Northern Agency Tronox Mines

FINAL
Appendix H28
Site-Specific Removal Site Evaluation Report
Mesa II, Mine No. 1, P-150 (M28)

Response, Assessment, and Evaluation Services (RAES)

Contract No. EP-S9-17-03

Task Order 0001

October 10, 2019

Submitted to

U.S. Environmental Protection Agency

Submitted by

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ACRONYMS AND ABBREVIATIONS

µR/hr	Microroentgen per hour
ABA	Acid-base accounting
amsl	Above mean sea level
ANSI	American National Standards Institute
ASPECT	Airborne Spectral Photometric Environmental Collection Technology
ASTM	ASTM International
AUM	Abandoned uranium mine
bgs	Below ground surface
BSA	Background study area
BSA-24	Background Study Area 24
BSA-29	Background Study Area 29
BTV	Background threshold value
COPC	Contaminant of potential concern
cpm	Count per minute
DEM	Digital elevation model
DQO	Data quality objective
EE/CA	Engineering evaluation/cost analysis
ERG	Environmental Restoration Group, Inc.
FSP	Field sampling plan
GIS	Geographic information system
GPS	Global positioning system
HDOP	Horizontal dilution of precision
HPIC	High pressure ionization chamber
Jml	Lower Morrison Formation
Jse	Undifferentiated Summerville Entrada Formation
Jste	Undifferentiated Summerville, Todilto, and Entrada Formations
Kerr-McGee	Kerr-McGee Oil Industries, Inc.
K-40	Potassium-40
LIDAR	Light detecting and ranging
MARLAP	*Multi-Agency Radiation Laboratory Analytical Protocols Manual*
MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*
MCAP	Mine Category Assessment Protocol

ACRONYMS AND ABBREVIATIONS (CONTINUED)

mg/kg	Milligram per kilogram
m^2	Square meter
NaI	Sodium iodide
NAMLRP	Navajo Abandoned Mine Lands Reclamation Program
Neptune	Neptune and Company, Inc.
NORM	Naturally occurring radioactive material
NRCS	U.S. Natural Resources Conservation Service
pCi/g	Picocuries per gram
pCi/L	Picocuries per liter
PCSM	Preliminary conceptual site model
ppt CaCO3	Tons of calcium carbonate equivalent per 1,000 tons of material
QA/QC	Quality assurance/quality control
Ra-226	Radium-226
Ra-228	Radium-228
RAES	Response, assessment, and evaluation services
RPM	Remedial Project Manager
RSE	Removal site evaluation
RSE Report	Northern Agency Tronox Mines Removal Site Evaluation Report
RSSI	Radiation survey and site investigation
SAP/QAPP	Sampling and Analysis Plan/Quality Assurance Project Plan
SPLP	Synthetic precipitation leaching procedure
SSRSE	Site-specific removal site evaluation
SOP	Standard operating procedure
TENORM	Technologically enhanced naturally occurring radioactive material
Tetra Tech	Tetra Tech, Inc.
TCLP	Toxicity characteristic leaching procedure
TSG	TerraSpectra Geomatics
U_3O_8	Triuranium octoxide
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
USL 95	95 percent upper simultaneous limit
UTL 95-95	95 percent upper tolerance limit
V_2O_5	Vanadium pentoxide

ACRONYMS AND ABBREVIATIONS (CONTINUED)

Weston	Weston Solutions, Inc.
XRF	X-ray fluorescence
yd^3	Cubic yards

EXECUTIVE SUMMARY

The purpose of this report is to document the objectives, methodology, and results of the Site-Specific Removal Site Evaluation (SSRSE) for Mesa II, Mine No. 1, P-150 (Tetra Tech ID M28), an underground abandoned uranium mine (AUM) formerly operated by Kerr-McGee Oil Industries, Inc. (also known as Tronox) that is situated in the Lukachukai Mountains within the Cove Chapter of Apache County, Arizona, inside the Navajo Nation. This AUM site is one of 39 Northern Agency Tronox Mines that are undergoing removal site evaluations (RSE) by the U.S. Environmental Protection Agency (USEPA) under the 2015 Tronox Settlement Agreement to address the legacy uranium mines in the Navajo Nation that were formerly operated by Tronox. The Mesa II, Mine No. 1, P-150 is located adjacent to Mesa II, Mine No. 1 & 2, P-21 (Tetra Tech ID M27). Potentially impacted drainages and historical mining roads related to Mesa II, Mine No. 1, P-150 are discussed in Appendix J and Appendix K of the Northern Agency Tronox Mines Removal Site Evaluation Report (RSE Report), respectively.

Reclamation activities were performed by the Navajo Abandoned Mines Land Reclamation Program (NAMLRP) at the site, which included the closure a of five portals (Portals 42a, 42b, 42c, 40, and 41), which were all excavated, stabilized, backfilled with polyurethane foam, and covered with fill material (Neptune and Company, Inc. [Neptune] and TerraSpectra Geomatics [TSG] 2018). Waste Pile 42 (renamed and expanded by Tetra Tech as Waste Pile M28) was inaccessible during the reclamation activities and left unreclaimed. Waste materials may include overburden, mine debris, and waste rock from the exploration and mining that occurred at the site. All ore that was extracted at the mine was milled at an offsite location, and no uranium tailings are present within the mine waste materials at the site.

An RSE field investigation was performed at Mesa II, Mine No. 1, P-150 to determine the (1) contaminants of potential concern (COPC); (2) lateral and vertical extent of mining-related contamination; and (3) volume of waste remaining at the site. The field investigation included site mapping, X-ray fluorescence (XRF) field surveys, gamma radiation surveys, surface soil sampling, and subsurface soil sampling during two separate investigations referred to as the Baseline Study and the Site Characterization Study. Background investigations were performed at Background Study Area 24 (BSA-24) and Background Study Area 29 (BSA-29), and a regional geological background investigation was also conducted within the Summerville Entrada Formation (Jse). The background investigations were performed to identify background threshold values (BTV) for gamma radiation and radionuclides and chemicals in soil. The lowest of the site-specific BSA-24, BSA-29 and the Jse regional BTVs were selected as the applied BTV for each analyte and used for the background comparison analysis presented in this report.

A total of 26,696 gamma radiation measurements were collected across the survey area using mobile global positioning system (GPS)-based gamma survey systems. A total of 222 in situ XRF measurements were collected across the survey area within systematic 10- by 10-meter square grids to estimate the concentrations of nine different analytes in surficial soil. In addition, fourteen XRF confirmation soil samples from a depth of 0 to 3 inches below ground surface (bgs) and six surface soil samples from a depth of 0 to 6 inches bgs were collected. A shallow subsurface investigation program was also implemented to complete five borings and collect environmental and radiological samples from each to a maximum depth of 12 inches bgs. The

soil samples were submitted for laboratory analysis of 28 analytes, including both chemicals and radionuclides. One XRF confirmation soil sample was also analyzed for mercury.

Site data were compared to the BTVs for the site. A total of 26 analytes were identified as COPCs based on exceedance of their respective BTV. COPCs identified in the surface environment were aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, molybdenum, nickel, radium-226 (Ra-226), selenium, silver, sodium, thallium, thorium, uranium, vanadium, and zinc. The same COPCs were identified in the subsurface except for barium, beryllium, lead, and manganese.

Out of 242 uranium surface soil samples, the detected results ranged from 0.19 to 660 milligrams per kilogram (mg/kg) with an average of 28 mg/kg. The maximum uranium concentration was observed in survey unit G7 at the eastern edge of Waste Pile M28. Out of 20 Ra-226 surface soil samples, the results ranged from 0.83 to 136 picocuries per gram (pCi/g) with an average of 27.3 pCi/g. The maximum Ra-226 concentration was also observed at survey unit G7 at the eastern edge of Waste Pile M28. The acid-base accounting (ABA) results at Mesa II, Mine No. 2, P-150 mine indicate that the waste rock is not acid producing.

There are five reclaimed portals at Mesa II, Mine No. 1, P-150. There is a single unreclaimed waste pile associated with the site. Approximately 18,000 cubic yards of waste material with COPC concentrations above the BTV remain at Mesa II, Mine No. 1, P-150, of which 50 percent is within the unreclaimed waste pile. The waste pile is located on a steep slope and extends into a drainage and is threatened by erosion with likely potential for offsite surface water migration pathways.

In general, the RSE investigation was successful at fulfilling the data quality objectives, and few data gaps remain for Mesa II, Mine No. 1, P-150. The remaining data gaps for Mesa II, Mine No. 1, P-150 are the depth to groundwater and the existing groundwater quality, as well as radon gas concentrations. The data generated during this investigation greatly expanded upon previous investigations and will be used to assist in developing and evaluating cleanup options in the engineering evaluation/cost analysis (EE/CA).

1.0 INTRODUCTION

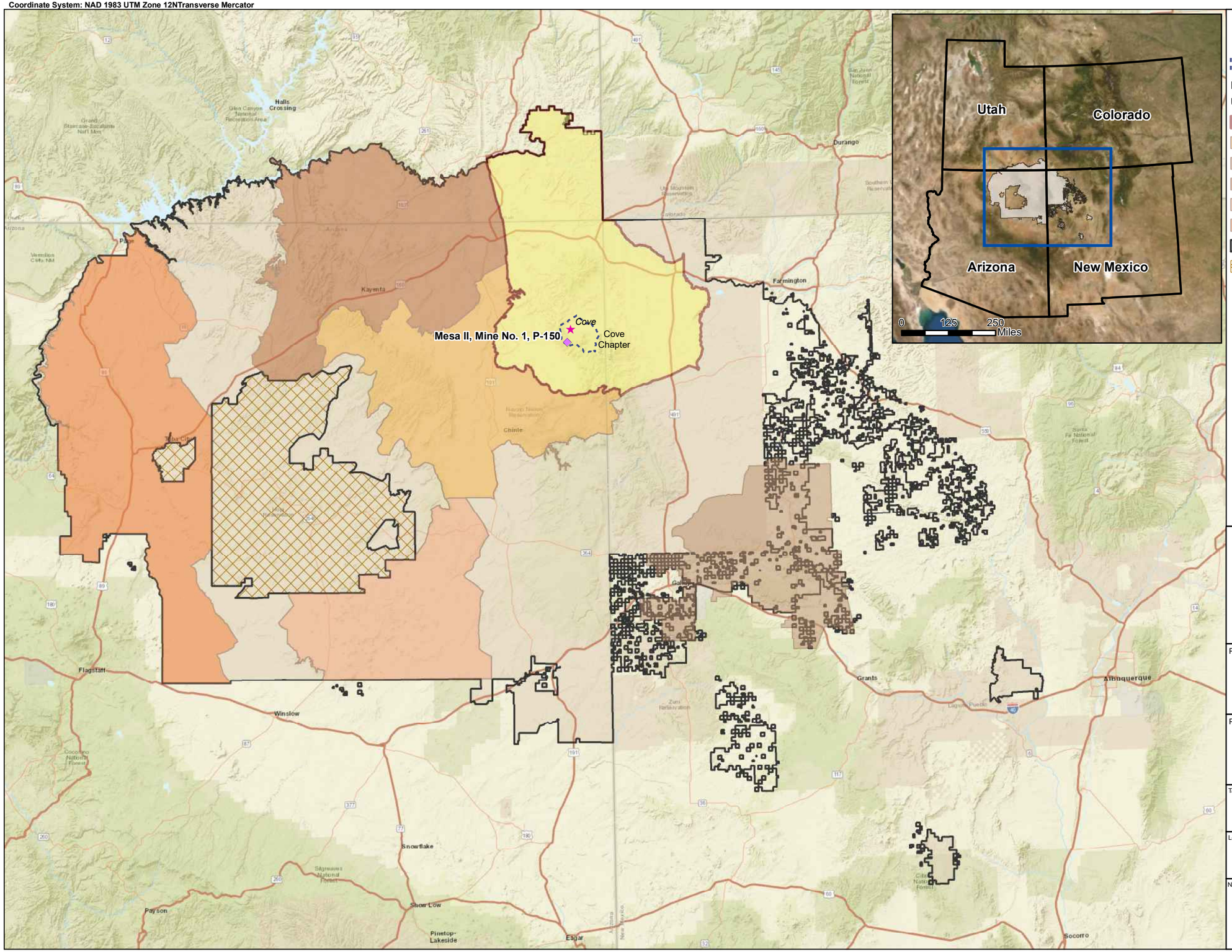
This Site-Specific Removal Site Evaluation (SSRSE) Report is included as Appendix H28 of the Northern Agency Tronox Mines Removal Site Evaluation Report (RSE Report). This report presents and documents the objectives, methodology, and results of the SSRSE performed at the abandoned uranium mine (AUM) site referred to as Mesa II, Mine No. 1, P-150 by Tetra Tech, Inc. (Tetra Tech) in support of the U.S. Environmental Protection Agency (USEPA) under Task Order 0001 of the Response, Assessment, and Evaluation Services (RAES) contract (EP-S9-17-03). The data generated during this investigation will be used to assist in developing and evaluating cleanup options in the engineering evaluation/cost analysis (EE/CA).

Mesa II, Mine No. 1, P-150 (Tetra Tech ID M28) is located within the Cove Chapter in the Navajo Nation. Figure H28-1 presents an overview map of the different AUM regions in the Navajo Nation and highlights the Northern AUM Region area of interest in which Mesa II, Mine No. 1, P-150 is located. Under Task Order 0001, Tetra Tech conducted removal site evaluation (RSE) field investigations at a number of AUM sites within the Navajo Nation that had previously been operated by, or likely associated with, Kerr-McGee Oil Industries, Inc. (Kerr-McGee) or its successor, Tronox (both Kerr-McGee and Tronox referred to herein as Tronox). Mesa II, Mine No. 1, P-150 was part of a larger complex of mines on Mesa II, which includes Mesa II, Mine No. 1 & 2, P-21 (M27) and Mesa I 3/4, Mine No. 2, P-150 (M26). This mine site is considered one of the Northern Agency Tronox Mines and is included under the 2015 Tronox Settlement Agreement managed by USEPA Region 9. The field sampling activities conducted at Mesa II, Mine No. 1, P-150 were performed in accordance with the Field Sampling Plan (FSP), included as Appendix F of the RSE Work Plan, and as part of the Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP), included as Appendix C of the RSE Work Plan (Tetra Tech 2018).

In the RSE Work Plan, Tetra Tech (2018) proposed to conduct a phased sampling approach, which included a Baseline Study and a Site Characterization Study. Both phases were completed during the 2018 field season. The Baseline Study was performed in June 2018, and the Site Characterization Study was performed in September 2018. The RSE investigation presented in this SSRSE was conducted to collect sufficient information to support the risk assessment and EE/CA, which will address the potential mine-related contamination associated with historical mining operations. This report only addresses the Mesa II, Mine No. 1, P-150 AUM site. Non-AUM Target sites are addressed in Appendix I of the RSE Report. Potentially impacted drainages and historical mining roads related to Mesa II, Mine No. 1, P-150 are discussed in Appendix J and Appendix K of the RSE Report, respectively.

All field work performed as part of the RSE investigation was conducted in accordance with the RSE Work Plan submitted on May 14, 2018 (Tetra Tech 2018). The RSE Work Plan identified a need for a comprehensive site characterization at the Mesa II, Mine No. 1, P-150 AUM site to satisfy data quality objectives (DQO) via gamma radiation surveys, X-ray fluorescence (XRF) field surveys, surface soil sampling, and subsurface soil sampling to establish the lateral and vertical extent of mining-related contamination of radionuclides and chemical constituents at the Northern Agency Tronox Mines. The RSE Work Plan discusses the DQOs in detail; however, a roadmap is provided in Section 1.2 to show how the specific DQO study questions are addressed in this SSRSE. The following subsection presents the primary purpose and objectives of the RSE investigation at Mesa II, Mine No. 1, P-150.

Coordinate System: NAD 1983 UTM Zone 12NTransverse Mercator



- Abandoned Uranium Mine Site
- Populated Place
- Affected Chapter Boundary

Navajo Nation Abandoned Uraniun Mine Regions

- Northern Region
- Central Region
- Eastern Region
- North Central Region
- Southern Region
- Western Region
- Navajo Nation
- Hopi Reservation

1 in = 26 mi

1:1,647,360

N W E S

26 13 0 26 Miles

REGIONAL OVERVIEW OF MESA II, MINE NO. 1, P-150

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Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location:	**Date:**
NAVAJO NATION	7/22/2019
Notes:	**Figure No.:**
	H28-1

1.1 PURPOSE AND OBJECTIVES

In 2018, Tetra Tech conducted a data gap analysis as part of a historical site assessment for Mesa II, Mine No. 1, P-150. Based on the results of that data gap analysis, Tetra Tech concluded that there was not sufficient data for USEPA to make risk management or cleanup decisions at the site. Therefore, Tetra Tech (2018) developed several DQOs as part of the RSE Work Plan. Survey design and planning processes were integrated into the RSE investigations performed at the Northern Agency Tronox Mines. The results of the data gap analysis are provided in Appendix A of the RSE Work Plan while a detailed list of DQOs are presented in the SAP/QAPP in Appendix C (Tetra Tech 2018). The objectives of the RSE investigation were as follows:

- Identify contaminants of potential concern (COPC) that exceed established background levels at Mesa II, Mine No. 1, P-150. The background levels were established within Appendix A of the RSE Report.
- Define the lateral and vertical extent of contamination at the site related to technologically enhanced naturally occurring radioactive material (TENORM) from historical mining operations.
- Calculate the volume of mine waste material estimated to have concentrations above background levels.
- Identify where DQOs affect or require modification of the RSE field sampling methods.

The following subsection presents the DQOs established for the site, explains how each of the DQOs were addressed as part of this RSE investigation, and provides a roadmap for where the results of each DQO are found.

1.2 DATA QUALITY OBJECTIVES

A primary objective of the RSE investigation was to address the DQOs established for both the Baseline Study and Site Characterization Study. The DQOs for the project are presented in Appendix C of the RSE Work Plan, and the site-specific DQOs are provided in the site-specific FSP provided in Appendix F of the RSE Work Plan. A roadmap for how the Baseline Study DQOs and the Site Characterization Study DQOs are addressed in this SSRSE Report is presented in Table H28-1 and Table H28-2, respectively. Baseline Study Question No. 4 regarding groundwater impacts was not addressed as part of this SSRSE or the project-wide RSE investigation based on technical direction from USEPA. This is discussed in the RSE Report in more detail.

Table H28-1. Baseline Study Data Quality Objective Roadmap

Phase of the RSE	Question No.	Principal Study Question	Activity Performed to Address DQO	Section of SSRSE Report
Baseline Study	1	What are the background levels of gamma radiation and what are the background concentrations of radionuclides and metals in soils and sediment that are representative of conditions at each site?	Background Sampling	Section 3.0
	2	What is the lateral extent of mine-related surficial contamination at each site?	Site Mapping	Section 2.6
			Gamma Radiation Survey	Section 5.1
			XRF Field Survey	Section 5.0 and Section 7.0
			Surface Soil Samples	Section 5.0 and Section 7.0
			Site Classification	Section 6.1
	3	Is there potential for contaminants to migrate offsite via surface water pathways at each site?	Drainage Survey	Section 8.0
	4	Is there potential for contaminants to migrate offsite via the groundwater pathway?[1]	NA	Main RSE Report
	5	What is the spatial extent, locations, and types of NORM and TENORM at the site?	Site Mapping	Section 8.0
	6	Have the Tronox NAUM risk prioritization factors been evaluated adequately (such as site accessibility, reclamation status, land use, and waste material characteristics)?[2]	Site Mapping	Section 2.0

Notes:

[1] Baseline Study Question No. 4 regarding groundwater impacts was not addressed as part of this SSRSE or the project-wide RSE investigation based on technical direction from USEPA; this is discussed in the main RSE Report (Tetra Tech 20105) in more detail.

[2] Tronox NAUM risk prioritization factors are being developed by stakeholders to prioritize cleanup at Northern Agency Tronox Mines.

DQO Data quality objective
NAUM Navajo Area Uranium Mines
NORM Naturally occurring radioactive material
RSE Removal site evaluation
SSRSE Site-specific removal site evaluation
TENORM Technologically enhanced naturally occurring radioactive material
XRF X-ray fluorescence

Table H28-2. Site Characterization Study Data Quality Objective Roadmap

Phase of the RSE	Question No.	Principal Study Question	Activity Performed to Address DQO	Section of SSRSE Report
Site Characterization Study	1	Did the Baseline Study adequately identify the lateral extent of surficial contamination at the site, downwind areas, and drainages?	Site Mapping	Section 2.6
			Gamma Radiation Survey	Section 5.1
			XRF Field Survey	Section 5.0 and Section 7.0
			Surface Soil Samples	Section 5.0 and Section 7.0
			Site Classification	Section 6.1
	2	Has the lateral extent of mine-related radionuclides and metals in surface soil, waste, or sediment been adequately defined?	Surface Soil Samples	Section 7.0 and Section 8.0
	3	What is the lateral and vertical extent of mine-related subsurface radionuclides and metals in soils and waste at each site?	Subsurface Sampling	Section 7.0 and Section 8.0
	4	Are mine-related radionuclides and metals in surface soils, waste, and drainage sediments potentially leaching to surface water or groundwater?	Geochemical Sampling	Section 5.2.4
	5	Has Groundwater been impacted by historical mining activities? [1]	NA	Main RSE Report
	6	What is the distribution of concentrations of radon gas present at accessible mine openings, waste piles, and drainages and is radon being emitted from buried waste cells?[2]	NA	Main RSE Report
	7	Have the physical characteristics of mine waste been adequately evaluated to support modeling, remedy evaluation, and evaluation of the Tronox NAUM risk prioritization factors?[3]	Geotechnical Sampling	Section 5.2.5

Notes:

[1] Site Characterization Study Question No. 5 regarding groundwater impacts was not addressed as part of this SSRSE or the project-wide RSE investigation based on technical direction from USEPA; this is discussed in the main RSE Report (Tetra Tech 2018) in more detail.

[2] Mesa II Mine, Mine No. 1, P-150 was not selected for a radon gas sampling location.

[3] Tronox NAUM risk prioritization factors are being developed by stakeholders to prioritize cleanup at Northern Agency Tronox Mines.

DQO	Data quality objective	SSRSE	Site-specific removal evaluation
NAUM	Navajo Area Uranium Mines	XRF	X-ray fluorescence
RSE	Removal site evaluation		

1.3 REPORT ORGANIZATION

This is the twenty-eighth report in Appendix H of the Northern Agency Tronox Mines RSE Report and presents the objectives, methodology, and results of the SSRSE activities performed at the Mesa II, Mine No. 1, P-150 AUM site. This appendix is organized as follows:

- Section 1.0 provides the introduction, purpose and objectives, and DQOs of the RSE investigation.
- Section 2.0 presents the site setting, including site identification and physical setting, geological and soils information, site mining and reclamation history, summary of previous investigations, and site features.
- Section 3.0 presents a summary of established background levels for Mesa II, Mine No. 1, P-150.
- Section 4.0 presents field sampling methods, laboratory analytical methods, quality assurance/quality control (QA/QC) methods, and desktop analysis methods used in the development of this report.
- Section 5.0 presents the field sampling results, including gamma radiation survey, XRF field survey, soil sampling, geochemical, and geotechnical results.
- Section 6.0 provides a background comparison analysis for all the analytes and sample types used in the identification process of COPCs.
- Section 7.0 provides a summary and mapping of the geospatial extent of primary analytes.
- Section 8.0 presents the evaluation of the lateral and vertical extent of mine-related contamination, including mine waste volume estimation and offsite migration pathways.
- Section 9.0 presents conclusions and identifies data gaps and recommendations.
- Section 10.0 presents the references for works cited in this report.

Attachments to this report provide important supporting information and data tables. The summary of attachments are as follows:

- Attachment H28-1 presents additional XRF field survey and soil sampling results tables.
- Attachment H28-2 presents the field documentation completed in support of the RSE investigation.
- Attachment H28-3 presents the photographic log of the RSE field investigation activities and important site features.
- Attachment H28-4 presents the gamma radiation survey comparison maps. These maps compare the gamma radiation survey data from the 2018 RSE investigation to the Mine Category Assessment Protocol (MCAP), site screen investigation gamma radiation survey data, and Airborne Spectral Photometric Environmental Collection Technology (ASPECT) flyover data.

Appendix H is intended to be used in conjunction with other appendices in the RSE Report that provide results and interpretation, which are:

- Appendix A Radiological and Chemical Background Investigation Report
- Appendix B XRF Data Evaluation Report
- Appendix C Gamma Correlation Report
- Appendix D Uranium Equilibrium Report
- Appendix E Geotechnical Evaluation Report
- Appendix F Geochemical Evaluation Report
- Appendix G Data Quality Assurance Summary Report
- Appendix I Target Site Evaluation Report
- Appendix J Drainage Investigation Report
- Appendix K Access Road Investigation Report
- Appendix L Laboratory Reports
- Appendix M Data Validation Reports

2.0 SITE SETTING

2.1 SITE IDENTIFICATION AND PHYSICAL SETTING

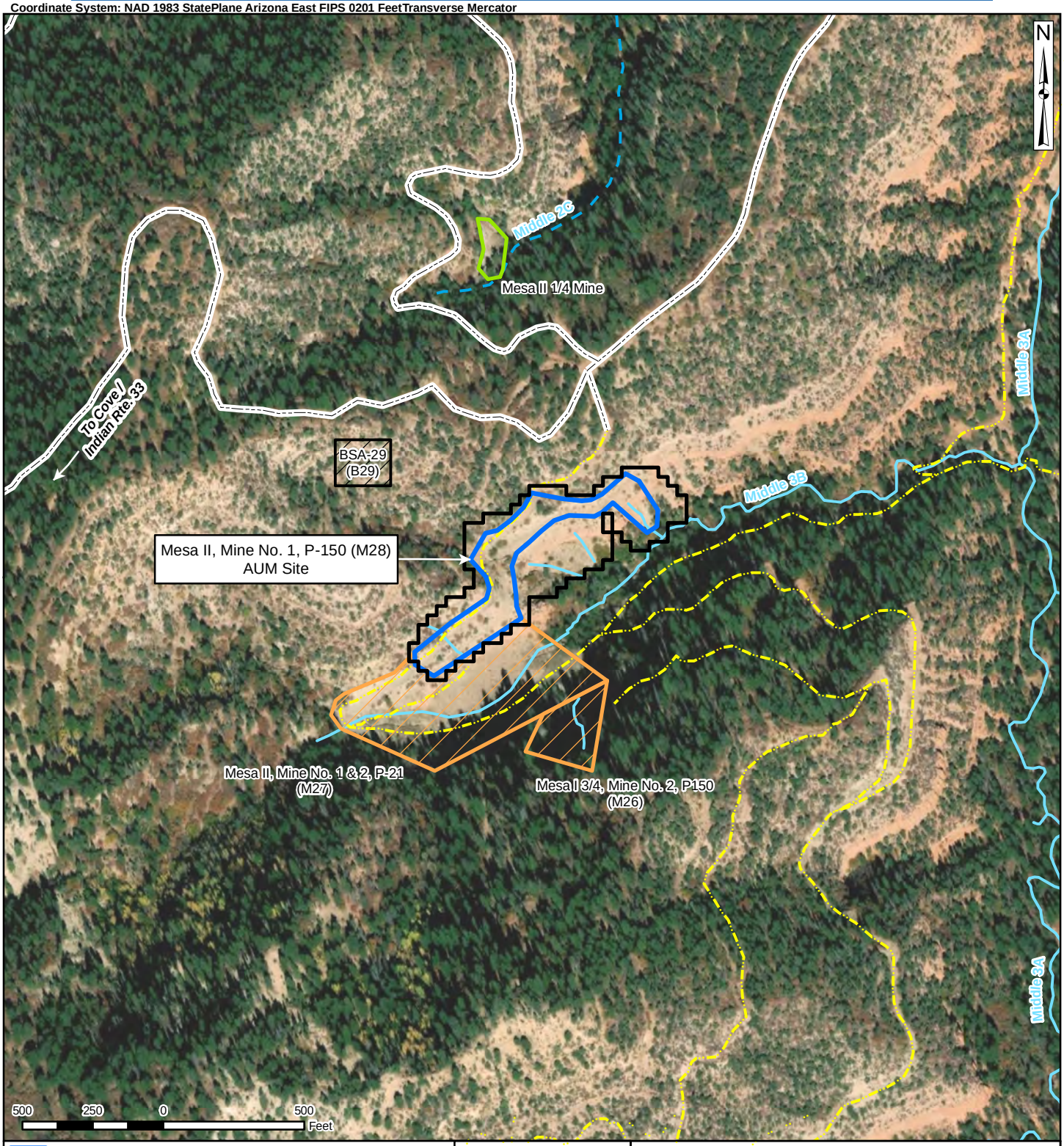
Mesa II, Mine No. 1, P-150 (Tetra Tech ID M28) is a former underground uranium-vanadium mine in the Lukachukai Mountains in Apache County, Arizona. This mine is part of a larger complex of mines located on Mesa II. Historical production and mining history of this site is described in Section 2.3. The RSE Work Plan (Tetra Tech 2018) geographically subdivided the project sites into 10 Subarea Groups (A through J) as shown in the RSE Report. This AUM site is within Subarea Group H of the Northern Agency Tronox Mine RSE investigation project as defined in the RSE Report.

The area in which this former mine is located is administered by the Cove Chapter and accessed by driving 45 minutes from Cove, Arizona, south on the Mesa V access road and east to the Mesa II access road. Once on the Mesa II access road it is an approximate 15-minute drive east to the Mesa II base camp. The northern portion of the site is a 10-minute moderate hike on an old haul road from the Mesa II base camp. There is currently no vehicle access on the old haul road to the site because there are large boulders present and other obstacles preventing vehicular access. The site location and access, along with nearby drainages, are shown in Figure H28-2.

Figure H28-2 shows Mesa II, Mine No. 1, P-150 with respect to drainages and other AUM sites. This figure displays the 2.9-acre AUM site boundary in blue and the 6.79-acre survey area in black. A digital version of the AUM site boundary was provided to Tetra Tech from the USEPA geodatabase (Neptune and Company, Inc. [Neptune] and TerraSpectra Geomatics [TSG] 2018). The survey area in the RSE Work Plan (Tetra Tech 2018) was selected based on multiple lines of evidence, including topographic data, mine features, and historical radiation data. The survey area was later subdivided into 275 survey units, each 100 square meters (m^2) in size. The 6.79-acre survey area is contiguous with Mesa II, Mine No. 1 & 2, P-21 to the south. Other AUM sites nearest to Mesa II, Mine No. 1, P-150 are Mesa I 3/4, Mine No. 2, P-150 (M26), which is contiguous with Mesa II, Mine No. 1 & 2, P-21.

From the 10-meter digital elevation model (DEM) available online from the U.S. Geological Survey (USGS), a topographic map was generated using the geographic information system (GIS) and the associated elevations and slopes for the AUM site were modeled. The topography generated from the DEM is provided in Figure H28-3. The Mesa II, Mine No. 1, P-150 survey area boundary has a mean elevation of 7,537 feet above mean sea level (amsl) and a mean slope of 38 degrees. There are significant elevation changes, and the site is difficult to access and perform the necessary survey work. Light detection and ranging (LIDAR) will be flown in 2019 to allow for a better estimate of waste slopes and volumes in the EE/CA.

There is an ephemeral drainage southeast of Mesa II, Mine No. 1, P-150 in the canyon below. The closest major drainage to the site is the Middle 3B reach of the Middle San Juan Watershed, which is adjacent to the site boundary. This drainage has been sampled in the past for surface water and sediment by Weston Solutions, Inc. (Weston) as part of the Cove Wash Watershed assessment (Weston 2018). This drainage was also sampled by Tetra Tech in 2018, and the results are presented in the Drainage Report in Appendix J of the RSE Report. There are no wells identified within the vicinity of this AUM site. The closest identified well (Deer Springs) is located 1.76 miles from the site according to the USEPA geodatabase (Neptune and TSG 2018).



AUM Site Boundary
Survey Area Boundary
Other Tronox AUM Site Boundary
Background Location
Non-Tronox AUM Site
Access Route - Foot
Access Route - Vehicular
Drainage - Field Mapped

*U.S Environmental Protection Agency, Region 9, Superfund Program, *Abandoned Uranium Mines and the Navajo Nation Part II Atlas With Geospatial Data. NN_Drainage_HR_AUM.shp.* July, 2007.

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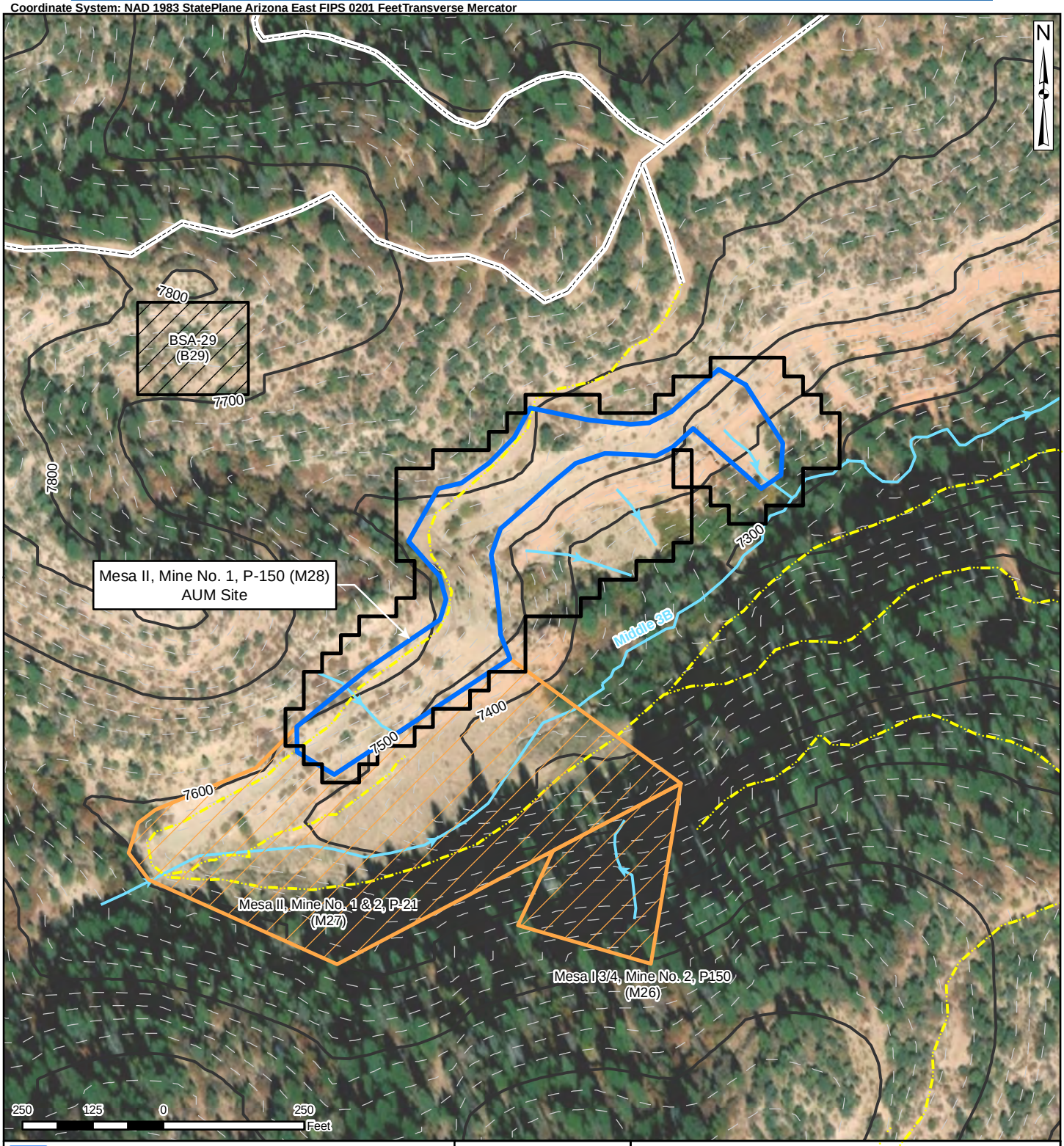
MESA II, MINE NO. 1, P-150 LOCATION AND ACCESS MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	H28-2
Location: COVE CHAPTER NAVAJO NATION	Date: 7/7/2019	

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



AUM Site Boundary
Survey Area Boundary
Background Location
Other Tronox AUM Site Boundary
Access Route - Foot
Access Route - Vehicular
Drainage - Field Mapped
100 ft Contour*
20 ft Contour*

*U.S. Geological Survey, The National Map, 2017, 3DEP products and services: The National Map, 3D Elevation Program Web page, accessed 02/19/2018 at https://nationalmap.gov/3DEP/3dep_prodserv.html.

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MESA II, MINE NO. 1, P-150
TOPOGRAPHIC MAP

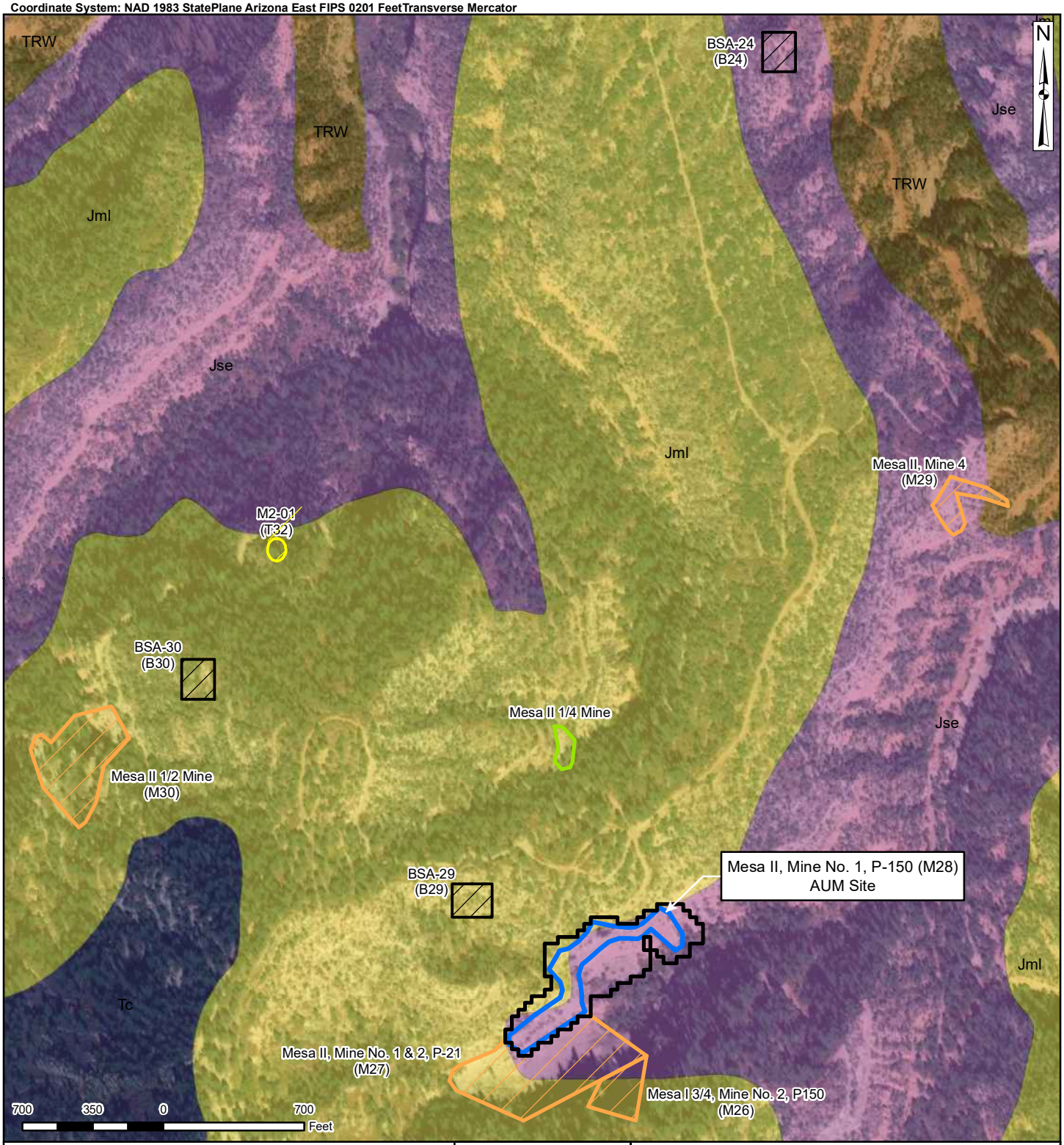
Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	H28-3
Location: COVE CHAPTER NAVAJO NATION	Date: 7/7/2019	

2.2 GEOLOGICAL SETTING

As noted in Section 2.1, Mesa II, Mine No. 1, P-150 is located in Lukachukai Mountains. The Mesa II, Mine No. 1, P-150 survey area is primarily (80 percent) within the Undifferentiated Summerville Entrada Formation (Jse), and secondarily (20 percent) within the Lower Morrison Formation (Jml) as shown in Figure H28-4. Jml is composed of the Recapture and Salt Wash Members. The depth to groundwater at this AUM site is unknown.

A map showing the different soil types near Mesa II, Mine No. 1, P-150 is provided in Figure H28-5. The majority (91 percent) of the survey area is situated within the Hozho-Quezcan-Rock outcrop soil complex (primarily sandstone bedrock with rapid surface runoff rate). This soil type is identified by symbol 413 in the Soil Survey of Shiprock Area by the U.S. Department of Agriculture (USDA) and U.S. Natural Resources Conservation Service (NRCS) (USDA and NRCS 2001). This complex consists of Hozho soil, Quezcan soil, and rock outcrops. The Hozho soil has typical characteristics of the following depth profiles: reddish brown cobbly sandy loam from 0 to 3 inches; reddish brown sandy loam from 3 to 6 inches; pinkish gray and very pale brown loamy sand from 6 to 14 inches; and soft sandstone bedrock at 14 inches. In general, Hozho soil is excessively drained with rapid surface runoff, has a very severe hazard of water erosion, and has a moderate hazard of soil blowing. The Quezcan soil has typical characteristics of the following depth profiles: light gray very cobbly clay loam from 0 to 3 inches; light gray gravelly clay loam from 3 to 6 inches; light gray clay loam from 6 to 10 inches; pink and light gray silty clay loam from 10 to 27 inches; and shale bedrock at 27 inches. In general, Quezcan soil is well drained with rapid runoff, has a very severe hazard for water erosion, and has a moderate hazard for soil blowing. In general, the rock outcrops consist of sandstone bedrock with rapid surface runoff. The remainder (9 percent) of the Mesa II, Mine No. 1, P-150 survey area is within the Narbona-Zilditloi complex. This soil type is identified by symbol 608 in the Soil Survey of Shiprock Area (USDA and NRCS 2001). The Narbona soil has typical characteristics of the following depth profiles: a one-inch thick covering of pine needles, oak leaves, and twigs; brown very flaggy loamy sand from 0 to 7 inches; pinkish gray very channery loamy sand 7 to 28 inches; and light brown and reddish yellow very stony sandy loam and very stony sandy clay loam from 28 to 63 inches. In general, Narbona soil is well drained with rapid surface runoff, a severe hazard of water erosion, and a slight hazard of soil blowing. The Zilditloi soil has typical characteristics of the following depth profiles: brown loamy sand from 0 to 7 inches; very pale brown sand from 7 to 31 inches; and very pale brown sand from 31 to 70 inches. In general, Zilditloi soil is excessively drained with rapid surface runoff, a very severe hazard of water erosion, and a moderate hazard of soil blowing. A more detailed discussion on regional and site-specific geology and soil types is provided in Appendix B of the RSE Work Plan and Appendix A of the RSE Report.

Two site-specific background study areas (Background Study Area 24 [BSA-24] and Background Study Area 29 [BSA-29]) were identified, investigated, and determined to be suitable areas based on the criteria identified in Appendix B of the RSE Work Plan. Further discussion of the background investigation and how it pertains to Mesa II, Mine No. 1, P-150 is presented in Section 3.0.



