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Interim Measures Work Plan for Chromium Contamination in Groundwater

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Prepared by
Environmental Stewardship Division–
Environmental Remediation and Surveillance Program

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EXECUTIVE SUMMARY

This interim measures work plan (work plan) describes the investigation that addresses chromium contamination in groundwater beneath Los Alamos National Laboratory (LANL or the Laboratory). The investigation will be conducted in accordance with requirements in the Compliance Order on Consent (hereafter, Consent Order) between the U.S. Department of Energy (DOE), the Regents of the University of California (UC), and the New Mexico Environment Department (NMED). The work plan is being prepared in response to a requirement in a letter from NMED dated December 29, 2005 (NMED 2005, 91683). The letter requires that the Laboratory submit an interim measures work plan pursuant to Section VII.B.2 of the Consent Order.

Characterization monitoring at R-28 in Mortandad Canyon in 2005 led to the identification of chromium in the groundwater at concentrations above NMED and U.S. Environmental Protection Agency standards (50 µg/L and 100 µg/L, respectively). R-28 is near water-supply wells PM-1, PM-3, PM-4, PM-5, and Otowi-4. In response to a requirement in NMED's letter (NMED 2005, 91683), a group of intermediate and regional groundwater wells (including water-supply wells) surrounding R-28 was sampled in late January- early February 2006 for an analyte suite intended to help characterize the chromium contamination and define potential sources. Results from the sampling event indicate that chromium contamination is present in the regional aquifer in a limited area beneath Sandia and Mortandad canyons and is present in intermediate-depth perched groundwater beneath Mortandad Canyon. Chromium contamination was not detected in water-supply wells.

The likely sources of chromium contamination are related to usage of chromate-containing compounds as a corrosion inhibitor in cooling-tower systems that were located in the upper portions of the Sandia, Los Alamos, and Mortandad watersheds. Preliminary indications are that Sandia Canyon received the largest mass of chromium. Available information indicates that the usage of chromates in cooling-tower systems ceased in the early 1970s.

This document presents the interim measures required by NMED to ensure the protection of drinking water while longer-term corrective action remedies are evaluated and implemented. Thus, the work presented herein represents an initial phase of the work to be conducted related to the chromium contamination. Data collected for this phase of the investigation will be used to reduce uncertainties in the conceptual model of the nature and extent of present-day chromium contamination. Results will also be used to assess current and potential future impacts of chromium contamination on the drinking water supply by merging conceptual and computer models that quantitatively describe the hydraulic and contaminant mass transport relationships between surface water, unsaturated strata, and groundwater. Subsequent phases will be guided by the results of this initial phase and by agreements with the NMED on the path forward. The specific goals of the investigation presented in this work plan are to

- determine the primary source(s) of chromium contamination and the nature of operations associated with releases,
- characterize the present-day spatial distribution of chromium and related constituents,
- collect data to evaluate the geochemical and physical/hydrologic processes that govern chromium transport, and
- collect and evaluate data to help guide subsequent investigations and remedy selection.

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

1. conduct quarterly sampling of selected regional aquifer and intermediate groundwater wells;
2. investigate surface water and alluvial groundwater loss in Sandia Canyon;
3. install six core holes in lower Sandia Canyon;
4. install five alluvial wells in lower Sandia Canyon;
5. determine chromium distributions in the upper vadose zone from archival and new cores collected from Los Alamos, Sandia, and Mortandad canyons;
6. rehabilitate well R-12 in lower Sandia Canyon;
7. refine the understanding of background concentrations and speciation of chromium in groundwater; and
8. collect and synthesize data and information to support conceptual model development and remedy selection.

An investigation report will be prepared and delivered to NMED on a date yet to be determined. The report will present the results of this interim measures work plan and will provide the basis for the next phase of work associated with the chromium contamination in groundwater.

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1.0 INTRODUCTION

This interim measures work plan (work plan) describes the investigation to address chromium contamination in groundwater beneath Los Alamos National Laboratory (LANL or the Laboratory). The investigation will be conducted in accordance with requirements in the March 1, 2005, Compliance Order on Consent (hereafter, Consent Order) between the U.S. Department of Energy (DOE), the Regents of the University of California (UC), and the New Mexico Environment Department (NMED). The work plan is being prepared in response to a requirement in a letter from NMED dated December 29, 2005 (NMED 2005, 91683). The letter requires that the Laboratory submit an interim measures work plan pursuant to Section VII.B.2 of the Consent Order.

This document presents the interim measures required by NMED to ensure the protection of drinking water while longer-term corrective action remedies are evaluated and implemented. Thus, the work presented herein represents an initial phase to be conducted related to the chromium contamination. Data collected for this phase of the investigation will be used to reduce uncertainties in the conceptual model for chromium contamination. Results will also be used to assess current and potential future impacts of chromium contamination on the drinking water supply by merging conceptual and computer models that quantitatively describe the hydraulic and contaminant mass transport relationships between surface water, unsaturated strata, and groundwater. Subsequent phases will be guided by the results of this initial phase and by agreements with the NMED on the path forward. Monitoring is an immediate and continuing means of ensuring protection of human health. As discussed later in this work plan, frequent sampling of regional and intermediate monitoring wells and production wells will be conducted as a central component of this project. The specific goals of the investigation presented in this work plan are to

- determine the primary source(s) of chromium contamination and the nature of operations associated with releases,
- characterize the present-day spatial distribution of chromium and related constituents,
- collect data to evaluate the geochemical and physical/hydrologic processes that govern chromium transport, and
- collect and evaluate data to help guide subsequent investigations and remedy selection.

The work plan presents background information on chromium contamination at the Laboratory in Section 2. Section 3 of the work plan presents a conceptual model that addresses sources and processes related to the chromium contamination, present-day distribution, and hydrologic and geochemical processes that are consistent with the observations of chromium in the regional aquifer. The scope described in Section 4 is developed specifically to address uncertainties in the conceptual model.

2.0 BACKGROUND

Groundwater sampling is conducted at the Laboratory for routine monitoring and for initial characterization purposes after new wells are installed. Characterization monitoring at R-28 in Mortandad Canyon in 2005 led to the identification of chromium in the groundwater at concentrations above NMED and U.S. Environmental Protection Agency (EPA) standards (50 µg/L and 100 µg/L, respectively). R-28 is near water-supply wells PM-1, PM-3, PM-4, PM-5, and Otowi-4 (Figure 2-1). In response to a requirement in NMED's letter (NMED 2005, 91683), a group of intermediate and regional groundwater wells (including water-supply wells) surrounding R-28 was sampled in late January–early February 2006 for an analyte suite intended to help characterize the chromium contamination and define potential sources (Table 2-1 and Figure 2-1). The results are presented in Appendix 6 on the enclosed CD. A key aspect of the suite was the inclusion of analysis for hexavalent chromium. The natural ratios of hexavalent to trivalent chromium in groundwater beneath the Laboratory are not currently known. Therefore, the data from the first round cannot be fully interpreted until further work is conducted to improve the conceptual model for speciation of natural chromium in groundwater. Additional characterization is proposed in Section 4 of this work plan to address this issue.

A review of solid waste management units (SWMUs) and areas of concern in Los Alamos, Sandia, and Mortandad canyons was conducted to identify the potential source(s) of chromium. Knowledge of operations at the Laboratory and groundwater flow paths supports a focus on those three watersheds as the likely sources. Appendix 1 provides a table of the sites thought to be the primary potential sources. The table also includes information on the operational processes and the nature of potential releases. In summary, the likely sources are related to usage of chromate-containing compounds as a corrosion inhibitor in cooling-tower systems that discharged to each of the three watersheds. Available information indicates that the usage of chromates for this purpose ceased in the early 1970s. Records also indicate that Sandia Canyon received the largest mass of chromium (Comprehensive Environmental Assessment and Response Program [CEARP] DOE 1987, 52975; Herceg 1973, 04966; Birdsell 2006, 91685). Further discussion of sources is provided in Section 3.

Significant additional information on background and environmental setting for the Los Alamos, Sandia, and Mortandad watersheds is presented in existing work plans for each (LANL 1995, 50290; LANL 1999, 64617; LANL 1997, 56835), and in the Los Alamos and Pueblo Canyons Investigation Report (LANL 2004, 87390).

3.0 SITE CONDITIONS

3.1 Chromium Sources

3.1.1 Natural Sources

Natural sources of chromium at Los Alamos occur within soils, sediments, Bandelier Tuff, Cerros del Rio basalt, Tschicoma Formation, Puye Formation, Santa Fe Group basalt, and Santa Fe Group sediments. This trace element is concentrated within iron-rich minerals, including hematite, magnetite, biotite, pyroxenes, ferric oxyhydroxide, smectite, and volcanic glass. Natural chromium is most often stable in the trivalent oxidation state, substituting for both iron and manganese in oxides and hydroxides.

The mean Laboratory background concentration of total chromium is 19.3 mg/kg within soil horizons (Ryti and Longmire 1998, 59730). Higher concentrations of natural total chromium are found within the Cerros del Rio basalts at concentrations ranging from 170 to 240 mg/kg beneath Mortandad Canyon (Broxton 2002, 76006) and in lavas of the Tschicoma Formation as well as Puye Formation detritus derived from Tschicoma sources at concentrations ranging from 24 to 39 mg/kg (Kopp 2002, 73707).

These iron-rich mineral phases are characterized by low solubilities under near-neutral pH conditions, which leads to low concentrations of dissolved chromium in groundwater. Background concentrations of dissolved total chromium range between 3 and 5 µg/L within perched-intermediate zones and the regional aquifer (LANL 2005, 90580). The natural ratio of hexavalent to trivalent chromium in groundwater is uncertain, but activities defined in Section 4 of this work plan address this speciation issue.

3.1.2 Historic Anthropogenic Sources

Several types of historic anthropogenic chromium sources are present in the Los Alamos, Sandia, and Mortandad canyon watersheds. These include facilities for electroplating and photoprocessing and for use as a corrosion inhibitor in cooling-tower systems. Based on the review of SWMUs in these watersheds, the highest chromium usage was as a corrosion inhibitor (see Appendix 1). Potassium dichromate ($K_2Cr_2O_7$), phosphate, and zinc were used in cooling-tower systems in the upper parts of the Los Alamos and Sandia canyon watersheds (e.g., Technical Area [TA] 02 in Los Alamos Canyon, TA-03 in Sandia Canyon, and possibly TA-48 in Mortandad Canyon). The process involved adding sulfuric acid to lower the pH of cooling-tower water to prevent precipitation of silica, calcium carbonate, and other solids. A mixture of potassium dichromate, phosphate, and zinc was then added to coat metal components with a corrosion-inhibiting film (Birdsell 2006, 91685). These chemicals were contained in cooling-tower blow-down released as effluent and in drift emitted with steam from the towers. Available records reviewed for this work plan indicate that use of chromate as a cooling-tower additive was suspended in the early to mid-1970s.

Sandia Canyon Sources

Available records indicate that the cooling tower for the TA-03 power plant at the head of Sandia Canyon [Consolidated Unit 03-012(b)-00, currently National Pollutant Discharge Elimination System (NPDES) outfall 01A-00, Figure 2-1] used the largest amounts of potassium dichromate at the Laboratory. The CEARP report (DOE 1987, 52975) summarizes chromium usage at the power plant as averaging 35.9 lb per day from 1950 to the mid-1970s. This amount was discharged into upper Sandia Canyon with blow-down water volumes ranging from 128,000 to 288,000 gal./day. Hexavalent chromium levels of up to 34 ppm were reported for discharge concentrations; average stream concentrations of 10 to 15 ppm were also reported (DOE 1987, 52975).

Los Alamos Canyon Sources

The cooling tower (SWMU 02-005) for the Omega West Reactor (OWR) (Figure 2-1) at TA-02 used potassium dichromate as a corrosion inhibitor from 1957 to 1973. It is believed to be the second largest source of potassium dichromate at the Laboratory. An estimated 5000 lb of chromate may have been used at the TA-02 cooling tower from 1957 to 1973 and released into Los Alamos Canyon (LANL 1993, 15314, p. 7.6-1). The cooling tower operated 8 h/day, Monday through Friday, with a discharge rate of roughly 12,000 to 15,000 gal./day (Birdsell 2006, 91685).

Mortandad Canyon Sources

The SWMU summary presented in Appendix 1 indicates several possible sources, including cooling-tower systems [e.g., Consolidated Unit 48-007(a)-00)] and plating processes (e.g., 03-045(h)-00). These smaller cooling-tower systems and plating processes are assumed to be smaller sources than those in Sandia and Los Alamos canyons, both in terms of discharge volumes and total chromium mass released. Results from the sediment investigation in the Mortandad watershed indicate that the highest chromium concentrations are in reach E-1FW at the head of Effluent Canyon (Figure 2-1), indicating a TA-48 source (LANL 2005, 89308).

3.2 Present-Day Distribution of Chromium

Data from media in the canyons (sediment, surface water, groundwater, and vadose zone pore water) provide some information on the present-day distribution of chromium, especially in the near-surface media in these watersheds. Sediment investigations in these watersheds indicate that the highest concentrations of chromium are found near the sources described above (Figure 2-1 and Appendix 4). Maximum observed sediment concentrations for total chromium are found in reach S-2 in Sandia Canyon at 3200 mg/kg, in reach E-1FW in Effluent Canyon at 2210 mg/kg, and in reach LA-2W in Los Alamos Canyon at 19.5 mg/kg (an excavated sample in reach LA-2E had a concentration of 38.4 mg/kg).

Present-day concentrations of chromium in persistent surface water and alluvial groundwater in Los Alamos and Mortandad canyons are generally low but are also highest near the sources described above (Appendix 3). A time series of chromium in alluvial groundwater at monitoring well LAO-1 (near the release site at the OWR) shows the decline in concentration over time since chromates ceased being used in the early 1970s (Figure 3-1). Alluvial groundwater data are not available for Sandia Canyon because to date there are no alluvial monitoring wells with consistent saturation, but similar rates of decline might be expected. Older (mid-1970s) alluvial groundwater data for Mortandad Canyon appear to have problems regarding the quality of the analytical results, so they are not plotted here.

The greatest uncertainty in the present-day distribution of chromium is for the deeper portions of the alluvium in these canyons and for the vadose zone beneath the alluvium. Intermediate groundwater is present beneath all three canyons, but among existing monitoring wells, chromium is only elevated in Mortandad Canyon intermediate wells. A hexavalent chromium concentration of 53.2 µg/L was present in MCOI-6 in January 2006 (Figure 3-2).

Within the regional aquifer, elevated hexavalent chromium levels were found in January to February 2006 at R-28 (406 µg/L), R-11 (26 µg/L), and possibly at R-15 (7 µg/L) (Figure 3-2). Chromium concentrations in surrounding wells are thought to represent background values ($\leq$ 5 µg/L), suggesting that the spatial extent of contamination in the regional groundwater may be limited to the area beneath the Sandia and Mortandad canyons.

3.3 Factors Governing Distribution of Chromium

The present-day distribution of chromium results from a series of hydrologic and geochemical processes that have affected its transport since its initial releases. The hydrologic pathways are generalized in Figure 3-3 and are further explained in this section.

Chromium is stable in the trivalent and hexavalent oxidation states in surface water and groundwater (Rai et al. 1987, 91686; Rai and Zachara 1986, 91684). Natural chromium commonly occurs in the reduced, trivalent oxidation state in groundwater containing reductants, including dissolved organic carbon, ferrous iron, and hydrogen sulfide. Chromium(III) is less mobile and less toxic than chromium(VI). Oxidizing agents including manganese dioxide, dissolved oxygen, and nitrate, however, enhance the stability of chromium(VI) in groundwater (Rai and Zachara 1986, 91684).

Natural attenuation of chromium can occur in the soil, surface water, and subsurface pore waters as chromium(VI) anions are reduced to form chromium hydroxide, which has a low aqueous solubility under near-neutral pH conditions (Rai et al. 1987, 91686; Rai and Zachara 1986, 91684). The dominant geochemical processes that are expected to influence the distribution of anthropogenic chromium in the environment are listed below:

- Chromium in the acidic pH cooling-tower effluent is stable in the hexavalent form as soluble anions including bichromate ($HCrO_4^-$) and chromate (CrO_4^{2-}). These anions have high mobility, similar to bicarbonate and sulfate anions, respectively, under near-neutral pH conditions and do not readily adsorb onto mineral surfaces (Rai et al. 1987, 91686; Rai and Zachara 1986, 91684).
- Reduction of chromate in surface water to chromium(III) aqueous and solid species can occur in organic-rich settings such as wetlands and floodplain sediments containing solid organic matter and ferrous iron.

- Adsorption of aqueous chromium(III) onto colloids, minerals, and solid organic matter and precipitation of chromium hydroxide immobilize chromium in the trivalent form. In the near surface, a fraction of chromium(III) is expected to be present, largely adsorbed to these solid phases.
- In the subsurface, further attenuation is expected to occur as chromate is reduced to chromium(III) in the presence of dissolved and solid-bound ferrous iron found within Cerros del Rio basalt and other mafic rocks contained within deeper rock units (e.g., Cerro Toledo interval, Puye Formation). However, the presence of manganese(III, IV) oxides and hydroxides and/or dissolved oxygen can reoxidize chromium(III) back to chromium(VI).

Not all of the chromium(VI) discharged from cooling towers is expected to be reduced to chromium(III), even though chemical reduction of chromium within higher organic settings in these watersheds can be substantial (Rai and Zachara 1986, 91684). Therefore, some mobile chromate is expected to migrate along complex hydrologic pathways shown in Figure 3-3 to arrive in the regional aquifer beneath the Pajarito Plateau. Both natural and anthropogenic surface water sources act as potential drivers for mobile chromium migration along these surface and subsurface hydrologic pathways. Surface water sources in the three canyons are derived from the following:

- Effluents have been released into Sandia Canyon near its headwaters at TA-03 since at least the early 1950s. Currently, three facilities discharge into Sandia Canyon: the combined effluent from the Sanitary Wastewater System Consolidation, the Power Plant cooling-tower at NPDES outfall 01A-001, and the Strategic Computing Complex (SCC) cooling-tower discharges at outfall 03A027. The combined discharges from these three facilities ranged from 108 million gallons per year (MGY) to 138 MGY between 2002 and 2005. Stormwater runoff and continuous power-plant discharges since 1950 have supplied a sufficient water volume to facilitate potential chromate transport.
- Discharges of cooling-tower blow-down associated with the OWR (Figure 2-1) were sufficient to facilitate chromate transport while that facility operated. In addition to effluent discharges, upper Los Alamos Canyon receives varying amounts of natural surface water flow and alluvial groundwater recharge from the upper watershed (LANL 2004, 87390). Between 1995 and 2000, surface flow past gage E025, located in Los Alamos Canyon west of the OWR site, averaged 67.4 MGY (Kwicklis et al. 2005).
- The largest water volumes disposed in Mortandad Canyon are from the TA-50 Radioactive Liquid Waste Treatment Facility (RLWTF) in Effluent Canyon. The RLWTF has been in operation since 1963, discharging from a historical maximum of 16 MGY in 1968 to 3 MGY in 2002. Lesser volumes of water associated with cooling towers at TAs-03, -48, and -55 also release into Mortandad Canyon. Snowmelt and stormwater runoff also contribute varying amounts of recharge.

Infiltration of surface water and alluvial groundwater is variable along the flow paths. Little infiltration of surface water is thought to occur along the steep bedrock-dominated sections of Sandia and Mortandad canyons. Los Alamos Canyon does not contain such sections in the investigation area. Surface water infiltration in Sandia Canyon will be assessed with the water balance investigation presented in this work plan.

Alluvial groundwater also infiltrates variably in these canyons. In each canyon, the areas of presumed infiltration from alluvium that correspond to historical chromium sources are described below:

- In Sandia Canyon, a preliminary water balance using data from gage stations E122 and E123 indicates little or no infiltration in the upper canyon. East of E123, the canyon is relatively steep and bedrock-dominated with little infiltration expected. Existing alluvial monitoring wells SCO-1 and SCO-2 in the lower canyon are historically dry, suggesting that the predominant area of infiltration is in the lower canyon as depicted in Figure 3-3. Aqueous-phase chromium (dissolved) is likely to have followed this same infiltration pathway.

- In Mortandad Canyon, maximum infiltration is thought to occur in the lower canyon near and immediately downstream of the confluence with Ten Site Canyon. Moisture and contaminant profiles obtained from investigations in Mortandad Canyon support this observation (Broxton et al. 2002, 76006).
- In Los Alamos Canyon, the areas with highest infiltration rates appear to occur west of the chromium source at OWR. Immediately downcanyon of the OWR, relatively low infiltration rates have been observed from a series of nested piezometers (LANL 2004, 87390). Higher infiltration rates are assumed further downcanyon where alluvium overlies the Cerros del Rio basalt. Nested piezometers placed in that area have not shown sufficient saturation to document this conceptual model, but the absence of alluvial groundwater in that segment supports the model.

