ESHID-602650

Los Alamos
NATIONAL LABORATORY
EST. 1943

*Associate Directorate for Environmental Management*
P.O. Box 1663, MS M992
Los Alamos, New Mexico 87545
(505) 606-2337

*Environmental Management*
1900 Diamond Drive, MS M984
Los Alamos, New Mexico 87544
(505) 665-5658/FAX (505) 606-2132

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*Date*: SEP 29 2017
*Refer To*: ADEM-17-0262
*LAUR*: 17-28239
*Locates Action No.*: n/a

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 Background Study Report**

Dear Mr. Kieling:

Enclosed please find two hard copies with electronic files of the Chromium Background Study Report. The report presents the results of implementation of the Chromium Background Study Work Plan. A pre-submission meeting was held between Los Alamos Nation Security, LLC, and the New Mexico Environment Department (NMED) on September 18, 2017, at which an overview of the report and results and recommendations were discussed. NMED had no concerns about or changes to the report.

If you have any questions, please contact Kent Rich at (505) 665-4272 (krich@lanl.gov) or Arturo Duran at (505) 665-7772 (arturo.duran@em.doe.gov).

Sincerely,

Bruce Robinson, Program Director
Environmental Remediation Program
Los Alamos National Laboratory

Sincerely,

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

BR/DR/KR:sm

Enclosures: Two hard copies with electronic files – Chromium Background Study Report (EP2017-0133)

Cy: (w/enc.)
Arturo Duran, DOE-EM-LA
Kent Rich, ADEM ER Program

Cy: (w/electronic enc.)
Laurie King, EPA Region 6, Dallas, TX
Steve Yanicak, NMED-DOE-OB, MS M894
emla.docs@em.doe.gov
Public Reading Room (EPRR)
ADESH Records
PRS Database

Cy: (w/o enc./date-stamped letter emailed)
lasomailbox@nnsa.doe.gov
Peter Maggiore, DOE-NA-LA
Kimberly Davis Lebak, DOE-NA-LA
David Rhodes, DOE-EM-LA
Bruce Robinson, ADEM ER Program
Randy Erickson, ADEM
Jocelyn Buckley, ADESH-EPC-CP
Mike Saladen, ADESH-EPC-CP
John Bretzke, ADESH-EPC-DO
Michael Brandt, ADESH
William Mairson, PADOPS
Craig Leasure, PADOPS

LA-UR-17-28239
September 2017
EP2017-0133

# Chromium Background Study Report

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Associate Directorate for Environmental Management

EP2017-0133

# Chromium Background Study Report

September 2017

Responsible project manager:

| | | | | |
|---|---|---|---|---|
| Kent Rich | | Project Manager | Environmental Remediation Program | 9/21/17 |
| Printed Name | Signature | Title | Organization | Date |

Responsible LANS representative:

| | | | | |
|---|---|---|---|---|
| for Randall Erickson | | Associate Director | Associate Directorate for Environmental Management | 9/21/17 |
| Printed Name | Signature | Title | Organization | Date |

Responsible DOE-EM-LA representative:

| | | | | |
|---|---|---|---|---|
| David S. Rhodes | | Office Director | Quality and Regulatory Compliance | 9-28-2017 |
| Printed Name | Signature | Title | Organization | Date |

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## 1.0 INTRODUCTION

This report presents the results of implementation of the "Chromium Background Study Work Plan" (hereafter, the work plan) (LANL 2017, 602400). The work plan was approved by the New Mexico Environment Department (NMED) in June 2017 (NMED 2017, 602418). The purpose of the study is to characterize the naturally occurring speciation of chromium in soil, sediment, and bedrock (Bandelier Tuff) at Los Alamos National Laboratory (LANL or the Laboratory). Understanding speciation of naturally occurring chromium is key to applying the appropriate soil screening level (SSL) to data to define the nature and extent of contamination at sites where there is no previous indication that chromium releases occurred.

## 2.0 BACKGROUND

The primary focus for defining the extent of contamination is characterizing contamination that potentially poses an unacceptable risk and may require additional sampling. As such, comparison with SSLs/screening action levels (SALs) is used as an additional step following a determination of whether extent is defined by decreasing concentrations with depth and distance and whether concentrations are below estimated quantitation limits or detection limits. The SSL/SAL comparison is not necessary if concentrations of all chemicals of potential concern (COPCs) are decreasing with depth and distance. However, if concentrations increase with depth or distance or do not exhibit any obvious trends, the SSLs/SALs are used to determine whether additional sampling for extent is warranted. If the COPC concentration or activity is sufficiently below the SSL/SAL (i.e., the SSL/SAL is 10 times [an order of magnitude] or more than all concentrations), the COPC does not pose a potential unacceptable risk, and no further sampling for extent is warranted. The validity of the assumption that the COPC does not pose a risk should be confirmed by the results of the risk-screening assessments.

Chromium exists in either the trivalent or hexavalent form, with the trivalent form being predominant under most environmental conditions. Hexavalent chromium is much more toxic than trivalent chromium, and the toxicity of hexavalent chromium results in the SSL for total chromium being only about 5 times the soil background value (BV). Therefore, the total chromium SSL will be less than 10 times any chromium detection above background, and the comparisons described above cannot be used to determine whether additional sampling for extent of chromium is warranted. At sites where there is no previous indication that hexavalent chromium was used and released, the U.S. Department of Energy (DOE) and Los Alamos National Security, LLC (LANS) have compared total chromium concentrations with trivalent chromium SSLs instead of total chromium SSLs to determine whether additional sampling for extent is warranted, assuming chromium is present almost entirely in the trivalent form. Because historical uses of hexavalent chromium at the Laboratory are limited (e.g., as a corrosion inhibitor in cooling towers and electroplating) and site conditions do not favor the formation of hexavalent chromium from trivalent chromium, DOE and LANS believe the use of the residential SSL for trivalent chromium in the nature and extent discussions is appropriate. However, the natural occurrence of hexavalent chromium in soil, sediments, and various bedrock units (Bandelier Tuff) at the Laboratory has not previously been quantified. This study quantifies the natural occurrence of hexavalent chromium at the Laboratory.

## 2.0 METHODOLOGY

Consistent with the approach presented in the approved work plan, three "reference" sites were identified for sampling at the Laboratory (Figure 2.0-1). The reference sites were selected to represent potential variability in key attributes that may affect chromium speciation, including the organic content in soil that may be a function of precipitation and plant abundance, iron content, and varying natural geochemistry of bedrock units that underlie mesa top soil (e.g., Bandelier Tuff Tshirege Units 2, 3, and 4). The reference sites were selected from areas within Laboratory property that have not been impacted by Laboratory operations. Each site is also located within a different Bandelier Tuff units (e.g., one site in Qbt2, one site in Qbt3, and one site in Qbt4).

At each reference site, samples were collected from mesa-top soil, from the underlying bedrock unit, and from mesa-slope sediment and tuff as described below:

- Four soil samples were collected from pothole walls at two sampling locations.
- Four mesa-top tuff samples were collected from the bottom of the soil pothole.
- Four sediment samples were collected from mesa-slope drainages.
- Four tuff samples were collected from exposed mesa-slope locations.

The thickness of each sample layer varied and was determined by field observations of stratigraphic breaks in soil horizons, thickness of sediment deposits in drainages, and competency of the different tuff units. Table 2.0-1 provides the samples collected and analysis requested for the three reference sites. Field observations about key attributes of the samples, including color and general descriptions of organic content and particle-size distribution for each sample, were also noted. Field observations were used to bias soil sample collection in each of the reference sites to represent potential factors such as iron content (reddish soil) and organic content (grayish soil and/or actual organic debris) that may affect chromium speciation. Tuff surfaces were thoroughly cleaned of overlying soil or sediment before sampling to ensure that the samples would be representative. The field methods are described in Appendix B.

