was recommended in the "Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations, Revision 1" (LANL 2008, 101330) and approved by the New Mexico Environment Department (NMED) in a letter dated March 28, 2008, "Approval with Direction Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations, Revision 1, Los Alamos National Laboratory" (NMED 2008, 101112). R-3 will be completed as a two-screen well to monitor contamination pathways in the regional aquifer near production well O-1 and monitoring well TW-1 (Figure 1). Contaminants detected in the regional aquifer at well O-1 include perchlorate, tritium, nitrate, and uranium. Well TW-1 was installed primarily to provide a monitoring point for the regional aquifer below Pueblo Canyon where contaminants could move in the regional aquifer. Examples of these possible contaminant 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. The upper screen in R-3 will monitor water quality near the top of the regional water table, expected to be at ~5690-ft elevation (Figure 2). Actual elevation of the regional static water level is uncertain at this location; data from TW-1 appear to be anomalously high and may be compromised by leakage of surface water downward along the annulus of that well, which lacks annular sealing materials. The deeper screen will be at an elevation comparable to that where zonal sampling at O-1 revealed elevated perchlorate and nitrate (~5320–5379-ft elevation). The exact depths of both screen intervals will be selected based on field observations of hydrology and stratigraphy during drilling. A sampling system capable of separately isolating, purging, and sampling each screen will be installed.
Conceptual Model	The current conceptual model for this segment of Pueblo Canyon implicates upstream abandoned Los Alamos National Laboratory (Laboratory) facilities as sources for possible perchlorate, nitrate, uranium, and tritium contamination as well as sewage sources (both current and abandoned Los Alamos County treatment plants and abandoned Laboratory treatment plants) for nitrate contamination. Construction of TW-1 did not use sealing materials in the annular space, which may have allowed water flow and migration of contaminants from surface or perched sources downward along the well annulus. This complicates both the characterization of contaminant pathways and the interpretation of depth to regional saturation in this area. Within the regional aquifer, groundwater flow is believed to be toward the east and/or east-southeast from the planned R-3 site toward O-1 and TW-1; R-3 will provide a monitoring point upgradient of these locations. A water-level transducer will be placed in R-3 to evaluate depth to regional saturation and hydraulic connections between this monitoring well and Los Alamos County water-supply wells in this vicinity. Water-supply well O-1 is not an active well at this time, but when it is pumped, water-level responses in the two R-3 screens may be used to evaluate hydraulic properties (laterally and vertically) of the regional aquifer.
Drilling Approach	R-3 will be installed using the following drilling methods. • A 16-in. surface casing will be advanced with auger or air-rotary methods through alluvium to the top of the Cerros del Rio basalt. • A 15-in. open borehole will be advanced with fluid-assisted air-rotary methods through the Cerros del Rio basalt and the perched water interval anticipated at ~190–240 ft within the Cerros del Rio lavas. After penetrating the perched zone, bentonite will be tremied into the borehole, and a 12-in. casing will be lowered and sealed in place. • Open-hole drilling will continue through underlying Santa Fe Group sediments and through anticipated Miocene lava at ~430–460-ft depth into deeper Santa Fe Group sediments. Introduction of drilling additives (e.g., foam) will stop 100 ft above the regional aquifer, expected to be at ~692-ft depth.

	• If needed, a 10-in. casing will be advanced to target depth of ~1100 ft without the use of drilling fluid additives. Municipal water may be added to cool the drill bit as needed. • The upper well screen will be set in sediments within the uppermost 80 ft of the aquifer in the zone that produces the most water or indicates elevated contamination in screening samples. • The lower screen will be set in sediments at an elevation comparable to that where zonal sampling showed the highest perchlorate concentrations at O-1. A possible target depth suggested for the deeper R-3 screen is ~1053–1073 ft (Figure 2).
Potential Drilling Fluids	The following fluids and additives have been characterized geochemically and are consistent with those previously used in the drilling program at the Laboratory: • potable water from the municipal water supply to cool the drill bit and to aid in delivery of other drilling additives • QUIK-FOAM, a blend of alcohol ethoxy sulfates, to be used as a foaming agent • AQF-2, an anionic surfactant, to be used as a foaming agent
Potential Groundwater Occurrence and Detection	Perched water is expected to occur at ~190–240-ft depth in the lower section of the Cerros del Rio lavas. Regional groundwater is expected to occur in sediments at ~692-ft depth. Methods for groundwater detection may include driller's observations, water-level measurements, borehole video, and borehole geophysics.
Core Sampling	Cuttings samples will be collected from R-3 at 5-ft increments for geologic characterization.
Core Analysis	Collection of core samples is not anticipated.
Groundwater Screening Sampling	The perched interval in the Cerros del Rio lavas at R-3 is adequately monitored by the screen at R-3i, so no screening water samples will be collected from the perched interval during drilling at R-3. Screening sample(s) will be collected from the regional aquifer at intervals sufficient to constrain screen locations (~10 water samples each from upper and lower screen target intervals). A screening water sample will be collected from each screen at the end of development. Screening samples of groundwater will be analyzed for dissolved cations/metals and anions by the Earth and Environmental Sciences Division (EES-6) chemistry laboratory and for tritium by the University of Miami.
Groundwater Characterization Sampling	Groundwater samples will be collected from each screen of the completed well 10 to 60 d after well development in accordance with the Compliance Order on Consent. These samples will be analyzed for a suite of constituents, including radionuclides; target analyte list metals; general inorganic chemicals; total organic carbon (TOC); volatile and semivolatile organic compounds; hexavalent chromium (at EES-6); and stable isotopes of hydrogen, nitrogen, oxygen, and chromium. Subsequent groundwater samples will be collected as specified in the "2007 Interim Facility-Wide Groundwater Monitoring Plan" (LANL 2007, 096665).