Geologic Units*

- Chuska sandstone - Tc
- Morrison Formation (Lower) - Jml
- Summerville, Entrada Formation (Undifferentiated) - Jse
- Wingate Sandstone - TRW

- AUM Site Boundary
- Survey Area Boundary
- Background Location
- Other Tronox AUM Site Boundary
- Non-AUM Target Site Boundary
- Non-Tronox AUM Site

*O'Sullivan, R.B., and Beikman, H.M. (1963). *Geology, structure, and uranium deposits of the Shiprock quadrangle, New Mexico and Arizona* . Accessed 01/10/2018. https://ngmdb.usgs.gov/Prodesc/proddesc_1389.htm

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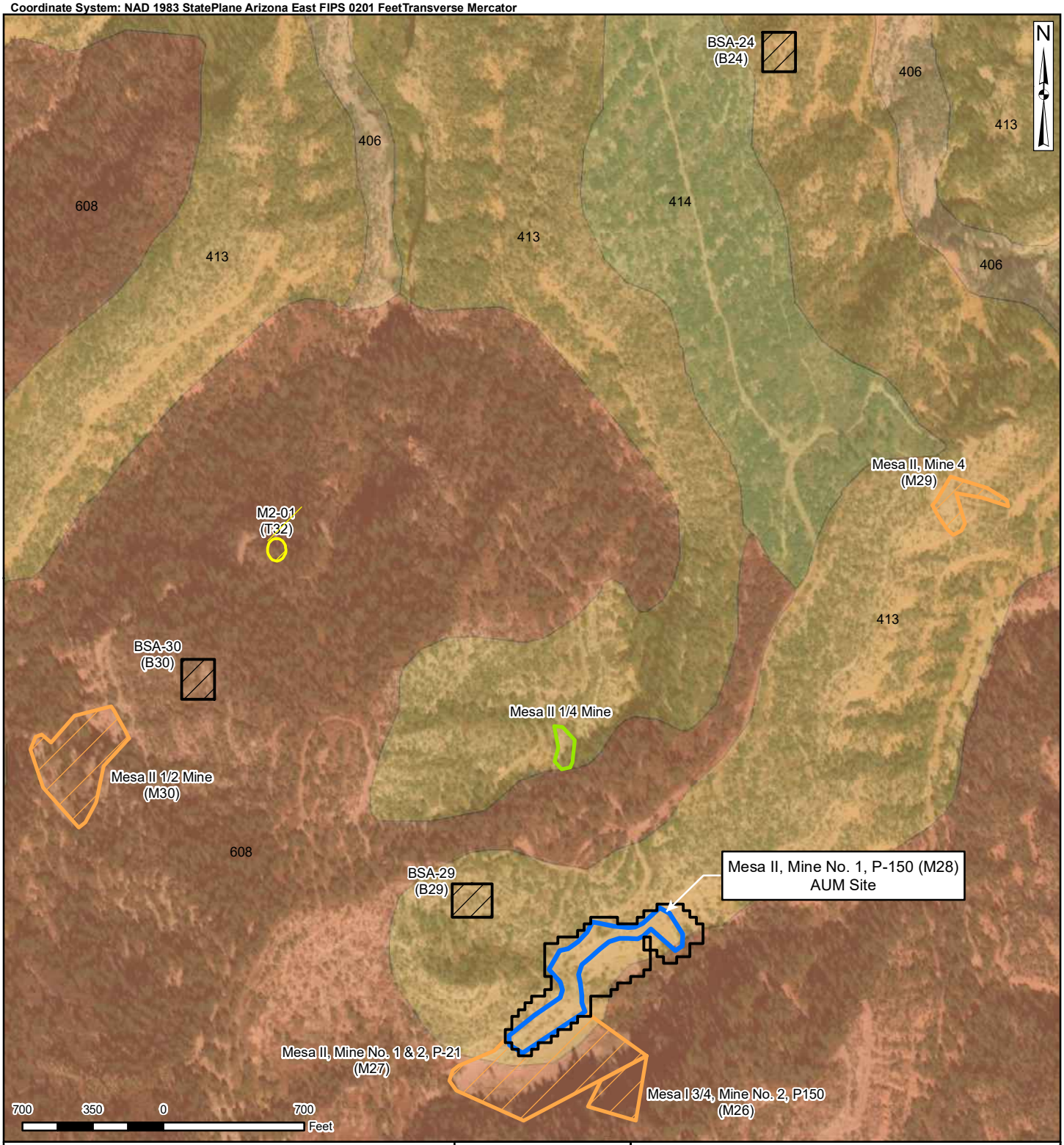
MESA II, MINE NO. 1, P-150 GEOLOGIC MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	H28-4
Location: COVE CHAPTER NAVAJO NATION	Date: 7/22/2019	

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



Soil Type*

- Rock outcrop-Nizhoni complex - 406
- Hozho-Quezcan-Rock outcrop complex - 413
- Arabrab-Wetherill complex - 414
- Narbona-Zilditloi complex - 608

- AUM Site Boundary
- Related Survey Area
- Background Location
- Other Tronox AUM Site Boundary
- Non-AUM Target Site Boundary
- Non-Tronox AUM Site

*Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. *Soil Survey Geographic (SSURGO) Database for Arizona*. Accessed 1/10/2018. https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

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MESA II, MINE NO. 1, P-150
SOILS MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	H28-5
Location: COVE CHAPTER NAVAJO NATION	Date: 7/22/2019	

2.3 SITE MINING HISTORY

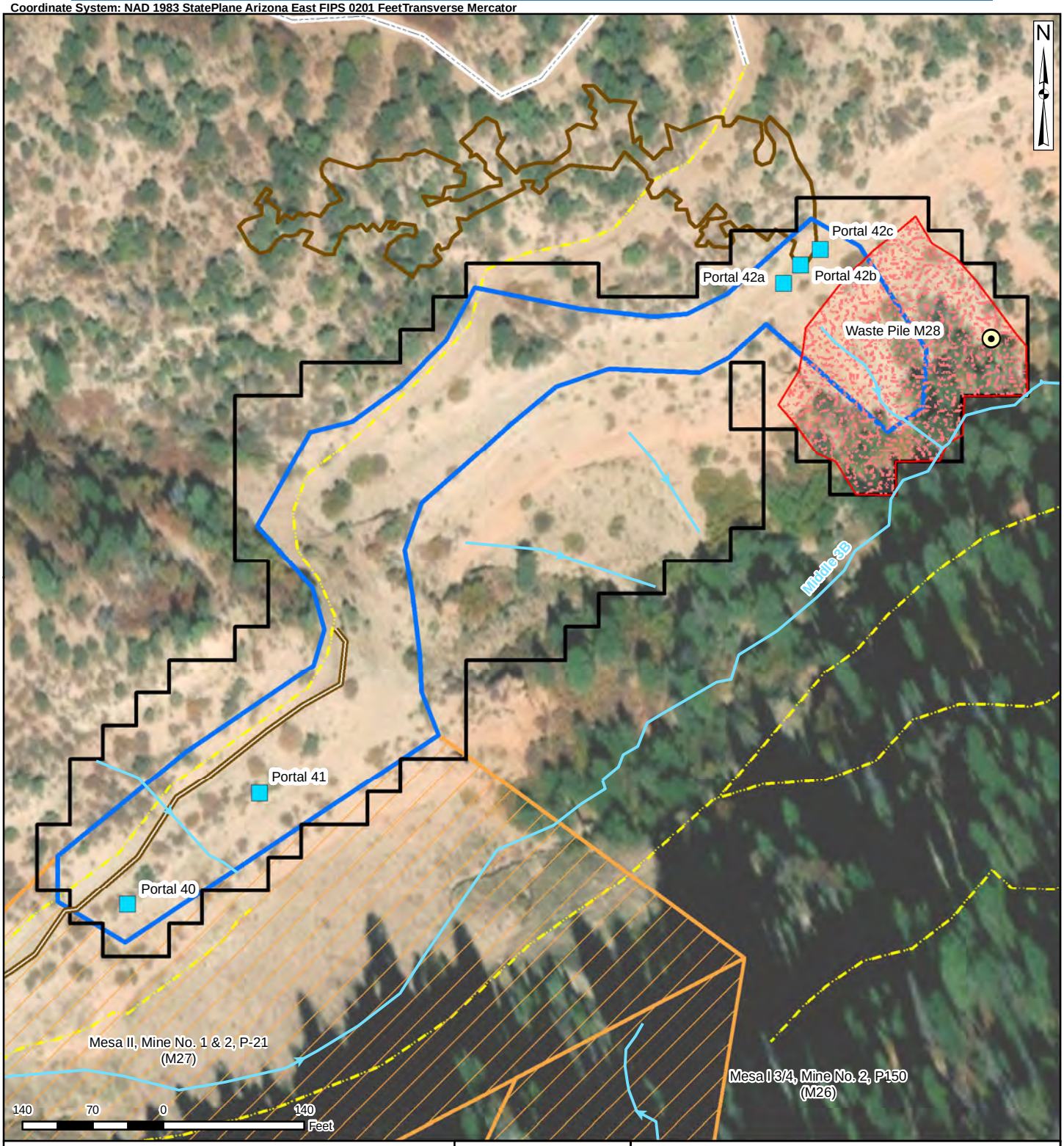
In May 1952, Tronox acquired the Navajo Uranium Company and a 75 percent interest in the Koley Black and Dan Phillips mine leases (Chenoweth 1988). Tronox signed operating agreements with David, Dan, and Henry Phillips for their unnumbered mining permits on Mesa II, I 3/4, and III respectively. Later that year, Tronox opened up two new mines, each on opposite sides of the canyon separating Mesa I 3/4 and Mesa II. The mine that opened on the Mesa II side of the canyon was Mesa II, Mine No. 1, P-150. The mine that opened on Mesa I 3/4 is Mesa I 3/4, Mine No. 1 & 2, P-150 (M26). Both of these mines were on the Dan Phillips permit, which would later be given the number P-150. Additionally, at this time, two other mines were opened up on the central part of Mesa II that included Mesa II, Mine 4 (M29) and Mesa II 1/2, Mine 4 (M31).

Mesa II, Mine No. 1, P-150 was operated by Kerr-McGee from 1952 to 1955 and produced a total of 3,825 tons of ore. The ore mined produced 20,241 pounds of triuranium octoxide (U_3O_8) at 0.26 percent and 77,045 pounds of vanadium pentoxide (V_2O_5) at 1.01 percent (Chenoweth 1988). The Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data also contains information on underground workings (U.S. Army Corps of Engineers [USACE] 2007). A georectified version of this plan view is shown in Figure H28-6, along with the site features for Mesa II, Mine No. 1, P-150. This figure shows the entire underground complex for Mesa II, Mine No. 1, P-150. Figure H28-7 depicts the pre- and post-mining conditions through historical and recent imagery.

Waste materials may include overburden, mine debris, and waste rock from the exploration and mining that occurred at the site. All ore that was extracted at the mine was milled at an offsite location, and no uranium tailings are present within the mine waste materials at the site.

2.4 SITE RECLAMATION HISTORY

Reclamation work was performed at Mesa II, Mine No. 1, P-150 by the NAMLRP as part of the NA-0312A Cove 3 Phase II reclamation project as described in Neptune and TSG (2018). The NA-0312A reclamation project included Mesa I 3/4, Mine No. 2, P-150 and Mesa II, Mine No. 1 & 2, P-21. This reclamation project commenced on July 18, 2001 and ended on December 25, 2001. The reclamation activities at Mesa II, Mine No. 1, P-150 included the closure of five portals (Portals 42a, 42b, 42c, 40, and 41), which were all excavated, stabilized, backfilled with polyurethane foam, and covered with fill material (Neptune and TSG 2018). Waste Pile 42 (renamed by Tetra Tech as Waste Pile M28) was inaccessible during the reclamation activities and left unreclaimed. Weston (2010) estimated 463 cubic yards (yd^3) remain on the site. According to the USEPA geodatabase (Neptune and TSG 2018), the waste pile is the only unreclaimed feature at the site.



AUM Site Boundary
Underground Workings
Survey Area Boundary
Other Tronox AUM Site Boundary

Waste Pile - Unreclaimed
Access Route - Foot
Access Route - Vehicular
Drainage - Field Mapped

Site Features

Closed Portal
Pipe - Field Mapped
Berm

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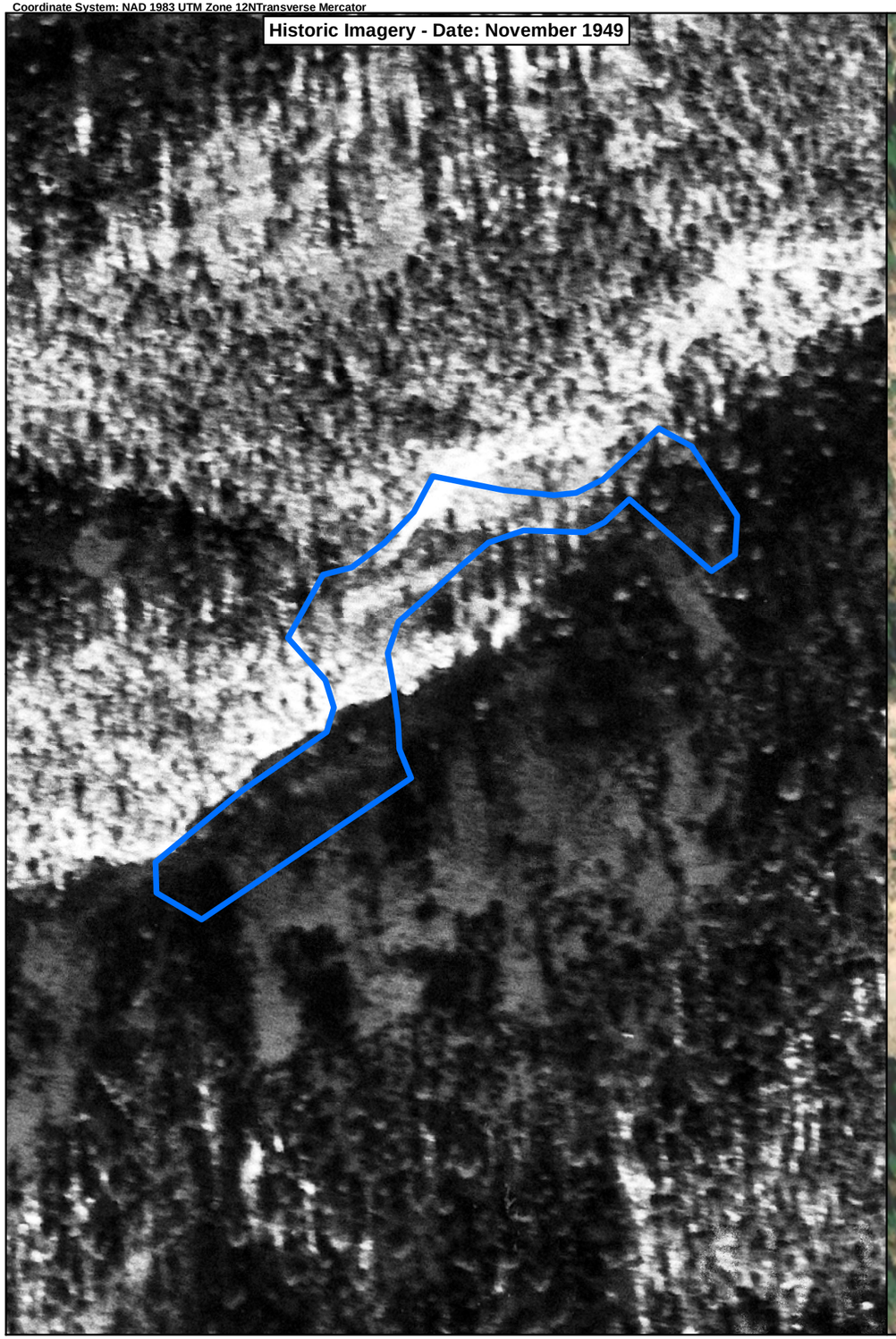
MESA II, MINE NO. 1, P-150 UNDERGROUND WORKINGS AND SITE FEATURES MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	H28-6
Location: COVE CHAPTER NAVAJO NATION	Date: 7/7/2019	

Coordinate System: NAD 1983 UTM Zone 12NTransverse Mercator



Abandoned Uranium Mine Site

1 in = 200 ft

1:2,400

N
W E
S

0 100 200 400
Feet

MESA II, MINE NO. 1, P-150
HISTORICAL IMAGERY ANALYSIS

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Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	Date: 7/11/2019
Reference: CURRENT IMAGERY BASEMAP USED BY U.S. EPA WITH PERMISSION FROM ESRI.; HISTORIC IMAGERY PROVIDED BY EROS, 2017.	Figure No.: H28-7

2.5 PREVIOUS INVESTIGATIONS

Prior to the RSE field investigations conducted by Tetra Tech and described in this report, no soil, sediment, surface water, or groundwater samples had been collected from within the survey area boundary of Mesa II, Mine No. 1, P-150; however, gamma measurements had been collected within the site boundary during previous investigations. The closest sediment sampling locations are CW-19 and CW-76, which are both within the Mesa II, Mine No. 1 & 2, P-21 site boundary, directly south approximately 169 feet. According to the logbook in the MCAP, gamma measurements were recorded during the initial visits by NAMLRP in May 1989 (Weston 2016). An unknown number of readings were taken at three portals and the waste pile. Measurements were made at 1 meter above the ground surface and at the rock contact at each location. The highest radiometric reading recorded was 700 microroentgen per hour (µR/hr), taken at 1 meter above ground surface, at one of the mine entrances. The exact locations or type of radiation instrumentation used to collect the gamma measurements was not documented.

As part of the preliminary assessment report in 2010, Weston attempted to conduct a gamma survey at Mesa II, Mine No. 1, P-150 (Weston 2010). However, because of steep grades, the waste pile and other site features could not be accessed. Measurements were therefore collected approximately 75 feet north of the site boundary. According to the Weston site screen report, a total of 244 gamma radiation measurements were taken north of the site, ranging from 7,212 to 15,203 cpm. Background measurements taken indicated an average background level of 7,906 cpm. The location and rationale for selection of the background study area (BSA) was not provided in the report. The original site boundary Weston (2018) referenced during the site screen investigation deviates from the site boundary contained within the USEPA geodatabase (Neptune and TSG 2018) provided to Tetra Tech. Attachment H28-4 provides a comparison of the two gamma radiation surveys from the previous investigation within the vicinity of this AUM site.

In 2014 and 2015, USEPA's ASPECT aircraft conducted flyovers within the Cove Region. The ASPECT surveys covered nearly 180 square miles of land. In May 2015, a ground-based characterization effort was organized to collect in situ gamma spectroscopy measurements at select locations and investigate the ASPECT survey (USEPA 2015). Attachment H28-4 provides a comparison of the 2018 RSE investigation ground-based gamma radiation survey results to the aerial flyover ASPECT results at Mesa II, Mine No. 1, P-150.

2.6 SITE FEATURES

The historical site assessment (Appendix A of the RSE Work Plan [Tetra Tech 2018]) and site mapping allow for a better understanding of the existing site features present at Mesa II, Mine No. 1, P-150. Site mapping at Mesa II, Mine No. 1, P-150 was performed during the Site Characterization Study. The characterization methods used for site mapping are discussed in Section 4.1, and the site mapping field forms can be found in Attachment H28-2. As described in Section 2.4, several reclamation activities have been performed at Mesa II, Mine No. 1, P-150, and a number of reclaimed and unreclaimed features remain at the site. The following reclaimed site features remain at the site:

- Five portals (Portals 42a, 42b, 42c, 40, and 41)

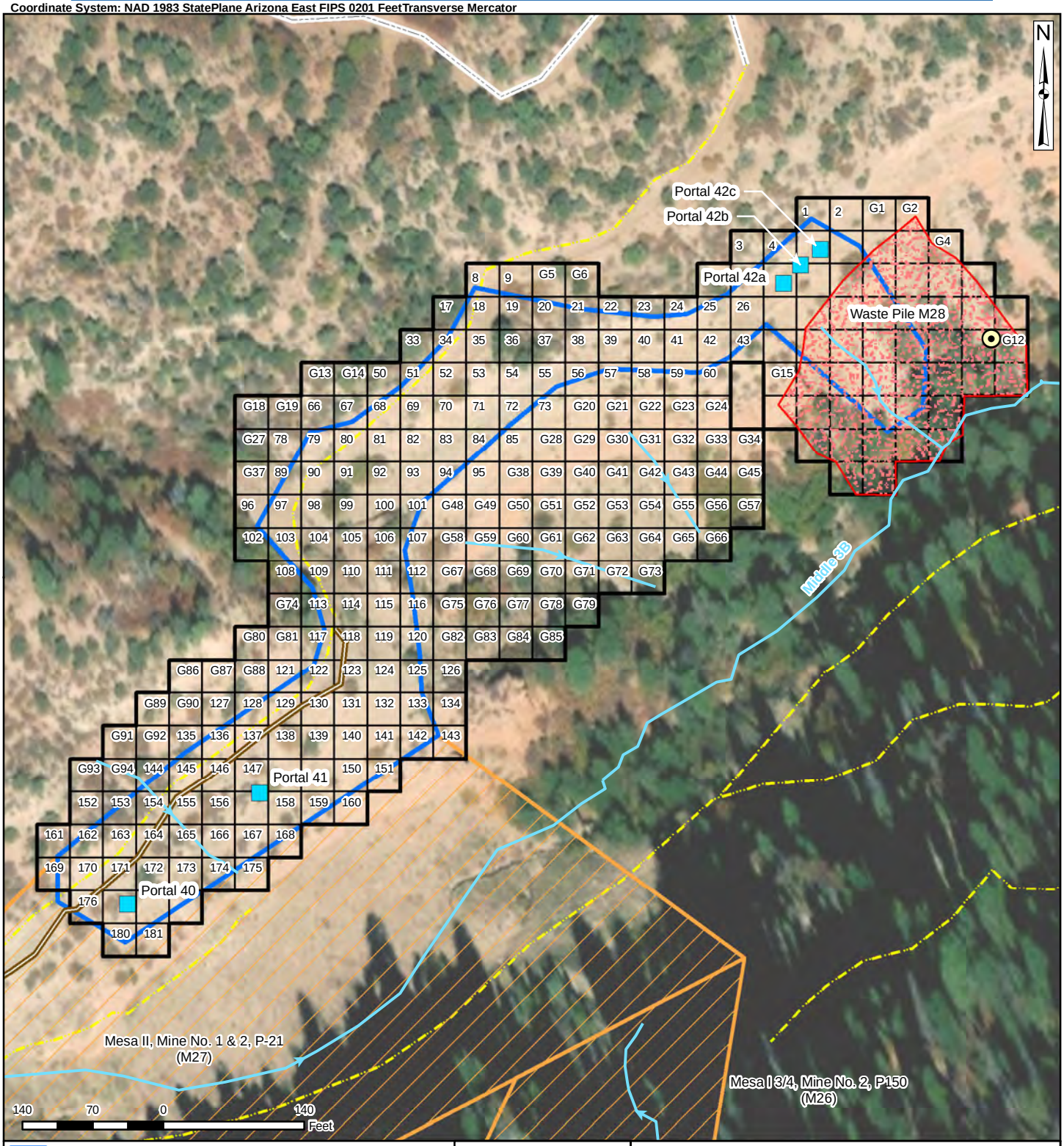
The following unreclaimed site feature remains at the site:

- Waste Pile M28

The unreclaimed waste pile (Waste Pile M28) that remains at Mesa II, Mine No. 1, P-150 was mapped by Tetra Tech. Previously, Waste Pile M28 was identified as Waste Pile 42 (Neptune and TSG 2018). The waste pile at Mesa II, Mine No. 1, P-150 is approximately 5 feet deep on a slope greater than 45 degrees in areas. The waste pile was expanded based on the gamma radiation survey measurements and elevated subsurface soil concentrations. The waste pile is highly erodible. Offsite migration from Waste Pile M28 has been documented and a drainage located on the waste pile connects with the Middle 3B drainage. The drainage on the waste pile was mapped by Tetra Tech during the 2018 RSE investigation. See Section 8.2 for discussion on offsite migration.

The five portals located at Mesa II, Mine No. 1, P-150 were confirmed to be closed and stable during site mapping. However, the cover material located on Portal 40 was observed to be eroded. The polyurethane foam was intact at Portal 40 and the portal remains closed, but there is potential for deterioration in the future. All site features identified above can be found in the USEPA geodatabase except for the extended boundary of Waste Pile M28 and the mapped drainage channel on the waste pile. A map showing the existing mine features at the mine is provided in Figure H28-8. All site features were confirmed by field personnel through the site mapping process.

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



AUM Site Boundary
Survey Unit (100 m²)
Survey Area Boundary
Other Tronox AUM Site Boundary

Waste Pile - Unreclaimed
Access Route - Foot
Access Route - Vehicular
Drainage - Field Mapped

Site Features

Closed Portal
Pipe - Field Mapped
Berm

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MESA II, MINE NO. 1, P-150
SITE FEATURES MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	H28-8
Location: COVE CHAPTER NAVAJO NATION	Date: 7/7/2019	

3.0 BACKGROUND THRESHOLD VALUES

A radiological and chemical soils background investigation was performed as part of the Northern Agency Tronox Mines RSE investigation. The results of this investigation are presented in Appendix A of the RSE Report. The RSE background investigation involved a site-specific background investigation and a regional background investigation. There were four primary geologies evaluated as part of the regional background investigation.

As described in Section 2.2, Mesa II, Mine No. 1, P-150 surface geology is 80 percent within Jse and 20 percent within Jml, and 91 percent of the survey area has the soil type of Hozho-Quezcan-Rock outcrop soil complex (symbol 413). As a result, there are a number of background scenarios for this site. BSA-24 and BSA-29 were both selected for those combinations of geologies and soil type. Additionally, the Jse regional geological background would also be applicable for this site. Appendix A of the RSE Report presents the site-specific and regional geological BTVs. The BTVs were estimated for BSA-24, BSA-29, and the regional Jse formation based on the soil sampling and gamma radiation survey results. The BTVs for a given analyte were calculated based on the 95 percent upper tolerance limit (UTL 95-95) or the 95 percent upper simultaneous limit (USL 95).

An applied BTV was selected to represent the unimpacted radiological and chemical conditions at Mesa II, Mine No. 1, P-150. Table H28-3 presents the estimated BTVs for 29 analytes and gamma radiation levels for both site-specific BSA-24 and BSA-29 as well as the Jse regional analysis. The "Applied BTV" for each analyte is the lowest of the two site-specific BTVs and the regional BTV.

Table H28-3. Summary of Applied Background Threshold Values for Mesa II Mine No. 1, P-150

Analyte	Units	Site-Specific BTV (BSA-24)	Site-Specific BTV (BSA-29)	Regional BTV (Jse)	Applied BTV[1]	Applied BTV Selection[2]
Aluminum	mg/kg	7,520	4,090	7,400	4,090	Site-Specific BTV BSA-29
Antimony	mg/kg	0.300	0.180	0.163	0.163	Regional BTV
Arsenic	mg/kg	4.7	2.0	4.8	2.0	Site-Specific BTV BSA-29
Barium	mg/kg	138	280	166	138	Site-Specific BTV BSA-24
Beryllium	mg/kg	0.54	0.70	0.51	0.51	Regional BTV
Cadmium	mg/kg	0.111	0.063	0.160	0.063	Site-Specific BTV BSA-29
Calcium	mg/kg	58,800	22,900	36,000	22,900	Site-Specific BTV BSA-29
Chromium	mg/kg	14	3.8	11	3.8	Site-Specific BTV BSA-29
Cobalt	mg/kg	5.6	3.4	4.4	3.4	Site-Specific BTV BSA-29
Copper	mg/kg	6.6	12	11	6.6	Site-Specific BTV BSA-24
Iron	mg/kg	10,100	8,470	8,000	8,000	Regional BTV
Lead	mg/kg	10	11	12	10	Site-Specific BTV BSA-24
Lithium	mg/kg	15	5.4	13	5.4	Site-Specific BTV BSA-29
Magnesium	mg/kg	6,100	2,510	7,000	2,510	Site-Specific BTV BSA-29
Manganese	mg/kg	600	329	500	329	Site-Specific BTV BSA-29
Mercury	mg/kg	0.0391	0.0111	0.0298	0.0111	Site-Specific BTV BSA-29
Molybdenum	mg/kg	0.32	0.26	0.34	0.26	Site-Specific BTV BSA-29
Nickel	mg/kg	11	3.6	11	3.6	Site-Specific BTV BSA-29
Potassium-40	pCi/g	22.8	21.3	23.7	21.3	Site-Specific BTV BSA-29
Radium-226	pCi/g	2.78	0.85	4.15	0.85	Site-Specific BTV BSA-29
Radium-228	pCi/g	0.84	-	0.84	0.84	Regional BTV/Site Specific BSA-24
Selenium	mg/kg	0.94	0.92	0.98	0.92	Site-Specific BTV BSA-29
Silver	mg/kg	0.120	0.040	0.055	0.040	Site-Specific BTV BSA-29
Sodium	mg/kg	44	45	36	36	Regional BTV
Thallium	mg/kg	0.077	0.069	0.091	0.069	Site-Specific BTV BSA-29
Thorium	mg/kg	4.6	5.4	3.6	3.6	Regional BTV
Uranium	mg/kg	2.7	1.1	3.4	1.1	Site-Specific BTV BSA-29
Vanadium	mg/kg	41	12	31	12	Site-Specific BTV BSA-29
Zinc	mg/kg	54	23	28	23	Site-Specific BTV BSA-29
Gamma Radiation	cpm	9,703	11,423	15,781	9,703	Site-Specific BTV BSA-24

Notes:

[1] The BTV that is the lower of the site-specific and regional background evaluation.
[2] The origin of the Applied BTV based on which BTV was lower between the site-specific or regional background evaluation.
- No BTV calculated, all background data was non-detect.
BSA-24 Background Study Area 24
BSA-29 Background Study Area 29
BTV Background threshold value
cpm Count per minute
Jse Summerville Entrada Formation
mg/kg Milligrams per kilogram
pCi/g Picocuries per gram

4.0 METHODS

Two primary field sampling phases of the RSE investigation were conducted at Mesa II, Mine No. 1, P-150: a Baseline Study and a Site Characterization Study. The Baseline Study was performed in June 2018 and involved the following field activities:

- XRF field surveys, including in situ XRF measurements and collection of XRF confirmation soil samples for laboratory analysis
- Gamma radiation surveys

The data collected from the Baseline Study were evaluated and used to update the sampling design for the Site Characterization Study. The field team returned to Mesa II, Mine No. 1, P-150 in September 2018 to conduct the Site Characterization Study, which involved the following field activities:

- Site mapping
- Goback XRF field surveys
- Goback gamma radiation surveys
- Surface and subsurface characterization through the shallow subsurface investigation and the collection of soil samples for laboratory analysis

Following the completion of the Baseline Study and Site Characterization Study, the data were evaluated to meet the objectives of the RSE investigation at Mesa II, Mine No. 1, P-150. The following data evaluation activities were performed:

- Third-party data validation of all analytical data; approximately 90 percent of the data underwent Stage 2B validation in accordance with the USEPA Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use (USEPA 2009) while the remaining 10 percent underwent Stage 4 validation
- Correlation of in situ XRF measurements to laboratory-reported concentrations in Appendix B of the RSE report
- Statistical evaluation of all data, including calculating summary statistics
- Development of contaminant mapping of primary analytes (defined in Section 7.1)
- Classification of Mesa II, Mine No. 1, P-150 using a *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (USEPA 2000) approach based on gamma radiation levels and historical knowledge of mining features
- Background comparison analysis of all data collected with the applied BTV
- Estimation of the lateral and vertical extent of contamination with contamination being considered a primary analyte concentration exceeding background
- Estimation of mine waste volumes within areas of the site above background

This section presents the field sampling methods and the desktop evaluation methods described above for the RSE investigation at Mesa II, Mine No. 1, P-150.

4.1 SITE MAPPING

Site mapping was performed at Mesa II, Mine No. 1, P-150 during the Site Characterization Study by a multidisciplinary team of environmental engineers, geologists, and radiation health physicists. The site mapping was completed to gain a better understanding of the site conditions in accordance with the methodology identified in the FSP for Mesa II, Mine No. 1, P-150 in Appendix F of the RSE Work Plan (Tetra Tech 2018). The objectives for conducting site mapping at the Northern Agency Tronox Mines included the following:

- Identifying any immediate physical hazards remaining at the site
- Locating access routes, including foot pathways and roads
- Differentiating naturally occurring radioactive material (NORM) from TENORM through geological assessment and visual observation
- Mapping all drainages and potential surface water pathways at the site
- Identifying any remaining exploration borings or roads
- Confirming existing mine site features and identifying additional site features relevant to the RSE investigation process
- Verifying soil types and geological formations at the site
- Identifying evidence of surface water erosion and offsite migration
- Conducting physical measurements and visual estimates of mine waste volumes of waste materials at the site

The process for identifying TENORM involved site mapping and inventory of mining- or reclamation-related impacts across the site, including waste piles, burial cells, exploration cuts or rimstrips, historical mining roads, ore or protore, portals, and other types of features that would indicate the presence of TENORM. The process for identifying NORM involved using gamma radiation survey data and geological information to identify potential natural outcrops or ore deposits that had not been physically disturbed or mined previously. Wastes within the majority of the site boundary of Mesa II, Mine No. 1, P-150 are considered TENORM because of the presence of roads and areas of disturbance from the mining and reclamation phases.

Site mapping consisted of recording the geospatial location of key site features using handheld Trimble Geo 7XH GPS units with subfoot accuracy after post processing. Additionally, the gamma radiation survey Mesa tablets were also capable of recording geospatial locations during the gamma radiation surveys and were used by field staff to geospatially locate obstacles, hazards, and site features discovered during field work.

The results of the site mapping are shown in Figure H28-8. All site mapping activities were documented by the field crew using GPS units or tablets and entered into the project geodatabase daily following field work. The site mapping field form for Mesa II, Mine No. 1, P-150 is included in Attachment H28-2, along with other field forms related to the site.

4.2 SITE CLASSIFICATION

Tetra Tech followed guidance from MARSSIM (USEPA 2000) to classify Mesa II, Mine No. 1, P-150. The RSE Work Plan (Tetra Tech 2018) describes the radiation survey and site investigation (RSSI) process followed by Tetra Tech. The RSSI process is a graded approach for assessing sites potentially contaminated with radiation that starts with site identification and the historical site assessment and is followed by other surveys, including scoping and characterization surveys, eventually leading to the final status survey. The historical site assessment has been completed for Mesa II, Mine No. 1, P-150 as summarized in Appendix A of the RSE Work Plan (Tetra Tech 2018); therefore, the next step is to classify the site. The Mesa II, Mine No. 1, P-150 survey area encompasses 6.79 acres, which was subdivided into 275 survey units (27,500 m^2) with each survey unit being a square grid consisting of 100 m^2. The survey unit labels in Figure H28-8 start with either a number or the letter "G." The labels that start with a number indicate that the survey unit was initially proposed as part of the Baseline Study in the FSP for Mesa II, Mine No. 1, P-150 in Appendix F of the RSE Work Plan (Tetra Tech 2018). The labels that start with G indicate that these are Goback survey units that were added as part of the Site Characterization Study.

The results of the classification can be used in the future for risk assessment and for designing a final status survey. The classification used in this RSE differs from MARSSIM because there are currently no established cleanup threshold limits for the site; instead, the classification is based on established BTVs for the site. The approach could easily be modified in a later phase of work to incorporate cleanup threshold limits into the classification scheme. Tetra Tech's site classification strategy was to classify each survey unit based on its potential for containing radiological contamination related to mining. There are three possible classification scenarios for each survey unit: Class 1, Class 2, and Class 3. It is also possible for a survey unit to be classified as inaccessible for either the gamma survey team or the XRF field survey team or both as discussed Section 4.10. All decisions on classification of inaccessibility were approved by the onsite USEPA Remedial Project Manager (RPM).

Figure H28-9 provides a flowchart detailing the classification process. The definitions of the three classification areas used by Tetra Tech to classify accessible areas are:

- **Class 1 Areas:** Areas that have, or had prior to remediation, a potential for radioactive contamination (based on site operating history) or known contamination (based on most recent radiation surveys). Any survey unit intersecting an unreclaimed mine feature boundary, including a burial cell or an unreclaimed waste pile, is automatically classified as Class 1. Any survey unit with a grid averaged gamma value greater than the applied gamma BTV is automatically classified as Class 1. Survey units that contain remediated or reclaimed mine features (such as a reclaimed waste pile) and contain at least one gamma measurement greater than the applied gamma BTV are also classified as Class 1.
- **Class 2 Areas:** Areas that have, or had prior to remediation, a potential for radioactive contamination or known contamination but are not expected to exceed the applied BTV. Any survey unit containing a mine feature, such as a reclaimed waste pile or similar, is automatically classified as Class 2. Any survey unit that does not intersect a reclaimed mine feature but contains at least one gamma radiation measurement greater than the applied gamma BTV becomes classified as Class 2.

- **Class 3 Areas:** Any impacted areas that are not expected to contain residual radioactivity above background levels. Class 3 areas are survey units that do not include any gamma measurements above the applied gamma BTV and do not contain any reclaimed or unreclaimed mine-related features (such as a burial cell, waste pile, or portal).

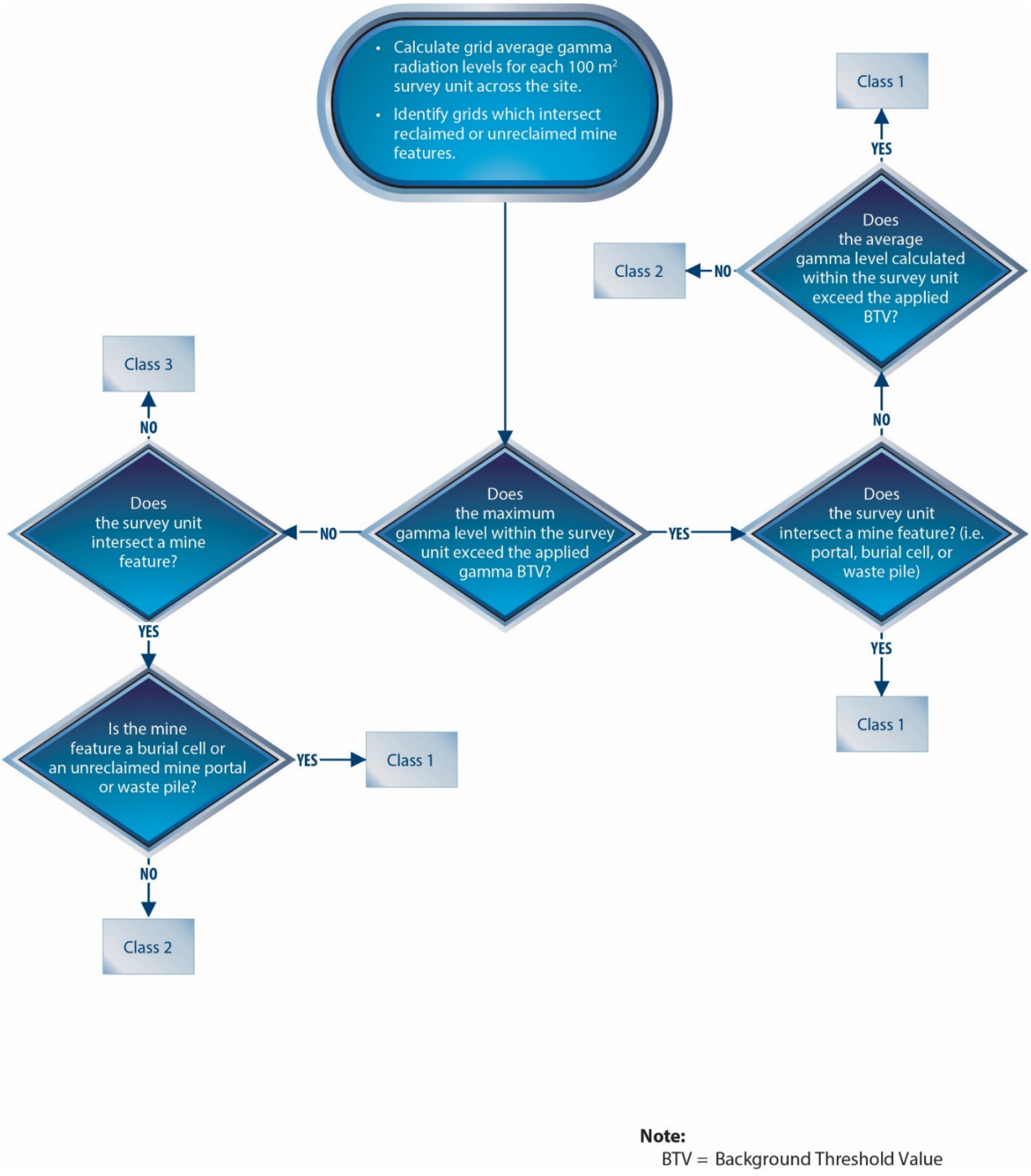


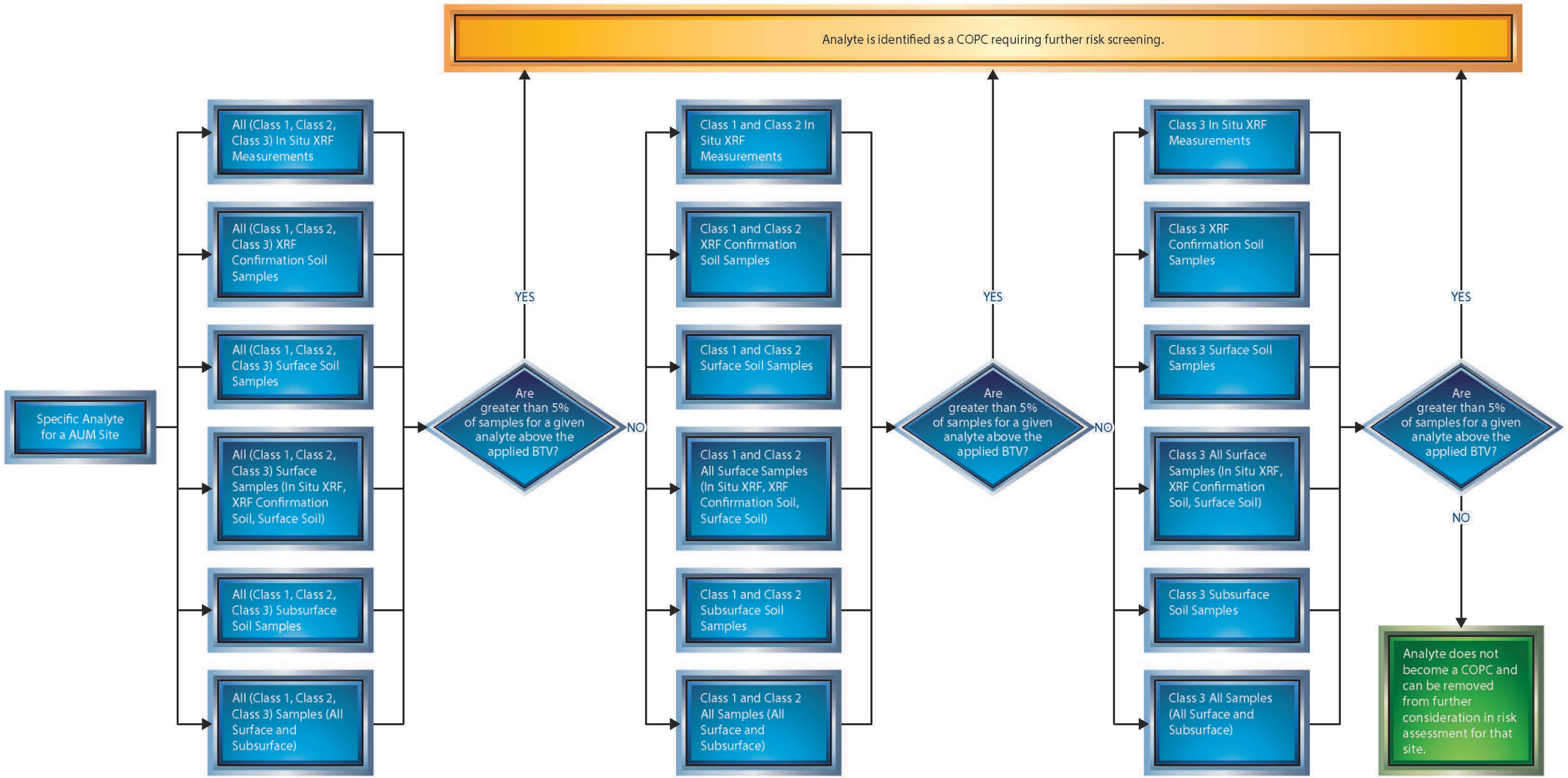
Figure H28-9. Flowchart for Site Classification

4.3 IDENTIFICATION OF CONTAMINANTS OF POTENTIAL CONCERN

Tetra Tech developed a process for the identification of COPCs for the Northern Agency Tronox Mines. The soil concentrations at the AUM site were measured using in situ XRF analysis and laboratory XRF confirmation surface soil samples, as well as through laboratory chemical and radiological analysis of surface and subsurface soil samples. Each of these methods are referred to as a sample type and are described in further detail in the following subsections. At a number of AUM sites, 29 metals and radionuclides are evaluated. At Mesa II, Mine No. 1, P-150, 29 metals were evaluated during the Baseline Study and 28 analytes were evaluated during the Site Characterization Study (mercury was not evaluated during the Site Characterization Study). An applied BTV has been selected for each analyte to represent pre-mining conditions at Mesa II, Mine No. 1, P-150. The estimated BTVs are the UTL 95-95 or the USL 95 for a given population; it is possible for a sample to have a result exceeding the BTV and still be part of the background population (that is, a false positive) and to have not been impacted by mining.

When there are more samples collected from unimpacted areas than mining impacted areas within a survey area boundary, the large number of samples collected from the unimpacted area may bias the data collected from the impacted area. As a result, some analytes may not be identified as COPCs because the results do not exceed the BTV in more than 5 percent of all the samples combined. Therefore, a strategy was put in place to further break up the survey units by classification types (Class 1 and Class 2 combined or Class 3) and evaluate exceedances for each classification type in addition to the entire data set. A criterion of greater than 5 percent of samples exceeding the applied BTV is used to identify a COPC as being above background for a particular sample type for Class 1 and Class 2 combined, Class 3 only, and all samples combined regardless of classification.

Figure H28-10 presents a flowchart depicting the process for the identification of COPCs. This is a robust and conservative process, and if an analyte exceeds the applied BTV in 5 percent or more of the sample type (or sample types grouped) for a given class (or all classes grouped), it will be considered a COPC. For example, if an analyte does not exceed the BTV on the surface, it may be present in a burial cell or buried waste pile; so, by comparing the population of the subsurface samples only, the analyte would still become a COPC. Section 6.0 presents the site classification approach for Mesa II, Mine No. 1, P-150 and provides a background comparison analysis for all the samples and sample types with the different analytes. Following the background comparison analysis, the COPCs for the site are carried through for further analysis and contaminant mapping, offsite migration analysis, and mine waste volume estimation purposes.



