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Date: APR 2 4 2018
Refer To: ADEM-18-0034
LAUR: 18-23082

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

Subject: Chromium Plume Control Interim Measure Performance Monitoring Work Plan

Dear Mr. Kieling:

Enclosed please find two hard copies with electronic files of the Chromium Plume Control Interim Measure Performance Monitoring Work Plan. This work plan had no specific due date but is being submitted to capture the 2018 startup of interim measure operations. Some performance monitoring has been underway under the New Mexico Environment Department–approved "Interim Facility-Wide Groundwater Monitoring Plan for the 2018 Monitoring Year, October 2017–September 2018."

If you have any questions, please contact Danny Katzman at (505) 667-6333 (katzman@lanl.gov) or Cheryl Rodriguez at (505) 665-5330 (cheryl.rodriguez@em.doe.gov).

Sincerely,

Enrique Torres, Program Director
Environmental Remediation Program
Los Alamos National Laboratory

Sincerely,

David S. Rhodes, Director
Office of Quality and Regulatory Compliance
Environmental Management
Los Alamos Field Office

ET/DR/DK

Enclosures: Two hard copies with electronic files – Chromium Plume Control Interim Measure Performance Monitoring Work Plan (EP2018-0055)

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LA-UR-18-23082
April 2018
EP2018-0055

Chromium Plume Control Interim Measure Performance Monitoring Work Plan

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Associate Directorate for Environmental Management

EP2018-0055

Chromium Plume Control Interim Measure Performance Monitoring Work Plan

April 2018

Responsible project manager:

Stephani Swickley	[signature]	Project Manager	Environmental Remediation Program	4/17/18
Printed Name	Signature	Title	Organization	Date

Responsible LANS representative:

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David S. Rhodes	[signature]	Office Director	Quality and Regulatory Compliance	4-20-2018
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1.0 INTRODUCTION

This interim measure (IM) performance monitoring work plan (PMWP) for chromium plume control proposes the monitoring and reporting that will be conducted to evaluate performance of the IM conducted under the Department of Energy and Los Alamos National Security (DOE/LANS) May 2015 "Interim Measures Work Plan for Chromium Plume Control" (IMWP) (LANL 2015, 600458). The data evaluation and reporting process will inform adaptive management of the extraction and injection system as necessary. Figure 1.0-1 provides context for the location of the chromium plume including monitoring wells, piezometers, and IM infrastructure wells.

The New Mexico Environment Department (NMED) provided an approval with modifications on the IMWP on October 15, 2015 (NMED 2015, 600959). Although no specific requirement for a performance monitoring work plan was established in NMED's approval with modifications, DOE/LANS and NMED have since discussed the need for a work plan that establishes the specifics of the performance monitoring that will be conducted in support of the IM.

The principle objective of the IM is to achieve and maintain the 50-ppb downgradient chromium plume edge within the Laboratory boundary with a specific metric of reduction of chromium concentrations at monitoring well R-50 to the 50-µg/L New Mexico groundwater standard or less over a period of approximately 3 yr. A secondary objective is to hydraulically control plume migration in the eastern downgradient portion of the plume. An opportunistic objective is to utilize the information obtained from pumping and injection to refine the understanding of aquifer properties (e.g., aquifer heterogeneity, hydraulic connections between pumping and observation wells) in the plume area by evaluating pressure responses and chromium transients associated with pumping and injection.

The objective of the performance monitoring and associated reporting is to collect, evaluate, and report on the performance of the IM. Key data that support the evaluation of IM performance include contaminant concentration and tracer transients at select monitoring wells, and pressure-response (water level) data associated with operation of the IM. Evaluation of these data will also be used to guide adjustments in the distribution and rates of extraction and injection.

1.1 Interim Measures Work Conducted to Date and Future Startup Plans

The last 2 yr since NMED's approval with modifications have been used to complete activities necessary to implement the IM. The following subsections describe these activities.

1.1.1 Interim Measure Infrastructure

In addition to CrEX-1, which was already in place at the time of 2015 IMWP, nine infrastructure wells were installed in 2016 and 2017. Chromium extraction well CrEX-3 and chromium injection wells CrIN-1, CrIN-2, CrIN-3, CrIN-4, and CrIN-5 were completed in 2016. Chromium extraction wells CrEX-2, CrEX-4 and chromium injection well CrIN-6 were completed in 2017.

A water-distribution system constructed to pipe water between extraction wells, treatment system, and injection wells was completed in January 2018. The piping network includes approximately 3.1 mi of double- and single-wall high-density polyethylene (HDPE) pipe. Pipelines were trenched, tested, and installed underground along preexisting roads in Mortandad Canyon. The central treatment unit consisting of ion exchange treatment, finished water holding tanks, and booster pumps was constructed on the well pad near monitoring well R-28. Untreated groundwater is pumped from the extraction wells through double-walled pipe to central treatment, treated via ion exchange, held in tanks, and then pumped and distributed through single-walled pipe to the injection wells by the booster pumps. The entire operation is controlled and monitored by a programmable SCADA (supervisory control and data acquisition) system.