Intermediate-perched zones of limited extent occur beneath all three canyons (Robinson et al., 2005 91682). It is not known whether these perched zones are relatively stagnant and/or if they facilitate lateral migration. The geometry of perching horizons is likely to strongly influence the flow behavior and the pathway locally, as indicated in Figure 3-3. Intermediate perched water was observed in wells PM-1, R-12, and R-10a in Sandia Canyon, as shown in Figure 3-3, predominantly within the Cerros del Rio basalt. In Mortandad Canyon, intermediate perched water was encountered in wells R-15, MCOBT-4.4, MCOI-4, MCOI-5, MCOI-6, and MCOI-8, also within the Cerros del Rio basalt. Unlike the localized perched zones in Sandia and Mortandad canyons, wells installed all along the length of Los Alamos Canyon intercept perched zones. Mobile chemicals, including nitrate, perchlorate, and tritium, have been observed in most of the perched zones, showing a connection to surface and alluvial waters.

The migration of chromium contamination is expected to include many of the geochemical and hydrologic factors described above. There is considerable uncertainty regarding the relative role and magnitude of each of these factors in and beneath each of these watersheds. The scope described in Section 4 is designed to address this uncertainty.

Water moving through the vadose zone ultimately mixes within the upper portion of the regional aquifer. A major control of the directions of flow and hydraulic gradient in the regional aquifer is provided by the zones of aquifer recharge (Sierra de los Valles and Jemez Mountain) and discharge (Albuquerque basin, Rio Grande). On a local scale beneath the Laboratory, the regional flow directions and gradients are expected to be a function of several variables, including potential effects of water-supply well pumping, local influences of recharge to the regional aquifer, stratigraphic and structural controls, and overall architecture of the facies in the regional aquifer.

Flow directions and hydraulic gradients in the shallow, phreatic (water-table) zone of the regional aquifer are expected to have a dominant influence on the migration of the observed contamination plume. Currently, there are two prevailing conceptual models for potential flow paths within the regional aquifer beneath the Laboratory. Two water-table maps are provided in this work plan to represent the two conceptual models for potential effects of pumping at regional production wells, Figures 3-4 and 3-5. The data used for this analysis were collected in accordance with the requirement in NMED's letter (NMED 2005, 91683) and are described in detail in Appendix 5.

The first conceptual model assumes that the water-supply wells strongly affect flow directions and hydraulic gradients in the phreatic zone. This conceptual model has been applied previously by Vesselinov and Keating (2002, 89752) to delineate capture zones of the water-supply wells. As a result, the capture zones extend to the water table, and contamination reaching the water table along the potential chromium pathways is likely to be captured by one or more of the water-supply wells. Figure 3-4 shows a contour map of the water-table elevation drawn using wellhead measurements collected on January 30, 2006. Water-level measurements and pressure data from R-wells and test wells were used to develop the water-table map. This approach yields a model with pumping-driven cones of depression around supply wells PM-1, PM-3, and O-4. From this analysis, migration of chromium observed at R-28 and R-11 would likely be toward O-4, PM-3, and possibly PM-1.

The second conceptual model proposes that the pumping water-supply wells have a minor effect on flow directions and hydraulic gradients in the phreatic zone, and the water-table shape is predominantly controlled by the spatial (and temporal) distribution of local aquifer recharge over the Pajarito Plateau (Vesselinov 2004, 90117; Vesselinov 2005, 89753; Vesselinov 2005, 90040). Figure 3-5 shows a contour map of the water-table elevation that is drawn using most of the same data as in Figure 3-4. However, water levels from wells R-9, R-12, R-5, TW-2, and R-4 are excluded in the interpretation because these data may not represent conditions at the water table. The resulting map indicates negligible impacts from pumping at PM-1, PM-3, and O-4 on the water-table shape. From this map, we can conclude that chromium observed at R-28 and R-11 is expected to migrate predominantly through the upper saturated portions of the regional aquifer. This conceptual model does not exclude the potential for some vertical mixing of shallow chromium contamination to deeper zones caused by downward flow components related to vertical leakage through laterally discontinuous aquitards/aquicludes due to pumping at production wells. If this mechanism exists, it is believed that PM-3 is the production well with the highest probability to be impacted.

4.0 SCOPE OF ACTIVITIES

This section describes the scope to address chromium contamination in groundwater. The investigation activities are designed to accomplish the goals described in Section 1 and to address key uncertainties in the conceptual model in support of optimizing subsequent investigation and/or remediation activities. These activities are

1. perform quarterly sampling of surface water and groundwater in Sandia and Mortandad canyons;
2. investigate surface water and alluvial groundwater loss in Sandia Canyon;
3. drill six core holes in lower Sandia Canyon;
4. install five alluvial wells in lower Sandia Canyon;
5. determine chromium distributions in the upper vadose zone from archival and new cores collected from Los Alamos, Sandia, and Mortandad canyons;
6. rehabilitate screens in well R-12 in lower Sandia Canyon;
7. refine the understanding of background concentrations and speciation of chromium in groundwater; and
8. collect and synthesize data and information to support conceptual model development and remedy selection.

4.1 Quarterly Sampling of Surface Water and Groundwater in Sandia and Mortandad Canyons

Sampling and analysis of surface water and groundwater in Sandia and Mortandad canyons are currently underway to determine the nature and extent of chromium contamination. The first round was conducted at selected intermediate and regional wells (see Table 2-1) pursuant to the requirement in the letter from NMED (NMED 2005, 91683) as described in Section 2. Subsequent rounds will include surface water and alluvial groundwater to provide snapshots of water quality throughout the hydrological system. Water-quality data from this sampling will provide information about constituents that can be used to fingerprint potential sources and pathways, leading to improved conceptual models of processes controlling chromium mobility and transport and subsequent remedy selection. The locations of all the sampling sites are shown in Figure 2-1. Both filtered and nonfiltered water samples will be collected, and the suite of analytes includes general inorganic constituents, metals (including total and hexavalent chromium), stable isotopes of hydrogen, nitrogen, and oxygen, perchlorate, volatile organic compounds (VOCs), high explosive (HE) compounds, total organic carbon (TOC), and tritium. The complete analytical suite for these wells is shown in Table 4-1. The field parameters for groundwater samples include temperature, conductivity, pH, alkalinity, dissolved oxygen, and turbidity.

The sampling locations and analytical suite presented in Table 4-1 will be included in the pending revision of the Laboratory's Interim Facility Groundwater Monitoring Plan, and the analytical results will be reported in periodic monitoring reports as well as in the report for this investigation.

4.2 Investigation of Surface Water and Alluvial Groundwater Loss

This work plan contains two activities designed to assess the loss of surface water and alluvial groundwater to deeper bedrock units. These activities include investigations of

- surface water loss in upper Sandia Canyon, and
- alluvial groundwater loss in lower Sandia Canyon.

Areas of surface water and alluvial groundwater loss probably coincide within those parts of the canyon floor that have been local zones of recharge to deeper perched zones and to the regional aquifer during and after the period of chromium release from the TA-03 power plant cooling tower. Results from these water-loss investigations will be integrated with results from the core-hole and alluvial-well investigations described below to identify potential deep infiltration pathways.

4.2.1 Water Loss in Upper Sandia Canyon

This activity will determine surface water and alluvial groundwater loss in two reaches of upper Sandia Canyon by evaluating the water balance using outfall and stream gage data. These reaches are the

- canyon floor wetland bracketed by the TA-03 power plant outfall on the west and surface water gaging station E123 on the east, and
- narrow bedrock-dominated portion of Sandia Canyon east of the wetland.

Discharge records from the TA-03 power plant outfall (presently 01A-001), the SCC outfall (03A-027), and the streamflow gage E122 will be used to constrain the input water volume entering the wetland. Streamflow gage data from E123 will be used to estimate the water volume exiting the wetland. Different periods of record (e.g., winter vs. summer) will be used to estimate evapotranspiration associated with cattails and other vegetation in the wetland. Downstream from the wetland, the stream channel runs for a distance of approximately 2200 m through a steep-walled canyon incised into unit Qbt 2 of the Tshirege Member of the Bandelier Tuff until the canyon widens and surface water infiltrates into the alluvial sediment deposits.

A temporary streamflow-monitoring station (conceptually shown as temporary gaging station E123.5 in Figure 2-1) will be installed at a suitable location near the downstream end of this reach where perennial flow is present in order to determine whether or not significant streamflow-infiltration losses occur within this reach. Comparison of these discharges with those measured at gage E123 will determine streambed infiltration losses that occur within this reach.

4.2.2 Alluvial Groundwater Loss in Lower Sandia Canyon

Two nests of piezometers, each containing up to three piezometers, will be installed to address uncertainties in the location and rate of infiltration of alluvial groundwater in lower Sandia Canyon. The water-level data collected from the piezometers will provide hydrologic information on hydraulic gradient and saturated thickness. The two piezometer nests will be installed near SC2 and SC3 (Figure 2-1), with the final locations contingent on the extent and thickness of alluvial saturation determined by core holes and alluvial wells that will be installed first. If possible, the piezometer nests will be installed near previously drilled core holes where the stratigraphy, lithology, and saturated intervals are identified. Lithologic logs will be prepared for both piezometer nests. Open-hole camera, gamma, and induction logs may be run to aid placement of the piezometer ports. The maximum depth for each of the piezometer nests is expected to be 30–50 ft, depending on the final locations selected.

4.3 Installation of Characterization Core Holes in Lower Sandia Canyon

Six deep characterization core holes will be drilled in lower Sandia Canyon to determine the nature and extent of chromium contamination in the upper vadose zone in order to identify infiltration pathways and to provide information for calculating contaminant inventories. Approximate locations of the characterization core holes are shown in Figure 2-1, designated as SCC-1 through SCC-6. Together with the alluvial wells described in the next section, these core holes will help define the extent of saturation in alluvium and will identify perched water in the underlying bedrock units. Both leachable pore water and solid cores will be analyzed to define contaminant distributions and to assess the geochemical processes controlling chromium mobility. The objectives for these core holes are listed in Table 4-2. Results from a direct-current resistivity survey conducted in the central portion of Sandia Canyon in 2005 (see Figure 4-1) and the Advanced Hydrotest Facility (AHF) core holes SC1 through SC5 (Kleinfelder 2002, 91687; also, see Appendix 2) were used to site the core holes in this work plan (Figure 2-1).

The six core holes will be drilled by using dry air-rotary coring methods. Before coring, surface casing will be installed to the base of alluvium to prevent alluvial groundwater from entering the deeper parts of the borehole and impacting moisture-sensitive samples collected during coring operations. The boreholes will be backfilled with bentonite and/or native material and abandoned after core samples have been collected. One well may be installed or the site may be earmarked for a future intermediate well if sufficient perched water is encountered in the bedrock units. Proposed locations and number of boreholes are shown in Figures 2-1 and 4-1 and include the following core holes:

- SCC-1 and SCC-2, the westernmost accessible sites in lower Sandia Canyon; both boreholes target the conductive zone west of SC2 on the resistivity profile
- SCC-3 and SCC-4 between SC2 and SC3; SCC-3 will penetrate a relatively resistive portion of the vadose zone and SCC-4 will penetrate an adjacent conductive zone
- SCC-5 penetrates a deep conductivity high near SC4
- SCC-6 investigates possible infiltration near SCO-1 and PM-3

Core samples will be selected for chemical analyses at 20-ft intervals in each core hole. Additional core samples will be selected for analysis at geologic contacts and features of interest such as soil horizons and fractures. Pore water leached from core and collocated solid core samples will be analyzed for moisture content, metals (including hexavalent chromium, uranium, boron, and molybdenum), anions, and TOC. The analyte suite for core collected from these boreholes is described in Table 4-3. Tritium will be analyzed at 40-ft intervals within the core samples. The remaining core will be protected against moisture loss and stored at the LABORATORY core storage facility.

The target horizon for the core holes is the top of the Cerros del Rio basalt. The predicted depth for reaching this target is given for each core hole in Table 4-2. The general stratigraphic sequence expected in the core holes includes, in descending stratigraphic order, alluvium, Tshirege Member of the Bandelier Tuff, Cerro Toledo interval, Otowi Member of the Bandelier Tuff (including the Guaje Pumice Bed), Puye Formation, and Cerros del Rio basalt. Lithologic logs will be prepared for all core holes. Whenever conditions permit, open-hole camera, gamma, and induction logs will be run after a core hole reaches the total depth to help define geologic contacts and to assess moisture conditions in the core hole. Screening water samples will be collected from any perched groundwater zones encountered, if possible. These screening samples will provide an indication of whether contaminants are present in perched groundwater. Screening samples will be analyzed for anions, metals, and tritium.

4.4 Installation of Alluvial Wells in Lower Sandia Canyon

Five alluvial wells, SCA-1 through SCA-5, will be drilled in lower Sandia Canyon to constrain the extent of alluvial saturation, to determine the nature and extent of chromium contamination within alluvial groundwater, and to provide information for calculating contaminant inventories. Water-quality data from these wells represent the first significant sampling of persistent alluvial groundwater in Sandia Canyon and will be used to determine if alluvial groundwater represents a continuing source of chromium to deeper groundwater. The projection of the new alluvial wells onto the resistivity profile for Sandia Canyon is shown in Figure 4-1. The target depth for each of the wells will be the base of the alluvial sequence. The locations of the new wells are shown in Figure 2-1 and include

- SCA-1, near the east end of the upper Sandia Canyon wetland,
- SCA-2, as far west as possible in lower Sandia Canyon to determine the western extent of alluvial perched groundwater,
- SCA-3, in lower Sandia Canyon near AHF borehole SC2 that contained shallow groundwater when drilled in the summer of 2002,
- SCA-4, in lower Sandia Canyon near AHF borehole SC3 that contained alluvial groundwater when drilled in the summer of 2002, and
- SCA-5, near the canyon axis north of AHF borehole SC5 and R-11 (both of which may have been dry in the alluvium because they are located too far from the canyon axis).

Lithologic logs will be prepared from cuttings for each alluvial well. Open-hole geophysical logs will be run in the boreholes, conditions permitting. Gamma logs will help define geologic contacts and induction logs and water-level measurements will be used to identify target horizons for well screens.

After each well is completed and developed, two rounds of groundwater samples will be collected and analyzed for metals (including hexavalent chromium, uranium, boron, and molybdenum), anions, stable isotopes of hydrogen, oxygen, nitrogen, tritium, HE compounds, VOCs, and TOC as described in Table 4-1. Filtered water samples will be collected for analyses of metals, hexavalent chromium, anions, and nitrogen isotopes. Nonfiltered water samples will be collected for metals, hexavalent chromium, VOCs, HE compounds, stable isotopes of hydrogen and oxygen, and tritium. The field parameters for groundwater samples include temperature, conductivity, pH, alkalinity, dissolved oxygen, and turbidity.

4.5 Analysis of Existing Core

Selected archival core samples from Los Alamos, Sandia, and Mortandad canyons will be sampled and analyzed to help bound the extent of chromium contamination in the vadose zone. The specific cores that are proposed for sampling are listed in Table 4-4. Analysis of these available cores will be used to determine the nature and extent of chromium contamination in the upper vadose zone, identify infiltration pathways, and provide information for calculating contaminant inventories. Data from the archival core will supplement the investigations proposed for Sandia Canyon in this work plan and provide new information to evaluate chromium distributions beneath Los Alamos and Mortandad canyons. Core samples will be selected for analysis at 20-ft intervals in each core hole, except for tritium, $\delta^{15}N$, and radiological screening which will be analyzed at a 40-ft interval. Additional core samples will also be selected for analysis at geologic contacts and features of interest such as soil horizons and fractures. Pore water leached from core and collocated solid core samples will be analyzed for the analyte suite described in Table 4-4.

4.6 Rehabilitation of Well R-12

The representativeness of groundwater data from all three screens at R-12 is presently compromised because of geochemical effects caused by the use of organic additives during drilling (LANL 2005, 91121). This well is equipped with a Westbay multilevel sampling system and has two well screens in perched-intermediate groundwater and one screen in the regional aquifer. R-12 is considered an important monitoring site because of its location along the eastern Laboratory boundary, its proximity to supply well PM-1, and its position potentially downgradient of chromium contamination within the regional aquifer (e.g., R-11 and R-28). In the recently published “Well Screen Analysis Report,” the well was rated as fair in its ability to produce reliable and representative water-quality samples for the regional aquifer screen, and the well was rated as poor for the upper perched-zone screen (LANL 2005, 91121, Figure 6-2b). The lower perched-zone screen was not evaluated because of a lack of water-quality data. The technical approach for well-screen rehabilitation is currently under consideration, and a pilot study for rehabilitation is currently planned to begin in the spring of 2006. The R-12 well rehabilitation will take place as part of the Laboratory’s pending well rehabilitation work plan, and R-12 will be identified as a high-priority well under that plan.

If attempts at rehabilitation of the screens are unsuccessful, a replacement well for the screen in the regional aquifer will be drilled. The specific location will be recommended and will be based on several factors related to the objectives of this work plan.

4.7 Background Chromium Concentrations in Groundwater

Background concentrations of dissolved total chromium and chromium(VI) will be evaluated at 21 selected springs and wells within the Sierra de los Valles, on the Pajarito Plateau, and within White Rock Canyon. Background concentrations represent natural chromium in groundwater in areas not affected by Laboratory operations and provide a baseline for evaluating the presence of anthropogenic chromium in Laboratory wells. The background sample sites in this investigation were selected based on their position within recharge and discharge zones and along groundwater flow paths. Testing for chromium along flow pathways is being undertaken to better understand natural variations in chromium concentrations and ratios of trivalent to hexavalent forms as the groundwater reacts with aquifer materials along the flow path. Table 4-5 provides names of sampling sites, field preparation of samples, and analyte suites.

4.8 Collection and Synthesis of Data to Support Conceptual Model Development and Remedy Selection

Other supporting activities include collecting and synthesizing data to support refinement of the conceptual model and potential remedy selection. Key components include modeling activities to support interpretations during data collection. Such interpretation can later guide decisions in the characterization activities and provide an overall framework for synthesis of the data after they are collected.

Numerical models of the hydrologic system, as it relates to chromium migration pathways, will be developed to provide the overall water and contaminant budgets and to support predictions of the fate and transport of contaminants. A key focus of the models will be to quantify fate and transport uncertainties to evaluate whether sufficient data have been collected. The regional aquifer analyses will particularly concentrate on estimation of potential impact of water-supply wells on the water-table flow and contaminant transport. If possible, data will be collected from several of the production wells discussed in this work plan (e.g., PM-3, PM-1) to enhance the understanding of variations in productivity along the long screens and to assess potential variations in water quality. Data may be obtained from spinner logs (or equivalent) and possibly from stratified sampling methods. The production wells are owned and operated by Los Alamos County, and consequently production schedules and well configuration may impact the ability to collect these data.

Finally, geochemical reactive transport modeling will be conducted to provide a basis for understanding processes (oxidation and reduction, adsorption, and precipitation) that control chromium transport. Recommendations regarding potential remedial alternatives will be based on an integration of characterization data and geochemical and contaminant-transport models.

5.0 INVESTIGATION METHODS

A list of the standard operating procedures (SOPs) that will be used in this investigation is given in Table 5-1. All work will be performed in accordance with the ENV-ECR Group quality management plan (QMP) and applicable quality procedures (QPs).

5.1 Drilling

Six characterization core holes, five alluvial wells, and two piezometer nests will be drilled by hollow-stem auger, air-rotary, direct-push, or hand-auger methods. A brief description of these methods is provided below. More information can be found in SOP-04.01, Drilling Methods and Drill Site Management.

5.1.1 Hollow-Stem Auger

The hollow-stem auger consists of a hollow-steel shaft with a continuous spiraled steel flight welded onto the exterior of the stem. The stem is connected to an auger bit and when rotated, it transports cuttings to the surface. The hollow stem of the auger allows drill rods, split-spoon core barrels, Shelby tubes, and other samplers to be inserted through the center of the auger so that samples may be retrieved during drilling operations. The hollow stem also acts to case the borehole temporarily, so that a well casing (riser) may be inserted down through the center of the auger once the desired depth is reached, thus minimizing the risk of possible collapse of the borehole. A bottom plug or pilot bit can be fastened onto the bottom of the auger to keep out most of the soils and/or water that have a tendency to clog the bottom of the augers during drilling. Drilling without a center plug is acceptable if the soil plug, formed in the bottom of the auger, is removed before sampling or installing a well casing. The soil plug can be removed by washing out the plug using a side-discharge rotary bit or augering out the plug with a solid-stem auger bit sized to fit inside the hollow-stem auger.

