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Date: November 19, 2007
Refer To: EP2007-0713

James P. Bearzi, Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

Subject: Submittal of Work Plan for Geochemical Characterization and Drilling for Fate and Transport of Contaminants Originating in Sandia Canyon

Dear Mr. Bearzi:

Enclosed please find two hard copies with electronic files of the Work Plan for Geochemical Characterization and Drilling for Fate and Transport of Contaminants Originating in Sandia Canyon. This work plan is submitted on schedule pursuant to a requirement in the New Mexico Environment Department's notice of disapproval for the Fate and Transport Modeling Report for Chromium Contamination from Sandia Canyon, dated October 17, 2007.

If you have any questions, please contact Danny Katzman at (505) 667-6333 (katzman@lanl.gov) or Mat Johansen at (505) 665-5046 (mjohansen@doeal.gov).

Sincerely,

Susan G. Stiger, Associate Director
Environmental Programs
Los Alamos National Laboratory

Sincerely,

For/ David R. Gregory, Project Director
Environmental Operations
Los Alamos Site Office

SS/DG/DK:sm

Enclosures: 1) Two hard copies with electronic files - Work Plan for Geochemical Characterization and Drilling for Fate and Transport of Contaminants Originating in Sandia Canyon (EP2007-0713)

Cy: (w/enc.)
Neil Weber, San Ildefonso Pueblo
Mat Johansen, DOE-LASO, MS A316
Danny Katzman, EP-LWSP, MS M992 (plus 20 copies)
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LA-UR-07-7579
November 2007
EP2007-0713

Work Plan for Geochemical Characterization and Drilling for Fate and Transport of Contaminants Originating in Sandia Canyon

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Environmental Programs Directorate

LA-UR-07-7579
EP2007-0713

Work Plan for Geochemical Characterization and Drilling for Fate and Transport of Contaminants Originating in Sandia Canyon

November 2007

Responsible project leader:

Danny Katzman		Project Leader	Environmental Programs	11·19·07
Printed Name	Signature	Title	Organization	Date

Responsible LANS representative:

Susan G. Stiger		Associate Director	Environmental Programs	11/19/07
Printed Name	Signature	Title	Organization	Date

Responsible DOE representative:

for David R. Gregory		Project Director	DOE-LASO	11/19/07
Printed Name	Signature	Title	Organization	Date

CONTENTS

Figures

1.0 INTRODUCTION

This work plan describes geochemistry experiments and analyses that are intended to characterize further long-term fate and transport of contaminants (particularly chromium) from Sandia Canyon. In addition, this work plan includes drilling work plans for one regional well in Mortandad Canyon and one perched-intermediate well in Sandia Canyon as recommended in the "Fate and Transport Modeling Report for Chromium Contamination from Sandia Canyon" (Fate and Transport Report) (LANL 2007, 098938). These new wells are intended to further define the nature and extent of contamination and address key uncertainties in the conceptual model for contaminant fate and transport from Sandia Canyon. This work plan proposes work to address concerns expressed by the New Mexico Environment Department (NMED) in their October 17, 2007, letter "Notice of Disapproval, Fate and Transport Modeling Report for Chromium Contamination from Sandia Canyon" (NMED 2007, 097586). This work plan builds on a series of existing NMED-approved work plans that are concurrently under implementation. These work plans include the "Work Plan for Sandia Canyon and Cañada del Buey" (LANL 1999, 064617), the "Interim Measures Work Plan for Chromium Contamination in Groundwater" (LANL 2006, 091987), and the "Addendum to the Work Plan for Sandia Canyon and Cañada del Buey" (LANL 2007, 095454).

Ongoing refinement of the numerical chromium fate and transport model will occur as part of this work as described in the Fate and Transport report (LANL 2007, 098938) and requested by NMED, Item 3 in their letter of October 17, 2007 (NMED 2007, 097586). The model is an important tool for integrating available data and knowledge about the fate and transport of chromium in the subsurface and later for supporting the corrective measures evaluation (CME). During the next phase, model development will include calibration to simulate the measured concentrations of chromium in the subsurface. Updates will incorporate field data and parameters obtained from experiments as these activities are completed. A revised fate and transport modeling report will be submitted to NMED by July 31, 2008. The Sandia Canyon investigation report will incorporate further model revisions and is scheduled for submittal to NMED by December 15, 2008. Results for field and laboratory tests conducted under the work plans described above and proposed in this plan will be incorporated into the July and December 2008 deliverables as well. A CME process is anticipated to follow the investigation report at which time data and the numerical model should be sufficient to support a focused evaluation of remedial alternatives. Specific evaluation of alternatives before collection of additional information and model development is considered premature.