Geophysical Testing of Wells	The suite and timing of geophysical logging will depend on borehole conditions. Borehole conditions permitting, the 10-in. casing (if used) will be pulled up above the regional aquifer, and a full suite of geophysical logs will be run in the open borehole. The logs will be collected by Schlumberger, Inc., and will include accelerator porosity sonde (neutron porosity), array induction, combined magnetic resonance, natural and spectral gamma, and Formation MicroImager logs. If the casing cannot be retracted for logging, the accelerator porosity sonde, elemental capture sonde, triple lithodensity, and natural and spectral gamma logs will be collected. These logs will be used to characterize the hydrogeologic properties of saturated rocks in the regional aquifer. The geophysical logs will also be used in conjunction with information from drill cuttings, driller's and on-site geologist's observations, screening water samples, and water-level measurements to select the well screen depth.
Well Design	The well screens at R-3 will be placed in (1) a productive interval identified within the upper 80 ft of the regional aquifer and (2) productive sediments at a depth comparable to the upper screened interval at O-1. Cuttings examined from O-1 suggest a possible transmissive horizon with abundant stream gravels at ~690–750-ft depth for the upper screen and clean sands below ~1050 ft for the lower screen. These are approximate depths because the dip of the rock units at this location is not well constrained. A conceptual well design is shown in Figure 2.
Well Development	The well will be developed by mechanical means, including swabbing, bailing, and pumping. The well screens will be isolated by packers during pumping development. Screening samples will be collected to guide adequacy of development. Target water-quality parameters are turbidity (<5 nephelometric turbidity units), TOC <2 ppm, and the stability of other field parameters.
Hydraulic Testing	Hydraulic testing will be considered if significant contamination is encountered. Response of transducers at each screen to pumping at all the production wells will be evaluated.
Investigation-Derived Waste Management	All investigation-derived waste (IDW) generated during implementation of this work plan will be managed in accordance with applicable EP-ERSS and ENV-RCRA standard operating procedures (SOPs). These SOPs incorporate the requirements of all applicable U.S. Environmental Protection Agency (EPA) and NMED regulations, U.S. Department of Energy (DOE) orders, and Laboratory requirements. SOPs applicable to the characterization and management of IDW are the following: • EP-ERSS-SOP-5022, Characterization and Management of Environmental Restoration Project Waste (http://int.lanl.gov/environment/all/docs/qa/ep_qa/EP-ERSS-SOP-5022.pdf) • ENV-RCRA-SOP-010, Land Application of Groundwater (http://int.lanl.gov/orgs/env/rcra/qa.shtml?6), which implements the NMED-approved notice of intent (NOI) decision tree for drilling, development, rehabilitation, and sampling purge water • ENV-RCRA-SOP-011, Land Application of Drill Cuttings (http://int.lanl.gov/orgs/env/rcra/qa.shtml?6), which implements the NMED-approved NOI decision tree for IDW solids from construction of wells and boreholes The primary waste streams include drill cuttings, purge water generated during drilling, water generated during development of the well, contact waste, and decontamination water. Data from the existing wells indicate that the wastes generated should be nonhazardous and nonradioactive. Therefore, all wastes will initially be managed as nonhazardous. Drill cuttings and purge water will be characterized with direct sampling immediately following completion of drilling activities (i.e., date of generation) and waste determinations made from validated data. Drill cuttings and purge water will initially be stored in aboveground- or belowground-lined pits. If validated analytical data show these wastes are hazardous, they will be containerized in U.S. Department of Transportation-compliant containers and placed in a

	registered accumulation area for shipment to an authorized treatment, storage, and disposal facility within 90 d of generation. Contact waste will be characterized based on the waste determination of the drill cuttings and purge water. Decontamination water will be characterized by direct sampling of containerized waste.
Schedule	R-3 will be installed by December 31, 2009. The out-year date reflects the fact that other planned wells support more immediate corrective measures evaluation needs. The well is located on Laboratory land that is scheduled for transfer to Los Alamos County, and additional time will be required to negotiate an intergovernmental agreement for its installation.

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The following list includes all documents cited in this plan. 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.

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LANL (Los Alamos National Laboratory), May 2007. "2007 Interim Facility-Wide Groundwater Monitoring Plan," Los Alamos National Laboratory document LA-UR-07-3271, Los Alamos, New Mexico. (LANL 2007, 096665)

LANL (Los Alamos National Laboratory), February 2008. "Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations, Revision 1," Los Alamos National Laboratory document LA-UR-08-1105, Los Alamos, New Mexico. (LANL 2008, 101330)