5.1.2 Air Rotary

The air-rotary method uses a drill pipe or drill stem coupled to a drill bit that rotates and cuts through soil and rock. The cuttings produced from the rotation of the drill bit are transported to the surface by compressed air, which is forced down the borehole through the drill pipe and returns to the surface through the annular space (between the drill pipe and the borehole wall). The circulation of the compressed air not only removes the cuttings from the borehole but also helps to cool the drill bit. The use of air-rotary drilling is best suited for hard-rock formations. In soft unconsolidated formations, casing is driven to keep the formation from caving. When using air rotary, the air compressor shall have an in-line organic filter system to filter the air coming from the compressor. The organic filter system shall be inspected regularly to ensure that the system is functioning properly. In addition, a cyclone-velocity dissipater or similar air-containment/dust-suppression system shall be used to funnel the cuttings to one location instead of allowing the cuttings to discharge uncontrolled from the borehole. Air rotary that employs the dual-tube (reverse-circulation) drilling system is acceptable because the cuttings are contained within the drill stem and are discharged through a cyclone-velocity dissipater to the ground surface.

5.1.3 Direct Push

Direct push is a subsurface sampling method that pushes a tool string into the ground using the weight of a truck in combination with a hydraulic ram or hammer. Various tool strings can be used for obtaining discrete samples, continuous samples, both discrete and continuous samples, and groundwater samples. The direct-push core samples to be collected in this investigation will be continuous. The inside of the continuous sampler is exposed to the subsurface environment while it is advanced to the sample interval. This is a dual-tube sampler, so named because it uses two sets of rods to collect soil cores. The outer rods receive the driving force from the hydraulic pushing method and provide a sealed hole from which soil samples may be recovered without the threat of cross-contamination or cave-in. The inner set of rods is placed within the outer rods and holds a sampler in place as the outer rods are driven to the sample interval. The inner rods are then retracted to retrieve the soil core. Water samples are collected using a grab-sample tool in the direct-push method. The grab-sample tool is installed temporarily to collect groundwater samples or hydrogeologic data and is then removed from the subsurface. Groundwater grab-samplers include profilers that can collect multiple, discrete samples during one downhole push and standard samplers, which can be driven to a desired depth at which a screen is exposed and a sample is collected through use of a check-valve apparatus or pump. The direct push methods will follow the American Society of Testing and Materials D18 Subcommittee on Direct Push Sampling (D18.21.01).

5.1.4 Hand Auger

Hand augers may be used to bore shallow holes (0 to 15 ft) such as SCA-1. The hand auger is advanced by turning or pounding the auger into the soil until the barrel is filled. The auger is then removed and the sample is dumped out. Motorized units for one or two operators may be used and can reach depths up to 30 ft under certain conditions.

5.2 Sampling and Analytical Methods

5.2.1 Core

Core is collected by means of a core barrel included at the bottom of the drill string. As the drill bit is advanced, the core barrel “shoe” (beveled cutting edge) slightly precedes the advancing drill bit. The core barrel assembly is stationary within the rotating drill string. In this fashion, undisturbed geologic materials are pushed up into the hollow core barrel and are not pulverized by the drill bit. When the core barrel is filled, the drilling is halted and the core barrel is retrieved. If contaminants are anticipated, portable field instruments are used to monitor the cuttings from the cored interval for radioactivity and volatile organic compounds. Guidance for collection, preservation, and storage of core can be found in SOP-06.10, Hand Auger and Thin-Wall Tube Sampling; SOP-0.6.24, Sample Collection from Split-Spoon Samplers and Shelby Tube Samplers; and SOP-06.26, Core Barrel Sampling for Subsurface Earth Materials.

Once the core is removed from the core barrel, it is screened in the field for hazardous contamination. Upon determining that the core is safe to handle, the core is measured and marked to determine core loss and the depth interval the core was collected from. The core is logged to document stratigraphic contacts, lithology, and any structural features. Portions of the core will be removed for analysis. Samples for chemical analysis are placed in appropriate containers and transported to the Sample Management Office (SMO) for off-site analysis or to Laboratory analytical labs.

Geologic samples are removed from the core and placed in appropriate containers, usually zip-type plastic bags. The core will be examined by binocular microscope to determine lithology and alteration features. Geologic samples are kept in the Laboratory Earth and Environmental Sciences Sample Storage Area.

The volumes and sample handling requirements for core and cuttings are specified in Table 4-3.

5.2.2 Water

Screening water samples may be collected from the core holes if perched water is encountered during drilling. Water samples will be collected from the alluvial wells after well development in the completed well. The procedure that is used for sampling water during drilling (screening samples) is different from the procedure for sampling from the completed well (characterization samples). Both methods are described in this section.

5.2.2.1 Collection of Water Samples during Core-Hole Drilling

If saturation is encountered as a characterization core-hole advances, drilling will be stopped to determine whether the water represents natural fluids and if a sufficient volume is available to analyze the water quality. These analyses will include metals, anions (including nitrate and perchlorate), alkalinity, and tritium. Generally, the total volume required for a turbid core-hole groundwater sample is approximately 2.0 L. Of this volume, 500 mL is nonfiltered and nonpreserved; another 500 mL is filtered and preserved with nitric acid. A 1-L sample is required for tritium analysis. If this minimum volume of groundwater cannot be collected, the borehole will be continued to the planned total depth (TD) or until saturation is encountered again and the process is repeated. Insufficient water sample volumes from discrete depths will not be composited to make the required volume for screening analysis.

Analytical suites for groundwater collected during drilling of the core holes are a subset of those specified in Table 4-1.

5.2.2.2 Collection of Water Samples from a Completed Alluvial Well

The alluvial wells will be constructed with single well screens. Guidance for collection of groundwater samples can be found in SOP-06.01, Purging and Sampling Methods for Single Completion Wells.

The first step in collecting a groundwater sample is to measure the static water level. This information, in conjunction with the TD and diameter of the well, is used to calculate the volume of water that must be purged before collecting a sample. The water is purged with either a submersible pump or a bailer. The total volume of water purged is recorded as are periodic measurements of discharge rate and water level. Field parameters are measured at the start of purging and several times thereafter. The well is ready to sample when three casing volumes have been removed, the field parameters have stabilized, and the turbidity is stable. Field parameters are also measured with each sample run. Purge water will be managed and characterized in accordance with the methodology described in the pending interim facility-wide groundwater monitoring plan.

The field parameters for groundwater samples include temperature, conductivity, pH, alkalinity, dissolved oxygen, and turbidity. Samples are collected when the representative field parameters are stable. If the field parameters do not stabilize, a sample is still collected and the field parameters are recorded so that the analytical data may be reviewed in the context of the field data.

After the groundwater sample has been collected and processed, aliquots of the sample are placed in appropriate containers and preserved according to SOP 01.02, Sample Container and Preservation. A 0.45-µm pore size filter is used to filter samples that are to be analyzed for dissolved constituents. These include anions, metals, nitrogen isotopes, and hexavalent chromium. Nonfiltered samples will be analyzed for tritium, metals, hexavalent chromium, stable isotopes of oxygen and hydrogen, TOC, total Kjeldahl nitrogen (TKN), ammonia (NH_3), VOCs, and HE compounds. Groundwater samples for chemical analysis are placed in appropriate secondary containers and transported to the SMO for shipment to off-site analytical laboratories or to the Laboratory analytical labs for more rapid local analysis; see SOP-01.03, Handling, Packaging, and Shipping of Samples for more details.

Analytical suites, estimated detection limits, and EPA analytical protocols for inorganic chemicals in postdevelopment well sampling are specified in Table 4-1.

5.2.2.3 Installation of Temporary Gaging Station

A 15-pounds-per-square-inch (psi) pressure transducer will be hung in a stilling well installed below the streambed and anchored into the bedrock to ensure a stable installation. A suitable location will be determined where the channel geometry is well defined by bedrock. The channel cross section will be surveyed so that the cross-sectional area of flow can be determined. Multiple flowmeter measurements will be performed at representative varying streamflow stage levels to generate a rating curve for the site whereby stream-stage levels measured with the transducer can be converted to volumetric discharges.

5.3 Borehole Geophysics

Borehole geophysical studies will be conducted to determine the distribution of saturation, to help interpret stratigraphy and lithology, and to aid in well design. The types of geophysical data collected are dependent on the objectives of each borehole.

Methods include natural gamma, induction, caliper, and borehole video following SOP-05.07, Operation of LANL Owned Borehole Logging Trailer. These tools will be used as necessary to supplement the information obtained from a geophysical logging contractor or in lieu of contractor data collection in wells where limited depth and constrained objectives do not justify the more expensive suite of contractor tools.

The natural gamma tool is used to measure naturally occurring variations in cumulative gross gamma radiation from potassium, uranium, and thorium. Use of the Laboratory natural gamma tool will be advantageous where a contractor geophysical suite is not deployed and there is a need to refine geologic contacts.

The induction tool provides information on conductivity and resistivity. This information will be important for comparison with core or cuttings in determining that component of rock resistivity/conductivity attributable to the degree of saturation. The Laboratory induction tool will not be required if a logging contractor array induction tool is used to meet resistivity/conductivity characterization objectives.

The caliper tool is a three-arm system that provides information about hole diameter to a maximum of 29 in. It is not anticipated that this tool will be used because the logging contractor's caliper tool will be used in those boreholes where diameter measurements are needed for defining washout intervals, which are critical for the evaluation of data from other tools in the contractor's suite.

The borehole video camera provides an axial downward view along the borehole in either unsaturated conditions or within saturation where the water is clear enough. This tool is not replicated in the standard contractor's suite and it provides unique information on borehole wall conditions (or condition of casing and screens in a completed well), moist or flowing intervals within the vadose zone, and fracture distributions. It can also supplement other tools in defining depth to water and lithology.

6.0 MONITORING AND SAMPLING PROGRAM

The surface water and alluvial, intermediate, and regional groundwater monitoring required under this work plan will be integrated with the requirements of the pending revision of the interim facility-wide groundwater monitoring plan. It is proposed that this monitoring be conducted by watershed, so that all sampling within a watershed be conducted within a 21-day sampling window. The sampling for Mortandad and Sandia canyons will be conducted either concurrently or with overlapping 21-day windows.

The next round of sampling following that conducted pursuant to NMED's letter (NMED 2005, 91683) will not include the Sandia Canyon alluvial wells because those are not expected to be installed in time for that round but will be included in subsequent rounds.

7.0 SCHEDULE, DELIVERABLES, AND REPORTING

7.1 Schedule

The scope described in this work plan is expected to take approximately 9 months to implement. A specific completion date cannot be determined at this time because it is dependent on the timing of NMED approval of this work plan and a variety of field conditions that may be encountered.

The proposed sequence for the drilling activities described in Section 4 is to drill the characterization core holes first to obtain useful information on the stratigraphy and extent and saturated thickness of alluvial groundwater. Installation of the nested piezometers and the alluvial monitoring wells will occur next. Drilling of the characterization core holes and installation of piezometers and alluvial wells is targeted to begin in early June and will require approximately 2 months to complete. Geochemical analysis of new core and sampling of the alluvial wells will follow.

Sampling and analysis of existing core, implementation of the chromium background study, and analysis of existing and new gage data will all begin upon approval of the work plan. Rehabilitation of all three screens at R-12 will begin after implementation of the well rehabilitation pilot study at R-16 and R-20 which is currently scheduled to begin in spring 2006.

Ongoing analysis of regional groundwater-level data and modeling will be conducted and updated with data collected under this work plan and will occur concurrent with implementation of the field activities. These analyses are expected to help inform subsequent investigation activities and potential remedy selection.

A report on the results of this investigation will be prepared and submitted to the NMED following completion of the field and analytical activities. The report will present all data and an updated conceptual model of the chromium contamination. If necessary, the report will also recommend subsequent work.

8.0 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 Stewardship–Environmental Remediation and Surveillance (ENV-ERS) Program Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the ENV-ERS Program 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 ENV-ERS Program. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

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Figure 2-1. **Locations of Sandia, Los Alamos, and Mortandad canyons showing major chromium release sites, stream-flow gages, and existing and planned boreholes, wells, and surface-water sampling stations**

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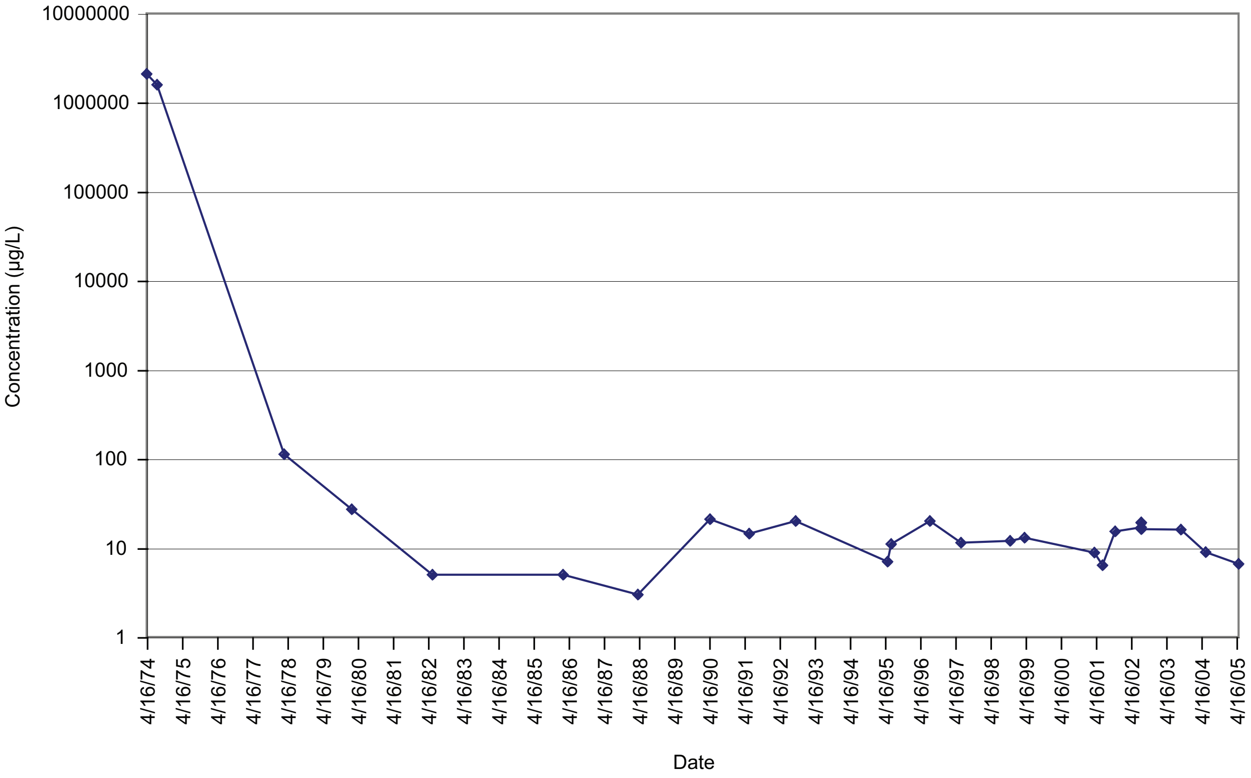


Figure 3-1. **Time-series plot of dissolved total chromium concentrations at alluvial well LAO-1, Los Alamos Canyon**

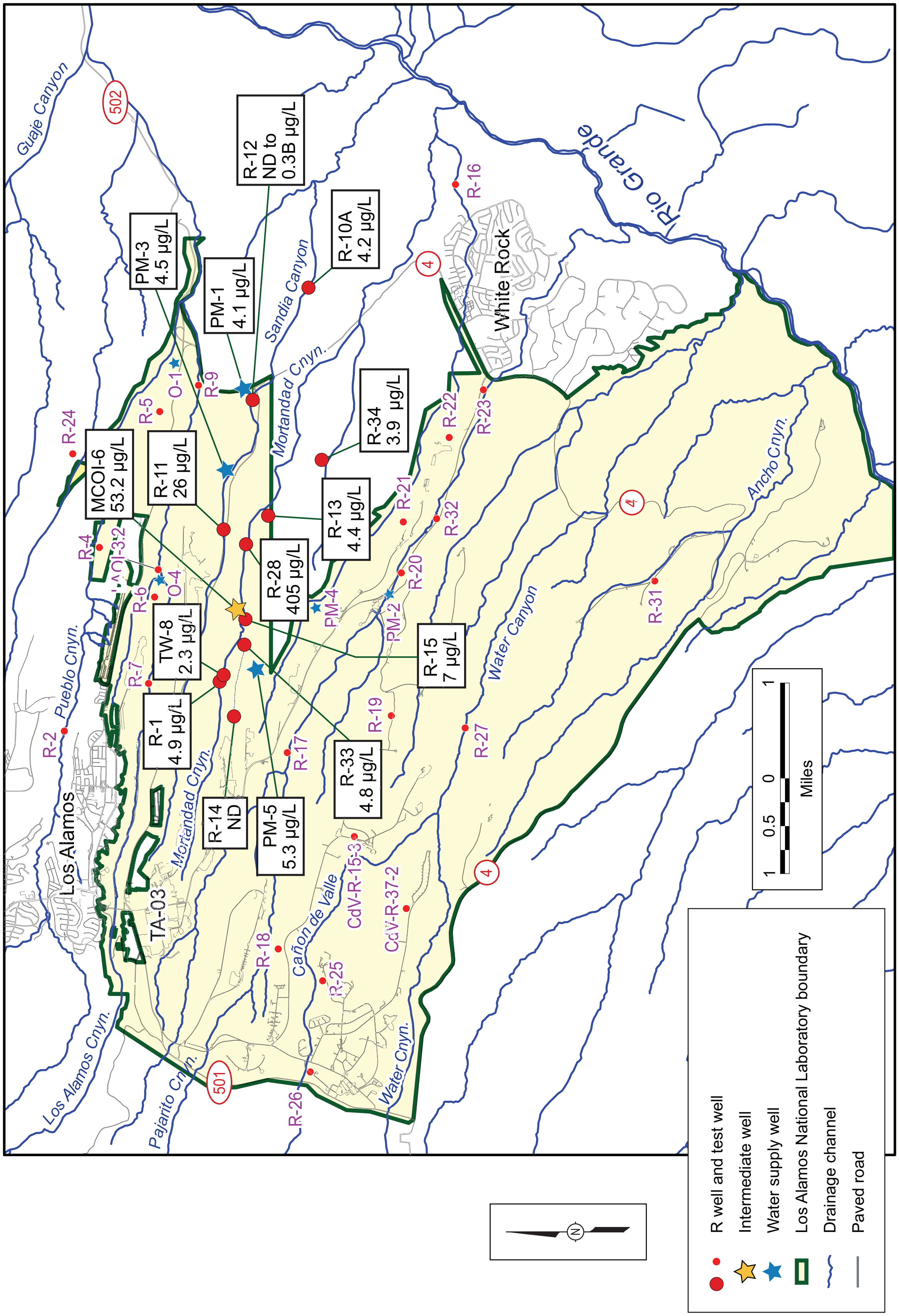
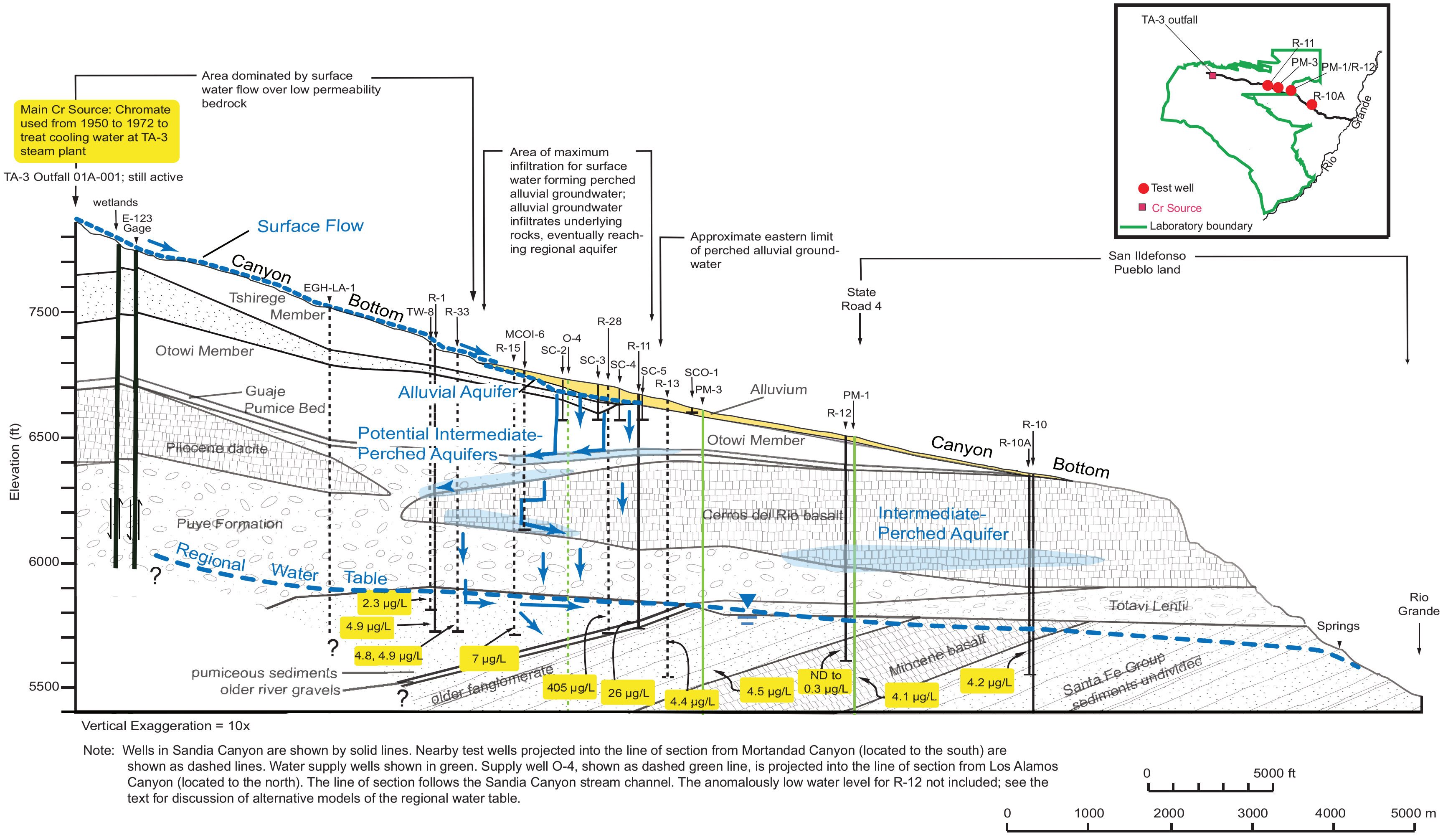


Figure 3-2. Hexavalent chromium concentrations (filtered) in regional and intermediate wells



Note: Wells in Sandia Canyon are shown by solid lines. Nearby test wells projected into the line of section from Mortandad Canyon (located to the south) are shown as dashed lines. Water supply wells shown in green. Supply well O-4, shown as dashed green line, is projected into the line of section from Los Alamos Canyon (located to the north). The line of section follows the Sandia Canyon stream channel. The anomalously low water level for R-12 not included; see the text for discussion of alternative models of the regional water table.