2.0 GEOCHEMICAL CHARACTERIZATION

Scope	Regulatory Application	Rationale/ Conceptual Model	Experimental Design or Analysis	Modeling Parameters	Geomedia	Characterization of Materials
Geochemical stability of the Sandia Canyon wetland chromium inventory	Addresses comment 1 “Assess Chromium Remaining in Wetland as a Potential Source” from NMED letter dated October 17, 2007 (NMED 2007, 097586)	The “Summary of Sandia Canyon Phase 1 Sediment Investigations” estimated that 5700 to 27,000 kg (essentially all of which is Cr(III)) is located in the wetland, representing ~65% to 90% of the Cr sediment inventory (LANL 2007, 098127, p. 4) and 8% to 87% of the original Cr released to Sandia Canyon (LANL 2007, 098938, Appendix A). This Cr(III) mass represents a secondary source that could potentially remobilize. Understanding future Cr mobility from wetland sediments is key to the evaluation of potential “downstream” impacts. Two potential oxidation mechanisms that might convert immobile Cr(III) to mobile Cr(VI) are oxidation by Mn(IV) contained in wetland sediments and oxidation caused by dewatering of wetland sediments. Competing reduction reactions involving SOM and Fe(II) enhance the stability of Cr(III).	During Phase I sediment investigations, chemical analyses determined Cr(III) and Mn(IV) concentrations. These data will be analyzed to determine the molar ratio of Mn(IV)/Cr(III), which will determine the theoretical maximum Cr(III) oxidation potential associated with the Mn(IV) inventory in the sediments. The molar ratios of Fe(II)/Mn(IV) and Fe(II)/Cr(VI) contributing to the reductive capacity of the wetland will be evaluated. Wetland sediment samples that represent a range of chromium, manganese, and water content for dewatering experiments will be collected. Oven-drying and air-drying dewatering, followed by leaching and measurement of Cr(VI) will be performed.	Estimates of future mobile Cr(VI) to use as source for Cr groundwater fate and transport modeling.	Sandia Canyon wetland sediments	Determine amount of reactive Mn(IV) available for reoxidation of Cr(III) to Cr(VI) through selective extractions from sediment samples. Determine amounts of Fe(II) and reactive solid organic matter (SOM) available for maintaining Cr(III) by conducting selective extractions. Leaching of sediment samples and measurement of Cr(VI) by ion chromatography and inductively coupled plasma mass spectrometry (ICP-MS). Evaluate adsorption capacity of the wetland containing hydrous ferric oxide (HFO) for Cr. Determine moisture content during dewatering experiments.

Scope	Regulatory Application	Rationale/ Conceptual Model	Experimental Design or Analysis	Modeling Parameters	Geomedia	Characterization of Materials
Adsorption and desorption of chromium	Addresses "Adsorption of Cr(VI)" activity proposed in the Fate and Transport report (LANL 2007, 098938) and comment 2a "Chromium Desorption in Vadose Zone" of NMED letter dated October 17, 2007 (NMED 2007, 097586).	Interaction of Cr with geomedia may immobilize Cr, leading to natural attenuation. Literature-derived Kd values for Cr(VI) and precipitation parameters for Cr(III) are not abundantly available, and those that are available do not represent conditions at Los Alamos National Laboratory (LANL or the Laboratory). The Laboratory-specific adsorption/ desorption data for Cr(VI) and precipitation data for Cr(III) have direct application to (1) addressing Cr adsorption reaction rates and retention capacities in the vadose zone and regional aquifer and (2) determining the leachability/reversibility of Cr from its immobilized form under site-specific conditions.	Batch and column tests will be run under saturated conditions. Batch tests will provide upper bounds of parameters for geochemical modeling as well as provide information about interaction mechanisms between Cr and geomedia. Column tests will provide data on kinetics and thermodynamics of Cr reactive transport relevant to the site-specific geological settings under various flow rates and input Cr(VI) concentration levels. Column and batch tests will quantify reversibility of Cr reactions with geomedia using noncontaminated site groundwater. Measurements of δ^{53}Cr from select batch and column tests will discriminate between sorption-related processes (non-fractionating) and reduction-related processes (fractionating).	Adsorption coefficients (Kd) for Cr(VI) and kinetic parameters for Cr(VI) reduction and subsequent Cr(III) precipitation. 1. Provide kinetic and thermodynamic parameters for Cr removal process using batch tests to bound the residence time and flow rate required for column tests relevant to field conditions. 2. Provide geochemical modeling parameters controlling leachability and reversibility of Cr(VI) adsorption within vadose zone and regional aquifer. 3. Results from batch tests will provide upper bounds for permeability, effective porosity, Kd values, and kinetic parameters for adsorption/ desorption reactions required for Cr reactive transport model. 4. Provide adsorption/ desorption rates for Cr(VI).	Use representative, noncontaminated vadose zone and aquifer material and groundwater from Cerros del Rio basalt and Puye Formation.	Conduct scanning electron microscopy (SEM) x-ray diffraction (XRD) to determine distribution and composition of solid phases within geomedia before and after exposure to Cr. Determine mass of HFO in geomedia for quantifying Cr(VI) adsorption capacity using dithionite/citrate-oxalate-pyrophosphate selective digestions. X-ray absorption spectroscopy (XAS) can be used to determine chemical form of Cr (Cr (III) or Cr(VI)) occurring during adsorption, precipitation, and redox processes. δ^{53}Cr measurements of sediment, input Cr(VI) and residual Cr(VI) by multicollector ICP-MS.

Scope	Regulatory Application	Rationale/ Conceptual Model	Experimental Design or Analysis	Modeling Parameters	Geomedia	Characterization of Materials
Cr(VI) reduction	Addresses “Adsorption of Cr(VI)” activity proposed in the Fate and Transport report (LANL 2007, 098938) and comment 2b “Chromium Reduction by Cerros del Rio Basalt” of NMED letter dated October 17, 2007 (NMED 2007, 097586).	Dissolved concentrations of Cr(III) are controlled, in part, by precipitation reactions. The specifics of this process in the vadose zone beneath Sandia Canyon (e.g., location, magnitude, etc.) are not yet well defined. Laboratory-specific reduction data for Cr(VI) to Cr(III) have direct application to (1) evaluating the stability of Cr(III) in the vadose zone and regional aquifer, (2) evaluating kinetics of Cr(VI) reduction and Cr(III) oxidation, and (3) constraining the Cr oxidation-reduction processes and its relation to Cr stable isotope data.	Batch and column experiments will be conducted under saturated conditions. Batch and column experiments will provide parameters characterizing redox processes controlling both the reduction and precipitation and the stability of precipitated Cr(III). Measurements of δ^{53}Cr from select batch and column tests will discriminate between sorption-related processes (non-fractionating) and reduction-related processes (fractionating).	Column tests will provide modeling parameters required for establishing Cr reactive transport model in coupling redox kinetics and redox buffering capacity for vadose zone and regional aquifer.	Use representative, noncontaminated aquifer material and groundwater from Cerros del Rio basalt and Puye Formation.	Conduct SEM and XRD to determine distribution and composition of solid phases of geomedia before and after exposure to Cr during batch and column tests. XAS can be used to determine the chemical form of Cr (Cr (III) or Cr(VI)) occurring during adsorption, precipitation, and redox processes. Determine concentrations and speciation of Fe in geomedia used in experiments and characterization investigation. δ^{53}Cr measurements of sediment, input Cr(VI) and residual Cr(VI) by multicollector ICP-MS.