NOTE: In Situ XRF Measurements are laboratory converted values for only nine analytes
BTV = Background Threshold Value
COPC = Contaminant of Potential Concern

Figure H28-10. Contaminant of Potential Concern Identification Process Diagram Flowchart

4.4 GAMMA RADIATION SURVEY

Tetra Tech performed GPS-based gamma radiation surveys of the 6.79-acre survey area of the Mesa II, Mine No. 1, P-150 as part of the Baseline Study in June 2018. Additional Goback gamma radiation surveys were performed during the Site Characterization Study in September 2018. The GPS-based gamma surveys are performed to (1) define the areal extent of TENORM; (2) help establish a basis from which the subsurface can be investigated; (3) establish a basis that can be used to predict Ra-226 concentrations across a site; and (4) establish a basis that can be used to predict radiation exposure rates across a site. The gamma radiation survey was performed at the Mesa II, Mine No. 1, P-150 following the methods outlined in Appendix C to the RSE Work Plan (Tetra Tech 2018). Field staff used mobile scanning systems with Ludlum Model 44-10 (2- by 2-inch) sodium iodide (NaI) gamma scintillation detectors coupled to Ludlum Model 2221 ratemeters/scalers set in ratemeter mode. The detectors were coupled to Environmental Restoration Group, Inc. (ERG) Model 105 GPS units. The ERG Model 105 GPS consists of a Juniper Mesa 2 field computer and geode GPS receiver. The gamma radiation survey was performed using a maximum spacing of 2-meter transect widths within the survey area of Mesa II, Mine No. 1, P-150. Detector height was 1 meter above ground surface as prescribed in the RSE Work Plan (Tetra Tech 2018). The "field of view" of the NaI detector in this configuration (2-meter transects and 1-meter height) provides 100-percent coverage of land areas. Gamma count rate measurements and associated geospatial coordinates were made and recorded every 1 second. Results of the gamma radiation survey are presented in Section 5.1. Table H28-4 provides a summary of which detection systems were used and when they were used during the gamma radiation survey at Mesa II, Mine No. 1, P-150.

All Ludlum Model 44-10/2221 instrument systems used in the gamma surveys were calibrated in accordance with the *American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments* (American National Standards Institute [ANSI] 1997) and Standard Operating Procedure (SOP) 002: Calibration of a Radiological Survey Meter and SOP 001: Calibration of a Radiological Survey Detector in Appendix D of the RSE Work Plan (Tetra Tech 2018). Calibration of the detection systems is required prior to their initial use, at least annually, and after any scheduled or unscheduled maintenance or repair that may affect their operation. General maintenance of the detection systems, such as cleaning, painting, and changing buttons, does not require that they be recalibrated. The instruments were function-checked daily, before and at the end of each work day in accordance with SOP 009: Operational Checkout of Single Detector with Meter in Appendix D of the RSE Work Plan (Tetra Tech 2018). Table H28-5 provides a summary of the detection equipment and calibration information.

Table H28-4. Detection Systems Used in the Mesa II, Mine No. 1, P-150 Gamma Radiation Survey

Survey Area	Ludlum Model 44-10	Ludlum Model 2221 Ratemeter/Scaler	Dates Used
Mesa II, Mine No. 1, P-150 (M28)	PR355763	271435	6/18/2018
			6/19/2018
			6/20/2018
			9/26/2018
	PR320678	176947	6/18/2018
			6/19/2018
			6/20/2018
			9/26/2018
	PR321856	271429	6/18/2018
			6/19/2018
	PR355781	271424	6/18/2018
			6/19/2018
			9/28/2018
	PR373554	103984	6/19/2018
	PR295015	282973	9/26/2018
	PR355763	271435	6/18/2018
			6/19/2018
			6/20/2018
			9/26/2018

Note:

[1] Serial number for radiation instrument used.

Table H28-5. Summary of Detection Equipment and Calibration Information

Equipment	Use/Calibration Summary	Relevant RPP SOP No.[1]
Ludlum 2221/ Ludlum 44-10 (or equivalent)	**Use:** Ludlum 2221 ratemeter/scaler instruments were paired with Ludlum 44-10 NaI detectors to measure surface gamma radiation. This detection system was paired with a GPS unit and data logger to record gamma survey and spatial location results in real-time. **Calibration:** Each system (Ludlum 2221/44-10 pair) was calibrated at least annually. Calibration was also performed following any maintenance or repair that could affect functionality. **Functional Checks:** Checks were performed on each system each day that they are used. One check was performed prior to use and one check when all measurement activities had been completed for the day. Checks utilize a standardized source, and net results (source less background counts) must be within ±20% of the results established as part of ongoing control charting.	SOP 001 SOP 002 SOP 009
ERG Model 105 GPS	**Use:** The ERG Model 105 GPS system was used to pair radiation instruments with GPS units to simultaneously record gamma measurements with geospatial locations. The system uses a handheld tablet computer to collect and display survey results in real-time and protect the data from manipulation. **Calibration:** NA **Functional Checks:** NA	NA

Notes:

[1] The SOPs are provided in Appendix D of the RSE Work Plan (Tetra Tech 2018).

ERG Environmental Restoration Group, Inc.
GPS Global positioning system
NA Not applicable
NaI Sodium iodide
RPP Radiation protection program
RSE Removal site evaluation
SOP Standard operating procedure
Tetra Tech Tetra Tech, Inc.

Gamma survey data were collected using the ERG 105 GPS and logged to a binary file such that modifications to the data are precluded. That is, the user has no interaction with the gamma measurements and there are no translation errors in their transmittal. The integrity of the file allows the original field data to be retained and referenced, if necessary, when tracking changes or reverting to the original version. The ERG RadSync and RadScene applications were used to transfer all gamma survey field data to the management computer. Only one computer was used for incoming field data to prevent duplication of data files. Files were not copied manually between the data logger and the project computer. In addition, raw data files were not renamed from their original filename.

The steps taken to validate and verify the gamma survey data were conducted in accordance with SOP 006: Validation and Verification of Gamma Survey Data (from Appendix C [SAP/QAPP] of the RSE Work Plan [Tetra Tech 2018]) as follows:

- The gamma measurements were reviewed in their shapefiles for minimum values to verify that they are within an appropriate range for the Ludlum Model 44-10 and survey

area. If low counts were detected, the cause of the counts was assessed. Invalid measurements could have been made if, for example, a GPS unit was left on unintentionally while traveling in a vehicle.

- The horizontal dilution of precision (HDOP) measurements from the GPS in the GPS-based gamma radiation survey were reviewed to verify that the values do not exceed 3.0. HDOP values that exceed this threshold may have a high positional error and would then be used cautiously during post-processing tasks, such as identifying locations of correlation samples and anomalies.
- Symbology was applied to the gamma measurements, which were then inspected visually for patterns that might indicate detector or cable problems.
- Invalid data of the types described above were removed from the shapefile in accordance with SOP 006.

The steps taken to analyze the gamma survey data were as follows:

- A total of 275 survey units (100 m^2 each) were applied to the site-wide (and areas extending outward) measurements. The accessible survey unit averages were analyzed statistically using ArcGIS software. These results were then compared to the results obtained in the background studies (Section 5.1).
- The gamma survey measurements were retained as cpm and converted to predicted exposure rates based on the regression analysis presented in Section 4.5.2. The data were interpreted only in terms of cpm. However, exposure rate maps are provided in the main RSE Report.
- The gamma survey measurements were analyzed using statistical software (ProUCL, JMP, and MS Excel), and applicable statistical parameters were generated. Parameters included the number of measurements, arithmetic or geometric mean, median, percentiles, and standard deviation.
- Symbology was applied to the gamma survey measurements according to intervals established as multiples of the applicable BTVs.

All QA/QC results and calibration documentation for all radiation detection equipment used in the Northern Agency Tronox Mine RSE investigation are included in the QA/QC Summary Report as Appendix G of the RSE Report. That report presents the daily calibration checks for the gamma radiation surveys at Mesa II, Mine No. 1, P-150.

4.5 GAMMA CORRELATION

The following subsections describe the activities of two types of correlation studies performed at Mesa II, Mine No. 1, P-150 as a part of the larger RSE investigation of the Northern Agency Tronox Mines. Section 4.5.1 presents the gamma-radium correlation and the relationship between Ra-226 concentrations in surface soils and gamma count rates. Section 4.5.2 presents the NaI/high pressure ionization chamber (HPIC) correlation and the relationship between exposure rates and gamma count rates.

4.5.1 GAMMA-RADIUM CORRELATION

Tetra Tech performed GPS-based gamma radiation surveys and collected nine-point composite samples of surface soils in 17 correlation plots within the Jse geology and 4 plots within the Jste geology between June 4 and September 26, 2018. The sample plot locations were distributed across many different AUM sites, and a background sites to obtain a representative distribution of the response between observed Ra-226 and gamma measurements. These areas were selected using criteria established in the RSE Work Plan. No DQO was established for homogeneity of the correlation plots; homogeneity of the correlation plots was evaluated qualitatively. A total of 9,076 gamma measurements were made across the 21 correlation plots, ranging from 6,376 to 51,055 cpm. The resulting observed Ra-226 measurements from the correlation plots ranged from 0.59 to 23.4 picocuries per gram (pCi/g). Upon quantitative investigation of the data, one outlier identified by use of the Dixon Q test for outliers was removed from the regression analysis. The results of the gamma-radium correlation are presented in more detail in Appendix C of the RSE Report.

The 2- by 2-inch NaI detectors used in this investigation are sensitive to surface Ra-226 decay products and other gamma emitting radionuclides. The purpose of the gamma correlation was to estimate Ra-226 concentrations in the upper 6 inches of soil. Tetra Tech and ERG field personnel selected correlation plots based on the range of gamma radiation levels observed. If surface soil concentrations of gamma emitting radionuclides were variable between correlation locations, the variability would be included in the regression model.

The soil correlation areas were selected using criteria established in the RSE Work Plan. The activities were performed contemporaneously by area and on the same day such that variations in the gamma count rate measurements could be limited largely to variability of soils and rocks at the locations. The soil samples were analyzed by ALS Environmental in Fort Collins, Colorado, for Ra-226, thorium-232, and potassium-40 (K-40) by USEPA Method 901.1.

The mean relationship between gamma count rates and concentrations of Ra-226 in surface soils (0 to 6 inches bgs) is shown in Figure H28-11 by a linear regression model:

Equation 1a: $$\gamma[cpm] = 12{,}539 + 1{,}150\left({}^{226}Ra\left[\frac{pCi}{g}\right]\right)$$

Equation 1b: $$\left({}^{226}Ra\left[\frac{pCi}{g}\right]\right) = 0.000869(\gamma[cpm]) - 10.904$$

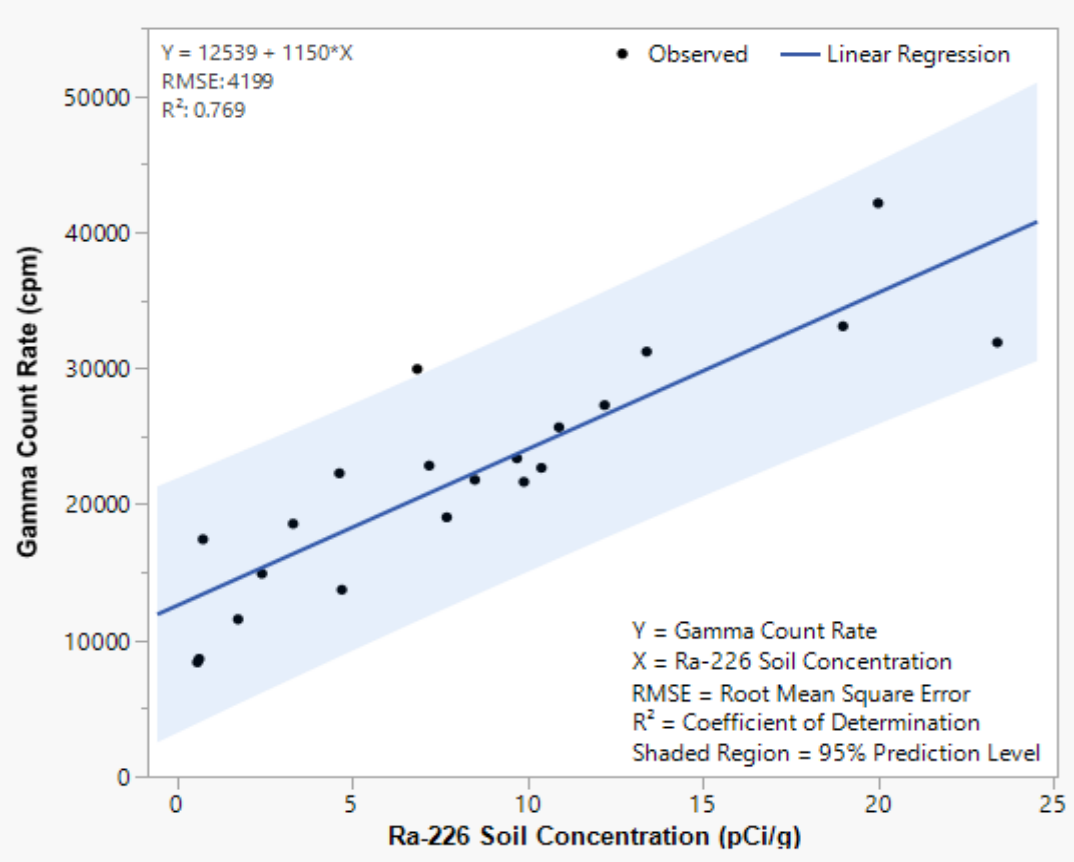


Figure H28-11. Gamma-Radium Correlation for Mesa II, Mine No. 1, P-150

4.5.2 GAMMA-EXPOSURE RATE CORRELATION

The purpose of the gamma-exposure rate correlation study and predicted energy-independent exposure rates is to translate the relatively high-density gamma measurements to more meaningful energy-independent measures of direct human exposure. This translation allows for the evaluation of human exposure across the entire area surveyed. The HPIC responds to ionizing radiation by collecting charges created by direct ionization within the detector gas through the application of an electric field. It measures interactions of gamma, X-rays, and cosmic radiation without discrimination.

The specific number and location of HPIC measurements were selected in the field by a certified health physicist, and the final analysis and results of the gamma exposure rate correlation are included in Appendix C of the RSE Report. HPIC measurements were strategically collected to span a large range of gamma survey results to allow for a robust correlation. Tetra Tech performed HPIC measurements at all types of sites, including AUM sites, Target sites, roads, drainages, and BSAs.

HPIC measurements were collected in accordance with SOP 003: Marking Exposure Rate Measurements Using a HPIC in Appendix C of the RSE Work Plan (Tetra Tech 2018). A summary of instrument-specific calibration and functional checks is provided in Table H28-6.

Table H28-6. High Pressurized Ionization Chamber Equipment Usage Summary

Equipment	Use/Calibration Summary	Relevant SOP No.
GE-Energy Model RSS-131 HPIC or similar	**Use:** HPIC instrumentation was used to collect energy-independent measurements of gamma exposure rates. At each measurement location, gamma exposure rate measurements were collected at 5-second intervals for a duration of 10 minutes. **Calibration:** The HPIC used was calibrated within the last year. Calibration was also performed after any maintenance or repair that could affect functionality. **Functional Checks:** NA	SOP 003

Notes:
HPIC High pressure ionization chamber
NA Not applicable
SOP Standard operating procedure

The final correlation is shown in Figure H28-12. The following equation can be used to convert a gamma level to an equivalent gamma exposure rate:

Equation 2: $$\gamma\left(\frac{\mu R}{hour}\right) = 8.476 + 0.000545 * (\gamma[cpm])$$

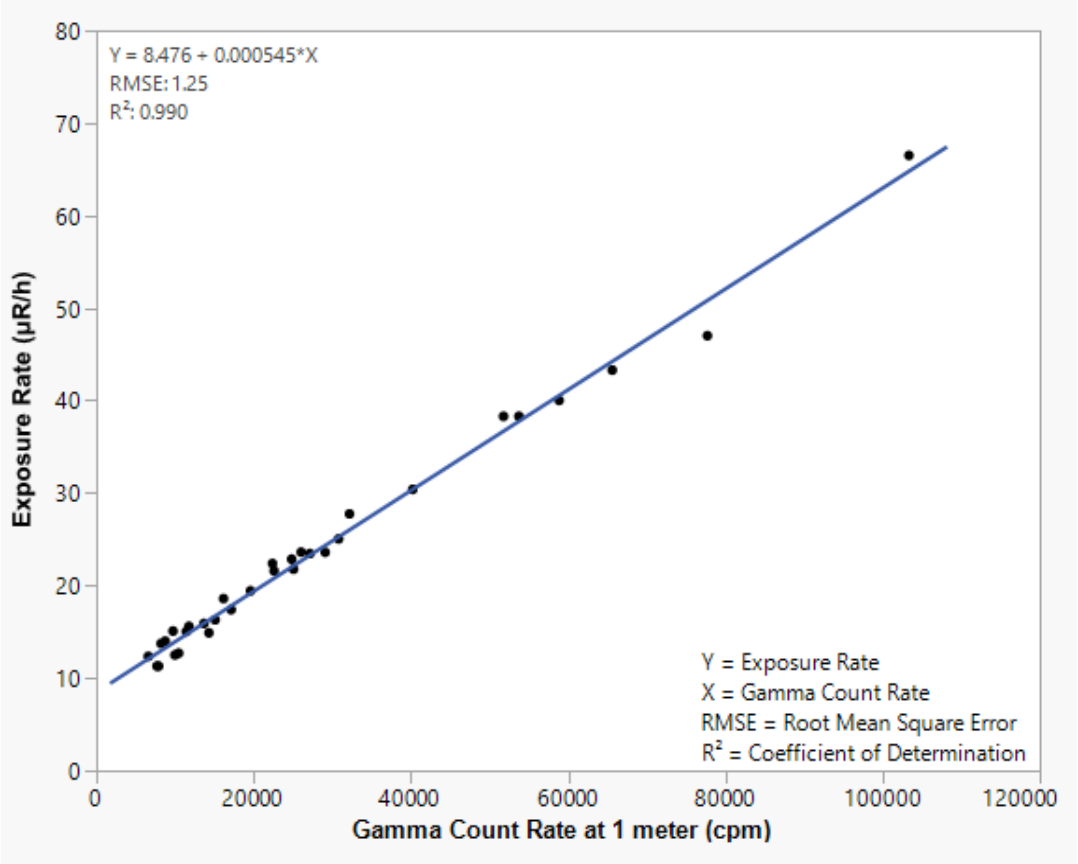


Figure H28-12. Gamma Count Rate (Counts per Minute) versus Exposure Rate (Microroentgens per Hour)

4.6 XRF FIELD SURVEY

Tetra Tech performed an XRF field survey at Mesa II, Mine No. 1, P-150 that involved the collection of an in situ XRF measurement within the approximate center of each 100 m^2 survey unit and the collection of XRF confirmation soil samples at a frequency of 5 percent. The XRF confirmation soil samples were collected at a depth of 0 to 3 inches bgs. A summary of the laboratory analytical procedures for the XRF confirmation soil samples is provided in Table H28-7. No soil samples were analyzed for mercury during the Site Characterization Study at Mesa II, Mine No. 1, P-150. Figure H28-13 provides the locations of the in situ XRF measurement locations and the XRF confirmation soil sample locations. Survey units that were classified as inaccessible during the XRF field survey are shown as gray squares on Figure H28-13 as discussed further in Section 4.10.

Tetra Tech used the Niton XL5 field portable analyzer (with filter settings of Main Filter: 30 seconds; Low Filter: 15 seconds; and High Filter: 15 seconds) to conduct the XRF field survey. The XL5 is a portable XRF technology that allows for built-in calibration checks (system checks) and lower detection capabilities for various analytes, including arsenic, uranium, and vanadium (all potential COPCs for the Northern Agency Tronox Mines).

Tetra Tech collected surface soil samples for laboratory analysis at a minimum of 5 percent of XRF measurement locations and minimized the impact of measurement error introduced by various factors, including soil moisture conditions, effects of particle size, and homogenization on comparability (USEPA 2007). A comparability study between XRF analyzer and laboratory reported concentrations was performed as part of Appendix B of the RSE Report, and strong correlations were found to exist for nine target analytes: arsenic, iron, lead, manganese, molybdenum, thorium, uranium, vanadium, and zinc. This study, conducted through a linear least squares regression analysis, identified correction factors for the nine analytes. The in situ XRF measurements collected at this site were converted into laboratory predicted values by using the correction factors developed from the regression analysis. See Appendix B of the RSE Report for further details on the procedures for the XRF field survey.

The protocol for the XRF field survey is described below:

1. At each in situ XRF measurement location, the soil from 0 to 3 inches bgs in an approximately 6-inch-square area was cleared of surface debris and thoroughly homogenized in place using a stainless-steel hand trowel or similar. The soil was visually assessed for signs of moisture. The homogenized soil was then patted down in place to provide a uniform surface for the XRF analysis using a stainless-steel hand trowel or a gloved hand. A soil guard (a plastic cover with a thin protective film provided by the manufacturer) was used for all in situ XRF measurements. The XRF analyzer with a soil guard was then placed directly against the homogenized soil for measurement. A single in situ XRF measurement was taken at each location. Whenever an XRF confirmation soil sample was collected, a duplicate in situ XRF measurement was taken before the soil sample was collected. Once per day per instrument, a series of seven replicate measurements were collected at a random location, and the instrument was not lifted off the ground surface between measurements. XRF measurements were collected in accordance with USEPA SW-846 Method 6200 and SOP 004: Field-Portable X-Ray

Fluorescence Analyzer Measurement in Appendix C of the RSE Work Plan (Tetra Tech 2018). Appendix B of the RSE Report describes the XRF field survey in more detail.

2. At a minimum of 5 percent of the in situ XRF measurement locations throughout the RSE program, an XRF confirmation sample was collected immediately after the XRF measurement. The soil collected in the field was placed into a resealable plastic bag. After removing debris, the samples were dried and homogenized in the lab. When the sample was prepared, it was measured in the field office in Farmington, New Mexico, a minimum of six times with an XRF analyzer and then submitted for laboratory analysis as specified in Table H28-7. This is referred to as the ex situ bulk sample. The ex situ bulk samples were used for a correlation study comparing the XRF dataset with the analytical dataset.

All XRF QA/QC results, including daily calibration checks and field replicate checks, are provided in Appendix B of the RSE Report. The results of XRF field survey are provided in Section 5.2.1.

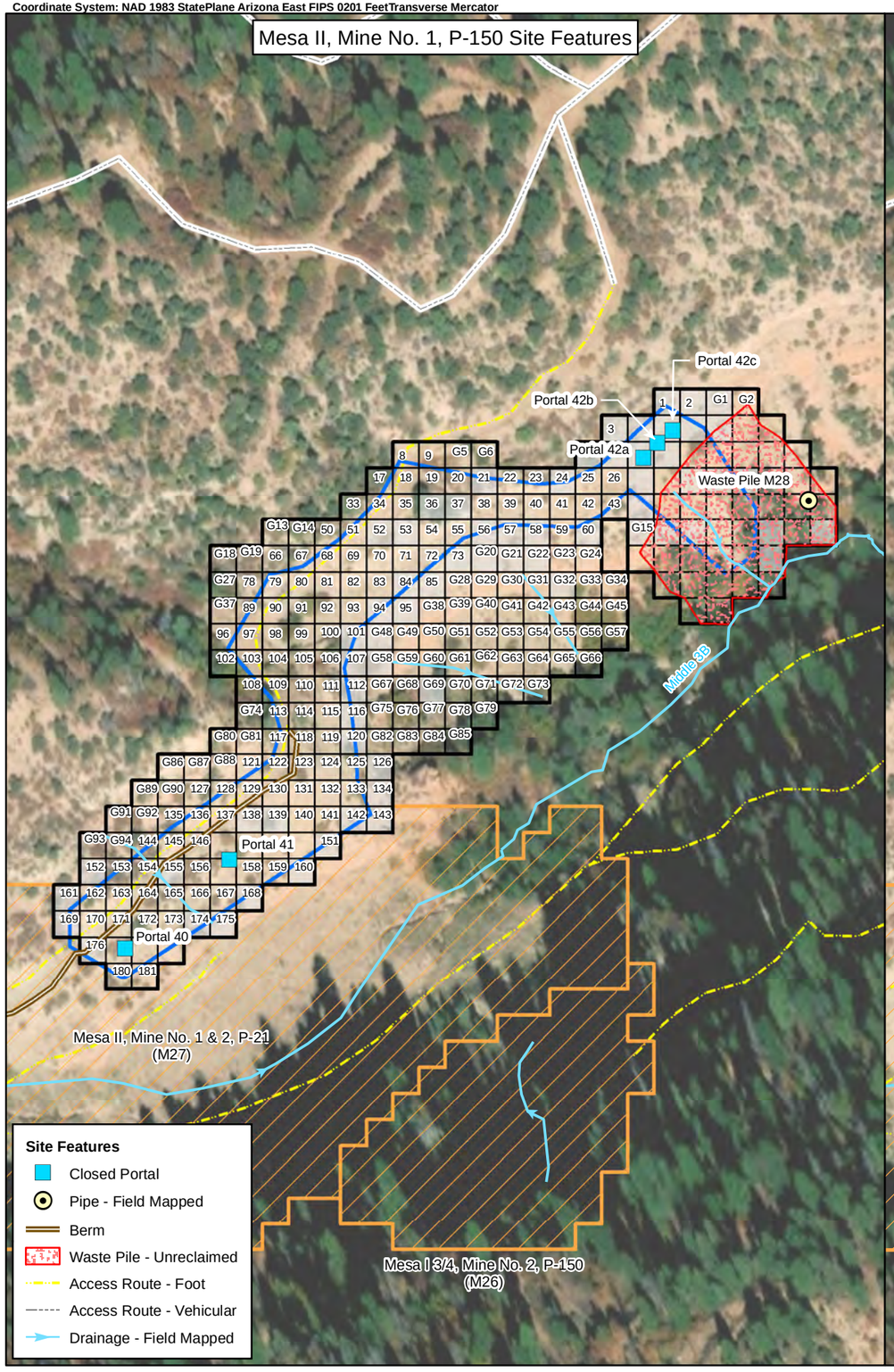
Table H28-7. Summary of Analytical Methods for XRF Confirmation Soil Samples

Analyte	Type	CAS Number	Analytical Method	# of XRF Confirmation Samples Analyzed
Aluminum	Metals	7429-90-5	USEPA SW-846 6020B	14
Antimony	Metals	7440-36-0	USEPA SW-846 6020B	14
Arsenic	Metals	7440-38-2	USEPA SW-846 6020B	14
Barium	Metals	7440-39-3	USEPA SW-846 6020B	14
Beryllium	Metals	7440-41-7	USEPA SW-846 6020B	14
Cadmium	Metals	7440-43-9	USEPA SW-846 6020B	14
Calcium	Metals	7440-70-2	USEPA SW-846 6020B	14
Chromium	Metals	7440-47-3	USEPA SW-846 6020B	14
Cobalt	Metals	7440-48-4	USEPA SW-846 6020B	14
Copper	Metals	7440-50-8	USEPA SW-846 6020B	14
Iron	Metals	7439-89-6	USEPA SW-846 6020B	14
Lead	Metals	7439-92-1	USEPA SW-846 6020B	14
Lithium	Metals	7439-93-2	USEPA SW-846 6020B	14
Magnesium	Metals	7439-95-4	USEPA SW-846 6020B	14
Manganese	Metals	7439-96-5	USEPA SW-846 6020B	14
Mercury	Metals	7439-97-6	USEPA SW-846 7471A	1
Molybdenum	Metals	7439-98-7	USEPA SW-846 6020B	14
Nickel	Metals	7440-02-0	USEPA SW-846 6020B	14
Potassium-40	Radionuclides	13966-00-2	USEPA 901.1	14
Radium-226	Radionuclides	13982-63-3	USEPA 901.1	14
Radium-228	Radionuclides	15262-20-1	USEPA 901.1	14
Selenium	Metals	7782-49-2	USEPA SW-846 6020B	14
Silver	Metals	7440-22-4	USEPA SW-846 6020B	14
Sodium	Metals	7440-23-5	USEPA SW-846 6020B	14
Thallium	Metals	7440-28-0	USEPA SW-846 6020B	14
Thorium	Metals	-	USEPA SW-846 6020B	14
Uranium	Metals	-	USEPA SW-846 6020B	14
Vanadium	Metals	7440-62-2	USEPA SW-846 6020B	14
Zinc	Metals	7440-66-6	USEPA SW-846 6020B	14

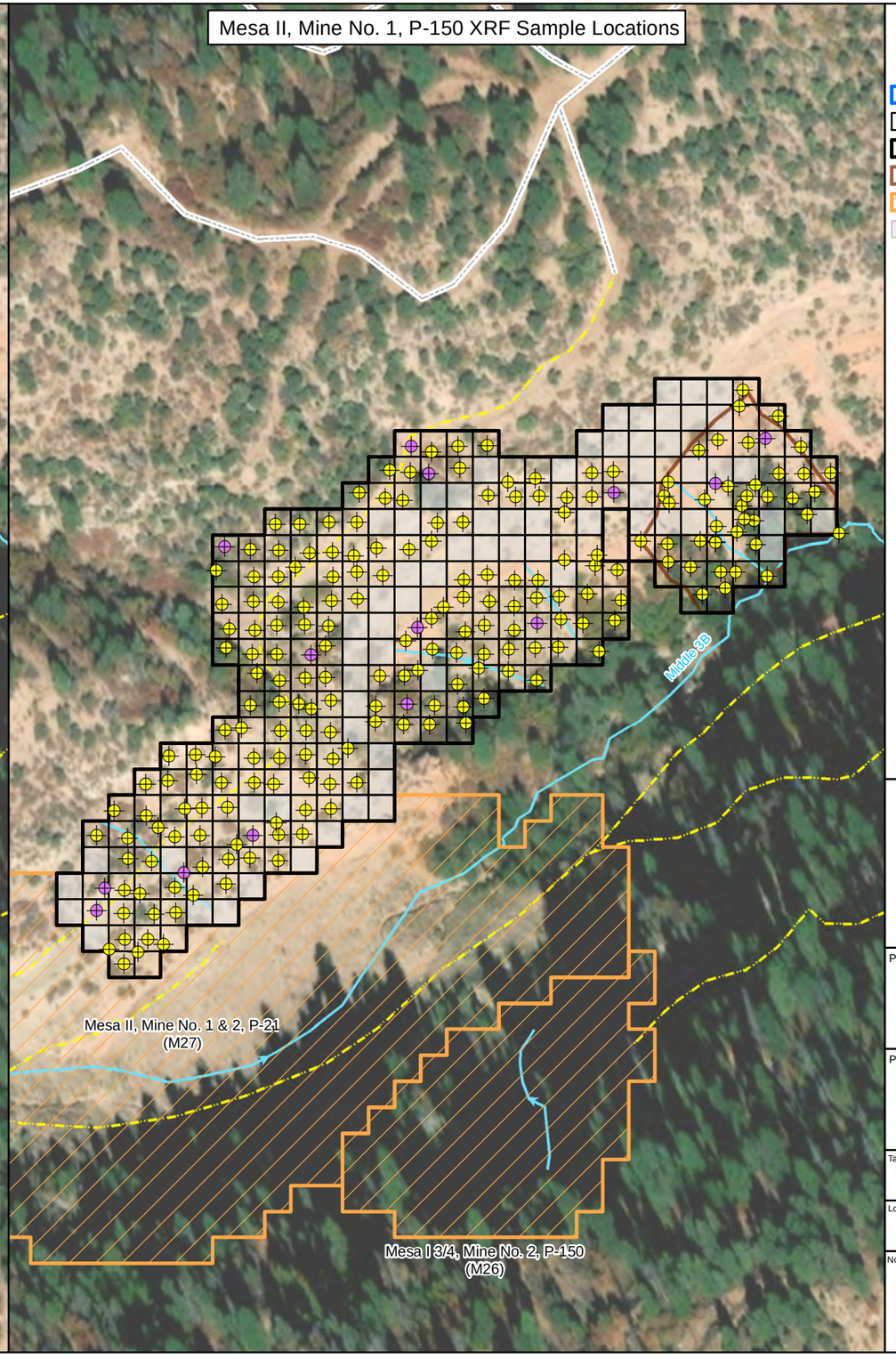
Notes:
- Not applicable
CAS Chemical Abstracts Service
USEPA U.S. Environmental Protection Agency
XRF X-ray fluorescence

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

Mesa II, Mine No. 1, P-150 Site Features



Mesa II, Mine No. 1, P-150 XRF Sample Locations



- In Situ XRF Measurement Location
- XRF Confirmation Soil Sample (0 - 3 inches bgs)
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Waste Pile Boundary
- Other Survey Area
- Inaccessible To XRF Survey

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150 XRF FIELD SURVEY MAP

Prepared For:

Prepared By:

TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	**Date:** 7/7/2019
Notes:	**Figure No.:** H28-13

4.7 SOIL SAMPLING

This section presents the three different soil sampling techniques used at Mesa II, Mine No. 1, P-150 for collecting laboratory samples, which are (1) XRF confirmation soil sampling, (2) surface soil sampling, and (3) subsurface soil sampling.

4.7.1 XRF CONFIRMATION SOIL SAMPLING (0 TO 3 INCHES)

The first type of analytical soil sample collected at Mesa II, Mine No. 1, P-150 was the XRF confirmation soil sample collected from 0 to 3 inches bgs following the field protocol described in Section 4.6. These samples were collected during the XRF field survey. Fourteen confirmation soil samples were collected at Mesa II, Mine No. 1, P-150 and submitted for laboratory analysis as presented in Table H28-7; the soil sample locations are shown in Figure H28-13. A subset of XRF confirmation soil samples were also submitted for selected radionuclides presented in Table H28-9. An evaluation of the in situ XRF measurements, ex situ bulk sample XRF measurements, and laboratory analytical results of the XRF confirmation soil samples is provided as the XRF Data Evaluation Report in Appendix B of the RSE Report. Figure H28-13 shows the locations of the XRF field survey soil samples and the XRF confirmation soil samples. The XRF confirmation soil samples are also provided in Figure H28-14. The XRF confirmation soil sample geospatial locations and associated laboratory report IDs, as well as the analytical results for all XRF confirmation soil samples, are provided in Attachment H28-1. The results of the XRF field survey, including the overall summary statistics of the XRF confirmation soil samples, are presented in Section 5.2.1.

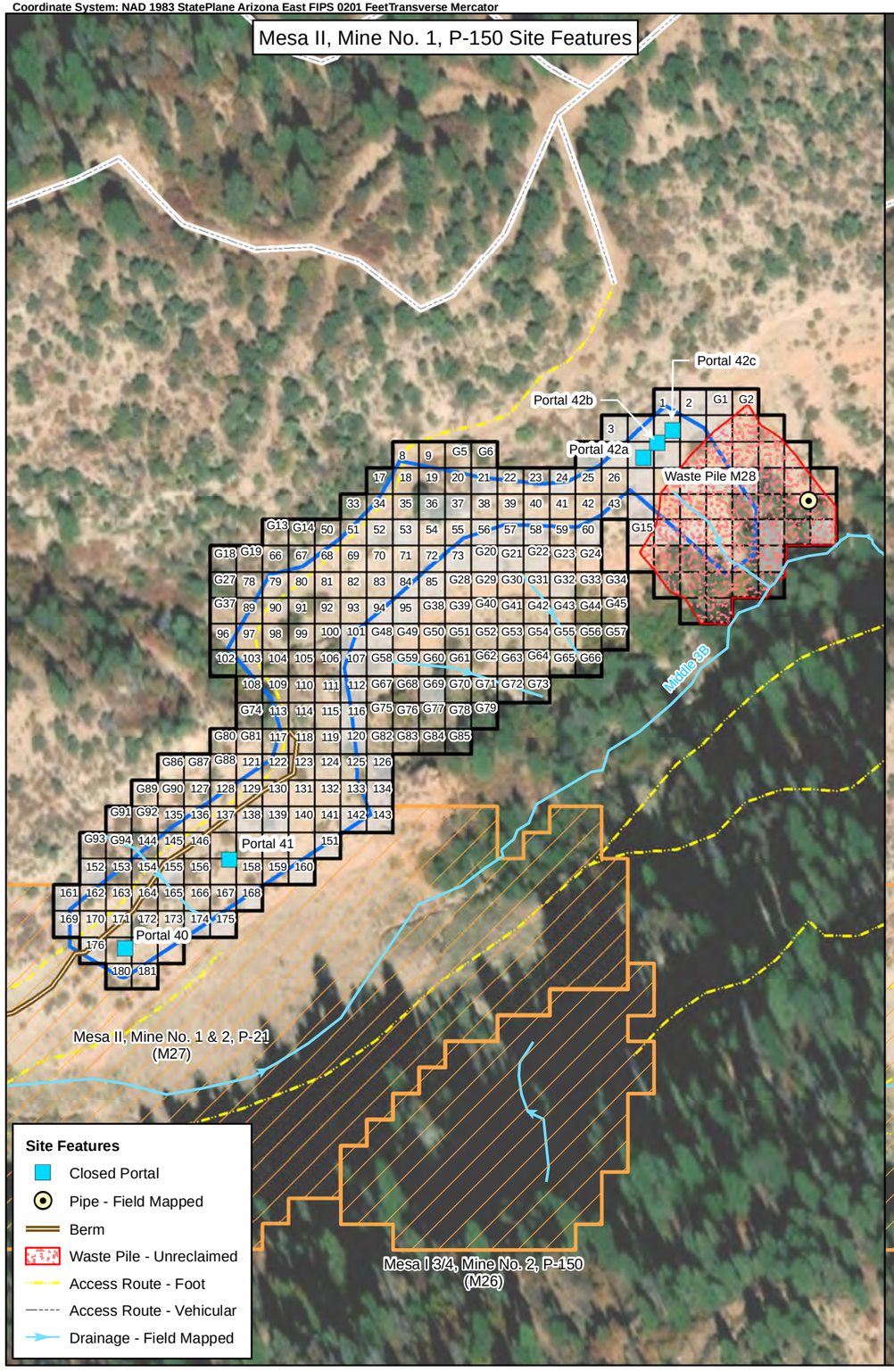
4.7.2 SURFACE SOIL SAMPLING (0 TO 6 INCHES)

The second type of analytical soil sample collected at Mesa II, Mine No. 1, P-150 involved sampling of the upper 6 inches of soil. Surface soil samples were collected during the shallow subsurface sampling investigation conducted during the Site Characterization Study. For every subsurface boring advanced, a surface soil sample was also collected to represent the upper layer of soil. Soil sampling was performed following methods outlined in Appendix C of the RSE Work Plan (Tetra Tech 2018) and following the same sampling procedures as the background investigation (Appendix A of the RSE Report). A total of six surface soil samples were collected for analyses for metals and radionuclides by use of a stainless-steel trowel and bowl. Soil sample locations were selected based on judgmental biased sampling to ensure the full range of concentrations were assessed, primarily relying on gamma radiation levels and material characteristics of known waste pile areas. Furthermore, the sample locations were based on delineating the footprint of unreclaimed waste pile present at the site.

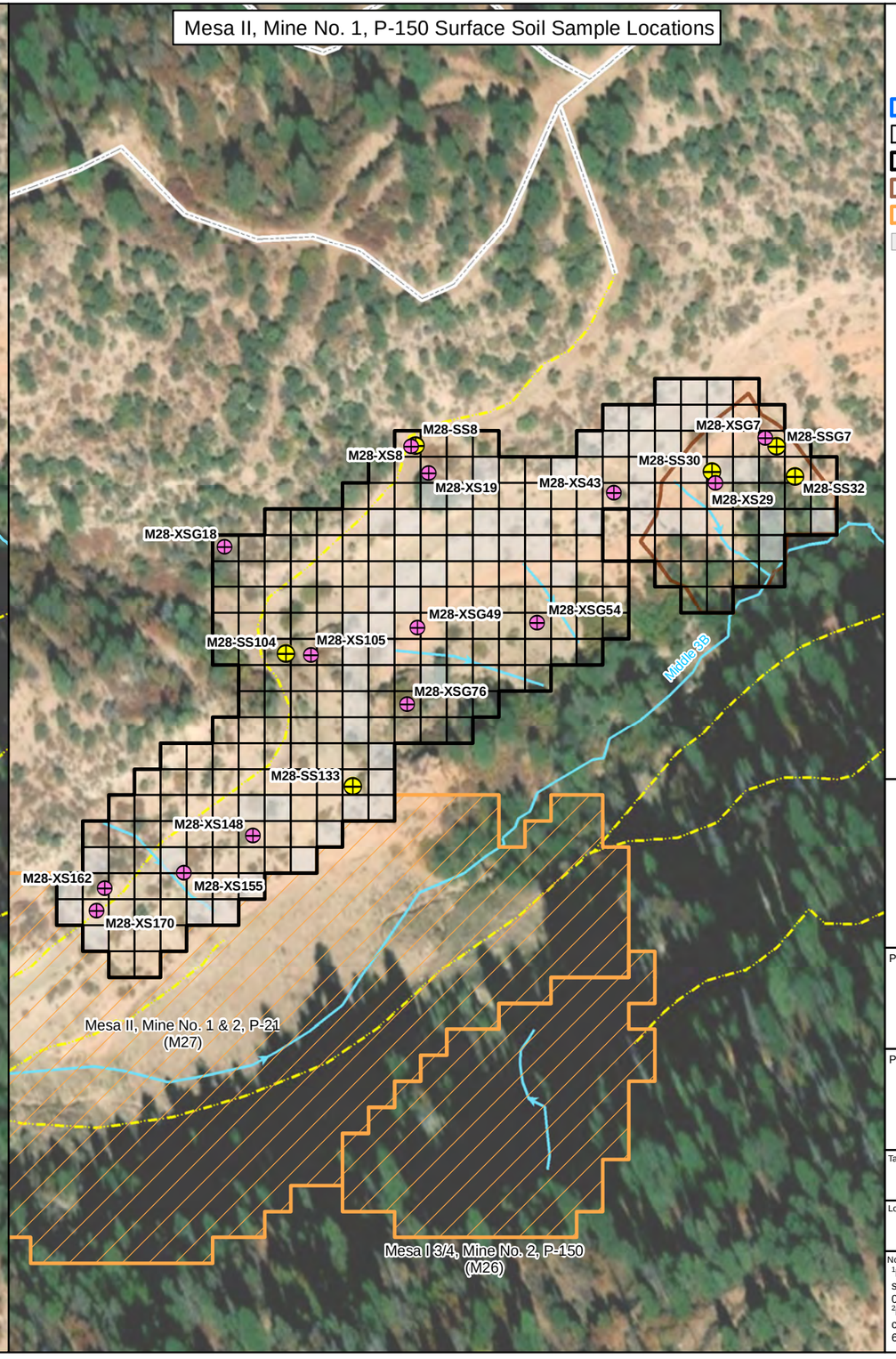
Figure H28-14 shows the locations of the surface soil samples. Survey units that were classified as inaccessible during the XRF field survey are shown as gray squares on Figure H28-14, as discussed further in Section 4.10. The surface soil geospatial locations and associated laboratory report IDs, as well as the analytical results for all surface soil samples, are provided in Attachment H28-1. Surface soil samples were analyzed for the suite of metals and radionuclides as shown in Table H28-8 and Table H28-9, respectively. Two surface soil samples were also analyzed for geochemical analysis of metals and radionuclides as shown in Table H28-10 and Table H28-11, respectively.

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

Mesa II, Mine No. 1, P-150 Site Features



Mesa II, Mine No. 1, P-150 Surface Soil Sample Locations



XRF Confirmation Soil Sample[1]
(0 - 3 inches bgs)

Surface Soil Sample[2]
(0 - 6 inches bgs)

AUM Site Boundary

Survey Unit (100 m²)

Survey Area Boundary

Waste Pile Boundary

Other Survey Area

Inaccessible To XRF Survey

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150

SURFACE SOIL SAMPLE LOCATION MAP

Prepared For:

Prepared By:

TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	Date: 7/11/2019

Notes:
[1]M28-XSG7 = site M28 XRF confirmation soil sample collected at survey unit G7. 0 - 3 in bgs = 0 to 3 inches below ground surface.
[2]M28-SSG7 = site M28 surface soil sample collected at survey unit G7. 0 - 6 in bgs = 0 to 6 inches below ground surface.

Figure No.: **H28-14**

Table H28-8. Laboratory Analysis of Metals for Surface and Subsurface Soil Samples

Analyte	Type	CAS Number	Analytical Method	# of Surface Soil Samples Analyzed	# of Subsurface Soil Samples Analyzed
Aluminum	Metals	7429-90-5	USEPA SW-846 6020B	6	5
Antimony	Metals	7440-36-0	USEPA SW-846 6020B	6	5
Arsenic	Metals	7440-38-2	USEPA SW-846 6020B	6	5
Barium	Metals	7440-39-3	USEPA SW-846 6020B	6	5
Beryllium	Metals	7440-41-7	USEPA SW-846 6020B	6	5
Cadmium	Metals	7440-43-9	USEPA SW-846 6020B	6	5
Calcium	Metals	7440-70-2	USEPA SW-846 6020B	6	5
Chromium	Metals	7440-47-3	USEPA SW-846 6020B	6	5
Cobalt	Metals	7440-48-4	USEPA SW-846 6020B	6	5
Copper	Metals	7440-50-8	USEPA SW-846 6020B	6	5
Iron	Metals	7439-89-6	USEPA SW-846 6020B	6	5
Lead	Metals	7439-92-1	USEPA SW-846 6020B	6	5
Lithium	Metals	7439-93-2	USEPA SW-846 6020B	6	5
Magnesium	Metals	7439-95-4	USEPA SW-846 6020B	6	5
Manganese	Metals	7439-96-5	USEPA SW-846 6020B	6	5
Mercury	Metals	7439-97-6	USEPA SW-846 7471A	0	0
Molybdenum	Metals	7439-98-7	USEPA SW-846 6020B	6	5
Nickel	Metals	7440-02-0	USEPA SW-846 6020B	6	5
Selenium	Metals	7782-49-2	USEPA SW-846 6020B	6	5
Silver	Metals	7440-22-4	USEPA SW-846 6020B	6	5
Sodium	Metals	7440-23-5	USEPA SW-846 6020B	6	5
Thallium	Metals	7440-28-0	USEPA SW-846 6020B	6	5
Thorium	Metals	-	USEPA SW-846 6020B	6	5
Uranium	Metals	-	USEPA SW-846 6020B	6	5
Vanadium	Metals	7440-62-2	USEPA SW-846 6020B	6	5
Zinc	Metals	7440-66-6	USEPA SW-846 6020B	6	5

Notes:
- Not applicable
CAS Chemical Abstracts Service
USEPA U.S. Environmental Protection Agency

Table H28-9. Laboratory Analysis of Select Radionuclides for Surface and Subsurface Soil Samples

Decay Series	Analyte	Type	CAS Number	Analytical Method	# of Surface Soil Samples Analyzed[1]	# of Subsurface Soil Samples Analyzed
Uranium	**Uranium-238**[2]	Radionuclides	7440-61-1	ASTM D3972 Modified	6	1
	Uranium-234	Radionuclides	13966-29-5	ASTM D3972 Modified	6	1
	Thorium-230	Radionuclides	14269-63-7	ASTM D3972 Modified	6	1
	Radium-226	Radionuclides	13982-63-3	USEPA 901.1	20	5
	Lead-210	Radionuclides	14255-04-0	Eichrom method	6	1
Actinide	**Uranium-235**	Radionuclides	15117-96-1	ASTM D3972 Modified	6	1
Thorium	**Thorium-232**[2]	Radionuclides	7440-29-1	ASTM D3972 Modified	6	1
	Radium-228	Radionuclides	15262-20-1	USEPA 901.1	20	5
	Thorium-228	Radionuclides	14274-82-9	ASTM D3972 Modified	6	1
Potassium	**Potassium-40**	Radionuclides	13966-00-2	USEPA 901.1	20	5

Notes:

[1] Includes surface soil samples (0 to 6 inches bgs) and XRF confirmation soil samples (0 to 3 inches bgs).