## 3.0 RESULTS

Analytical data from this study include concentrations for total chromium and for hexavalent chromium for each location and depth interval. These results provide the basis for evaluations of naturally occurring chromium and its speciation. Tables 3.0-1, 3.0-2, and 3.0-3 present the detected total chromium and hexavalent chromium results at each reference site and associated field observation notes. Where applicable, for the locations where soil or sediment and tuff were collected, the results are organized in stratigraphic sequence from the surface downward. Figures 3.0-1, 3.0-2, and 3.0-3 show the spatial distribution of chromium detected at the reference sites. Analytical results, analytical reports, and SCLs/COCs are included on DVD in Appendix C.

The results for total chromium in soil are all below the soil background value (BV) of 19.3 mg/kg. Two of twelve results for total chromium in sediment slightly exceed the BV of 10.5 mg/kg at 11.0 mg/kg and 11.6 mg/kg at Reference Site 3. Two of twenty-four results for total chromium in Bandelier Tuff units slightly exceed the Qbt 2, 3, 4 BV of 7.14 mg/kg at 7.44 mg/kg (Reference Site 1) and 8.36 mg/kg (Reference Site 3). All results are below the residential SSLs for total chromium (96.6 mg/kg).

Hexavalent chromium was detected at very low (J-flag) values ranging from 0.126 mg/kg to 0.270 mg/kg in 4 of the 48 samples collected for the study. All hexavalent chromium detections were in Bandelier Tuff: 3 were in in Qbt3 and 1 was in Qbt4. One possible source of hexavalent chromium in Bandelier Tuff may be chromium-bearing minerals such as magnetite, hornblende, or pyroxenes (Broxton and Eller 1995, 058207) that have not undergone the same reduction to trivalent chromium as may have occurred in soils and sediment because of the lack of direct contact with reducing agents such as organic matter or ferrous iron.

## 4.0 CONCLUSIONS

Hexavalent chromium was detected in 4 of 48 background samples collected for this study. For the sampling locations where hexavalent chromium was detected, the ratio of total chromium to hexavalent chromium ranged from 4.5 to 32.6. The predominance of nondetects for hexavalent chromium and low concentrations for the few detections indicate naturally occurring chromium is predominantly in the trivalent form. Therefore, the appropriate SSL for comparisons to data at sites with no known chromium releases is the trivalent SSL (117,000 mg/kg).

## 5.0 RECOMMENDATIONS

As a result of the low number of detects of hexavalent chromium in background samples collected at the Laboratory, DOE/LANS recommends using comparisons to the residential SSL for trivalent chromium instead of the SSL for total chromium in nature and extent discussions at sites where there is no previous indication that hexavalent chromium was used and released. For risk-screening comparisons, total chromium SSLs will continue to be used to evaluate total chromium data at sites where there is no previous indication that hexavalent chromium was used and released.

## 6.0 REFERENCES AND MAP DATA SOURCES

### 6.1 References

*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.*

Broxton, D.E., and P.G. Eller (Eds.), June 1995. "Earth Science Investigations for Environmental Restoration—Los Alamos National Laboratory, Technical Area 21," Los Alamos National Laboratory report LA-12934-MS, Los Alamos, New Mexico. (Broxton and Eller 1995, 058207)

LANL (Los Alamos National Laboratory), September 22, 1998. "Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-98-4847, Los Alamos, New Mexico. (LANL 1998, 059730)

LANL (Los Alamos National Laboratory), May 22, 2017. "Chromium Background Study Work Plan," Los Alamos National Laboratory document LA-UR-17-23664, Los Alamos, New Mexico. (LANL 2017, 602400)

NMED (New Mexico Environment Department), June 1, 2017. "Approval [for the] Chromium Background Study Work Plan," New Mexico Environment Department letter to D. Hintze (DOE-EM-LA) and B. Robinson (LANL) from J.E. Kieling (NMED-HWB), Santa Fe, New Mexico. (NMED 2017, 602418)

## 6.2 Map Data Sources

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

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

SWMU or AOC boundary: Potential Release Sites; Los Alamos National Laboratory, ESH&Q Waste & Environmental Services Division, Environmental Data and Analysis Group.

LANL Areas Used and Occupied; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Office; 19 September 2007; as published 21 June 2017.

Road centerline; Road Centerlines for the County of Los Alamos; County of Los Alamos, Information Services; as published 04 March 2009.

Sampling location; As published; EIM data pull; 2017.

Hypsography; Los Alamos National Laboratory, ER-ES, As published, GIS projects folder; \\slip\gis\GIS\Projects\12-Projects\12-0063\shp\; revise_merge_contour.shp; 2017.

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

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

Communication Lines; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 08 August 2002; as published 29 November 2010.