Scope	Regulatory Application	Rationale/ Conceptual Model	Experimental Design or Analysis	Modeling Parameters	Geomedia	Characterization of Materials
In-situ chromium distribution in deeper vadose zone	Addresses comment 2c “Chromium distribution in deeper vadose zone” of NMED letter dated October 17, 2007 (NMED 2007, 097586).	The conceptual model for Cr transport assumes that the Cerros del Rio basalt may retain Cr in the deep vadose zone either through a reduction reaction with Fe(II) and/or through adsorption onto HFO. The degree to which this occurs may affect remediation options. Field evidence for this mechanism will help to establish the degree to which this occurs. The redox buffering and adsorption capacities of the Puye Formation for Cr are not known. The Puye Formation may serve as a sink for Cr through precipitation and adsorption processes.	1. Acid-soluble and porewater-dissolved Cr concentrations were determined from core samples in the 6 previous core holes drilled in Sandia Canyon (LANL 2006, 091987, Figure 5.5-1). These core holes extend into the Puye Formation and a few feet into the Cerros del Rio basalt. Upper-bound field-scale Kd values for the Puye Formation and the basalt will be estimated from these data. 2. Chromium concentrations for noncontaminated Cerros del Rio basalt core and Puye Formation samples will be analyzed using an acid leach test (U. S. Environmental Protection Agency [EPA] method 3050) to estimate the contribution of natural Cr concentrations. Background concentrations of Cr can be used to adjust calculated Kd values from item 1 above. 3. Core from the deeper vadose zone will be collected during drilling of SCI-2 in Sandia Canyon. These core samples will be analyzed to determine acid-soluble and pore-water Cr concentrations.	Field-scale Kd or reduction buffering capacities of deeper vadose-zone units.	Cerros del Rio basalt and Puye Formation.	Core leaching with DI water coupled with EPA-3050 digestion to determine the nature and distribution of Cr in core. Determine effective Kd values for Cr using both leaching methods. Perform XRD and SEM analyses on selected samples from the Cerros del Rio basalt and Puye Formation to determine minerals and amorphous solids containing Cr. Both fresh and chemically weathered samples will be selected for characterization and determining background Cr concentrations within the Cerros del Rio basalt and Puye Formation. Background concentrations of other metals/trace elements such as Fe, Al, Mn, Sr, As etc. will also be determined.

3.0 DRILLING

General location and purpose	A regional aquifer well and a perched-intermediate well are planned for Mortandad and Sandia Canyons, respectively, to augment the existing groundwater monitoring system that is used to characterize chromium contamination in the area. Both wells will be installed with one well screen and sampled with a submersible pump. Figure 1 shows the locations of the proposed new intermediate well SCI-2 and regional well R-42. Figure 2 is a generic well completion diagram showing the preliminary design for the perched-intermediate well. Similarly, Figure 3 is a generic diagram showing the preliminary design for the regional well. Figure 4 is a borehole-to-borehole cross section showing the distribution of hydrostratigraphic units near Mortandad and Sandia Canyons.
Purpose and design of new intermediate monitoring well	Intermediate hole SCI-2 is being drilled to obtain core samples of the Cerros del Rio lavas and the underlying Puye Formation beneath Sandia Canyon in order to investigate the contaminant distributions in rocks of the vadose zone and water quality of perched groundwater, if present. If sufficient water is present, an intermediate well will be installed to monitor the temporal trends in water quality and water levels of perched water. Nearby boreholes (SCI-1, SCC-2, SCC-3) encountered limited perched saturation at the top of the Cerros del Rio lavas; however, these boreholes were not deep enough to determine if significant zones of perched groundwater are present deeper within this lava series (Figure 1). This information is important because significant zones of perched water in the basalt may provide a southward migration pathway that could carry chromium-contaminated water between Sandia and Mortandad Canyons before it reaches the regional aquifer. This pathway might explain the presence of elevated chromium concentrations at well R-28 in Mortandad Canyon from a suspected Sandia Canyon chromium source. SCI-2 may penetrate perched saturation above the Cerros del Rio lavas similar to that encountered at adjacent core hole SCC-2 and screened by well SCI-1, which is located 600 ft to the northwest. However, the main goal for SCI-2 is to determine if perched groundwater occurs in substantial quantities within the interior of the basalt. The base of the basalt is predicted to be at approximately 625 ft depth; the depth to possible top of perched saturation within the basalt is unknown, but perched groundwater occurs near the base of the basalts to the south in Mortandad Canyon. Another goal of SCI-2 is to collect core samples within the Cerros del Rio lavas and the underlying Puye Formation beneath Sandia Canyon to investigate the contaminant distributions in the lower part of the vadose zone. Previous investigations have shown that little chromium mass remains in the upper vadose zone beneath Sandia Canyon. This investigation will determine if significant chromium contamination is present in the lower part of the vadose zone and is a potential secondary source of chromium for contamination of the regional aquifer. Figure 2 shows the stratigraphy and proposed well design for SCI-2. Figure 4 is a set of comparative borehole profiles, including gamma logs, showing the distribution of hydrostratigraphic units near SCI-2. The upper two perched zones predicted for SCI-2 (at 54 to 60 ft and 356 to 377 ft) are based on information from adjacent core hole SCC-2; the deeper perched zone shown near the base of the basalts is hypothetical. The perched-intermediate core hole will be drilled to a maximum target depth of approximately 100 ft above the top of regional saturation. Any perched groundwater encountered is likely to be located in Cerros del Rio basalt. Well screen intervals will be determined based on conditions found during drilling but will probably range from 20 to 40 ft in length. Coring may be terminated higher in the stratigraphic sequence if significant perched water is encountered and cannot be sealed from entering the borehole through the use of drill casing.