1.1.2 Interim Measure Operations and Related Activities

A number of short-duration (approximately 1-wk scale) pumping and injection activities have been conducted at extraction and injection wells over the past 2 yr. Most of those short-duration activities involved pumping and injection for infrastructure testing. The only significant operational activity that directly relates to implementation of the IM involved extraction from CrEX-1 and injection into CrIN-4 and CrIN-5 from January 6, 2017, through June 26, 2017. Interruptions in pumping and injection occurred during that period including a full shutdown from the period between April 27 and May 30, but the pumping was otherwise mostly continuous. The pumping rate at CrEX-1 during the January through June period was approximately 70 gallons per minute (gpm), and injection varied slightly around approximately 35 gpm into each of the two injection wells. Extraction at CrEX-1 and injection into CrIN-4 and CrIN-5 was terminated in late June 2017 to enable construction of additional infrastructure.

The 2018 IM startup will occur in phases. The initial operational phase will involve pumping at CrEX-1, CrEX-2, and CrEX-3 with corresponding injection occurring in CrIN-3, CrIN-4, and CrIN-5. This initial operational phase focuses on hydraulic control along the Laboratory boundary with the Pueblo de San Ildefonso. The IM operational approach along the eastern portion of the plume is pending additional evaluation of the optimal operational strategy for CrIN-1, CrIN-2, and CrIN-6. An evaluation report that presents the optimized operational strategy for the second startup phase will be submitted to NMED by April 30, 2018.

1.1.3 Tracer Testing

In May of 2017, tracers were introduced into CrIN-4 and CrIN-5 to characterize the groundwater pathways and the rate of migration of treated (and traced) water away from the injection wells. Tracers were introduced with injection water in accordance with the January 19, 2017, notice of intent from DOE/LANS and the response letter from the NMED Groundwater Quality Bureau dated February 20, 2017, stating that no permit is required for deployment of tracers (LANL 2017, 602984; NMED 2017, 602983). On May 18, 2017, 50 kg of the tracer sodium-1,5 naphthalene disulfonate (Na-1,5 NDS) was deployed into CrIN-4; and on May 23, 2017, 50 kg of Na-1,6 NDS was deployed into CrIN-5. For each of these two tracer deployments, 50 kg of tracer was mixed with 15,000 gal. of potable water and injected during work hours over a 2-d period. The CrIN-4 and CrIN-5 tracer deployments occurred approximately one month before the June, 2017, cessation of injection into CrIN-4 and CrIN-5. Neither of these two tracers was detected in monthly monitoring that was being conducted at wells R-50 and SIMR-2, possibly because injection into CrIN-4 and CrIN-5 was not sufficiently continuous after tracer deployment to push the tracers to the monitoring points. The deployment of tracers into the remaining four CrIN wells has not been conducted. DOE/LANS will be redeploying tracer into CrIN-4 and CrIN-5, and conducting first-time deployments into other injection wells, once full-scale injection is underway in each well. Redeployment in CrIN-4 and CrIN-5 will utilize different tracers than the two used in May 2017. A tracer will also be deployed in CrIN-3 shortly after the 2018 phase 1 system startup. Tracers will also be deployed into remaining injection wells once the second phase of the system startup occurs.

2.0 PERFORMANCE MONITORING

2.1 Rationale

Performance monitoring will be conducted to evaluate plume response associated with IM operations and will also be used to guide necessary adjustments in operational strategies, including changes in the distribution and/or rates of injection. Groundwater monitoring at chromium plume-area wells has been conducted for years predominantly on a quarterly basis under each annual "Interim Facility-Wide Groundwater Monitoring Plan" (IFGMP). The primary purpose and rationale for quarterly monitoring has historically been to characterize and monitor overall plume behavior. Chromium (and related contaminant) concentrations at many of these wells often exhibit significant quarterly variability superimposed on a longer-scale temporal trend. Figure 2.0-1 shows an example for R-50 screen 1 where concentrations of chromium can increase or decrease quarterly by as much as approximately 15–30 percent. Plots like these will include monthly data and be used in IM reports (described below) to track IM performance by evaluating the trends in key constituents.

In order to improve resolution of temporal trends and to provide information that can be used to determine if a potentially unfavorable plume response is occurring due to IM operations, the performance monitoring wells will be sampled on a monthly basis. Because the IM objective is focused on hydraulic control, and establishment and control of a 50-µg/L plume edge within the Laboratory boundary, performance monitoring wells are generally located near the plume periphery and downgradient of the 50-µg/L plume edge.

2.2 Conceptual Model for Interim Measure Performance

The overarching assumption guiding the IM strategy is that the dominant mass and mass flux of contamination in the medial and peripheral portions of the plume is in the upper 50–60 ft of the water table in the strata with the highest hydraulic conductivity. Hydraulically tighter strata may contain chromium mass but are likely less important from a mass flux perspective. Figure 2.0-2 shows the detailed stratigraphy described from core obtained from sonic drilling at core hole 2 (CrCH-2, shown as CrPZ-2 on Figure 1.0-1). The stratigraphic analysis shown in Figure 2.0-2 is representative of the hydraulics in the Puye Formation, the transitional Pumiceous Puye subunit, and the Miocene Pumiceous unit. A relatively small percentage of the stratigraphic section appears to have preferential hydraulic conductivities greater than 4 ft per d as estimated by the Kozeny-Carman method (Chapuis and Aubertin 2003, 602994).