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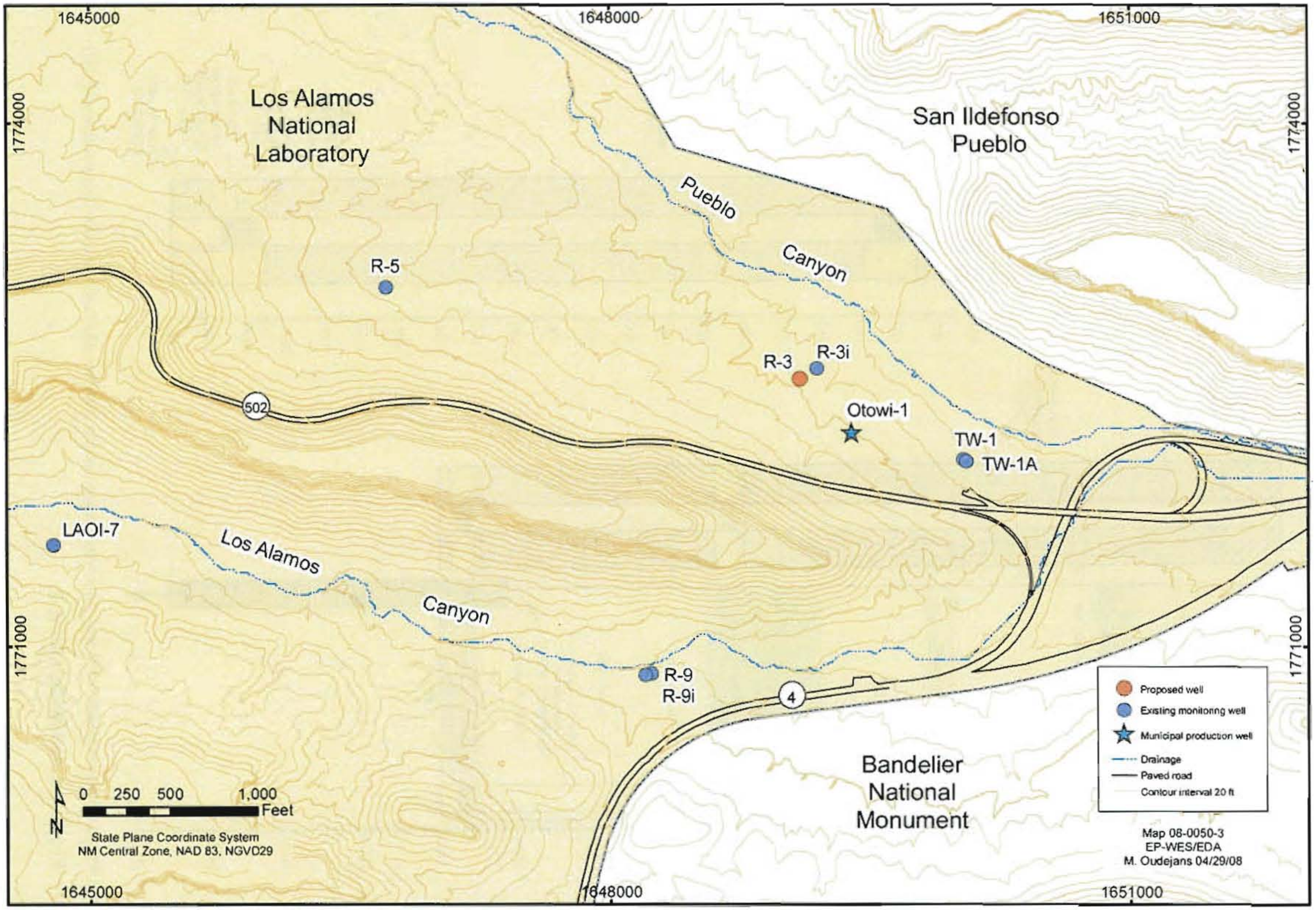
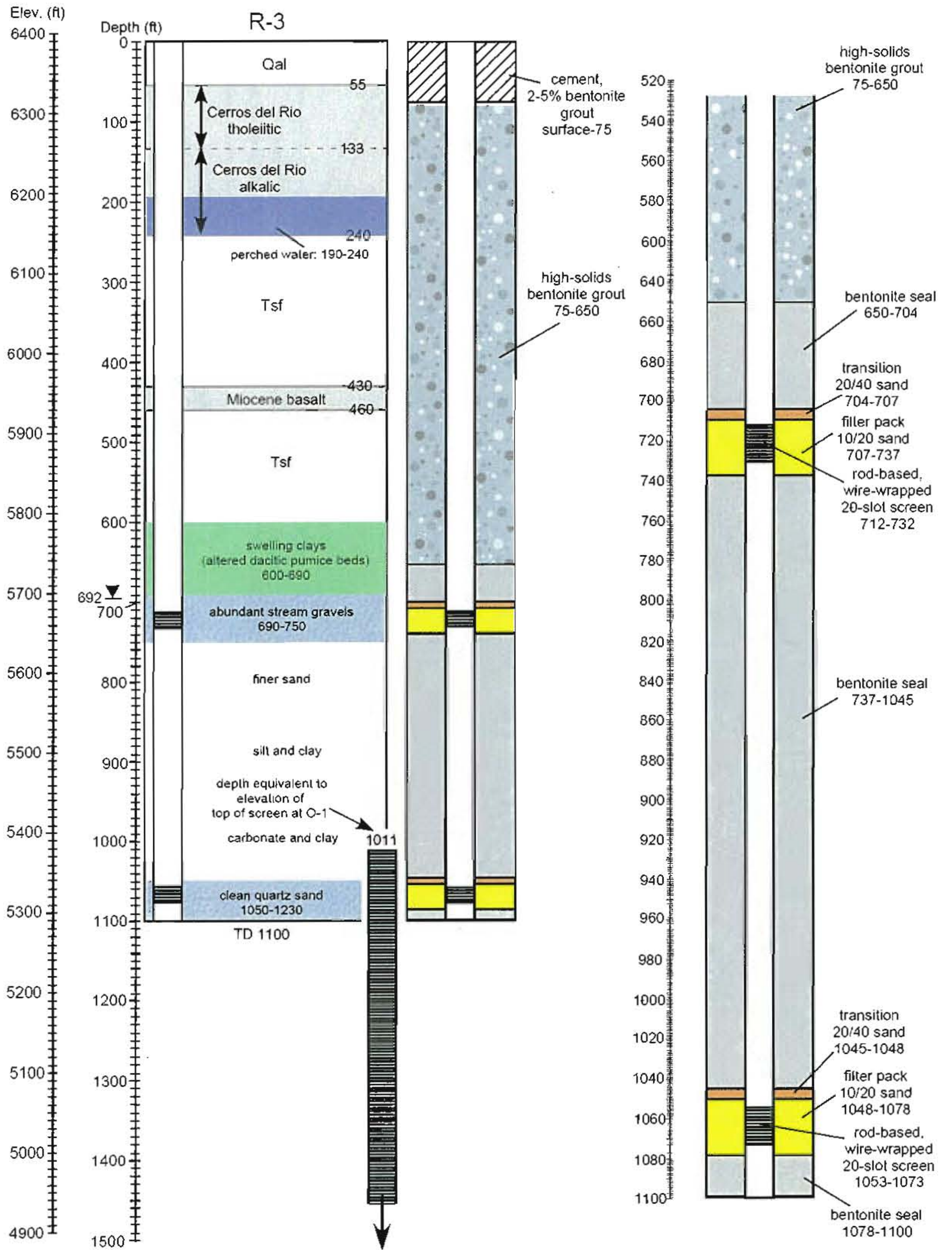


Figure 1 **Locations of selected monitoring wells, production well Otowi-1, and well R-3 planned for installation in 2009**



Notes: All depths and elevations shown are in feet. Abbreviations are used for alluvium (Qal) and Santa Fe Group sediments (Tsf).

Figure 2 Proposed well design for R-3

Drilling Work Plan for TW-2A Replacement in Pueblo Canyon

Primary Purpose	A perched intermediate monitoring well is being installed in Pueblo Canyon to replace existing well TW-2A, which is being plugged and abandoned. Replacement of TW-2A was recommended in the "Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations, Revision 1" (LANL 2008, 101330) and approved by the New Mexico Environment Department (NMED) in a letter dated March 28, 2008, "Approval with Direction Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations, Revision 1, Los Alamos National Laboratory" (NMED 2008, 101112). The replacement well at TW-2A will monitor water quality and water levels in a perched intermediate groundwater zone within the Puye Formation located at a depth of about 100 ft beneath middle Pueblo Canyon (Figure 1). The well will monitor potential contaminants from Los Alamos National Laboratory (Laboratory) sources that include Acid Canyon, former sewage plants in upper Pueblo Canyon, and Manhattan-era buildings in the townsite. Outfalls releasing liquid effluent from former Technical Area 01 (TA-01) and former TA-45 to Acid Canyon are the primary sources of radionuclides, perchlorate, and other contamination in Pueblo Canyon. Radioactive effluent included untreated liquid waste released from TA-01 between 1944 and 1951 and treated liquid waste from TA-45 between 1951 and 1964. Mobile constituents released into Acid Canyon that have contaminated groundwater are tritium, perchlorate, uranium, and nitrate. In addition, wastewater treatment plants (WWTPs) and septic systems discharged to Pueblo Canyon over the past 60 yr, most notably to the former Pueblo Canyon WWTP and the former Central WWTP. The Pueblo Canyon WWTP—Solid Waste Management Unit (SWMU) 00-018(a)—is located in Pueblo Canyon above the Acid Canyon confluence and 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 inorganic and organic contaminants.
Conceptual Model	Pueblo Canyon heads in the Sierra de los Valles and has a drainage area of 8.3 mi^2. The geology beneath the canyon floor varies downstream between the Acid Canyon confluence and the TW-2A location. Near the Acid Canyon, Tschicoma dacite lavas are present from beneath the alluvium to the regional aquifer. Farther downcanyon to the east, near TW-2A, thin deposits of Otowi Member and Guaje Pumice Bed (Qbog) underlie the canyon floor. The perched intermediate groundwater at TW-2A occurs in the upper part of the underlying Puye Formation, which consists of stratified gravels and coarse sands. This intermediate perched zone is probably recharged by infiltration of intermittent to ephemeral surface water and alluvial groundwater farther upcanyon. Some infiltration of surface water or alluvial groundwater may occur where the Rendija and Guaje Mountain faults cross Pueblo Canyon to the west, but no perched intermediate zones were found in wells TW-4 or R-2. Alluvial groundwater is generally present from PAO-1 to a location west of TW-2A. Data indicating potential infiltration at R-2 include elevated moisture contents in the Otowi Member and elevated perchlorate concentrations in the vadose zone into the Puye Formation.
Drilling Approach	TW-2A replacement will be installed using the following drilling methods. • A 12-in. open borehole will be advanced using fluid-assisted air-rotary methods to a target depth of 150 ft. • Introduction of drilling additives (e.g., foam) will stop at the top of the Puye Formation. This corresponds to about 63 ft below ground surface. Municipal water may be added to cool the drill bit as needed to advance the borehole through the Puye Formation. • A single-screen well will be completed within the upper part of the perched intermediate zone; however, final screen placement will be based on the geology encountered.