<table>
<tr><td>Purpose and design of new regional monitoring well</td><td>The regional aquifer well (R-42) will be located upgradient of R-28 in Mortandad Canyon. R-28 has consistently shown the highest concentration of chromium in the regional aquifer at the Laboratory. Well R-42 is located adjacent to borehole MCOBT-8.5, which has been plugged and abandoned. R-42 will help determine source and flowpath immediately upgradient of R-28. The well is expected to penetrate the top of Miocene pumiceous sediments beneath the Puye Formation at approximately 958 ft depth. Well screen intervals will be determined based on conditions found during drilling but will probably range from 20 to 40 ft in length.</td></tr>
<tr><td>Conceptual model of hydrogeology</td><td>The current conceptual model for chromium contamination at R-28 in Mortandad Canyon implicates chromate used to treat cooling-tower water at Technical Area (TA) 3 that was released to the headwaters of Sandia Canyon. Other chromium sources at the Laboratory are believed to be of insufficient mass to result in the high level of contamination at R-28. Other contaminants including nitrate, perchlorate, sulfate, chloride, and tritium suggest mixed Mortandad and Sandia sources at R-28 and/or possible east-northeastward communication from Mortandad to Sandia as sampled at R-11 (Figure 1). Data from new well R-42 will test these assumptions.

Persistent surface-water flow along Sandia Canyon ends to the west of SCI-2 but feeds an alluvial aquifer that extends east of SCI-2; the saturated alluvium could feed a deeper perched system. Data from adjacent core hole SCC-2 provided evidence of saturation near the top of the Cerro Toledo interval and at the top of the Cerros del Rio lavas. At SCI-2, possible perched saturation may occur within or near the base of the Cerros del Rio lavas at a depth that has not previously been reached by drilling in this part of the canyon (Figure 2). The possible occurrence of perched groundwater within or at the base of the Cerros del Rio basalt is based on known occurrences in this setting from wells in Sandia Canyon (e.g., R-12) and Mortandad Canyon (e.g., MCOI-5 and MCOI-6).

The proposed screen for R-42 is in Miocene sedimentary rocks characterized by abundant vitric-aphyric rhyolitic pumice. This unit is highly transmissive in many aquifer performance tests (especially at R-28), and the unit hosts the high-chromium groundwater at R-28. The proximal upgradient position within a common transmissive unit make this location a critical sampling point for understanding the nature and extent of chromium contamination in the regional aquifer and contaminant pathways toward the screen at R-28.</td></tr>
<tr><td>Drilling approach for intermediate aquifer well</td><td>A two-hole drilling approach will be used at SCI-2.

• Using a drill rig specifically designed for coring with casing advance, an approximately 6-in.-diameter hole will be drilled using fluid-assisted casing advance through the Bandelier Tuff, the Guaje Pumice bed, and upper Puye Formation sediments to the top of the Cerros del Rio basalt.
• Starting at the top of the Cerros del Rio basalts the core hole will be advanced with a combination of core collection and casing advance. The interval will be continuously cored and casing will be advanced as needed to maintain hole stability. Core (approximately 3.5-in.-diameter) will be collected through the basalts and into approximately 150 ft of the Puye Formation (stopping at least 100 ft above the regional aquifer). No drilling fluids will be used and only potable water may be used as needed to cool the drill bit and lift cuttings. However, additional drilling additives (air-foam) may be required to advance the casing to the planned depths.
• If conditions allow, the casing will be pulled back so Laboratory geophysics and video can be run and water-producing zones characterized within the basalts.
• The core hole will be completely plugged to the surface with bentonite or cement-bentonite mixture in compliance with plugging requirements given in the March 1, 2005, Compliance on Consent Order.
• If water-producing zones are found, a larger drill rig will advance a new borehole with 16-in. surface casing with fluid-assisted air-rotary methods through the 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 air-rotary methods through the Cerros del Rio basalts and any associated perched water. Potable water will be used as needed to</td></tr>
</table>