Figure 3-3. Conceptual hydrogeologic cross section showing potential chromium transport pathways and dissolved hexavalent chromium values (µg/L) for monitoring wells and water supply wells in the vicinity of Sandia Canyon

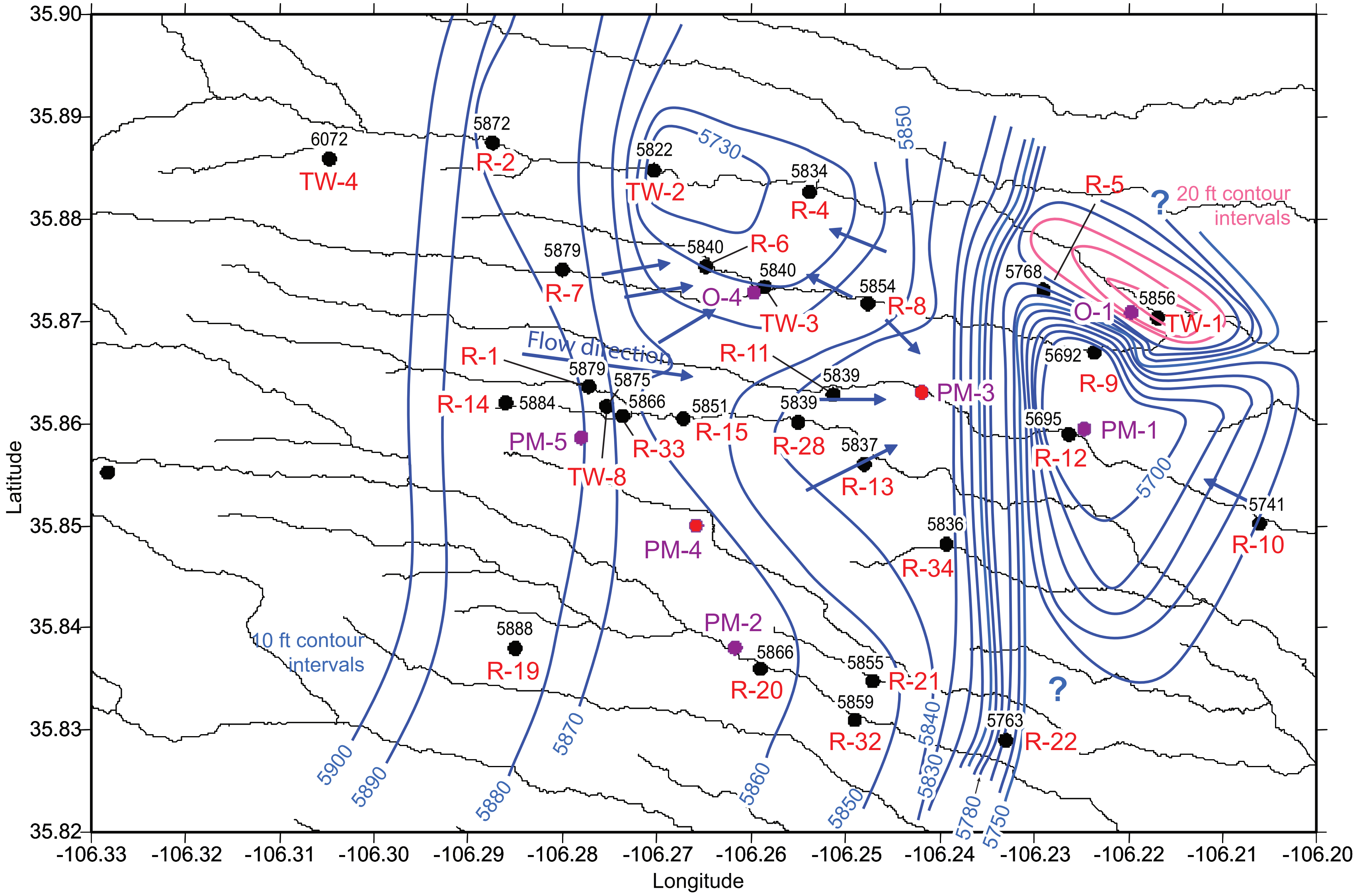


Figure 3-4. **Conceptual Model A: Data-driven contour map (10- and 20-ft intervals) of the water table based on January 30, 2006, measurements at the monitoring wells. Blue arrows define flow directions. Contour lines suggest that pumping at water-supply wells (at O-4, PM-3 and PM-1) impacts flow directions at the water table.**

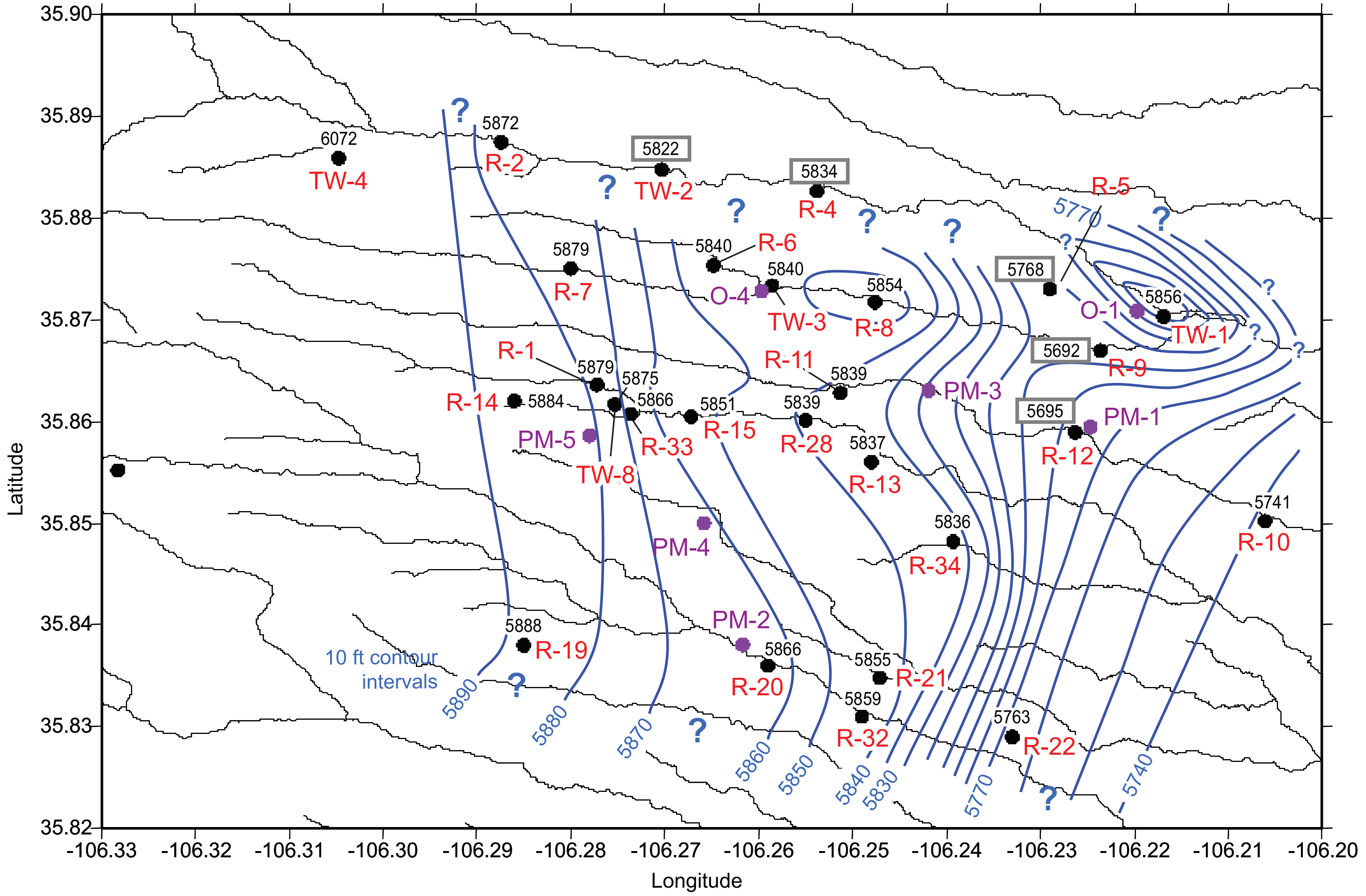
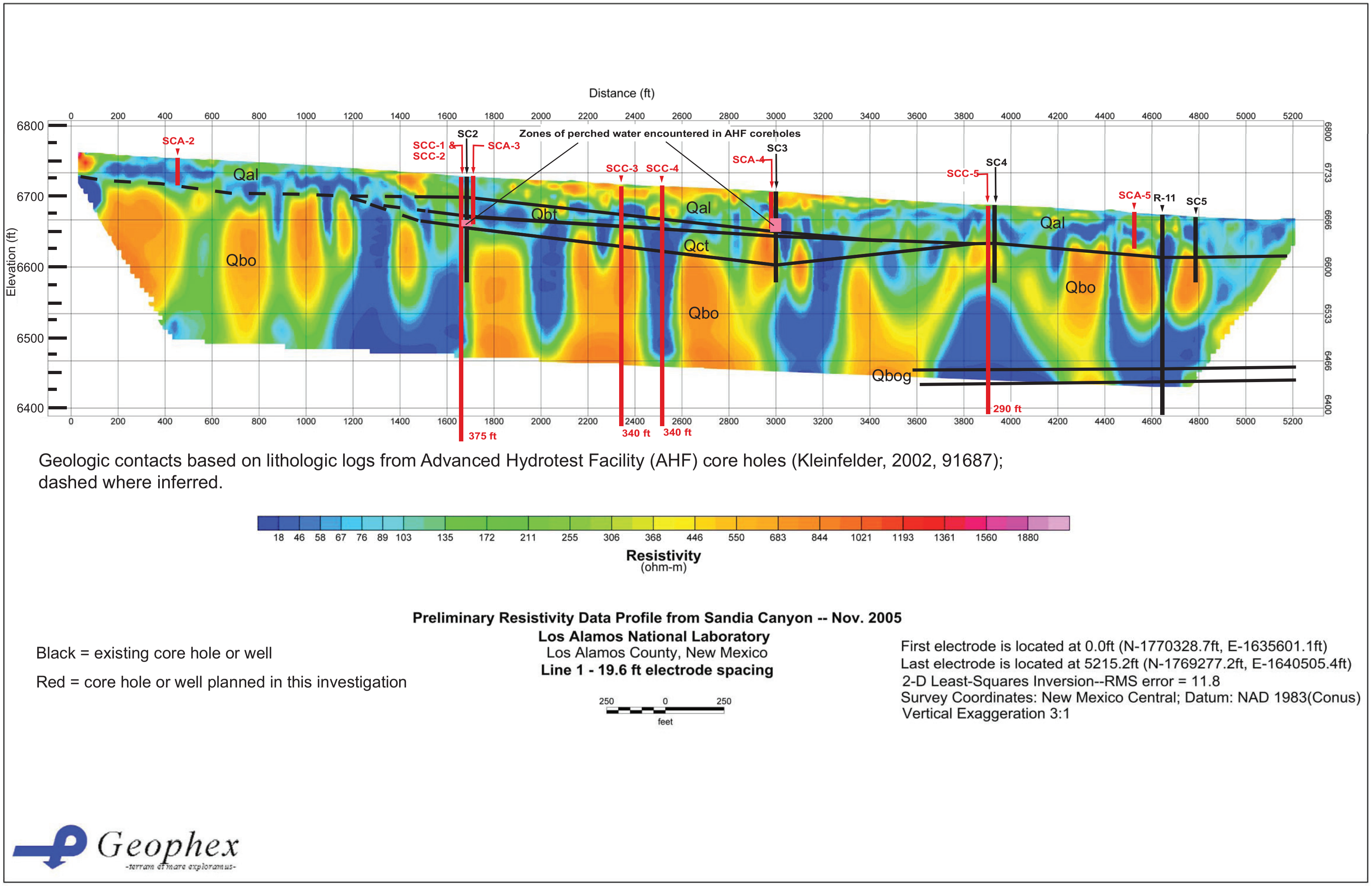


Figure 3-5. Conceptual Model B: Data-driven contour map (10-ft intervals) of the water table based on January 30, 2006, measurements at the monitoring wells (TW-2, R-4, R-5, R-9 and R-12 well data have been ignored). Contour lines suggest that infiltration recharge along canyons impacts flow directions at the water table.



Geologic contacts based on lithologic logs from Advanced Hydrotest Facility (AHF) core holes (Kleinfelder, 2002, 91687); dashed where inferred.

Preliminary Resistivity Data Profile from Sandia Canyon -- Nov. 2005
Los Alamos National Laboratory
Los Alamos County, New Mexico
Line 1 - 19.6 ft electrode spacing

Black = existing core hole or well

Red = core hole or well planned in this investigation

First electrode is located at 0.0ft (N-1770328.7ft, E-1635601.1ft)
Last electrode is located at 5215.2ft (N-1769277.2ft, E-1640505.4ft)
2-D Least-Squares Inversion--RMS error = 11.8
Survey Coordinates: New Mexico Central; Datum: NAD 1983(Conus)
Vertical Exaggeration 3:1

Figure 4-1. 2005 DC resistivity survey profile of lower Sandia Canyon showing existing and new wells and core holes

Table 2-1
Analytical Suites and Field Preparation for Intermediate and Regional Wells Selected for Enhanced Quarterly Sampling

Location	Monitored Zone	Analytical Suite/Field Preparation															
		General Inorganics[a] (F[b])	Metals[c] (F/NF[d])	Hexavalent Chromium (IC) (F/NF)	Stable Isotopes (EES-6)[e] (see footnote for prep)	TKN + NH_3 (NF)	NO_3/NO_2 (F)	TOC (NF)	Humic Acid (F)	VOCs (NF)	Perchlorate (F)	Low-Level Perchlorate (LC/MS/MS) (F)	Expanded HE Suite (NF)	Low-Level Tritium	Tritium (Liquid Scintillation) (NF)	Field Parameters[f]	Water Levels (method)
Intermediate-Depth Groundwater (Mortandad)																	
MCOI-8	Intermediate	√	√	√	√	√	√	√	√	√	√	—[g]	—	—	√	√	XD[h]
MCOI-4	Intermediate	√	√	√	√	√	√	√	√	√	√	—	—	—	√	√	XD
MCOI-5	Intermediate	√	√	√	√	√	√	√	√	√	√	—	—	—	√	√	XD
MCOI-6	Intermediate	√	√	√	√	√	√	√	√	√	√	—	—	—	√	√	XD
MCOBT-4.4	Intermediate	√	√	√	√	√	√	√	√	√	√	—	—	—	√	√	XD
Regional Groundwater (Sandia and Mortandad)																	
R-1	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	XD
R-14, screen 1	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	XD
R-14, screen 2	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	XD
R-33, screen 1	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	manual
R-33, screen 2	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	manual
R-15	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	XD
R-28	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	XD
R-13	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	XD
R-11	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	XD
R-12(i)-1	Intermediate	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	XD
R-12(i)-2	Intermediate	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	XD
R-12	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	XD

Table 2-1 (continued)

Location	Monitored Zone	Analytical Suite/Field Preparation															
		General Inorganics[a] (F[b])	Metals[c](F/NF[d])	Hexavalent Chromium (IC) (F/NF)	Stable Isotopes (EES-6)[e] (see footnote for prep)	TKN + NH$_3$ (NF)	NO$_3$/NO$_2$ (F)	TOC (NF)	Humic Acid (F)	VOCs (NF)	Perchlorate (F)	Low-Level Perchlorate (LC/MS/MS) (F)	Expanded HE Suite (NF)	Low-Level Tritium	Tritium (Liquid Scintillation) (NF)	Field Parameters[f]	Water Levels (method)
TW-8	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	XD
R-34	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	XD
R-10a	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	manual

[a] General inorganics consist of anions including alkalinity, bromide, chloride, fluoride, nitrate and nitrite, phosphate, and sulfate.

[b] F = Filtered.

[c] Metals include target analyte list (TAL) metals plus boron, molybdenum, and uranium.

[d] N = Not filtered.

[e] Water samples collected for analysis of oxygen and hydrogen isotopes are not filtered. Water samples collected for analysis of nitrogen isotopes are filtered and chilled.

[f] Field parameters include pH, temperature, specific conductance, turbidity, and dissolved oxygen.

[g] — = Not analyzed.

[h] XD = Transducer.