Potential Drilling Fluids	The following fluids and additives have been characterized geochemically and are consistent with those previously used in the drilling program at the Laboratory: • potable water from the municipal water supply to cool the drill bit and to aid in delivering other drilling additives • QUIK-FOAM, a blend of alcohol ethoxy sulfates, to be used as a foaming agent • AQF-2, an anionic surfactant, to be used as a foaming agent
Potential Groundwater Occurrence and Detection	Perched intermediate groundwater is expected to occur in the Puye Formation at about 107-ft depth. Recognition and characterization of the perched zone will be made by driller's and on-site geologist's observations, core samples, water-level measurements, borehole video, and borehole geophysics.
Core Collection	Continuous core samples will be collected for geologic and geochemical characterization.
Core Analysis	Samples of the core will be analyzed for cations, anions, and metals/trace elements using both deionized water leach at the Earth and Environmental Sciences (EES-6) chemistry laboratory and partial acid digestion at an off-site laboratory, following the U.S. Environmental Protection Agency (EPA) Method 3050.
Groundwater Characterization Sampling	Groundwater samples will be collected from the completed well 10 to 60 d after well development in accordance with the Compliance Order on Consent Order. These samples will be analyzed for a suite of constituents, including radionuclides; target analyte list metals; general inorganic chemicals; total organic carbon (TOC); volatile and semivolatile organic compounds; hexavalent chromium (at EES-6); and stable isotopes of hydrogen, nitrogen, oxygen, and chromium. Subsequent groundwater samples will be collected as specified in the "2007 Interim Facility-Wide Groundwater Monitoring Plan" (LANL 2007, 096665).
Geophysical Testing of Wells	The suite and timing of geophysical logging will depend on borehole conditions. The borehole may be characterized numerous times with the Laboratory's natural gamma, induction (conductivity), caliper, and downhole video tools. Critical times for running these tools include after the open hole is advanced through the perched zone and at any time before casing is introduced to stabilize the borehole.
Well Completion Design	A 20-ft well screen will be placed in the most productive interval identified near the top of the perched zone. A conceptual well design is shown in Figure 2.
Well Development	The well will be developed by mechanical means, including swabbing, bailing, and pumping, if the perched zone produces a sufficient quantity of water. Screening samples will be collected to guide adequacy of development. Target water-quality parameters relied on to evaluate development are turbidity (<5 nephelometric turbidity units), TOC <2 parts per million, and stability of other field parameters.
Hydraulic Testing	Hydraulic testing will be considered if a significant water-producing horizon is encountered.

Investigation-Derived Waste Management	All investigation-derived waste (IDW) generated during implementation of this work plan will be managed in accordance with applicable EP-ERSS and ENV-RCRA standard operating procedures. These SOPs incorporate the requirements of all applicable EPA and NMED regulations, U.S. Department of Energy (DOE) orders, and Laboratory requirements. SOPs applicable to the characterization and management of IDW are the following: • EP-ERSS-SOP-5022, Characterization and Management of Environmental Restoration Project Waste (http://int.lanl.gov/environment/all/docs/qa/ep_qa/EP-ERSS-SOP-5022.pdf) • ENV-RCRA-SOP-010, Land Application of Groundwater (http://int.lanl.gov/orgs/env/rcra/qa.shtml?6), which implements the NMED-approved notice of intent (NOI) decision tree for drilling, development, rehabilitation, and sampling purge water • ENV-RCRA-SOP-011, Land Application of Drill Cuttings (http://int.lanl.gov/orgs/env/rcra/qa.shtml?6), which implements the NMED-approved NOI decision tree for IDW solids from construction of wells and boreholes The primary waste streams include drill cuttings, purge water generated during drilling, water generated during development of the well, contact waste, and decontamination water. Data from the existing wells indicate that the wastes generated should be nonhazardous and nonradioactive. Therefore, all wastes will initially be managed as nonhazardous. Drill cuttings and purge water will be characterized with direct sampling immediately following completion of drilling activities (i.e., date of generation) and waste determinations made from validated data. Drill cuttings and purge water will initially be stored in aboveground- or belowground-lined pits. If validated analytical data show these wastes are hazardous, they will be containerized in U.S. Department of Transportation-compliant containers and placed in a registered accumulation area for shipment to an authorized treatment, storage, and disposal facility within 90 d of generation. Contact waste will be characterized based on the waste determination of the drill cuttings and purge water. Decontamination water will be characterized by direct sampling of containerized waste.
Schedule	TW-2A replacement will be installed by April 30, 2010. The out-year date reflects the fact that other planned wells support more immediate corrective measures evaluation needs. Additionally, existing TW-2A will continue to provide water-quality data until the replacement well is installed. The available time-series water-quality data from existing TW-2A indicate that contaminant trends are stable for this perched zone.