Long-screen extraction and injection wells and monitoring wells, including the performance monitoring wells included in this plan, are likely measuring chromium concentrations dominated by the primary porosity. Injection water is also assumed to predominantly access those same strata. Therefore, performance monitoring should be effectively monitoring the reduction in concentrations due to the injection of a large volume of treated water into the strata where mass flux is occurring.

Preliminary data may indicate that dual storage (chromium mass in primary and secondary porosity) may not be significant in the vicinity of the injection wells. Data collected from CrIN-4 and CrIN-5 in September 2017 was nondetect for chromium, 3 mo following cessation of injection into those wells in late June 2017. If significant contamination was stored in secondary porosity near the injection wells, it may have manifested as some degree of rebound of chromium concentrations in the September 2017 samples.

2.3 Locations, Frequency, and Suite for Performance Monitoring

Monthly monitoring of select performance monitoring wells began in February 2017 and initially included results from the Laboratory's Geochemistry and Geomaterials Research Laboratories (GGRL). Wells R-50 (screens 1 and 2), and SIMR-2 were the first wells placed on a monthly monitoring frequency because of their proximity to the operations that were conducted at CrEX-1, CrIN-4, and CrIN-5 in 2017 (See section 1.1.2). Monthly monitoring at R-44 (screens 1 and 2), R-45 (screens 1 and 2), and R-61 began in October 2017. Although these additional well locations are not in close proximity to the portion of the plume where the 2017 operations were conducted, monthly data collected before the start of IM operations near those wells will improve resolution of the temporal variations under baseline conditions and enable better comparisons with IM operational conditions. Injection well CrIN-6 was sampling following completion in July 2017 and found to have approximately 260 ppb chromium. As a result, nearby downgradient wells R-35a and R-35b will also be put on a monthly monitoring frequency for performance monitoring and to specifically monitor potential plume response near Los Alamos County water-supply well PM-3 (Figure 1.0-1). Sampling at these monitoring wells will be conducted in a manner consistent with the sampling protocol used for IFGMP wells.

Additional monitoring will occur under this PMWP on a quarterly basis at the six piezometers within the plume area, CrPZ-1, CrPZ-2a, CrPZ-2b, CrPZ-3, CrPZ-4, and CrPZ-5. These piezometers were completed in the sonic core holes and are screened within the regional aquifer (LANL 2015, 600457). The piezometers are constructed with 2-in.-inside-diameter (2.375-in.-outside-diameter) stainless-steel well screens inside a nominal 6-in.-diameter borehole. The primary purpose of the piezometers is to provide pressure-response and water-level data to supplement data from nearby monitoring wells for use in interpreting plume response to the IM. Sampling of the piezometers is planned under the IM to obtain screening-level data that may be useful to supplement data from monitoring wells. However, because of small-diameter casing and screens, the piezometers cannot be developed (pumped) in a traditional manner because of limitations in pumping rates for pumps that fit inside a 2-in.-diameter casing and because of the depths of the piezometer screens. Sampling at these piezometers occurs with Bennet pumps that are capable of delivering water to the surface at only approximately 0.5 gpm. One exception is CrPZ-2b, which is sampled with a bailer system because a small protrusion in the casing causes concerns that a pump may get stuck downhole. The Bennet pumps operate with nitrogen to lift water to the surface. Water-quality data from the piezometers will be considered “screening-level” data and labeled as such in the database. A purge protocol for the piezometers will be explored to optimize data quality and may vary initially until an ideal purge protocol is established.

The analyte suite for sampling at performance monitoring wells is different for the intervening monthly samples than for the quarterly samples collected for the same wells under the IFGMP. Table 2.0-1 shows the performance monitoring wells and piezometers and the sample frequency for each constituent category.

3.0 REPORTING

Reports on performance of the IM will be submitted on a semiannual basis with the first report being submitted by September 28, 2018. The key evaluation tools that are anticipated to be utilized and reported on for evaluation of IM performance include the following:

- Time-series plots that include data for chromium, perchlorate, nitrate, and tritium from monthly sampling in performance monitoring wells. These plots will include the full period of record to facilitate an evaluation of the rate of change for each constituent.

- Time-series plots that include data for injection well tracers from monthly sampling in performance monitoring wells. These data will provide insights into aquifer properties between injection wells and performance monitoring wells.
- Water-table maps that evaluate potential changes in gradient associated with IM operations. The maps presented in the semiannual reports will be the same as those presented in quarterly reports provided under discharge permit (DP)-1835. The example shown in Figure 3.0-1 shows the water-table configuration 5 mo after the start of pumping CrEX-1 and injection into CrIN-4 and CrIN-5. Figure 3.0-2 shows the water-table configuration 5 mo after cessation of continuous pumping and injection. The relatively short duration of pumping and injection in a relatively small area did not apparently alter the water-table configuration in a discernable way. Similar maps will be included in performance monitoring reports as an additional line of evidence for evaluating IM performance.
- Cumulative chromium mass removal estimates. Although mass removal rates and efficiency are not directly related to IM performance, they may provide insights into observed plume response.
- Time-series plots that include data for chromium, perchlorate, nitrate, and tritium for extraction wells. These data may provide insights into capture zones achieved by each extraction well because of the spatial variability of these constituents within the overall plume footprint.