Table 4-1
Analytical Suites and Field Parameters for Surface and Groundwater Sampling

Location	Monitored Zone	General Inorganics[a] (F[b])	Metals[c] (F/NF[d])	Hexavalent Chromium (IC) (F/NF)	Stable Isotopes (EES-6)[e] (see footnote for prep)	TKN + NH3 (NF)	NO3/NO2 (F)	TOC (NF)	Humic Acid (F)	VOCs (NF)	Perchlorate (F)	Low-Level Perchlorate (LC/MS/MS) (F)	High Explosives (NF)	Low-Level Tritium (NF)	Tritium (Liquid Scintillation) (NF)	Field Parameters[f]	Water Levels/Flow Estimates
Sandia Watershed																	
South Fork of Sandia Canyon at E122	Baseflow	√	√	√	√	√	√	√	√	√	—[g]	√	√	√	—	√	√
Sandia below Wetlands (E123)	Baseflow	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
Middle Sandia at terminus of persistent baseflow	Baseflow	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
SCA-1	Alluvial	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
SCA-2	Alluvial	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
SCA-3	Alluvial	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
SCA-4	Alluvial	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
SCA-5	Alluvial	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
SCO-1	Alluvial	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
SCO-2	Alluvial	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
R-12, screen 1	Intermediate	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
R-12, screen 2	Intermediate	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
R-10, screen 1	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
R-10, screen 2	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
R-10a	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
R-11	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
R-12, screen 3	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√

Table 4-1 (continued)

Location	Monitored Zone	General Inorganics[a] (F[b])	Metals[c] (F/NF[d])	Hexavalent Chromium (IC) (F/NF)	Stable Isotopes (EES-6)[e] (see footnote for prep)	TKN + NH3 (NF)	NO3/NO2 (F)	TOC (NF)	Humic Acid (F)	VOCs (NF)	Perchlorate (F)	Low-Level Perchlorate (LC/MS/MS) (F)	High Explosives (NF)	Low-Level Tritium (NF)	Tritium (Liquid Scintillation) (NF)	Field Parameters[f]	Water Levels/Flow Estimates
Mortandad Watershed																	
Surface water in reach E-1FW	Baseflow	√	√	√	√	√	√	√	√	√	—	√	√	—	√	√	√
Surface water in reach E-1W	Baseflow	√	√	√	√	√	√	√	√	√	—	√	√	—	√	√	√
Surface water in reach E-1E	Baseflow	√	√	√	√	√	√	√	√	√	—	√	√	—	√	√	√
Mortandad below Effluent Canyon (E200)	Baseflow	√	√	√	√	√	√	√	√	√	—	√	√	—	√	√	√
Surface Water in reach M-1W	Baseflow	√	√	√	√	√	√	√	√	√	—	√	√	—	√	√	√
Surface water in reach M-1E	Baseflow	√	√	√	√	√	√	√	√	√	—	√	√	—	√	√	√
Surface water in reach M-2E	Baseflow	√	√	√	√	√	√	√	√	√	—	√	√	—	√	√	√
Surface water in reach TS-1W	Baseflow	√	√	√	√	√	√	√	√	√	—	√	√	—	√	√	√
Surface water in reach TS-2E	Baseflow	√	√	√	√	√	√	√	√	√	—	√	√	—	√	√	√
MCO-0.6	Alluvial	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√
MCA-1	Alluvial	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√
MCA-5	Alluvial	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√
MCO-2	Alluvial	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√

Table 4-1 (continued)

Location	Monitored Zone	General Inorganics[a] (F[b])	Metals[c] (F/NF[d])	Hexavalent Chromium (IC) (F/NF)	Stable Isotopes (EES-6)[e] (see footnote for prep)	TKN + NH3 (NF)	NO3/NO2 (F)	TOC (NF)	Humic Acid (F)	VOCs (NF)	Perchlorate (F)	Low-Level Perchlorate (LC/MS/MS) (F)	High Explosives (NF)	Low-Level Tritium (NF)	Tritium (Liquid Scintillation) (NF)	Field Parameters[f]	Water Levels/Flow Estimates
MCO-3	Alluvial	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√
MCO-4B	Alluvial	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√
MCO-5	Alluvial	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√
MCO-6	Alluvial	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√
TSCA-6	Alluvial	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√
MCA-2	Alluvial	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√
MCO-7.5	Alluvial	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√
MT-1	Alluvial	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√
MT-2, MT-3, or MT-4	Alluvial	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√
MCOI-8	Intermediate	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√
MCOI-4	Intermediate	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√
MCOI-5	Intermediate	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√
MCOI-6	Intermediate	√	√	√	√	√	√	√	√	√	√	—	√	—	√	√	√
R-1	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
R-14, screen 1	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
R-14, screen 2	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
R-33, screen 1	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
R-33, screen 2	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
R-15	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
R-28	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
R-13	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√

Table 4-1 (continued)

Location	Monitored Zone	General Inorganics[a] (F[b])	Metals[c] (F/NF[d])	Hexavalent Chromium (IC) (F/NF)	Stable Isotopes (EES-6)[e] (see footnote for prep)	TKN + NH3 (NF)	NO3/NO2 (F)	TOC (NF)	Humic Acid (F)	VOCs (NF)	Perchlorate (F)	Low-Level Perchlorate (LC/MS/MS) (F)	High Explosives (NF)	Low-Level Tritium (NF)	Tritium (Liquid Scintillation) (NF)	Field Parameters[f]	Water Levels/Flow Estimates
R-34	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√
TW-8	Regional	√	√	√	√	√	√	√	√	√	—	√	√	√	—	√	√

[a] General inorganics consist of anions including alkalinity, bromide, chloride, fluoride, nitrate and nitrite, phosphate, and sulfate.

[b] F = Filtered.

[c] Metals include target analyte list (TAL) metals plus boron, molybdenum, and uranium.

[d] N = Not filtered.

[e] Water samples collected for analysis of oxygen and hydrogen isotopes are not filtered. Water samples collected for analysis of nitrogen isotopes are filtered and chilled.

[f] Field parameters include pH, temperature, specific conductance, turbidity, and dissolved oxygen.

[g] — = Not analyzed.

Table 4-2
Objectives for Characterization Core Holes in Sandia Canyon

	SCC-1 and SCC-2	**SCC-3 and SCC-4**	**SCC-5 and SCC-6**
Conceptual Model Uncertainty	Constrain location of cooling-tower effluent infiltration. Reduce uncertainty in contaminant distributions and chromium speciation in area where Sandia Canyon widens and the alluvium thickens east of narrow slot canyon. Located near gaging station E124. SCC-1 is sited on historic stream channel identified by aerial photos and SCC-2 is adjacent to the present-day stream channel.	Constrain location of cooling-tower effluent infiltration. Reduce uncertainty in contaminant distributions and chromium speciation in lower Sandia Canyon. SCC-3 and SCC-4 are paired wells examining contrasting geophysical anomalies identified in the surface DC resistivity survey of 2005. SCC-3 is centered on a resistive anomaly and SCC-4 is centered on the adjacent conductive anomaly.	Constrain the eastern extent of location of cooling-tower effluent infiltration. Reduce uncertainty in contaminant distributions and chromium speciation in lower Sandia Canyon. The locations of SCC-5 and SCC-6 are expected to bracket the eastern limit of chromium infiltration in the canyon. SCC-6 will determine if infiltration has occurred near the water-supply well PM-3.
Projected Depth	~375 ft	~340 ft	SCC-5 ~290 ft, SCC-6 ~225 ft
Geology	Determine thickness variations of alluvium and Cerro Toledo deposits along N-S cross section of canyon floor. Identify western pinch out of Cerros del Rio basalt.	Relate contrasting geophysical anomalies to variations in geology or in rock properties. Identify areas where Cerro Toledo deposits subcrop canyon-floor alluvium.	Determine E-W thickness variations of Bandelier Tuff and the Puye Formation as these units become thinner over the Cerros del Rio basalt highland to the east.
Hydrology	Determine moisture content in Bandelier Tuff. Identify perched water in bedrock units. Extent of alluvial saturation.	Determine moisture content in Bandelier Tuff. Identify perched water in bedrock units. Extent of alluvial saturation.	Determine moisture content in Bandelier Tuff. Identify perched water in bedrock units. Extent of alluvial saturation.
Geochemistry/ Contaminant Chemistry	Determine contaminant profiles for metals (including hexavalent chromium), anions, nitrogen isotopes, total organic carbon (TOC), and tritium.	Determine contaminant profiles for metals (including hexavalent chromium), anions, nitrogen isotopes, TOC, and tritium.	Determine contaminant profiles for metals (including hexavalent chromium), anions, nitrogen isotopes, TOC, and tritium.
Core Needs	Collect core samples (every 20 ft) to total depth (~300 ft). The core-hole target depth is 20 ft into the top of the Cerros del Rio basalt.	Collect core samples (every 20 ft) to total depth (~325 ft). The core-hole target depth is 20 ft into the top of the Cerros del Rio basalt.	Collect core samples (every 20 ft) to total depth (~350 ft). The core-hole target depth is 20 ft into the top of the Cerros del Rio basalt.

Table 4-3
Core and Extracted Pore Water Analyte Suite, Sample Containerization, and Sample Frequency

Analyte Suite	Sample Size	Container	Sample Frequency
Target analyte list metals (including hexavalent Cr, U, Mo, and B)	0.5 ft of 2-in. diameter core	Sealed plastic bag and core protected; samples will be frozen until they are analyzed	Collect samples at 20-ft intervals from the bottom of surface casing to total depth (TD)
Anions, moisture, and total organic carbon	0.4 ft of 2-in. diameter core	8-oz preweighed glass jar	Collect samples at 20-ft intervals from the bottom of surface casing to TD
Tritium	0.5 ft of 2-in. diameter core	Sealed plastic bag wrapped with tape and core-protected	Collect samples at 40-ft intervals from the bottom of surface casing to TD
$\delta^{15}N$	0.5 ft of 2-in diameter core	Sealed plastic bag and core-protected; samples will be frozen until they are analyzed	Collect samples at 20-ft intervals from the bottom of surface casing to TD
Radiological screening for gross alpha, beta, and gamma (for off-site transport of samples)	0.2 ft of 2-in. diameter core	Sealed plastic bag	Collect samples at 40-ft intervals from the bottom of surface casing to TD

Note: Priority of sample core collection when recovery is less than 100% should be metals, anions, total organic carbon, moisture, nitrogen isotopes, tritium, and radiological screening.

Table 4-4
Archival Cores Selected for Characterization of Contaminant Distributions in the Upper Vadose Zone

Hole	Watershed	Core Depth	Anions	DI Leach Cr	EPA 3050 Leach Cr	Core in Moisture Protect for Cr(VI) Analysis (ft)	Chromium (VI)	Dried Core for DI and 3050 Leach of Cr (ft)	TAL Metals	Nitrogen Isotopes	Tritium	TOC
LAOI(A)-1.1	Los Alamos	320	C[a]	X[b]	X		no	use available material	X	X	X	X
LAOI-3.2/3.2a	Los Alamos	266	C	X	X		no	use available material	X	X	X	X
LAOI-7	Los Alamos	365.5	C	X	X		no	7.5 to 379 (12 samples)	X	X	X	X
LADP-3	Los Alamos	342	C	X	X		no	use available material	X	X	X	X
R-8	Los Alamos	261	C	X	X		no	7 to 229.8 (39 samples)	X	X	X	X
R-9	Los Alamos	intermittent	C	X	X		no	0 to 692	X	X	X	X
R-1	Mortandad	399	C	X	X	32.3, 63.7, 91.5, 151.2, 201.5, 251.5, 276.5, 301.2, 350.8	6 samples	21.5, 40.9, 51.1, 76, 101.1, 126.6, 176.5, 226.5	X	X	X	X
R-14	Mortandad	300	C	X	X		no	2.9 to 299.6 (24 samples)	X	X	X	X
R-15	Mortandad	750	C	X	X		no	2 to 746	X	X	X	X
R-28	Mortandad	325	C	X	X	31.4, 51.5, 76.3, 126.5, 251.5, 276.5, 319.8	7 samples	9.7 to 319.8	X	X	X	X
MCOI-6	Mortandad	498	C	X	X		no	9 to 498 (36 samples)	X	X	X	X
MCOI-8	Mortandad	478	C	X	X		no	8 to 478 (46 samples)	X	X	X	X
MC-1-AHF	Mortandad	146	C	X	X		no	3 to 146 (18 samples)	X	X	X	X
MC-2-AHF	Mortandad	161	C	X	X		no	3 to 161 (10 samples)	X	X	X	X
MC-3-AHF	Mortandad	119	C	X	X		no	5 to 119 (21 samples)	X	X	X	X
35-2028	Mortandad	298	C	X	X		no	use available material	X	X	X	X
R-11	Sandia	296.5	C	X	X	8.6 to 250.0 (13 samples)	6 samples	8.6 to 250.0 (13 samples)	X	X	X	X
R-12	Sandia	intermittent	C	X	X		no	5 to 880	X	X	X	X
SC-2-AHF	Sandia	146.5	X	X	X		no	use available material	X	X	X	X

Table 4-4 (continued)

Hole	Watershed	Core Depth	Anions	DI Leach Cr	EPA 3050 Leach Cr	Core in Moisture Protect for Cr(VI) Analysis (ft)	Chromium (VI)	Dried Core for DI and 3050 Leach of Cr (ft)	TAL Metals	Nitrogen Isotopes	Tritium	TOC
SC-3-AHF	Sandia	121.2	X	X	X		no	use available material	X	X	X	X
SC-4-AHF	Sandia	99	X	X	X		no	use available material	X	X	X	X
SC-5-AHF	Sandia	84	X	X	X		no	use available material	X	X	X	X

[a] C = Completed.

[b] X = Perform the analysis.

Table 4-5
Sampling Sites, Field Preparation, and Analyte Suites for Background Chromium Activity

Location	Analytical Suite/Field Preparation					
	Anions (EES-6)[a] (F[b])	Metals[c](EES-6) (F)	Hexavalent Chromium[d] (Severn Trent) (F)	Hexavalent Chromium[e] (EES-6) (F)	Field Parameters[f]	Water Levels/Flow Estimates
Alluvial Groundwater						
LAO-B	X	X	X	X	X	X
Intermediate-Depth Groundwater						
LAOI(a) - 1.1	X	X	X	X	X	X
Regional Groundwater						
R-27	X	X	X	X	X	X
R-2	X	X	X	X	X	X
R-18	X	X	X	X	X	X
R-24	X	X	X	X	X	X
Guaje-5	X	X	X	X	X	X
Otowi-4	X	X	X	X	X	X
Springs						
Campsite Spring	X	X	X	X	X	X
Young Spring	X	X	X	X	X	X
Sacred Spring	X	X	X	X	X	X
Sandia Spring	X	X	X	X	X	X
Spring 1	X	X	X	X	X	X
La Mesita Spring	X	X	X	X	X	X
Spring 3	X	X	X	X	X	X
Spring 5	X	X	X	X	X	X
Spring 6	X	X	X	X	X	X
Spring 9A	X	X	X	X	X	X
Spring 9B	X	X	X	X	X	X
Spring 4A	X	X	X	X	X	X
Spring 4B	X	X	X	X	X	X

[a] Anions by ion chromatography include Br^-, Cl^-, F^-, NO_3^-, NO_2^-, PO_4^{-3}, $C_2O_4^{-2}$ (oxalate), and SO_4^{-2}, total alkalinity (as $mgCaCO_3/L$).

[b] F = Filtered.

[c] Metals at EES-6 laboratory by inductively coupled optical emission spectroscopy and inductively coupled plasma mass spectroscopy w/cation exchange column for hexavalent chromium.

[d] Hexavalent Cr at Severn Trent by ion chromatography.

[e] Hexavalent Cr at EES-6 by ion chromatography.

[f] Field parameters include dissolved oxygen, pH, temperature, specific conductance, and turbidity.

Table 5-1
Applicable Standard Operating Procedures

Procedure	Title
SOP-01.01	General Instructions for Field Investigations
SOP-01.02	Sample Containers and Preservation
SOP-01.03	Handling, Packaging, and Shipping of Samples
SOP-01.04	Sample Control and Field Documentation
SOP-01.05	Field Quality Control Samples
SOP-01.06	Management of Environmental Restoration Project Waste
SOP-01.08	Field Decontamination of Drilling and Sampling Equipment
SOP-01.10	Waste Characterization
SOP-04.01	Drilling Methods and Drill Site Management
SOP-04.04	Contract Geophysical Logging
SOP-04.05	Leaching of Soil and Rock Samples for Anions
SOP-05.01	Well Construction
SOP-05.02	Well Development
SOP-05.03	Monitor Well and RFI Borehole Abandonment
SOP-05.07	Operation of LANL-Owned Borehole Logging Trailer
SOP-06.01	Purging and Sampling Methods for Single Completion Wells
SOP-06.02	Field Analytical Measurements of Groundwater Samples
SOP-06.10	Hand Auger and Thin-Wall Tube Sampling
SOP-06.13	Surface Water Sampling
SOP-06.24	Sample Collection from Split-Spoon Samplers and Shelby Tube Samplers
SOP-06.26	Core Barrel Sampling for Subsurface Earth Materials
SOP-07.01	Pressure Transducers
SOP-07.02	Water Level Measurements
SOP-09.10	Field Sampling of Core and Cuttings for Geological Analysis
SOP-09.11	Petrography
SOP-12.01	Field Logging, Handling, and Documentation of Borehole Materials
SOP-12.02	Transportation, Receipt, and Admittance of Borehole Samples to the Field Support Facility
SOP-12.04	Physical Processing, Storage, and Examination of Borehole Material at the Field Support Facility

Appendix 1

SWMU Review

Appendix 1 presents a review of solid waste management units (SWMUs) in Los Alamos, Sandia, and Mortandad canyons that are associated with chromium usage. The review was conducted using the Laboratory's potential release site database which derives information from a number of sources. The list of sites provided in the summary presented herein is not intended to be a complete list of all sites where chromium was used but are rather the most potentially significant sites. Emphasis was placed on SWMUs that had a combination of chromium usage and significant volumes of water released.

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TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
Los Alamos Watershed								
TA-02		02-005	Drift loss, cooling tower blow-down	An area affected by drift loss of potassium dichromate from the Omega West Reactor (OWR) cooling tower (structure 02-49) from 1957 to the mid-1970s.	SWMU Report 1990, Vol. 1 of 4 (LA-UR-90-3400)	Warner, C.L. 1971 (04251). "Potassium Dichromate Entrainment in OWR Cooling Tower Drift, "Los Alamos Scientific Laboratory memorandum to OWR Committee, December 10, 1971. See also Radzinski, B. 1992 (40068.1), "Cooling Tower Water Treatments"	The SWMU report states potassium dichromate was used to treat cooling water for the Omega cooling tower (structure 2-49) in the early days of operation. During the 1987 CEARP field survey, an employee recalled that the drift loss of potassium dichromate turned the hillside green. Measurements in 1971 indicate 0.05 lb of hexavalent chromium per hour of operations was lost.	See CEARP 1987, Section TA2-5-CA-I-HW (Potassium dichromate drift) p.TA2-9
					CEARP 1987 Phase I: Installation Assessment, Volume 1 of 2 (ERID 08663)		The CEARP states that potassium dichromate was used on the cooling tower (structure 2-49) at Omega. Measurements in 1971 indicated that 0.05 lb of hexavalent chromium per hour of operation of the cooling tower under normal loads was being lost because of the drift loss in the cooling tower (Warner 1971).	The 1987 CEARP also states that during the CEARP field survey in 1987, one employee recalled that the loss potassium dichromate "turned things green." When the heat exchangers were rebuilt and stainless steel was used rather than aluminum, there was no longer a need to use potassium dichromate, and the "greening of the landscape" went away. See CEARP 1987, Section TA2-5-CA-I-HW (Potassium dichromate drift) p.TA2-9

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-02		02-004(b)	Reactor facility effluent storage tank	Associated with Omega West Reactor activities	CEARP 1987 Phase I: Installation Assessment, Volume 1 of 2 (ERID 08663)	Frechette, Muriel A. 1964 (04242). "Monthly Progress Report for Period January 21, 1964 through February 20, 1964, " Los Alamos Scientific Laboratory memorandum to Dean D. Meyer, February 24, 1964. See also Radzinski, B. 1992 (40068.1), "Cooling Tower Water Treatments"	The CEARP says in Feb. 1964, 125 gal. of slightly acidic liquid waste containing 2 mCi chromium-51, 0.43 mCi antimony-124, 0.2 mCi iron-59, and 0.2 mCi manganese-54 was reported to have been discharged from the OWR storage tanks to Los Alamos Canyon. How often this type of discharge occurred is not known (Frechette 1964) (p.TA2-8).	See CEARP 1987, Section "TA2-2-CA/S/UST-A/I-HW/RW (Sumps, lines and manholes) p. TA2-6
TA-02		02-011(e)	Former NPDES-permitted outfall [duplicate of 02-008(a)]	Associated with operation of Omega West Reactor	SWMU Report 1990, Vol. 1 of 4 (LA-UR-90-3400)	Duplicate of 02-008(a); Neely, Glenn, 1992. "Personal Communication to R. Brown (ERM/Golder) from G. Neely, Los Alamos National Laboratory," October 20, 1992. See also Radzinski, B. 1992 (40068.1), "Cooling Tower Water Treatments"	The 1990 SWMU report says that this outfall may have released hazardous materials associated with treating coolant waters.	
TA-02		02-008(a)	Outfall	Associated with operation of Omega West Reactor	SWMU Report 1990, Vol. 1 of 4 (LA-UR-90-3400)	RFI Work Plan for Operable Unit 1098 (LA-UR-93-3825); Neely, Glenn, 1992. "Personal Communication to R. Brown (ERM/Golder) from G. Neely, Los Alamos National Laboratory," October 20, 1992. See also Radzinski, B. 1992 (40068.1), "Cooling Tower Water Treatments"	The SWMU report says the cooling tower (structure 02-49) blow-down in early days of operation discharged to this outfall and the blow-down contained chromium. The discharge may have also included radioisotopes of chromium, zinc, and antimony.	PRS 02-011(e) is a duplicate of this PRS 02-008(a).

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-02		02-004(c)	Reactor facility effluent storage tank	Associated with Omega West Reactor activities	CEARP 1987 Phase I: Installation Assessment, Volume 1 of 2 (ERID 08663)	Frechette, Muriel A. 1964 (04242). "Monthly Progress Report for Period January 21, 1964 through February 20, 1964, " Los Alamos Scientific Laboratory memorandum to Dean D. Meyer, February 24, 1964. See also Radzinski, B. 1992 (40068.1), "Cooling Tower Water Treatments"	The CEARP says in Feb. 1964, 125 gal. of slightly acidic liquid waste containing 2mCi chromium-51, 0.43 mCi antimony-124, 0.2 mCi iron-59, and 0.2 mCi manganese-54 was reported to have been discharged from the OWR storage tanks to Los Alamos Canyon. How often this type of discharge occurred is not known (Frechette 1964) (p.TA2-8).	See CEARP 1987, Section "TA2-2-CA/S/UST-A/I-HW/RW (Sumps, lines and manholes) p. TA2-6
TA-02		02-004(d)	Reactor facility effluent storage tank	Associated with Omega West Reactor activities	CEARP 1987 Phase I: Installation Assessment, Volume 1 of 2 (ERID 08663)	Frechette, Muriel A. 1964 (04242). "Monthly Progress Report for Period January 21, 1964 through February 20, 1964, " Los Alamos Scientific Laboratory memorandum to Dean D. Meyer, February 24, 1964. See also Radzinski, B. 1992 (40068.1), "Cooling Tower Water Treatments"	The CEARP says in Feb. 1964, 125 gal. of slightly acidic liquid waste containing 2mCi chromium-51, 0.43 mCi antimony-124, 0.2 mCi iron-59, and 0.2 mCi manganese-54 was reported to have been discharged from the OWR storage tanks to Los Alamos Canyon. How often this type of discharge occurred is not known (Frechette 1964) (p.TA2-8).	See CEARP 1987, Section "TA2-2-CA/S/UST-A/I-HW/RW (Sumps, lines and manholes) p. TA2-6
TA-02		02-011(d)	Former NPDES-permitted outfall	Associated with the Omega West Reactor facility equipment building	SWMU Report 1990, Vol. 1 of 4 (LA-UR-90-3400)	See also Radzinski, B. 1992 (40068.1), "Cooling Tower Water Treatments"	The 1990 SWMU reports says that this outfall may have released hazardous materials associated with treating coolant waters.	

