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Date: JUL 30 2010
Refer To: EP2010-0290

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

JUL 2010

Subject: Submittal of the Phase II Investigation Work Plan for Sandia Canyon

Dear Mr. Bearzi:

Enclosed please find two hard copies with electronic files of the Phase II Investigation Work Plan for Sandia Canyon. The Los Alamos National Laboratory (the Laboratory) received the New Mexico Environment Department's May 13, 2010, letter approving our request for an extension from May 21, 2010, to July 30, 2010, to submit the Phase II Investigation Work Plan for Sandia Canyon.

This work plan describes the collection and analyses of additional information to further define the nature and extent of contamination and addresses key uncertainties in the conceptual model for contaminant fate and transport of contaminants from Sandia Canyon. The proposed work addresses concerns in determining the nature and extent of chromium contamination, which are not sufficiently understood to address corrective measures alternatives.

If you have any questions, please contact Steve Veenis at (505) 667-0013 (veenis@lanl.gov) or Nancy Werdel at (505) 665-3619 (nwerdel@doeal.gov).

Sincerely,

Daniel R Cox for MJG
Michael J. Graham, Associate Director
Environmental Programs
Los Alamos National Laboratory

Sincerely,

for GJR
George J. Rael, Manager
Environmental Projects Office
Los Alamos Site Office

33836

MG/GR/DM/SV/DB:sm

Enclosures: Two hard copies with electronic files – Phase II Investigation Work Plan for Sandia Canyon (LA-UR-10-4921)

Cy: (w/enc.)
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LA-UR-10-4921
July 2010
EP2010-0290

Phase II Investigation Work Plan for Sandia Canyon

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Environmental Programs Directorate

LA-UR-10-4921
EP2010-0290

Phase II Investigation Work Plan for Sandia Canyon

July 2010

Responsible project manager:

Steve Veenis	[signature]	Project Manager	Environmental Programs	7-28-10
Printed Name	Signature	Title	Organization	Date

Responsible LANS representative:

Michael J. Graham	[signature] for MJG	Associate Director	Environmental Programs	7-29-10
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Responsible DOE representative:

George J. Rael	[signature] for GJR	Manager	DOE-LASO	7-30-10
Printed Name	Signature	Title	Organization	Date

EXECUTIVE SUMMARY

This Phase II work plan for Sandia Canyon describes the collection and analyses of additional information to further define the nature and extent of contamination and addresses key uncertainties in the conceptual model for fate and transport of contaminants from Sandia Canyon. The proposed work addresses concerns in determining the nature and extent of chromium contamination, which are not sufficiently understood to address corrective measures alternatives. Specifically, the goals of the Phase II work plan are to

- assess whether deep infiltration occurs beneath the Sandia wetland;
- better define the nature and extent of contamination in surface sediments in Sandia Canyon;
- provide additional constraints on the nature and extent of chromium and other contaminants in groundwater beneath Sandia and Mortandad Canyons;
- determine if the chromium in the regional aquifer represents releases only from Sandia Canyon or if a second chromium plume is associated with the Mortandad/Ten Site watershed;
- better define infiltration and migration pathways beneath Sandia and Mortandad Canyons;
- determine if advective transport of contaminants in the regional aquifer may be diverted to the southeast because of aquifer heterogeneity and anisotropy or because of mounding from aquifer recharge;
- develop analytical models and a transient three-dimensional (3-D) numerical model of the groundwater flow and transport in the regional aquifer that accounts for the 3-D structure of aquifer properties, the impacts of aquifer recharge caused by enhanced infiltration along Sandia and Mortandad Canyons, the effects of water-supply pumping on water levels, and the geochemical transients in monitoring wells; and
- provide information about the impact of the vertical decline of hydraulic heads with depth on the vertical distribution of the chromium plume.

To accomplish these goals and to address key uncertainties in the conceptual model, the work plan includes the following activities:

- Perform a surface-based direct current–resistivity geophysical survey
- Install three perched-intermediate wells and two regional-aquifer wells
- Sample an additional sediment reach
- Integrate previously reported and new geochemical data
- Develop analytical models and a transient 3-D numerical model of the groundwater flow and transport in the regional aquifer near Sandia Canyon
- Perform a cross-hole pumping test at well R-28

A Phase II investigation report will be prepared that synthesizes the information obtained in the Phase I and Phase II investigations. The Phase II report will also address comments and direction provided by the New Mexico Environment Department in its review of the Sandia Canyon investigation report.

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Appendix

1.0 INTRODUCTION

This Phase II work plan for Sandia Canyon describes the collection and analyses of additional information to further define the nature and extent of contamination and addresses key uncertainties in the conceptual model for contaminant fate and transport from Sandia Canyon. The proposed work addresses the New Mexico Environment Department's (NMED's) concerns in its February 9, 2010, letter, "Approval with Modification Investigation Report for Sandia Canyon, Los Alamos National Laboratory" (NMED 2010, 108683), that the nature and extent of chromium contamination are not sufficiently understood to determine corrective measures evaluation (CME) alternatives. Appendix A of this work plan lists NMED's concerns in its February 9, 2010, letter and provides a crosswalk showing how investigations proposed in this work plan address those concerns. Also included in Appendix A are some proposed alternative approaches to those directed by NMED.

This work plan builds on a series of existing NMED-approved work plans prepared by Los Alamos National Laboratory (the Laboratory) that 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). The results of these previous investigations are summarized in the "Investigation Report for Sandia Canyon" (LANL 2009, 107453).

This work plan is organized into the following sections. Section 2 describes the objectives of this work plan. Section 3 discusses the site conceptual model, emphasizing key uncertainties about the nature and extent of contamination, migration pathways, and sources of chromium and related contaminants. Three conceptual models are proposed to explain the distribution of chromium and other contaminants such as nitrate and tritium in perched-intermediate and regional groundwater in the chromium investigation area mainly beneath Sandia and Mortandad Canyons. Section 4 of this work plan describes investigations to reduce these key conceptual model uncertainties. Sections 5 and 6 provide a schedule and references, respectively.

Information on radioactive materials and radionuclides, including the results of sampling and analysis of radioactive constituents, is voluntarily provided to NMED in accordance with U.S. Department of Energy policy.

2.0 OBJECTIVES

The primary objective of this work plan is to further define the nature and extent of contamination and address key uncertainties in the conceptual model for contaminant fate and transport. Specifically, the goals of the Phase II work plan are to

- assess whether deep infiltration occurs beneath the Sandia wetland;
- better define the nature and extent of contamination in surface sediments in Sandia Canyon;
- provide additional constraints on the nature and extent of chromium and other contaminants in groundwater beneath Sandia and Mortandad Canyons;
- determine if the chromium in regional aquifer represents releases only from Sandia Canyon or if a second chromium plume is associated with the Mortandad/Ten Site watershed;
- better define infiltration and migration pathways beneath Sandia and Mortandad Canyons;

- determine if advective transport of contaminants in the regional aquifer may be diverted to the southeast because of aquifer heterogeneity and anisotropy or because of mounding from aquifer recharge;
- develop analytical models and a transient three-dimensional (3-D) numerical model of the groundwater flow and transport in the regional aquifer that accounts for the 3-D structure of aquifer properties, the impacts of aquifer recharge caused by enhanced infiltration along Sandia and Mortandad Canyons, the effects of water-supply pumping on water levels, and the geochemical transients in monitoring wells; and
- provide information about the impact of the vertical decline of hydraulic heads with depth on the vertical distribution of the chromium plume.

3.0 CONCEPTUAL MODEL

Previous reports submitted as part of the Sandia Canyon and chromium investigations provide conceptual models describing the nature and extent and the fate and transport for chromium and other contaminants associated with the cooling towers at the Technical Area 03 (TA-03) power plant (TA-03-22) at the head of Sandia Canyon. The following discussion emphasizes remaining conceptual uncertainties about the nature and extent of contamination, migration pathways, and sources of contaminants. Three conceptual models are proposed to explain the distribution of chromium and other contaminants, such as nitrate, perchlorate, and tritium, in perched-intermediate and regional groundwater in the chromium investigation area primarily beneath Sandia and Mortandad Canyons. New work proposed in section 4 of this work plan is designed to provide information relevant to these conceptual model uncertainties.

Conceptual Model 1

Sandia Canyon was the only source of chromium in the current contaminant plume in the regional aquifer beneath Mortandad Canyon. Although chromium was derived from Sandia Canyon, other contaminants collocated with the chromium in the regional aquifer (e.g., nitrate, perchlorate, sulfate, and tritium) were probably derived from other potential contaminant sources, resulting in a comingling of contaminant plumes. In this scenario, elevated chromium concentrations in the regional aquifer beneath Mortandad Canyon were derived from releases from the TA-03 power plant at the head of Sandia Canyon. Chromium(VI) was transported downcanyon where percolation of alluvial groundwater resulted in deeper saturated and unsaturated flow into suballuvial bedrock units. Moisture-gradient-driven flow and lateral spreading along stratigraphic contacts caused lateral diversion of flow towards Mortandad Canyon. Potential breakthrough locations into the regional aquifer are believed to be located near well R-42.