Reports will also be used to document the operational configurations that occurred during the reporting period as well as the rationale for adjustments that may have occurred. Because it may require up to 1 yr to see clear indication of plume response at performance monitoring wells, it is unlikely that major operational changes will occur because of observed changes in the temporal trends in chromium concentrations at performance monitoring wells.

4.0 REFERENCES AND MAP DATA SOURCES

The following reference list includes documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ERID or ESHID. This information is also included in text citations. ERIDs were assigned by the Associate Directorate for Environmental Management's (ADEM's) Records Processing Facility (IDs through 599999), and ESHIDs are assigned by the Environment, Safety, and Health Directorate (IDs 600000 and above). IDs are used to locate documents in the Laboratory's Electronic Document Management System and in the Master Reference Set. The NMED Hazardous Waste Bureau and ADEM maintain copies of the Master Reference Set. The set ensures that NMED has the references to review documents. The set is updated when new references are cited in documents.

4.1 References

Chapuis, R.P., and M. Aubertin, 2003. "On the Use of the Kozeny–Carman Equation to Predict the Hydraulic Conductivity of Soils," *NCR Research Press,* pp. 616-628. (Chapuis and Aubertin 2003, 602994)

LANL (Los Alamos National Laboratory), May 2015. "Interim Measures Work Plan for Chromium Plume Control," Los Alamos National Laboratory document LA-UR-15-23126, Los Alamos, New Mexico. (LANL 2015, 600458)

LANL (Los Alamos National Laboratory), May 2015. "Completion Report for Chromium Project Coreholes 1 through 5," Los Alamos National Laboratory document LA-UR-15-23197, Los Alamos, New Mexico. (LANL 2015, 600457)

LANL (New Mexico Environment Department), January 19, 2017. "Notice of Intent to Conduct a Tracer Study at Los Alamos National Laboratory," to M. Hunter (NMED) from J. Bretzke (LANL), and C. Rodriguez (DOE-EM). (LANL 2017, 602984)

NMED (New Mexico Environment Department), October 15, 2015. "Approval with Modifications, Interim Measures Work Plan for Chromium Plume Control," New Mexico Environment Department letter to D. Hintze (DOE-NA-LA) and M. Brandt (LANL) from J.E. Kieling (NMED-HWB), Santa Fe, New Mexico. (NMED 2015, 600959)

NMED (New Mexico Environment Department), February 20, 2017. "Response to Notice of Intent to Discharge; DP-1835; Los Alamos National Laboratory," New Mexico Environment Department letter to J. Bretzke (LANL), and C. Rodriguez (DOE-EM) from M. Hunter (NMED), Santa Fe, New Mexico. (NMED 2017, 602983)

4.2 MAP DATA SOURCES

Hillshade; Los Alamos National Laboratory, ER-ES, As published; \\slip\gis\Data\HYP\LiDAR\2014\Bare_Earth\BareEarth_DEM_Mosaic.gdb; 2014.

Unpaved roads; Los Alamos National Laboratory, ER-ES, As published, GIS projects folder; \\slip\gis\GIS\Projects\14-Projects\14-0062\project_data.gdb\digitized_site_features\digitized_roads; 2017.

Drainage channel; Los Alamos National Laboratory, ER-ES, As published, GIS projects folder; \\slip\gis\GIS\Projects\15-Projects\15-0080\project_data.gdb\correct_drainage; 2017.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 29 November 2010.

Paved Road Arcs; Los Alamos National Laboratory, FWO Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 29 November 2010.

Chromium plume > 50 ppb; Los Alamos National Laboratory, ER-ES, As published; \\slip\gis\GIS\Projects\13-Projects\13-0065\shp\chromium_plume_2.shp; 2018.

Regional groundwater contour May 2017, 4-ft interval; Los Alamos National Laboratory, ER-ES, As published; \\slip\gis\GIS\Projects\16-Projects\16-0027\project_data.gdb\line\contour_wl2017may_2ft; 2017.

Regional groundwater contour November 2017, 2-ft interval; Los Alamos National Laboratory, ER-ES, As published; \\slip\gis\GIS\Projects\16-Projects\16-0027\project_data.gdb\line\contour_wl2017nov_2ft; 2017.

Point features; As published; EIM data pull; 2017.

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Office; September 2007; as published 13 August 2010.