[2] Measured via alpha and gamma spectroscopy. Only the results from the alpha spectroscopy are presented in the report because the detection limits from the gamma spectroscopy are high.

ASTM ASTM International
bgs Below ground surface
CAS Chemical Abstracts Service
USEPA U.S. Environmental Protection Agency

Table H28-10. Laboratory Geochemical Analysis of Metals for Surface and Subsurface Soil Samples

Analyte	Geochemical Parameter	CAS Number	Analytical Method	# of Surface Soil Samples Analyzed	# of Subsurface Soil Samples Analyzed
Aluminum	SPLP	7429-90-5	USEPA SW-846 6020B	2	1
Antimony	SPLP	7440-36-0	USEPA SW-846 6020B	2	1
Arsenic	SPLP, TCLP	7440-38-2	USEPA SW-846 6020B	2	1
Barium	SPLP, TCLP	7440-39-3	USEPA SW-846 6020B	2	1
Beryllium	SPLP	7440-41-7	USEPA SW-846 6020B	2	1
Cadmium	SPLP, TCLP	7440-43-9	USEPA SW-846 6020B	2	1
Calcium	SPLP	7440-70-2	USEPA SW-846 6020B	2	1
Chromium	SPLP, TCLP	7440-47-3	USEPA SW-846 6020B	2	1
Cobalt	SPLP	7440-48-4	USEPA SW-846 6020B	2	1
Copper	SPLP	7440-50-8	USEPA SW-846 6020B	2	1
Iron	SPLP	7439-89-6	USEPA SW-846 6020B	2	1
Lead	SPLP, TCLP	7439-92-1	USEPA SW-846 6020B	2	1
Lithium	SPLP	7439-93-2	USEPA SW-846 6020B	2	1
Magnesium	SPLP	7439-95-4	USEPA SW-846 6020B	2	1
Manganese	SPLP	7439-96-5	USEPA SW-846 6020B	2	1
Molybdenum	SPLP	7439-98-7	USEPA SW-846 6020B	2	1
Nickel	SPLP	7440-02-0	USEPA SW-846 6020B	2	1
Selenium	SPLP, TCLP	7782-49-2	USEPA SW-846 6020B	2	1
Silver	SPLP, TCLP	7440-22-4	USEPA SW-846 6020B	2	1
Sodium	SPLP	7440-23-5	USEPA SW-846 6020B	2	1
Thallium	SPLP	7440-28-0	USEPA SW-846 6020B	2	1
Vanadium	SPLP	7440-62-2	USEPA SW-846 6020B	2	1
Zinc	SPLP	7440-66-6	USEPA SW-846 6020B	2	1
Thorium	SPLP	-	USEPA SW-846 6020B	2	1
Uranium	SPLP	-	USEPA SW-846 6020B	2	1
paste pH	pH	-	USDA60	2	1
Acid-Base Accounting	Total Sulfur, Acid Potential, Neutralization Potential	-	Modified Sobek Method	2	1

Notes:
- Not applicable
CAS Chemical Abstracts Service
SPLP Synthetic precipitation leaching procedure
TCLP Toxicity characteristic leaching procedure
USDA U.S. Department of Agriculture
USEPA U.S. Environmental Protection Agency

Table H28-11. Laboratory Geochemical Analysis of Radionuclides for Surface and Subsurface Soil Samples

Decay Series	Analyte	Geochemical Parameter	CAS Number	Analytical Method	# of Surface Soil Samples Analyzed	# of Subsurface Soil Samples Analyzed
Uranium	Uranium-238[1]	SPLP	7440-61-1	ASTM D3972 Modified	2	1
	Uranium-234	SPLP	13966-29-5	ASTM D3972 Modified	2	1
	Thorium-230	SPLP	14269-63-7	ASTM D3972 Modified	2	1
	Radium-226	SPLP	13982-63-3	USEPA 901.1	2	1
	Lead-210	SPLP	14255-04-0	Eichrom method	2	1
	Polonium-210	SPLP	15117-96-1	ASTM D3972 Modified	2	1
Actinide	Uranium-235	SPLP	7440-29-1	ASTM D3972 Modified	2	1
Thorium	Thorium-232[1]	SPLP	15262-20-1	ASTM D3972 Modified	2	1
	Radium-228	SPLP	14274-82-9	ASTM D3972 Modified	2	1
	Thorium-228	SPLP	13966-00-2	USEPA 901.1	2	1

Notes:

[1] Measured via alpha spectroscopy.

ASTM ASTM International

CAS Chemical Abstracts Service

SPLP Synthetic precipitation leaching procedure

USEPA U.S. Environmental Protection Agency

4.7.3 SHALLOW SUBSURFACE SOIL SAMPLING

Because of the limited accessibility and steep topography, a shallow subsurface investigation was performed by hand at Mesa II, Mine No. 1, P-150. The purpose of the subsurface program was to evaluate the subsurface conditions of the mine waste present at Mesa II, Mine No. 1, P-150 to the extent practicable given the accessibility conditions.

Subsurface sampling activities were performed using hand tools following Appendix C of the RSE Work Plan (Tetra Tech 2018). A surface soil sample was obtained with a hand trowel from the surface to 6 inches bgs. A shovel was used to collect the subsurface soil samples by creating a small test pit and measuring the depth. Discrete soil samples were collected based on soil conditions in 6-inch intervals. Samples were placed into dedicated plastic bags and designated for either metals or radionuclide laboratory analyses as described in Section 4.7.2. Given the shallow nature of the subsurface sampling downhole, gamma readings were not collected. Borings were backfilled using the surrounding soil.

Five boring locations were selected as part of the shallow subsurface sampling design based on site knowledge and, specifically, to cover the extent of the expected range of soil concentrations, as well location of the unreclaimed waste pile identified during the site mapping. The laboratory analytical results of the samples collected as part of the subsurface investigation are presented in Attachment H28-1. A photographic log showing the sampling that took place is provided in Attachment H28-3. Results of the subsurface sampling program are discussed in Section 5.2.2.

Table H28-12 presents the boring IDs and depth ranges while Figure H28-15 presents the locations of the subsurface borings and their appropriate depth range. Survey units that were classified as inaccessible during the XRF field survey are shown as gray squares on Figure H28-15, as discussed further in Section 4.10. Subsurface soil samples were analyzed for the suite of metals and radionuclides as shown in Table H28-8 and Table H28-9, respectively. One subsurface soil sample was also analyzed for geochemical parameters as shown in Table H28-10 and Table H28-11. Three subsurface soil samples were also analyzed for geotechnical parameters as shown in Table H28-13.

Table H28-12. Subsurface Boring IDs and Depth Ranges

Boring ID	Depth Range (inches)	
	#1	#2
M28-SB8	0-6	6-12
M28-SB30	0-6	6-12
M28-SB32	0-6	6-12
M28-SB104	0-6	6-12
M28-SB133	0-6	6-12

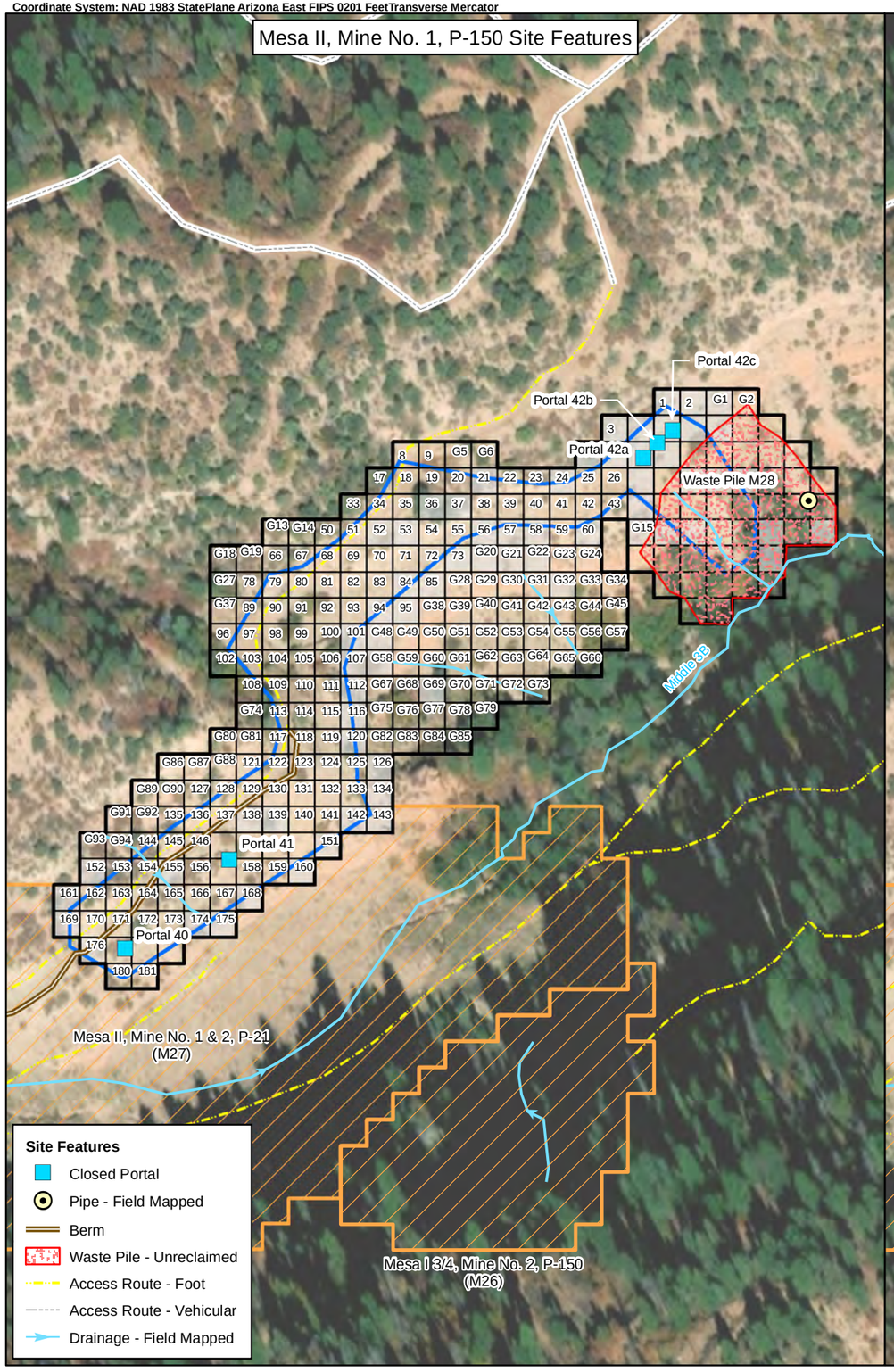
Table H28-13. Selected Geotechnical Analysis for Surface and Subsurface Soil Samples

Analyte	Type	Analytical Method	# of Surface Soil Samples Analyzed	# of Subsurface Soil Samples Analyzed
Wet Sieve[1]	Geotechnical	ASTM D6913	0	3
Atterberg limits	Geotechnical	ASTM D4318	0	3
Proctor	Geotechnical	ASTM D698	0	3

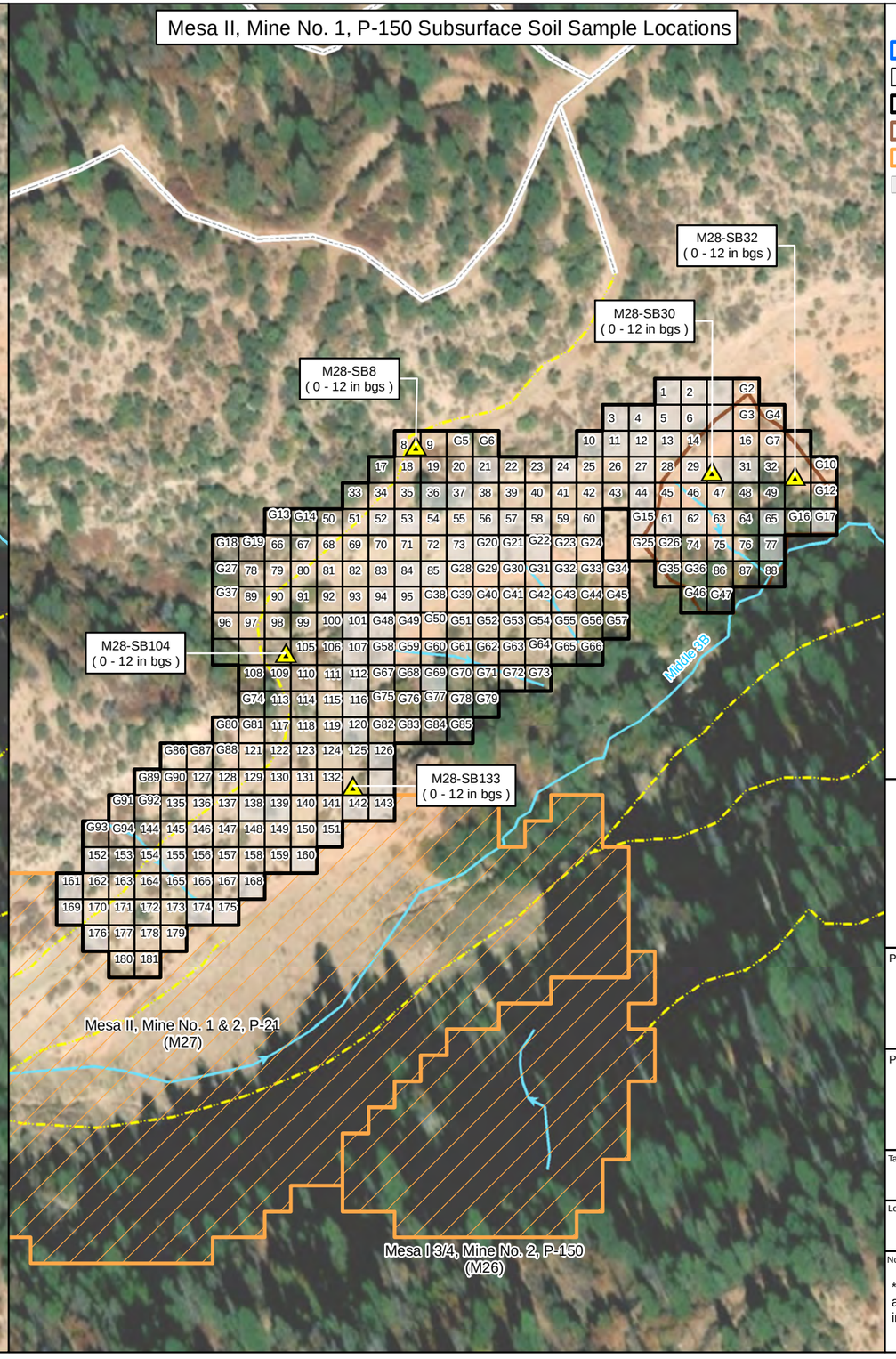
Notes:
[1] Sieve stack including #200, #100, #80, #40, #10, #4, and 3/8 inches.
ASTM ASTM International

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

Mesa II, Mine No. 1, P-150 Site Features



Mesa II, Mine No. 1, P-150 Subsurface Soil Sample Locations



- Boring Location*
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Waste Pile Boundary
- Other Survey Area
- Inaccessible To XRF Survey

Note: Figure includes only sample locations where sample was collected at a top depth greater than 6 inches below ground surface.

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150
SUBSURFACE SOIL SAMPLE MAP

Prepared For:

Prepared By:

TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	**Date:** 7/7/2019

Notes:

*M28-SB30 = site M28 soil boring collected at survey unit 30. 0 - 12 in bgs = 0 to 12 inches below ground surface.

Figure No.: **H28-15**

4.8 CULTURAL AND BIOLOGICAL SURVEYS

Dinetahdoo Cultural Resources Management LLC conducted cultural resource surveys under a separate contract with USEPA. The survey areas included the survey boundary of Mesa II, Mine No. 1, P-150. The cultural survey personnel conducted monitoring during ground disturbing activities of the project and were present during the gamma radiation surveys, XRF field surveys, and soil sampling. There were no survey units identified as culturally sensitive within the Mesa II, Mine No. 1, P-150 survey area. Additionally, Tetra Tech provided cultural survey assistance to USEPA as needed to support initial consultations with the Navajo Nation Heritage and Historic Preservation Department. On February 13, 2018, Tetra Tech provided USEPA a summary of anticipated RSE field activities and sampling locations to support cultural survey work. Furthermore, a summary of the biological desktop study inclusive of the Lukachukai Mountain region where Mesa II, Mine No. 1, P-150 is located is presented in the main text of the RSE Report.

4.9 QUALITY ASSURANCE/QUALITY CONTROL

QA/QC procedures were implemented throughout the data collection and analysis tasks completed under Task Order 0001. Specific QA/QC procedures were implemented to both minimize and evaluate potential sources of inaccuracy during sample collection and analysis, including field and laboratory quality control sample analysis. The QA/QC procedures were designed to consider relevant guidance from USEPA, as well as from MARSSIM and the *Multi-Agency Radiological Laboratory Analytical Protocols Manual* (MARLAP) (USEPA 2004).

All project QA/QC data are included in appendices to the RSE Report and not provided in this report. The XRF field survey QA/QC results are in Appendix B, the gamma radiation survey QA/QC results are in Appendix C, and the soil, sediment, and water sampling QA/QC results are in Appendix G. All factory calibration documentation for field equipment is provided in the relevant appendices. All laboratory reports are in Appendix L, and data validation reports are in Appendix M. All laboratory analytical reports underwent 100 percent third-party data validation. Tetra Tech underwent numerous random field audits by USEPA's RPM. All QA/QC results, both field and laboratory, met the performance criteria identified in the SAP/QAPP of the RSE Work Plan (Tetra Tech 2018).

4.10 STATEMENT ON ACCESSIBILITY

The terrain within the Mesa II, Mine No. 1, P-150 survey area sometimes posed a risk to the health and safety of the project team. An attempt was made to collect in situ XRF measurements and gamma radiation survey data within every 100 m^2 survey unit within the survey area. However, given the site-specific limitations encountered mostly because of the extreme terrain and health and safety concerns, some survey units may not have contained an in situ XRF measurement, soil sample, or gamma radiation survey measurement data. In some cases, the XRF field survey team or the gamma radiation survey team, but not both, could not physically access an area because of differences in field measurement instrumentation, differences in the personal judgement of field staff, direction from the onsite USEPA RPM, or direction from Tetra Tech health and safety management. Inaccessible survey units for either the XRF field survey or the gamma radiation survey are shown as gray squares on the figures.

Out of the total 275 survey units at Mesa II, Mine No. 1, P-150, 66 were classified as inaccessible by the XRF field survey team and did not contain in situ XRF measurements and 50 were classified as inaccessible by the gamma survey team and did not contain gamma radiation measurements. A total of 33 survey units were considered inaccessible by both survey types. The onsite USEPA RPM was consulted during field operations and made the final determination for areas considered inaccessible for any type of field sampling based on the project DQOs. Tetra Tech field team staff or a health and safety officer, in consultation with the onsite USEPA RPM, determined accessibility for field sampling teams based on health and safety concerns. It should be noted that a survey unit identified as inaccessible may still be classified as Class 1 or Class 2 based on the proximity to a site feature (such as a burial cell or waste pile). The following section presents the RSE field investigation results. Figure H28-16 shows an example of a portion of an inaccessible survey unit at Mesa II, Mine No. 1, P-150.

Figure H28-16. An Inaccessible Area of Mesa II Mine 1, P-150

5.0 RESULTS

5.1 GAMMA RADIATION SURVEY

This section presents an overview of the gamma radiation survey performed at Mesa II, Mine No. 1, P-150 and the raw gamma radiation and grid averaged gamma radiation survey results.

An initial gamma radiation survey was performed as part of the Baseline Study at Mesa II, Mine No. 1, P-150 in June 2018 following the methods outlined in Section 4.4. The results of the survey were evaluated following the completion of the Baseline Study to determine how many additional Goback survey units would need to be added as part of the Site Characterization Study survey design. Additional gamma radiation surveys were performed in September 2018 to collect data within the Goback survey units. Additionally, a gamma radiation survey was performed on drainages and roads within the area, and the results are presented in Appendices J and K of the RSE Report, respectively. The applied gamma BTV for Mesa II, Mine No. 1, P-150 is 9,703 cpm. A total of 26,696 measurements were collected as part of the gamma radiation survey at Mesa II, Mine No. 1, P-150 across 225 accessible survey units. Because of the steep topography, not all survey units were scanned at 100 percent density. An average scan density of 100 measurements per survey unit was calculated. See Table H28-14 for a summary of the gamma radiation survey results.

Table H28-14. Summary of Gamma Radiation Survey Results for Mesa II, Mine No. 1, P-150

Summary Statistic	Units	Raw Gamma Radiation Survey Results	Grid Averaged Gamma Radiation Survey Results
Applied Gamma BTV	cpm	9,703	
Measurements[1]	#	26,696	225
Minimum[2]	cpm	7,269	8,875
Maximum[2]	cpm	219,903	136,020
Average[2]	cpm	26,719	25,323
Median[2]	cpm	18,910	19,574
Standard Deviation	cpm	26,728	21,728
90th Percentile	cpm	47,797	43,460
95th Percentile	cpm	93,581	72,009
99th Percentile	cpm	142,998	115,907
Measurements per Survey Unit	#/grid	119	
Measurements Above Gamma BTV	#	25,805	222
Measurements Above Gamma BTV	%	97	99

Notes:

[1] Measurements for grid average is equal to the number of accessible survey units.

[2] Minimum, maximum, average, and median in right column are the grid averages from the survey units.

BTV Background threshold value

cpm Counts per minute

5.1.1 RAW GAMMA RADIATION SURVEY RESULTS

The gamma radiation survey at Mesa II, Mine No. 1, P-150 was conducted in two phases. Because of the steep slopes and inaccessible regions within the survey area, a 100 percent scan coverage was not always feasible for safety reasons. Figure H28-17 provides an individual value plot showing the spread of gamma radiation survey data collected at the site compared to the BSA-24 gamma survey results. This graph shows that the spread of radiation data at the site (shown on left) begins within the range of BSA-24 background gamma levels (shown on right) and then reaches more than 10 times background radiation. A box plot showing the quartiles of the data sets is provided in Figure H28-18. The box plot shows the median of the site radiation levels is higher than the median of the background data set and higher than the applied gamma BTV. In general, Mesa II, Mine No. 1, P-150 has surficial gamma radiation levels above background levels in the majority of the site except for a portion along the western boundary which approaches background radiation levels.

A map showing the results of the gamma radiation survey is provided in Figure H28-19. Survey units that were classified as inaccessible during the gamma radiation survey are shown as gray squares on Figure H28-19 and discussed further in Section 4.10. The results of the gamma radiation survey confirmed elevated gamma readings within the original geodatabase boundaries of Waste Pile M28 with an upper range in some cases exceeding between 10 to 20 times the applied gamma BTV (9,703 cpm). Contamination associated with the unreclaimed Waste Pile M28 also appeared to extend outside of the original boundary provided in the USEPA geodatabase (Neptune and TSG 2018), which was then confirmed using multiple lines of evidence (see Section 2.6). Based on these findings, the extent of the Waste Pile M28 boundary was expanded.

There are three general areas of contamination at Mesa II, Mine No. 1, P-150. The elevated readings were recorded (1) along the bench below the close portals 40 and 41 (2) below cliffs in the central portion of the site is an area of elevated gamma not associated with any mine features (3) at the eastern portion of the site within Waste Pile M28. In addition to the elevated readings in these three areas of the site, the gamma measurements taken in Middle 3B directly downgradient of the site are elevated above the applied gamma BTV as shown in Figure H28-19.

The gamma survey data collected within Mesa II, Mine No. 1, P-150 are sufficient for helping estimate waste volume and for site classification. The gamma radiation survey data are used to help classify the site based on gamma activity in addition to the known site features, following the site classification methods presented in Section 4.2. There are several survey units across the site that include exceedances of the applied gamma BTV, and the site contains higher levels of gamma radiation within the waste pile. In general, the elevated areas of gamma radiation, along with the lateral extent of surficial radiation levels, have been fully characterized. The following subsection presents the grid averaged results of the gamma radiation survey.

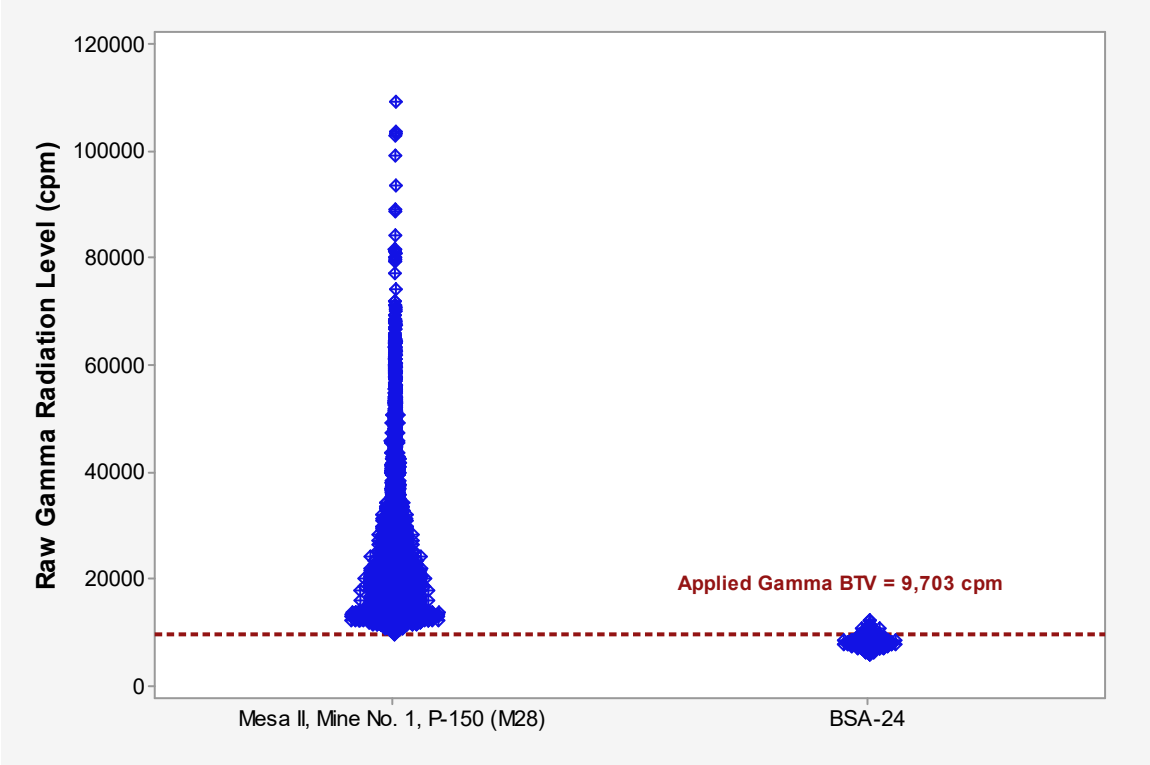


Figure H28-17. Individual Value Plot of Raw Gamma Radiation Levels at Mesa II Mine No. 1, P-150 and BSA-24

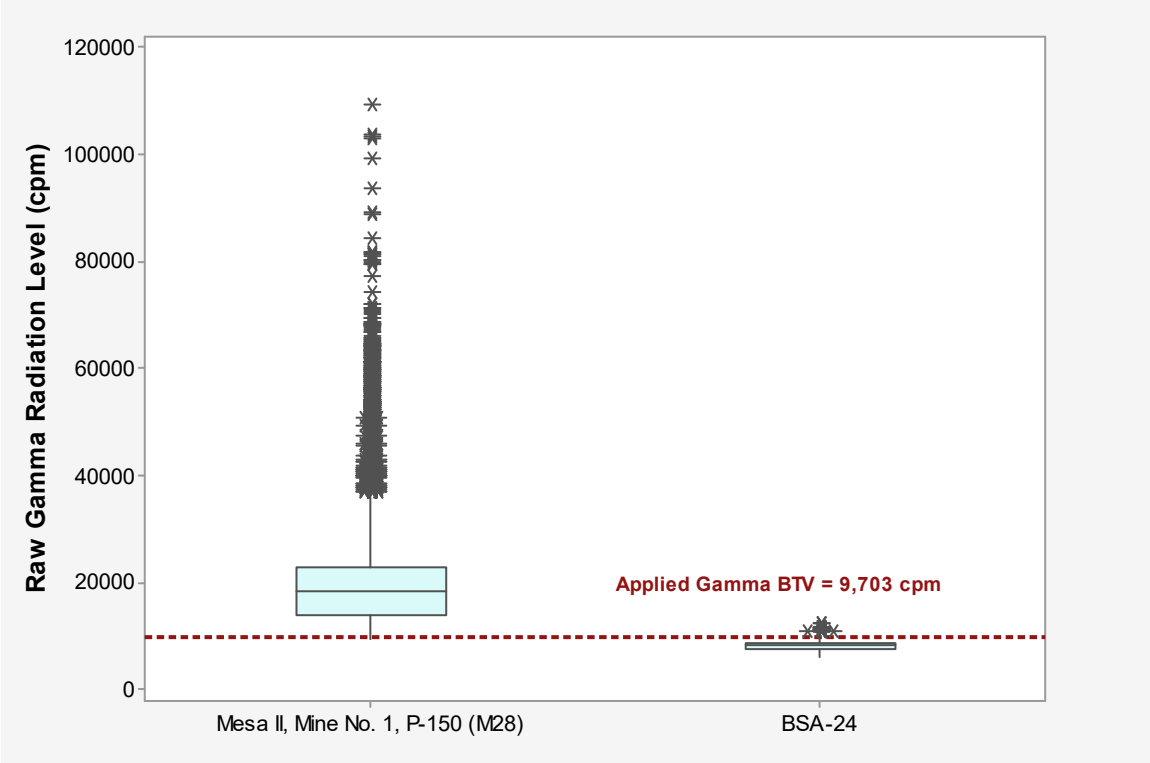
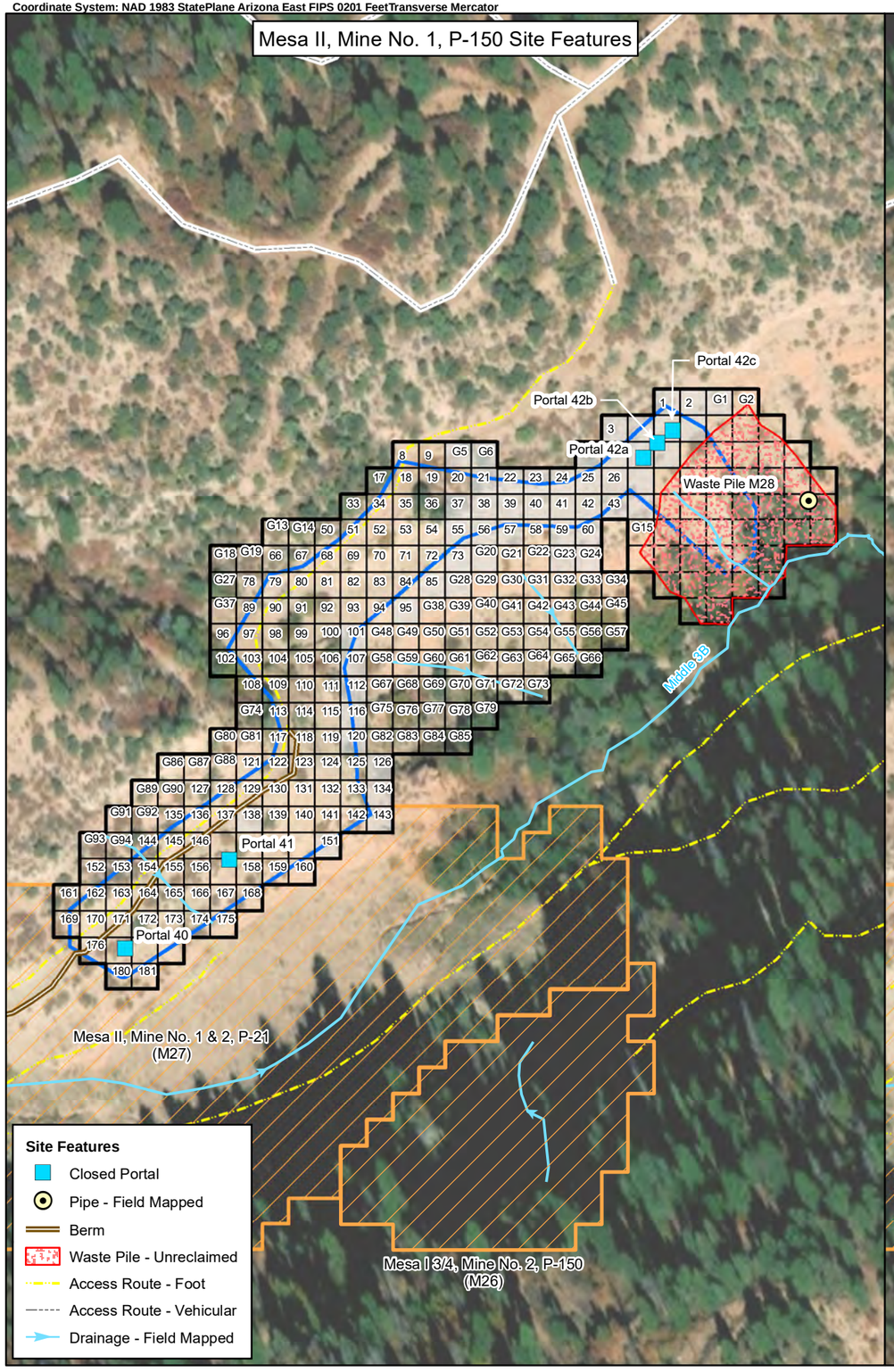


Figure H28-18. Box Plot of Raw Gamma Radiation Levels at Mesa II Mine No. 1, P-150 and BSA-24

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

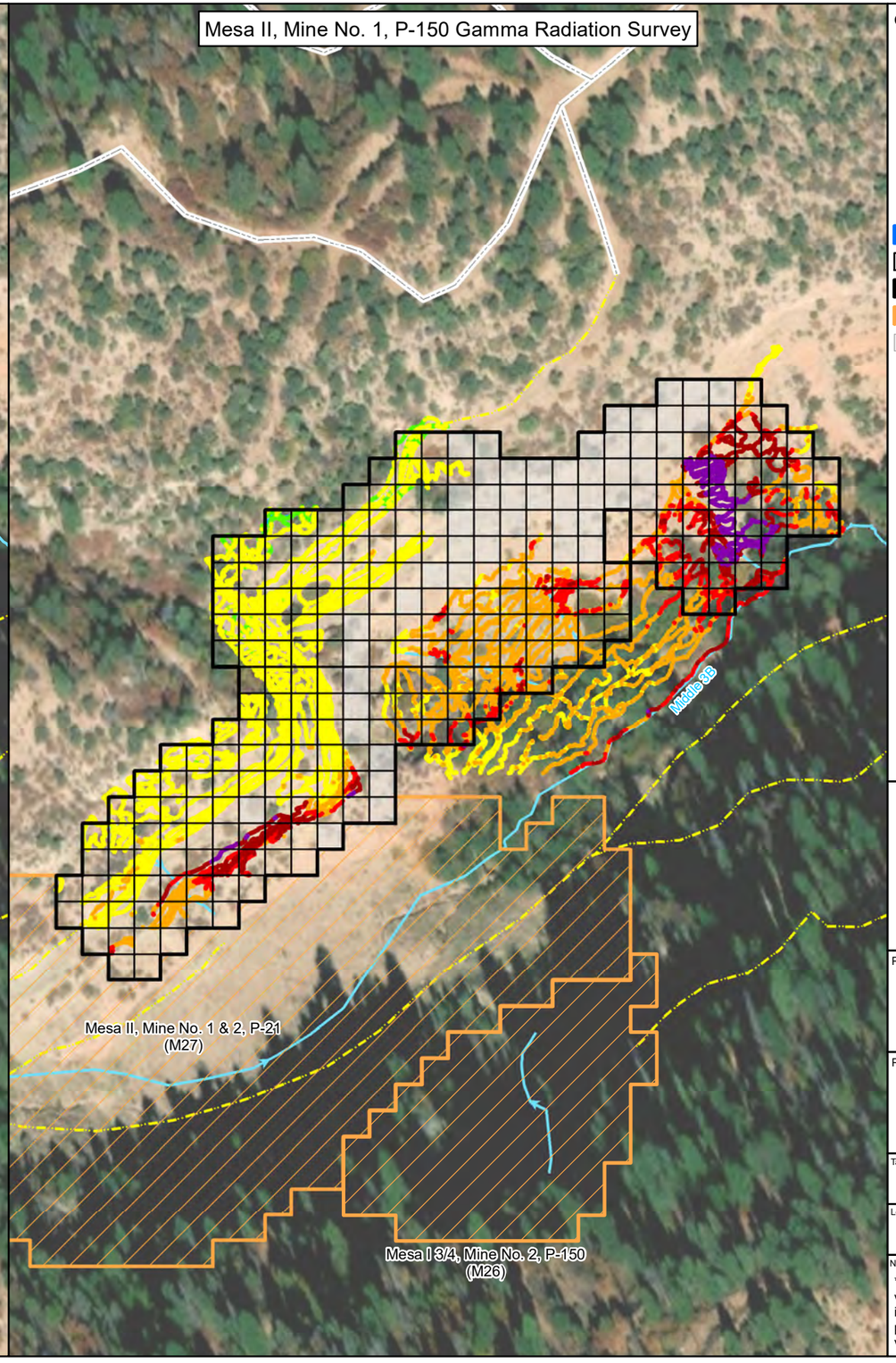
Mesa II, Mine No. 1, P-150 Site Features



Site Features

- Closed Portal
- Pipe - Field Mapped
- Berm
- Waste Pile - Unreclaimed
- Access Route - Foot
- Access Route - Vehicular
- Drainage - Field Mapped

Mesa II, Mine No. 1, P-150 Gamma Radiation Survey



Gamma Reading (cpm)*

≤ 8,123	≤ Avg. BG
8,123 - 9,703	Avg. BG - 1 x BTV
9,703 - 19,406	1 x BTV - 2 x BTV
19,406 - 29,109	2 x BTV - 3 x BTV
29,109 - 38,812	3 x BTV - 4 x BTV
38,812 - 97,030	4 x BTV - 10 x BTV
≥ 97,030	≥ 10 x BTV

- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Other Survey Area
- Inaccessible To Gamma Survey

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150
GAMMA RADIATION SURVEY MAP

Prepared For:

Prepared By:

TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	**Date:** 7/7/2019

Notes:
*The applied gamma background threshold value (BTV) for Mesa II, Mine No. 1, P-150 is 9,703 cpm derived from BSA-24 as presented in Appendix A. Avg. BG: Average value of the background data set.

Figure No.: **H28-19**

5.1.2 GRID AVERAGED GAMMA RADIATION SURVEY RESULTS

The raw results of the gamma radiation survey are presented in Section 5.1.1, and the summary statistics of the grid averaged analysis of the gamma radiation survey data are provided in Section 5.1. Figure H28-20 and Figure H28-21 show an individual value plot and a box plot, respectively, for the grid averaged gamma radiation data (shown on left) compared to the site-specific BSA (shown on right). A total of 98 percent of the survey units (166 in total) within the survey area of Mesa II, Mine No. 1, P-150 had a grid averaged gamma radiation level above the applied gamma BTV.

A map showing the site features (on left) and the grid averaged gamma radiation levels (shown on right) with color-coordinated levels is provided in Figure H28-22. Survey units that were classified as inaccessible during the gamma radiation survey are shown as gray squares on Figure H28-22 and discussed further in Section 4.10. This map shows the locations of survey units exceeding the gamma BTV. The elevated regions of the site correspond well with the unreclaimed waste pile, as well as with the old haul road beneath the portals. The procedure for grid averaging the gamma radiation levels in survey units is useful for the site classification methods described in Section 4.2 and presented in Section 6.1. Any survey unit that contained an average radiation level exceeding the gamma BTV is automatically classified as Class 1 and considered a potentially impacted survey unit. Results from surface and subsurface soil samples collected at the site are presented in Section 5.2.