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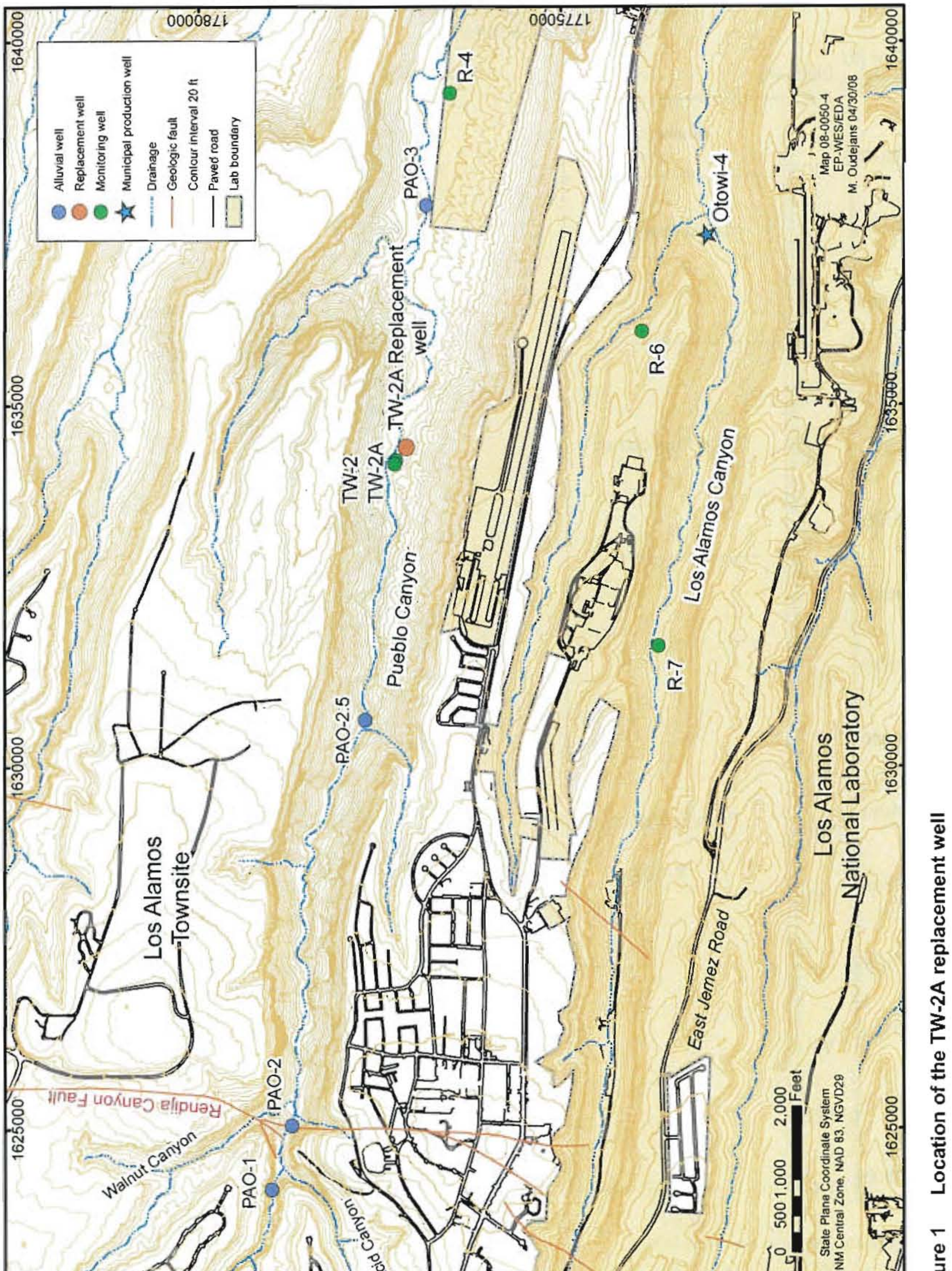
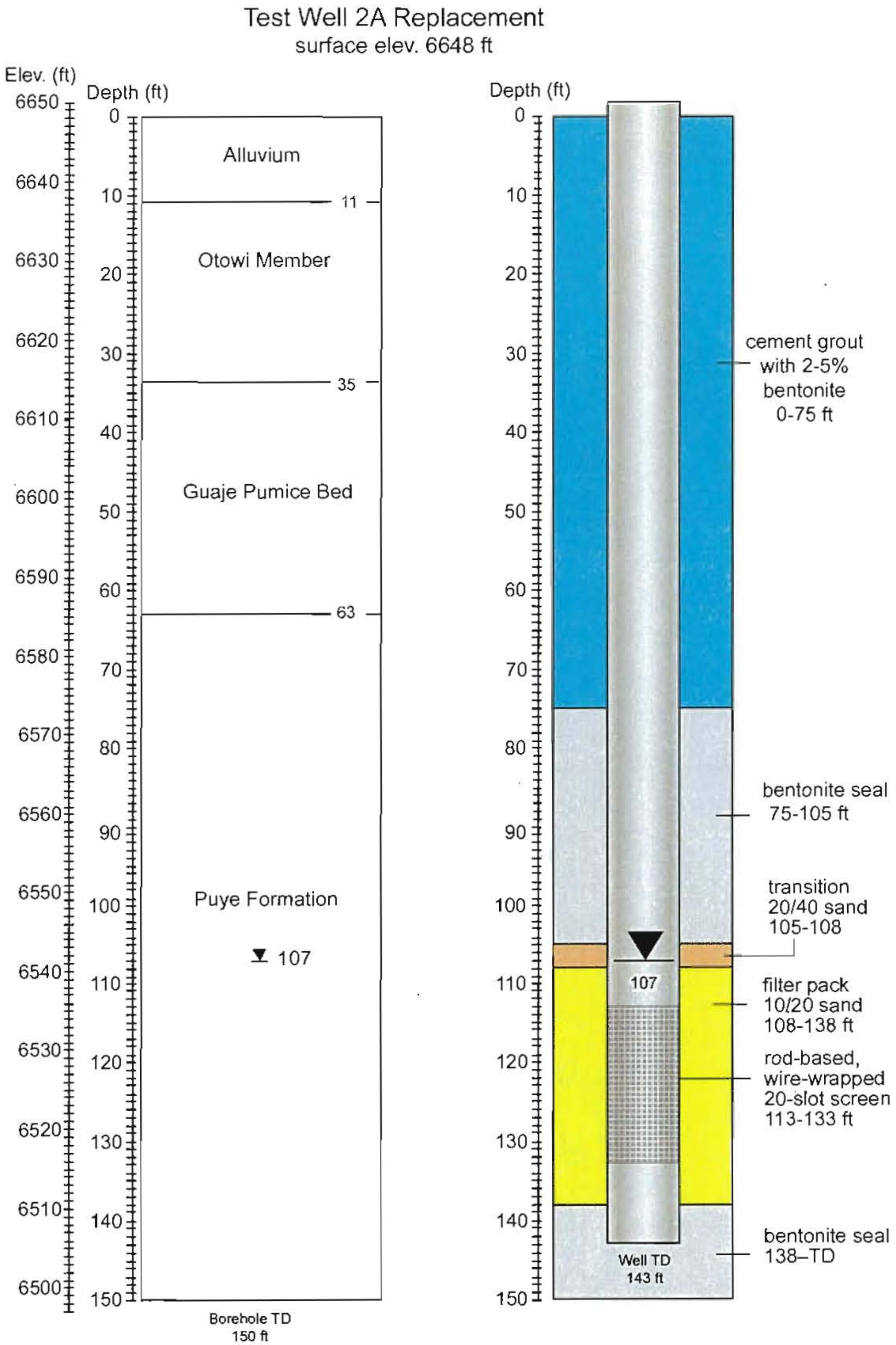


Figure 1 Location of the TW-2A replacement well



Note: All depths and elevations are shown in feet.

Figure 2 Proposed well design for the TW-2A replacement well

Work Plan to Plug and Abandon Pueblo Canyon Wells TW-1, TW-1A, TW-2, and TW-2A

This work plan summarizes the methods Los Alamos National Laboratory (the Laboratory) proposes to use in plugging and abandoning groundwater-monitoring wells TW-1, TW-1A, TW-2, and TW-2A. Well abandonment will be consistent with the requirements and guidelines of the "New Mexico Environment Department Ground Water Pollution Prevention Section Monitoring Well Construction and Abandonment Guidelines" (NMED 2007, 101333) and Sections IV.B.1.b.v and X.D (Well Abandonment) of the Compliance Order on Consent (the Consent Order). Plugging and abandoning these wells was recommended in the "Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations, Revision 1" (LANL 2008, 101330). This recommendation was approved by the New Mexico Environment Department (NMED) in a letter dated March 28, 2008, "Approval with Direction Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations, Revision 1, Los Alamos National Laboratory" (NMED 2008, 101112).