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

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

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

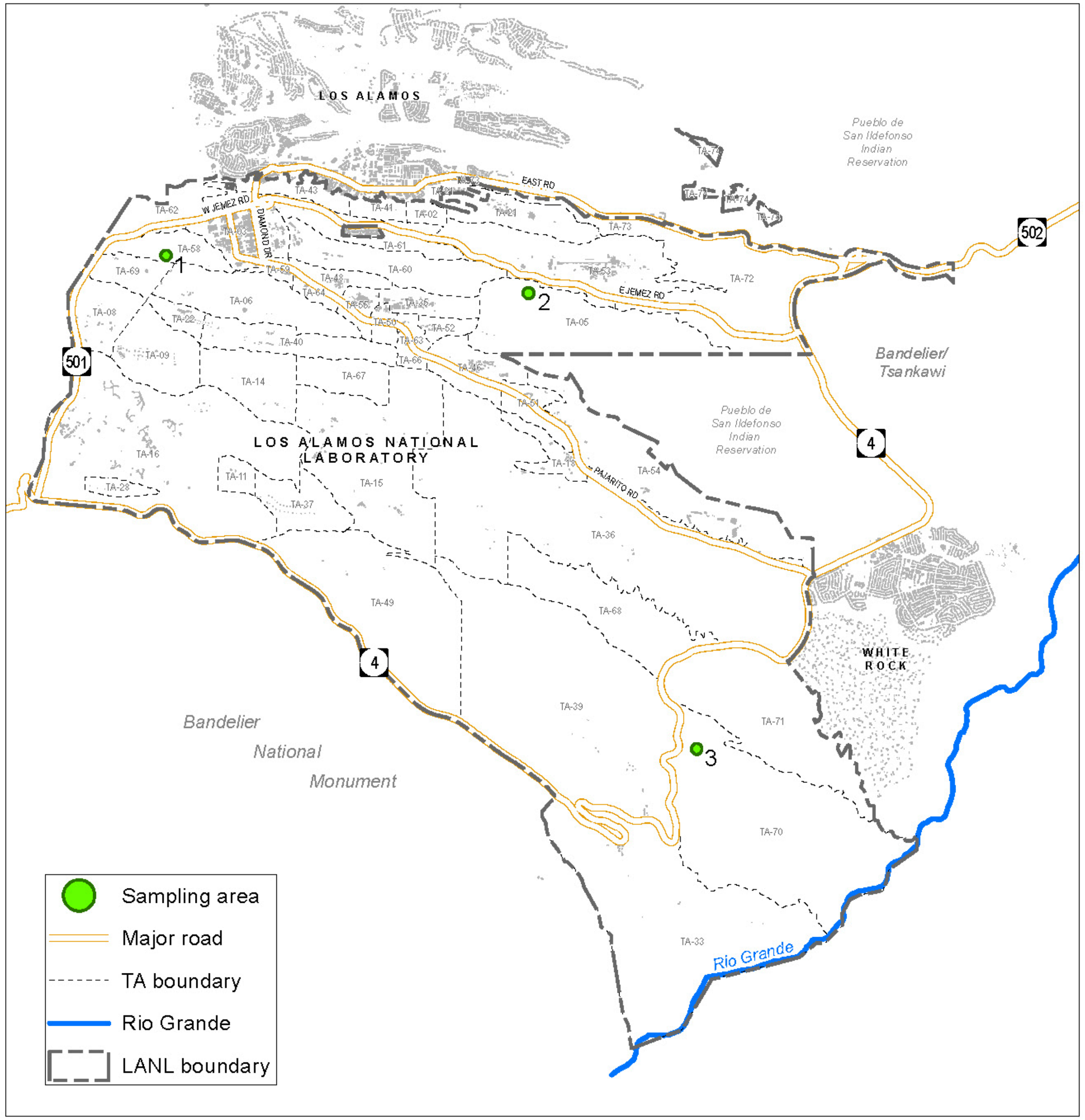

**Figure 2.0-1** **Chromium background study reference sites with respect to Laboratory TAs**

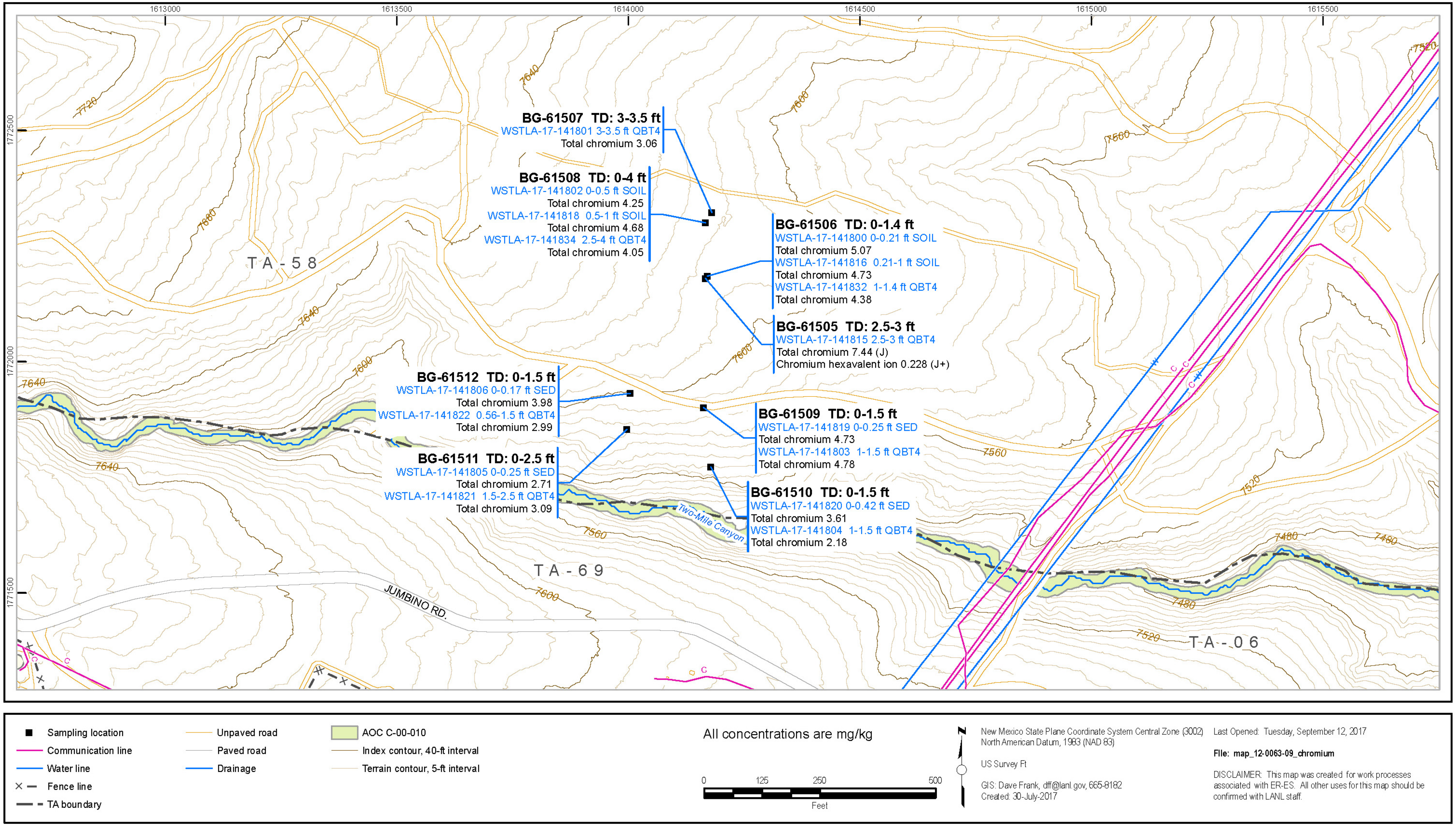

**Figure 3.0-1 Site map and chromium sampling results at Reference Site 1**

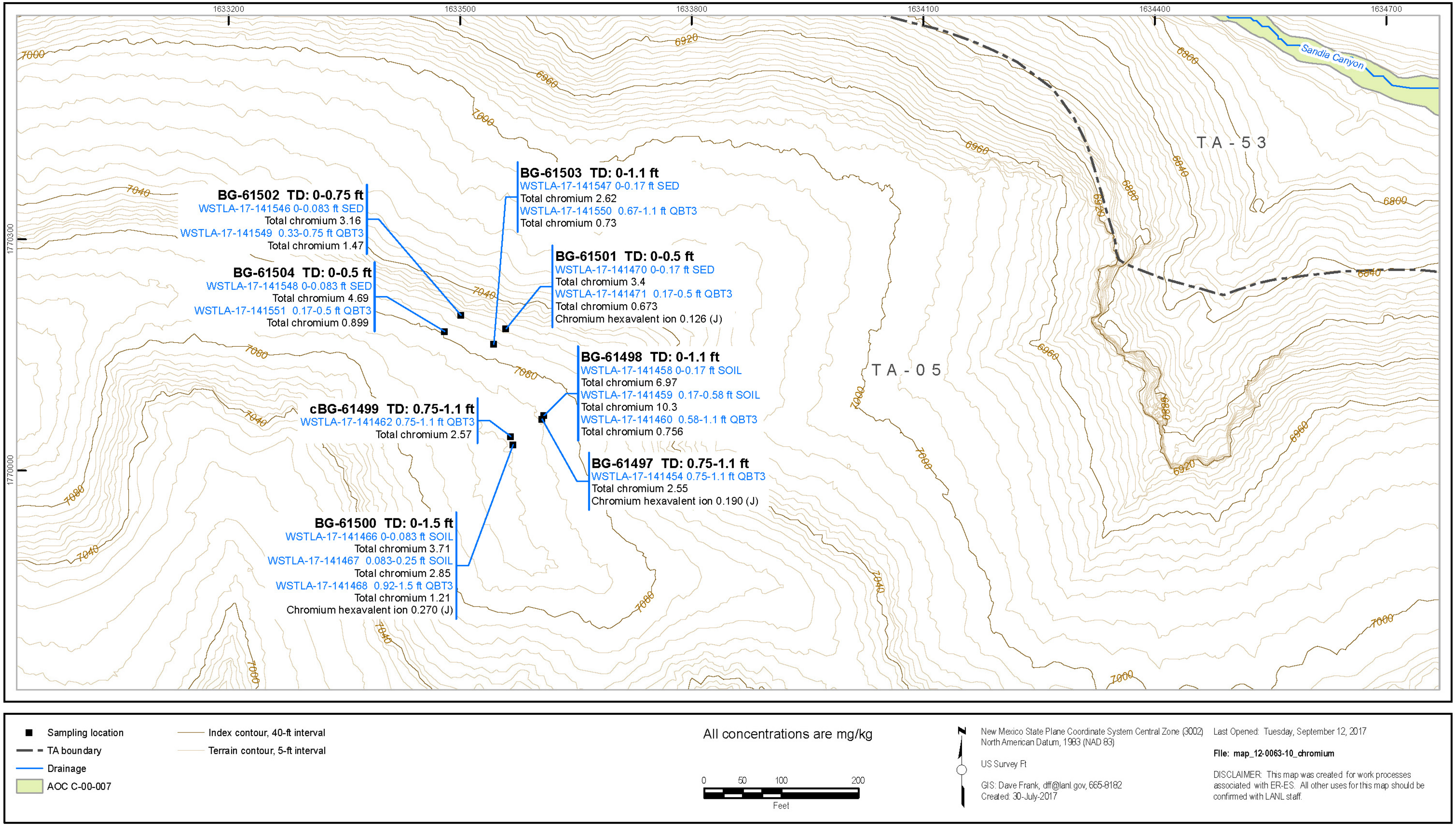

**Figure 3.0-2 Site map and chromium sampling results at Reference Site 2**

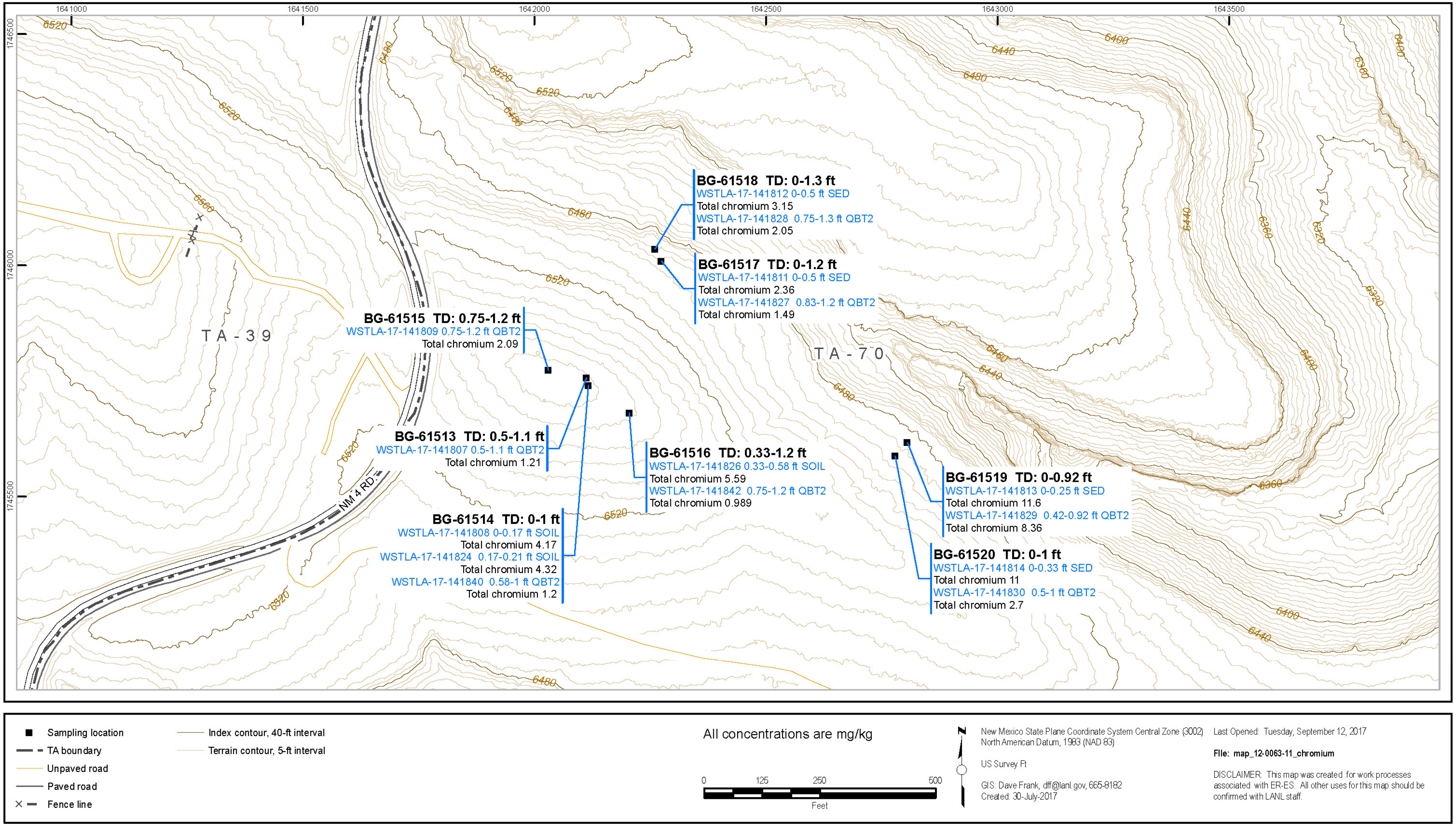

**Figure 3.0-3** Site map and chromium sampling results at Reference Site 3

### Table 2.0-1
### Samples Collected and Analyses Requested

| Sample ID | Location ID | Depth (ft) | Media | Target Analyte List Metals | Hexavalent Chromium | pH | Total Organic Carbon |
|---|---|---|---|---|---|---|---|
| **Reference Site 1** | | | | | | | |
| WSTLA-17-141815 | BG-61505 | 2.5–3 | QBT4 | 2017-1912* | 2017-1912 | 2017-1912 | 2017-1912 |
| WSTLA-17-141800 | BG-61506 | 0–0.21 | SOIL | 2017-1912 | 2017-1912 | 2017-1912 | 2017-1912 |
| WSTLA-17-141816 | BG-61506 | 0.21–1 | SOIL | 2017-1912 | 2017-1912 | 2017-1912 | 2017-1912 |
| WSTLA-17-141832 | BG-61506 | 1–1.4 | QBT4 | 2017-1912 | 2017-1912 | 2017-1912 | 2017-1912 |
| WSTLA-17-141801 | BG-61507 | 3–3.5 | QBT4 | 2017-1912 | 2017-1912 | 2017-1912 | 2017-1912 |
| WSTLA-17-141802 | BG-61508 | 0–0.5 | SOIL | 2017-1912 | 2017-1912 | 2017-1912 | 2017-1912 |
| WSTLA-17-141818 | BG-61508 | 0.5–1 | SOIL | 2017-1912 | 2017-1912 | 2017-1912 | 2017-1912 |
| WSTLA-17-141834 | BG-61508 | 2.5–4 | QBT4 | 2017-1912 | 2017-1912 | 2017-1912 | 2017-1912 |