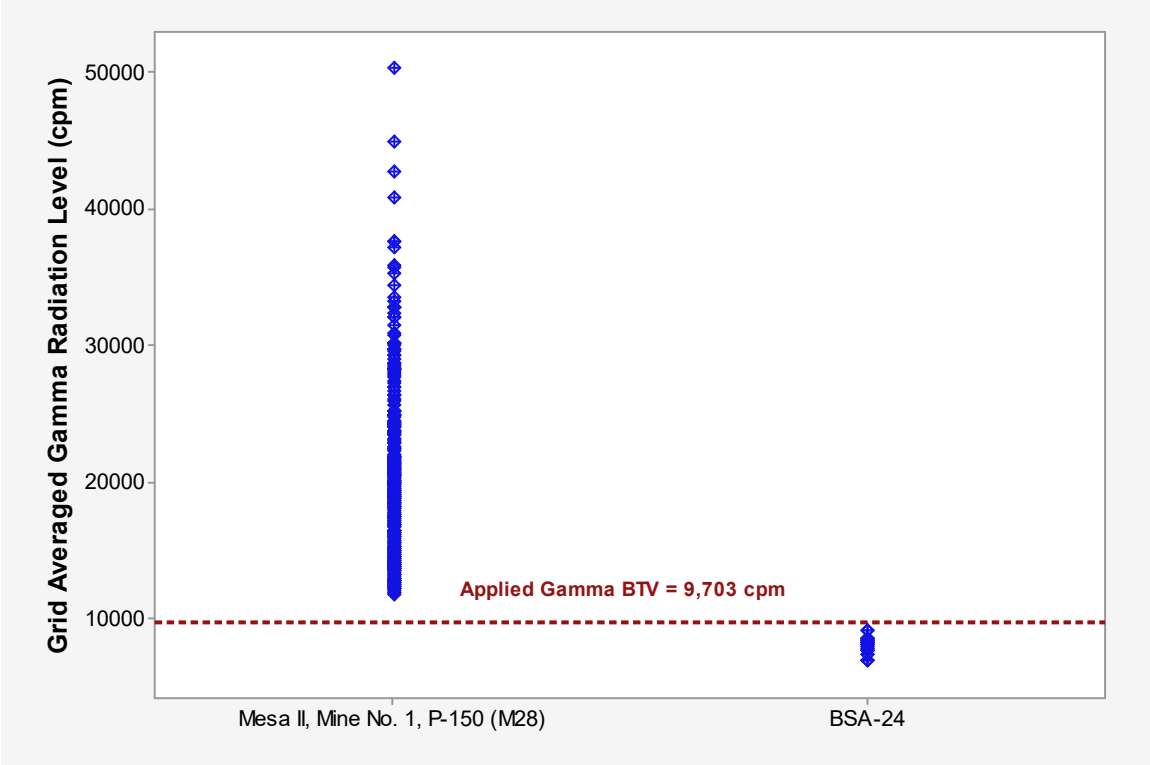


Figure H28-20. Individual Value Plot of Grid Averaged Gamma Radiation Levels at Mesa II Mine No. 1, P-150 and BSA-24

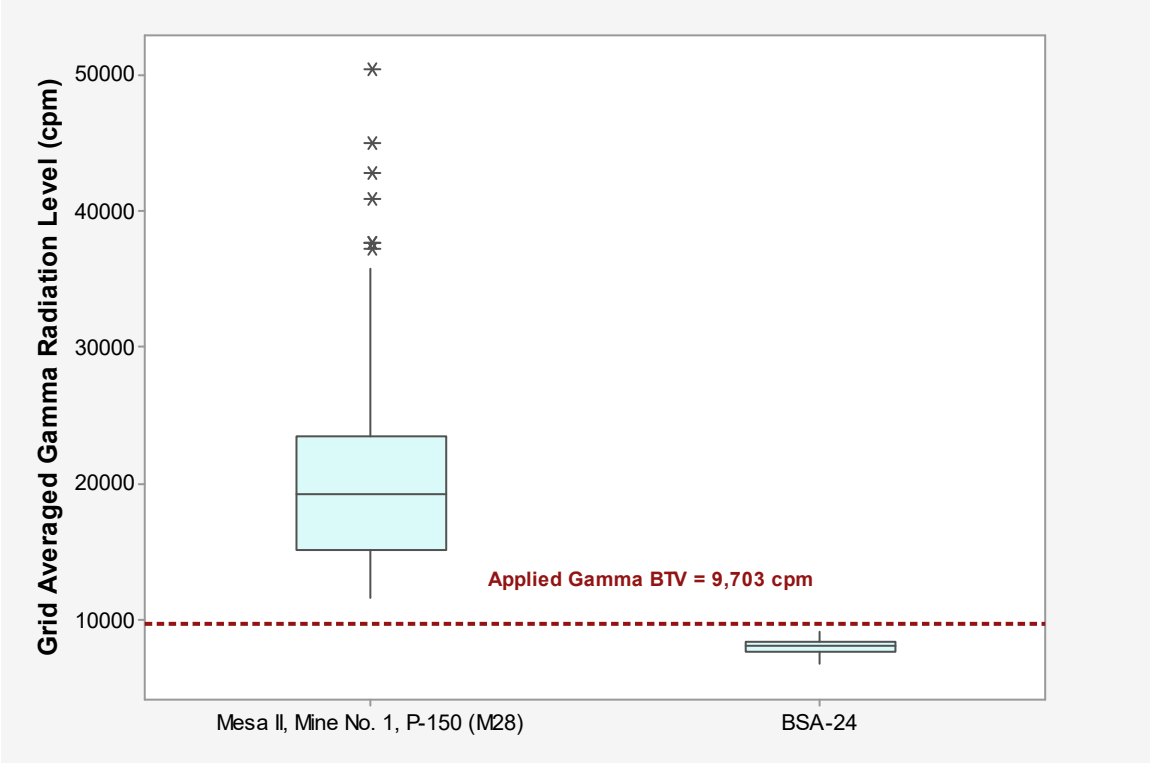
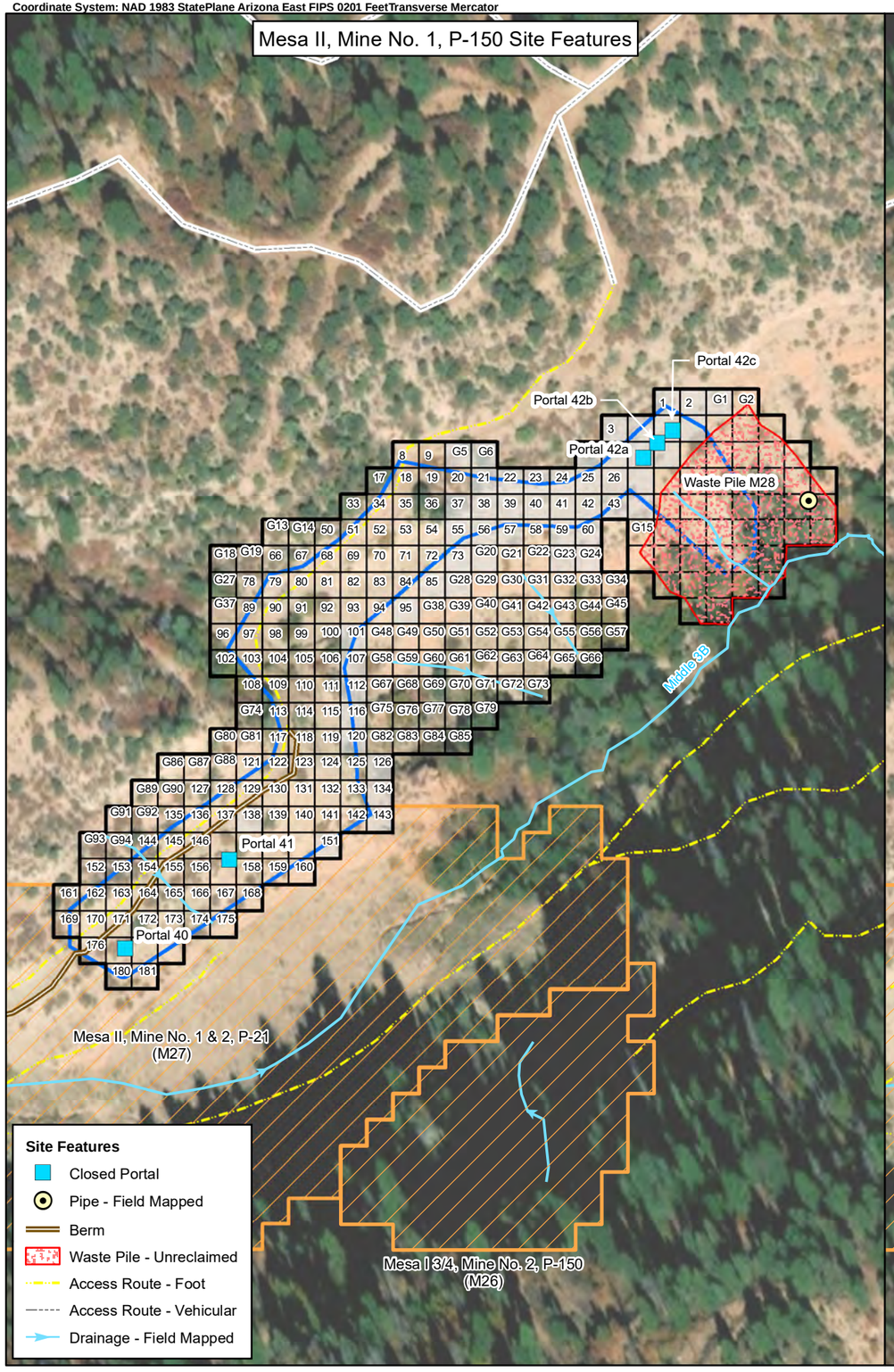


Figure H28-21. Box Plot of Grid Averaged Gamma Radiation Levels at Mesa II Mine No. 1, P-150 and BSA-24

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

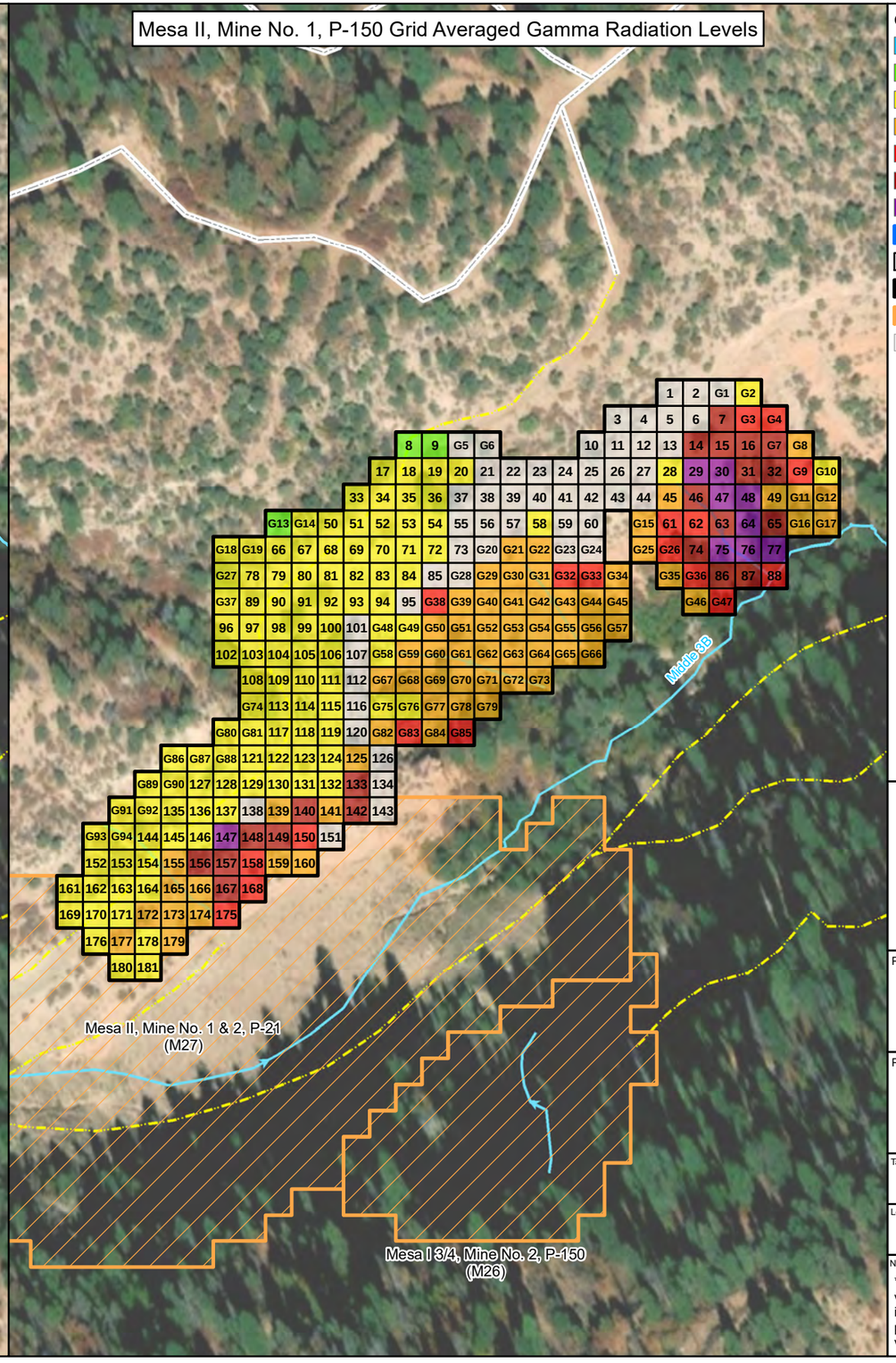
Mesa II, Mine No. 1, P-150 Site Features



Site Features

- Closed Portal
- Pipe - Field Mapped
- Berm
- Waste Pile - Unreclaimed
- Access Route - Foot
- Access Route - Vehicular
- Drainage - Field Mapped

Mesa II, Mine No. 1, P-150 Grid Averaged Gamma Radiation Levels



Grid Averaged Gamma Reading (cpm)*

≤ 8,123	≤ Avg. BG
8,123 - 9,703	Avg. BG - 1 x BTV
9,703 - 19,406	1 x BTV - 2 x BTV
19,406 - 29,109	2 x BTV - 3 x BTV
29,109 - 38,812	3 x BTV - 4 x BTV
38,812 - 97,030	4 x BTV - 10 x BTV
≥ 97,030	≥ 10 x BTV

- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Other Survey Area
- Inaccessible To Gamma Survey

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150
GRID AVERAGED
GAMMA RADIATION LEVELS

Prepared For:

Prepared By:

TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	**Date:** 7/7/2019

Notes:
*The applied gamma background threshold value (BTV) for Mesa II, Mine No. 1, P-150 is 9,703 cpm derived from BSA-24 as presented in Appendix A. Avg. BG: Average value of the background data set.

Figure No.: **H28-22**

5.2 SOIL SAMPLING RESULTS

This section presents the results of analyses for soil within the survey area of Mesa II, Mine No. 1, P-150. Radionuclide and metal concentrations within the surface environment (top 6 inches) and the subsurface environment (greater than 6 inches bgs) were investigated following the methods described in Section 4.7. The surface was evaluated using three sample types: (1) in situ XRF measurements; (2) XRF confirmation soil samples at a depth of 0 to 3 inches bgs; and (3) surface soil samples collected at a depth of 0 to 6 inches bgs. The results from these three sample types are presented in Section 5.2.1. A shallow subsurface investigation was conducted by hand as described in Section 4.7.3. The results of the subsurface sampling are presented in Section 5.2.2.

5.2.1 SURFACE SAMPLING

As described above, there are three primary surface sample types for Mesa II, Mine No. 1, P-150: (1) in situ XRF measurements; (2) XRF confirmation soil samples; and (3) surface soil samples. A description of the geospatial locations and laboratory sample delivery group identification for the XRF confirmation soil samples and the surface soil samples is presented in Table H28-1-1 in Attachment H28-1. All the results of the final in situ XRF measurements, XRF confirmation soil samples, and surface soil samples are presented in Table H28-1-2 through Table H28-1-4, respectively, in Attachment H28-1.

The XRF field survey was performed on a systematic square grid system at Mesa II, Mine No. 1, P-150 following the methods outlined in Section 4.6 and shown in Figure H28-13. The in situ XRF measurements were corrected to represent the predicted laboratory soil concentrations for nine analytes following the methodology presented in Appendix B of the RSE Report. The in situ XRF measurements presented in Table H28-1-2 of Attachment H28-1 include the final corrected measurement for the nine analytes. Across the 209 of 275 survey units that were accessible, a total of 222 measurements were collected at Mesa II, Mine No. 1, P-150 during the Baseline Study and Site Characterization Study. The summary statistics of the XRF field survey results are provided in Table H28-15.

Per USEPA Method 6200 (USEPA 2007), confirmatory soil samples were also collected at Mesa II, Mine No. 1, P-150 at a depth of 0 to 3 inches bgs. Thirteen XRF confirmation soil samples were collected during the XRF field survey. The laboratory analytical results for the XRF confirmation soil samples are presented in Table H28-1-3 in Attachment H28-1. The summary statistics for the XRF confirmation soil samples are provided in Table H28-16.

The third surface sample type was the surface soil samples collected at a depth of 0 to 6 inches bgs during the Site Characterization Study in September 2018. A total of six surface soil samples were taken, and all six samples were collocated with the shallow subsurface boring locations discussed in Section 5.2.2. The summary statistics of the surface soil samples are provided in Table H28-17.

Table H28-18 presents the summary statistics for all surface sample types. Surface sample results were compared with background levels for each analyte to identify COPCs in Section 6.0. The results of the combined surface soil results for select analytes in the form of contaminant maps are provided in Section 7.0. The following section presents the results of the subsurface soil sampling.

Table H28-15. Summary of XRF Field Survey Sampling Results (In Situ Converted)

Summary Statistic[1]	Units	Arsenic	Iron	Lead	Manganese	Molybdenum	Thorium	Uranium	Vanadium	Zinc
Applied BTV[2]	mg/kg	2.0	8,000	10	329	0.26	3.6	1.1	12	23
Measurements	#	222	222	222	222	222	222	222	222	222
Detects	#	153	207	207	206	76	219	211	117	207
Nondetects	#	69	15	15	16	146	3	11	105	15
Minimum	mg/kg	1.8	2,392	1.2	83	0.039	1.0	0.19	16	8.1
Maximum	mg/kg	104	25,531	22	795	58	11	507	1,000	90
Standard Deviation	mg/kg	10	3,213	2.3	84	7.3	1.3	63	127	11
Average	mg/kg	6.9	7,634	6.0	213	3.7	2.6	24	68	23
Median	mg/kg	4.3	7,376	6.0	198	1.4	2.4	5.8	32	21
Relative Standard Deviation	%	149	42	38	40	197	48	265	188	48
90th Percentile	mg/kg	12	10,947	8.0	293	7.2	3.8	43	104	32
95th Percentile	mg/kg	16	13,217	8.6	359	8.5	4.4	97	202	43
99th Percentile	mg/kg	47	17,534	14	508	33	7.6	340	676	64

Notes:

[1] Summary statistics for in situ XRF measurements presented are detected (only) laboratory equivalent values.

[2] Applied BTVs are presented and discussed in Section 3.0.

BTV Background threshold value
mg/kg Milligrams per kilogram
XRF X-ray fluorescence

Table H28-16. Summary of XRF Confirmation Soil Sampling Results (0 to 3 Inches)

Analyte[1]	Units	Applied BTV	# of XRF Confirmation Samples	# of Detects	# of Nondetects	Minimum	Maximum	Average	Median	Standard Deviation	90th Percentile	95th Percentile	99th Percentile	Relative Standard Deviation
Aluminum	mg/kg	4,090	14	14	0	2,300	14,000	5,843	5,050	3,308	10,380	12,700	13,740	57%
Antimony	mg/kg	0.163	14	14	0	0.033	0.350	0.101	0.055	0.104	0.263	0.331	0.346	103%
Arsenic	mg/kg	2.0	14	14	0	1.0	53	14	4.9	18	43	47	52	134%
Barium	mg/kg	138	14	14	0	16	160	82	68	38	131	147	157	47%
Beryllium	mg/kg	0.51	14	14	0	0.13	0.75	0.33	0.27	0.19	0.62	0.73	0.75	56%
Cadmium	mg/kg	0.063	14	13	1	0.032	0.950	0.188	0.064	0.291	0.596	0.806	0.921	155%
Calcium	mg/kg	22,900	14	14	0	4,100	49,000	19,257	16,500	12,747	34,400	39,900	47,180	66%
Chromium	mg/kg	3.8	14	14	0	1.6	7.1	3.8	3.0	1.8	6.5	7.0	7.1	48%
Cobalt	mg/kg	3.4	14	14	0	1.5	15	4.1	3.3	3.5	7.1	11	14	86%
Copper	mg/kg	6.6	14	14	0	3.3	23	9.4	8.9	5.5	17	20	22	59%
Iron	mg/kg	8,000	14	14	0	3,700	16,000	7,514	6,750	3,752	13,140	15,350	15,870	50%
Lead	mg/kg	10	14	14	0	3.3	16	7.0	6.0	3.5	11	13	15	49%
Lithium	mg/kg	5.4	14	14	0	2.9	29	12	11	8.0	25	28	29	65%
Magnesium	mg/kg	2,510	14	14	0	1,200	13,000	5,157	4,550	3,637	10,960	13,000	13,000	71%
Manganese	mg/kg	329	14	14	0	81	500	196	180	109	290	383	477	56%
Mercury	mg/kg	0.0111	1	1	0	0.0065	0.0065	-	-	-	-	-	-	-
Molybdenum	mg/kg	0.26	14	14	0	0.060	60	5.3	0.31	16	6.1	26.1	53	302%
Nickel	mg/kg	3.6	14	14	0	1.7	13	5.2	4.1	3.3	9.7	12	13	64%
Potassium-40	pCi/g	21.3	14	14	0	11.0	20.1	15.7	16.0	2.64	18.3	19.1	19.9	17%
Radium-226	pCi/g	0.85	14	13	1	0.83	136	28	4.5	45	92	111	131	161%
Radium-228	pCi/g	0.84	14	0	14	-	-	-	-	-	-	-	-	-
Selenium	mg/kg	0.92	14	14	0	0.31	7.5	1.5	0.81	1.9	2.6	4.4	6.9	125%
Silver	mg/kg	0.040	14	14	0	0.010	0.210	0.047	0.027	0.053	0.094	0.145	0.197	112%
Sodium	mg/kg	36	14	11	3	20	2,500	280	38	737	130	1,315	2,263	264%
Thallium	mg/kg	0.069	14	14	0	0.022	0.550	0.186	0.062	0.209	0.540	0.544	0.549	112%
Thorium	mg/kg	3.6	14	14	0	1.5	7.6	3.2	2.7	1.8	5.9	7.1	7.5	56%
Uranium	mg/kg	1.1	14	14	0	0.27	660	85	5.6	184	234	387	605	217%
Vanadium	mg/kg	12	14	14	0	5.1	800	104	18	226	310	547	749	217%
Zinc	mg/kg	23	14	13	1	8.4	50	22	18	12.4	41	47	49	56%

Notes:
[1] All summary statistics presented are calculated from detected XRF confirmation soil sample analytical results; samples were collected from a depth of 0 to 3 inches below ground surface only.
- Not applicable
BTV Background threshold value
mg/kg Milligrams per kilogram
pCi/g Picocuries per gram
XRF X-ray fluorescence

Table H28-17. Summary of Surface Soil Sampling Results (0 to 6 Inches)

Analyte[1]	Units	Applied BTV	# of Surface Soil Samples	# of Detects	# of Nondetects	Minimum	Maximum	Average	Median	Standard Deviation	90th Percentile	95th Percentile	99th Percentile	Relative Standard Deviation
Aluminum	mg/kg	4,090	6	6	0	2,500	5,600	3,917	4,100	1,199	5,100	5,350	5,550	31%
Antimony	mg/kg	0.163	6	6	0	0.040	0.180	0.069	0.047	0.055	0.117	0.148	0.174	80%
Arsenic	mg/kg	2.0	6	6	0	2.1	12	5.1	2.9	4.2	10	11	12	82%
Barium	mg/kg	138	6	6	0	35	120	76	82	33	108	114	119	43%
Beryllium	mg/kg	0.51	6	6	0	0.14	0.39	0.27	0.26	0.11	0.39	0.39	0.39	43%
Cadmium	mg/kg	0.063	6	6	0	0.043	0.830	0.193	0.061	0.313	0.470	0.650	0.794	162%
Calcium	mg/kg	22,900	6	6	0	7,200	20,000	14,033	13,500	4,544	19,000	19,500	19,900	32%
Chromium	mg/kg	3.8	6	6	0	1.9	3.0	2.4	2.3	0.42	2.9	2.9	3.0	18%
Cobalt	mg/kg	3.4	6	6	0	1.4	3.9	2.7	2.9	1.1	3.7	3.8	3.9	39%
Copper	mg/kg	6.6	6	6	0	2.6	15	8.3	8.7	4.9	14	14	15	59%
Iron	mg/kg	8,000	6	6	0	2,200	7,400	4,867	5,450	1,947	6,600	7,000	7,320	40%
Lead	mg/kg	10	6	6	0	2.0	8.2	5.1	5.5	2.2	7.2	7.7	8.1	44%
Lithium	mg/kg	5.4	6	6	0	5.6	12	8.6	7.5	2.7	12	12	12	32%
Magnesium	mg/kg	2,510	6	6	0	2,100	5,400	3,500	3,250	1,156	4,800	5,100	5,340	33%
Manganese	mg/kg	329	6	6	0	76	200	146	150	53	195	198	200	37%
Molybdenum	mg/kg	0.26	6	6	0	0.068	2.7	0.64	0.18	1.0	1.7	2.2	2.6	160%
Nickel	mg/kg	3.6	6	6	0	2.0	5.3	3.6	3.9	1.3	4.9	5.1	5.3	37%
Potassium-40	pCi/g	21.3	6	6	0	9.00	18.9	14.4	14.9	3.93	18.4	18.6	18.8	27%
Radium-226	pCi/g	0.85	6	6	0	0.91	127	25.5	6.38	49.8	68.8	97.9	121	195%
Radium-228	pCi/g	0.84	6	0	6	-	-	-	-	-	-	-	-	-
Selenium	mg/kg	0.92	6	6	0	0.70	7.0	1.9	1.0	2.5	4.1	5.5	6.7	130%
Silver	mg/kg	0.040	6	6	0	0.021	0.320	0.077	0.031	0.119	0.180	0.250	0.306	154%
Sodium	mg/kg	36	6	5	1	21	47	33	30	10	44	45	47	32%
Thallium	mg/kg	0.069	6	6	0	0.029	0.190	0.070	0.045	0.062	0.134	0.162	0.184	89%
Thorium	mg/kg	3.6	6	6	0	1.1	3.4	2.3	2.3	0.94	3.3	3.4	3.4	41%
Uranium	mg/kg	1.1	6	6	0	0.91	230	49	14	90	132	181	220	182%
Vanadium	mg/kg	12	6	6	0	8.4	550	121	42	212	312	431	526	175%
Zinc	mg/kg	23	6	6	0	7.7	21	15	16	5.6	20	21	21	38%

Notes:

[1] All summary statistics presented are calculated from detected analytical results for surface soil samples collected from a depth of 0 to 6 inches below ground surface only.

- Not applicable
BTV Background threshold value
mg/kg milligrams per kilogram
pCi/g picocuries per gram

Table H28-18. Summary Statistics of All Surface Sample Types

Analyte[1]	Units	Applied BTV	# of All Surface Sample Types[2]	# of Detects	# of Nondetects	Minimum	Maximum	Average	Median	Standard Deviation	90th Percentile	95th Percentile	99th Percentile	Relative Standard Deviation
Aluminum	mg/kg	4,090	20	20	0	2,300	14,000	5,265	4,600	2,947	7,140	12,100	13,620	56%
Antimony	mg/kg	0.163	20	20	0	0.033	0.350	0.091	0.047	0.092	0.194	0.322	0.344	101%
Arsenic	mg/kg	2.0	242	173	69	1.0	104	7.4	4.3	11	13	18	55	150%
Barium	mg/kg	138	20	20	0	16	160	80	74	36	122	141	156	45%
Beryllium	mg/kg	0.51	20	20	0	0.13	0.75	0.31	0.27	0.17	0.42	0.72	0.74	54%
Cadmium	mg/kg	0.063	20	19	1	0.032	0.950	0.189	0.064	0.289	0.734	0.842	0.928	153%
Calcium	mg/kg	22,900	20	20	0	4,100	49,000	17,690	15,000	11,074	33,200	35,700	46,340	63%
Chromium	mg/kg	3.8	20	20	0	1.6	7.1	3.3	2.9	1.6	5.5	7.0	7.1	49%
Cobalt	mg/kg	3.4	20	20	0	1.4	15	3.7	3.1	3.0	5.0	8.4	14	83%
Copper	mg/kg	6.6	20	20	0	2.6	23	9.1	8.9	5.2	15	19	22	58%
Iron	mg/kg	8,000	242	227	15	2,200	25,531	7,554	6,977	3,241	10,947	13,820	17,511	43%
Lead	mg/kg	10	242	227	15	1.2	22	6.0	5.9	2.3	8.0	8.9	16	39%
Lithium	mg/kg	5.4	20	20	0	2.9	29	11	9.4	7.0	19	28	29	63%
Magnesium	mg/kg	2,510	20	20	0	1,200	13,000	4,660	4,150	3,164	6,880	13,000	13,000	68%
Manganese	mg/kg	329	242	226	16	76	795	210	198	86	293	359	508	41%
Mercury	mg/kg	0.0111	1	1	0	0.0065	0.0065	-	-	-	-	-	-	-
Molybdenum	mg/kg	0.26	242	96	146	0.039	60	3.7	1.2	8.8	7.2	8.5	58	236%
Nickel	mg/kg	3.6	20	20	0	1.7	13	4.7	4.1	2.9	7.2	11	13	62%
Potassium-40	pCi/g	21.3	20	20	0	9.00	20.1	15.3	16.0	3.04	18.5	19.0	19.9	20%
Radium-226	pCi/g	0.85	20	19	1	0.83	136	27.3	4.96	45.3	101	128	134	166%
Radium-228	pCi/g	0.84	20	0	20	-	-	-	-	-	-	-	-	-
Selenium	mg/kg	0.92	20	20	0	0.31	7.5	1.6	0.94	2.0	3.1	7.0	7.4	124%
Silver	mg/kg	0.040	20	20	0	0.010	0.320	0.056	0.028	0.076	0.120	0.216	0.299	136%
Sodium	mg/kg	36	20	16	4	20	2,500	203	37	614	125	723	2,145	303%
Thallium	mg/kg	0.069	20	20	0	0.022	0.550	0.151	0.054	0.184	0.540	0.541	0.548	122%
Thorium	mg/kg	3.6	242	239	3	1.0	11	2.6	2.4	1.3	3.8	4.6	7.6	49%
Uranium	mg/kg	1.1	242	231	11	0.19	660	28	5.8	77	58	118	345	274%
Vanadium	mg/kg	12	242	137	105	5.1	1,000	74	31	144	107	391	770	194%
Zinc	mg/kg	23	242	226	16	7.7	90	23	21	11	32	44	62	49%

Notes:
[1] All summary statistics presented are calculated from detected values of in situ XRF measurements converted to laboratory equivalent values, XRF confirmation soil samples, and surface soil samples.
[2] Arsenic, iron, lead, manganese, molybdenum, thorium, uranium, vanadium, and zinc include in situ XRF measurements, XRF confirmation soil samples, and surface soil samples. The remaining analytes only include XRF confirmation soil and surface soil samples.
- Not applicable
BTV Background threshold value
mg/kg milligrams per kilogram
pCi/g picocuries per gram
XRF X-ray fluorescence

5.2.2 SUBSURFACE SOIL SAMPLING

The methodology for conducting subsurface soil sampling at Mesa II, Mine No. 1, P-150 is provided in Section 4.7.3. A total of five borings were sampled to a maximum depth of 12 inches, and ten samples were collected. The depth ranges and number of samples varied per boring and are provided in Section 4.7.3. The borings were selected to delineate and confirm the existence of potential areas of radiological or chemical contamination, including the existing waste piles and the area for which the waste pile was eventually extended. The surface level results for each of the five borings were presented in the previous section. All the borings contained soil samples that exceeded background levels of at least one primary analyte (see the discussion of primary analytes in Section 7.1), indicating the potential presence of mine waste. The laboratory analytical results for each of the samples collected across the different depths of the borings are provided in Attachment H28-1. An analysis was performed to evaluate the summary statistics for all the subsurface samples grouped together and is presented in Table H28-19.

The primary purpose of the subsurface investigation was to evaluate the depth, where possible, of contamination and to confirm or refute the location of the waste piles with respect to historical records. Given the difficult terrain for mechanical drilling access and the depth of soil above sandstone, it was difficult to reach depths greater than 12 inches without mechanical means. Subsurface data were used to estimate the total volume of potentially contaminated soil and mine waste at Mesa II, Mine No. 1, P-150. Further discussion of the results of the subsurface soil sampling is provided in Section 6.3. Maps showing the depth of contamination for the different primary analytes are provided in Section 7.0.

Table H28-19. Summary Statistics of Subsurface Soil Sampling Results (All Depths Below 6 Inches)

Analyte[1]	Units	Applied BTV	# of Subsurface Soil Samples	# of Detects	# of Nondetects	Minimum	Maximum	Average	Median	Standard Deviation	90th Percentile	95th Percentile	99th Percentile	Relative Standard Deviation
Aluminum	mg/kg	4,090	5	5	0	2,400	6,300	4,040	4,000	1,704	5,820	6,060	6,252	42%
Antimony	mg/kg	0.163	5	5	0	0.046	0.230	0.092	0.064	0.078	0.166	0.198	0.224	85%
Arsenic	mg/kg	2.0	5	5	0	2.3	15.0	6.3	3.3	5.5	12	14	15	88%
Barium	mg/kg	138	5	5	0	39	120	76	79	32	109	114	119	42%
Beryllium	mg/kg	0.51	5	5	0	0.11	0.47	0.29	0.31	0.16	0.45	0.46	0.47	53%
Cadmium	mg/kg	0.063	5	5	0	0.045	1.200	0.304	0.086	0.502	0.776	0.988	1.158	165%
Calcium	mg/kg	22,900	5	5	0	8,200	26,000	17,440	18,000	7,802	25,200	25,600	25,920	45%
Chromium	mg/kg	3.8	5	5	0	1.6	4.1	2.4	1.9	1.0	3.6	3.8	4.0	42%
Cobalt	mg/kg	3.4	5	5	0	1.4	5.0	3.1	2.9	1.5	4.7	4.8	5.0	47%
Copper	mg/kg	6.6	5	5	0	2.9	15	8.8	8.7	4.9	14	14	15	56%
Iron	mg/kg	8,000	5	5	0	2,600	9,000	5,540	5,200	2,395	8,000	8,500	8,900	43%
Lead	mg/kg	10	5	5	0	3.1	7.5	5.6	6.0	1.6	7.0	7.3	7.5	29%
Lithium	mg/kg	5.4	5	5	0	5.7	16	9.1	8.1	4.1	13	15	16	44%
Magnesium	mg/kg	2,510	5	5	0	1,700	6,600	3,740	3,100	2,096	6,040	6,320	6,544	56%
Manganese	mg/kg	329	5	5	0	82	250	174	190	65	234	242	248	37%
Molybdenum	mg/kg	0.26	5	5	0	0.056	3.3	0.98	0.24	1.4	2.4	2.9	3.2	138%
Nickel	mg/kg	3.6	5	5	0	2.1	7.0	4.0	3.2	2.1	6.3	6.6	6.9	52%
Potassium-40	pCi/g	21.3	5	4	1	13.6	19.1	15.3	14.2	2.59	17.7	18.4	19.0	17%
Radium-226	pCi/g	0.85	5	5	0	1.50	175	48.0	10.6	73.8	125	150	170	154%
Radium-228	pCi/g	0.84	5	0	5	-	-	-	-	-	-	-	-	-
Selenium	mg/kg	0.92	5	5	0	0.90	7.2	2.3	1.1	2.7	4.9	6.0	7.0	116%
Silver	mg/kg	0.040	5	5	0	0.023	0.280	0.085	0.043	0.110	0.190	0.235	0.271	129%
Sodium	mg/kg	36	5	3	2	23	65	49	59	22.7	64	64	65	46%
Thallium	mg/kg	0.069	5	5	0	0.037	0.360	0.122	0.048	0.137	0.264	0.312	0.350	113%
Thorium	mg/kg	3.6	5	5	0	1.3	4.0	2.4	2.3	1.2	3.7	3.9	4.0	49%
Uranium	mg/kg	1.1	5	5	0	1.3	400	89	13.0	174	252	326	385	195%
Vanadium	mg/kg	12	5	5	0	9.3	820	190	21	354	529	674	791	186%
Zinc	mg/kg	23	5	5	0	8.3	27	17	16	8.2	25	26	27	49%

Notes:
[1] All summary statistics presented in this table are calculated from all detected results of subsurface soil samples collected from all borings from depths below 6 inches below ground surface.
- Not applicable
BTV Background threshold value
mg/kg milligrams per kilogram
pCi/g picocuries per gram

5.2.3 COMBINED SOIL RESULTS (ALL SAMPLES)

The previous sections presented the results for the three types of surface soil samples and subsurface soil samples. Summary statistics were also calculated for all the surface and subsurface measurements. The summary statistics of all sample types collected at Mesa II, Mine No. 1, P-150 are presented in Table H28-20.

Table H28-20. Summary Statistics of All Surface and Subsurface Measurement Results

Analyte[1]	Units	Applied BTV	# of Total Samples[2]	# of Detects	# of Nondetects	Minimum	Maximum	Average	Median	Standard Deviation	90th Percentile	95th Percentile	99th Percentile	Relative Standard Deviation
Aluminum	mg/kg	4,090	25	25	0	2,300	14,000	5,020	4,600	2,759	6,480	10,920	13,520	55%
Antimony	mg/kg	0.163	25	25	0	0.033	0.350	0.091	0.050	0.088	0.210	0.302	0.343	96%
Arsenic	mg/kg	2.0	247	178	69	1.0	104	7.4	4.3	11	13	18	54	149%
Barium	mg/kg	138	25	25	0	16	160	79	79	35	120	136	155	44%
Beryllium	mg/kg	0.51	25	25	0	0.11	0.75	0.31	0.27	0.16	0.45	0.67	0.74	53%
Cadmium	mg/kg	0.063	25	24	1	0.032	1.20	0.213	0.064	0.334	0.794	0.932	1.14	157%
Calcium	mg/kg	22,900	25	25	0	4,100	49,000	17,640	16,000	10,356	31,400	34,600	45,640	59%
Chromium	mg/kg	3.8	25	25	0	1.6	7.1	3.2	2.8	1.5	5.3	6.7	7.1	49%
Cobalt	mg/kg	3.4	25	25	0	1.4	15	3.6	2.9	2.8	4.8	7.5	13	78%
Copper	mg/kg	6.6	25	25	0	2.6	23	9.0	8.8	5.1	15	18	22	56%
Iron	mg/kg	8,000	247	232	15	2,200	25,531	7,510	6,955	3,234	10,931	13,656	17,505	43%
Lead	mg/kg	10	247	232	15	1.2	22	6.0	6.0	2.3	8.0	8.8	15	39%
Lithium	mg/kg	5.4	25	25	0	2.9	29	11	8.8	6.5	17	26	29	60%
Magnesium	mg/kg	2,510	25	25	0	1,200	13,000	4,476	4,100	2,966	6,440	11,720	13,000	66%
Manganese	mg/kg	329	247	231	16	76	795	209	198	85	292	358	508	41%
Mercury	mg/kg	0.0111	1	1	0	0.0065	0.0065	-	-	-	-	-	-	-
Molybdenum	mg/kg	0.26	247	101	146	0.039	60	3.6	1.2	8.6	7.0	8.4	58	239%
Nickel	mg/kg	3.6	25	25	0	1.7	13	4.6	3.8	2.8	6.9	10	13	61%
Potassium-40	pCi/g	21.3	25	24	1	9.00	20.1	15.3	15.8	2.92	18.8	19.1	19.9	19%
Radium-226	pCi/g	0.85	25	24	1	0.83	175	31.6	5.60	51.3	117	135	166	162%
Radium-228	pCi/g	0.84	25	0	25	-	-	-	-	-	-	-	-	-
Selenium	mg/kg	0.92	25	25	0	0.31	7.5	1.8	1.0	2.1	5.3	7.2	7.4	121%
Silver	mg/kg	0.040	25	25	0	0.010	0.320	0.062	0.028	0.082	0.170	0.266	0.310	133%
Sodium	mg/kg	36	25	19	6	20	2,500	178	38	563	122	367	2,073	316%
Thallium	mg/kg	0.069	25	25	0	0.022	0.550	0.145	0.049	0.174	0.468	0.540	0.548	119%
Thorium	mg/kg	3.6	247	244	3	1.0	11	2.6	2.4	1.3	3.9	4.6	7.6	49%
Uranium	mg/kg	1.1	247	236	11	0.19	660	29	5.9	80	58	149	381	272%
Vanadium	mg/kg	12	247	142	105	5.1	1,000	78	31	155	109	409	812	198%
Zinc	mg/kg	23	247	231	16	7.7	90	22	21	11.0	32	44	61	49%

Notes:

[1] All summary statistics presented are calculated from detected values of in situ XRF measurements converted to laboratory equivalent values, XRF confirmation soil samples, surface soil samples, and subsurface soil samples.

[2] Arsenic, iron, lead, manganese, molybdenum, thorium, uranium, vanadium, and zinc include in situ XRF measurements, XRF confirmation soil samples, surface soil samples, and subsurface soil samples. The remaining analytes only include XRF confirmation soil, surface soil, and subsurface soil samples.

- Not applicable
BTV Background threshold value
mg/kg milligrams per kilogram
pCi/g picocuries per gram
XRF X-ray fluorescence

5.2.4 GEOCHEMICAL RESULTS

A total of three soil samples were collected at survey units 30 and G7 within Mesa II, Mine No. 1, P-150 at depths of 0 to 6 and 6 to 12 inches bgs and submitted for geochemical analyses. Survey units 30 and G7 are located within unreclaimed Waste Pile M28. The geochemical analyses included acid-base accounting (ABA), toxicity characteristic leaching procedure (TCLP), and synthetic precipitation leaching procedure (SPLP). The laboratory analytical results for the geochemical soil samples are presented in Tables H28-1-6 through H28-1-9 in Attachment H28-1. A summary of the sample results is provided in this section, and a complete analysis of the results is provided in Appendix F of the RSE Report.

The majority of the TCLP results were nondetects. Arsenic, barium, cadmium, and selenium were detected in at least one of the TCLP samples, but the results were below the permissible limits. The results indicate that the soil samples meet the TCLP requirements for disposal at a permitted landfill or a low-level radioactive waste disposal facility.

The majority of the SPLP results for the eight primary analytes were detects. However, lead and selenium were not detected in any of the leachate samples. The SPLP results for arsenic, vanadium, and Ra-226 exceeded the maximum observed background concentrations for surface water and groundwater within the Cove Wash Watershed (Weston 2018). The SPLP results for molybdenum and uranium were within the observed range of background concentrations within the Cove Wash Watershed (Weston 2018). Thorium was detected; however, no range of background concentrations has been established for thorium.

The ABA results ranged from 30 to 39 tons of calcium carbonate equivalent per 1,000 tons of material (ppt $CaCO_3$). Samples with negative ABA results are considered acid producing while samples with positive ABA results are considered non-acid producing. The results indicate that the sample from Waste Pile M28 is not acid producing.

5.2.5 GEOTECHNICAL RESULTS

Three samples (GEO 30, GEO 104, and GEO 133) were collected from Mesa II, Mine No. 1, P-150 and submitted for geotechnical analyses as shown in Table H28-13. Samples were collected from the surface to depths of 12, 15, and 12 inches where the excavations terminated due to practical refusal. A summary of the sample results is provided in this section, and a complete analysis of the results is provided in Appendix E of the RSE Report. Survey unit 30 is located within Waste Pile M28. Sample GEO 30 was identified in the field as a gray, silty sand with sandstone gravel. Survey unit 104 is located outside of any mine feature boundary and was described as a brown silty sand in the field. Survey unit 133 is located along the bench elevation of the closed portals. GEO 133 was identified in the field as a gray to tan silty loam, possibly derived from weathered shale.

Organic debris and gravel sized particles were removed from the samples in the field prior to geotechnical laboratory testing. The maximum particle size measured in the laboratory samples passed a #4 sieve (4.75 millimeters). Particle size distribution testing (ASTM International [ASTM] D6913) of GEO 30 resulted in a fines content (passing #200 sieve) of 9 percent. Atterberg limits (ASTM D4318) testing indicated the soil was non-plastic. A Unified Soil

Classification System (USCS) classification of poorly graded silty sand (SP-SM) was determined using laboratory test results for GEO 30. A USCS classification of silty sand (SM) was assigned based on laboratory test results of GEO 104 and GEO 133. Particle size distribution testing resulted in a fines content of 14 and 15 percent. Atterberg limits testing yielded a liquid limit of 23 for both GEO 104 and GEO 133 with a respective plasticity index of 1 and 3.

6.0 BACKGROUND COMPARISON ANALYSIS

6.1 SITE CLASSIFICATION

The site classification utilized the RSE gamma radiation survey data and the known locations of pertinent site features. There are a total of 275 survey units, each 100 m^2, located within the survey area of Mesa II, Mine No. 1, P-150. A process flowchart showing the site classification approach is presented in Figure H28-9. Out of the total 275 survey units at Mesa II, Mine No. 1, P-150, 66 were classified as inaccessible for the XRF field survey team and did not contain in situ XRF measurements and 50 were classified as inaccessible by the gamma survey team and did not contain gamma radiation measurements. A total of 33 survey units were considered inaccessible by both survey types.

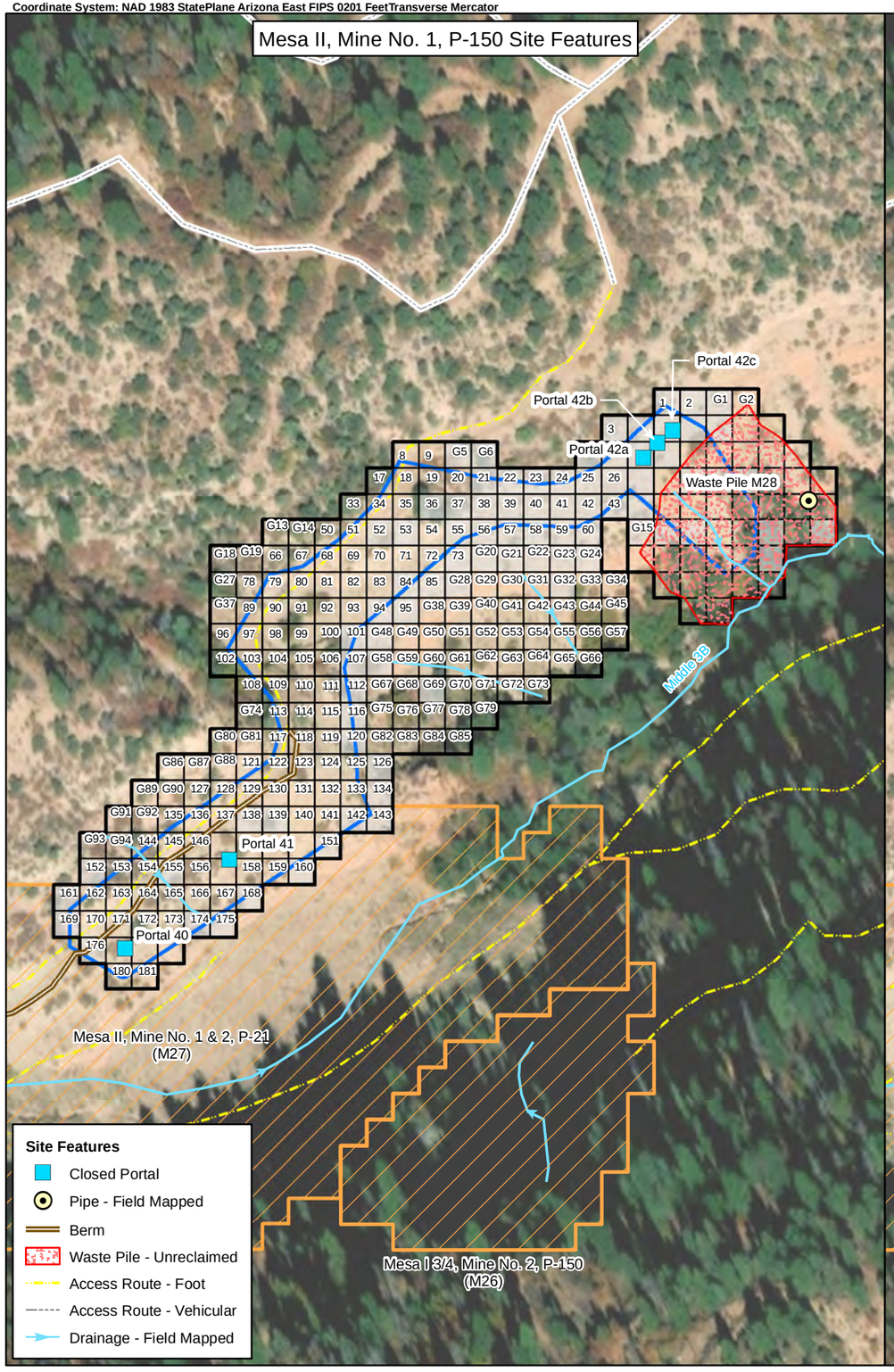
During the RSE investigation at Mesa II, Mine No. 1, P-150, the site was mapped to differentiate between NORM and TENORM. The entire Mesa II, Mine No. 1, P-150 area was classified as TENORM because of the breadth of mining and reclamation work and site disturbance that occurred as a result. Additionally, several haul roads, which caused significant disturbance related to mining, exploration, or both, remain at the site. Furthermore, the existing Lower Morrison Salt Wash Member outcrops exposed at the site were likely explored through land-disturbing activities. Therefore, all the survey units were classified as Class 1, Class 2, Class 3, or inaccessible.