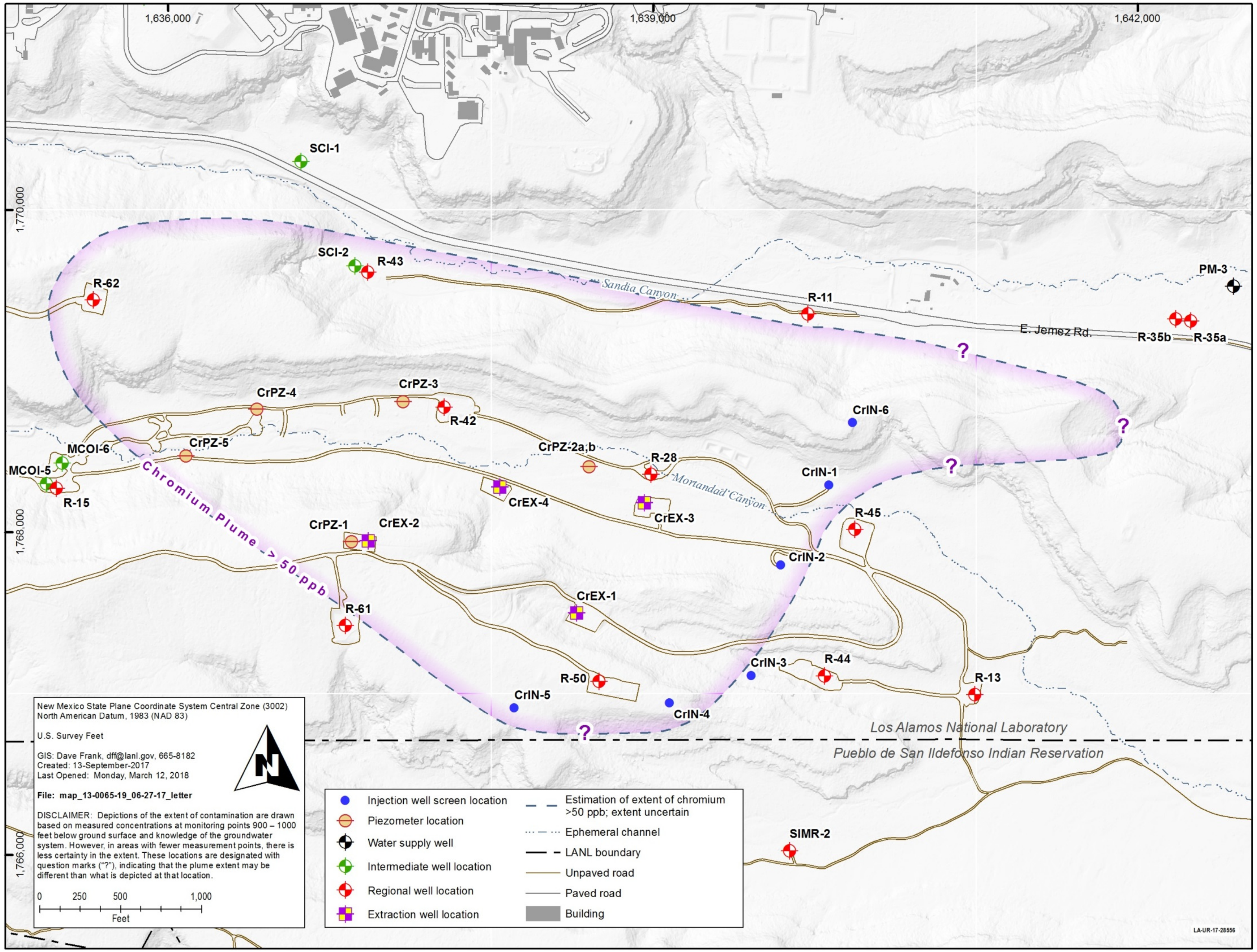

Figure 1.0-1 Map showing the approximate extent of the hexavalent chromium plume as defined by the 50-µg/L New Mexico groundwater standard. Locations of monitoring wells, piezometers, extraction wells and injection wells are also shown.