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-01	01-001(a)-99	01-006(a)	Drainlines and outfall	Associated with cooling tower 80	SWMU Report 1990, Vol. 1 of 4 (LA-UR-90-3400)	RFI Report for TA-01: Aggregates E, G, PRSs 01-001(g), 01-003(b), 0-006(a,g), 01-001(c), 01-006(b,c,d,n), 01-007(a,b,c,j)(p.31-49) (ERID 54465, LA-UR-96-1019, p. 32); LANL 1987 (02956), "Analytical Results of Verification Sampling Former Main Technical Area (TA-01) Los Alamos National Laboratory Environmental Surveillance Group (HSE-8) and Health and Environmental Chemistry Group (HSE-9)" May.	In the PRS database the description says it is speculated that the chromium-containing biocides may have been added to the cooling tower.	
Mortandad Watershed								
TA-03		03-054(e)	Outfall	Outfall that receives runoff from originates from several sources at the CMR (Building 03-29)	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	??	The 1990 SWMU report says cooling tower discharges may have contained chromates.	Possible associated cooling towers with structure numbers 3-102 and 3-156 (SEE 1990 SWMU Report)

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-46		46-004(y)	Outfall	Historical blow-down outfall from the cooling tower that serves Building 46-31.	PRS Database	LANL 1996 (54929.3) "RFI Report for Potential Release Sites in TA-46: PRSs 46-003(h), 46-004(b,g,h,m,q,s,u,v,x,y,z,a2, b2,c2,d2,e2,f2), 46-006(a,b,c,d,f,g), 46-007, 46-008(b), 46-010(d), C-46-002, C-46-003, Field Unit 3" (p.88-93; LA-UR-96-1957); LANL 1993 (20952.1) "RFI Work Plan for Operable Unit 1140" (p. 5-127; LA-UR-93-1940); Radzinski, B. 1992 (40068.1), "Cooling Tower Water Treatments" McCulla, A. 1992 (40095), "Summary of Summer Work (Outfalls)"	SWMU 46-004(y) was the historical blow-down outfall from the cooling tower that serves Building 46-31. It also received effluent from the building's floor and roof drains, as well as its laboratory sinks.	
TA-03	03-049(b)-00	03-049(b)	Operational release	Discharge area at the south wall of the press building (Building 03-35) associated with an inactive vacuum pump that served furnaces in Building 03-35	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	??	The 1990 SWMU report says gold citrate and HCW are produced in the gold electroplating process, in addition numerous metals, acids and cyanide were used in the process of chromium plating. The cooling tower was treated with organo-chelates. Oil and grease may have been discharged from the vacuum pump.	
TA-03		03-049(e)	Outfall	Possible soil contamination from an outfall pipe located south of the Sigma Building (Building 03-66)	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	??	The 1990 SWMU report says gold citrate and HCW are produced in the gold electroplating process, in addition numerous metals, acids and cyanide were used in the process of chromium plating. The cooling tower was treated with organo-chelates. Oil and grease may have been discharged from the vacuum pump.	

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-03	03-045(h)-00	03-049(a)	Outfall	NPDES-permitted outfall associated with cooling towers	PRS Database	LANL 1997 (56660-4), "RFI Report for TA-03 for Potential Release Sites 3-004(c,d), 3-007, 3-014(k,l,o), 3-021, 3-049(a), 3-052(b), 3-056(k), C-03-014, Field Unit 1" (LA-UR-97-3571); LANL 1995 (57590), "RFI Work Plan for Operable Unit 1114, Addendum 1" (p. 5-13-1)	Between the 1950s and 1970s chromates were used to treat cooling water. The cooling tower has operated since 1960. From 1984 to 1990, the outfall also received discharge from rinse tanks associated with the electroplating operation in Building 03-66. The tanks contained the final rinse from electroplating and surface-finishing experimental components. Although the rinse tanks were flushed continually with tap water to preclude contaminant buildup, trace amounts of metals, acids, cyanide, and depleted uranium were introduced into the rinse water. The NPDES permit allowed discharge of 4680 gal. per day of treated cooling water and 24,000 gal. per day of electroplating rinse water. Since 1990, the outfall has received only treated cooling water and roof-drain runoff. The outfall discharges to Mortandad Canyon.	
					SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	Mitchell, J. 1990 (no ERId), "Sigma Complex Drains and Outfalls Meeting Notes, June 22, 1990, Los Alamos National Laboratory Memorandum MST-DO/SRW-90-19 from J. Mitchell (MST-DO) to S. Whittington (MST-DO)"	The 1990 SWMU Report says gold citrate and HCW are produced in the gold electroplating process, in addition numerous metals, acids and cyanide were used in the process of chromium plating. The cooling tower was treated with organo-chelates. Oil and grease may have been discharged from the vacuum pump.	3-127 (structure number for associated cooling tower)
					CEARP 1987 Phase I: Installation Assessment, Volume 1 of 2 (ERID 08663)	Miller, E.L. 1971 (01088). "Effluent from Plant Cooling Towers," Los Alamos Scientific Laboratory memorandum to C. Christenson, July 30, 1971.	CEARP report states that "There are numerous cooling towers in TA-3 that have blow-down discharges to canyon outfalls. According to several employees, cooling tower water for the tower serving TA-3-66 had chromium added during the early years of operation. Blow-down was discharged to Mortandad Canyon.	See CEARP 1987, section TA3-6-CA/O-A/I-HW/RW (Outfalls) pp. TA3-12 to TA3-13 3-127 (structure number for associated cooling tower)

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-46	46-004(d2)-99	46-004(g)	Outfall / stack emissions	Reported as potentially contributing to surface soil contamination at TA-46 in the form of airborne releases of radionuclides or hazardous constituents through building stacks.	CEARP 1987 Phase I: Installation Assessment, Volume 1 of 2 (ERID 08663)	Miller, E.L. 1971 (01088). "Effluent from Plant Cooling Towers," Los Alamos Scientific Laboratory memorandum to C. Christenson, July 30, 1971.	A 1971 memo reported that building 1 had a cooling tower with a discharge of 10500 gal. per year. Between the 1950s and 1970s chromates were used to treat cooling water (p.TA46-5).	See CEARP 1987, section TA46-1-CA/O-I-HW/RW (outfalls and storm sewer) p. TA46-5
TA-48	48-007(a)-00	48-007(a)	Drains and outfalls	Outfall used to discharge treated cooling tower blow-down from two cooling towers located on the roof of Building 48-1	1990 SWMU report, Volume 3 of 4 (LA-UR-90-3400)	??	Report says water from cooling towers at TA-48-1discharges to this outfall.	
					PRS Database	LANL 1992 (07666), "RFI Work Plan for OU 1129" (LA-UR-92-0800; p. 3-102); Radzinski, B., July 20, 1991 (No ERId). "Personal communication between L. Clark and B. Radzinski, International Technology (IT) Corporation Telephone Log" LANL 1995 (50289.1) "RFI Report for TA-48: PRSs 48-001, 48-002(e), 48-003, 48-005, 48-007(a,b,c,d, f), 48-010 (located in former Operable Unit 1129)" (LA-UR-95-3328)	SWMU 48-007(a) is an active outfall used to discharge treated cooling tower blow-down from two cooling towers located on the roof of Building 48-1. This outfall is located east of Building 48-1 and discharges up to 750 gal. per hour of cooling tower blow-down. Water discharges from PRS 48-007(a) flows to impoundment PRS 48-010 The date that this outfall began operation is not known, but Building 48-1 was constructed in 1957, so discharges should not have preceded this date. Between the 1950s and 1970s chromates were used to treat cooling water.	

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-48	48-007(a)-00	48-007(d)	Drains and outfalls	Outfall used to discharge noncontact cooling water used to cool a vacuum pump housed in the south end of building 48-1.	1990 SWMU report, Volume 3 of 4 (LA-UR-90-3400)	??	Reports say water from cooling towers at TA-48-1discharges to this outfall.	
					PRS Database	??	Active outfall used to discharge noncontact cooling water used to cool a vacuum pump housed in the south end of Building 48-1. The date that this outfall began operation is not known, but Building 48-1 was constructed in 1957. Between the 1950s and 1970s chromates were used to treat cooling water.	
TA-48	48-007(a)-00	48-010	Surface impound-ment	Receives cooling tower blow-down discharged from 48-007(a), noncontact cooling water discharged from 48-007(d), and stormwater runoff from parking lot for Building 48-45.	1990 SWMU report, Volume 3 of 4 (LA-UR-90-3400)	??	Reports says water from cooling towers at TA-48-1discharges to this outfall.	
					PRS Database	LANL 1992 (07666), "RFI Work Plan for OU 1129" (LA-UR-92-0800; p. 3-102); No references in Work Plan or RFI Report: see possibly (03853.18) "LASL Survey of Effluent Streams ENG-4 TA-48 Bldg. 1" LANL 1995 (50289.1) "RFI Report for TA-48: PRSs 48-001, 48-002(e), 48-003, 48-005, 48-007(a,b,c,d, f), 48-010 (located in former Operable Unit 1129) (p.4-34 to 4-48)" (p. 4-35, LA-UR-95-3328)	Received treated cooling water. Between the 1950s and 1970s chromates were used to treat cooling water.	

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-03		03-012(a)	Controlled operational release	Site of a controlled operational release located on the north slope of Mortandad Canyon	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	??	The 1990 SWMU report says between 1950s and 1970s chromates were used to treat cooling water from the steam/electric generating plant, TA-03-22. Drift loss and cooling water discharge contributed to elevated hexavalent chromium in the surrounding area.	This controlled operational release is stated to contain 600-700 lb of soluble fluoride, which was released to Mortandad Canyon; however, because chromates were used to treat cooling water, this PRS is a also possible source chromium. SEE 1987 CEARP REFERENCE
					CEARP 1987 Phase I: Installation Assessment, Volume 1 of 2 (ERID 08663)	??	CEARP report states that, "According to several employees, cooling tower water for the tower serving TA-3-66 had chromium added during the early years of operation. Blow-down was discharged to Mortandad Canyon" (p. TA3-13)	The release was a controlled operational pipe cleaning procedure. See CEARP 1987, Section TA3-6-CA/O-A/I-W/RW (outfalls) p.TA3-13
TA-03		03-026(c)	Tank and/or associated equipment	11 sumps located at the base of cooling towers in the CMR Building (Building 3-29) that received blow-down water	PRS Database	LANL 1995 (57590) "RFI Work Plan for Operable Unit 1114, Addendum 1" (p. 6-43 to 6-44; LA-UR-95-0731) (RFI Work Plan cites SWMU Report); however, see also Rhodes 1993 (63188.3), "Chromate Use in TA-3 Cooling Towers"	Sump received blow-down water from cooling towers in the CMR building. Between the 1950s and 1970s chromates were used to treat cooling water.	

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-35		35-016(e)	Outfall	Inactive outfall for discharge of noncontact cooling water from the chemical laser facility (Building 35-85)	PRS Database	LANL 1996 (54373.3) "RFI Report for TA-35: PRSs 35-003(h,j,k), 35-004(b), 35-008, 35-009(a,b,c,d), 35-014 (a,b,d,e1,e2,f), 35-015(b), 35-016(e,f,i)" (p. 5-30 to 5-37, LA-UR-96-1293) LANL 1985 (00853), "Cross Index of NPDES Serial #s to Technical Areas and Types of Discharge" (Report also references 1990 SWMU Report)	The outfall consists of two adjacent 2-in. diameter steel pipes, insulated with fiberglass and wrapped with protective aluminum coating, that originate from cooling towers on the roof of Building 35-85. Between the 1950s and 1970s chromates were used to treat cooling water.	
TA-46		46-004(i)	Outfall	Two inactive outfalls, identified as Outfalls D and E, which discharged into Cañada del Buey	SWMU Report, 1990 Volume 3 of 4 (LA-UR-90-3400)	??	Outfall D received blow-down from a cooling tower, Structure TA-46-0086. No chromates or other hazardous additives were reportedly used in cooling towers at TA-46. Outfall E, located directly above Outfall D, served a holding tank located east of the cooling tower. The tank contained dilute lithium hydroxide solutions that were generated in Building TA-46-0031. The lithium hydroxide solutions were reportedly diluted to about 96 ppm with blow-down water before discharge. The outfalls were included on the Laboratory's National Pollutant Discharge Elimination System (NPDES) permit as Outfall 03A044. Outfall 03A044 was removed from the NPDES permit prior to 1990.	46-86 (structure number for associated cooling tower)

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-46		46-004(j)	Outfall	Inactive outfall received blow-down from a cooling tower located at Building TA-46-0001.	SWMU Report, 1990 Volume 3 of 4 (LA-UR-90-3400)	??	Inactive outfall that formerly discharged into Cañada del Buey. This outfall received blow-down from a cooling tower located at Building TA-46-0001. No chromates or other hazardous additives were reportedly used in cooling towers at TA-46. The outfall was included on the Laboratory's NPDES permit as Outfall 03A042. Outfall 03A042 was removed from the NPDES permit on March 10, 1998.	
TA-46		46-004(k)	Outfall		SWMU Report, 1990 Volume 3 of 4 (LA-UR-90-3400)	??	Received cooling water. Between the 1950s and 1970s chromates were used to treat cooling water.	
TA-46		46-004(l)	Outfall		SWMU Report, 1990 Volume 3 of 4 (LA-UR-90-3400)	??	Received cooling water. Between the 1950s and 1970s chromates were used to treat cooling water.	
TA-46		46-004(m)	Outfall		SWMU Report, 1990 Volume 3 of 4 (LA-UR-90-3400)	??	Received noncontact cooling water. Between the 1950s and 1970s chromates were used to treat cooling water.	
TA-46		46-004(n)	Outfall		SWMU Report, 1990 Volume 3 of 4 (LA-UR-90-3400)	??	Received noncontact cooling water. Between the 1950s and 1970s chromates were used to treat cooling water.	
TA-46		46-004(o)	Outfall		SWMU Report, 1990 Volume 3 of 4 (LA-UR-90-3400)	??	Received treated cooling water. Between the 1950s and 1970s chromates were used to treat cooling water.	

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-48		48-007(b)	Drains and outfalls	Outfall used to discharge noncontact cooling water used to cool a magnet and laser housed in the main radiochemistry laboratory at TA-48	1990 SWMU report, Volume 3 of 4 (LA-UR-90-3400)	Looked in RFI Report for TA-48: PRSs 48-001, 48-002(e), 48-003, 48-005-48-007(a,b,c,d, f), 48-010 (located in former Operable Unit 1129) (p. 4-48 to 4-57), but it mentioned noncontact cooling water. LANL 1985 (00853), "Cross Index of NPDES Serial #s to Technical Areas and Types of Discharge"	Report says water from cooling towers at TA-48-1discharges to this outfall.	
TA-48		48-007(c)	Drains and outfalls	Outfall that receives discharges from nine floor drains, a trench drain, and six roof drains at the main radiochemistry laboratory at TA-48	1990 SWMU report, Volume 3 of 4 (LA-UR-90-3400)	Looked in RFI Report for TA-48: PRSs 48-001, 48--002(e), 48-003, 48-005, 48-007(a,b,c,d, f), 48-010 (located in former Operable Unit 1129) (p. 4-48 to 4-57), but it mentioned noncontact cooling water. LANL 1985 (00853), "Cross Index of NPDES Serial #s to Technical Areas and Types of Discharge"	Report says water from cooling towers at TA-48-1discharges to this outfall.	
TA-50		50-001(a)	Waste treatment facility TA-50-1 - RCRA Unit (active)	Active radioactive liquid waste treatment plant (Building 50-1) that has operated continuously since its construction in 1963	CEARP 1987 Phase I: Installation Assessment, Volume 1 of 2 (ERID 08663)	??	A liquid waste batch treatment system is located in Building 1 at TA-50. Wastes that have been treated include chromate plating solutions (p. TA50-7)	CEARP text states there is no evidence of residual environmental contamination. See CEARP 1987, Section TA50-7-CA-I/A-HW (batch processing plant) p. TA50-7

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
Sandia Watershed								
TA-03	03-045(h)-00	03-045(h)	Outfall (industrial or sanitary wastewater treatment)	NPDES-permitted outfall associated with cooling towers	CEARP 1987 Phase I: Installation Assessment, Volume 1 of 2 (ERID 08663)	Request for Permit Modification, Units Proposed for NFA, September 1996, Volume I (ERID 55102.4, LA-UR-96-3357); see also Radzinski, B. 1992 (40068.1), "Cooling Tower Water Treatments"	Between the 1950s and 1970s chromates were used to treat cooling water. Treated cooling water and stormwater were discharged at the outfall into Sandia Canyon. CEARP report states that "There are numerous cooling towers in TA-03 that have blow-down discharges to canyon outfalls." In 1971 the following cooling systems discharging to Sandia Canyon were noted: TA-03-187; TA-03-285; and TA-3-127. Although the chemicals added were reported to be "biodegradable and nontoxic" (Miller 1971), chromates are known to have been added to cooling tower water between the 1950s and 1970s (p.TA03-13)	3-187 (structure number for associated cooling tower)
TA-03		03-054(c)	Outfall	Former cooling tower, pump house (structures 03-156 and -163) and an inactive outfall (deleted from the NPDES permit on 7/11/95)	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	LANL 1995 (57590), "RFI Work Plan for Operable Unit 1114, Addendum 1" (p. 6-71 to 6-72, LA-UR-95-0731)	PRS includes a former cooling tower, pump house (structures 03-156 and 163) and an inactive outfall (removed from the NPDES permit on 7/11/95). The cooling tower was located southwest of the Sherwood Complex (Building 03-105) and northwest of the Syllac Building (Building 03-287) and was used to cool an electromagnet formerly located in the Sherwood Complex. The outfall discharged into the storm sewer formerly located 25 ft east of the cooling tower. Between the 1950s and 1970s chromates were used to treat cooling water. Outfall received cooling tower water from TA-03-156. This cooling tower was noted to be leaking onto the surrounding soil in 1989.	