Based on water-table maps, the hydraulic gradient should generally transport the contaminants towards the east. However, the advective transport of contaminants may be diverted to the southeast because of the dip of sedimentary strata making up the regional aquifer in this area. Under Conceptual Model 1, the chromium concentrations detected at well R-50 are a result of southeastern contaminant transport in the regional aquifer from a relatively focused breakthrough location carrying contaminants to the regional aquifer near R-42. The southeast direction of the contaminant transport is predominantly the result of aquifer anisotropy and potentially also of infiltration mounding of the aquifer near R-42. Stiff diagrams of major cations and anions indicate the water chemistry in the center of the contaminant plume at wells R-42 and R-28 is similar to that at intermediate well SCI-2 beneath Sandia Canyon and that the plume chemistry differs significantly from major-ion chemistries at more distal monitoring wells in the regional aquifer to the north, east and south (Figure 3.0-1). Water chemistries at wells R-28, R-42, and SCI-2 are characterized by elevated concentrations of tritium, nitrate, bromide, chloride, sulfate, and calcium. These constituents are typical of cooling-tower and treated-sewage waste streams associated with releases into the head of Sandia Canyon.

Conceptual Model 2

According to Conceptual Model 2, Sandia Canyon is again the only source of the chromium in the contaminant plume in the regional aquifer beneath Mortandad Canyon, but the potential breakthrough location transporting chromium to the regional aquifer is spatially elongated to the south. Under this conceptual model, the chromium concentrations detected at well R-50 are a result of a relatively elongated breakthrough location or a series of breakthrough locations producing arrival of contaminants at the top of the regional aquifer in an area that extends to the south of well R-42. The mass of chromium entering the regional aquifer decreases southward along the breakthrough locations. The direction of contaminant transport in the regional aquifer for this conceptual model is predominantly to the east, although a southerly component of the flow may result from aquifer anisotropy and potential infiltration mounding of the regional aquifer near well R-42. The major differences between Conceptual Models 1 and 2 are in the shape of the breakthrough location(s) (more focused near well R-42 under Model 1 and more elongated to the south of well R-42 under Model 2) and in the predominant direction of contaminant transport in the regional aquifer (more to the southeast under Model 1 and more to the east under Model 2).

Under the Model 2 scenario, flow of chromium-bearing perched-intermediate groundwater beneath Sandia Canyon is diverted laterally towards Mortandad Canyon along dipping hydrostratigraphic surfaces before it arrives at the regional aquifer at multiple breakthrough locations or a broad area of breakthrough along the pathway. Perched-intermediate groundwater occurs within the Puye Formation on top of the Cerros del Rio basalt between well SCI-1 and core hole SCC-4 in Sandia Canyon and wells MCOI-4 and former MCOBT-4.4 in Mortandad Canyon. The top of the Cerros del Rio basalt generally dips westward in this area. A deeper perched-intermediate zone is penetrated by well SCI-2 in Sandia Canyon within fractured lavas and interflow breccias in the lower part of the Cerros del Rio basalt. Chromium concentrations exceed 650 ppb in this well. Perched-intermediate groundwater also occurs in the lower part of the Cerros del Rio basalt at wells MCOI-5 and MCOI-6 in Mortandad Canyon. Groundwater at wells SCI-2, MCOI-5, and MCOI-6 is perched above the contact between the Cerros del Rio basalt and the underlying Puye Formation; this contact dips towards the south and south-southeast.

Although perched groundwater in the basalt was not encountered at a number of wells and boreholes in Mortandad Canyon (e.g., wells MCOBT-8.5, MCI-10, R-42, and R-28), the distal reaches of perched zones may manifest as one or more ribbon-like bodies that are difficult to detect in widely spaced boreholes. Water chemistry at wells MCOI-4, MCOI-5, and MCOI-6 indicate they contain components of discharges from the TA-50 Radioactive Liquid Waste Treatment Facility (tritium, perchlorate, and nitrate derived from nitric acid); however, a component from Sandia Canyon could be present as well, as suggested by elevated concentrations of chromium and increasing chloride that may be derived from treated sewage effluent and road salt.

Further investigation to evaluate the hydrologic and geochemical connection between the known perched groundwater zones beneath Sandia and Mortandad Canyons is proposed in section 4 of this work plan. The proposed work uses geochemical modeling to assess whether perched groundwater beneath Mortandad Canyon can be derived from Sandia Canyon waters. Under this scenario, surface water containing elevated chromium concentrations infiltrated the alluvium of Sandia Canyon, was diverted towards Mortandad Canyon as perched groundwater, and reached the regional aquifer somewhere in the area between wells R-15 and R-50 as well as in the area near well R-42.

Conceptual Model 3

Two distinct sources of chromium are present in the contaminant plume in the regional aquifer beneath Mortandad Canyon. One is associated with Sandia Canyon and the other with the Mortandad/Ten Site watershed. The highest concentrations of dissolved chromium, which are detected in wells R-42 and R-28, are primarily derived from releases from the TA-03 power plant in Sandia Canyon, as described in Conceptual Model 1 above. Lower concentrations of chromium in wells R-15 and R-50 may have been derived from release sites at TA-35 and TA-48 in the Mortandad/Ten Site watershed. Under this scenario, the predominant direction of contaminant transport in the regional aquifer is to the east. The higher concentrations of chromium found at wells R-42 and R-28 reflect that the total chromium mass released and effluent-discharge volumes in Sandia Canyon were more than an order of magnitude greater than those released in Mortandad Canyon. Wells R-15 and R-50 have different chemical and nitrogen-isotope signatures from wells R-28, R-42, and SCI-2 and may represent a Mortandad Canyon groundwater source that has not mixed with the comingled contaminant plume at R-28 and R-42 described in Conceptual Models 1 and 2.

Preliminary R-50 groundwater samples have lower concentrations of nitrate, bromide, chloride, sulfate, and calcium than do samples from wells R-28, R-42, and SCI-2. Nitrogen isotope results for R-15 (δ^{15}N values about 4 per mil) indicate a neutralized nitric acid source and not a sewage source as observed at R-28, SCI-2, and R-42 where δ^{15}N values range between 10 and 20 per mil. Nitrogen isotope results (δ^{15}N values) for wells R-50, R-45, and R-44 range between 3 and 4 per mil, which is close to background values, but concentrations of nitrate are elevated in the upper screens. Perched groundwater in Mortandad Canyon intermediate wells MCOI-4, MCOI-5, and MCOI-6 contains elevated concentrations of chromium, and the wells contain other contaminants generally associated with Mortandad Canyon, including perchlorate, nitrate, and tritium. Under this scenario, surface water containing elevated chromium concentrations infiltrated the alluvium of Mortandad Canyon and reached the regional aquifer somewhere in the area between wells R-15 and R-50. Additional chromium entered the regional aquifer in much larger amounts from pathways originating in Sandia Canyon.

4.0 SCOPE OF ACTIVITIES

The Phase II work proposed in this section is designed to provide information that will address the objections described in section 2 and reduce key conceptual model uncertainties described in section 3. The new activities include the following activities:

- Perform a surface-based direct current– (DC-) resistivity geophysical survey (section 4.1)
- Install three perched-intermediate wells and two regional-aquifer wells (section 4.2)
- Sample an additional sediment reach (section 4.3)
- Integrate previously reported and new geochemical data (section 4.4)
- Develop analytical models and a transient 3-D numerical model of the groundwater flow and transport in the regional aquifer near Sandia Canyon (section 4.5)
- Perform a cross-hole pumping test at well R-28 (section 4.6)

4.1 DC-Resistivity Profiling in Upper Sandia Canyon

The objective of DC-resistivity profiling in the wetland of upper Sandia Canyon is to examine potential infiltration of surface water and groundwater beneath the wetland. The resistivity profiling will be used to map the resistivity structure of bedrock units beneath the wetland. The survey will also cross traces of the

Rendija Canyon fault, shown in cross-hatched pattern in Figure 4.1-1. Detailed mapping of fault traces north and south of the wetland for the Laboratory's Seismic Hazards Program reveals that the fault forms a broad zone of deformation that contains multiple, lesser fault splays trending northeast-southwest across the wetland. To examine the subsurface for evidence of infiltration in bedrock and along fault splays, a set of at least three subparallel DC-resistivity profiles is proposed, as shown in the red, olive green, and blue lines in Figure 4.1-1.

At least three subparallel resistivity profiles will be generated to address an interpretation issue encountered in earlier single-trace resistivity profiling in other canyons at the Laboratory. The issue of concern is the interpretation of 3-D resistivity structure represented in a two-dimensional (2-D) profile, where electrical current migration paths projected onto the 2-D plane may be interpreted as conductivity structures within the 2-D plane that are actually displaced away from the line of deployed electrical probes. The use of parallel DC-resistivity profiles allows for a more accurate interpretation of true resistivity structure at depth. The orientation of these resistivity profiling lines at a high angle to fault structures will permit a test of whether conductivity features detected correlate with specific fault splays that cross all three lines of resistivity data. Because it is likely that faults and fractures beneath the canyon floor will contain conductive clay minerals, interpretation of the survey results will include some uncertainty about whether vertical conductive structures represent potential contaminant pathways or tightly sealed structures that inhibited the infiltration chromium-era discharges.

The total length of three resistivity profiles as shown in Figure 4.1-1 is approximately 5000 ft. With 20-ft probe spacing along each line, this amounts to the use of approximately 250 DC-resistivity probes, a number well within the scope of previous DC-resistivity profiling in canyons at the Laboratory. The practical depth of interrogation will be approximately 300 ft, sufficient to see well into bedrock beneath alluvial fill.