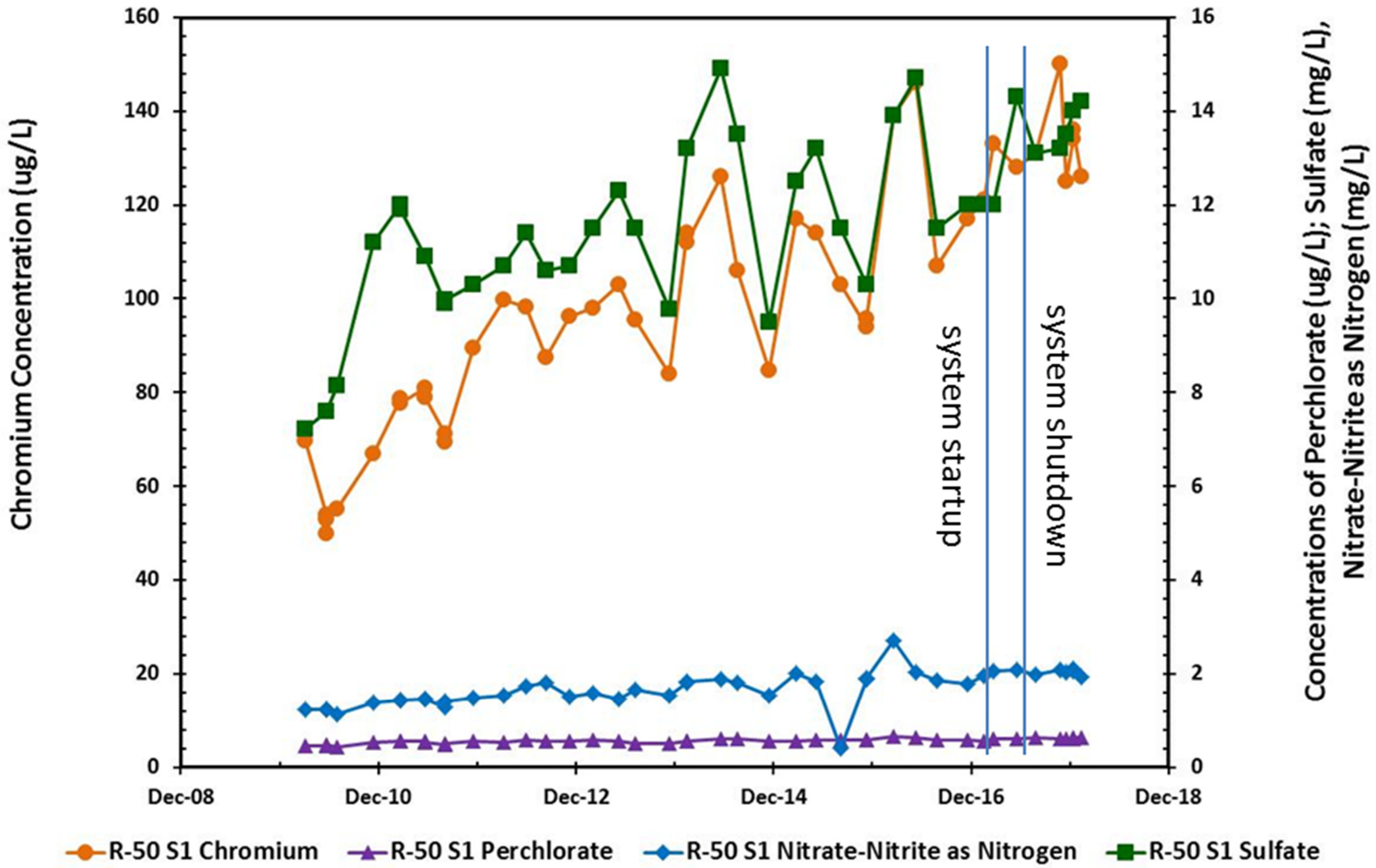

Figure 2.0-1 **Time-series plot for R-50 screen 1 highlighting variability in concentrations of key constituents. The start and stop dates for pumping at CrEX-1 and injection into CrIN-4 and CrIN-5 are shown on the plot. Monthly sampling at R-50 began in February 2017 and provides additional resolution of variability.**