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-53		53-012(e)	Outfall	Drainline and outfall associated with the equipment test lab (Building 53-2).	PRS Database	RFI Report for TAs -20, -53, and -72 (located in the former Operable Unit 1100) (ERID 54466.4, LA-UR-96-0906)	Primary source of wastewater is blow-down from the Building 53-2 cooling tower, which is discharged to one of the trench drains. Between the 1950s and 1970s chromates were used to treat cooling water.	
TA-03	03-014(a)-99	03-014(a)	Wastewater treatment facility	WWTP Imhoff tanks	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	LANL 1996 (52930), "RFI Report for 53 Potential Release Sites in TAs -03, -59, -60, -61" (p. 83-94, LA-UR-96-0276); Root Reference from SWMU Report: Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	In previous years, unknown quantities of industrial liquids may have been included in waste received at this WWTP. In a 1985 memo it was noted that 167,000 gal/day of non-sanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-03-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-3-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)
TA-03	03-014(a)-99	03-014(b)	Wastewater treatment facility	WWTP dosing siphon	SWMU Report 1990, Volume 1 of 4 (LA-UR-90--3400)	Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-03-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-3-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
0-03	03-014(a)-99	03-014(b2)	Outfall	WWTP historical outfall to Sandia Canyon	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	LANL 1996 (52930), "RFI Report for 53 Potential Release Sites in TAs -03, -59, -60, -61" (p. 94-102, LA-UR-96-0276); Root Reference from SWMU Report: Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of non-sanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-03-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-03-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)
TA-03	03-014(a)-99	03-014(c)	Wastewater treatment facility	WWTP trickling filter	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-03-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-3-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-03	03-014(a)-99	03-014(c2)	Outfall	WWTP historical outfall to Sandia Canyon	PRS (potential relaease site) Database	RFI Report for 53 Potential Release Sites in TAs -03, -59, -60, -61(p.102-113) (ERID 52930, LA-UR-96-0726)	Effluent received by this outfall consisted of materials that previously were diverted to the TA-03 power plant (Building 03-22) for use as cooling tower water	
					SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-3-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-03-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)
TA-03	03-014(a)-99	03-014(d)	Wastewater treatment facility	WWTP final clarifying tanks	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-03-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-03-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-03	03-014(a)-99	03-014(e)	Wastewater treatment facility	WWTP Imhoff tanks	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	LANL 1996 (52930), "RFI Report for 53 Potential Release Sites in TAs -03, -59, -60, -61" (p. 83-94, LA-UR-96-0276); Root Reference from SWMU Report: Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-03-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-03-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)
TA-03	03-014(a)-99	03-014(f)	Wastewater treatment facility	WWTP dosing siphon	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-03-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-03-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)
TA-03	03-014(a)-99	03-014(g)	Wastewater treatment facility	WWTP trickling filter	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-3-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-03-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-03	03-014(a)-99	03-014(h)	Wastewater treatment facility	WWTP final clarifying tanks	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-03-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-03-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)
TA-03	03-014(a)-99	03-014(i)	Wastewater treatment facility	WWTP Splitter box, comminutor, and bar racks	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-3-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-03-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)
TA-03	03-014(a)-99	03-014(j)	Wastewater treatment facility	WWTP chlorination system added in 1985	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-3-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-03-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-03	03-014(a)-99	03-014(k)	Wastewater treatment facility	WWTP unlined sludge drying beds	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	Reference to chromium found in LANL 1997 (56660.4) RFI Report for TA-03 for Potential Release Sites 3-004(c,d), 3-007, 3-014(k,l,o), 3-021, 3-049(a), 3-052(b), 3-056(k), C-03-014, Field Unit 1 (p. 57-78, LA-UR-97-3571); Root Reference in SWMU Report: Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-03-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-03-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)
TA-03	03-014(a)-99	03-014(l)	Wastewater treatment facility	WWTP unlined sludge drying beds	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	Reference to chromium found in LANL 1997 (56660.4) RFI Report for TA-03 for Potential Release Sites 3-004(c,d), 3-007, 3-014(k,l,o), 3-021, 3-049(a), 3-052(b), 3-056(k), C-03-014, Field Unit 1 (p. 57-78, LA-UR-97-3571); Root Reference from SWMU Report: Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-3-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-03-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-03	03-014(a)-99	03-014(m)	Wastewater treatment facility	WWTP unlined sludge drying beds	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-3-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-03-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)
TA-03	03-014(a)-99	03-014(n)	Wastewater treatment facility	WWTP unlined sludge drying beds	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-3-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-03-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)
TA-03	03-014(a)-99	03-014(o)	Wastewater treatment facility	WWTP lower sludge drying beds that received overflow	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-3-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-03-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-03	03-014(a)-99	03-014(p)	Wastewater treatment facility	WWTP sewage lift station	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-3-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-03-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)
TA-03	03-014(a)-99	03-014(u)	Wastewater treatment facility	WWTP sludge bed effluent holding tank	SWMU Report 1990, Volume 1 of 4 (LA-UR-90-3400)	Sitzberger, E. 1985 (03979), "Improvements to the TA-3 Domestic Waste Treatment Plant" December 10.	Unknown quantities of industrial liquids may have been included in the waste in previous years. In a 1985 memo it was noted that 167,000 gal/day of nonsanitary waste was being diverted to the sewage treatment plant. This nonsanitary waste apparently included plating rinse water from TA-3-66, laser cooling water commingled with administratively controlled radioactive/toxic contaminated process water from TA-43-1 and cooling water from TA-41 and TA-03-29.	Plating waste and cooling tower water may contain chromium. In addition, photographic wastes were received (see SWMU Report)

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-03	03-012(b)-00	03-012(b)	Operational release and outfall	Discharge point that received effluent from the TA-03 steam plant neutralization tank, the chlorine building, and a former cooling tower (3-58). This outfall served two cooling towers (structures 03-25 and 03-58)	CEARP 1987 Phase I: Installation Assessment, Volume 1 of 2 (ERID 08663)	Reinig, L.P.I415 Report-Chromate Problem," Los Alamos Scientific Laboratory, March 7, 1972. Shaykin, Jerome D. 1968. "Health Protection Appraisal Report, Los Alamos Area Office and the Zia Company, Los Alamos, NM," Los Alamos Scientific Laboratory, December 17-19, 1968 Zia Company. 1972. "Conceptual Design Report for Chemical Reduction System, TA-3 Power Plant, Los Alamos, NM," February 1, 1972	Chromate from drift loss during the early years of operation may be present in soils near the TA-3 power plant (p. TA3-9); Corrosion inhibitors of the blended chromate-phosphate-zinc type were apparently used from 1950 to the mid-1970s. Chromate usage was 35.9 lb per day. Blow-down was at 288,000 gal. per day with hexavalent chromium at levels up to 34 ppm in the discharge. Shaykin (1968) reports that "total chromate analyses of the stream before it disappears averages 10–15 ppm, half of which is estimated to be in the hexavalent or toxic form" (p. TA3-13).	See CEARP 1987, Section "TA3-1-CA-A/I-HW/RW (Facilities)," p. TA3-9 and Section "TA3-6-CA/O-A/I-HW/RW (Outfalls)," p. TA3-12, 3-58 and 3-25 are structure numbers for associated cooling towers
					1990 SWMU Report, Volume 1 of 4 (LA-UR-90-3400)	??	Between the 1950s and 1970s chromates were used to treat cooling water from the steam/electric generating plant (TA-03-22). Drift loss and the cooling water discharge to Sandia Canyon contributed to elevated hexavalent chromium in the surrounding area.	3-58 and 3-25 are structure numbers for associated cooling towers

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-03	03-012(b)-00	03-014(q)	Wastewater treatment facility	Power plant holding tank, which received blow-down from the boilers and wastewater from the water treatment area	CEARP 1987 Phase I: Installation Assessment, Volume 1 of 2 (ERID 08663)	Reinig, L.P.I415 Report-Chromate Problem," Los Alamos Scientific Laboratory, March 7, 1972. Shaykin, Jerome D. 1968. "Health Protection Appraisal Report, Los Alamos Area Office and the Zia Company, Los Alamos, NM," Los Alamos Scientific Laboratory, December 17-19, 1968. Shulte, Harry F.1968. "Disposal of Chemical Waste," Los Alamos Scientific Laboratory memorandum to Harold H. Soenke, September 24, 1968. Zia Company. 1972. "Conceptual Design Report for Chemical Reduction System, TA-3 Power Plant, Los Alamos, NM," February 1, 1972	PRS 03-014(q) is a holding tank associated with TA-03-22. Chromate from drift loss during the early years of operation may be present in soils near the TA-03 power plant (p. TA3-9); Corrosion inhibitors of the blended chromate-phosphate-zinc type were apparently used from 1950 to the mid-1970s. Chromate usage was 35.9 lb per day. Blow-down was at 288,000 gal. per day with hexavalent chromium at levels up to 34 ppm in the discharge. Shaykin (1968) reports that "total chromate analyses of the stream before it disappears averages 10–15 ppm, half of which is estimated to be in the hexavalent or toxic form" (p. TA3-13).	See CEARP 1987, Section "TA3-1-CA-A/I-HW/RW (Facilities)," p. TA3-9 and Section "TA3-6-CA/O-A/I-HW/RW (Outfalls)," p. TA3-12

TA[a]	Parent Consolidated Unit	Child PRS[b]	Brief Description	Operation (from PRS database)	Reference	Root Reference (?? = reference unknown)	Chromium-Related Activities	Notes
TA-03	03-012(b)-00	03-045(b)	Industrial or sanitary wastewater treatment		***Same site as 03-012(b); CEARP 1987 Phase I: Installation Assessment, Volume 1 of 2***	Reinig, L.P.I415 Report-Chromate Problem," Los Alamos Scientific Laboratory, March 7, 1972. Shaykin, Jerome D. 1968. "Health Protection Appraisal Report, Los Alamos Area Office and the Zia Company, Los Alamos, NM," Los Alamos Scientific Laboratory, December 17-19, 1968 Zia Company. 1972. "Conceptual Design Report for Chemical Reduction System, TA-3 Power Plant, Los Alamos, NM," February 1, 1972	PRS is a permitted outfall associated with TA-03-22. Chromate from drift loss during the early years of operation may be present in soils near the TA-03 power plant (p. TA-03-9); Corrosion inhibitors of the blended chromate-phosphate-zinc type were apparently used from 1950 to the mid-1970s. Chromate usage was 35.9 lbs. per day. Blow-down was at 288,000 gal. per day with hexavalent chromium at levels up to 34 ppm in the discharge. Shaykin (1968) reports that "total chromate analyses of the stream before it disappears averages 10–15 ppm, half of which is estimated to be in the hexavalent or toxic form" (p. TA3-13).	See CEARP 1987, Section "TA3-1-CA-A/I-HW/RW (Facilities)," p. TA3-9 and Section "TA3-6-CA/O-A/I-HW/RW (Outfalls)," p. TA3-12
TA-03	03-012(b)-00	03-045(c)	Outfall	Former cooling tower, pump house (structures 03-156 and -163) and an inactive outfall (deleted from the NPDES permit on 7/11/95)	CEARP 1987 Phase I: Installation Assessment, Volume 1 of 2 (ERID 08663)	Miller, E.L. 1971 (01088). "Effluent from Plant Cooling Towers," Los Alamos Scientific Laboratory memorandum to C. Christenson, July 30, 1971.	CEARP report (p. TA3-13) states that "There are numerous cooling towers in TA-3 that have blow-down discharges to canyon outfalls. In 1971 the following cooling systems discharging to Sandia Canyon were noted: TA-03-187; TA-03-285; and TA-03-127. Although the chemicals added were reported to be 'biodegradable and nontoxic' (Miller 1971), chromates are known to have been added to cooling tower water between the 1950s and 1970s."	See also CEARP 1987, Section "TA3-1-CA-A/I-HW/RW (Facilities)," p. TA3-9 and Section "TA3-6-CA/O-A/I-HW/RW (Outfalls)," p. TA3-12 3-285 (structure number for associated cooling tower)
					PRS Database	??	This outfall receives effluent from a cooling tower (structure 03-285), which serves the generators that power LANL's computer system. This outfall may have received chromate-treated water.	

[a] TA = Technical area.

[b] PRS = Potential release site.

Appendix 2

Advanced Hydrotest Facility Report and Data
(on CD included with this document)

Appendix 2 includes information from core holes drilled in Mortandad and Sandia canyons for a project conducted in support of the potential Advanced Hydrotest Facility (AHF).

As part of the preliminary characterization for the proposed AHF, three core holes were drilled in 2002 in Mortandad and Sandia canyons to obtain samples from the Otowi Member of the Bandelier Tuff for rock properties testing (Kleinfelder 2002, 91687). The holes were continuously cored from the surface into the Otowi Member with a hollow-stem auger rig. Once the rock-property samples were removed, the core was sampled on approximately 5-ft intervals to 10 ft and approximately every 10 ft thereafter to the bottom of the core. Samples were collected from the Mortandad Canyon cores for anions (bicarbonate, bromide, chloride, nitrate, nitrite, perchlorate, phosphate, oxalate, and sulfate) and cations (aluminum, calcium, iron, potassium, magnesium, manganese, sodium, and silicon). The Sandia Canyon cores will be analyzed as part of this investigation.

Depth profiles were plotted for all three Mortandad Canyon cores using analytical data derived from a deionized water leaching procedure (for more details about the procedure, see Broxton et al. 2001, 71252; LANL 1996, 59118). Leachates were analyzed using ion chromatography for the anions and inductively coupled plasma optical emission spectroscopy for the cations. In situ pore water concentrations were then calculated using the leachate concentrations, gravimetric moisture contents, and bulk densities for the various stratigraphic units. Moisture contents were determined gravimetrically on each sample before the sample was leached.

The complete geotechnical report is included in pdf format on the enclosed CD. The analytical data from pore fluids collected from core and depth profiles are included as Excel tables in electronic format on the enclosed CD.

REFERENCES

The following list includes all documents cited in this appendix. Parenthetical information following each reference provides the author(s), publication date, and ER ID number. This information is also included in text citations. ER ID numbers are assigned by the Environmental Stewardship–Environmental Remediation and Surveillance (ENV-ERS) Program Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the ENV-ERS Program 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 ENV-ERS Program. 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.

Broxton, D.E., R. Warren, D. Vaniman, B. Newman, A. Crowder, M. Everett, R. Gilkeson, P. Longmire, J. Marin, W. Stone, S. McLin, and D. Rogers, May 2001. “Characterization Well R-12 Completion Report,” Los Alamos National Laboratory report LA-13822-MS, Los Alamos, New Mexico. (Broxton et al. 2001, 71252)

Kleinfelder, Inc., 2002. “Report of Pre-Conceptual Geotechnical Investigations, Advanced Hydrotest Facility Project, TA-53,” Kleinfelder, Inc., report Project Number C59010120, prepared for Los Alamos National Laboratory, New Mexico. (Kleinfelder 2002, 91687)

LANL (Los Alamos National Laboratory), 1996. “Vadose Zone Water Movement at Area G, Los Alamos National Laboratory, TA-54: Interpretations Based on Chloride and Stable Isotope Profiles.” Los Alamos National Laboratory document LA-UR-96-4682, Los Alamos, New Mexico. (LANL 1996, 59118)

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Appendix 3

Groundwater-Data Screening Tables
(on CD included with this document)

Appendix 3 includes summary screening tables for water data from Los Alamos, Sandia, and Mortandad canyons. Two groups of data are screened and presented in two different sets of tables. The first group (Table A3-1) includes a screen of data from the complete period of record, and the second group (Table A3-2) includes data from 2000 to the present. Water types presented include persistent surface water (baseflow), snowmelt, springs, alluvial groundwater, perched-intermediate groundwater, and regional groundwater. These tables are included in the attached CD.

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Appendix 4

Sediment-Data Screening Tables
(on CD included with this document)

Appendix 4 includes summary screening tables for sediment collected from Los Alamos, Sandia, and Mortandad canyons as part of geomorphic investigations conducted for the canyons' work plans. The frequency of detection tables are included in hard copy in this appendix, and the data from which they are derived are included as Excel tables in electronic format on the enclosed CD.

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Table A4-1
Los Alamos Canyon Sediment Summary

Reach	Analyte Name	Number of Samples	Number of Detects	Min Detect	Avg Detect	Max Detect	Number of NDs[a]	Min ND	Avg ND	Max ND	Frequency of Detects	Number of D[b]>BV[c] (10.5 mg/kg)
LA-0	Chromium[d]	2	2	3.16	4.28	5.39	—[e]	—	—	—	2/2	0
LA-1C	Chromium	12	12	2.1	5.02	14.1	—	—	—	—	12/12	1
LA-1E	Chromium	6	6	3.1	6.33	10.6	—	—	—	—	6/6	1
LA-1FW	Chromium	4	3	3.12	3.34	3.5	1	1.3	1.3	1.3	3/4	0
LA-1W	Chromium	14	14	2.56	4.52	6.55	—	—	—	—	14/14	0
LA-1W+	Chromium	5	5	2.3	4.48	6.5	—	—	—	—	5/5	0
LA-2E	Chromium	6	6	4.8	8.50	18.9	—	—	—	—	6/6	1
LA-2E (excavated data)	Chromium	2	2	4.7	21.55	38.4	—	—	—	—	2/2	1
LA-2FE	Chromium	6	6	3.4	8.25	15	—	—	—	—	6/6	1
LA-2W	Chromium	6	6	4.4	9.99	19.5	—	—	—	—	6/6	2
LA-3E	Chromium	8	8	2.2	6.55	12.2	—	—	—	—	8/8	2
LA-3FE	Chromium	13	13	1.4	7.36	11.8	—	—	—	—	13/13	3
LA-3W	Chromium	7	7	1.85	5.55	11	—	—	—	—	7/7	1
LA-4E	Chromium	7	5	1.9	3.42	5.3	2	1.7	2.15	2.6	5/7	0
LA-4FE	Chromium	16	16	1.1	5.17	9	—	—	—	—	16/16	0
LA-4W	Chromium	6	6	2.15	3.41	4.7	—	—	—	—	6/6	0
LA-5	Chromium	8	8	2.46	6.55	9.4	—	—	—	—	8/8	0
LA-5E	Chromium	12	12	0.94	3.25	5.9	—	—	—	—	12/12	0
LA-BKG	Chromium	7	7	4.3	6.36	10	—	—	—	—	7/7	0

Note: All values are in mg/kg.

[a] ND = Non-detected.

[b] D = Detected.

[c] BV = Background value.

[d] Chromium refers to total chromium.

[e] — = Not applicable.

Table A4-2
Sandia Canyon Sediment Summary

Reach	Analyte Name	Number of Samples	Number of Detects	Min Detect	Avg Detect	Max Detect	Number of NDs[a]	Min ND	Avg ND	Max ND	Frequency of Detects	Number of D[b]>BV[c] (10.5 mg/kg)
S-1N	Chromium[d]	3	3	5	5.43	5.9	—[e]	—	—	—	3/3	0
S-1S	Chromium	6	5	9.2	52.84	160	1	9.1	9.1	9.1	5/6	4
S-1S	Chromium hexavalent ion	1	—	—	—	—	1	0.64	0.64	0.64	0/1	—
S-2	Chromium	30	30	5.6	448.73	3200	—	—	—	—	30/30	27
S-2	Chromium hexavalent ion	4	—	—	—	—	4	0.63	0.95	1.5	0/4	—
S-3	Chromium	9	9	7	91.64	330	—	—	—	—	9/9	7
S-5W	Chromium	7	7	4	18.39	42	—	—	—	—	7/7	4

Note: All values are in mg/kg.

[a] ND = Non-detected.

[b] D = Detected.

[c] BV = Background value.

[d] Chromium refers to total chromium.

[e] — = Not applicable.

Table A4-3
Mortandad Canyon Sediment Summary

Reach	Analyte Name	Number of Samples	Number of Detects	Min Detect	Avg Detect	Max Detect	Number of NDs[a]	Min ND	Avg ND	Max ND	Frequency of Detects	Number of D[b]>BV[c] (10.5 mg/kg)
E-1E	Chromium[d]	47	46	1.3	18.93	140	1	1.14	1.14	1.14	46/47	14
E-1FW	Chromium	20	20	5	363.25	2210	—[e]	—	—	—	20/20	19
E-1FW	Chromium hexavalent ion	7	3	0.531	1.10	1.99	4	0.53	1.095	1.46	3/7	—
E-1W	Chromium	29	29	1.4	33.05	636	—	—	—	—	29/29	13
E-1W	Chromium hexavalent ion	1	—	—	—	—	1	0.14	0.14	0.14	0/1	—
LA-BKG	Chromium	3	3	3.45	4.27	5.3	—	—	—	—	3/3	0
M-1C	Chromium	9	9	4	11.70	19.6	—	—	—	—	9/9	6
M-1E	Chromium	24	24	1.56	13.13	18.8	—	—	—	—	24/24	19
M-1W	Chromium	18	18	2.27	5.24	9.7	—	—	—	—	18/18	0
M-2E	Chromium	46	46	1.1	6.30	14	—	—	—	—	46/46	6
M-2W	Chromium	71	71	1.31	8.34	22	—	—	—	—	71/71	18
M-3	Chromium	93	93	1.2	6.07	17.5	—	—	—	—	93/93	13
M-4	Chromium	80	80	1.29	4.81	14.5	—	—	—	—	80/80	6
M-4 (excavated data)	Chromium	8	7	1.4	5.13	11.9	1	1.3	1.3	1.3	7/8	1
M-5E	Chromium	19	19	0.96	3.67	5.4	—	—	—	—	19/19	0
M-5W	Chromium	9	9	1.8	5.34	7.3	—	—	—	—	9/9	0
M-6	Chromium	14	14	2.86	5.49	8.14	—	—	—	—	14/14	0
MCW-1	Chromium	8	8	2.28	5.38	8.96	—	—	—	—	8/8	0
MCW-2E	Chromium	7	7	2.14	5.68	8.59	—	—	—	—	7/7	0
MCW-2N	Chromium	9	9	1.7	4.63	6.34	—	—	—	—	9/9	0
MCW-2W	Chromium	9	8	0.713	4.18	7.24	1	0.78	0.78	0.78	8/9	0

Table A4-3 (continued)

Reach	Analyte Name	Number of Samples	Number of Detects	Min Detect	Avg Detect	Max Detect	Number of NDs[a]	Min ND	Avg ND	Max ND	Frequency of Detects	Number of D[b]>BV[c] (10.5 mg/kg)
TS-1C	Chromium	80	80	1.2	4.61	10.4	—	—	—	—	80/80	0
TS-1E	Chromium	18	18	1.22	4.47	9.05	—	—	—	—	18/18	0
TS-1W	Chromium	26	26	1.5	4.82	10.3	—	—	—	—	26/26	0
TS-2C	Chromium	17	17	1.3	6.61	22.3	—	—	—	—	17/17	1
TS-2E	Chromium	14	14	1.8	8.03	26.8	—	—	—	—	14/14	2
TS-2W	Chromium	14	14	2.5	5.08	7.3	—	—	—	—	14/14	0
TS-3	Chromium	17	17	1.6	5.22	9.1	—	—	—	—	17/17	0

Note: All values are in mg/kg.