	cool the drill bit and lift cuttings. However, an air-foam mixture may be used if necessary to advance the 15-in. open borehole to 20 ft above the target depth for the well screen; the screen interval will be drilled using only potable water, if possible. • A 12-in. casing-advance may be used to complete the borehole if needed. Only potable water (no drilling additives) will be used in the saturated interval. • The well screen will be set at the previously identified zone that produces the most water within the Cerros del Rio basalt.
Drilling approach for regional aquifer well	The following drilling methods will be used for regional well R-42. • A 16-in. surface casing will be advanced with fluid-assisted air-rotary methods through the 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. Introduction of drilling additives (e.g., foam) will stop 100 ft above the regional aquifer. • If perched water is present, bentonite will be tremied into the borehole, and a 12-in. casing will be lowered and sealed in place. Perched water is not anticipated, based on observations at MCOBT-8.5. • If indeed no perched water is encountered, the 12-in. casing will be lowered into the open borehole and advanced to refusal. • If needed, a 10-in. casing will be advanced to target depth of 150 ft into the regional aquifer without the use of drilling fluid additives. Municipal water may be added to cool the drill bit as needed. • The well screen will be set in the Puye Formation within the uppermost 100 ft of the aquifer in the zone that produces the most water.
Potential drilling fluids	Fluids and additives, which may be used have been characterized geochemically and are consistent with those previously used in the drilling program at the Laboratory, include • 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; and • AQF-2, an anionic surfactant, to be used as a foaming agent.
Potential groundwater occurrence and detection	**Intermediate Well** Groundwater may occur in the Cerros del Rio basalt at SCI-2, as found in wells MCOI-5 and MCOI-6 to the south in Mortandad Canyon. Likely depth of encounter is approximately 580 to 625 ft. **Regional well** Regional groundwater is expected to occur in the lower Puye Formation at ~930 ft depth. Methods for groundwater detection may include driller's observations, water-level measurements, borehole video, and borehole geophysics.
Core sampling	**Intermediate Well** Approximately 453 ft of continuous core will be collected from the top of the Cerros del Rio basalt (approximately 377 ft depth) and into the Puye Formation to a target depth of about 830 ft (100 ft above the regional water table). Coring may be terminated if significant perched groundwater is encountered, and the producing zone cannot be isolated from the advancing core hole using drill casing. **Regional Well** No core collection is planned at R-42 because core was previously collected from adjacent MCOBT-8.5.

Core analysis	Samples of the core will be analyzed or tested for selected properties. The samples selected will be selected from fractured basalts and interflow zones. The analyses to be conducted will include cations, anions, and metals/trace elements using both deionize water leach and EPA 3050 partial digestion.
Groundwater screening sampling	Screening water samples will be collected during drilling at any perched horizon producing sufficient water for sampling and at the top of the regional aquifer. 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 (Group EES-6) chemistry laboratory.
Groundwater characterization sampling	Groundwater samples will be collected from the completed wells between 10 and 60 days after well development in accordance with the Consent Order. These samples will be analyzed for the full suite of constituents including: radionuclides, metals/cations, general inorganic chemicals, volatile and semi-volatile organic compounds, and stable isotopes of hydrogen, nitrogen, and oxygen. Subsequent groundwater samples will be collected as specified in the “Interim Measures Work Plan for Chromium Contamination in Groundwater” (LANL 2006, 091987) and the “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. **Intermediate well** The Laboratory’s borehole video camera, natural gamma, and induction (conductivity) tools will be used to log the borehole if open-hole conditions allow; this may include parts of the borehole where casing can be retracted without causing borehole stability problems. A gamma log will be collected in cased portions of the borehole. **Regional well** Borehole conditions permitting, the 10-in. casing also 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 micro-imager logs. If the casing cannot be retracted for logging, the accelerator porosity sonde, elemental capture sonde, triple litho-density, 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 depth.
Well completion design	**Intermediate well** After the core hole reaches total depth, it will be plugged and abandoned using a bentonite or cement-bentonite mixture in accordance with plugging requirements in the Consent Order. If significant perched water is present in the basalts, a second larger-diameter borehole will be drilled to place one well screen in the uppermost perched interval that has any indication of lateral hydrologic connectivity, if present. **Regional well** One well screen will be placed in the most productive interval identified within the upper 100 ft of the regional aquifer.
Well development	**Intermediate well** To the extent possible, the perched-intermediate well will be developed by mechanical means, including swabbing, bailing, and pumping. **Regional well** The well will be developed by mechanical means, including swabbing, bailing, and pumping. Target water-quality parameters are turbidity <5 nephelometric turbidity units, total organic carbon <2 parts per million (ppm), and other parameters stable.

Hydraulic testing	**Intermediate well** Intermediate zones generally do not produce sufficient water to allow hydrologic testing. If sufficient water is present, a constant rate-pumping test will be conducted. **Regional well** Hydraulic testing will be considered if a significant contaminant horizon is encountered.
Investigation-derived waste management	Fluids produced during drilling will be managed and disposed of in accordance with the NMED-approved Notice of Intent Decision Tree: Drilling, Development, Rehabilitation, and Sampling Purge Water (November 2006). Cuttings produced during drilling will be managed and disposed of in accordance with the Decision Tree for Management of Investigation-Derived Waste Solids from Drilling Operations, which is pending review and approval from the NMED.
Schedule	This chromium-drilling program is anticipated to begin in June 2008 following completion of several ongoing drilling projects. Both wells shall be drilled and installed by August 2008. The Laboratory will regularly review the status the progress of work with NMED as information is obtained during drilling.

4.0 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.