Because the construction design for these wells differs, the abandonment methods proposed in this work plan vary. For each well, all aboveground and belowground appurtenances will be removed, including pumps, transducers, data loggers, control panels, etc. The wells will then be inspected with a downhole camera, and a natural gamma log will be collected to document the current conditions.

TW-1

In 1950, single-screen regional monitoring well 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. (inside diameter [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 (DTW) at TW-1 is about 510 ft.

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 when 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 that extends from 210- to 225-ft depth. Based on the available well completion notes, TW-1 does not have annular space outside the 8-in.-I.D. casing. Therefore, there is no annular seal, nor is there a filter pack around the screen.

To plug and abandon, the 8-in. casing will be cut at 200-ft depth and removed from the borehole. The entire screen length (632–642 ft) will either be ripped or perforated. Available options include both mechanically actuated and air-actuated ripping/perforating devices. Regardless of the method selected, the Laboratory will avoid using high explosives (HE) or other chemicals. The entire 642 ft will then be filled with cement from the bottom to the top using a tremie pipe. Samples of oxidized iron casing material will be collected and analyzed by the Earth and Environmental Sciences Division to evaluate the potential of contaminants (in particular, uranium) adsorbing onto the casing material.

TW-1A

In 1950, single-screen perched intermediate monitoring well 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 (Figure 2). There are discrepancies among various reports, but the bottom of the screen is believed to be between 223 and 225 ft. Current DTW at TW-1A is about 182 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 when 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.

To remove the potential annular conduit at TW-1A between the 12-in. and 6-in. casing, the 6-in. casing will be cut at approximately 60 ft below ground surface (bgs) and removed. To plug and abandon the remainder of well, the entire screen length (214–224 ft) will either be ripped or perforated. Available options include both mechanically actuated and air-actuated ripping/perforating devices. Regardless of the method selected, the Laboratory will avoid using HE or other chemicals. The entire 224 ft will then be filled with cement from the bottom to the top using a tremie pipe.

TW-2

In 1949, single-screen regional monitoring well 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 3). Original DTW was 759 ft.

Water levels at TW-2 declined significantly over time. 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 (Figure 3). 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 DTW was in 2000, with a measured DTW of about 803 ft.

The types of well materials used during the original construction of TW-2 are not specified in reports documenting its installation. Use of carbon-steel drive and well casings was common practice when 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.

To remove the potential annular conduit at TW-2 between the 16-in., 12-in., and 10-in. casings, the 10-in. and 12-in. casings will be cut at approximately 60 ft bgs and removed. To plug and abandon the remainder of well, the entire screen length (774–824 ft) will either be ripped or perforated. Available options include both mechanically actuated and air-actuated ripping/perforating devices. Regardless of the method selected, the Laboratory will avoid using HE or other chemicals. The entire 834 ft will then be filled with cement from the bottom to the top using a tremie pipe.

TW-2A

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 4). Open hole was drilled from 118 to 133 ft. Current DTW at TW-2A is about 107 ft.

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 when 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. There is no record of annular fill between the 12-in., 8-in., and 6-in. casings.

To remove the potential annular conduit at TW-2A between the 12-in. and 8-in. casings, the 8-in. casing will be removed. To plug and abandon the remainder of well, the entire screen length (128–133 ft) will either be ripped or perforated. Available options include both mechanically actuated and air-actuated ripping/perforating devices. Regardless of the method selected, the Laboratory will avoid using HE or other chemicals. The entire 133 ft will then be filled with cement from the bottom to the top using a tremie pipe.

SURFACE COMPLETION

Once the wells have been cement grouted to within 2 ft of ground surface, the well casings will be cut off at the ground surface. A 2-ft × 2-ft cement monument will be placed over the abandoned borehole. A brass marker will be surveyed in accordance with Section IX.B.2.f of the Consent Order, which states that pertinent structures may be horizontally located with a global positioning system to within 0.5 ft.

SUMMARY REPORT

A brief report will be prepared detailing the methods used, presenting borehole logs (video and natural gamma), and providing the final abandonment design. Figures depicting the location of the abandoned wells and backfill completion will also be included in the report. The proposed schedule for completion of well abandonment and reporting follows.

SCHEDULE

TW-1 and TW-1A plugging and abandonment activities are scheduled to take place in conjunction with the well installation activities at nearby well R-3. After R-3 is installed, the drill rig will move over to TW-1 and TW-1A to plug and abandon those wells. TW-1 and TW-1A will be plugged and abandoned by January 31, 2010.

TW-2 and TW-2A plugging and abandonment activities are scheduled to take place in conjunction with the installation of TW-2A replacement. After TW-2A replacement is installed, the drill rig will move over to TW-2 and TW-2A to plug and abandon those wells. TW-2 and TW-2A will be plugged and abandoned by January 31, 2010.

A report summarizing the plugging and abandonment activities at TW-1, TW-1A, TW-2, and TW-2A will be submitted to NMED by March 15, 2010.