| WSTLA-17-141819 | BG-61509 | 0–0.25 | SED | 2017-1912 | 2017-1912 | 2017-1912 | 2017-1912 |
| WSTLA-17-141803 | BG-61509 | 1–1.5 | QBT4 | 2017-1912 | 2017-1912 | 2017-1912 | 2017-1912 |
| WSTLA-17-141820 | BG-61510 | 0–0.42 | SED | 2017-1912 | 2017-1912 | 2017-1912 | 2017-1912 |
| WSTLA-17-141804 | BG-61510 | 1–1.5 | QBT4 | 2017-1912 | 2017-1912 | 2017-1912 | 2017-1912 |
| WSTLA-17-141805 | BG-61511 | 0–0.25 | SED | 2017-1912 | 2017-1912 | 2017-1912 | 2017-1912 |
| WSTLA-17-141821 | BG-61511 | 1.5–2.5 | QBT4 | 2017-1912 | 2017-1912 | 2017-1912 | 2017-1912 |
| WSTLA-17-141806 | BG-61512 | 0–0.17 | SED | 2017-1912 | 2017-1912 | 2017-1912 | 2017-1912 |
| WSTLA-17-141822 | BG-61512 | 0.56–1.5 | QBT4 | 2017-1912 | 2017-1912 | 2017-1912 | 2017-1912 |
| **Reference Site 2** | | | | | | | |
| WSTLA-17-141454 | BG-61497 | 0.75–1.1 | QBT3 | 2017-1881 | 2017-1881 | 2017-1881 | 2017-1881 |
| WSTLA-17-141458 | BG-61498 | 0–0.17 | SOIL | 2017-1881 | 2017-1881 | 2017-1881 | 2017-1881 |
| WSTLA-17-141459 | BG-61498 | 0.17–0.58 | SOIL | 2017-1881 | 2017-1881 | 2017-1881 | 2017-1881 |
| WSTLA-17-141460 | BG-61498 | 0.58–1.1 | QBT3 | 2017-1881 | 2017-1881 | 2017-1881 | 2017-1881 |
| WSTLA-17-141462 | BG-61499 | 0.75–1.1 | QBT3 | 2017-1881 | 2017-1881 | 2017-1881 | 2017-1881 |
| WSTLA-17-141466 | BG-61500 | 0–0.083 | SOIL | 2017-1881 | 2017-1881 | 2017-1881 | 2017-1881 |
| WSTLA-17-141467 | BG-61500 | 0.083–0.25 | SOIL | 2017-1881 | 2017-1881 | 2017-1881 | 2017-1881 |
| WSTLA-17-141468 | BG-61500 | 0.92–1.5 | QBT3 | 2017-1881 | 2017-1881 | 2017-1881 | 2017-1881 |
| WSTLA-17-141470 | BG-61501 | 0–0.17 | SED | 2017-1881 | 2017-1881 | 2017-1881 | 2017-1881 |
| WSTLA-17-141471 | BG-61501 | 0.17–0.5 | QBT3 | 2017-1881 | 2017-1881 | 2017-1881 | 2017-1881 |