For Mesa II, Mine No. 1, P-150, 228 survey units were classified as Class 1, 2 survey units were classified as Class 2, and 1 survey unit was classified as Class 3. A total of 50 survey units were deemed inaccessible and were not classified as Class 1, Class 2, or Class 3. Of these inaccessible survey units, 6 were considered Class 1 based on their proximity to a mine feature, and 44 were considered Class 3 for the background comparison analysis.

Figure H28-23 presents the classification scheme for Mesa II, Mine No. 1, P-150. The survey unit classification is used for the background comparison analysis of the different sampling types presented in the following subsections.

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

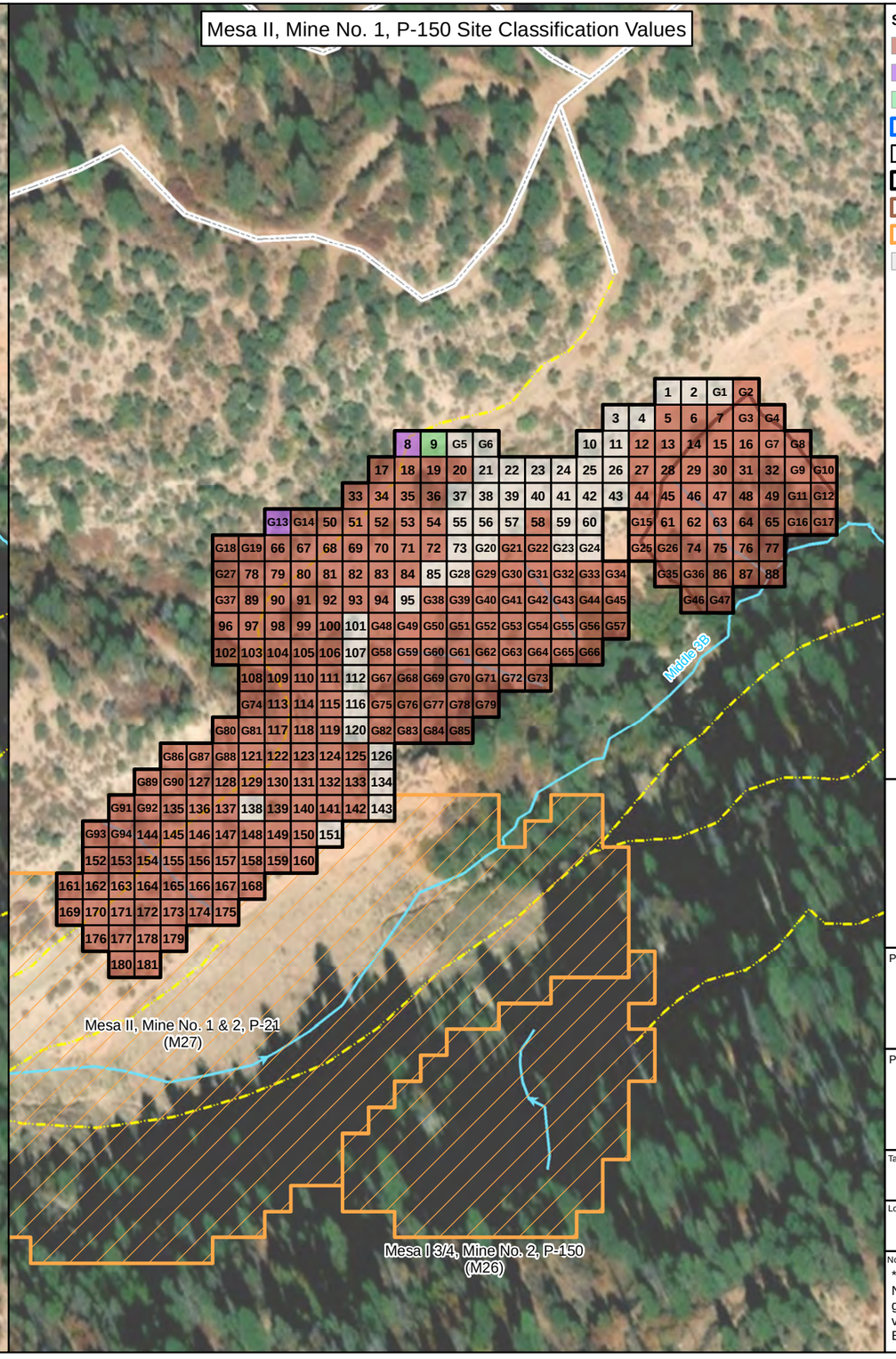
Mesa II, Mine No. 1, P-150 Site Features



Site Features

- Closed Portal
- Pipe - Field Mapped
- Berm
- Waste Pile - Unreclaimed
- Access Route - Foot
- Access Route - Vehicular
- Drainage - Field Mapped

Mesa II, Mine No. 1, P-150 Site Classification Values



Site Classification Scale*

- Class 1
- Class 2
- Class 3
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Waste Pile Boundary
- Other Survey Area
- Inaccessible

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150 SITE CLASSIFICATION MAP

Prepared For:

Prepared By:

TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	**Date:** 7/7/2019

Notes:
*Site classification values for Mesa II, Mine No. 1, P150 are based on an applied gamma radiation background threshold value (BTV) of 9,703 cpm derived from BSA-24 as presented in Appendix A.

Figure No.: **H28-23**

6.2 SURFACE SOIL BACKGROUND COMPARISON ANALYSIS

There were three surface sample types collected at the Mesa II, Mine No. 1, P-150 as described in Section 4.6 and Section 4.7: (1) in situ XRF measurements that have been converted to predicted laboratory soil concentrations; (2) XRF confirmation soil samples (0 to 3 inches); and (3) surface soil samples (0 to 6 inches). All sample types are considered representative of surficial soil chemical and radionuclide concentrations. The results for each sample type are presented in Section 5.2. The sample locations for each surface sample are shown in Figure H28-13 for XRF measurements and in Figure H28-14 for soil samples. As described in Section 6.1, each 100 m^2 survey unit was classified as Class 1, Class 2, or Class 3, and each surface sample was classified according to the survey unit from which the boring was collected.

A comparison was made between the values measured for each different type of surface sampling method and the applied BTV presented in Section 3.0 to identify COPCs within surface and subsurface soil. Using the classification scheme discussed in the previous subsection and presented in Figure H28-23, the different values for each sample type were further subdivided into Class 1 and Class 2 combined, Class 3, and all values combined regardless of classification. The purpose of this is to ensure that contaminants are considered COPCs when there is a contaminated tract of land within an impacted area unaffected by historical mining operations but still having potential for windblown contamination (that is, a Class 3 area). A criterion of greater than 5 percent of measurements exceeding the applied BTV is used to identify a COPC as being above background for a particular soil type for Class 1 and Class 2 combined, Class 3 only, and all samples combined regardless of classification.

Table H28-21 presents the background comparison analysis for the XRF field survey data. This table shows the number of samples that exceed the BTV for the nine analytes measured using XRF. This comparison shows the breakdown for all measurements, Class 1 and Class 2 measurements combined, and Class 3 measurements. Out of the nine analytes, eight analytes were determined to exceed the BTV in greater than 5 percent of the samples for all samples combined, Class 1 or Class 2 measurements combined, or Class 3 measurements only. The only analyte not identified as a COPC for in situ XRF measurements was lead.

A similar analysis was performed for XRF confirmation soil samples. Table H28-22 presents the background comparison analysis for these samples. A total of 14 XRF confirmation soil samples were collected at Mesa II, Mine No. 1, P-150 and tested for the 28 analytes. One of the 14 XRF confirmation soil samples was tested for mercury in addition to the 28 analytes. Thirteen of the 14 XRF confirmation soil samples were Class 1 or Class 2. The analytes identified as COPCs for XRF confirmation soil samples included all analytes evaluated except mercury, K-40, and radium-228 (Ra-228).

A total of six surface soil samples were collected at Mesa II, Mine No. 1, P-150. Table H28-23 presents the background comparison results for the surface samples for Class 1 and Class 2 combined, Class 3 only, and all samples combined. All six samples were Class 1 or Class 2. The analytes identified as COPCs for surface soil samples were aluminum, antimony, arsenic, cadmium, cobalt, copper, lithium, magnesium, molybdenum, nickel, Ra-226, selenium, silver, sodium, thallium, uranium, and vanadium. Table H28-24 presents the analytes identified as COPCs for all surface measurement types combined. There were 25 analytes identified as COPCs for all surface measurement types combined.

Table H28-21. Background Comparison Table for In Situ XRF Measurement Results

Analyte[1]	In Situ XRF Measurements (All)[2]			In Situ XRF Measurements (Class 1 or Class 2)[3]			In Situ XRF Measurements (Class 3)[3]			COPC Identified
	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	
Arsenic	222	151	68%	205	138	67%	17	13	76%	**Arsenic**
Iron	222	79	36%	205	75	37%	17	4	24%	**Iron**
Lead	222	4	1.8%	205	4	2.0%	17	0	0%	
Manganese	222	13	5.9%	205	12	5.9%	17	1	5.9%	**Manganese**
Molybdenum	222	65	29%	205	60	29%	17	5	29%	**Molybdenum**
Thorium	222	27	12%	205	25	12%	17	2	12%	**Thorium**
Uranium	222	203	91%	205	186	91%	17	17	100%	**Uranium**
Vanadium	222	117	53%	205	113	55%	17	4	24%	**Vanadium**
Zinc	222	82	37%	205	75	37%	17	7	41%	**Zinc**

Notes:
Shaded **red** indicates that the analyte exceeded the applied BTV in more than 5 percent of the samples for that classification group. The **purple** text in the far-right column indicates that the analyte was carried over as a COPC because it exceeded background.

[1] There are nine analytes that the XRF can be used for prediction purposes. All in situ XRF measurements were converted to laboratory equivalent soil concentrations.

[2] Indicates all survey unit classifications of in situ XRF measurements (that is, Class 1, Class 2, and Class 3).

[3] Class 1, Class 2, or Class 3 are defined in Section 6.1 based on surface radiation levels and mine features.

BTV Background threshold value
COPC Contaminant of potential concern
XRF X-ray fluorescence

Table H28-22. Background Comparison Table for XRF Confirmation Soil Sample Results

Analyte	XRF Confirmation Samples (All)[1]			XRF Confirmation Samples (Class 1 or Class 2)[2]			XRF Confirmation Samples (Class 3)[2]			COPC Identified
	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	
Aluminum	14	10	71%	13	9	69%	1	1	100%	Aluminum
Antimony	14	2	14%	13	1	7.7%	1	1	100%	Antimony
Arsenic	14	10	71%	13	9	69%	1	1	100%	Arsenic
Barium	14	2	14%	13	2	15%	1	0	0%	Barium
Beryllium	14	2	14%	13	2	15%	1	0	0%	Beryllium
Cadmium	14	8	57%	13	7	54%	1	1	100%	Cadmium
Calcium	14	4	29%	13	4	31%	1	0	0%	Calcium
Chromium	14	6	43%	13	6	46%	1	0	0%	Chromium
Cobalt	14	7	50%	13	7	54%	1	0	0%	Cobalt
Copper	14	9	64%	13	9	69%	1	0	0%	Copper
Iron	14	4	29%	13	4	31%	1	0	0%	Iron
Lead	14	2	14%	13	2	15%	1	0	0%	Lead
Lithium	14	11	79%	13	10	77%	1	1	100%	Lithium
Magnesium	14	10	71%	13	9	69%	1	1	100%	Magnesium
Manganese	14	1	7.1%	13	1	7.7%	1	0	0%	Manganese
Mercury	1	0	0%	1	0	0%	0	0	0%	
Molybdenum	14	8	57%	13	7	54%	1	1	100%	Molybdenum
Nickel	14	9	64%	13	8	62%	1	1	100%	Nickel
Potassium-40	14	0	0%	13	0	0%	1	0	0%	
Radium-226	14	12	86%	13	11	85%	1	1	100%	Radium-226
Radium-228	14	0	0%	13	0	0%	1	0	0%	
Selenium	14	6	43%	13	6	46%	1	0	0%	Selenium
Silver	14	4	29%	13	3	23%	1	1	100%	Silver
Sodium	14	7	50%	13	7	54%	1	0	0%	Sodium
Thallium	14	6	43%	13	5	38%	1	1	100%	Thallium
Thorium	14	4	29%	13	4	31%	1	0	0%	Thorium
Uranium	14	12	86%	13	11	85%	1	1	100%	Uranium
Vanadium	14	10	71%	13	9	69%	1	1	100%	Vanadium
Zinc	14	4	29%	13	4	31%	1	0	0%	Zinc

Notes:
Shaded **red** indicates that the analyte exceeded the applied BTV in more than 5 percent of the samples for that classification group. The **purple** text in the far-right column indicates that the analyte was carried over as a COPC because it exceeded background.
[1] Indicates all survey unit classifications (that is, Class 1, Class 2, and Class 3) of XRF confirmation soil samples collected from 0 to 3 inches below ground surface.
[2] Class 1, Class 2, or Class 3 are defined in Section 6.1 based on surface radiation levels and mine features.

BTV Background threshold value
COPC Contaminant of potential concern
XRF X-ray fluorescence

Table H28-23. Background Comparison Table for Surface Soil Sample Results

Analyte	Surface Samples (All)[1]			Surface Soil Samples (Class 1 or Class 2)[2]			Surface Soil Samples (Class 3)[2]			COPC Identified
	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	
Aluminum	6	3	50%	6	3	50%	0	0	0%	**Aluminum**
Antimony	6	1	17%	6	1	17%	0	0	0%	**Antimony**
Arsenic	6	6	100%	6	6	100%	0	0	0%	**Arsenic**
Barium	6	0	0%	6	0	0%	0	0	0%	
Beryllium	6	0	0%	6	0	0%	0	0	0%	
Cadmium	6	3	50%	6	3	50%	0	0	0%	**Cadmium**
Calcium	6	0	0%	6	0	0%	0	0	0%	
Chromium	6	0	0%	6	0	0%	0	0	0%	
Cobalt	6	2	33%	6	2	33%	0	0	0%	**Cobalt**
Copper	6	4	67%	6	4	67%	0	0	0%	**Copper**
Iron	6	0	0%	6	0	0%	0	0	0%	
Lead	6	0	0%	6	0	0%	0	0	0%	
Lithium	6	6	100%	6	6	100%	0	0	0%	**Lithium**
Magnesium	6	5	83%	6	5	83%	0	0	0%	**Magnesium**
Manganese	6	0	0%	6	0	0%	0	0	0%	
Molybdenum	6	2	33%	6	2	33%	0	0	0%	**Molybdenum**
Nickel	6	3	50%	6	3	50%	0	0	0%	**Nickel**
Potassium-40	6	0	0%	6	0	0%	0	0	0%	
Radium-226	6	6	100%	6	6	100%	0	0	0%	**Radium-226**
Radium-228	6	0	0%	6	0	0%	0	0	0%	
Selenium	6	4	67%	6	4	67%	0	0	0%	**Selenium**
Silver	6	1	17%	6	1	17%	0	0	0%	**Silver**
Sodium	6	2	33%	6	2	33%	0	0	0%	**Sodium**
Thallium	6	2	33%	6	2	33%	0	0	0%	**Thallium**
Thorium	6	0	0%	6	0	0%	0	0	0%	
Uranium	6	5	83%	6	5	83%	0	0	0%	**Uranium**
Vanadium	6	4	67%	6	4	67%	0	0	0%	**Vanadium**
Zinc	6	0	0%	6	0	0%	0	0	0%	

Notes:
Shaded **red** indicates that the analyte exceeded the applied BTV in more than 5 percent of the samples for that classification group. The **purple** text in the far-right column indicates that the analyte was carried over as a COPC because it exceeded background.
[1] Indicates all survey unit classifications (that is, Class 1, Class 2, and Class 3) of surface soil samples collected from 0 to 6 inches below ground surface.
[2] Class 1, Class 2, or Class 3 are defined in Section 6.1 based on surface radiation levels and mine features.
BTV Background threshold value
COPC Contaminant of potential concern

Table H28-24. Background Comparison Table for All Surface Soil Samples and XRF Measurement Results

Analyte[1,2]	All Surface Data (All) [1,2,3,4]			All Surface Data (Class 1 or Class 2) [1,2,4]			All Surface Data (Class 3) [1,2,4]			COPC Identified
	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	
Aluminum	20	13	65%	19	12	63%	1	1	0%	Aluminum
Antimony	20	3	15%	19	2	11%	1	1	0%	Antimony
Arsenic	242	167	69%	224	153	68%	18	14	78%	Arsenic
Barium	20	2	10%	19	2	11%	1	0	0%	Barium
Beryllium	20	2	10%	19	2	11%	1	0	0%	Beryllium
Cadmium	20	11	55%	19	10	53%	1	1	0%	Cadmium
Calcium	20	4	20%	19	4	21%	1	0	0%	Calcium
Chromium	20	6	30%	19	6	32%	1	0	0%	Chromium
Cobalt	20	9	45%	19	9	47%	1	0	0%	Cobalt
Copper	20	13	65%	19	13	68%	1	0	0%	Copper
Iron	242	83	34%	224	79	35%	18	4	22%	Iron
Lead	242	6	2.5%	224	6	2.7%	18	0	0%	
Lithium	20	17	85%	19	16	84%	1	1	0%	Lithium
Magnesium	20	15	75%	19	14	74%	1	1	0%	Magnesium
Manganese	242	14	5.8%	224	13	5.8%	18	1	5.6%	Manganese
Mercury	1	0	0%	1	0	0%	0	0	0%	
Molybdenum	242	75	31%	224	69	31%	18	6	33%	Molybdenum
Nickel	20	12	60%	19	11	58%	1	1	0%	Nickel
Potassium-40	20	0	0%	19	0	0%	1	0	0%	
Radium-226	20	18	90%	19	17	89%	1	1	0%	Radium-226
Radium-228	20	0	0%	19	0	0%	1	0	0%	
Selenium	20	10	50%	19	10	53%	1	0	0%	Selenium
Silver	20	5	25%	19	4	21%	1	1	0%	Silver
Sodium	20	9	45%	19	9	47%	1	0	0%	Sodium
Thallium	20	8	40%	19	7	37%	1	1	0%	Thallium
Thorium	242	31	13%	224	29	13%	18	2	11%	Thorium
Uranium	242	220	91%	224	202	90%	18	18	100%	Uranium
Vanadium	242	131	54%	224	126	56%	18	5	28%	Vanadium
Zinc	242	86	36%	224	79	35%	18	7	38.9%	Zinc

Notes:
Shaded **red** indicates that the analyte exceeded the applied BTV in more than 5 percent of the samples for that classification group. The **purple** text in the far-right column indicates that the analyte was carried over as a COPC because it exceeded background.

1 There are nine analytes that the XRF can be used for prediction purposes. For these analytes, there are also XRF confirmation soil samples and surface soil samples.
2 All other analytes only include XRF confirmation soil data and surface soil samples.
3 Indicates all survey unit classifications (that is, Class 1, Class 2, and Class 3) of in situ XRF measurements (if applicable), XRF confirmation soil samples, and surface soil samples.
4 Class 1, Class 2, or Class 3 are defined in Section 6.1 based on surface radiation levels and mine features.

BTV Background threshold value
COPC Contaminant of potential concern
XRF X-ray fluorescence

6.3 SUBSURFACE SOIL BACKGROUND COMPARISON ANALYSIS

Subsurface soil samples were collected from five borings at Mesa II, Mine No. 1, P-150 as described in Section 4.7.3. The results of the subsurface soil sampling investigation are presented in Attachment H28-1 and discussed in Section 5.2.2. The locations of the subsurface borings are shown in Figure H28-15. As discussed in Section 6.1, each 100 m^2 survey unit was classified as Class 1, Class 2, Class 3, or inaccessible; therefore, each subsurface boring and associated samples collected within the survey area of Mesa II, Mine No. 1, P-150 can then be classified as one of those three classifications based on which survey unit the boring falls within.

Table H28-25 presents the background comparison analysis for the subsurface soil samples. This table shows the number of samples that exceed the BTV for the 28 analytes measured in the subsurface soil samples and depths. Mercury was not evaluated. This comparison shows the breakdown for all measurements, Class 1 and Class 2 samples combined, and Class 3 samples. Out of the 28 analytes, 22 were determined to exceed the BTV in greater than 5 percent of all samples combined, Class 1 or Class 2 samples combined, or Class 3 samples only. Any cell shown in red indicates an exceedance for that analyte, and this analyte would, therefore, be considered a COPC. The analytes identified as COPCs for subsurface soil samples included analytes listed in Table H28-25.

Table H28-25. Background Comparison Table for All Subsurface Soil Sample Results

Analyte	Subsurface Samples (All)[1]			Subsurface Samples (Class 1 or Class 2)[2]			Subsurface Samples (Class 3)[2]			COPC Identified
	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	
Aluminum	5	2	40%	5	2	40%	0	0	0%	Aluminum
Antimony	5	1	20%	5	1	20%	0	0	0%	Antimony
Arsenic	5	5	100%	5	5	100%	0	0	0%	Arsenic
Barium	5	0	0%	5	0	0%	0	0	0%	
Beryllium	5	0	0%	5	0	0%	0	0	0%	
Cadmium	5	3	60%	5	3	60%	0	0	0%	Cadmium
Calcium	5	2	40%	5	2	40%	0	0	0%	Calcium
Chromium	5	1	20%	5	1	20%	0	0	0%	Chromium
Cobalt	5	2	40%	5	2	40%	0	0	0%	Cobalt
Copper	5	3	60%	5	3	60%	0	0	0%	Copper
Iron	5	1	20%	5	1	20%	0	0	0%	Iron
Lead	5	0	0%	5	0	0%	0	0	0%	
Lithium	5	5	100%	5	5	100%	0	0	0%	Lithium
Magnesium	5	3	60%	5	3	60%	0	0	0%	Magnesium
Manganese	5	0	0%	5	0	0%	0	0	0%	
Molybdenum	5	2	40%	5	2	40%	0	0	0%	Molybdenum
Nickel	5	2	40%	5	2	40%	0	0	0%	Nickel
Potassium-40	5	0	0%	5	0	0%	0	0	0%	
Radium-226	5	5	100%	5	5	100%	0	0	0%	Radium-226
Radium-228	5	0	0%	5	0	0%	0	0	0%	
Selenium	5	4	80%	5	4	80%	0	0	0%	Selenium
Silver	5	3	60%	5	3	60%	0	0	0%	Silver
Sodium	5	2	40%	5	2	40%	0	0	0%	Sodium
Thallium	5	2	40%	5	2	40%	0	0	0%	Thallium
Thorium	5	1	20%	5	1	20%	0	0	0%	Thorium
Uranium	5	5	100%	5	5	100%	0	0	0%	Uranium
Vanadium	5	3	60%	5	3	60%	0	0	0%	Vanadium
Zinc	5	2	40%	5	2	40%	0	0	0%	Zinc

Notes:
Shaded **red** indicates that the analyte exceeded the applied BTV in more than 5 percent of the samples for that classification group. The **purple** text in the far-right column indicates that the analyte was carried over as a COPC because it exceeded background.
[1] Indicates all survey unit classifications (that is, Class 1, Class 2, and Class 3) of subsurface soil samples collected from greater than 6 inches below ground surface.
[2] Class 1, Class 2, or Class 3 are defined in Section 6.1 based on surface radiation levels and mine features.
BTV Background threshold value
COPC Contaminant of potential concern

6.4 COMBINED SOIL DATA BACKGROUND COMPARISON ANALYSIS

The previous two subsections presented background comparison tables for individual surface soil types (that is, situ XRF measurements only, XRF confirmation soil samples only, and surface soil samples only), all surface soil types combined, and subsurface samples only. The final analysis involves combining all possible soil sample types together and comparing the different classification schemes with background levels. The same criterion is used here as described previously (that is, greater than 5 percent exceeding applied BTV). Table H28-26 presents the background comparison analysis for all the samples, including in situ XRF measurements and analytical laboratory results. This table combines the previous five tables and presents a final analysis and identification of the COPCs. In total, 25 analytes are considered COPCs based on the full set of data as shown in the last column of Table H28-26. Section 6.5 breaks down the COPCs identified for the six scenarios discussed in Table H28-21 through Table H28-26 and presents a final identification of COPCs in both the surface and subsurface environments.

Table H28-26. Background Comparison Table for All Soil and XRF Sample Results

Analyte[1,2]	All Surface and Subsurface Samples (All Classes)[3]			All Surface and Subsurface Samples (Class 1 or Class 2)[4]			All Surface and Subsurface Samples (Class 3)[4]			COPC Identified
	# of Samples[3]	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	# of Samples	# of Samples Exceeding Applied BTV	% of Samples Exceeding Applied BTV	
Aluminum	25	15	60%	24	14	58%	1	1	0%	**Aluminum**
Antimony	25	4	16%	24	3	13%	1	1	0%	**Antimony**
Arsenic	247	172	70%	229	158	69%	18	14	78%	**Arsenic**
Barium	25	2	8.0%	24	2	8.3%	1	0	0%	**Barium**
Beryllium	25	2	8.0%	24	2	8.3%	1	0	0%	**Beryllium**
Cadmium	25	14	56%	24	13	54%	1	1	0%	**Cadmium**
Calcium	25	6	24%	24	6	25%	1	0	0%	**Calcium**
Chromium	25	7	28%	24	7	29%	1	0	0%	**Chromium**
Cobalt	25	11	44%	24	11	46%	1	0	0%	**Cobalt**
Copper	25	16	64%	24	16	67%	1	0	0%	**Copper**
Iron	247	84	34%	229	80	35%	18	4	22%	**Iron**
Lead	247	6	2%	229	6	3%	18	0	0%	
Lithium	25	22	88%	24	21	88%	1	1	0%	**Lithium**
Magnesium	25	18	72%	24	17	71%	1	1	0%	**Magnesium**
Manganese	247	14	5.7%	229	13	5.7%	18	1	5.6%	**Manganese**
Mercury	1	0	0%	1	0	0%	0	0	0%	
Molybdenum	247	77	31%	229	71	31%	18	6	33%	**Molybdenum**
Nickel	25	14	56%	24	13	54%	1	1	0%	**Nickel**
Potassium-40	25	0	0%	24	0	0%	1	0	0%	
Radium-226	25	23	92%	24	22	92%	1	1	0%	**Radium-226**
Radium-228	25	0	0%	24	0	0%	1	0	0%	
Selenium	25	14	56%	24	14	58%	1	0	0%	**Selenium**
Silver	25	8	32%	24	7	29%	1	1	0%	**Silver**
Sodium	25	11	44%	24	11	46%	1	0	0%	**Sodium**
Thallium	25	10	40%	24	9	38%	1	1	0%	**Thallium**
Thorium	247	32	13%	229	30	13%	18	2	11%	**Thorium**
Uranium	247	225	91%	229	207	90%	18	18	100%	**Uranium**
Vanadium	247	134	54%	229	129	56%	18	5	28%	**Vanadium**
Zinc	247	88	36%	229	81	35%	18	7	39%	**Zinc**

Notes:

Shaded **red** indicates the analyte exceeded the applied BTV in more than 5 percent of the samples for that classification group. The **purple** text in the far-right column indicates that the analyte was carried over as a COPC because it exceeded background.

[1] There are nine analytes that the XRF can be used for prediction purposes. For these analytes, there are also XRF confirmation soil samples, surface soil samples, and subsurface soil samples.

[2] All other analytes only include XRF confirmation soil data, surface soil samples, and subsurface soil samples.

[3] Indicates all survey unit classifications (that is, Class 1, Class 2, and Class 3) of in situ XRF measurements (if applicable), XRF confirmation soil samples, surface soil samples, and subsurface soil samples.

[4] Class 1, Class 2, or Class 3 are defined in Section 6.1 based on surface radiation levels and mine features.

BTV Background threshold value
COPC Contaminant of potential concern
XRF X-ray fluorescence

6.5 IDENTIFICATION OF CONTAMINANTS OF POTENTIAL CONCERN

A site-to-background analysis was performed on the different data types collected at Mesa II, Mine No. 1, P-150 to identify the radionuclide and metal COPCs in the surface and subsurface environments. The previous tables present six potential scenarios for identifying COPCs using BTVs:

- Table H28-21 presented the background comparison results for only the nine analytes measured using the field portable XRF and converting the resulting values into laboratory equivalent soil concentrations from established regressions developed in Appendix B of the RSE Report.
- Table H28-22 presented the background comparison analysis of the XRF confirmation soil samples collected from 0 to 3 inches bgs.
- Table H28-23 presented the background comparison analysis of the surface soil samples collected from 0 to 6 inches bgs.
- Table H28-24 presented the background comparison analysis for all three surface sample types together.
- Table H28-25 presented the background comparison analysis for all subsurface samples grouped together.
- Table H28-26 presented the background comparison analysis for all sample types grouped together. For each of the five scenarios described above, an analysis was performed for Class 1 and Class 2 samples combined, Class 3 samples only, and all samples combined. If any of these scenarios exceeded the criterion of greater than 5 percent exceedances of the applied BTV, then the analyte was identified as a COPC.

Table H28-27 presents a summary of the six scenarios described above. If an analyte was identified in any one of those scenarios, it was carried over for final COPC determination. The first six columns represent the COPCs identified in Table H28-21 through Table H28-26. The "Final COPC Determination" column shows which COPCs will be carried over for further evaluation. All COPCs identified will be further evaluated in the EE/CA. The following section presents COPC mapping and discusses primary and secondary analytes.

Table H28-27. Selected List of Analytes that Are Above Applied Background Threshold Values

Analyte	In Situ XRF Measurements[1]	XRF Confirmation Soil Samples	Surface Soil Samples	All Surface Sample Types[2]	Subsurface Soil Samples	All Sample Types[3]	Final COPC Determination
Aluminum		✓	✓	✓	✓	✓	✓
Antimony		✓	✓	✓	✓	✓	✓
Arsenic	✓	✓	✓	✓	✓	✓	✓
Barium		✓		✓		✓	✓
Beryllium		✓		✓		✓	✓
Cadmium		✓	✓	✓	✓	✓	✓
Calcium		✓		✓	✓	✓	✓
Chromium		✓		✓	✓	✓	✓
Cobalt		✓	✓	✓	✓	✓	✓
Copper		✓	✓	✓	✓	✓	✓
Iron	✓	✓		✓	✓	✓	✓
Lead		✓					✓
Lithium		✓	✓	✓	✓	✓	✓
Magnesium		✓	✓	✓	✓	✓	✓
Manganese	✓	✓		✓		✓	✓
Molybdenum	✓	✓	✓	✓	✓	✓	✓
Nickel		✓	✓	✓	✓	✓	✓
Radium-226		✓	✓	✓	✓	✓	✓
Selenium		✓	✓	✓	✓	✓	✓
Silver		✓	✓	✓	✓	✓	✓
Sodium		✓	✓	✓	✓	✓	✓
Thallium		✓	✓	✓	✓	✓	✓
Thorium	✓	✓		✓	✓	✓	✓
Uranium	✓	✓	✓	✓	✓	✓	✓
Vanadium	✓	✓	✓	✓	✓	✓	✓
Zinc	✓	✓		✓	✓	✓	✓

Notes:

[1] In situ XRF measurements were converted to laboratory predicted values; this only applied to nine analytes (arsenic, iron, lead, manganese, molybdenum, thorium, uranium, vanadium, and zinc).

[2] All surface sample types include in situ XRF measurements, XRF confirmation soil samples, and surface soil samples grouped together.

[3] All sample types include in situ XRF measurements, XRF confirmation soil samples, surface soil samples, and subsurface samples grouped together.

7.0 PRIMARY CONTAMINANT MAPPING

7.1 OVERVIEW

A total of 29 analytes were evaluated for this investigation, not including gamma radiation. These analytes include radionuclides and chemical constituents, each with its own applied BTV determined through a background investigation (see Section 3.0). The previous section explored a comparative analysis of each analyte to applied BTVs for each sample type, as well as how the sample type was classified based on the potential for mine-related contamination. This analysis allowed for the identification of COPCs at the site that were above background based on specified statistical criteria. Because of the large number of analytes evaluated as part of this study, and with concentrations above background, the analytes were categorized as either primary or secondary. Primary analytes were identified as being typically associated with uranium-vanadium mining activities and generally more hazardous to the environment and human health than secondary analytes. The primary analytes include the following:

- Arsenic
- Lead
- Molybdenum
- Ra-226
- Selenium
- Thorium
- Uranium
- Vanadium

There are 21 analytes not listed above that are considered secondary analytes; all analytes that were selected as COPCs are shown in Table H28-27. The primary reasons for differentiating between primary and secondary analytes are for contaminant mapping and mine waste volume estimation in the RSE. All COPCs (primary and secondary) identified for this site will be evaluated as part of the EE/CA. Primary analytes are likely to be risk drivers, and the maps provided in this section are focused only on these contaminants. The results for all primary analytes are presented in Section 7.3 through Section 7.10 regardless if the concentrations exceed applied BTVs. The eight primary analytes are discussed in each SSRSE report. Additionally, the volumetric waste estimate considered only the primary analytes for estimating the lateral and vertical extent of contamination.

This section presents a summary of the occurrence and distribution of all primary analytes in the surface and subsurface environments, regardless of whether the concentrations exceeded the applied BTVs. Section 7.2 presents a summary of COPCs identified for this site and further breaks these into COPCs that are found above background in the surface environment only, in the subsurface environment only, or in both the surface and subsurface environments. A discussion and map of individual surface and subsurface measurements are presented for each primary analyte in Section 7.3 through Section 7.10. The data presented in these maps and elsewhere are used to help define the lateral and vertical extent of contamination and develop volume estimates of waste materials above the BTV established for Mesa II, Mine No. 1, P-150. Each soil contaminant map for metals in surface soil presents each sample type as a different shape (that is, triangle, square, or diamond), and each point is color coded based on its relationship to the applied BTV for the primary analyte. Any point that is blue or green is below the applied BTV for the primary analyte, and any color that is yellow, orange, red, burgundy, or

purple is above the applied BTV. The color codes are associated with how many times the value is above the BTV (that is, blue is below the mean of the background; green is above the mean but below 1 times BTV; yellow represents 1 to 2 times BTV; orange represents 2 to 3 times BTV; red represents 3 to 4 times BTV; burgundy represents 4 to 10 times BTV; and purple represents ≥10 times BTV). Any point with a gray color indicates a nondetect result for that sample. Each soil contaminant map for metals in subsurface soil presents the results for each sampling location in a callout box.

7.2 SUMMARY OF CONTAMINANTS OF POTENTIAL CONCERN

Using the process described in Section 4.3, 26 analytes were identified as COPCs at Mesa II, Mine No. 1, P-150. Table H28-28 presents a summary of the identified COPCs and specifies whether the COPC was identified in any of the three categories: (1) found in surface soils; (2) found in subsurface soils; and (3) found in both surface and subsurface soil environments.

Of the 26 total COPCs, all 26 were identified as occurring within the surface environment and a subset of 22 were identified as occurring within the subsurface environment.

Table H28-28. Summary of Identified Contaminants of Potential Concern

Analyte Identified as a COPC[1]	Type of COPC[2]	COPC Identified in Surface Environment	COPC Identified in Subsurface Environment	COPC Identified in Both Surface and Subsurface Environments
Aluminum	Secondary	✓	✓	✓
Antimony	Secondary	✓	✓	✓
Arsenic	Primary	✓	✓	✓
Barium	Secondary	✓		
Beryllium	Secondary	✓		
Cadmium	Secondary	✓	✓	✓
Calcium	Secondary	✓	✓	✓
Chromium	Secondary	✓	✓	✓
Cobalt	Secondary	✓	✓	✓
Copper	Secondary	✓	✓	✓
Iron	Secondary	✓	✓	✓
Lead	Primary	✓		
Lithium	Secondary	✓	✓	✓
Magnesium	Secondary	✓	✓	✓
Manganese	Secondary	✓		
Molybdenum	Primary	✓	✓	✓
Nickel	Secondary	✓	✓	✓
Radium-226	Primary	✓	✓	✓
Selenium	Primary	✓	✓	✓
Silver	Secondary	✓	✓	✓
Sodium	Secondary	✓	✓	✓
Thallium	Secondary	✓	✓	✓
Thorium	Primary	✓	✓	✓
Uranium	Primary	✓	✓	✓
Vanadium	Primary	✓	✓	✓
Zinc	Secondary	✓	✓	✓

Notes:

[1] Identified as a COPC above the applied BTV through the process presented in Section 6.0.

[2] Primary analytes include arsenic, lead, molybdenum, radium-226, selenium, thorium, uranium, and vanadium.

BTV Background threshold value

COPC Contaminant of potential concern

7.3 ARSENIC

Arsenic was identified as a COPC in both surface and subsurface environments as shown in Table H28-28. The applied BTV for arsenic is 2.0 milligrams per kilogram (mg/kg) for Mesa II Mine No. 1, P-150 as presented in Section 3.0. The analytical results for arsenic for all the different sample types (surface and subsurface) are provided in Attachment H28-1. Figure H28-24 presents an individual value plot of detectable arsenic soil concentrations for the three different surface sample types. Figure H28-25 presents a box plot of detectable arsenic soil concentrations for the three different sample types. Summary statistics for all sample types are provided in Section 5.0.

The arsenic concentrations measured in the surface soils at Mesa II Mine No. 1, P-150 ranged between 1.0 and 104 mg/kg with an average and standard deviation of 7.4 mg/kg and 11 mg/kg, respectively. The average arsenic concentration observed in surface soils slightly greater than the applied BTV for arsenic. A soil contaminant map showing the individual arsenic concentrations observed at the site from the different surface sample types (that is, in situ XRF measurements, XRF confirmation samples, and surface soil samples) is provided in Figure H28-26. The arsenic concentrations exceeded the applied BTV for arsenic in all five surface soil sample locations.

Arsenic concentrations exceeding the applied BTV were identified in the surface and subsurface environments. Figure H28-27 provides a map showing the subsurface exceedances for arsenic. The tables shown on Figure H28-27 provide the sample ID for the sample collected from 0 to 6 inches bgs at each boring location. A total of five subsurface soil samples were collected from five borings at Mesa II Mine No. 1, P-150. Two borings (M28-SB30 and M28-SB32) were located in Waste Pile M28 and the other three borings were collected outside of the waste pile. The arsenic concentrations measured in the subsurface soils at Mesa II Mine No. 1, P-150 ranged between 2.3 and 15 mg/kg with an average and standard deviation of 6.3 mg/kg and 5.5 mg/kg, respectively. The arsenic concentrations exceeded the applied BTV for arsenic in all five subsurface soil samples.

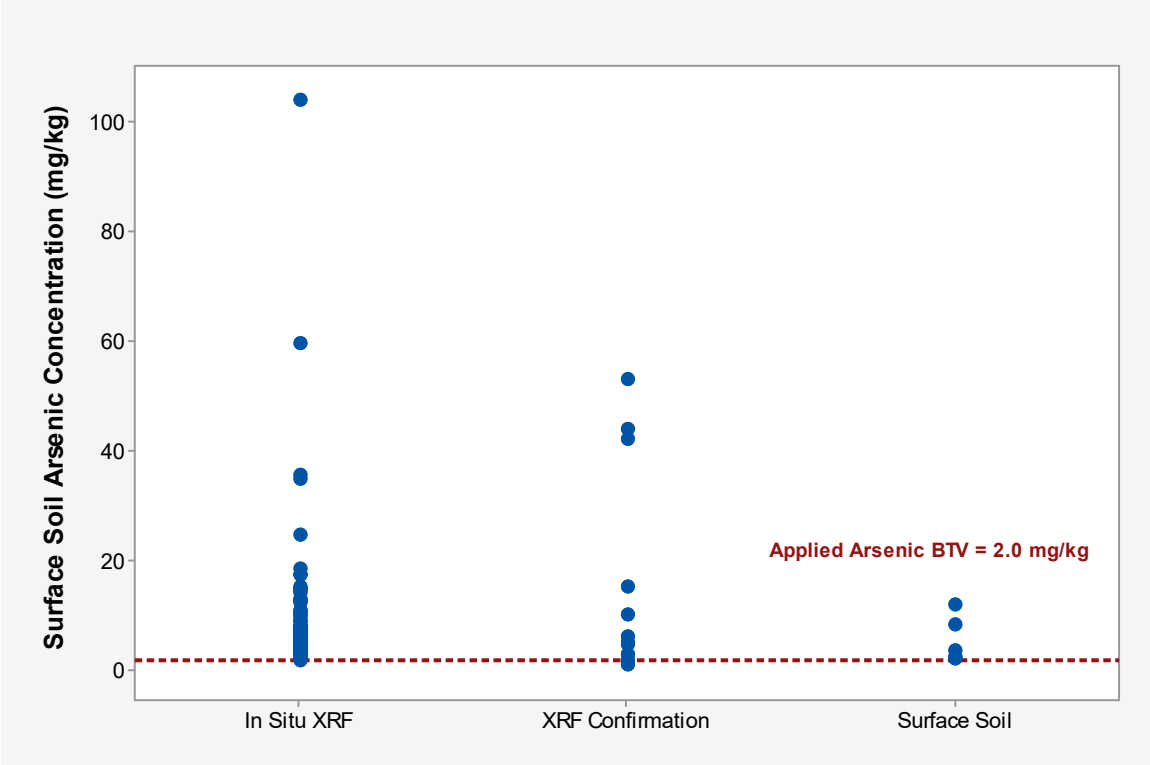


Figure H28-24. Individual Value Plot of Surface Soil Arsenic Concentrations

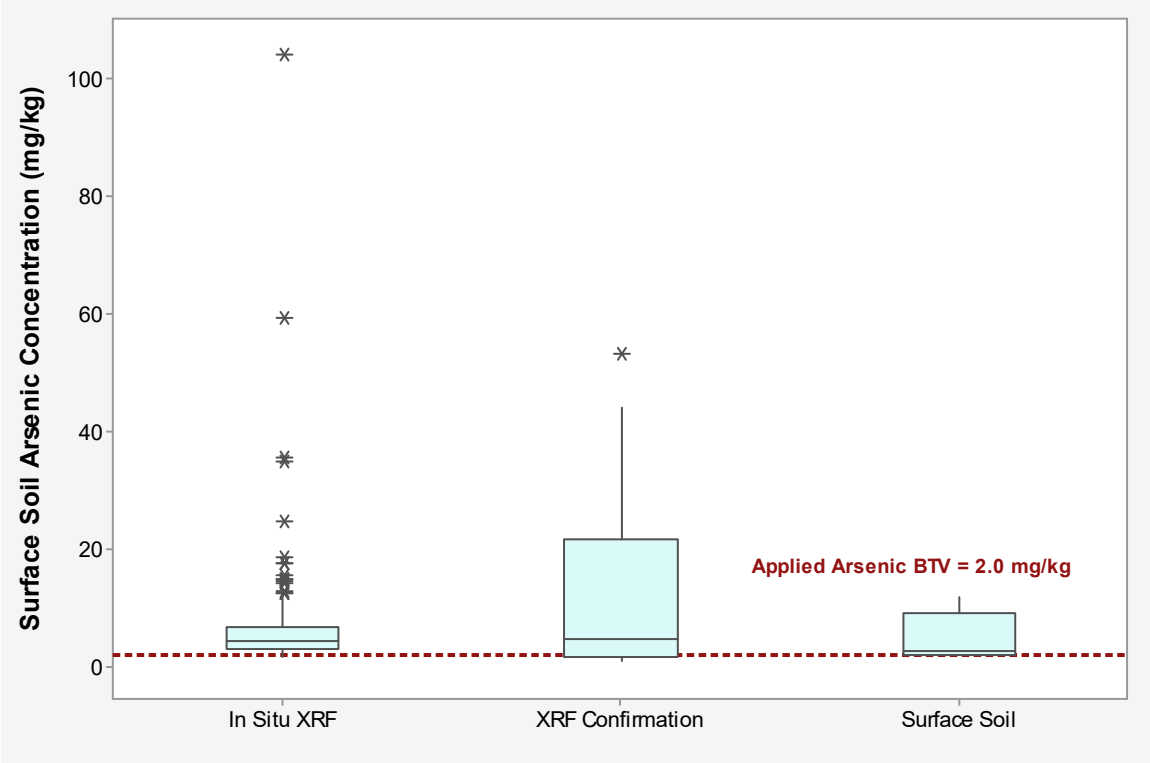
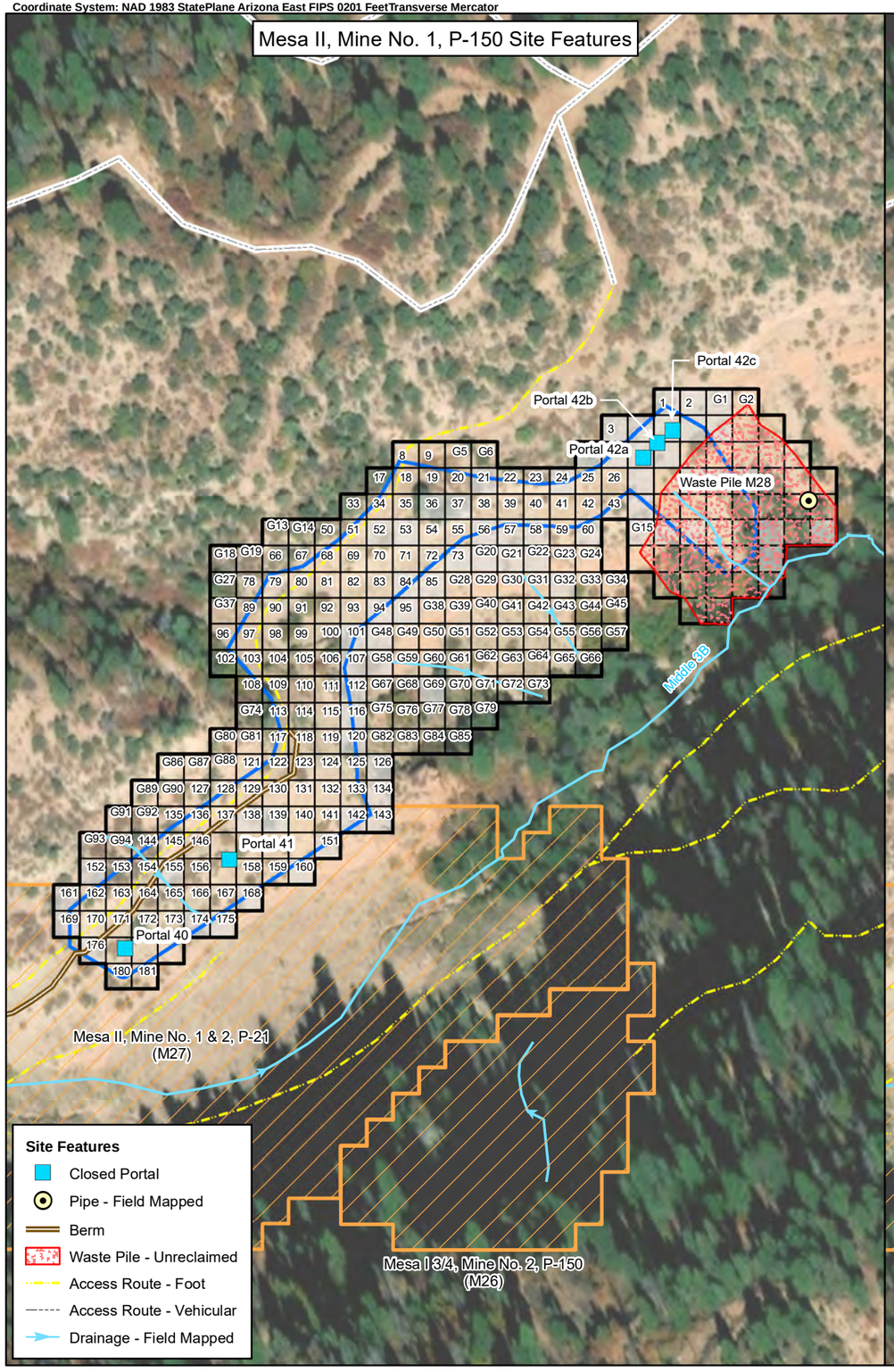