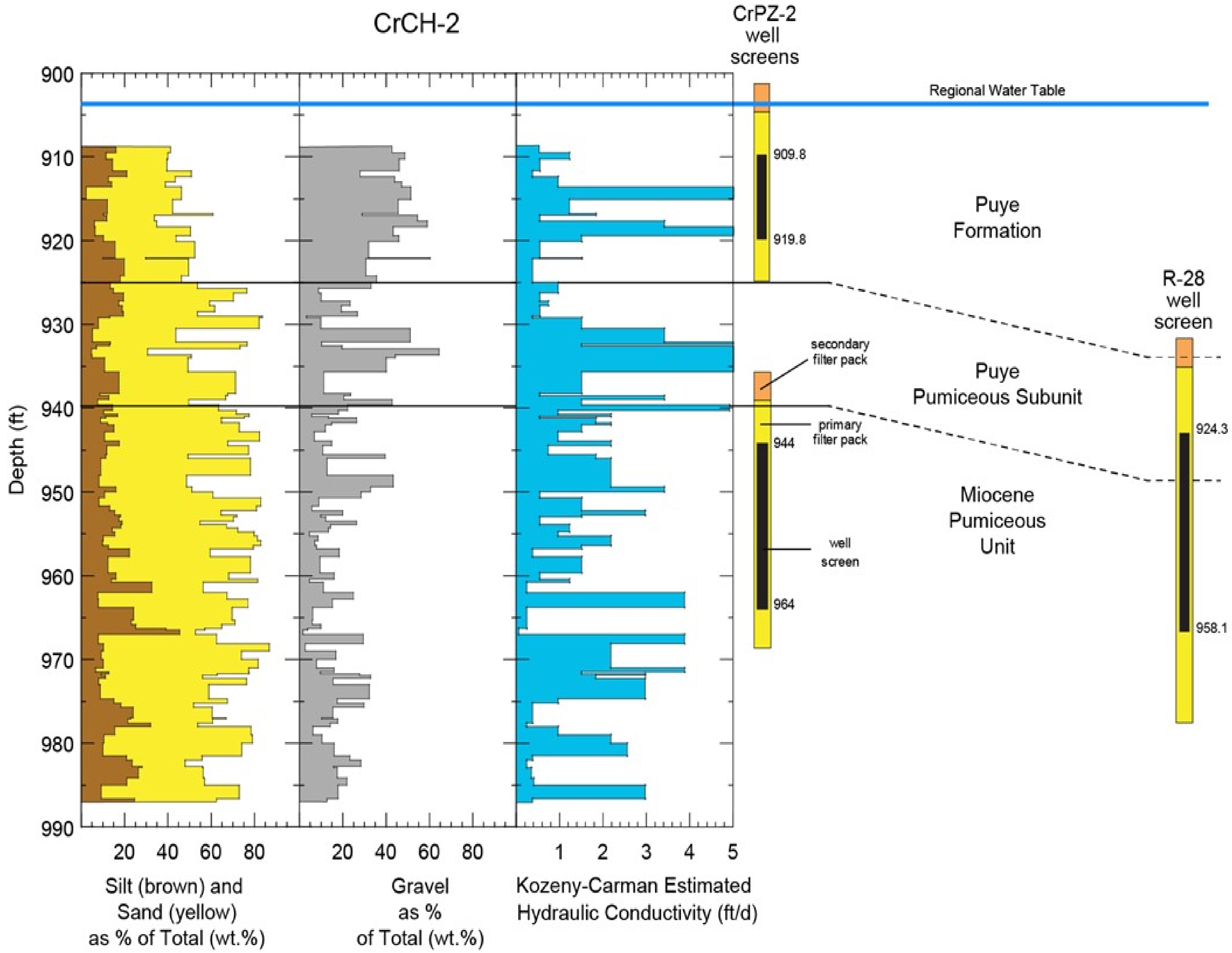

Figure 2.0-2 Detailed stratigraphy of the Puye Formation, Puye Pumiceous subunit, and Miocene Pumiceous unit from sonic core hole location (CrCH-2) near well R-28. The Kozeny-Carman estimates of hydraulic conductivity highlight the considerable variability in the hydraulics in the regional aquifer. The illustration also shows the relation of likely preferential pathways to the screen locations at CrPZ-2(a,b) and R-28.

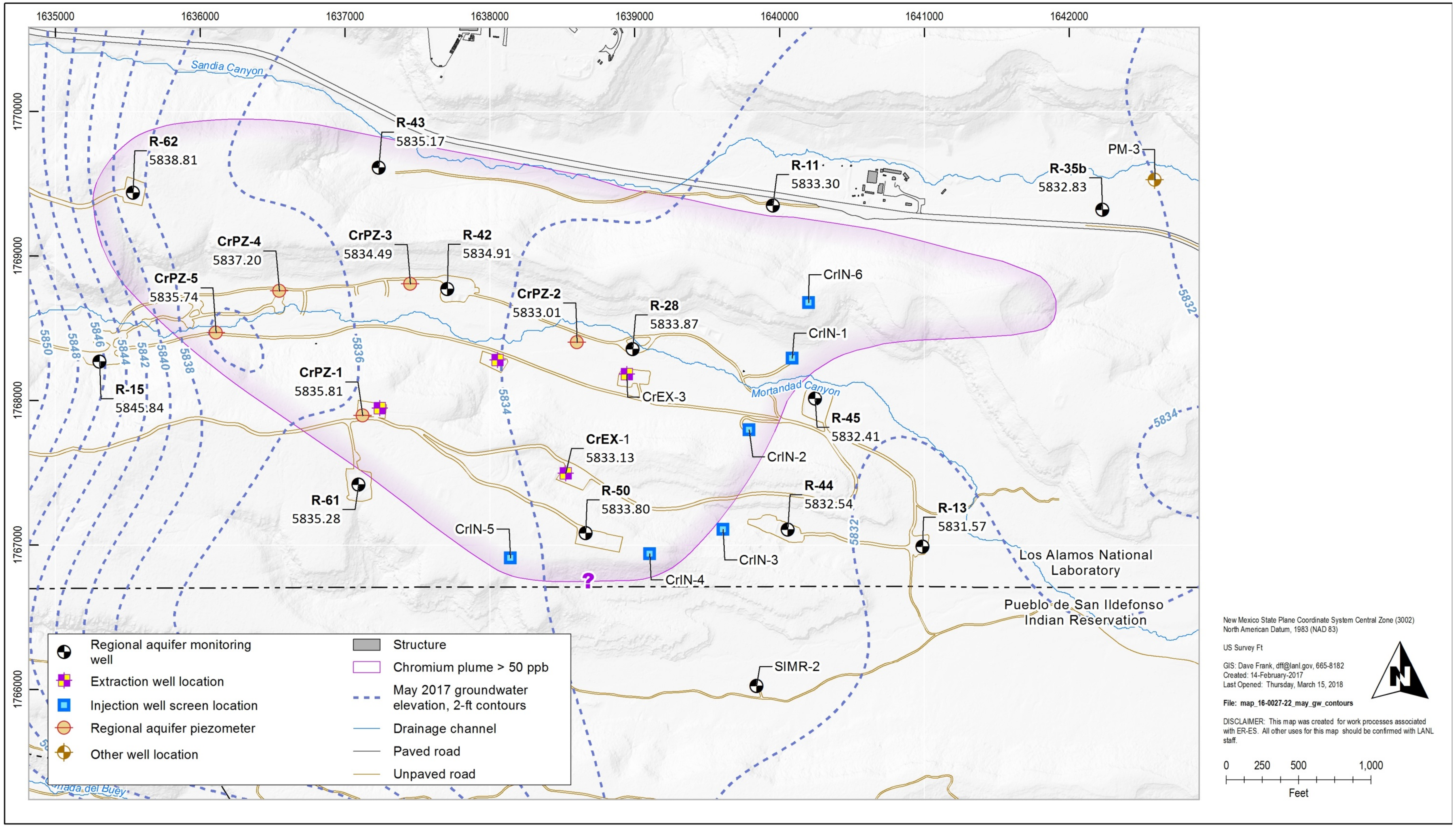

Figure 3.0-1 Water-table map for the chromium plume area for May 2017. Several factors affect the water-table map, including pumping and injection associated with the IM and pumping from Los Alamos County water-supply wells.