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), September 1999. "Work Plan for Sandia Canyon and Cañada del Buey," Los Alamos National Laboratory document LA-UR-99-3610, Los Alamos, New Mexico. (LANL 1999, 064617)

LANL (Los Alamos National Laboratory), March 2006. "Interim Measures Work Plan for Chromium Contamination in Groundwater," Los Alamos National Laboratory document LA-UR-06-1961, Los Alamos, New Mexico. (LANL 2006, 091987)

LANL (Los Alamos National Laboratory), April 2007. "Addendum to the Work Plan for Sandia Canyon and Cañada del Buey, Revision 1," Los Alamos National Laboratory document LA-UR-07-2186, Los Alamos, New Mexico. (LANL 2007, 095454)

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), September 2007. "Fate and Transport Modeling Report for Chromium Contamination from Sandia Canyon," Los Alamos National Laboratory document LA-UR-07-6018, Los Alamos, New Mexico. (LANL 2007, 098938)

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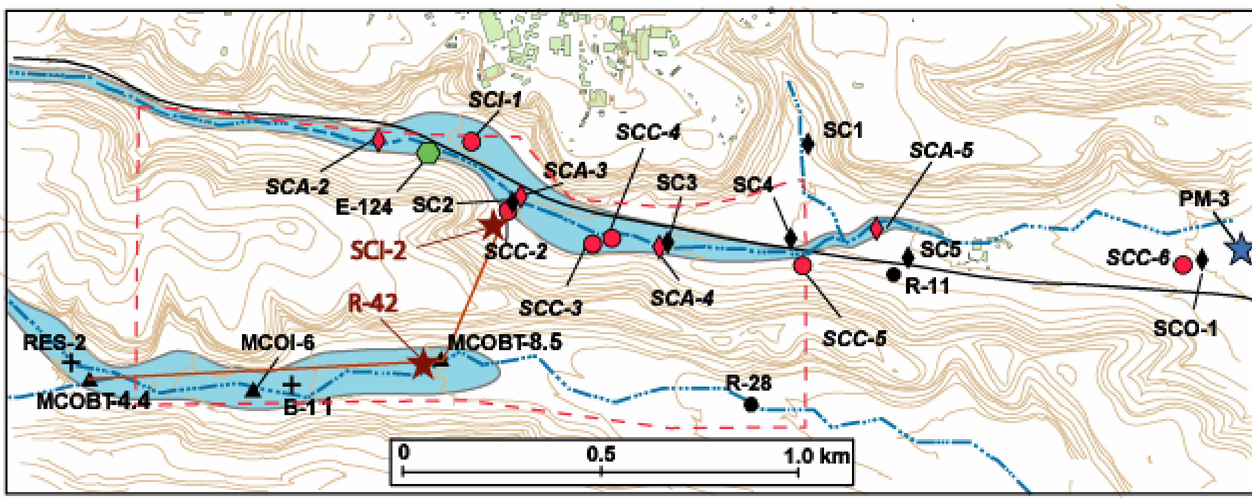
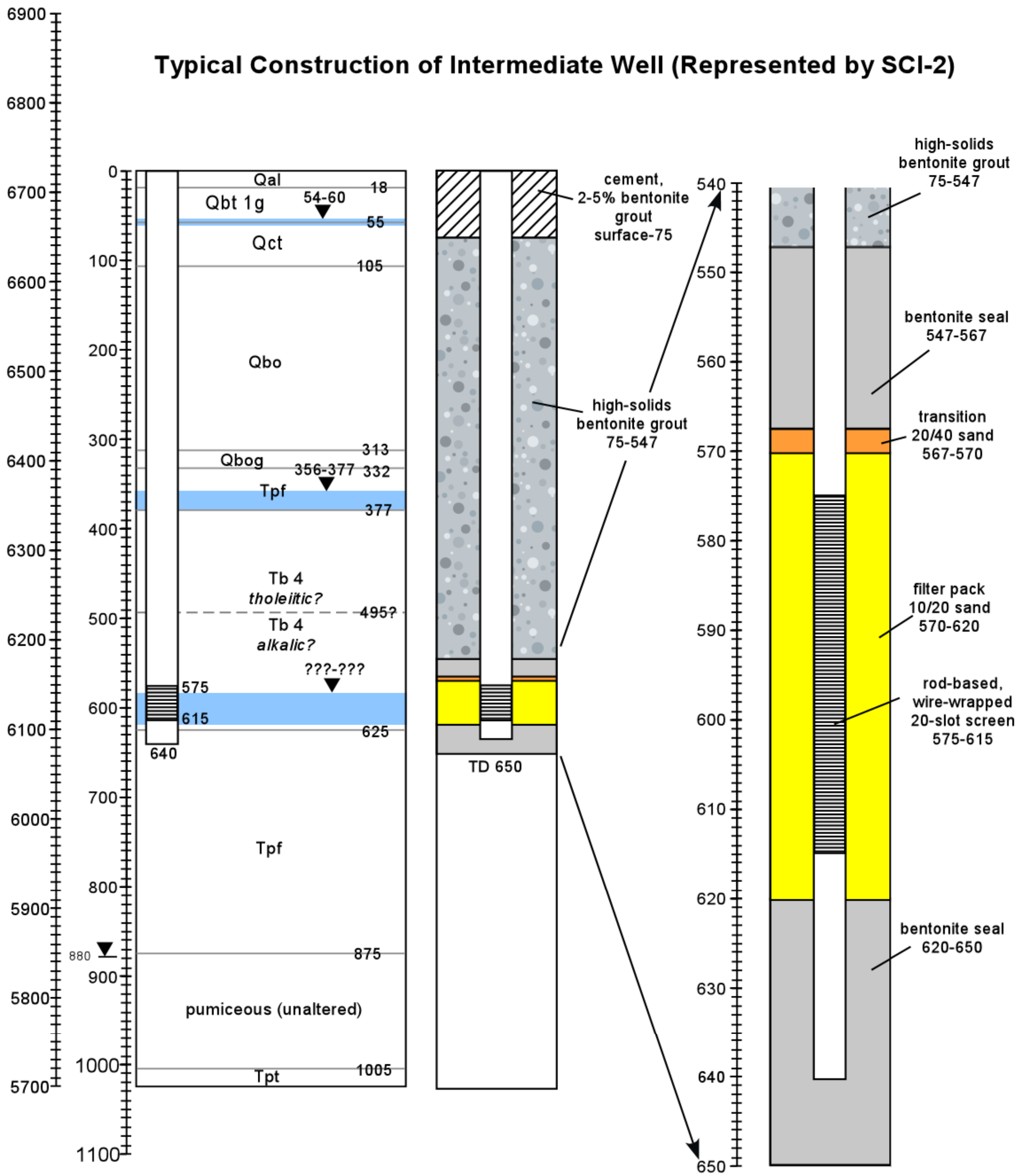
NMED (New Mexico Environment Department), October 17, 2007. "Notice of Disapproval, Fate and Transport Modeling Report for Chromium Contamination from Sandia Canyon," New Mexico Environment Department letter to D. Gregory (DOE LASO) and D. McInroy (LANL) from J.P. Bearzi (NMED HWB), Santa Fe, New Mexico. (NMED 2007, 097586)