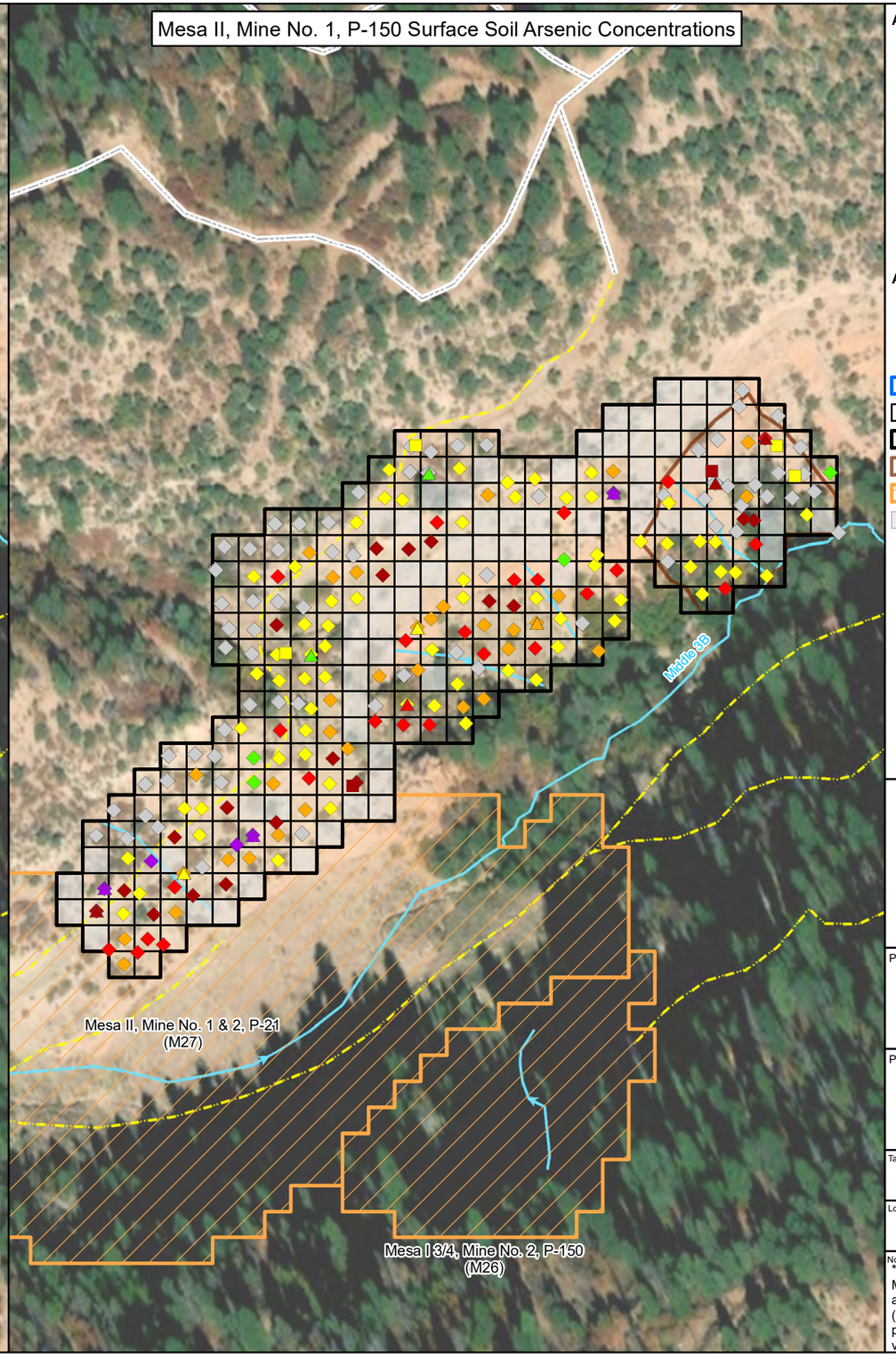
Figure H28-25. Box Plot of Surface Soil Arsenic Concentrations

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

Mesa II, Mine No. 1, P-150 Site Features



Mesa II, Mine No. 1, P-150 Surface Soil Arsenic Concentrations



Arsenic Concentration Scale (mg/kg)*

≤ 0.94	≤ Avg. BG
0.94 - 2.0	Avg. BG - 1 x BTV
2.0 - 4.0	1 x BTV - 2 x BTV
4.0 - 6.0	2 x BTV - 3 x BTV
6.0 - 8.0	3 x BTV - 4 x BTV
8.0 - 20	4 x BTV - 10 x BTV
≥ 20	≥ 10 x BTV
Non-Detect (Less Than Limit of Detection)	

Arsenic Concentration Value Source

- In Situ XRF Measurement
- XRF Confirmation Soil Sample
- Surface Soil Sample
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Waste Pile Boundary
- Other Survey Area
- Inaccessible To XRF Survey

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150 SURFACE SOIL ARSENIC CONCENTRATION MAP

Prepared For:

Prepared By:

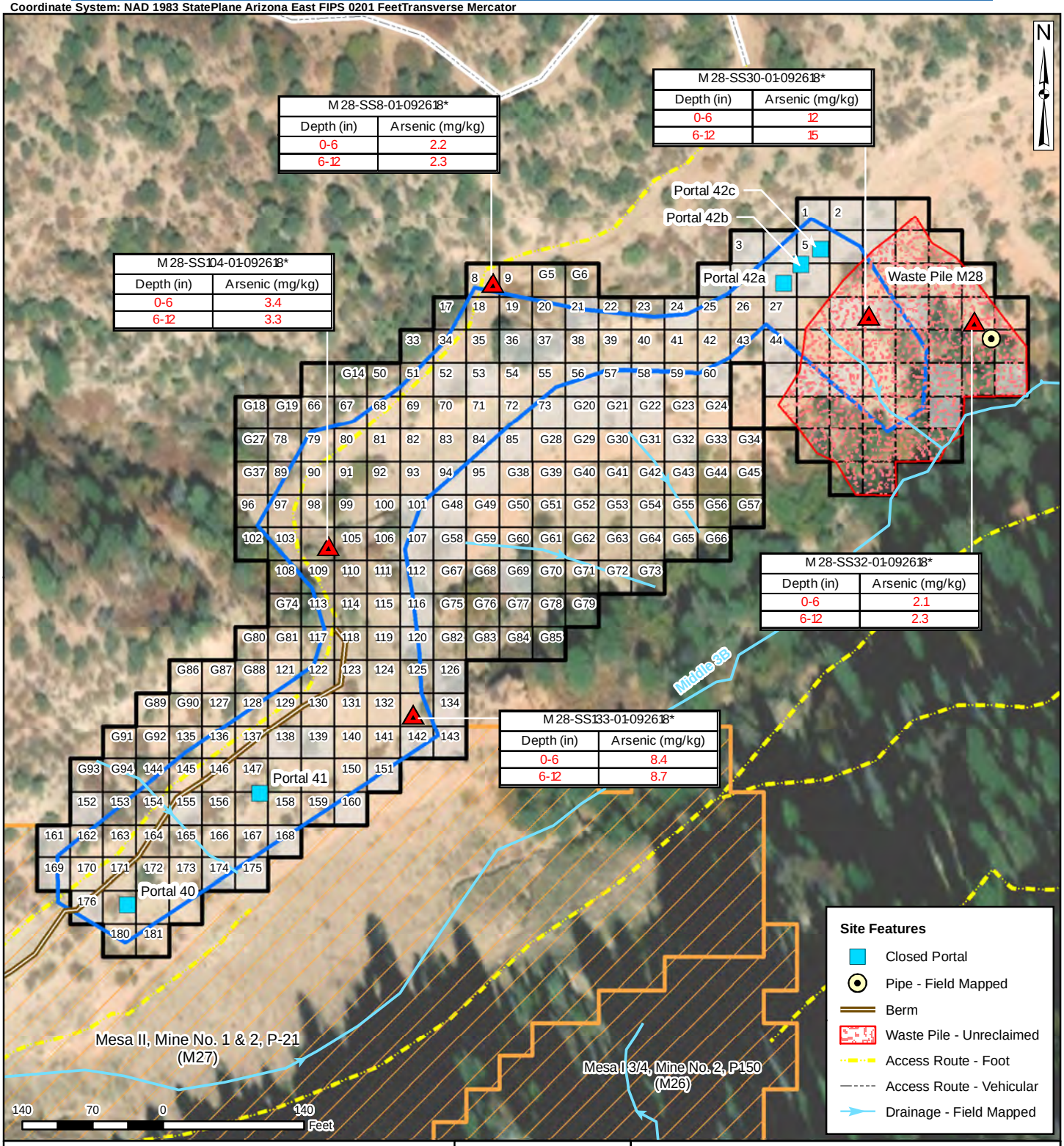
TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	**Date:** 7/7/2019

Notes:
*Arsenic concentration scale values for Mesa II, Mine No. 1, P-150 are based on an applied background threshold value (BTV) of 2.0 mg/kg derived from BSA-29 as presented in Appendix A. Avg. BG: Average value of the background data set.

Figure No.: **H28-26**

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



Subsurface Soil Samples

- Primary COPC In Exceedance of Background Threshold Value
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Other Survey Area
- Inaccessible To XRF Survey

*Red font indicates sample COPC concentration above BTV value of 2.0 mg/kg.

Prepared for: USEPA Region 9

Prepared By: TETRA TECH, 1999 Harrison Street, Suite 500, Oakland, CA 94612

MESA II, MINE NO. 1, P-150 SUBSURFACE SAMPLING ARSENIC RESULTS MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	H28-27
Location: COVE CHAPTER NAVAJO NATION	Date: 7/7/2019	

7.4 LEAD

Lead was identified as a COPC in the surface soil environment but not the subsurface soil environment as shown in Table H28-28. The applied BTV for lead is 10 mg/kg for Mesa II Mine No. 1, P-150 as presented in Section 3.0. The analytical results for lead for all the different scenarios (surface and subsurface) are provided in Attachment H28-1. Figure H28-28 presents an individual value plot of detectable lead soil concentrations for the three different surface sample types. Figure H28-29 presents a box plot of detectable lead soil concentrations for the three different sample types. Summary statistics for all sample types are provided in Section 5.0.

The lead concentrations within surface soils at the Mesa II Mine No. 1, P-150 ranged between 1.2 and 22 mg/kg with an average and standard deviation of 6.0 mg/kg and 2.3 mg/kg, respectively. The average lead concentration observed in surface soils is below the applied BTV for lead. A soil contaminant map showing the individual lead concentrations observed at the site from the different surface sample types (that is, in situ XRF measurements, XRF confirmation samples, and surface soil samples) is provided in Figure H28-30.

A total of five subsurface soil samples were collected from five borings at Mesa II Mine No. 1, P-150. Two borings (M28-SB30 and M28-SB32) were located in Waste Pile M28 and the other three borings were collected outside of the waste pile. The measurements of lead did not exceed the applied BTV in any of the subsurface soil samples and lead was not considered a COPC in the subsurface environment. Figure H28-31 provides a map showing the subsurface exceedances for lead. The tables shown on Figure H28-31 provide the sample ID for the sample collected from 0 to 6 inches bgs at each boring location.

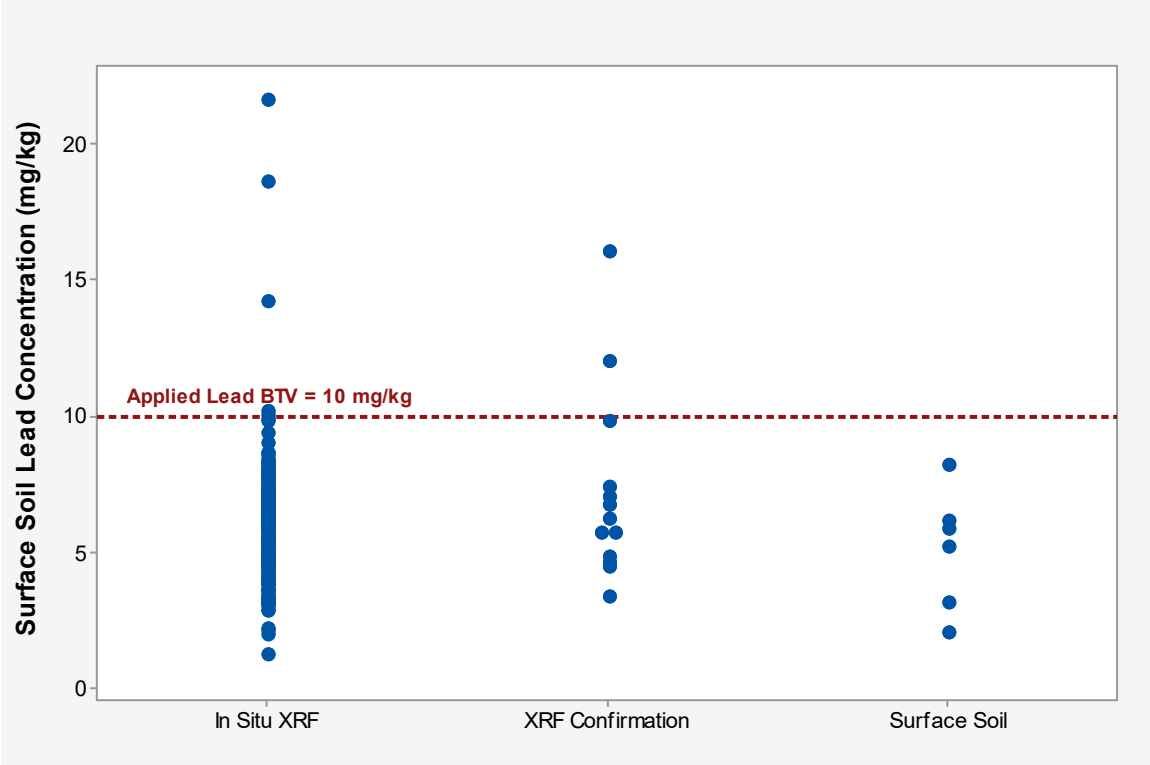


Figure H28-28. Individual Value Plot of Surface Soil Lead Concentrations

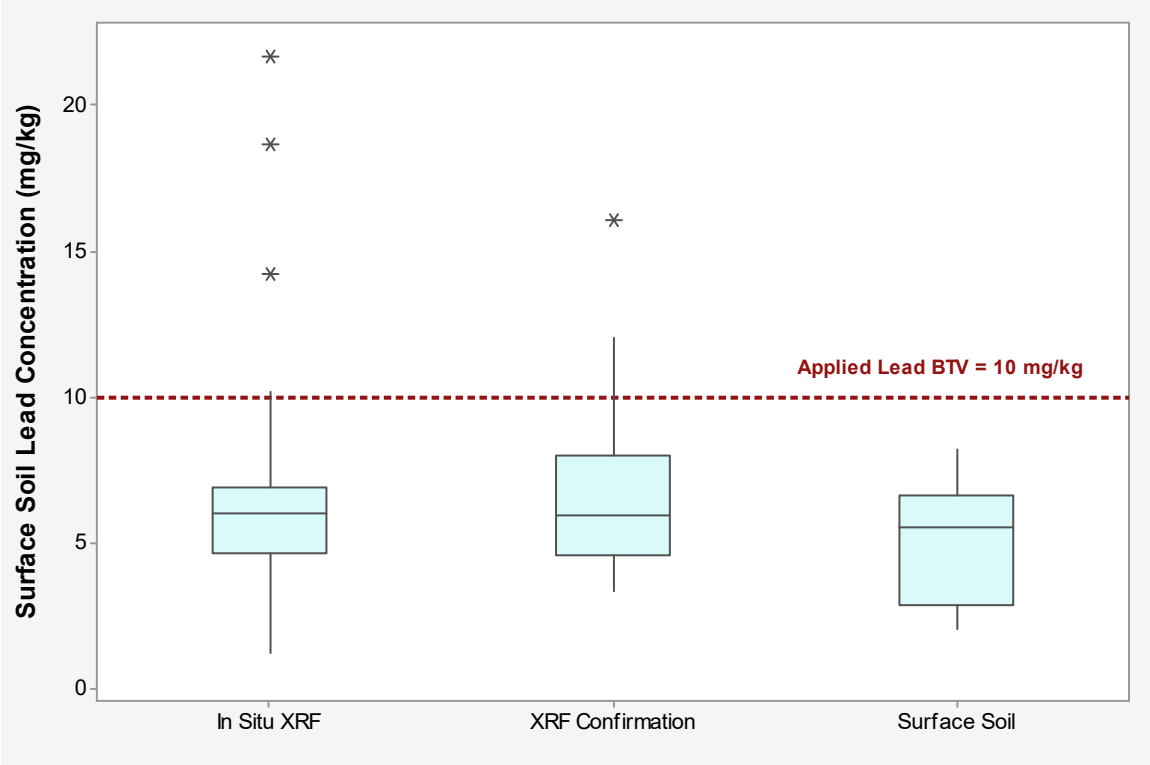
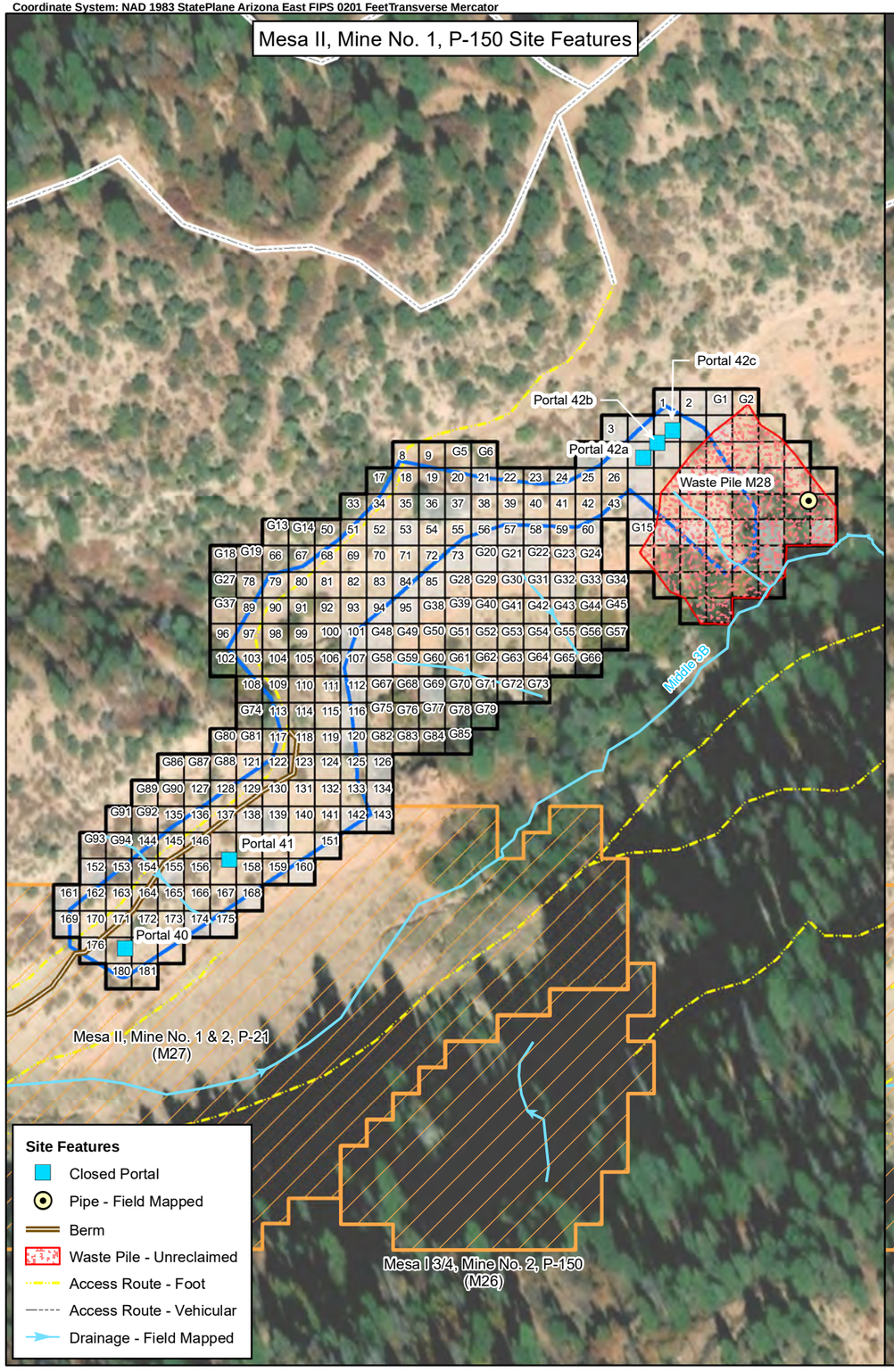


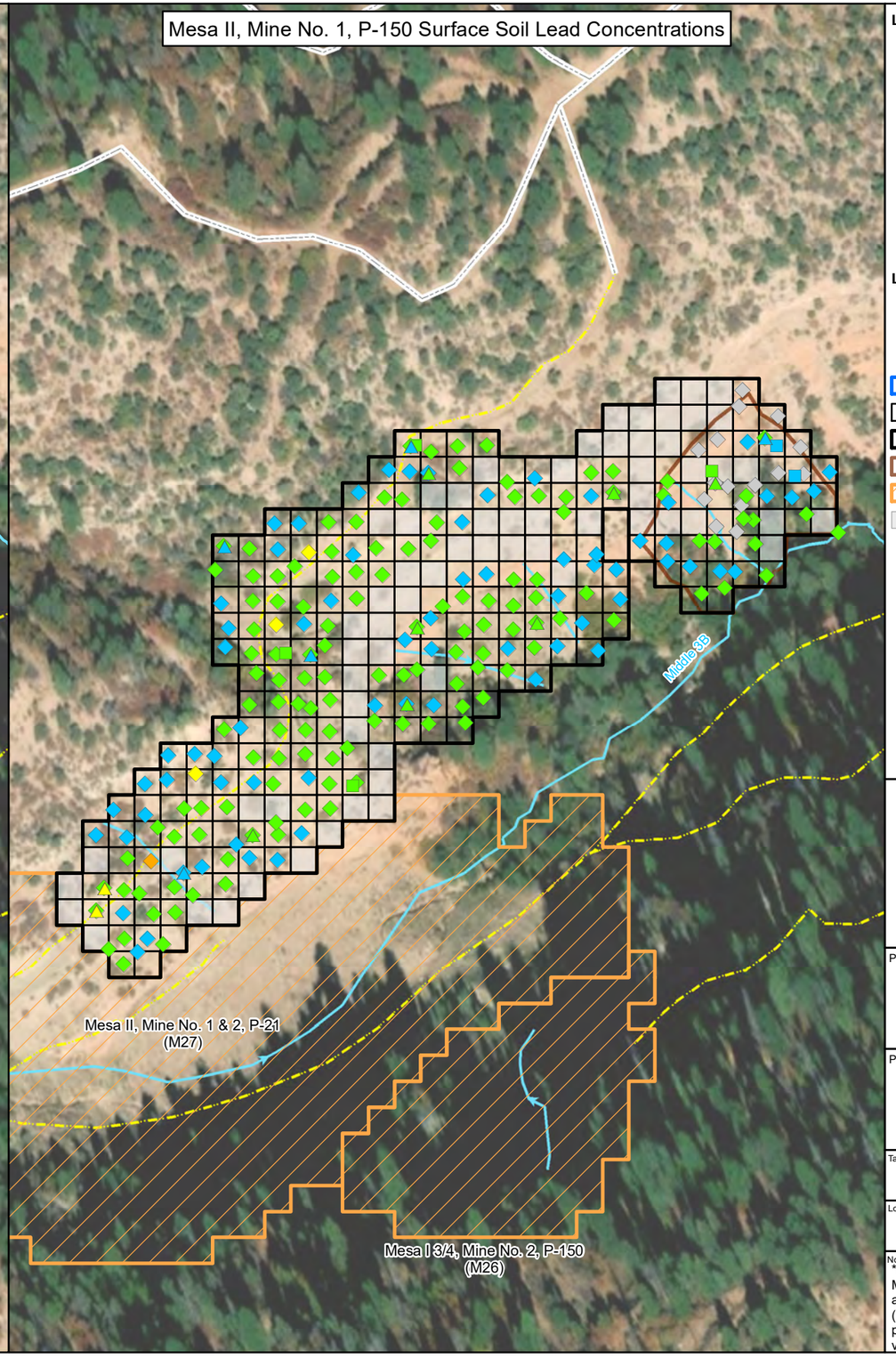
Figure H28-29. Box Plot of Surface Soil Lead Concentrations

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

Mesa II, Mine No. 1, P-150 Site Features



Mesa II, Mine No. 1, P-150 Surface Soil Lead Concentrations



Lead Concentration Scale (mg/kg)*

≤ 5.0	≤ Avg. BG
5.0 - 10	Avg. BG - 1 x BTV
10 - 20	1 x BTV - 2 x BTV
20 - 30	2 x BTV - 3 x BTV
30 - 40	3 x BTV - 4 x BTV
40 - 100	4 x BTV - 10 x BTV
≥ 100	≥ 10 x BTV
Non-Detect (Less Than Limit of Detection)	

Lead Concentration Value Source

- In Situ XRF Measurement
- XRF Confirmation Soil Sample
- Surface Soil Sample
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Waste Pile Boundary
- Other Survey Area
- Inaccessible To XRF Survey

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150 SURFACE SOIL LEAD CONCENTRATION MAP

Prepared For:

Prepared By:

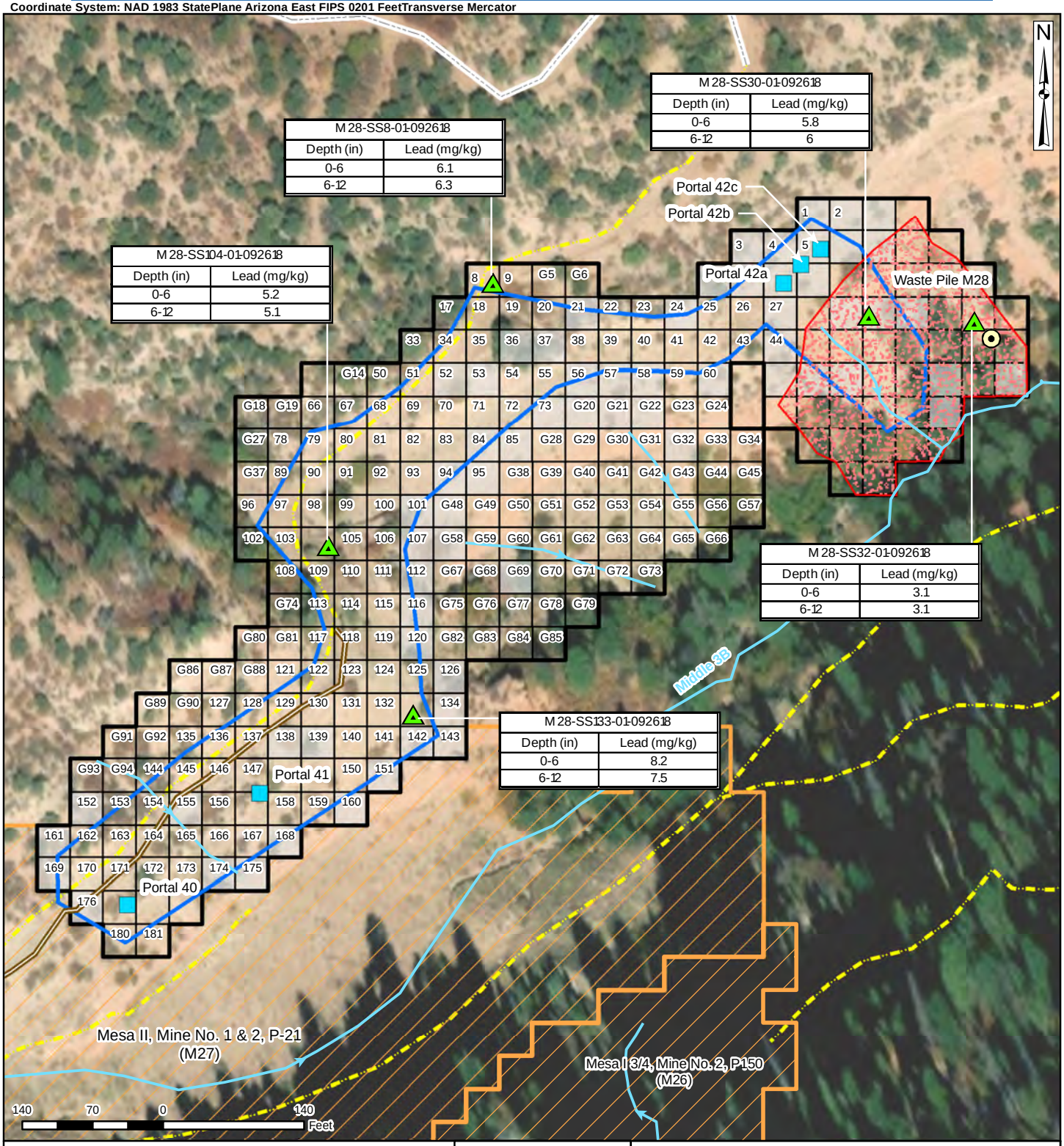
TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	**Date:** 7/7/2019

Notes:
*Lead concentration scale values for Mesa II, Mine No. 1, P-150 are based on an applied background threshold value (BTV) of 10 mg/kg derived from BSA-24 as presented in Appendix A. Avg. BG: Average value of the background data set.

Figure No.: **H28-30**

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



Subsurface Soil Samples

- Primary COPC Less Than Background Threshold Value
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Other Survey Area
- Inaccessible To XRF Survey

Site Features

- Closed Portal
- Pipe - Field Mapped
- Berm
- Waste Pile - Unreclaimed
- Access Route - Foot
- Access Route - Vehicular
- Drainage - Field Mapped

Prepared for: USEPA Region 9

Prepared By:

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MESA II, MINE NO. 1, P-150 SUBSURFACE SAMPLING LEAD RESULTS MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	H28-31
Location: COVE CHAPTER NAVAJO NATION	Date: 7/7/2019	

7.5 MOLYBDENUM

Molybdenum was identified as a COPC in both the surface and subsurface soil environments as shown in Section 7.2. The applied BTV for molybdenum is 0.26 mg/kg for Mesa II, Mine No. 1, P-150 as presented in Section 3.0. The analytical results for molybdenum for all the different scenarios (surface and subsurface) are provided in Attachment H28-1. Figure H28-32 presents an individual value plot of detectable molybdenum soil concentrations for the three different surface sample types. Figure H28-33 presents a box plot of detectable molybdenum soil concentrations for the three different sample types. Summary statistics for all sample types are provided in Section 5.0.

The molybdenum concentrations within surface soils at Mesa II, Mine No. 1, P-150 ranged between 0.039 and 60 mg/kg with an average and standard deviation of 3.7 mg/kg and 8.8 mg/kg, respectively. The average molybdenum concentration observed in surface soils is above the applied BTV for molybdenum. A soil contaminant map showing the individual molybdenum concentrations observed at the site from the different surface sample types (that is, in situ XRF measurements, XRF confirmation samples, and surface soil samples) is provided in Figure H28-34.

The measurements of molybdenum exceeded the applied BTV in the surface environment and were also found to be elevated above the applied BTV within the subsurface environment. Figure H28-35 provides a map showing the subsurface exceedances for molybdenum. The tables shown on Figure H28-35 provide the sample ID for the sample collected from 0 to 6 inches bgs at each boring location. The molybdenum concentrations within subsurface soils at Mesa II, Mine No. 1, P-150 ranged between 0.06 and 3.3 mg/kg with an average and standard deviation of 0.98 mg/kg and 1.4 mg/kg, respectively. Molybdenum was found to exceed the BTV in two of the five subsurface soil samples (borings M28-SB30 and M28-SB133). Boring M28-SB30 is located in unreclaimed Waste Pile M28 and boring M28-SB133 is located outside of the waste pile.

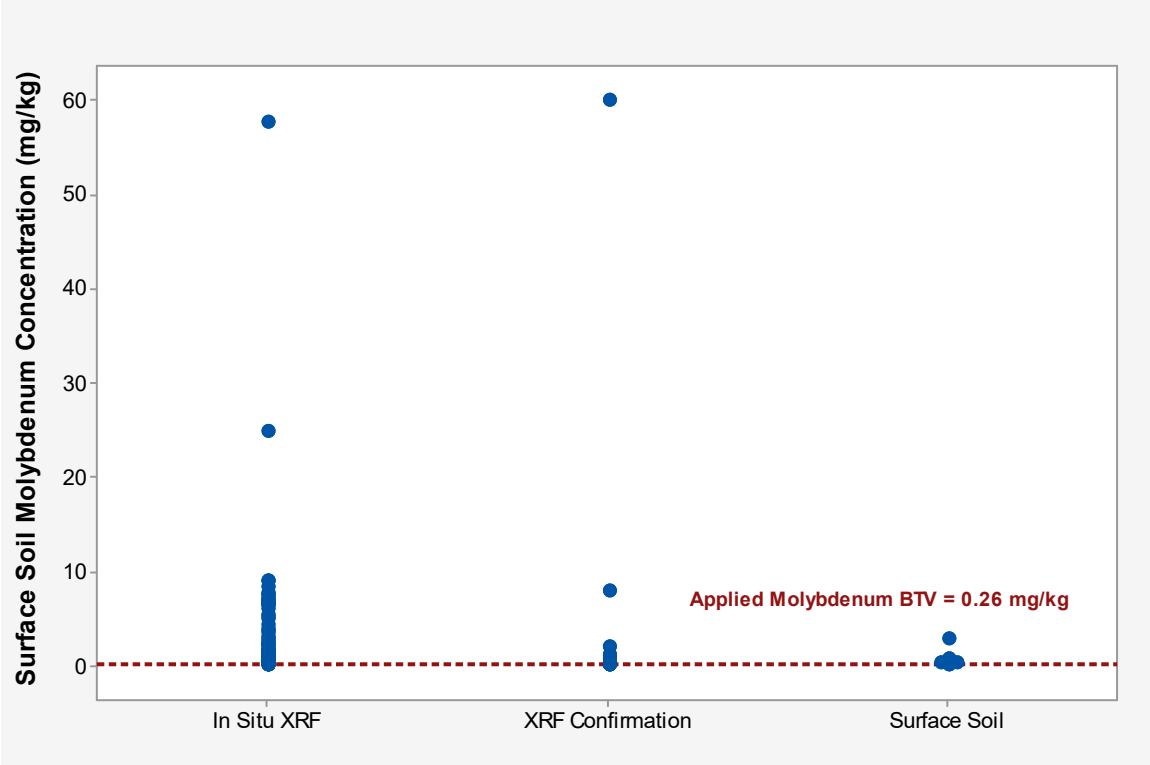


Figure H28-32. Individual Value Plot of Surface Soil Molybdenum Concentrations

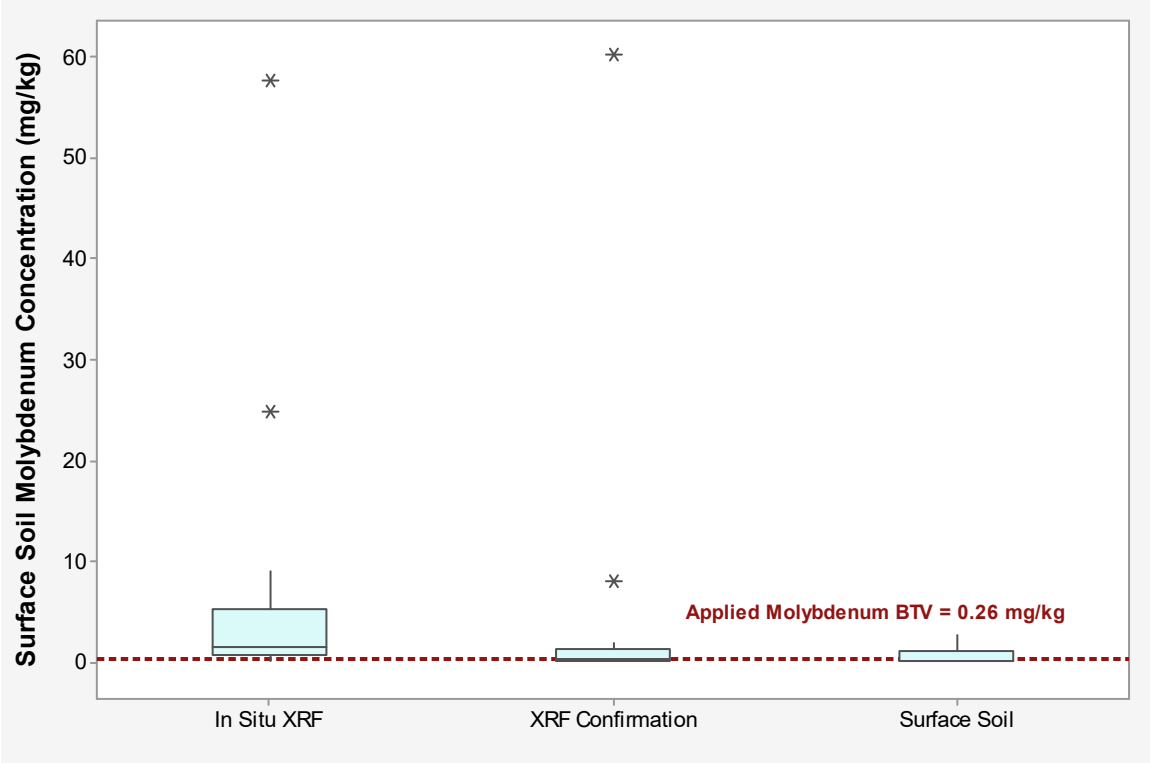
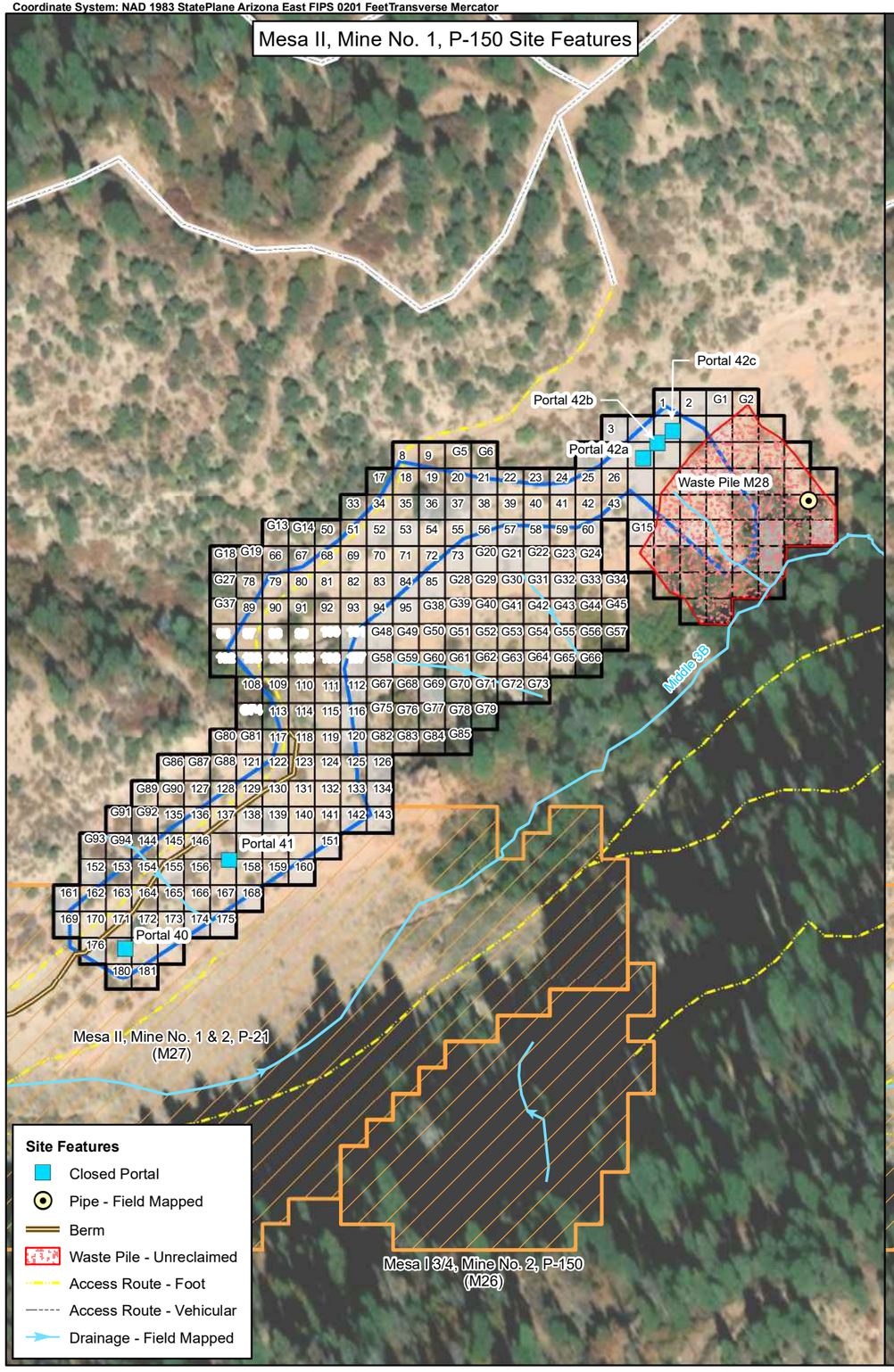