### Table 2.0-1 (continued)

| Sample ID | Location ID | Depth (ft) | Media | Target Analyte List Metals | Hexavalent Chromium | pH | Total Organic Carbon |
|---|---|---|---|---|---|---|---|
| **Reference Site 2** | | | | | | | |
| WSTLA-17-141546 | BG-61502 | 0–0.083 | SED | 2017-1881 | 2017-1881 | 2017-1881 | 2017-1881 |
| WSTLA-17-141549 | BG-61502 | 0.33–0.75 | QBT3 | 2017-1881 | 2017-1881 | 2017-1881 | 2017-1881 |
| WSTLA-17-141547 | BG-61503 | 0–0.17 | SED | 2017-1881 | 2017-1881 | 2017-1881 | 2017-1881 |
| WSTLA-17-141550 | BG-61503 | 0.67–1.1 | QBT3 | 2017-1881 | 2017-1881 | 2017-1881 | 2017-1881 |
| WSTLA-17-141548 | BG-61504 | 0–0.083 | SED | 2017-1881 | 2017-1881 | 2017-1881 | 2017-1881 |
| WSTLA-17-141551 | BG-61504 | 0.17–0.5 | QBT3 | 2017-1881 | 2017-1881 | 2017-1881 | 2017-1881 |
| **Reference Site 3** | | | | | | | |
| WSTLA-17-141807 | BG-61513 | 0.5–1.1 | QBT2 | 2017-1968 | 2017-1968 | 2017-1968 | 2017-1968 |
| WSTLA-17-141808 | BG-61514 | 0–0.17 | SOIL | 2017-1968 | 2017-1968 | 2017-1968 | 2017-1968 |
| WSTLA-17-141824 | BG-61514 | 0.17–0.21 | SOIL | 2017-1968 | 2017-1968 | 2017-1968 | 2017-1968 |
| WSTLA-17-141840 | BG-61514 | 0.58–1 | QBT2 | 2017-1968 | 2017-1968 | 2017-1968 | 2017-1968 |
| WSTLA-17-141809 | BG-61515 | 0.75–1.2 | QBT2 | 2017-1968 | 2017-1968 | 2017-1968 | 2017-1968 |
| WSTLA-17-141810 | BG-61516 | 0–0.33 | SOIL | 2017-1968 | 2017-1968 | 2017-1968 | 2017-1968 |
| WSTLA-17-141826 | BG-61516 | 0.33–0.58 | SOIL | 2017-1968 | 2017-1968 | 2017-1968 | 2017-1968 |
| WSTLA-17-141842 | BG-61516 | 0.75–1.2 | QBT2 | 2017-1968 | 2017-1968 | 2017-1968 | 2017-1968 |
| WSTLA-17-141811 | BG-61517 | 0–0.5 | SED | 2017-1968 | 2017-1968 | 2017-1968 | 2017-1968 |
| WSTLA-17-141827 | BG-61517 | 0.83–1.2 | QBT2 | 2017-1968 | 2017-1968 | 2017-1968 | 2017-1968 |
| WSTLA-17-141812 | BG-61518 | 0–0.5 | SED | 2017-1968 | 2017-1968 | 2017-1968 | 2017-1968 |
| WSTLA-17-141828 | BG-61518 | 0.75–1.3 | QBT2 | 2017-1968 | 2017-1968 | 2017-1968 | 2017-1968 |
| WSTLA-17-141813 | BG-61519 | 0–0.25 | SED | 2017-1968 | 2017-1968 | 2017-1968 | 2017-1968 |
| WSTLA-17-141829 | BG-61519 | 0.42–0.92 | QBT2 | 2017-1968 | 2017-1968 | 2017-1968 | 2017-1968 |
| WSTLA-17-141814 | BG-61520 | 0–0.33 | SED | 2017-1968 | 2017-1968 | 2017-1968 | 2017-1968 |
| WSTLA-17-141830 | BG-61520 | 0.5–1 | QBT2 | 2017-1968 | 2017-1968 | 2017-1968 | 2017-1968 |

* Analytical request number.

### Table 3.0-1
### Chromium Detected Results and Field Collection Notes at Reference Site 1

| Sample ID | Location ID | Depth (ft) | Media | Total Chromium | Chromium Hexavalent Ion | Field Notes |
|---|---|---|---|---|---|---|
| **Soil BV**[a] | | | | **19.3** | **na**[b] | |
| **Sediment BV** | | | | **10.5** | **na** | |
| **Qbt2, 3, 4 BV** | | | | **7.14** | **na** | |
| WSTLA-17-141815 | BG-61505 | 2.5–3 | QBT4 | 7.44 (J) | 0.228 (J+) | Qbt4 |
| WSTLA-17-141800 | BG-61506 | 0–0.21 | SOIL | 5.07 | —[c] | Silty very fine-grained sand with scattered fine to coarse quartz granules; minor organic debris; roots; dark brown |
| WSTLA-17-141816 | BG-61506 | 0.21–1 | SOIL | 4.73 | — | Silty very fine-grained sand; increase in clay content at contact; organic debris; roots; dark brown |
| WSTLA-17-141832 | BG-61506 | 1–1.4 | QBT4 | 4.38 | — | Qbt4 |
| WSTLA-17-141801 | BG-61507 | 3–3.5 | QBT4 | 3.06 | — | Qbt4 |
| WSTLA-17-141802 | BG-61508 | 0–0.5 | SOIL | 4.25 | — | Silty very fine-grained sand with minor scattered fine to medium quartz granules; accumulation of organic content; minor organic debris; roots; light grayish-brown |
| WSTLA-17-141818 | BG-61508 | 0.5–1 | SOIL | 4.68 | — | Silty very fine-grained sand with minor scattered medium quartz granules; minor Fe; increase of clay and organic debris at tuff interface; reddish-brown |
| WSTLA-17-141834 | BG-61508 | 2.5–4 | QBT4 | 4.05 | — | Qbt4 |
| WSTLA-17-141819 | BG-61509 | 0–0.25 | SED | 4.73 | — | Silty very fine-grained sand with scattered medium to coarse sand; dark (burned?) organic debris; roots; medium-dark brown |
| WSTLA-17-141803 | BG-61509 | 1–1.5 | QBT4 | 4.78 | — | Qbt4 |
| WSTLA-17-141820 | BG-61510 | 0–0.42 | SED | 3.61 | — | Silty fine to medium-grained sand with scattered medium to coarse sand; pumice granules; organic debris; minor roots; light brown |
| WSTLA-17-141804 | BG-61510 | 1–1.5 | QBT4 | 2.18 | — | Qbt4 |
| WSTLA-17-141805 | BG-61511 | 0–0.25 | SED | 2.71 | — | Silty fine-medium-grained sand; pumice granules; scattered organic debris; reddish-brown |
| WSTLA-17-141821 | BG-61511 | 1.5–2.5 | QBT4 | 3.09 | — | Qbt4 |
| WSTLA-17-141806 | BG-61512 | 0–0.17 | SED | 3.98 | — | Very fine-grained sand with scattered medium to coarse sand; pumice granules; organic content at tuff interface; burned organic debris; minor roots; light-pinkish brown |
| WSTLA-17-141822 | BG-61512 | 0.56–1.5 | QBT4 | 2.99 | — | Qbt4 |