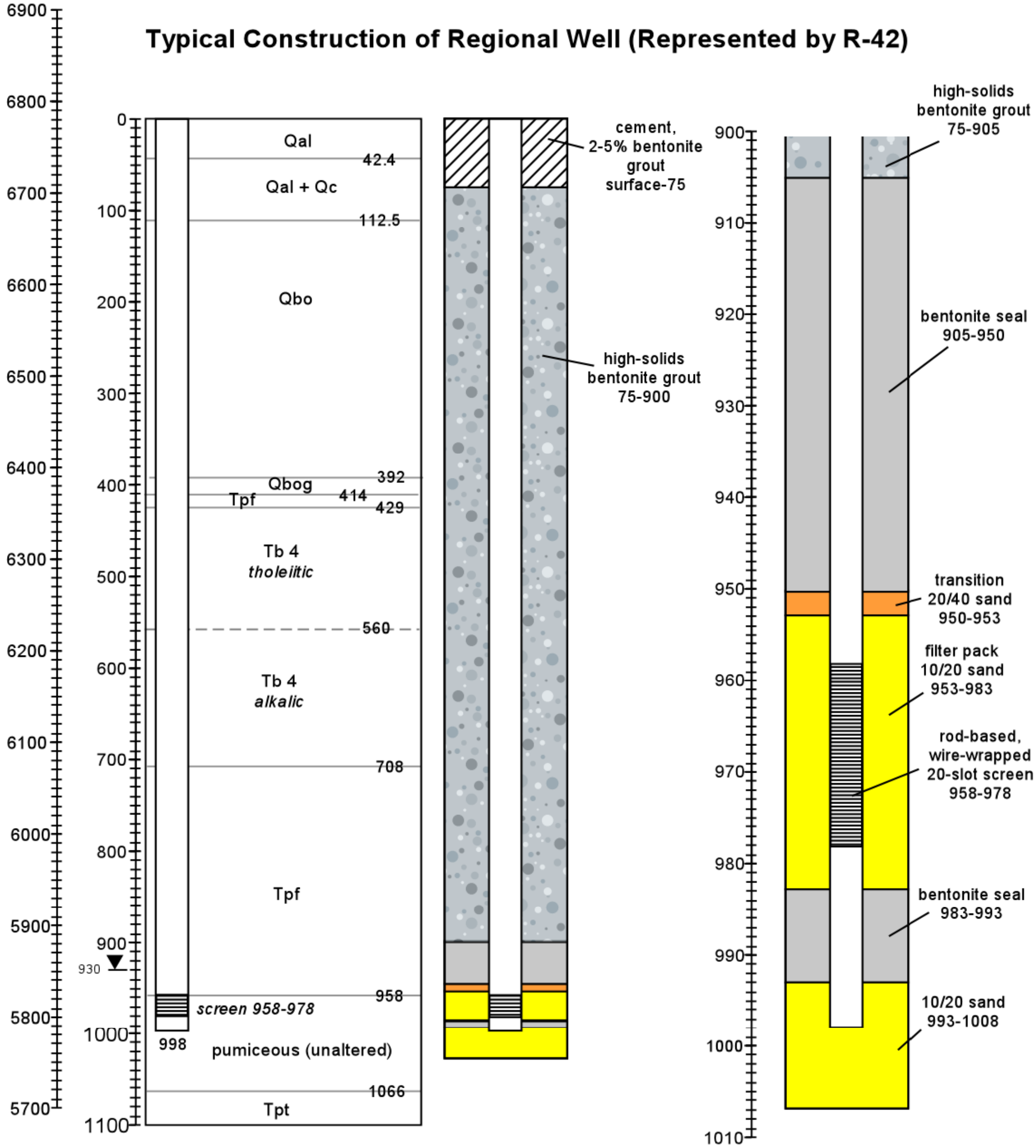
Notes: The blue fields indicate the extent of alluvial saturation that may feed underlying perched zones. Locations of R-42 and SCI-2 are indicated by dark red stars. The location of municipal supply well PM-3 is indicated by a blue star. Solid orange line shows the position of the well-to-well section presented in Figure 4.

Figure 1 Locations of selected monitoring wells (black circles), existing Sandia Canyon core holes and intermediate well SCI-1 (red circles), Mortandad Canyon intermediate wells (black triangles), and other boreholes (black diamonds or black crosses). Also shown is gaging station E-124 (green hexagon).