4.2 Installation of Perched-Intermediate and Regional Monitoring Wells

Three perched-intermediate wells (SCI-3, SCI-4, and R-10i) and two regional aquifer wells (R-61 and R-62) are proposed for installation in the Phase II work plan. Geochemical and hydrologic data collected from these perched-intermediate and regional aquifer wells will be used in conjunction with existing well data to further define nature and extent of contamination and to differentiate between the three conceptual models discussed in section 3. The proposed locations for wells SCI-3, SCI-4, R-61, and R-62 are shown in Figure 4.2-1. Well R-10i is not shown in Figure 4.2-1, but it is located about 10,000 ft southeast of well R-36 (Figure 4.2-1) in lower Sandia Canyon. General information about the number and placement of well screens and characterization activities is provided below, but details about drilling, well construction, sample collection, and analytical suites will be provided in the drilling work plans for each of these wells.

The goals of the perched-intermediate wells SCI-3 and SCI-4 are to provide information about the distribution of perched groundwater present at well SCI-2, the direction of perched-intermediate groundwater flow, the geochemical characteristics of perched-intermediate groundwater, and potential insights into the geochemical and hydrologic interactions between perched groundwater and the regional aquifer. Wells SCI-3 and SCI-4 may encounter two zones of perched-intermediate groundwater. The upper zone that may be present was encountered in Puye Formation sediments perched on top of the Cerros del Rio volcanic series at nearby wells SCI-1 and TA-53i in and north of Sandia Canyon and at wells MCOI-4 and MCOBT-4.4 in Mortandad Canyon (Figure 4.2-1). If present at wells SCI-3 and SCI-4, the saturated thickness of this zone is likely to be approximately 2 to 25 ft based on data from nearby wells and core holes. The lower zone of perched groundwater that may be present was encountered at nearby well SCI-2. This lower zone is the target for the wells SCI-3 and SCI-4 wells because concentrations of chromium at well SCI-2 exceed 600 ppb. If present, the lower perched zone is expected to occur within fractured lavas and interflow breccias in the lower part of the Cerros del Rio volcanic series. The thickness of the potential lower perched zone is not certain, but it probably ranges between 20 and 110 ft. Similar zones of perched groundwater occur in the lower part of the Cerros del Rio volcanic series in wells MCOI-5, MCOI-6, and R-15 in Mortandad Canyon, suggesting the lower perched zone may be a continuous zone of saturation between these wells.

Perched-intermediate well SCI-3 will be located in Sandia Canyon approximately 1000 ft northwest of SCI-2 (Figure 4.2-1). Well SCI-3 targets perched groundwater between depths of approximately 550 and 660 ft within basaltic rocks of the Cerros del Rio volcanic series. The borehole will be cored continuously from the surface and penetrate the entire Cerros del Rio basalt section. Cores will be analyzed for moisture content, major ions, anion tracers such as bromide, boron, chlorate, and chemicals of potential concern (COPCs). The analyses will include both deionize water leach and U.S. Environmental Protection Agency (EPA) 3050 partial digestion. The proposed total depth is 685 ft. The well will be completed with a single screen set within the lower perched zone, if present.

Perched-intermediate well SCI-4 will be located on a narrow ridge separating Sandia and Mortandad Canyons at the east end of Sigma Mesa, about 1450 ft west of SCI-2 (Figure 4.2-1). It will be drilled on the same drill pad as regional well R-62, which is being installed first, and will determine whether the potential perched groundwater is present. Well SCI-4 will be installed if data from the R-62 borehole show that perched groundwater is present in quantities sufficient for a well that is capable of being developed and sampled. Well SCI-4 targets perched groundwater that may occur between depths of approximately 770 and 878 ft within basaltic rocks of the Cerros del Rio volcanic series. Core will be collected continuously from 200 ft below ground surface to the base of the Cerros del Rio volcanic series. Cores will be analyzed for moisture content, major ions, anion tracers such as boron, bromide, and chlorate, and COPCs. The analyses will include both deionize water leach and EPA 3050 partial digestion. The proposed total depth is 900 ft. The well will be completed with a single screen set within the lower perched zone, if present.

Perched-intermediate well R-10i will be located on the same drill pad as wells R-10 and R-10A in lower Sandia Canyon on San Ildefonso Pueblo land. The goal of well R-10i is to monitor a perched-intermediate zone that was identified during drilling of the adjacent regional wells. Screening samples collected during drilling of the regional wells indicated the presence of low concentrations of Laboratory-derived constituents. Well R-10i will supplement Laboratory boundary and off-site perched groundwater monitoring that is currently provided by wells R-9i, R-12, and R-23i. The R-10i borehole is expected to penetrate perched groundwater at a depth of approximately 304 ft within Pliocene sedimentary deposits that are present between two Cerros del Rio basalt flows. The proposed depth for the R-10i borehole is 400 ft. The well will be completed with a single screen set near the top of the perched zone within the Pliocene sediments.

Regional aquifer well R-61 will be located on the mesa south of Mortandad Canyon, about 1850 ft west of well R-50 and 2000 ft southeast of well R-15 (Figure 4.2-1). Well R-61 is being installed to reduce uncertainty about the nature and extent of chromium contamination in the area south of wells R-42 and R 28 near the Laboratory boundary with San Ildefonso Pueblo. The lateral and vertical extent of chromium contamination in this area are not fully characterized, and better delineation of the chromium plume is needed because elevated chromium concentrations were detected in recently installed well R-50. Geochemical and hydrological data from well R-61 will also be used to assess whether two distinct sources contribute to the chromium present in the regional aquifer beneath Mortandad Canyon. Conceptual Model 3 in section 3 discusses the possibility that the elevated chromium found at wells R-15 and R-50 may be derived from release sites in the Mortandad/Ten Site watershed. Well R-61 will also provide information about the presence or absence of perched groundwater, contributing to the evaluation of Conceptual Model 3 described in section 3. Well R-61 is expected to penetrate the top of regional saturation at a depth of approximately 1103 ft within sedimentary deposits of the Puye Formation. The target borehole depth is set at approximately 1265 ft within Miocene riverine deposits. The well will be completed with two well screens, one located just below the water table and the other approximately 100 ft below the upper screen. The two-screen configuration provides information about shallow versus deep contaminant pathways, vertical hydraulic gradients, geochemical compositions, and the response of different levels in the aquifer to pumping from the nearby municipal water-supply wells.

Regional aquifer well R-62 will be located on a narrow ridge separating Sandia and Mortandad Canyons at the east end of Sigma Mesa, on the same drill pad as well SCI-4 (Figure 4.2-1). Well R-62 is being installed to reduce uncertainty about the upgradient extent of chromium contamination in the area west-northwest of wells R-42 and R-28. The primary purpose of this well is to determine if significant chromium contamination is present in the regional aquifer in the area west and northwest of the contaminant plume that is defined by the existing network of monitoring wells. The location of R-62 will test an important aspect of the conceptual model by determining if infiltration in upper reaches of Sandia Canyon contributes to elevated chromium found in the regional aquifer in the vicinity of wells R-28 and R-42. Data from well R-62 will also be used to assess whether two distinct sources are impacting the regional aquifer. Furthermore, the data will provide information about the presence or absence of perched groundwater, contributing to the evaluation of Conceptual Model 3 described in section 3 and indicating the need for perched-intermediate well SCI-4. Well R-62 is expected to penetrate the top of regional saturation at a depth of approximately 1138 ft within Miocene pumiceous sedimentary deposits. The target borehole depth is set at approximately 1305 ft in Miocene riverine deposits. The well will be completed with two well screens: one located just below the water table and the other approximately 100 ft below the upper screen. The two-screen configuration provides information about shallow versus deep contaminant pathways, vertical hydraulic gradients, geochemical compositions, and the response of different levels in the aquifer to pumping from the nearby municipal wells.

4.3 Collection of Additional Sediment Data in Sandia Canyon

Sediment data will be collected in a new reach in Sandia Canyon east of reach S-5C and well PM-3 to better define the nature and extent of chromium contamination in surface sediments. The new reach contains a large sediment deposition area where a single defined stream channel is replaced by a broad canyon-bottom fan. The new reach, designated S-5EC (S-5 East-Central), will be at least 600 ft long and will encompass the sediment deposition area (Figure 4.3-1). These new sediment data are being collected to define the sediment thickness, volume, and contaminant inventory in a poorly characterized area, and they will be used to revise the conceptual model of contaminant distribution and inventory, as necessary. The new reach data will also be evaluated in the context of potential human health risk, if required.

Post-1942 geomorphic units will be mapped in this reach at a scale of 1:200, and sediment thicknesses and characteristics in each unit will be determined in a series of hand-dug holes. If the post-1942 sediment is too thick to be examined in hand-dug holes (>4 ft), auger holes will supplement the hand-dug holes. Ten sediment samples will be collected in this reach, including both surface and subsurface layers and a range in particle sizes. These samples will be analyzed for the full suite of inorganic and organic COPCs identified in the adjacent reaches (S-5C and S-5E) (LANL 2009, 107453). This chemical suite will include target analyte list metals, molybdenum, perchlorate, pesticides, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, semivolatile organic compounds, total petroleum hydrocarbons–diesel range organics, and volatile organic compounds.