Notes: Results are in mg/kg. Data qualifiers are defined in Appendix A.

[a] BVs are from Laboratory guidance (LANL 1998, 059730).

[b] na = Not available.

[c] — = Not detected or not detected above BV.

## Table 3.0-2
## Chromium Detected Results and Field Collection Notes at Reference Site 2

| Sample ID | Location ID | Depth (ft) | Media | Total Chromium | Chromium Hexavalent Ion | Field Notes |
|---|---|---|---|---|---|---|
| **Soil BV**[a] | | | | **19.3** | **na**[b] | |
| **Sediment BV** | | | | **10.5** | **na** | |
| **Qbt2, 3, 4 BV** | | | | **7.14** | **na** | |
| WSTLA-17-141454 | BG-61497 | 0.75–1.1 | QBT3 | 2.55 | 0.190 (J) | Qbt3 |
| WSTLA-17-141458 | BG-61498 | 0–0.17 | SOIL | 6.97 | —[c] | Silty medium to coarse-grained sand with scattered granules; minor Fe; clay coatings; granules are pumice |
| WSTLA-17-141459 | BG-61498 | 0.17–0.58 | SOIL | 10.3 | — | Clay rich; red, medium to coarse-grained sand with minor scattered pumice granules; waxy; sits directly over unweathered tuff |
| WSTLA-17-141460 | BG-61498 | 0.58–1.1 | QBT3 | 0.756 | — | Qbt3 |
| WSTLA-17-141462 | BG-61499 | 0.75–1.1 | QBT3 | 2.57 | — | Qbt3 |
| WSTLA-17-141466 | BG-61500 | 0–0.083 | SOIL | 3.71 | — | Silty very fine-grained sand with scattered medium to coarse quartz grains from dacite; light brown; very little to no organic content |
| WSTLA-17-141467 | BG-61500 | 0.083–0.25 | SOIL | 2.85 | — | Silty very fine-grained sand with scattered medium-coarse sand; slight gray color indicating minor organic content |
| WSTLA-17-141468 | BG-61500 | 0.92–1.5 | QBT3 | 1.21 | 0.270 (J) | Qbt3 |
| WSTLA-17-141470 | BG-61501 | 0–0.17 | SED | 3.4 | — | Fine to medium-grained sand; scattered organic debris; loose |
| WSTLA-17-141471 | BG-61501 | 0.17–0.5 | QBT3 | 0.673 | 0.126 (J) | Qbt3 |
| WSTLA-17-141546 | BG-61502 | 0–0.083 | SED | 3.16 | — | Very fine-grained sand with scattered medium to coarse grains; organic debris; light brown |
| WSTLA-17-141549 | BG-61502 | 0.33–0.75 | QBT3 | 1.47 | — | Qbt3 |
| WSTLA-17-141547 | BG-61503 | 0–0.17 | SED | 2.62 | — | Fine to medium-grained sand; scattered organic debris; light brown |
| WSTLA-17-141550 | BG-61503 | 0.67–1.1 | QBT3 | 0.73 | — | Qbt3 |
| WSTLA-17-141548 | BG-61504 | 0–0.083 | SED | 4.69 | — | Very fine-grained sand; medium-grained sand; scattered organic debris; organic accumulation at tuff interface; light brown |
| WSTLA-17-141551 | BG-61504 | 0.17–0.5 | QBT3 | 0.899 | — | Qbt3 |

Notes: Results are in mg/kg. Data qualifiers are defined in Appendix A.

[a] BVs are from Laboratory guidance (LANL 1998, 059730).

[b] na = Not available.

[c] — = Not detected or not detected above BV.

## Table 3.0-3
## Chromium Detected Results and Field Collection Notes at Reference Site 3

| Sample ID | Location ID | Depth (ft) | Media | Total Chromium | Chromium Hexavalent Ion | Field Notes |
|---|---|---|---|---|---|---|
| **Soil BV**[a] | | | | **19.3** | **na**[b] | |
| **Sediment BV** | | | | **10.5** | **na** | |
| **Qbt2, 3, 4 BV** | | | | **7.14** | **na** | |
| WSTLA-17-141807 | BG-61513 | 0.5–1.1 | QBT2 | 1.21 | —[c] | Qbt2 |
| WSTLA-17-141808 | BG-61514 | 0–0.17 | SOIL | 4.17 | — | Silty very fine-grained sand with scattered medium-coarse sand; pumice granules; abundant organic content; organic debris; roots; dark-grayish brown |
| WSTLA-17-141824 | BG-61514 | 0.17–0.21 | SOIL | 4.32 | — | Silty fine to medium-grained sand with scattered medium sand; pumice granules; organic content at tuff interface; roots; reddish-brown |
| WSTLA-17-141840 | BG-61514 | 0.58–1 | QBT2 | 1.2 | — | Qbt2 |
| WSTLA-17-141809 | BG-61515 | 0.75–1.2 | QBT2 | 2.09 | — | Qbt2 |
| WSTLA-17-141810 | BG-61516 | 0–0.33 | SOIL | n/a[d] | n/a | Silty very fine-grained sand; organic content; roots; light-medium brown |
| WSTLA-17-141826 | BG-61516 | 0.33–0.58 | SOIL | 5.59 | — | Silty fine to medium-grained sand; increase in clay content at base of contact; pumice granules; organic debris; roots; reddish-brown |
| WSTLA-17-141842 | BG-61516 | 0.75–1.2 | QBT2 | 0.989 | — | Qbt2 |
| WSTLA-17-141811 | BG-61517 | 0–0.5 | SED | 2.36 | — | Silty fine-grained sand with scattered medium to coarse sand; pumice granules; organic debris; roots |
| WSTLA-17-141827 | BG-61517 | 0.83–1.2 | QBT2 | 1.49 | — | Qbt2 |
| WSTLA-17-141812 | BG-61518 | 0–0.5 | SED | 3.15 | — | Silty very fine-grained sand with scattered medium to coarse sand; pumice granules; roots; reddish-brown |
| WSTLA-17-141828 | BG-61518 | 0.75–1.3 | QBT2 | 2.05 | — | Qbt2 |
| WSTLA-17-141813 | BG-61519 | 0–0.25 | SED | 11.6 | — | Silty medium to coarse-grained sand; pumice fragments; organic content; roots; dry; reddish-brown |
| WSTLA-17-141829 | BG-61519 | 0.42–0.92 | QBT2 | 8.36 | — | Qbt2 |
| WSTLA-17-141814 | BG-61520 | 0–0.33 | SED | 11 | — | Very fine-grained sand with scattered medium to coarse sand; pumice granules; reddish-brown |
| WSTLA-17-141830 | BG-61520 | 0.5–1 | QBT2 | 2.7 | — | Qbt2 |

Notes: Results are in mg/kg. Data qualifiers are defined in Appendix A.