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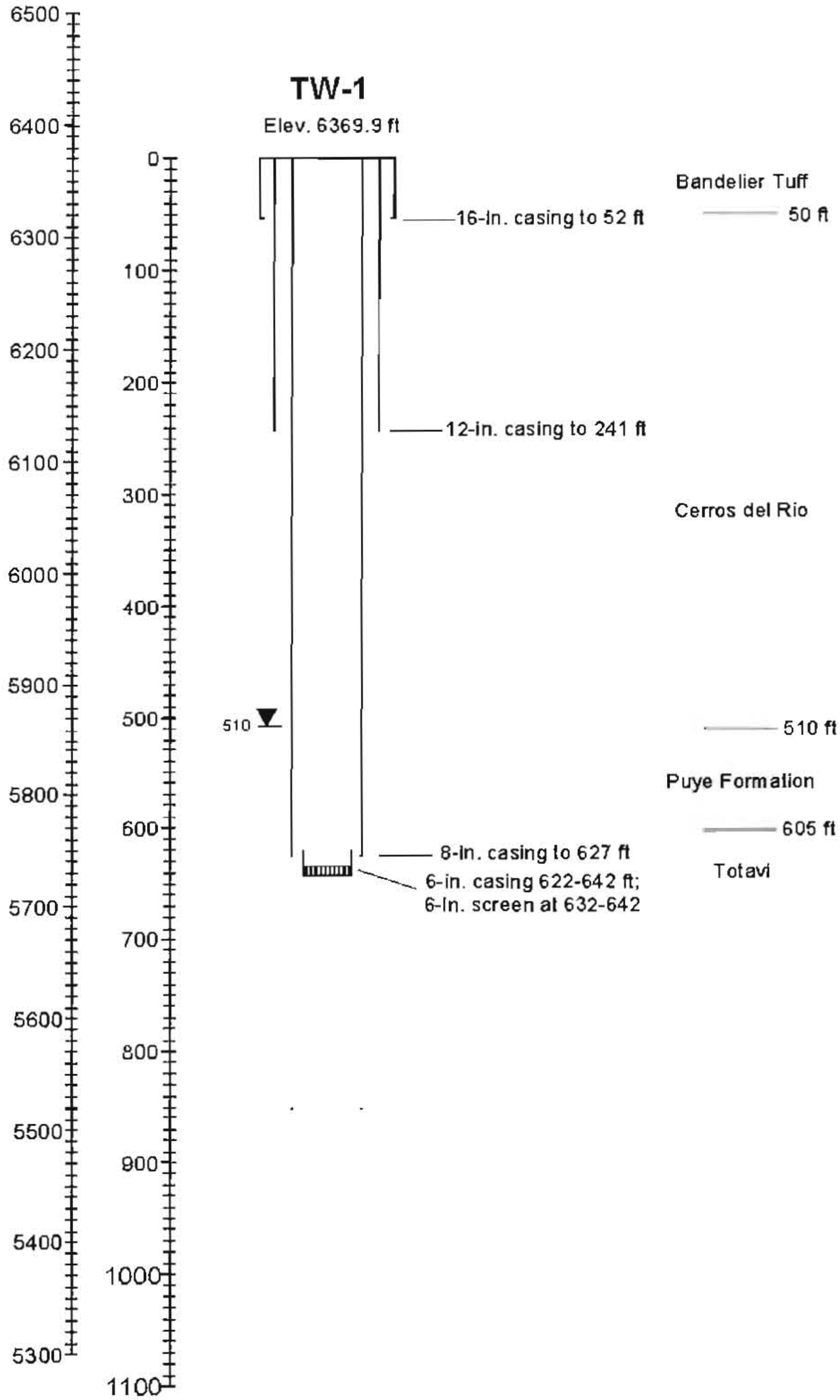