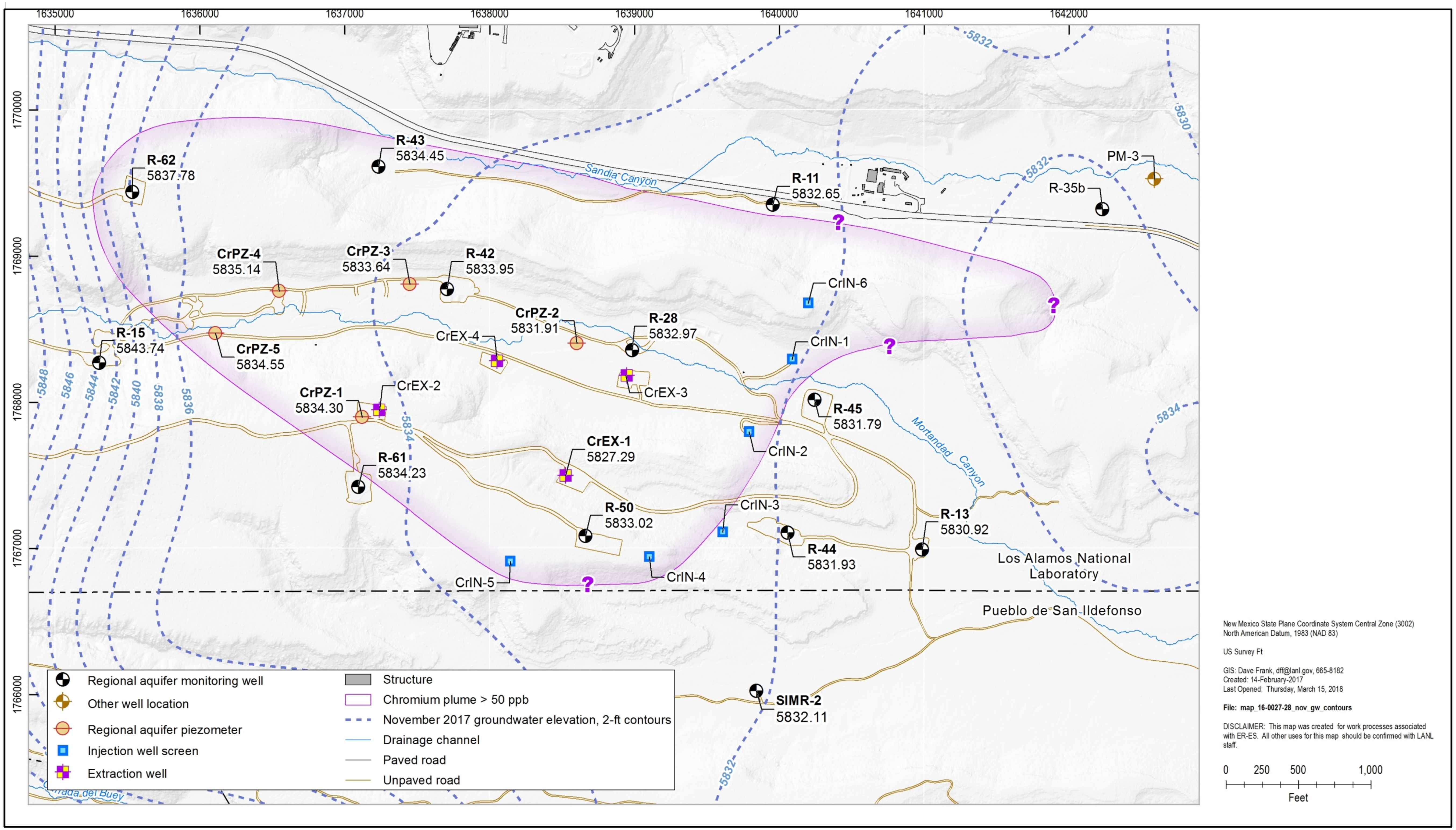

Figure 3.0-2 Water-table map for the chromium plume area for November 2017. Several factors affect the water-table map, including pumping and injection associated with the IM and pumping from Los Alamos County water-supply wells.

Table 2.0-1
Performance Monitoring Locations and Analyte Suite, including Tracers that Have Been or Will Be Deployed in Monitoring Wells, Piezometers, and Injection Wells in the Project Area

Location	Metals	Low-Level Tritium	General Inorganics[a]	Naphthalene Sulfonate Tracers	Sodium Bromide Tracer	Sodium Perrhenate Tracer	Deuterated Water Tracer
R-11	M[b]	Q[c]	M	M	M	M	M
R-35a	M	Q	M	M	—[d]	M	M
R-35b	M	Q	M	M	—	M	M
R-44 S1	M	Q	M	M	—	M	—
R-44 S2	M	Q	M	M	—	M	—
R-45 S1	M	Q	M	M	M	M	M
R-45 S2	M	Q	M	M	M	M	M
R-50 S1	M	Q	M	M	—	—	—
R-50 S2	M	Q	M	M	—	—	—
R-61 S1	M	Q	M	M	—	—	—
SIMR-2	M	Q	M	M	—	—	—
CrPZ-1	Q	Q	Q	—	—	—	—
CrPZ-2a	Q	Q	Q	—	—	—	—
CrPZ-2b	Q	Q	Q	—	—	—	—
CrPZ-3	Q	Q	Q	—	—	—	—
CrPZ-4	Q	Q	Q	—	—	—	—
CrPZ-5	Q	Q	Q	—	—	—	—

[a] Includes nitrate, sulfate, and perchlorate.

[b] M = monthly.

[c] Q = quarterly.

[d] — = Not analyzed at the noted location.