[a] BVs are from Laboratory guidance (LANL 1998, 059730).

[b] — = Not detected or not detected above BV.

[c] na = Not available.

[d] n/a = Not applicable. Analytical laboratory result rejected.

# Appendix A

## *Acronyms and Abbreviations,*
## *Metric Conversion Table, and Data Qualifier Definitions*

## A-1.0 ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ADEM | Associate Directorate for Environmental Management |
| AOC | area of concern |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| bgs | below ground surface |
| BV | background value |
| COC | chain of custody |
| Consent Order | Compliance Order on Consent |
| COPC | chemical of potential concern |
| DOE | Department of Energy (U.S.) |
| GPS | global positioning system |
| LANL | Los Alamos National Laboratory |
| LANS | Los Alamos National Security, LLC |
| NMED | New Mexico Environment Department |
| QC | quality control |
| RCT | radiological control technician |
| SAL | screening action level |
| SCL | sample collection log |
| SMO | Sample Management Office |
| SOP | standard operating procedures |
| SSL | soil screening level |

## A-2.0 METRIC CONVERSION TABLE

| Multiply SI (Metric) Unit | by | To Obtain U.S. Customary Unit |
|---|---|---|
| kilometers (km) | 0.622 | miles (mi) |
| kilometers (km) | 3281 | feet (ft) |
| meters (m) | 3.281 | feet (ft) |
| meters (m) | 39.37 | inches (in.) |
| centimeters (cm) | 0.03281 | feet (ft) |
| centimeters (cm) | 0.394 | inches (in.) |
| millimeters (mm) | 0.0394 | inches (in.) |
| micrometers or microns (µm) | 0.0000394 | inches (in.) |
| square kilometers ($km^2$) | 0.3861 | square miles ($mi^2$) |
| hectares (ha) | 2.5 | acres |
| square meters ($m^2$) | 10.764 | square feet ($ft^2$) |
| cubic meters ($m^3$) | 35.31 | cubic feet ($ft^3$) |
| kilograms (kg) | 2.2046 | pounds (lb) |
| grams (g) | 0.0353 | ounces (oz) |
| grams per cubic centimeter ($g/cm^3$) | 62.422 | pounds per cubic foot ($lb/ft^3$) |
| milligrams per kilogram (mg/kg) | 1 | parts per million (ppm) |
| micrograms per gram (µg/g) | 1 | parts per million (ppm) |
| liters (L) | 0.26 | gallons (gal.) |
| milligrams per liter (mg/L) | 1 | parts per million (ppm) |
| degrees Celsius (°C) | 9/5 + 32 | degrees Fahrenheit (°F) |

## A-3.0 DATA QUALIFIER DEFINITIONS

| Data Qualifier | Definition |
|---|---|
| U | The analyte was analyzed for but not detected. |
| J | The analyte was positively identified, and the associated numerical value is estimated to be more uncertain than would normally be expected for that analysis. |
| J+ | The analyte was positively identified, and the result is likely to be biased high. |
| J- | The analyte was positively identified, and the result is likely to be biased low. |
| UJ | The analyte was not positively identified in the sample, and the associated value is an estimate of the sample-specific detection or quantitation limit. |
| R | The data are rejected as a result of major problems with quality assurance/quality control (QA/QC) parameters. |

# Appendix B

*Field Methods*

## B-1.0 INTRODUCTION

This appendix summarizes the field methods used during the chromium background study at Los Alamos National Laboratory (LANL or Laboratory). Table B-1.0-1 presents a summary of the field methods used, and the following sections provide more detailed descriptions of these methods. All activities were conducted in accordance with approved Laboratory standard operating procedures (SOPs) listed in Table B-1.0-2 and are available at http://www.lanl.gov/environment/plans-procedures.php.

## B-2.0 EXPLORATORY DRILLING CHARACTERIZATION

No exploratory drilling characterization was conducted during the chromium background study.

## B-3.0 FIELD-SCREENING METHODS

This section summarizes the field-screening methods used during the investigation activities. Field screening for organic vapors was conducted for all samples at all locations, except when the moisture content of the material exceeded instrument detection limits. Field screening for radioactivity was performed on every sample submitted to the Sample Management Office (SMO).

### B-3.1 Field Screening for Radioactivity

All samples collected were field screened for radioactivity before they were submitted to the SMO, targeting alpha and beta/gamma emitters. A Laboratory radiological control technician (RCT) conducted radiological screening using an Eberline E-600 radiation meter with an SHP-380AB alpha/beta scintillation detector held within 1 in. of the sample. The Eberline E-600 with attachment SHP-380AB consists of a dual phosphor plate covered by two Mylar windows housed in a light-excluding metal body. The phosphor plate is a plastic scintillator used to detect beta and gamma emissions and is thinly coated with zinc sulfide to detect alpha emissions. The operational range varies from trace emissions to 1 million disintegrations per minute. Screening measurements were recorded on the sample collection logs (SCLs) and chain of custody (COC) forms and are provided in Appendix E on DVD.

## B-4.0 FIELD INSTRUMENT CALIBRATION

All instruments were calibrated before use. Calibration of the Eberline E-600 was conducted by the RCT. All calibrations were performed according to the manufacturers' specifications and requirements.

### B-4.1 Eberline E-600 Instrument Calibration

The Eberline E-600 was calibrated daily by the RCT before local background levels for radioactivity were measured. The instrument was calibrated using plutonium-239 and chloride-36 sources for alpha and beta emissions, respectively. The following five checks were performed as part of the calibration procedures:

- calibration date
- physical damage
- battery
- response to a source of radioactivity
- background

All calibrations performed for the Eberline E-600 met the manufacturer’s specifications; the requirements of SOP-5006, “Control of Measuring and Test Equipment”; and the applicable radiation detection instrument manual. Calibrations were recorded in daily activity logs.

## B-5.0 SURFACE AND SUBSURFACE SAMPLING

This section summarizes the methods used to collect surface and subsurface samples, including soil, tuff, and sediment samples, according to the approved work plan (LANL 2017, 602400; NMED 2017, 602418).

### B-5.1 Sampling Methods

Samples were collected using a hand-auger or spade and scoop method. Samples were collected in accordance with ER-SOP-20069, “Soil, Tuff, and Sediment Sampling.” A hand auger was used to collect material in approximately 6-in. increments. The hand auger is advanced by turning the auger into tuff until the barrel is filled. The material is removed from the auger and placed in a stainless-steel bowl for homogenization. The process is repeated until the sampling depth is reached and sufficient material is available to satisfy the volume required for the analytical suite. Soil and sediment samples were collected from pothole walls and drainages, respectively, using a stainless-steel spade or scoop and a stainless-steel bowl for homogenization before they were transferred to sterile sample collection jars or bags. Samples were preserved using coolers to maintain the required temperature in accordance with ER-SOP-20235, “Sample Containers, Preservation, and Field Quality Control.”

Samples were appropriately labeled, sealed with custody seals, and documented before it was transported to the SMO. Samples were managed according to ER-SOP-20236, “Handling, Packaging, and Transporting Field Samples,” and OIO-QP-219, “Sample Control and Field Documentation.”

Sample collection tools were decontaminated (see section B-5.7) immediately before each sample was collected in accordance with ER-ERSS-SOP-5061, “Field Decontamination of Equipment.”

### B-5.2 Borehole Logging

At all locations, the required sampling depths could be reached by hand augers, and therefore a drill rig with a hollow-stem auger was not used to collect subsurface samples and the boreholes did not require logging.