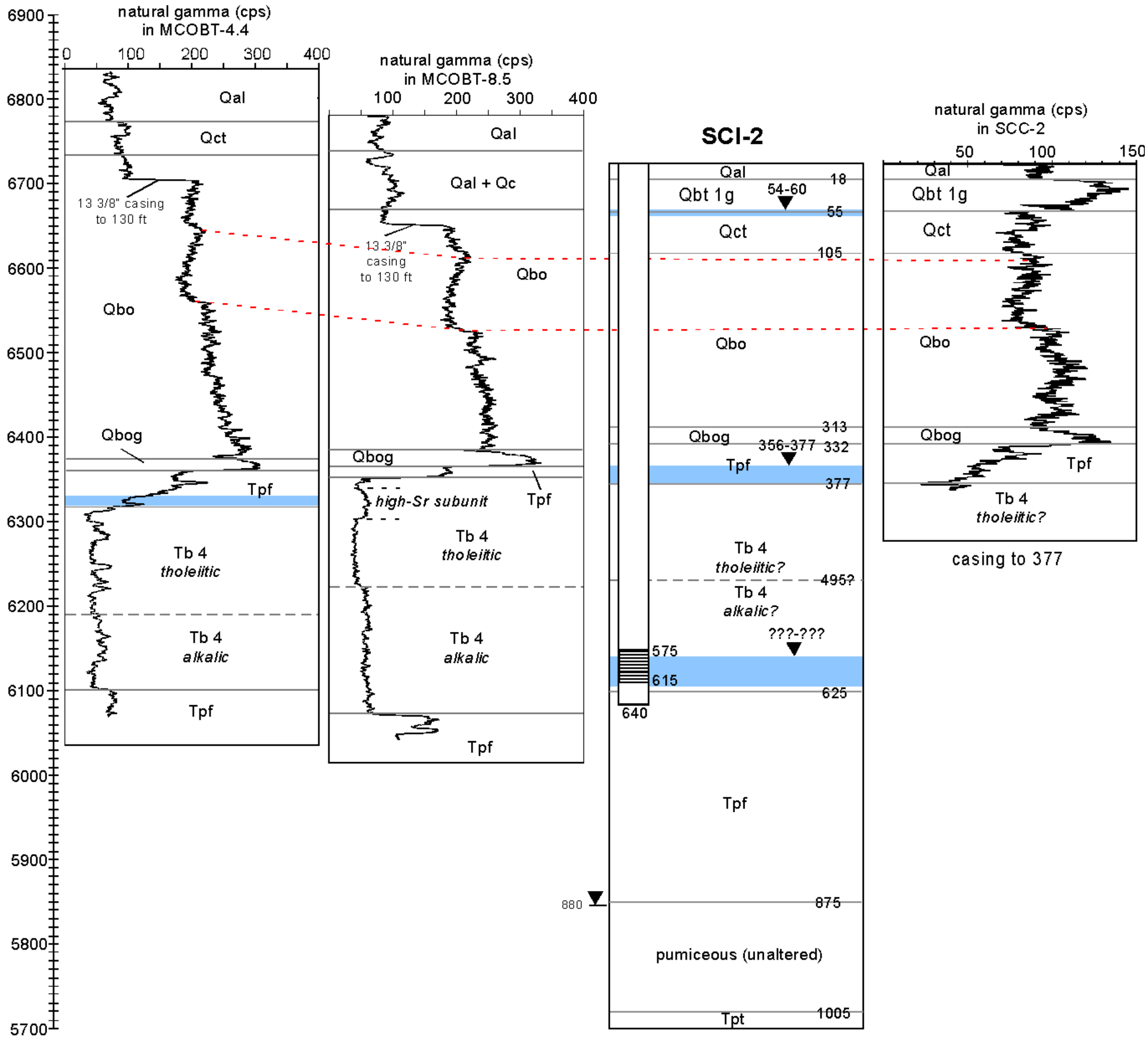
Notes: Qal = alluvium, Qbt 1g = unit 1g of the Tshirege Member of the Bandelier Tuff, Qct = Cerro Toledo Interval, Qbo = Otowi Member of the Bandelier Tuff, Qbog = Guaje Pumice of the Otowi Member of the Bandelier Tuff, Tpf = Puye Formation, Tb4 = Cerros del Rio lavas. Potential perched-intermediate groundwater is shown by blue shading in the stratigraphic column; these zones are based on nearby borehole and well data in Sandia and Mortandad canyons. The scale on left is elevation in feet; all depths shown are also in feet.

Figure 2 Proposed well design for a typical intermediate well, represented by the possible design for SCI-2



Notes: Qal = alluvium; Qc = colluvium; Qbo = Otowi Member of the Bandelier Tuff; Qbog = Guaje Pumice of the Otowi Member of the Bandelier Tuff; Tpf = Puye Formation, Tb4 = Cerros del Rio lavas; Tpt = Totavi-like stream gravels.

Figure 3 **Proposed well design for a typical regional well, represented by the possible design for R-42**



Notes: Blue fields represent perched saturation. The two uppermost perched intervals at SCI-2 are based on information from core hole SCC-2; a possible deeper perched interval at the base of the Ceros del Rio lavas is targeted by SCI-2. Note: Qal = alluvium, Qc = colluvium; Qbt 1g = unit 1g of the Tshirege Member of the Bandelier Tuff; Qct = Cerro Toledo Interval; Qbo = Otowi Member of the Bandelier Tuff; Qbog = Guaje Pumice of the Otowi Member of the Bandelier Tuff; Tpf = Puye Formation, Tb4 = Cerros del Rio lavas; Tpt = Totavi-like river gravels. Scale on left is elevation in feet; depths shown for SCI-2 are also in feet.

Figure 4 Direct-line borehole-to-borehole cross section (crossing mesas and canyons) from MCOBT-4.4 to MCOBT-8.5 in Mortandad Canyon to the SCI-2/SCC-2 location in Sandia Canyon