[a] ND = Nondetected.

[b] D = Detected.

[c] BV = Background value.

[d] Chromium refers to total chromium.

[e] — = Not applicable.

Appendix 5

Water-Level Data

The groundwater-level data presented in this work plan are provided to support an assessment of potential variations in the regional piezometric surface related to pumping cycles in production wells. Data from a single day are provided to represent a snapshot of the groundwater levels and to avoid potential ambiguity that might arise if the data were collected over a longer time period, such as those caused by variations in aquifer recharge rate, barometric pressure, or the water-supply pumping schedule.

Groundwater levels are reported for January 30, 2006, for the wells that were sampled as part of the interim action and for additional monitoring wells in adjacent watersheds. Groundwater-level data are reported for wells sampled in Mortandad Canyon and Sandia Canyon and for monitoring wells in the adjacent watersheds of Los Alamos Canyon to the north and Pajarito Canyon to the south. Groundwater-level data are reported for both intermediate groundwater and the regional aquifer.

Pressure transducers are used in most monitoring wells at Los Alamos National Laboratory (LANL or the Laboratory) to measure groundwater levels at 60-min intervals. The mean daily (MD) water level was calculated for each well from the 24 hourly measurements; the MD value is reported for each well in Table A5-1. The MD value is used to create the potentiometric water-level maps included in Section 3 (Figures 3-4 and 3-5). Standard deviations of the MD values are also shown in Table A5-1. The accuracy of the transducer and of the manual groundwater level measurements is also provided in Table A5-1.

The Los Alamos County water-supply wells are routinely operated during off-peak electric usage hours to take advantage of lower electric utility rates. These wells usually operate during nighttime hours and are turned off during daytime hours. Table A5-2 lists the water-supply well operational status on the nights of January 29 and 30, the on/off times, and the run times for the wells in operation. During the early morning hours of January 30, wells in operation in the vicinity of Sandia and Mortandad canyons included O-4, PM-1, PM-2, and PM-5.

In an effort to evaluate the potential effect of water-supply well pumping on each monitoring well, two additional mean values were calculated from the hourly transducer groundwater level data for each well on January 30, 2006. The mean groundwater levels for two 6-h periods, from midnight to 6:01 am (nighttime value was used to evaluate water levels during pumping) and from noon to 6:01 pm (daytime value was used to evaluate water levels during nonpumping), were calculated for each monitoring well; these mean values and associated standard deviations are also shown in Table A5-1.

Daily atmospheric temperature changes cause diurnal atmospheric pressure fluctuations, which in turn affect water levels in intermediate-depth and regional-aquifer single-completion wells that are open to the atmosphere. Borehole barometric efficiency describes how efficiently a change in barometric pressure changes the water level in a borehole but not necessarily the water level within the formation. The barometric efficiency approximates 100% in the Laboratory intermediate and regional aquifer wells (e.g., Kleinfelder and Associates 2005, 91693); thus, atmospheric pressure fluctuations cause significant water-level variability (generally, up to 0.5 ft in magnitude) in most intermediate and regional aquifer wells at the Laboratory. The effects of barometric efficiency are not observed in the Westbay-completed wells that are not open to the atmosphere. The water-level change in single completion wells that could be attributable to atmospheric pressure differences during midnight to 6:01 am and noon to 6:01 pm periods on January 30 was calculated from atmospheric pressure data obtained from the Laboratory Technical Area 06 meteorological tower.

The water-level change in these wells that was attributable to atmospheric pressure fluctuations on January 30, 2006, was calculated to be 0.02 ft higher in the afternoon than during the early morning hours. This water-level change was subtracted from the difference between the mean afternoon water levels (noon to 6:01 pm) and the mean early morning water level (midnight to 6:01 am) for the single completion wells only to estimate the water-level change in the aquifer, which can be potentially attributed to pumping of the water-supply wells. This correction was not applied to Westbay-completed wells, where the mean afternoon water level was subtracted from the mean early morning water level to determine the water-level change in the aquifer (Table A5-1).

The results of the evaluation done on January 30, 2006, for the potential effects of water-supply pumping on monitoring wells are shown in Table A5-1. The results indicate that all except two of the monitoring-well screens do not show a significant difference (less than 0.1 ft) between afternoon groundwater levels and early morning groundwater levels; therefore, they do not seem to be influenced by the supply-well pumping on January 30, 2006. The deeper regional aquifer screens in two wells, R-5 in Pueblo Canyon and R-20 in Pajarito Canyon, do show changes in afternoon water levels compared with the early morning water levels. Screen 4 in R-5 shows a higher mean afternoon water level of 0.48 ft, and screen 3 in R-20 shows a higher mean afternoon water level of 0.26 ft, both of which are attributable to supply-well pumping. Monitoring well R-20 is near supply well PM-2, and monitoring well R-5 is near supply wells O-1 and PM-1. However, it is important to note that the measurements at both screens are associated with uncertainty of ±0.58 ft (Table A5-1). Therefore, the observed water-level differences might be statistically insignificant. The screens in wells R-5 and R-20 that are located at the top of the regional aquifer do not show an apparent impact from supply-well pumping. Thus, it appears that impacts to the gradients in the shallow, water-table zone of the regional aquifer by water-supply pumping on January 30, 2006, are negligible.

The above evaluation of pumping effects on monitoring wells applies only to the groundwater levels observed on January 30, 2006, and is not a comprehensive evaluation of monitoring-well response to supply-well pumping. Additional discussion of the effects of pumping supply wells on monitoring wells at the Laboratory is addressed in Section 3.

REFERENCE

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

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Kleinfelder and Associates, April 2005. “Final Completion Report, Characterization Wells R-6/R-6i, Los Alamos National Laboratory, Los Alamos, New Mexico Project No. 37151, Appendix E, Aquifer Testing Report and Aquifer Test Data,” by David Schafer, Los Alamos, New Mexico. (Kleinfelder 2005, 91693)

Table A5-1
Groundwater Level Data from Selected Monitoring Wells during Groundwater Sampling Event for Chromium, January 30, 2006

Well Name	Port Common Name	Date Time	Type of Measurement[a]	Well Elevation (ft)	Mean Daily Water Elevation (ft amsl)	Std Dev of MD (ft)	Measurement Uncertainty (ft)[b]	Midnight to 6:00 am Mean Water Level (ft)	Midnight to 6:00 am Std Dev (ft)	Noon to 6:00 pm Mean Water Level (ft)	Noon to 6:00 pm Std Dev (ft)	Daytime Mean WL minus Nightime Mean WL (ft)[c]	WL Change due to Atmospheric Pressure (ft)	Daytime Minus Nightime Aquifer WL Change (ft)[c]	Comment
Intermediate-Depth Groundwater (Mortandad)															
MCOBT-4.4	SC	1/30/2006	MD	6836.20	6313.86	0.083	0.07	6313.86	0.045	6313.83	0.081	-0.02	0.02	-0.04	
MCOI-1	SC	1/30/2006	Manual	7106.20	Dry										
MCOI-4	SC	1/30/2006	MD	6837.20	6317.82	0.060	0.07	6317.85	0.045	6317.79	0.053	-0.06	0.02	-0.09	
MCOI-5	SC	1/30/2006	MD	6819.70	6129.77	0.033	0.07	No Data		6129.76	0.030				
MCOI-6	SC	1/30/2006	MD	6811.10	6146.71	0.033	0.07	6146.69	0.007	6146.73	0.036	0.04	0.02	0.01	
MCOI-8	SC	1/30/2006	Transducer	6859.20	Dry (water in sump)										
Regional Groundwater (Mortandad)															
R-1	SC	1/30/2006	MD	6881.21	5879.14	0.044	0.07	5879.13	0.007	5879.15	0.034	0.02	0.02	-0.01	
R-10a	SC	1/30/06 8:57	Manual	6363.7	6741.03		0.06								
R-13	SC	1/30/2006	MD	6673.05	5836.63	0.033	0.07	5836.62	0.006	5836.64	0.033	0.02	0.02	0.00	
R-14, screen 1	MP1A	1/30/2006	MD	7062.08	5883.59	0.029	0.23	5883.62	0.013	5883.57	0.018	-0.05		-0.05	
R-14, screen 2	MP2A	1/30/2006	MD	7062.08	5883.06	0.032	0.23	5883.07	0.035	5883.04	0.029	-0.03		-0.03	
R-15	SC	1/30/2006	MD	6820.00	5850.74	1.172	0.07	5851.06	0.004	5849.93	2.045	-1.13	0.02	-1.15	Well sampled on 1/30/06
R-28	SC	1/30/2006	MD	6728.61	5839.28	0.037	0.07	5839.27	0.005	5839.29	0.032	0.02	0.02	0.00	
R-33, screen 1	Screen 1			6853.33	No Data										Groundwater level data unavailable
R-33, screen 2	Screen 2			6853.33	No Data										Groundwater level data unavailable
R-34	SC	1/30/2006	MD	6629.99	5835.71	0.029	0.07	5835.69	0.014	5835.72	0.027	0.03	0.02	0.00	
TW-8	SC	1/30/2006	MD	6873.5	5875.25	0.031	0.07	5875.25	0.005	5875.25	0.028	0.00	0.02	-0.02	

Table A5-1 (continued)

Well Name	Port Common Name	Date Time	Type of Measurement[a]	Well Elevation (ft)	Mean Daily Water Elevation (ft amsl)	Std Dev of MD (ft)	Measurement Uncertainty (ft)[b]	Midnight to 6:00 am Mean Water Level (ft)	Midnight to 6:00 am Std Dev (ft)	Noon to 6:00 pm Mean Water Level (ft)	Noon to 6:00 pm Std Dev (ft)	Daytime Mean WL minus Nightime Mean WL (ft)[c]	WL Change due to Atmospheric Pressure (ft)	Daytime Minus Nightime Aquifer WL Change (ft)[c]	Comment
Sandia Canyon															
R-11	SC	1/30/2006	MD	6673.72	5838.57	0.038	0.07	5838.56	0.006	5838.58	0.031	0.03	0.02	0.00	
R-12 Screen 1 (Intermed)	MP1B	1/30/2006	MD	6499.6	6073.10	0.009	0.23	6073.09	0.004	6073.11	0.000	0.02		0.02	
R-12 Screen 2 (Intermed)	MP2B	1/30/2006	MD	6499.6	6073.57	0.008	0.23	6073.57	0.007	6073.57	0.010	0.00		0.00	
R-12 Screen 3	MP3B	1/30/2006	MD	6499.6	5695.27	0.008	0.58	5695.28	0.010	5695.27	0.000	-0.01		-0.01	
Regional Groundwater Cañada del Buey															
R-16 Screen 2	MP2A	1/30/2006	MD	6256.87	5641.87	0.036	0.58	5641.87	0.020	5641.86	0.010	-0.01		-0.01	
R-16 Screen 3	MP3A	1/30/2006	MD	6256.87	5557.24	0.039	0.58	5557.24	0.029	5557.24	0.018	0.01		0.01	
R-16 Screen 4	MP4A	1/30/2006	MD	6256.87	5545.22	0.042	1.15	5545.21	0.044	5545.22	0.027	0.00		0.00	
R-21	SC	1/30/2006	MD	6656.24	5854.59	0.034	0.07	5854.59	0.017	5854.60	0.042	0.01	0.02	-0.01	
R-22		1/30/2006	MD	6650.5											Data logger failure, no data
Los Alamos Canyon															
LADP-3 (Intermed)	SC	1/30/2006	MD	6756.7	6436.49	0.045	0.07	6436.46	0.006	6436.51	0.031	0.04	0.02	0.02	
LAOI(A)-1.1 (Intermed)	SC	1/30/2006	MD	6835.2	6544.38	0.036	0.07	6544.37	0.007	6544.40	0.029	0.03	0.02	0.00	
LAOI-3.2 (Intermed)	SC	1/30/2006	MD	6622.6	6477.46	0.128	0.07	6477.32	0.027	6477.52	0.058	0.20	0.02	0.18	WL impacted by nearby drilling
R-6	SC	1/30/2006	MD	6995.8	5839.90	0.040	0.07	5839.89	0.004	5839.90	0.035	0.01	0.02	-0.01	
R-6i (Intermed)	SC	1/30/2006	MD	6996.9	6403.79	0.037	0.07	6403.78	0.006	6403.80	0.028	0.02	0.02	0.00	
R-8 Screen 1	MP1A	1/30/2006	MD	6544.74	5855.64	0.005	0.23	5855.64	0.005	5855.65	0.005	0.00		0.00	
R-8 Screen 2	MP2A	1/30/2006	MD	6544.74	5837.33	0.006	0.23	5837.33	0.000	5837.33	0.005	0.00		0.00	

Table A5-1 (continued)

Well Name	Port Common Name	Date Time	Type of Measurement[a]	Well Elevation (ft)	Mean Daily Water Elevation (ft amsl)	Std Dev of MD (ft)	Measurement Uncertainty (ft)[b]	Midnight to 6:00 am Mean Water Level (ft)	Midnight to 6:00 am Std Dev (ft)	Noon to 6:00 pm Mean Water Level (ft)	Noon to 6:00 pm Std Dev (ft)	Daytime Mean WL minus Nightime Mean WL (ft)[c]	WL Change due to Atmospheric Pressure (ft)	Daytime Minus Nightime Aquifer WL Change (ft)[c]	Comment
R-9	SC	1/30/2006	MD	6382.8	5692.05	0.045	0.07	5692.05	0.006	5692.07	0.027	0.02	0.02	0.00	
R-9i (Intermed)	MP1A	1/30/2006	MD	6383.2	6238.63	0.018	0.23	6238.62	0.010	6238.64	0.016	0.02		0.02	
R-9i (Intermed)	MP2A	1/30/2006	MD	6383.2	6128.47	0.017	0.23	6128.47	0.008	6128.48	0.008	0.01		0.01	
TW-3	SC	1/30/2006	MD	6626.9	5840.08	0.053	0.07	5840.06	0.013	5840.09	0.043	0.03	0.02	0.01	
Pueblo Canyon															
R-2	SC	1/30/2006	MD	6770.38	5872.00	0.045	0.07	5872.00	0.008	5871.98	0.049	-0.02	0.02	-0.05	
R-4	SC	1/30/2006	MD	6577.49	5833.58	0.045	0.07	5833.56	0.008	5833.60	0.034	0.04	0.02	0.02	
R-5 (Intermed)	MP2A	1/30/2006	MD	6472.6	6133.99	0.012	0.58	6133.99	0.012	6133.99	0.011	0.00		0.00	
R-5 Screen 3	MP3B	1/30/2006	MD	6472.6	5768.15	0.011	0.58	5768.15	0.011	5768.15	0.011	0.00		0.00	
R-5 Screen 4	MP4A	1/30/2006	MD	6472.6	5749.70	0.192	0.58	5749.42	0.038	5749.90	0.047	0.48		0.48	Response to PM-1 pumping
TW-1	SC	1/30/2006	MD	6369.19	5855.57	0.132	0.07	5855.59	0.074	5855.53	0.083	-0.06	0.02	-0.08	
TW-2A (Intermed)	SC	1/30/2006	MD	6650.4	6538.10	0.036	0.23	6538.10	0.024	6538.07	0.012	-0.03	0.02	-0.05	
TW-4	SC	1/30/2006	MD	7244.6	6071.52	0.033	0.07	6071.51	0.007	6071.52	0.029	0.01	0.02	-0.02	
POI-4 (Intermed)	SC	1/30/2006	MD	6372.29	6213.49	0.015	0.07	6213.50	0.006	6213.50	0.010	0.00	0.02	-0.03	
Pajarito Canyon															
R-18	SC	1/30/2006	MD	7404.83	6117.95	0.031	0.07	6117.95	0.017	6117.96	0.038	0.01	0.02	-0.01	
R-19 (Intermed)	MP2A	1/30/2006	MD	7066.3	6168.75	0.007	0.23	6168.75	0.005	6168.75	0.005	-0.01		-0.01	
R-19 Screen 3	MP3B	1/30/2006	MD	7066.3	5887.66	0.004	0.23	5887.66	0.004	5887.66	0.005	0.00		0.00	
R-19 Screen 4	MP4A	1/30/2006	MD	7066.3	5880.31	0.025	0.58	5880.30	0.010	5880.30	0.030	0.00		0.00	
R-19 Screen 5	MP5A	1/30/2006	MD	7066.3	5877.39	0.027	0.58	5877.38	0.030	5877.37	0.017	-0.01		-0.01	
R-19 Screen 6	MP6A	1/30/2006	MD	7066.3	5870.80	0.031	0.58	5870.78	0.020	5870.80	0.015	0.02		0.02	
R-19 Screen 7	MP7A	1/30/2006	MD	7066.3	5866.43	0.038	1.15	5866.42	0.028	5866.42	0.036	0.00		0.00	
R-20 Screen 1	MP1A	1/30/2006	MD	6694.35	5866.12	0.050	0.23	5866.10	0.047	5866.15	0.021	0.05		0.05	

Table A5-1 (continued)

Well Name	Port Common Name	Date Time	Type of Measurement[a]	Well Elevation (ft)	Mean Daily Water Elevation (ft amsl)	Std Dev of MD (ft)	Measurement Uncertainty (ft)[b]	Midnight to 6:00 am Mean Water Level (ft)	Midnight to 6:00 am Std Dev (ft)	Noon to 6:00 pm Mean Water Level (ft)	Noon to 6:00 pm Std Dev (ft)	Daytime Mean WL minus Nightime Mean WL (ft)[c]	WL Change due to Atmospheric Pressure (ft)	Daytime Minus Nightime Aquifer WL Change (ft)[c]	Comment
R-20 Screen 2	MP2A	1/30/2006	MD	6694.35	5861.26	0.060	0.58	5861.29	0.022	5861.24	0.055	-0.05		-0.05	
R-20 Screen 3	MP3A	1/30/2006	MD	6694.35	5836.15	0.726	0.58	5836.03	0.601	5836.29	0.333	0.26		0.26	Response to PM-2 pumping
R-23	SC	1/30/2006	MD	6527.75	5697.90	0.043	0.07	5697.89	0.007	5697.92	0.034	0.03	0.02	0.01	
R-23i (Intermed) Screen 1	SC	1/30/06 14:10	Manual	6527.9	6121.99		0.04								
R-32 Screen 1	MP1A	1/30/2006	MD	6637.63	5859.42	0.010	0.23	5859.42	0.009	5859.42	0.004	0.00		0.00	
R-32 Screen 2	MP2	1/30/2006	MD	6637.63	5849.01	0.035	0.23	5849.01	0.028	5848.99	0.015	-0.03		-0.03	
R-32 Screen 3	MP3A	1/30/2006	MD	6637.63	5849.31	0.030	0.23	5849.32	0.018	5849.29	0.015	-0.03		-0.03	

Note: All groundwater-level data are preliminary and subject to change pending further data review and validation.

[a] MD = mean daily groundwater level; Manual = manual measurement; WL = water level.

[b] Measurement uncertainty of transducer measurements represents 0.1% of full scale transducer rating. Uncertainty of manual measurements represents 0.01 ft per 100 ft of measurement or 0.01%.

[c] Positive numbers indicate higher mean afternoon groundwater levels, negative numbers indicate lower mean afternoon groundwater levels.

Table A5-2
Los Alamos County Water-Supply Well Status January 30, 2006

Well Name	Status	Time On (Day Hr:Min)	Time Off (Day Hr:Min)	Run Time (Hr:Min)
G-1A	Off			
G-2A	On	1/30/2006 0:08	1/30/2006 5:49	5:40
G-3A	On	1/30/2006 0:10	1/30/2006 5:48	5:38
G-4A	Off			
G-5A	Off			
O-1	Off			
O-4	On	1/30/2006 0:01	1/30/2006 6:30	6:28
PM-1	On	1/29/2006 7:11	1/30/2006 0:38	0:38
PM-2	On	1/30/2006 0:01	1/30/2006 6:43	6:42
PM-3	Off			
PM-4	Off			
PM-5	On	1/30/2006 0:07	1/30/2006 6:09	6:02

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Appendix 6

Groundwater Data for
First Chromium Interim Measures Sampling Round
(on CD included with this document)

Appendix 6 includes four tables related to the data set for the group of wells and analytical suite presented in Table 2-1 of this work plan. All the tables are included in the attached CD. These analytical data are presented in Table A6-1. Supporting tables are provided for reference to the analytical data. Table A6-2 is an explanation of the validation qualifiers. Table A6-3 is a dictionary of analytical lab qualifiers. Table A6-4 lists the results that have not been received from the analytical laboratory as of the submittal date of this work plan.

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