4.4 Supplemental Analytical Suites

Geochemical data collected from perched-intermediate and regional aquifer wells will be used in conjunction with existing well data to further the define nature and extent of contamination and differentiate between the three conceptual models discussed in section 3. The scope presented in this work plan will address two key areas of uncertainty in the conceptual models: (1) infiltration and migration pathways and (2) potential multiple contaminant sources that have emerged as monitoring data from recently installed wells, specifically wells R-44, R-45, and R-50, have become available. These uncertainties are described in more detail in the conceptual models presented in section 3.

Contaminant sources originating in different canyons, specifically in Los Alamos/DP, Sandia, and Mortandad/Ten Site Canyons, may contribute to the detections of chromium, tritium, perchlorate, and nitrate in the regional aquifer primarily beneath Mortandad Canyon. Key constituents, including the “primary” contaminants such as tritium, perchlorate, nitrate, and chromium, and “secondary” constituents, including bromide, oxalate, chlorate, sulfate, and chloride, associated uniquely with discrete sources, may potentially be used to assess infiltration and migration pathways and potential mixing of sources.

The 2010 Interim Facility-Wide Groundwater Monitoring Plan (IFGMP) (LANL 2010, 109830) presents an analyte suite for the group of wells that are part of the “chromium investigation monitoring group.” Most of the constituents useful for evaluating sources and pathways are included in that monitoring suite. Supplemental analytes have been added to this work plan to support the pathway and source analyses and include low-level chlorate, low-level bromide, and low-level oxalate with method detection limits of 0.0002, 0.02, and 0.0009 ppm, respectively. In addition to the stable isotopes of nitrogen and oxygen in nitrate already included in the 2010 IFGMP, sulfur and oxygen in sulfate will be included as part of the expanded analytical suite.

A number of tools and techniques will be applied to the display and analysis of the geochemical data. These techniques include, but are not limited to, isoconcentration maps of key contaminants, including chromium; tritium; perchlorate; nitrate; and tracers (bromide, boron, chloride, chlorate, molybdenum, and oxalate). Bivariate plots may be useful in this investigation to compare contaminant concentrations versus time and distance; concentrations of contaminant ratios versus specific contaminants; contaminant concentrations versus groundwater age (submodern and modern fractions); contaminant concentrations versus stable isotope ratios; and contaminant concentrations versus concentrations of other anthropogenic tracers (chloride, chlorate, oxalate, molybdenum, and sulfate) and semireactive chemicals (fluoride and calcium). Stiff and piper plots will be explored as appropriate. Geochemical calculations using computer programs such as Geochemist’s Workbench and PHREEQC will be used to quantify speciation, adsorption, mineral equilibrium, mixing, and one-dimensional transport of chromium and other contaminants and tracers relevant to this work plan. Groundwater-monitoring data and previously collected experimental data are anticipated to provide input to geochemical calculations.

4.5 Groundwater Modeling

A 3-D model of the groundwater flow and transport in the regional aquifer near Sandia Canyon will be developed to advance the understanding of the nature and extent and the fate of the existing chromium plume. Modeling analysis of the spatial and temporal characteristics of past, current, and future transport of chromium in groundwater is important for evaluating the fate of the plume, particularly as it relates to evaluations of potential remediation options. The work will include detailed analysis of the available data using various data analysis and modeling tools, new data from recently installed monitoring wells R-44, R-45, and R-50, and data from new monitoring wells included in this work plan. The spatial and transient distribution of the chromium(VI) concentrations and other key geochemical tracers and element/isotope ratios (e.g., tritium, nitrate, fluoride, oxalate, perchlorate, chlorate, boron, bromide, δ^{53}Cr, and δ^{15}N) will be analyzed to investigate information about the predominant groundwater flow direction in the area, including the potential transients in the groundwater flow because of variability in aquifer recharge, especially beneath Sandia and Mortandad Canyons, and water-supply pumping effects.

The major goals of the modeling analyses are as follows:

1. Test, evaluate the feasibility, and quantify uncertainty associated with various conceptual models proposed for describing the nature and extent and fate and transport of chromium in the environment (section 3).

2. Provide model predictions of the future fate and 3-D extent of the chromium distributions within the regional aquifer.

3. Estimate the directions of groundwater flow and transport in the regional aquifer beneath Sandia and Mortandad Canyons (including potential transients).

Various types of data and qualitative information will be applied during model development. Essential model inputs are (1) a 3-D geologic framework model; (2) water-level transients observed at the monitoring wells in the project area (including wells R-43, R-42, R-28, R-44, R-45, R-50, R-11, R-33, R-15, R-8, R-35a, R-35b, R-36, and R-34); (3) transients in the infiltration recharge along Sandia and Mortandad Canyons; (4) transients in the water-supply pumping rates (wells O-4, PM-3, PM-5, PM-4, PM-2, etc.); and (5) geochemical trends observed at wells in the study area (e.g., chromium[VI], tritium, nitrate, fluoride, oxalate, perchlorate, chlorate, boron, bromide, δ^{53}Cr, and δ^{15}N).

The model will (1) represent the current understanding of hydrostratigraphy (including information about aquifer heterogeneity and anisotropy), (2) take into account the potential impact of aquifer recharge and water-supply pumping on the flow and transport directions, and (3) be calibrated to represent existing water-level (pressure) and relevant geochemical data.

The modeling analyses will include (1) analytical models for characterization of the pumping effects on the water-level transients, (2) analytical models for simulation of the contaminant transport in the regional aquifer, and (3) 3-D numerical models of groundwater flow and transport in the subsurface.

Important tasks that will be performed for the model analyses include the following.

1. Three-dimensional spatial and transient analysis of the available data (water levels, concentrations, and ratios of key constituents in the regional aquifer and the vadose zone, permeabilities, etc.) near the chromium plume. The analyses will include investigations of the correlations between water-level and concentration fluctuations. The final products will include an updated water-table map, a 3-D view of the groundwater flow net, estimates of pumping effects on the water-level transients, and spatial analysis of aquifer heterogeneity, layering and anisotropy.

2. Further development of the existing analytical model of contaminant transport of the regional aquifer. The model will be calibrated against the spatial and temporal geochemical and water-level (pressure) data. The analysis will provide information about the potential locations of contaminant arrival at the top of the regional aquifer.

3. Development of a transient 3-D numerical model of flow and transport near the chromium plume, taking into account the 3-D structure of aquifer properties and the impact of infiltration recharge and water-supply pumping on the water-level and geochemical transients. The analysis will also provide information about the impact of vertical decline of hydraulic heads with depth on the vertical distribution of the chromium plume.

4.6 Additional Aquifer Testing to Support the Development of 3-D Numerical Model

A cross-hole pumping test is proposed at well R-28 to better define the spatial distribution of regional aquifer heterogeneity and anisotropy in the vicinity of the chromium plume near wells R-28 and R-42. These data will be used to constrain flow parameters used in the model for the groundwater flow and transport in the regional aquifer described in section 4.5. Recent monitoring data collected at well R-50 indicate the spatial distribution of aquifer properties (the aquifer heterogeneity and anisotropy) potentially affects groundwater flow and transport (see section 3). Currently, most of the information about aquifer properties is collected at the existing monitoring wells using lithological logs, borehole video, geophysical logs, and single-hole pumping tests. As a result, this information is representative of the small-scale (3–15 ft) aquifer heterogeneities close to the wells. Contaminant transport, however, occurs at much larger scales (300–3000 ft). Therefore, aquifer heterogeneities that exist over larger scales (30–300 ft) than the scale of the well data (3–15 ft) are expected to provide more important controls on groundwater flow and transport. To characterize aquifer heterogeneity at the scale of groundwater flow and transport, larger-scale information is needed to augment the well-scale data. This type of information can be collected from a cross-hole pumping test in which one well is pumped and pressures in the nearby monitoring wells are monitored for pumping responses.

During the 24-h pumping tests conducted at wells R-44 and R-45, drawdowns were observed at the nearby wells (LANL 2009, 106418; LANL 2009, 106427). Wells R-11, R-28, R-13, and R-44 responded to R-45 pumping, and wells R-13, R-28, and R-45 responded to pumping at R-44. However, these tests did not provide sufficient information about aquifer heterogeneity because relatively low pumping rates were used, and the observed drawdowns were relatively small (on the order of 0.01 ft) and did not provide sufficient data for detailed analyses of the aquifer properties in the area between the pumping and observation wells. Longer pumping tests conducted at a higher pumping rate will produce more pronounced drawdowns at the observational wells and allow for better characterization of the aquifer properties.

A pumping test with a pumping rate of about 20 gallons per minute (gpm) for up to 10 d is proposed for well R-28. Pumping at this rate and duration is expected to produce measureable responses at nearby observation wells; these wells will include R-43, R-42, R-11, R-35b, R-36, R-45, R-44, R-50, R-15, and R-33 (Figure 4.2-1). In the wells close to R-28, the drawdown is expected to be more than 0.1 m, which is sufficient for analysis of aquifer properties. Because of aquifer heterogeneity and anisotropy, it is not expected that all boreholes will respond during the pumping test; however, the lack of a response is also important calibration information for model development. It is preferable that municipal supply wells PM-5 and PM-3 are not in an active pumping mode during the pumping test to eliminate the potentially interfering signal on the water-levels. The Los Alamos County (LAC) Department of Public Utilities, owner and operator of these wells, will be approached to see if municipal pumping can be halted at wells PM-5 and PM-3 during the proposed test. LAC will probably grant this request during the winter when demand is low. Spatial analyses of the observed drawdowns at multiple wells surrounding well R-28 using analytical and numerical modeling techniques will provide important information about the spatial distribution of aquifer heterogeneity and aquifer anisotropy. The data collected during this cross-hole pumping test (together with the other single-hole and cross-hole pumping test data) will be applied to calibrate the transient 3-D flow and transport numerical model of the chromium plume (see section 4.5). Well R-61 (section 4.2) should be installed before the pump test is conducted so it can be used as an additional observation well.