Figure 1 Well construction and stratigraphy at TW-1

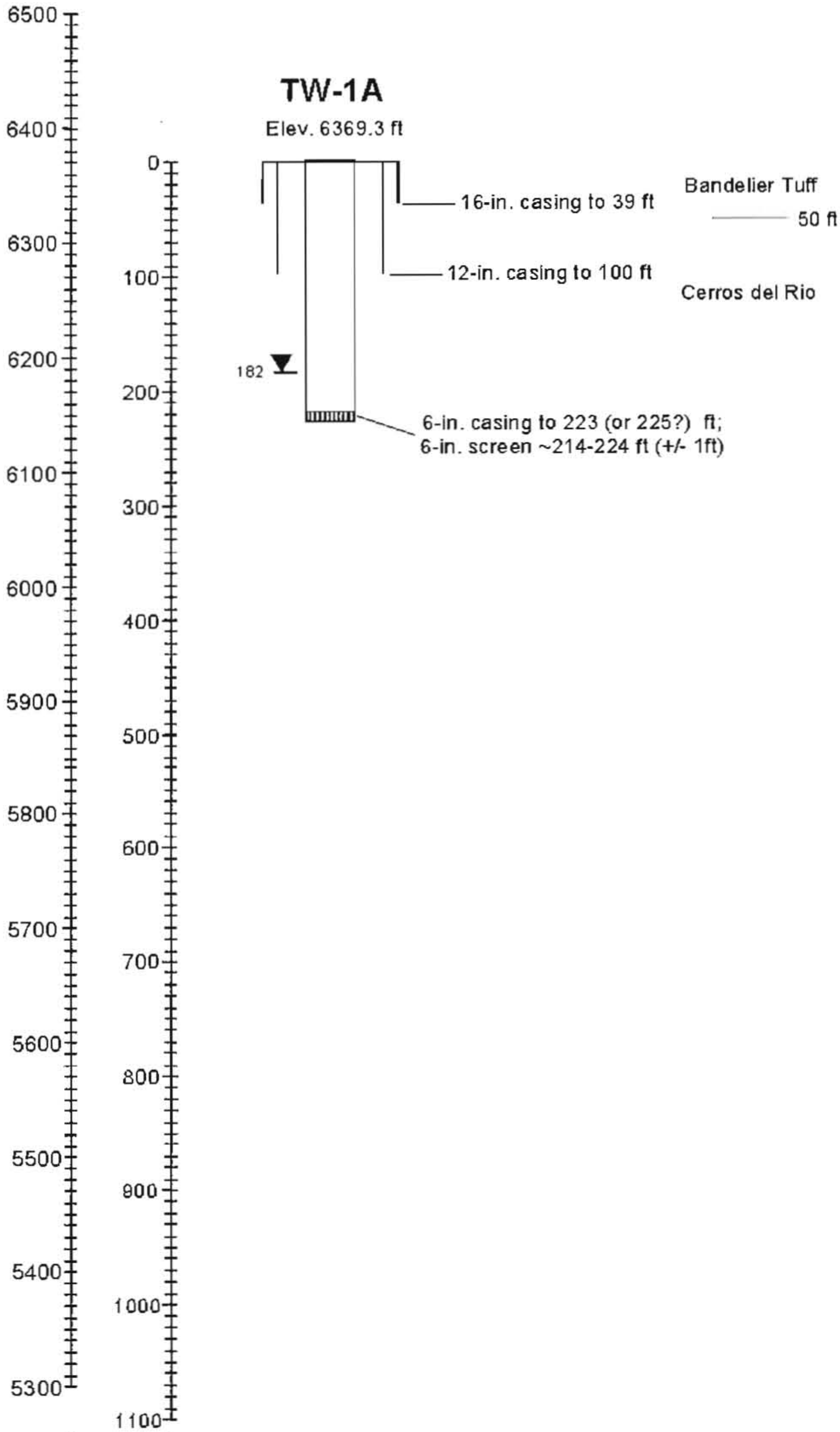

Figure 2 Well construction and stratigraphy at TW-1A

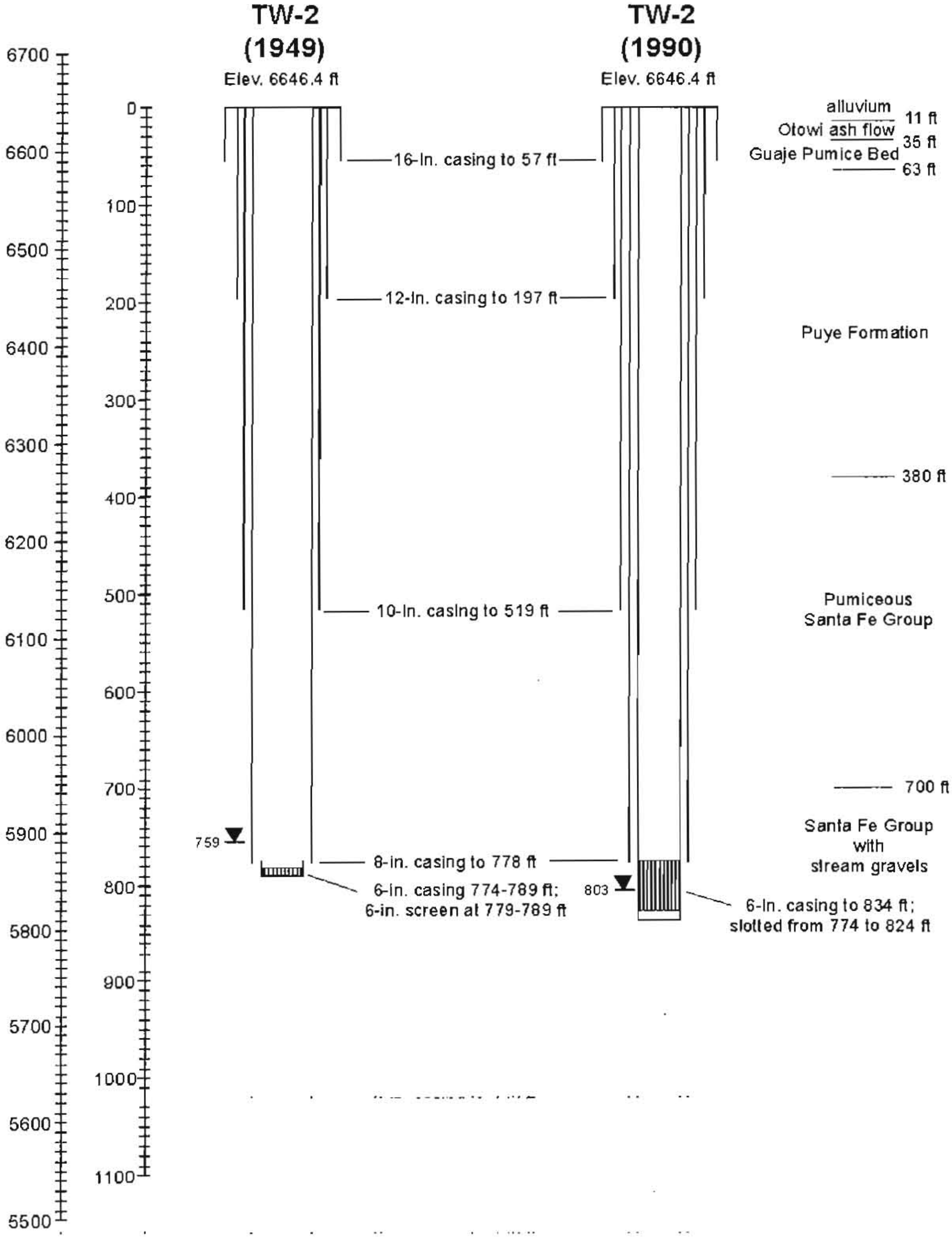

Figure 3 Original and modified well construction at TW-2 with stratigraphy

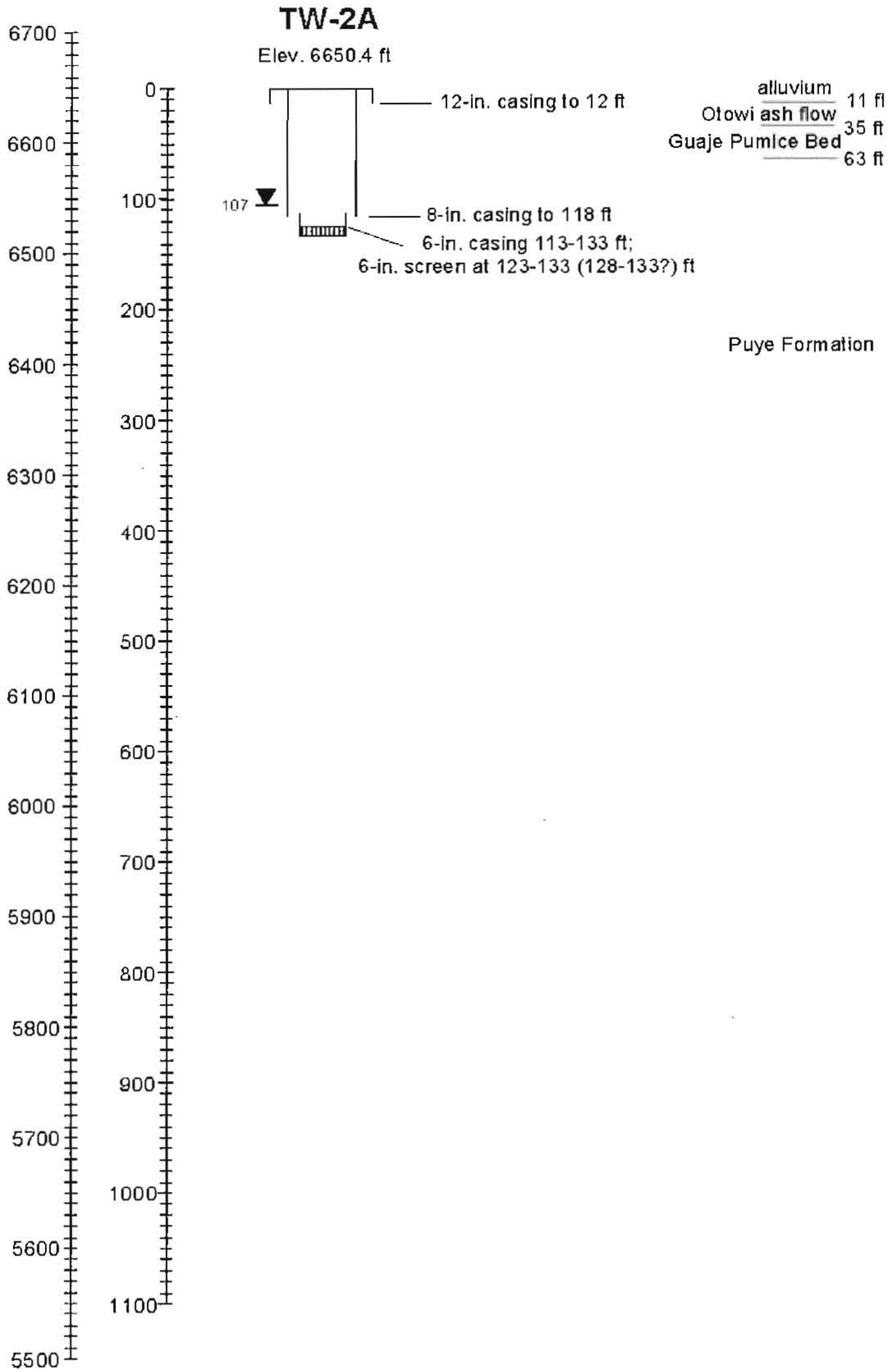

Figure 4 Well construction and stratigraphy at TW-2A