### B-5.3 Quality Control Samples

Quality control (QC) samples were collected in accordance with ER-SOP-20235, “Sample Containers, Preservation, and Field Quality Control.” The QC samples included field duplicates and field rinsate blanks. Field duplicate samples were collected from the same material as the regular investigation samples and submitted for the same analyses. Field duplicate samples were collected at a frequency of at least 1 duplicate sample for every 10 samples.

Field rinsate blanks were collected to evaluate field decontamination procedures. Rinsate blanks were collected by rinsing sampling equipment (i.e., auger buckets and sampling bowls and spoons) after decontamination with deionized water. The rinsate water was collected in a sample container and submitted to the SMO. Field rinsate blank samples were analyzed for target analyte list metals and were collected from sampling equipment at a frequency of at least 1 rinsate sample for every 10 solid samples.

### B-5.5 Sample Documentation and Handling

Field personnel completed an SCL and COC form for each sample. Sample containers were sealed with signed custody seals and placed in coolers at approximately 4°C. Samples were handled in accordance with ER-SOP-20236, “Handling, Packaging, and Transporting Field Samples,” and ER-SOP-20235, “Sample Containers, Preservation, and Field Quality Control.” Swipe samples were collected from the exterior of sample containers and analyzed by the RCT before the sample containers were removed from the site. Samples were transported to the SMO for processing and shipment to off-site contract analytical laboratories. The SMO personnel reviewed and approved the SCLs and COC forms and accepted custody of the samples. The SCLs and COC forms are provided in Appendix E (on DVD).

### B-5.6 Borehole Abandonment

No boreholes were drilled during the background study.

### B-5.7 Decontamination of Sampling Equipment

The hand augers and all sampling equipment that came (or could have come) in contact with sample material were decontaminated after each samples was collected. Decontamination included wiping the equipment with Fantastik and paper towels. Residual material adhering to equipment was removed using dry decontamination methods such as the use of wire brushes and scrapers. Decontamination activities were performed in accordance with ER-ERSS-SOP-5061, “Field Decontamination of Equipment.”

## B-6.0 GEODETIC SURVEYING

Surveys were conducted in accordance with the latest version of SOP EP-ERSS-SOP-5028, “Coordinating and Evaluating Geodetic Surveys.” The surveyors used a Trimble GeoXT handheld global positioning system (GPS) or equivalent to provide “map-grade” coordinates to document sampling locations. The coordinate values are expressed in the New Mexico State Plane Coordinate System (transverse mercator), Central Zone, North American Datum 1983. Elevations are reported as per the National Geodetic Vertical Datum of 1929. All GPS equipment used met the accuracy requirements specified in the SOP.

## B-7.0 INVESTIGATION-DERIVED WASTE STORAGE AND DISPOSAL

All investigation-derived waste (IDW) generated during the field investigation was managed in accordance with ER-DIR-SOP-10021, “Characterization and Management of Environmental Programs Waste.” This procedure incorporates the requirements of all applicable U.S. Environmental Protection Agency (EPA) and New Mexico Environment Department regulations, U.S. Department of Energy orders, and Laboratory requirements.

## B-8.0 REFERENCES

*The following reference list includes documents cited in this appendix. 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.*

LANL (Los Alamos National Laboratory), May 22, 2017. "Chromium Background Study Work Plan," Los Alamos National Laboratory document LA-UR-17-23664, Los Alamos, New Mexico. (LANL 2017, 602400)

NMED (New Mexico Environment Department), June 1, 2017. "Approval [for the] Chromium Background Study Work Plan," New Mexico Environment Department letter to D. Hintze (DOE-EM-LA) and B. Robinson (LANL) from J.E. Kieling (NMED-HWB), Santa Fe, New Mexico. (NMED 2017, 602418)

## Table B-1.0-1
## Summary of Field Investigation Methods

| Method | Summary |
|---|---|
| Spade and Scoop Collection of Soil Samples | This method was used to collect shallow (i.e., approximately 0−1.0 ft) soil or sediment samples. The spade-and-scoop method involved digging a hole to the desired depth, as prescribed in the approved investigation work plan, and collecting a discrete grab sample. Sample material was placed in a clean stainless-steel bowl for transfer into various sample containers. |
| Hand Auger Sampling | This method is typically used for sampling soil or sediment at depths of less than 10.0–15.0 ft, but in some cases may be used to collect samples of weathered or nonwelded tuff. The method involves hand-turning a stainless-steel bucket auger (typically 3.0–4.0 in. inside diameter), creating a vertical hole that can be advanced to the desired sampling depth. When the desired depth was reached, the auger was decontaminated before the hole was advanced through the sampling depth. The sample material was transferred from the auger bucket to a stainless-steel sampling bowl before the various required sample containers were filled. |
| Handling, Packaging, and Shipping of Samples | Field team members sealed and labeled samples before packing to ensure the sample and the transport containers were free of external contamination.<br>Field team members packaged all samples to minimize the possibility of breakage during transport.<br>After all environmental samples were collected, packaged, and preserved a field team member transported them to the SMO. The SMO arranged to ship the samples to the analytical laboratories. |
| Sample Control and Field Documentation | The collection, screening, and transport of samples were documented on standard forms generated by the SMO. These included SCLs, COC forms, and sample container labels. SCLs were completed at the time of sample collection, and the logs were signed by the sampler and a reviewer who verified the logs for completeness and accuracy. Corresponding labels were initialed and applied to each sample container, and custody seals were placed around each sample container. COC forms were completed and signed to verify that the samples were not left unattended. |
| Field Quality Control Samples | Field QC samples were collected as follows:<br>*Field Duplicates*: At a frequency of 10%; collected at the same time as a regular sample and submitted for the same analyses<br>*Equipment Rinsate Blank*: At a frequency of 10%; collected by rinsing sampling equipment with deionized water, which was collected in a sample container and submitted for laboratory analysis |
| Field Decontamination of Drilling and Sampling Equipment | Dry decontamination was used to minimize the generation of liquid waste. Dry decontamination included the use of a wire brush or other tool to remove soil or other material adhering to the sampling equipment, followed by use of a commercial cleaning agent (nonacid, waxless cleaners) and paper wipes. |
| Containers and Preservation of Samples | Specific requirements/processes for sample containers, preservation techniques, and holding times are based on EPA guidance for environmental sampling, preservation, and quality assurance. Specific requirements for each sample were printed on the SCL provided by the SMO (size and type of container [e.g., glass, amber glass, or polyethylene]). All samples were preserved by placing them in insulated containers with ice to maintain a temperature of 4°C. |

### Table B-1.0-1 (continued)

| Method | Summary |
|---|---|
| Coordinating and Evaluating Geodetic Surveys | Geodetic surveys focused on obtaining survey data of acceptable quality to use during project investigations. Geodetic surveys were conducted with a Trimble GeoXT handheld GPS or equivalent to provide “map-grade” coordinates to document sampling locations. The survey data conformed to Laboratory Information Architecture project standards IA-CB02, GIS Spatial Reference System, and IA-D802, Geospatial Positioning Accuracy Standards for A/E/C/ and Facility Management. All coordinates were expressed as State Plane Coordinate System 83, NM Central, U.S. feet. All elevation data were reported relative to the National Geodetic Vertical Datum of 1983. |

### Table B-1.0-2
### SOPs Used for Investigation Activities Conducted

| |
|---|
| ER-DIR-SOP-10021, Characterization and Management of Environmental Programs Waste |
| ER-SOP-20069, Soil, Tuff, and Sediment Sampling |
| ER-SOP-20235, Sample Containers, Preservation, and Field Quality Control |
| ER-SOP-20236, Handling, Packaging, and Transporting Field Samples |
| OIO-QP-219, Sample Control and Field Documentation |
| EP-ERSS-SOP-5028, Coordinating and Evaluating Geodetic Surveys |
| ER-ERSS-SOP-5061, Field Decontamination of Equipment |

# Appendix C

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*Analytical Suites and Results and Analytical Reports*
*(on CD included with this document)*