5.0 SCHEDULE

The Phase II investigation report for Sandia Canyon will be submitted to NMED by April 30, 2012. Work plans for the five Phase II investigation wells will be submitted to NMED on the following dates:

- R-61 October 15, 2010
- R-62 October 30, 2010
- SCI-3 January 30, 2011
- SCI-4 February 28, 2011
- R-10i April 30, 2011

The Phase II investigation wells will be installed according to a schedule that ensures at least three rounds of groundwater monitoring data are included in the Phase II investigation report, with the possible exception of well R-10i. The R-10i well will produce at least two rounds of monitoring data by the time the investigation report is submitted. The two rounds of monitoring data should be sufficient to address whether Laboratory contaminants are migrating off-site at that location.

6.0 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. This information is also included in text citations. ER IDs are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

LANL (Los Alamos National Laboratory), July 1996. "Environmental Surveillance at Los Alamos During 1994," Los Alamos National Laboratory report LA-13047-ENV, Los Alamos, New Mexico. (LANL 1996, 054769)

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LANL (Los Alamos National Laboratory), May 2009. “Completion Report for Regional Aquifer Well R-44,” Los Alamos National Laboratory document LA-UR-09-3066, Los Alamos, New Mexico. (LANL 2009, 106418)

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NMED (New Mexico Environment Department), February 9, 2010. “Approval with Modification, Investigation Report for Sandia Canyon,” New Mexico Environment Department letter to G.J. Rael (DOE-LASO) and M. Graham (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2010, 108683)

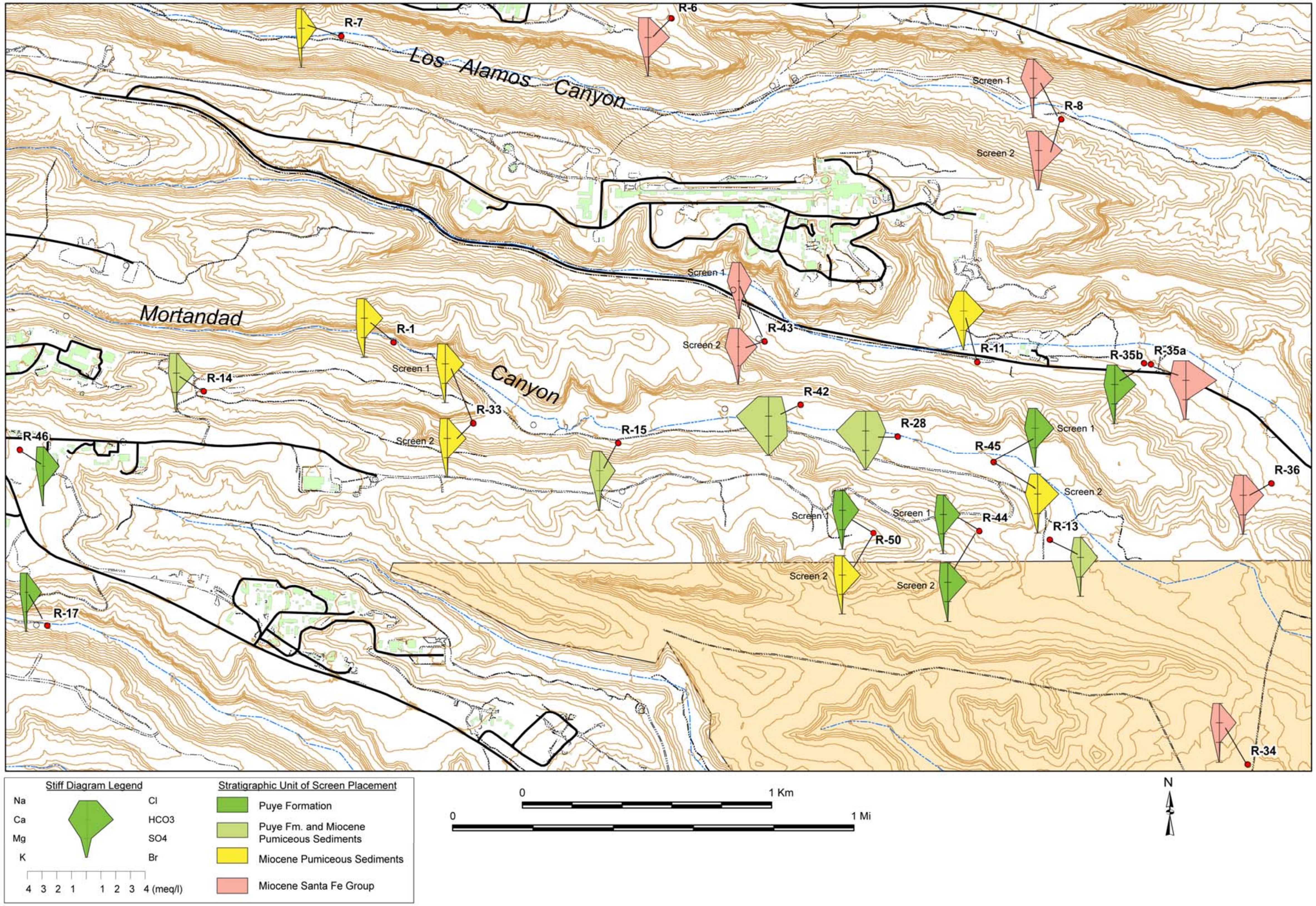


Figure 3.0-1 Stiff diagrams for regional aquifer monitoring wells in the vicinity of the chromium plume near wells R-28 and R-42

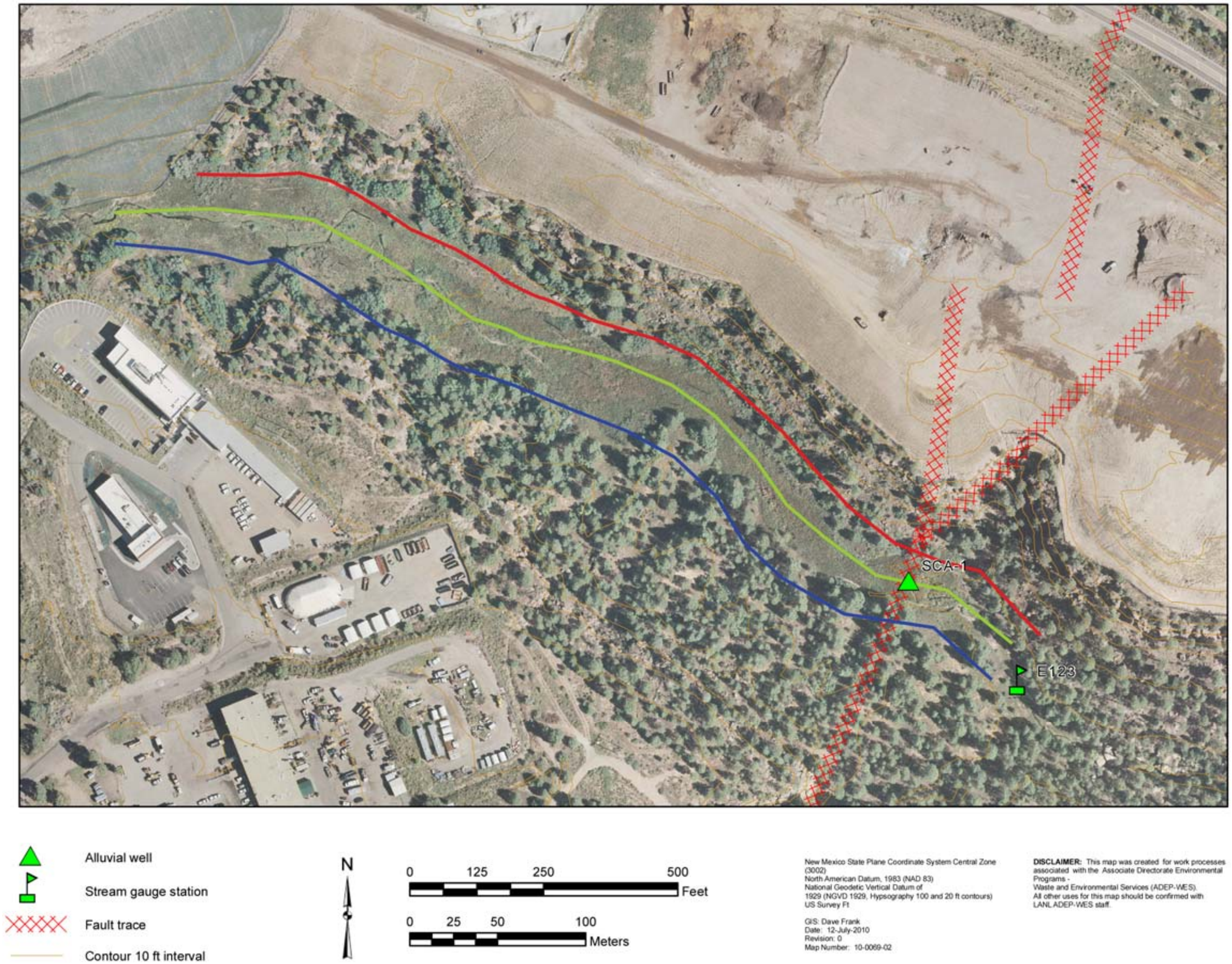
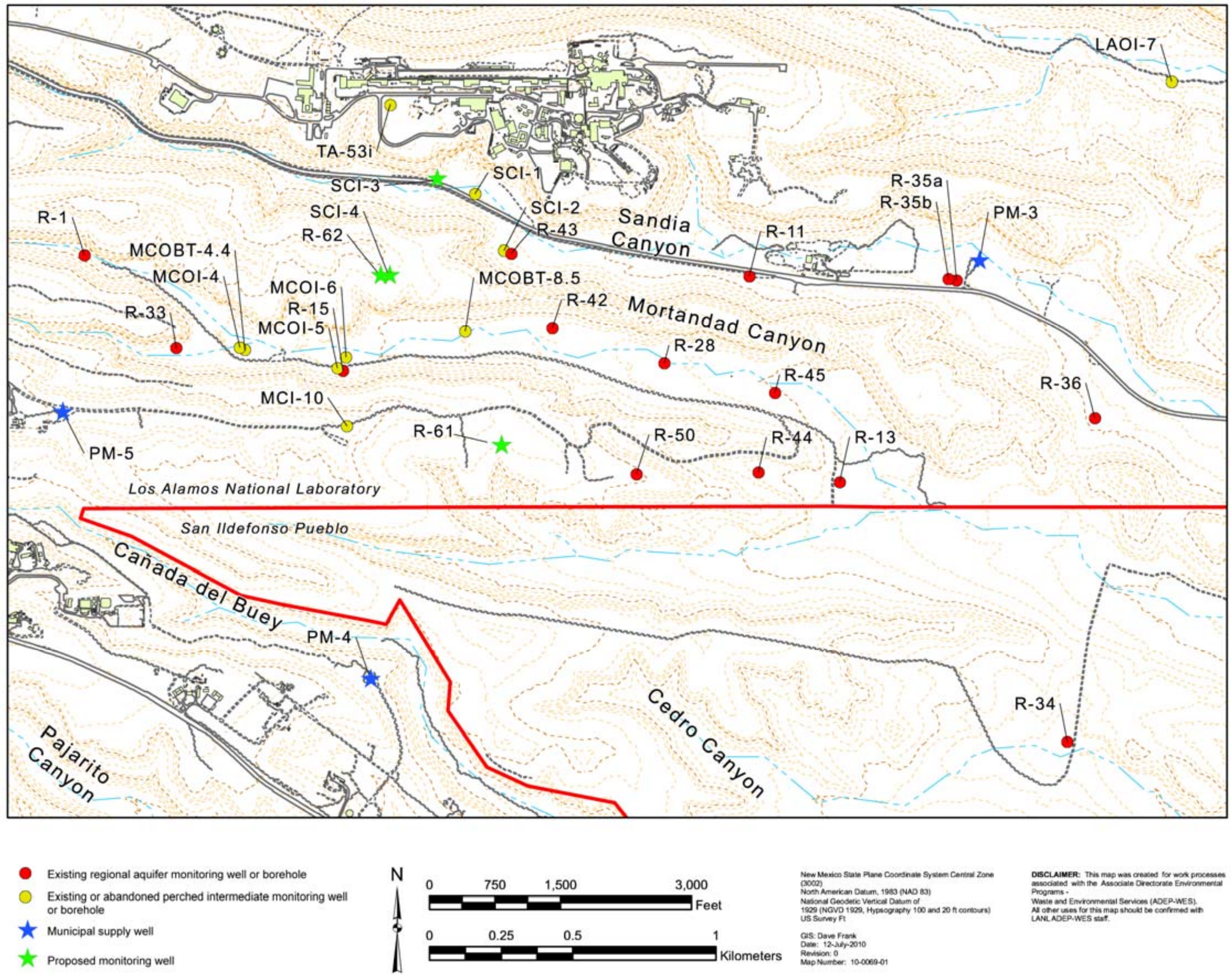


Figure 4.1-1 Aerial view of the upper Sandia Canyon wetlands showing the trace of the Rendija Canyon fault (hatched red line) and the proposed DC-resistivity lines (red, olive green, and blue lines)



Note: Well R-10i is not shown, but it is located about 10,000 ft southeast of well R-36 in lower Sandia Canyon.

Figure 4.2-1 Locations of proposed perched-intermediate and regional aquifer monitoring wells SCI-3, SCI-4, R-61, and R-62 (green stars)

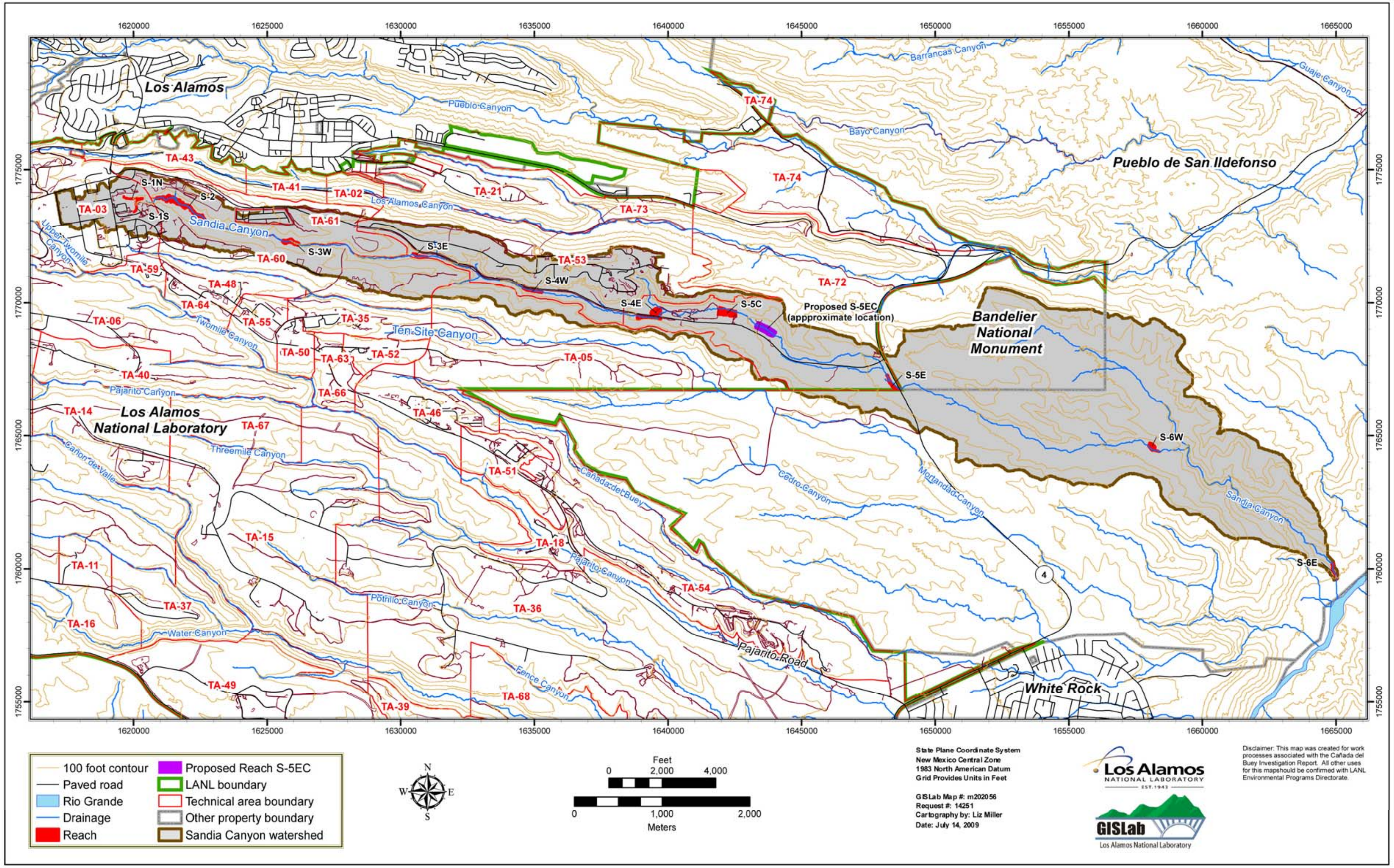


Figure 4.3-1 New sediment investigation reach S-5EC in Sandia Canyon

Appendix A

Crosswalk of New Mexico Environment Department Approval with Modifications for the Sandia Canyon Investigation Report with the Phase II Investigation Work Plan for Sandia Canyon

NMED Comment No.	Summary of NMED Comment and Requirement	LANL Proposed Action	Rationale for Proposed Action if Different from NMED Requirement
1	Per the Approval with Direction letter for the Sandia Canyon investigation report (NMED 2010, 108683), Los Alamos National Laboratory (LANL) must produce a Phase II Sandia Canyon investigation work plan. The work plan must include details of additional groundwater monitoring wells, methodology for more rigorous analysis of existing and to-be-acquired contaminant and hydrochemical data and procedures for comprehensive examination of physical aspects of aquifer interconnectivity. A Phase II investigation report shall replace the current report, synthesizing Phase I and Phase II information.	A Phase II investigation report will be submitted to the New Mexico Environment Department (NMED) synthesizing Phase I and Phase II information.	n/a*
2	A single well (SCI-2) is insufficient to characterize chromium contamination in perched-intermediate groundwater beneath Sandia Canyon. Knowledge of the lateral extent of saturation, direction of groundwater flow, and degree of interaction with the regional groundwater system is limited. Install two perched-intermediate wells to the base of the Cerros del Rio basalt. The boreholes must be cored and sampled for moisture, anions, cations, and chemicals of potential concern (COPCs). An additional work plan will be required if either of the two planned wells encounters chromium at concentrations greater than the maximum value in the regional aquifer.	Installation of two perched-intermediate wells to the base of the Cerros del Rio basalt is proposed in this work plan (see section 4.2 of the Phase II work plan). The well locations are shown in Figure 4.2-1. The proposed location for well SCI-3 is a short distance downcanyon and to the north side of East Jemez Road from the location proposed in NMED's Approval with Direction letter (NMED 2010, 108683). The decision to drill SCI-4 will be contingent upon whether perched groundwater is observed in the Cerros del Rio basalt during drilling of the regional well R-62 at this location.	In consultation with NMED in the field, well SCI-3 was moved to provide better access to the drill site. Moving the well to this location meets the original intent expressed by NMED for this well. Well SCI-4 is being drilled at the same location as regional well R-62. Well R-62 will be installed first, and steps will be taken during drilling to characterize potential perched groundwater to the base of the Cerros del Rio basalt. Well SCI-4 will be installed if perched groundwater is present in quantities sufficient for installing a well capable of being developed and sampled.

NMED Comment No.	Summary of NMED Comment and Requirement	LANL Proposed Action	Rationale for Proposed Action if Different from NMED Requirement
3	The vertical and western extents of the chromium plume in the regional aquifer are not adequately defined. LANL will install a dual-screen well at depths of 150 and 300 ft below the water table in the regional aquifer at well R-28 to define the vertical extent of contamination and will also install a second dual-screen well west of well R-42 on the mesa separating Sandia and Mortandad Canyons.	Two regional aquifer wells are proposed in this work plan (section 4.2). The well locations are shown in Figure 4.2-1. The location for well R-61 has been changed from the original NMED requirement to define the vertical extent of contamination near well R 28. The new proposed location and dual-screen design for well R-61 reduce uncertainty about the nature and extent of chromium contamination in light of recent observed chromium concentrations detected at newly installed well R-50, and they help to delineate the vertical extent of chromium contamination at that location. A second dual screen well, R-62, will be installed west of well R-42 on the mesa separating Sandia and Mortandad Canyons, in accordance with NMED's requirement.	Recent data from newly installed well R-50 shows that chromium is present at or above regulatory standards in the upper part of the regional aquifer near the LANL boundary with San Ildefonso Pueblo, potentially indicating a southerly component of groundwater flow different from that predicted by groundwater gradients alone or possibly additional breakthrough points or sources of chromium. As discussed with NMED at a meeting on June 3, 2010, these new results highlight important uncertainties about conceptual models for chromium migration. These uncertainties are discussed in section 3 of this work plan. Monitoring data from existing dual-screen wells, including R-50, provide good evidence that chromium migration occurs in the upper part of the aquifer and that the vertical extent of chromium is sufficiently constrained by the existing network of wells (see Figures A-1 and A-2). The proposed well R-61 will further define the nature and extent of chromium contamination south of well R-42 by installing a dual-screen well that monitors groundwater at the water table and approximately 100 ft below the water table. The proposed location for well R-61 will provide key information about contaminant distributions and water chemistry that will be important for evaluating the conceptual model uncertainties for the chromium infiltration pathway, migration within the regional aquifer, and a potential additional source, as discussed in section 3.

NMED Comment No.	Summary of NMED Comment and Requirement	LANL Proposed Action	Rationale for Proposed Action if Different from NMED Requirement
4	LANL must use a heat-pulse flow meter, colloidal borescope, or other NMED-approved method to measure the vertical and horizontal flow velocities and vectors in all regional and perched-intermediate wells in the vicinity of the chromium plume and develop a three-dimensional (3-D) flow-net model for the regional aquifer in the vicinity of the chromium plume.	A 3-D flow-net model will be developed for the regional aquifer in the vicinity of the chromium plume using existing data and supplemented by additional aquifer testing in regional aquifer well R-28. The model will include calibration against pressures measured from all screens within the model domain.	As discussed with NMED at a meeting on June 3, 2010, the downhole instrumentation proposed by NMED in the Approval with Direction letter cannot be used in the wells in the chromium monitoring area because of the presence of dedicated downhole sampling systems, including the Baski system. Inquiries into the field conditions necessary for the specific instruments in NMED's letter also noted that the casing diameter would need to be substantially smaller than exists in LANL's wells. The approach proposed in section 4.6 of this work plan provides resolution at an appropriate field scale and can be incorporated into the 3-D model of groundwater flow and contaminant transport for the site.
5	The focus of infiltration during the period of chromium release may have occurred upcanyon of the reach between alluvial wells SCA-2 and SCA-5. LANL must revise conceptual model for surface water transport and vertical infiltration pathways in the Phase II investigation report.	In the Phase II investigation report, the conceptual model discussion will state more clearly that surface water flow rates have changed over time and that these changes may have affected infiltration pathways. Core data from perched-intermediate well SCI-3 in Sandia Canyon will augment vadose zone data already collected and will provide information concerning this potential infiltration pathway. Vadose-zone modeling results presented as part of this investigation showed that under current conditions, it is likely considerable infiltration takes place upcanyon of well SCA-2. These modeling results were based on the surface-water balance studies that showed significant water loss in that part of the canyon.	n/a

NMED Comment No.	Summary of NMED Comment and Requirement	LANL Proposed Action	Rationale for Proposed Action if Different from NMED Requirement
6	LANL must expand the geochemical assessment of hydrologic connections between perched and regional groundwater zones beyond the major ions and contaminants trends and distributions discussed in the investigation report. LANL must expand the analysis to include examination of trends and distributions of stable isotopes and contaminant tracers such as chlorate and bromide and present the refined analysis in the Phase II investigation report.	The geochemical assessment of hydrologic connections between perched and regional groundwater zones will be expanded, as described in sections 4.4 and 4.5 of this work plan. The refined analysis will be presented in the Phase II investigation report.	n/a
7	In July 1994, after the main chromium release period ended, samples of surface-water collected at stations SCS-2 and SCS-3 were found to contain 760 ppb and 17 ppb chromium. These analyses were not included in the investigation report. LANL must investigate whether this release represents a release distinct from the release that occurred during the 1956–1972 period and evaluate whether this present release is the source of chromium at SCI-2. This evaluation must be presented in the Phase II investigation report.	No action	The 1994 Environmental Surveillance Report (ESR) (LANL 1996, 054769) lists the SCS-2 sample with 760 ppb chromium and the SCS-3 sample with 17 ppb (Table VI-7). The ESR notes that the SCS-2 sample was incorrectly identified as filtered. However, it was a nonfiltered sample that was analyzed using hydrofluoric acid digestion. The ESR states that this sample has a high metal content because of suspected sampling or analytical problems. The ESR also noted that neither upstream nor downstream samples collected on the same day have elevated metal concentrations.

NMED Comment No.	Summary of NMED Comment and Requirement	LANL Proposed Action	Rationale for Proposed Action if Different from NMED Requirement
8	LANL must conduct a surface-based direct current– (DC-) resistivity geophysical survey in the vicinity of the Sandia Canyon wetland and use the survey results to identify the most likely area of infiltration beneath the wetlands. In addition, LANL must drill a core hole to 200 ft depth and characterize the core for moisture, anions, cations, and COPCs.	LANL will conduct a surface-based DC-resistivity geophysical survey in the vicinity of the Sandia Canyon wetland, as discussed in section 4.1 of this work plan. The geophysical results will be used to decide whether and where a core hole is needed to define the vertical extent of contamination.	As discussed with NMED at a meeting on June 3, 2010, surface-water balance studies presented in three previous chromium-related reports indicate infiltration beneath the wetland is minimal (LANL 2006, 094431; LANL 2007, 098938; LANL 2008, 102996). If the geophysical survey corroborates the water-balance data, a core hole will not need to be drilled to define the vertical extent of contamination. A core hole will be drilled if the geophysical results suggest there are areas of focused infiltration.
9	LANL must install a perched-intermediate well at R-10/R-10A.	LANL will install a perched intermediate well at R-10/R-10A, as discussed in section 4.2 of this work plan.	n/a
10	It is likely that contaminants from Sandia Canyon sources have migrated to the Rio Grande. RACER data for the sediment sampling station at the mouth of Sandia Canyon show chromium, nickel, and uranium concentrations above background values. LANL must review data from sediment sampling stations and from the Rio Grande to assess the possibility of sediment transport from Sandia Canyon to the Rio Grande. This possible transport must be addressed in the Phase II investigation report.	Environmental Surveillance Program sediment data from lower Sandia Canyon and the Rio Grande will be evaluated in the Phase II investigation report in the context of potential contaminant transport.	n/a

NMED Comment No.	Summary of NMED Comment and Requirement	LANL Proposed Action	Rationale for Proposed Action if Different from NMED Requirement
11	A large alluvial fan deposit located 2000 ft east of PM-3 may have caused damming of floodwaters on the canyon floor and deposition of sediments onto the adjacent floodplain. These deposits were not investigated during the Sandia Canyon investigation. LANL must collect surface and subsurface sediment samples from these deposits and analyze the samples for a full suite of inorganic and organic compounds. The results must be reported in the Phase II investigation report.	An additional sediment investigation reach will be added in the area of Sandia Canyon east of PM-3, including the area of maximum sediment deposition. These data will be used to better define the nature and extent of chromium contamination in surface sediments. Ten sediment samples, including both surface and subsurface samples, will be collected in this reach and analyzed for the full suite of inorganic and organic chemicals that have been identified as COPCs in the adjacent reaches (reaches S-5C and S-5E), as described in section 4.3. The results of this investigation will be used to revise the conceptual model of contaminant distribution and inventory, as necessary. The new reach data will also be evaluated in the context of potential human health risk, if required. Results will be presented in the Phase II investigation report.	n/a
12	The risk assessment is incomplete because the investigation on which it is based is incomplete. An updated risk assessment must be included in the Phase II investigation report.	An updated risk assessment will be included in the Phase II investigation report.	n/a
13	The report contains numerous inaccuracies, omissions, and internal inconsistencies.	These problems will be corrected in the Phase II investigation report.	n/a

*n/a = Not applicable.

REFERENCES

The following list includes all documents cited in this appendix. Parenthetical information following each reference provides the author(s), publication date, and ER ID. This information is also included in text citations. ER IDs are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.

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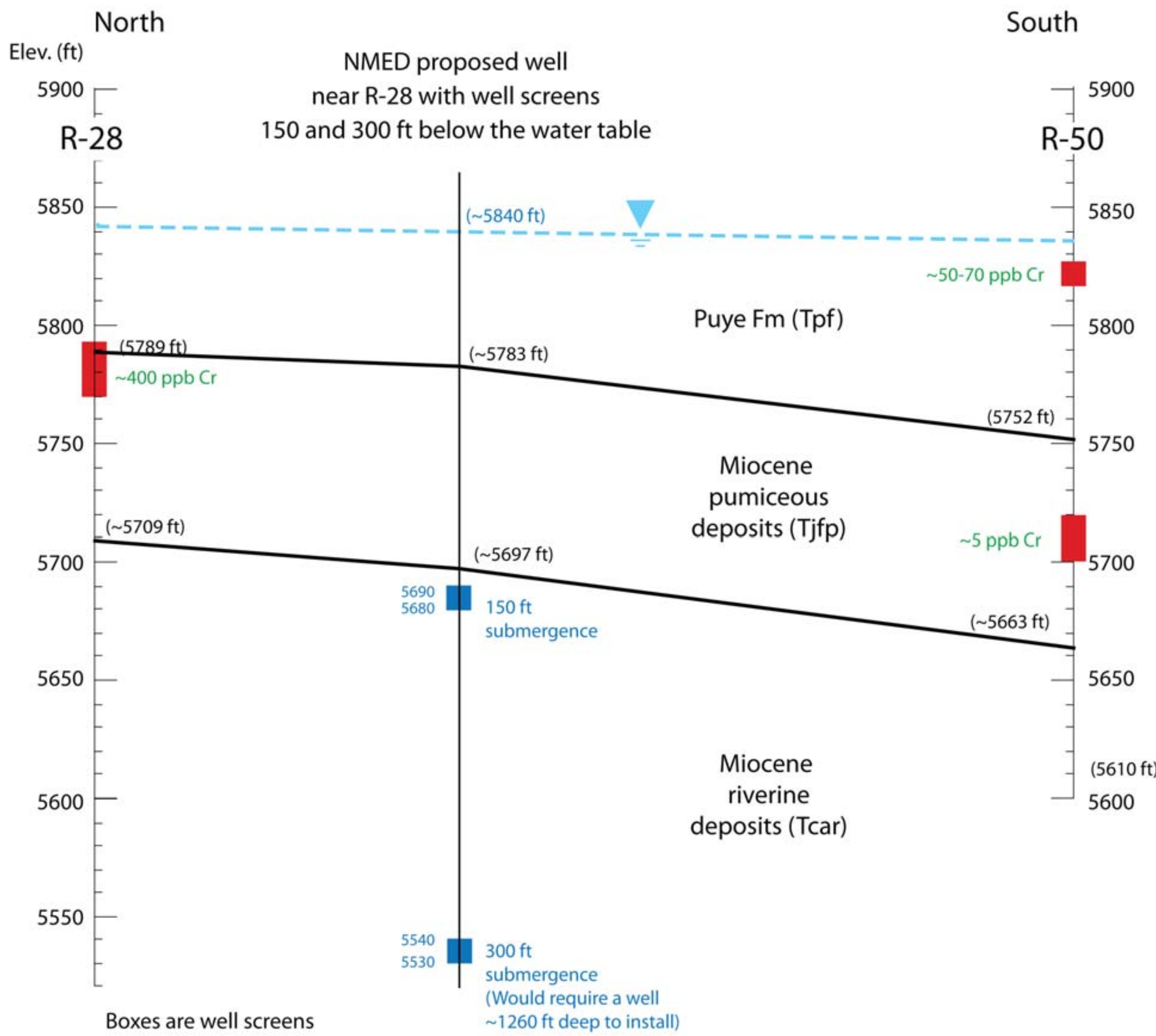

Figure A-1 **Conceptual north-south hydrogeologic cross-section for the regional aquifer in the vicinity of the chromium plume showing the positions of well screens in the monitoring wells. The regional water table is shown as the light-blue dashed line at the top of the figure. Screen positions for an NMED-proposed well with deep well screens near well R-28 are also shown for reference. This work plan proposes to modify the goal and location of the NMED-proposed well near well R-28, and the new well is designated as well R-61 in this work plan.**

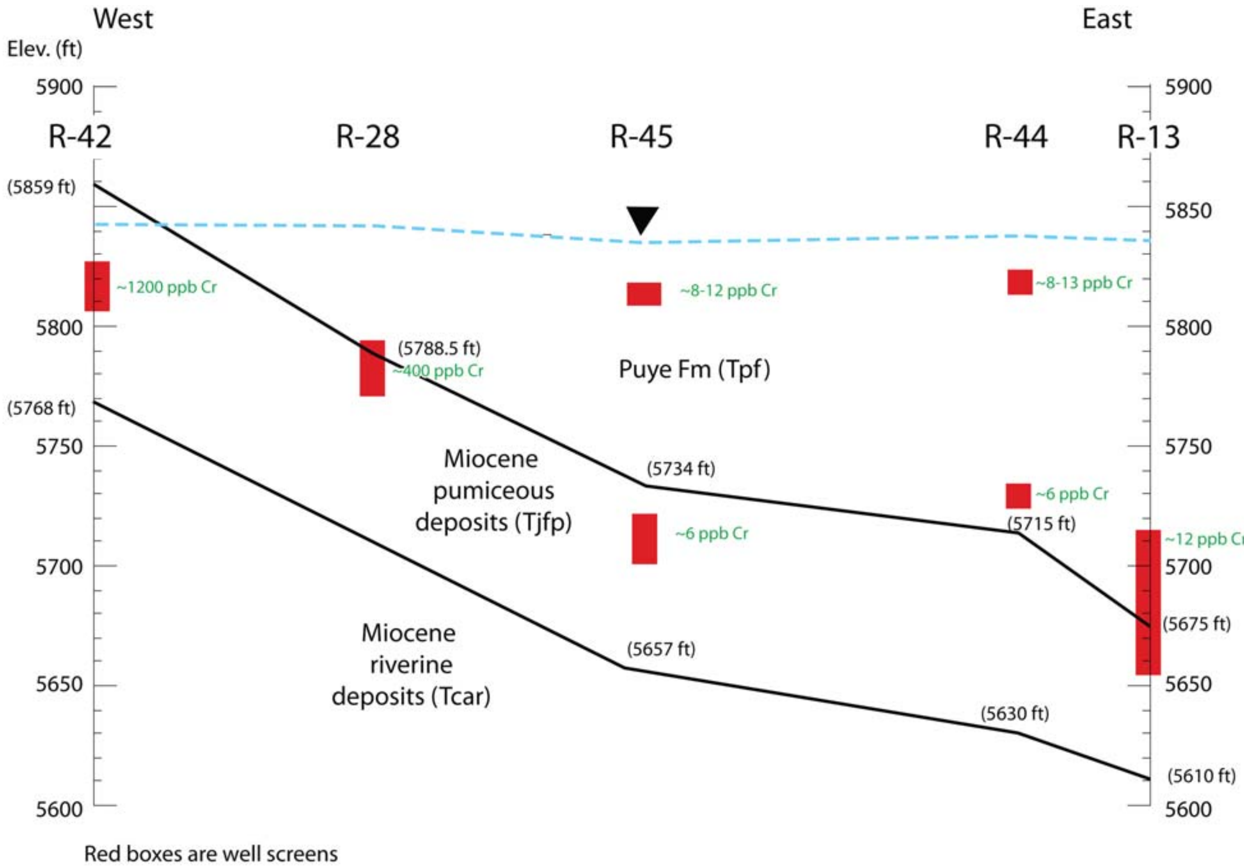

Figure A-2 **Conceptual west-east hydrogeologic cross-section for the regional aquifer in the vicinity of the chromium plume showing the positions of well screens in monitoring wells. The regional water table is shown as the light-blue dashed line at the top of the figure.**