Figure H28-33. Box Plot of Surface Soil Molybdenum Concentrations

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

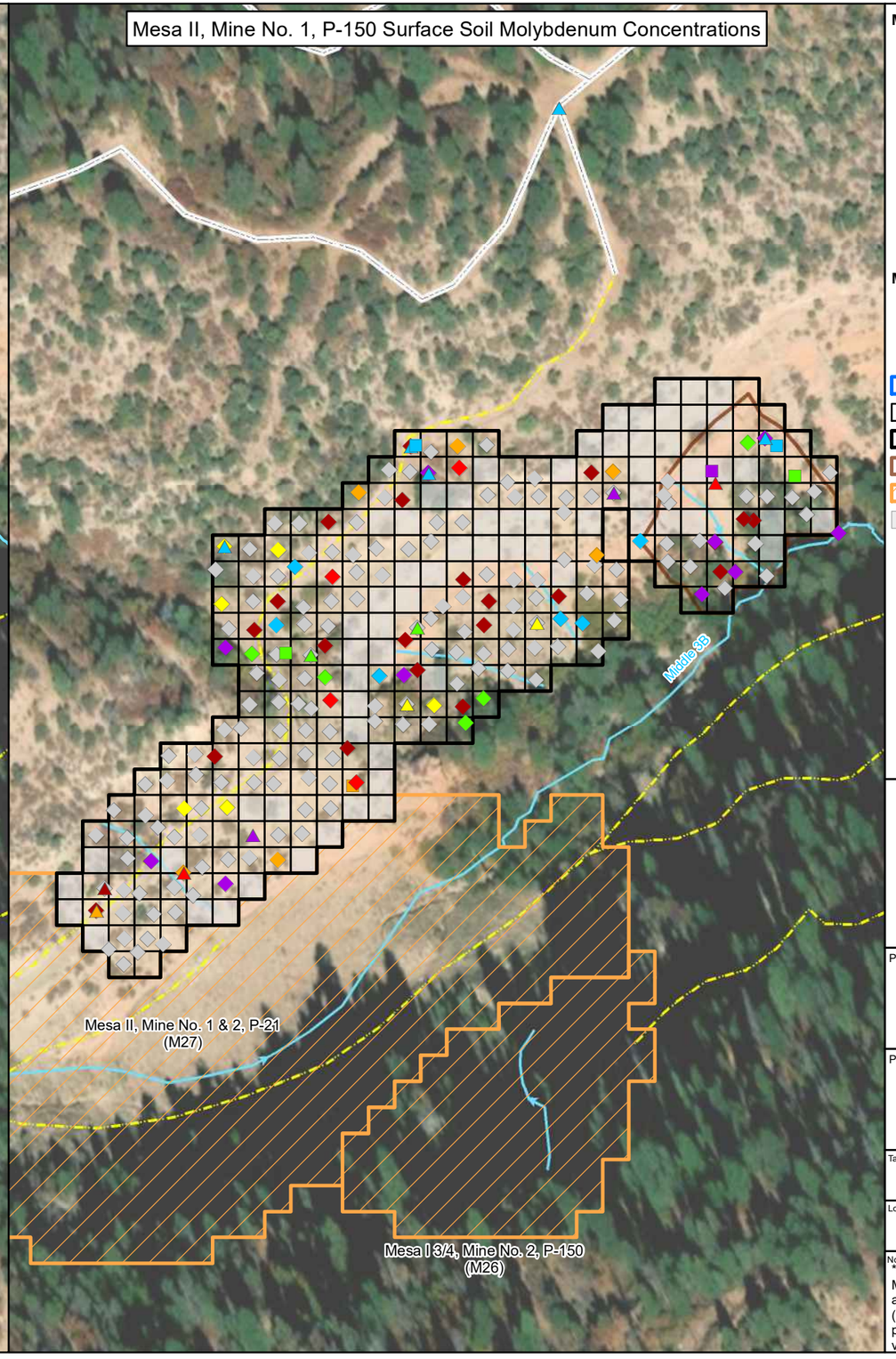
Mesa II, Mine No. 1, P-150 Site Features



Site Features

- Closed Portal
- Pipe - Field Mapped
- Berm
- Waste Pile - Unreclaimed
- Access Route - Foot
- Access Route - Vehicular
- Drainage - Field Mapped

Mesa II, Mine No. 1, P-150 Surface Soil Molybdenum Concentrations



Molybdenum Concentration Scale (mg/kg)*

≤ 0.13	≤ 0.5 x BTV
0.13 - 0.26	0.5 x BTV - 1 x BTV
0.26 - 0.52	1 x BTV - 2 x BTV
0.52 - 0.78	2 x BTV - 3 x BTV
0.78 - 1.0	3 x BTV - 4 x BTV
1.0 - 2.6	4 x BTV - 10 x BTV
≥ 2.6	≥ 10 x BTV
Non-Detect (Less Than Limit of Detection)	

Molybdenum Concentration Value Source

- In Situ XRF Measurement
- XRF Confirmation Soil Sample
- Surface Soil Sample
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Waste Pile Boundary
- Other Survey Area
- Inaccessible To XRF Survey

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150 SURFACE SOIL MOLYBDENUM CONCENTRATION MAP

Prepared For:

Prepared By:

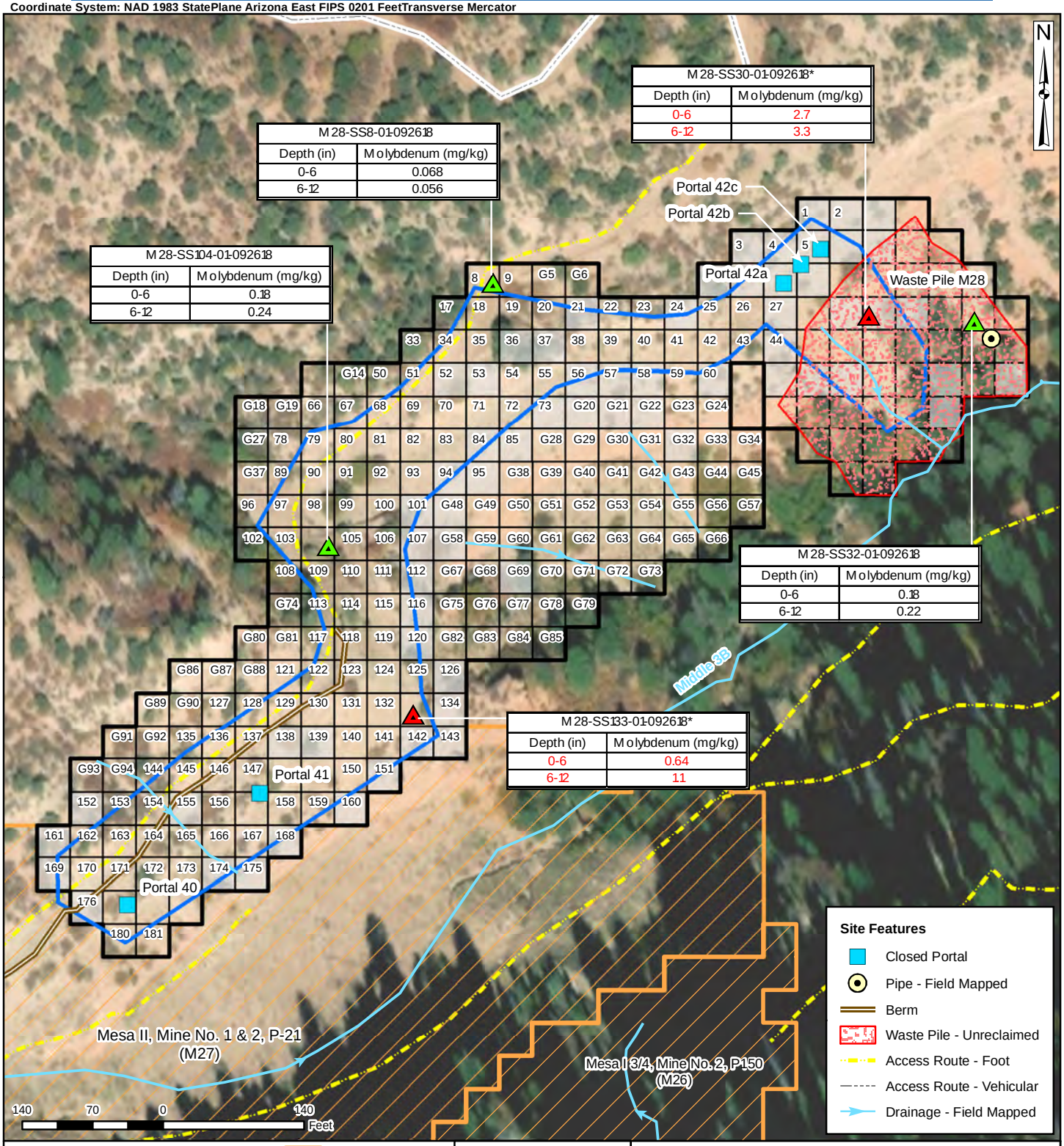
TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	**Date:** 7/22/2019

Notes:
*Molybdenum concentration scale values for Mesa II, Mine No. 1, P-150 are based on an applied background threshold value (BTV) of 0.26 mg/kg derived from BSA-29 as presented in Appendix A. Only 1 detected value for Molybdenum (0.26) at BSA-29.

Figure No.: **H28-34**

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



Subsurface Soil Samples

- Primary COPC Less Than Background Threshold Value
- Primary COPC In Exceedance of Background Threshold Value
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Other Survey Area
- Inaccessible To XRF Survey

*Red font indicates sample COPC concentration above BTV value of 0.26 mg/kg.

Prepared for: USEPA Region 9

Prepared By: TETRA TECH, 1999 Harrison Street, Suite 500, Oakland, CA 94612

MESA II, MINE NO. 1, P-150 SUBSURFACE SAMPLING MOLYBDENUM RESULTS MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	H28-35
Location: COVE CHAPTER NAVAJO NATION	Date: 7/7/2019	

7.6 RADIUM-226

Ra-226 was identified as a COPC in both the surface and subsurface soil environments as shown in Section 7.2. The applied BTV for Ra-226 is 0.85 pCi/g for Mesa II, Mine No. 1, P-150 as presented in Section 3.0. The analytical results for Ra-226 for all the different scenarios (surface and subsurface) are provided in Attachment H28-1. Figure H28-36 presents an individual value plot of detectable Ra-226 soil concentrations for the two different surface sample types, which include XRF confirmation soil samples and surface soil samples. Figure H28-37 presents a box plot of detectable Ra-226 soil concentrations for the two different sample types. Summary statistics for all sample types are provided in Section 5.0.

The Ra-226 concentrations from the analytical surface soil samples collected at Mesa II, Mine No. 1, P-150 ranged between 0.83 and 136 pCi/g with an average and standard deviation of 27.3 pCi/g and 45.3 pCi/g, respectively. A gamma-radium correlation was performed as described in Section 4.5.1 and in further detail in Appendix C of the RSE Report. The gamma radiation measurements are converted to Ra-226 concentrations using the correlation model and are presented in Figure H28-38. These values are then averaged within each survey unit and presented with actual samples collected in Figure H28-39. The estimated measurements of Ra-226 from the gamma survey exceeded the applied BTV in the surface environment and are found to be elevated 10 times above the applied BTV within Waste Pile M28 and outside of the waste pile. In general, the Ra-226 concentrations predicted from the gamma-radium correlation tend to slightly overpredict the Ra-226 soil concentrations at lower levels and under predicts at higher levels. Further discussion on the evaluation of the gamma-radium correlation is presented in Section 8.3.

Figure H28-40 provides a map showing the subsurface exceedances for Ra-226. The tables shown on Figure H28-40 provide the sample ID for the sample collected from 0 to 6 inches bgs at each boring location. The Ra-226 concentrations within subsurface soils at Mesa II, Mine No. 1, P-150 ranged between 1.50 and 175 pCi/g with an average and standard deviation of 48.0 pCi/g and 73.8 pCi/g, respectively. The average Ra-226 concentration and the results in all subsurface soils at Mesa II, Mine No. 1, P-150 is above the applied BTV for Ra-226.

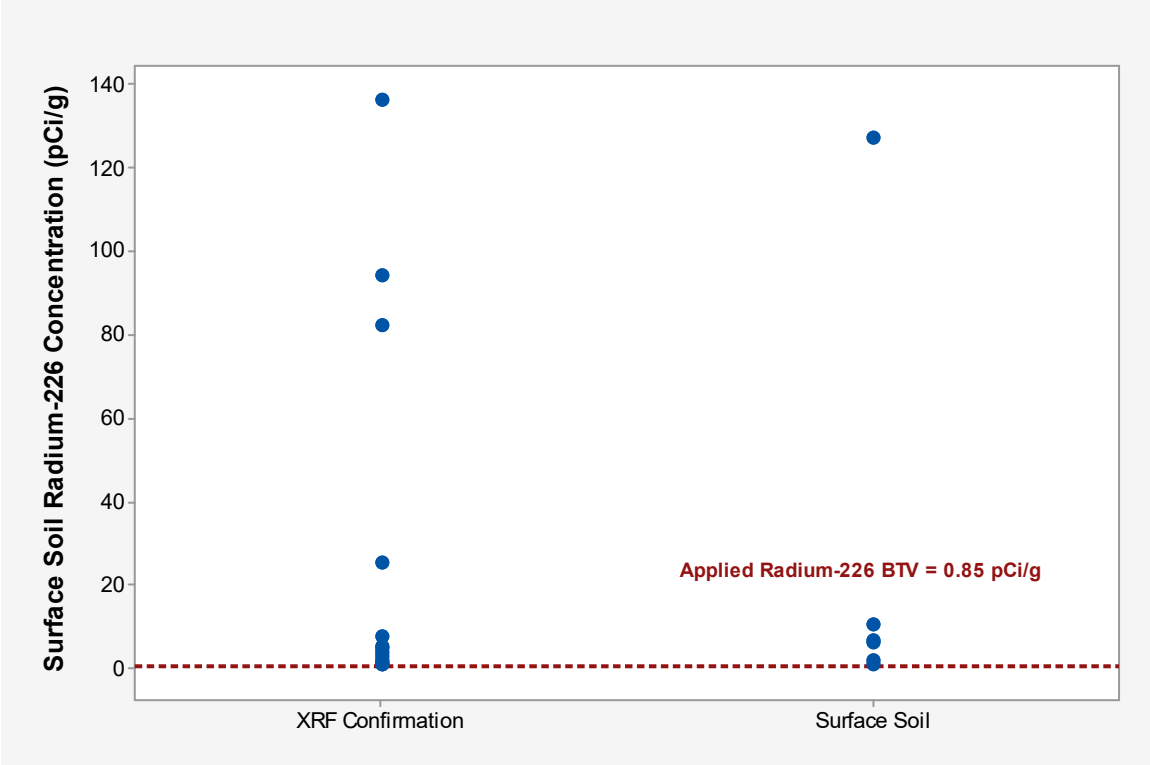


Figure H28-36. Individual Value Plot of Surface Soil Radium-226 Concentrations

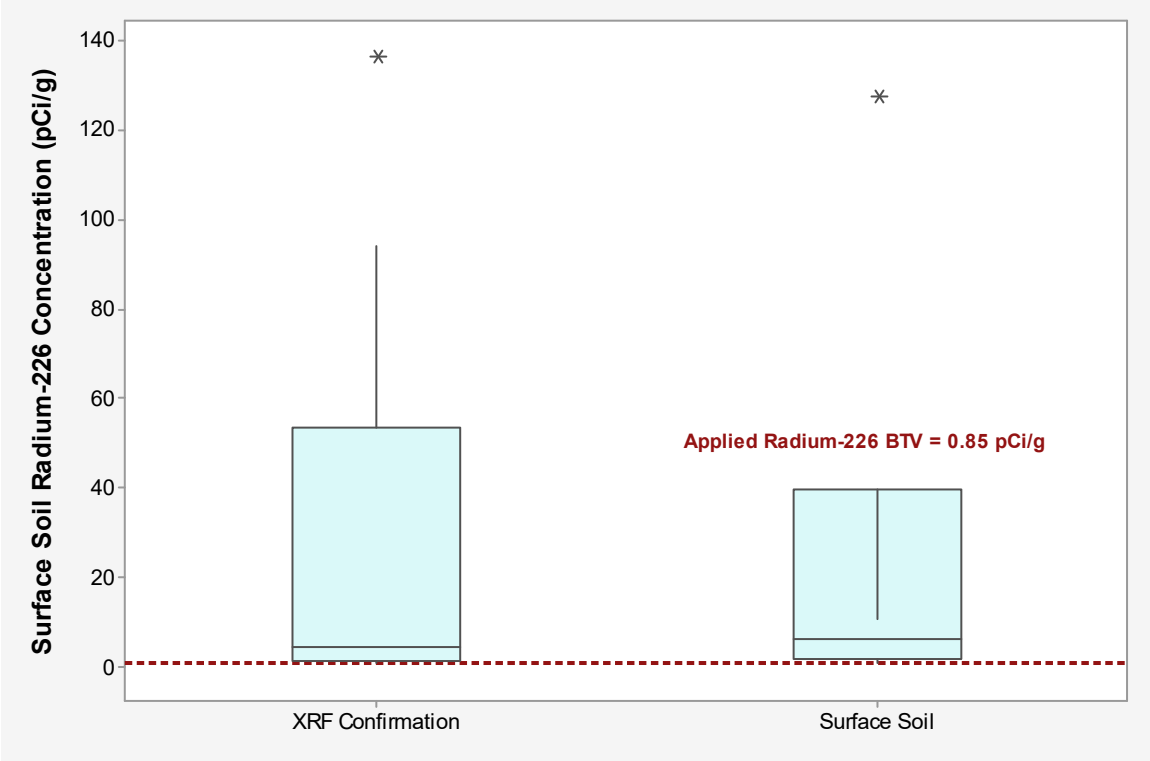
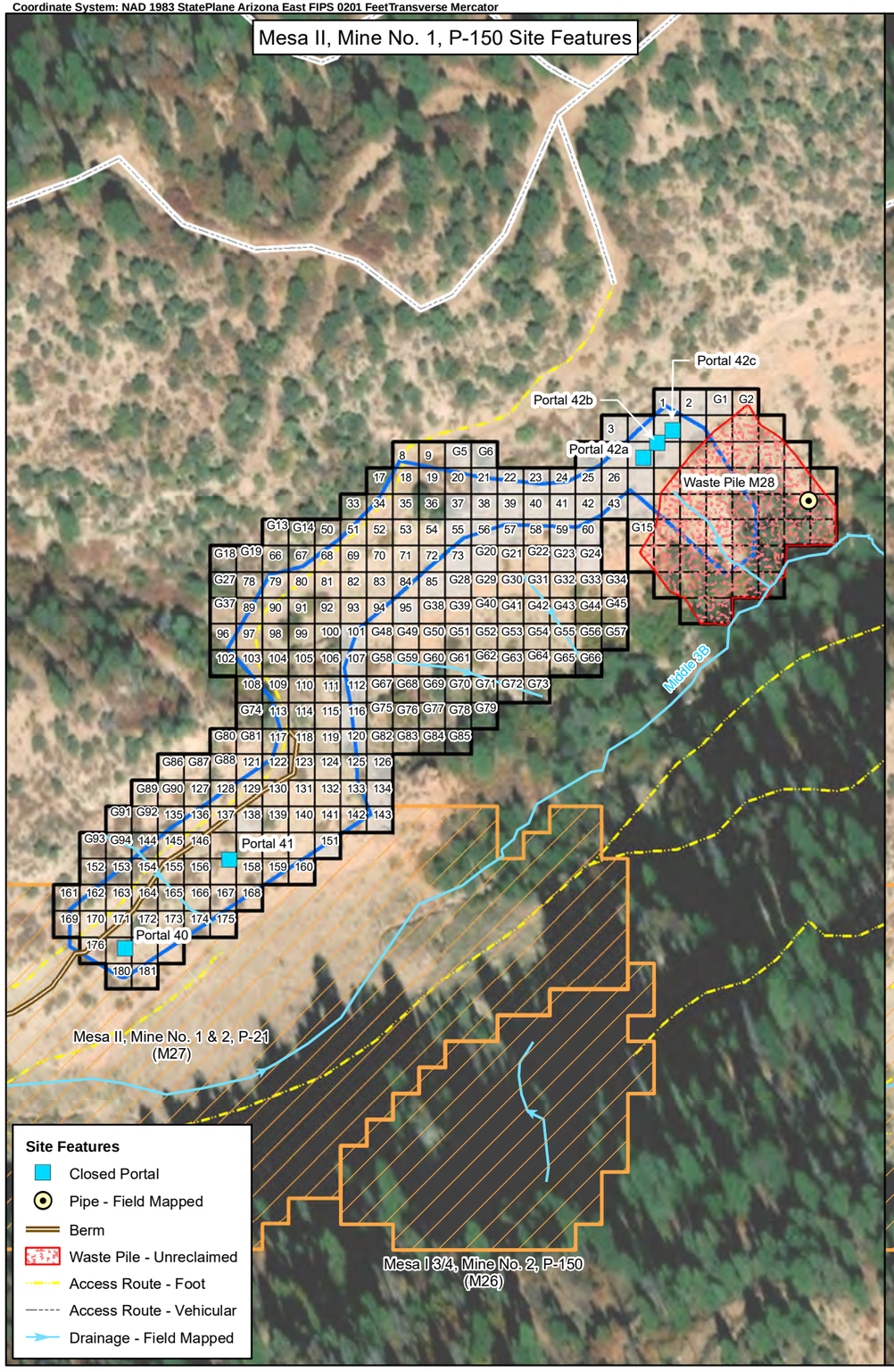


Figure H28-37. Box Plot of Surface Soil Radium-226 Concentrations

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

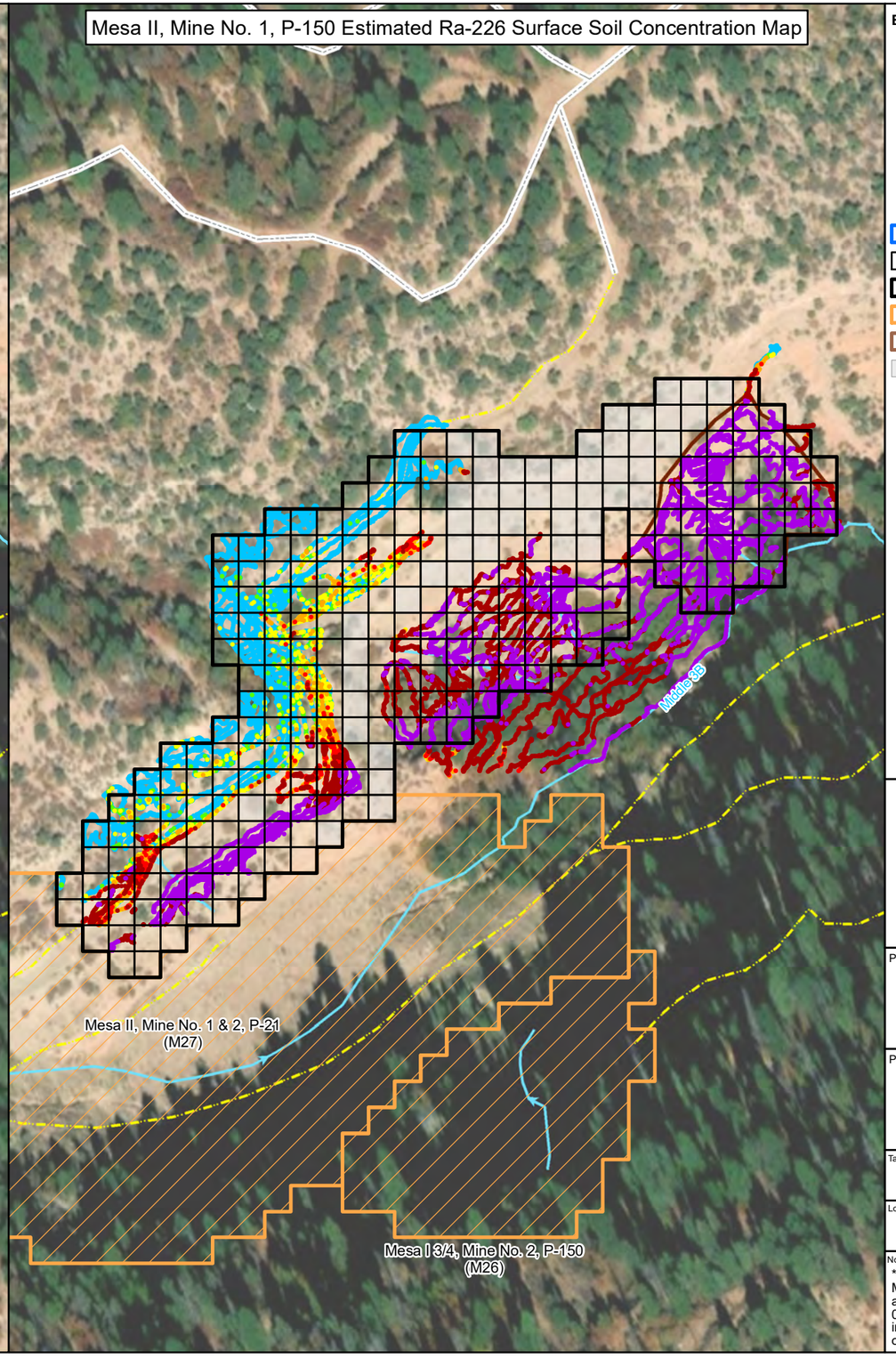
Mesa II, Mine No. 1, P-150 Site Features



Site Features

- Closed Portal
- Pipe - Field Mapped
- Berm
- Waste Pile - Unreclaimed
- Access Route - Foot
- Access Route - Vehicular
- Drainage - Field Mapped

Mesa II, Mine No. 1, P-150 Estimated Ra-226 Surface Soil Concentration Map



Estimated Ra-226 Soil Concentration (pCi/g)

≤ 0.60	≤ Avg. BG
0.60 - 0.85	Avg. BG - 1 x BTV
0.85 - 1.70	1 x BTV - 2 x BTV
1.70 - 2.55	2 x BTV - 3 x BTV
2.55 - 3.40	3 x BTV - 4 x BTV
3.40 - 8.50	4 x BTV - 10 x BTV
≥ 8.50	≥ 10 x BTV

- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Other Survey Area
- Waste Pile Boundary
- Inaccessible To Gamma Survey

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150
ESTIMATED SURFACE SOIL
RADIUM-226 CONCENTRATION MAP

Prepared For:

Prepared By:

TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

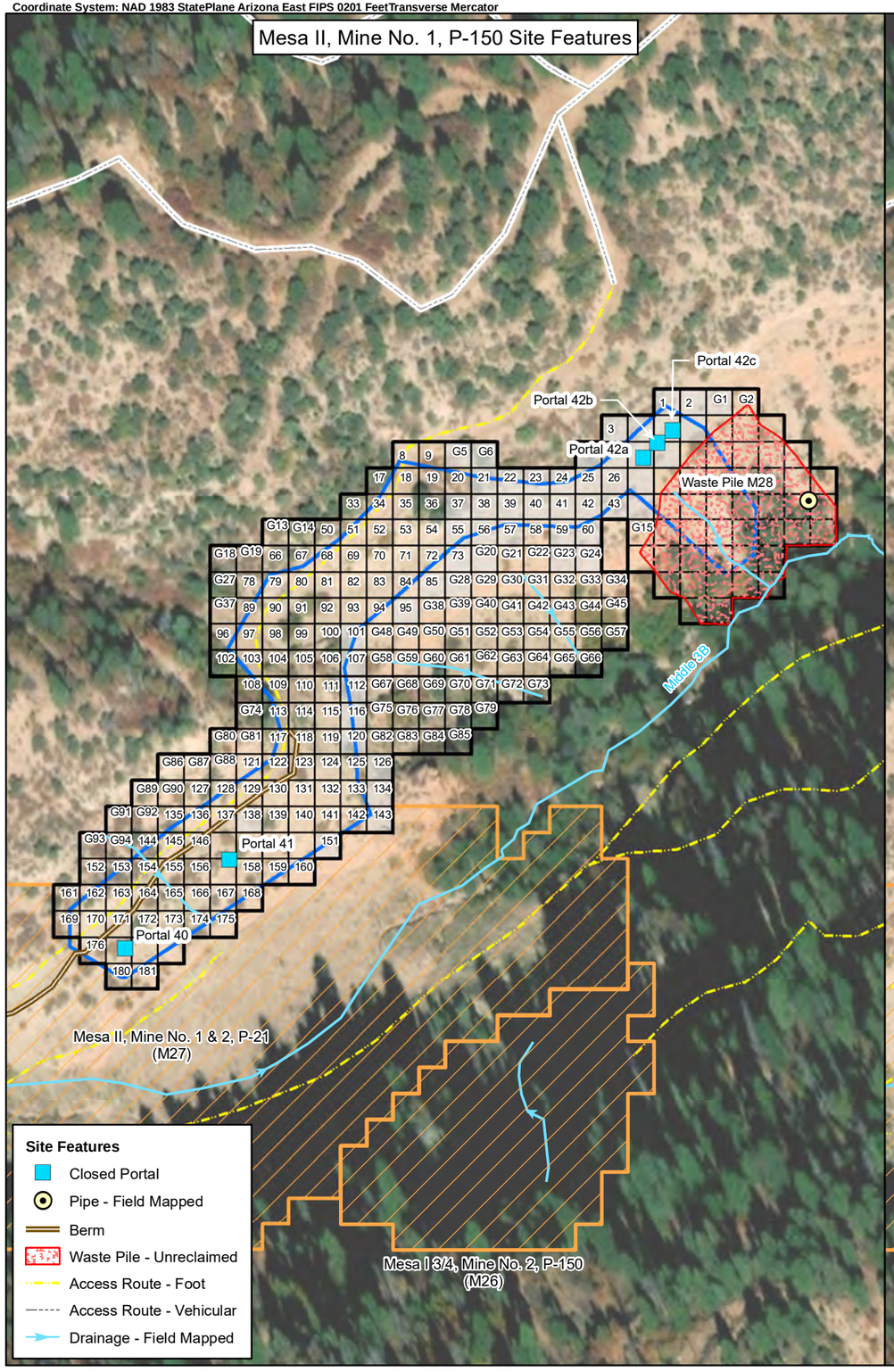
Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	**Date:** 7/7/2019

Notes:
*Radium-226 concentration scale values for Mesa II, Mine No. 1, P-150 are based on an applied background threshold value (BTV) of 0.85 pCi/g derived from BSA-29 as presented in Appendix A. Avg. BG: Average value of the background data set.

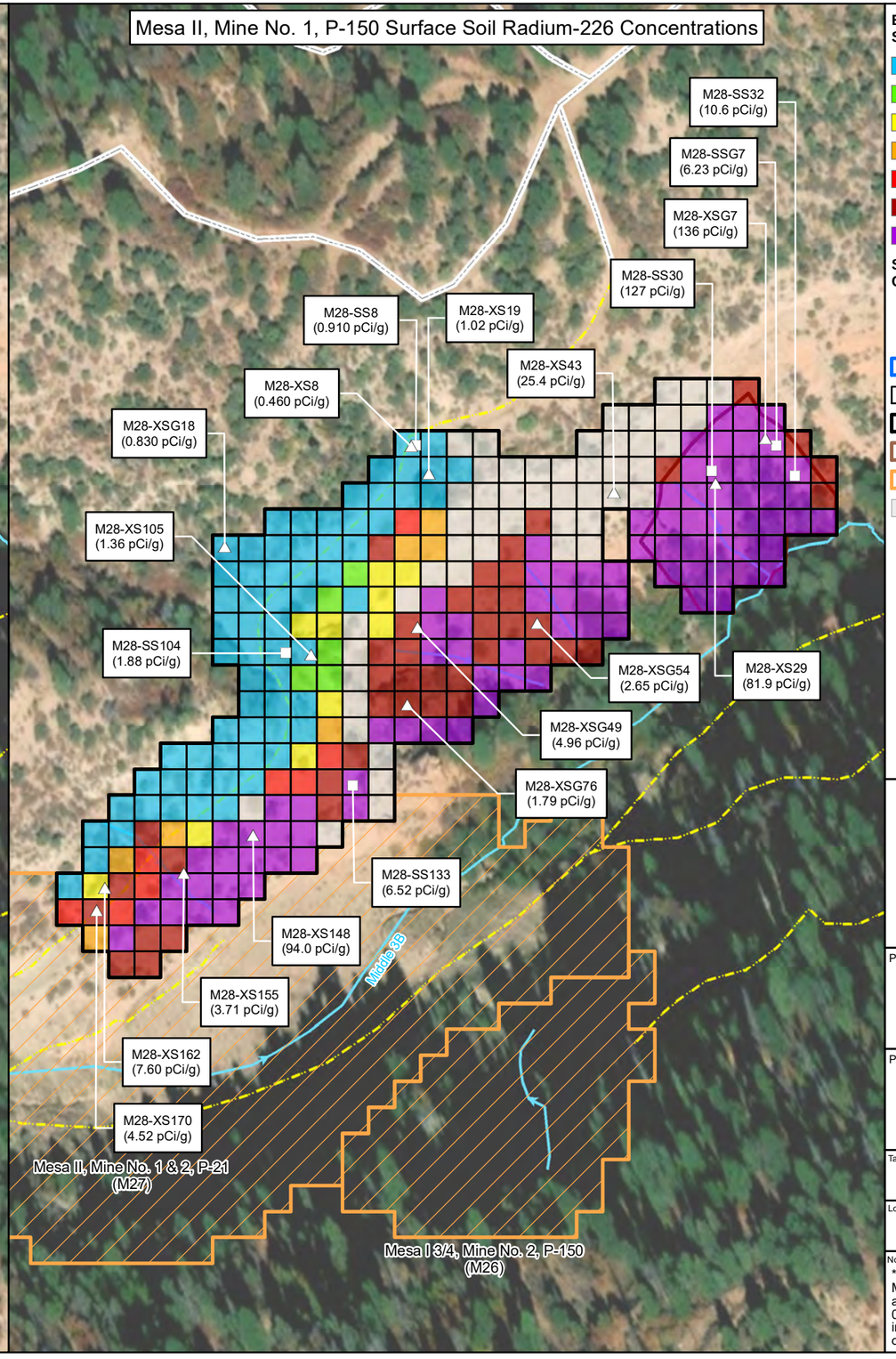
Figure No.: **H28-38**

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

Mesa II, Mine No. 1, P-150 Site Features



Mesa II, Mine No. 1, P-150 Surface Soil Radium-226 Concentrations



Estimated Grid Averaged Ra-226 Soil Concentration (pCi/g)

≤ 0.60	≤ Avg. BG
0.60 - 0.85	Avg. BG - 1 x BTV
0.85 - 1.70	1 x BTV - 2 x BTV
1.70 - 2.55	2 x BTV - 3 x BTV
2.55 - 3.40	3 x BTV - 4 x BTV
3.40 - 8.50	4 x BTV - 10 x BTV
≥ 8.50	≥ 10 x BTV

Surface Soil Ra-226 Concentrations

- XRF Confirmation Soil Sample
- Surface Soil Sample
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Waste Pile Boundary
- Other Survey Area
- Inaccessible To Gamma Survey

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150 ESTIMATED GRID AVERAGED SURFACE SOIL RADIUM-226 CONCENTRATION MAP

Prepared For:

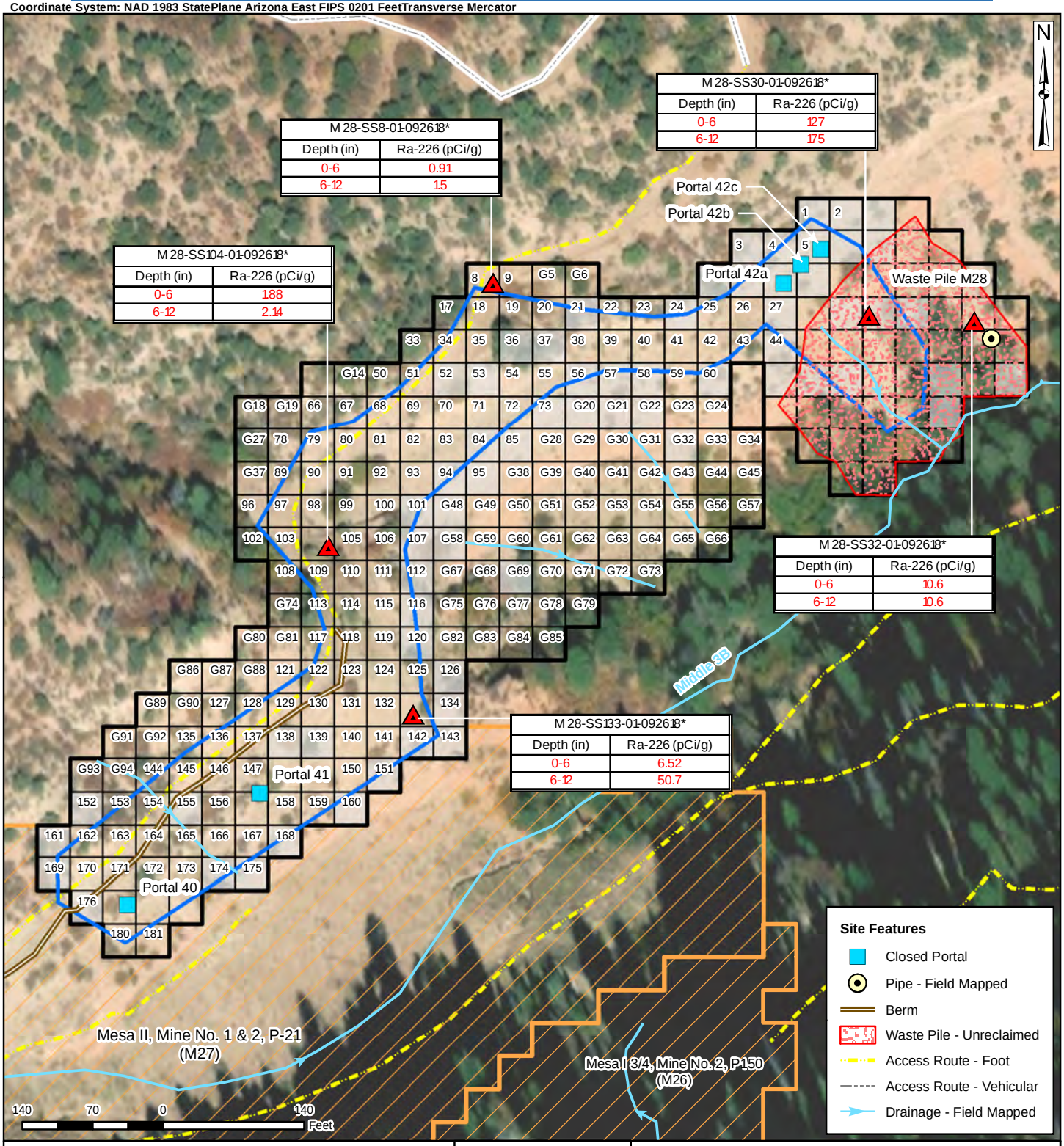
Prepared By:

TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	**Date:** 7/7/2019

Notes:
*Radium-226 concentration scale values for Mesa II, Mine No. 1, P-150 are based on an applied background threshold value (BTV) of 0.85 pCi/g derived from BSA-29 as presented in Appendix A. Avg. BG: Average value of the background data set.

Figure No.: **H28-39**



Subsurface Soil Samples

- Primary COPC In Exceedance of Background Threshold Value
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Other Survey Area
- Inaccessible To XRF Survey

*Red font indicates sample COPC concentration above BTV value of 0.85 pCi/g.

Prepared for: USEPA Region 9

Prepared By: TETRA TECH, 1999 Harrison Street, Suite 500, Oakland, CA 94612

MESA II, MINE NO. 1, P-150 SUBSURFACE SAMPLING RADIUM-226 RESULTS MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	H28-40
Location: COVE CHAPTER NAVAJO NATION	Date: 7/7/2019	

7.7 SELENIUM

Selenium was identified as a COPC in both the surface and subsurface soil environments as shown in Table H28-28. The applied BTV for selenium is 0.92 mg/kg for Mesa II, Mine No. 1, P-150 as presented in Section 3.0. The in situ XRF measurements do not detect selenium accurately and, therefore, these cannot be used to predict selenium in the surface soils.

The analytical results for selenium for all the different sample types (surface and subsurface) are provided in Attachment H28-1. Figure H28-41 presents an individual value plot of detectable selenium soil concentrations for the two different surface sample types. Figure H28-42 presents a box plot of detectable selenium soil concentrations. Summary statistics for all sample types are provided in Section 5.0.

The selenium concentrations within surface soils at Mesa II, Mine No. 1, P-150 ranged between 0.31 and 7.5 mg/kg with an average and standard deviation of 1.6 mg/kg and 2.0 mg/kg, respectively. The average selenium concentration observed in surface soils is above the applied BTV for selenium. A soil contaminant map showing the individual selenium concentrations observed at the site from the different surface sample types (that is, XRF confirmation samples and surface soil samples) is provided in Figure H28-43.

The measurements of selenium exceeded the applied BTV in the surface environment and were also found to be elevated above the applied BTV within the subsurface soil samples collected. Figure H28-44 provides a map showing the subsurface exceedances for selenium. The tables shown on Figure H28-44 provide the sample ID for the sample collected from 0 to 6 inches bgs at each boring location. The selenium concentrations measured in the subsurface soils at Mesa II, Mine No. 1, P-150 ranged between 0.90 and 7.2 mg/kg with an average and standard deviation of 2.3 mg/kg and 2.7 mg/kg, respectively. The average selenium concentration found in subsurface soils at Mesa II, Mine No. 1, P-150 is slightly above the applied BTV for selenium. The selenium concentrations exceeded the applied BTV for selenium in four of the five subsurface soil samples at borings, M28-SB8, M28-SB104, M28-SB133, and M28-SB30. Boring M28-SB30 is located in unreclaimed Waste Pile M28.

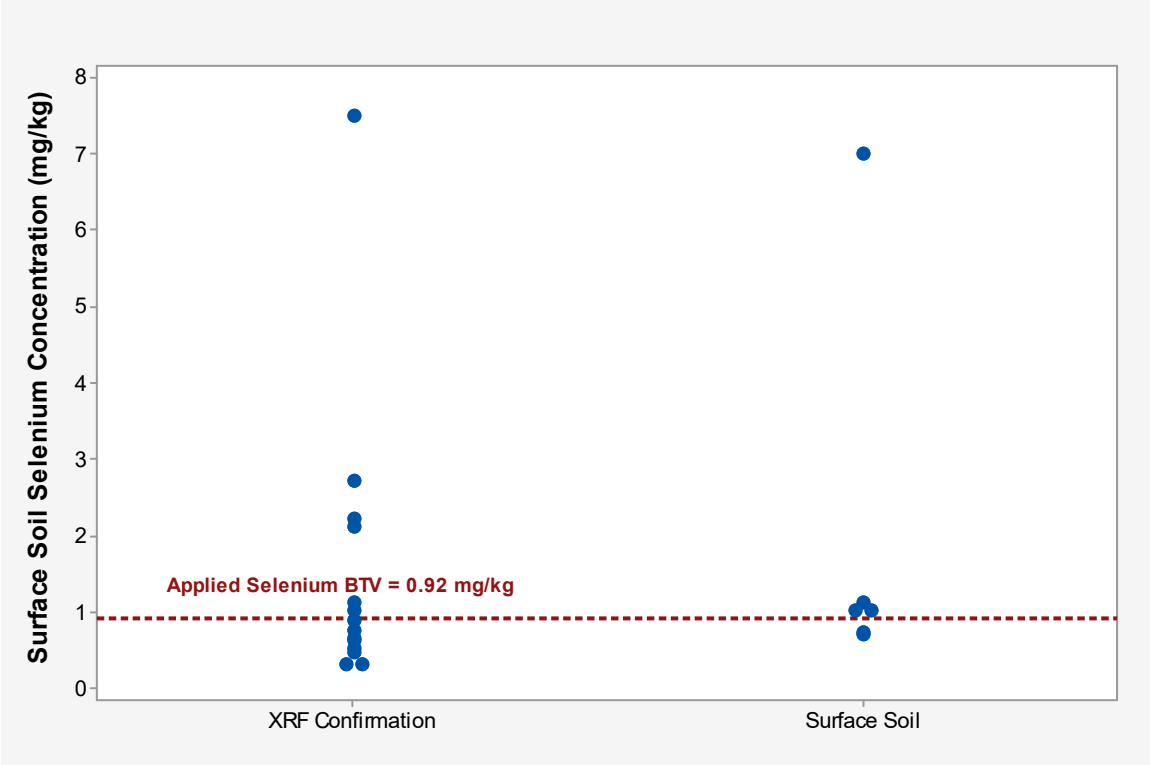


Figure H28-41. Individual Value Plot of Surface Soil Selenium Concentrations

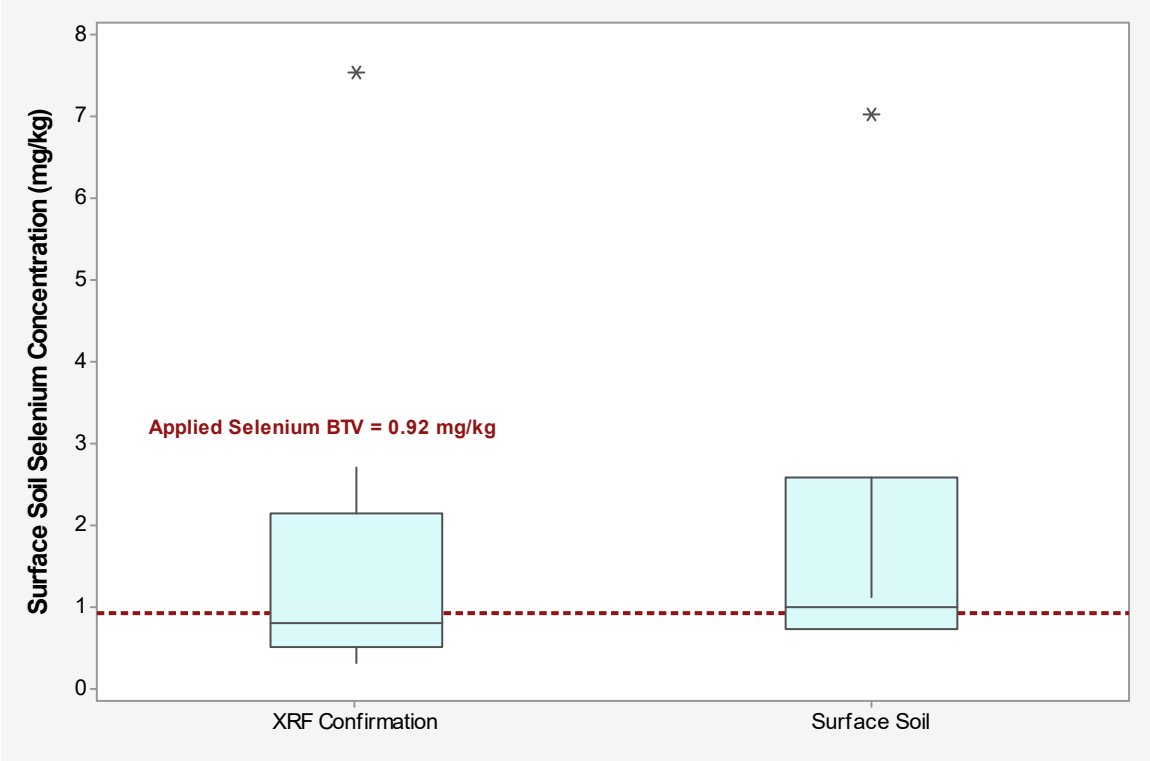
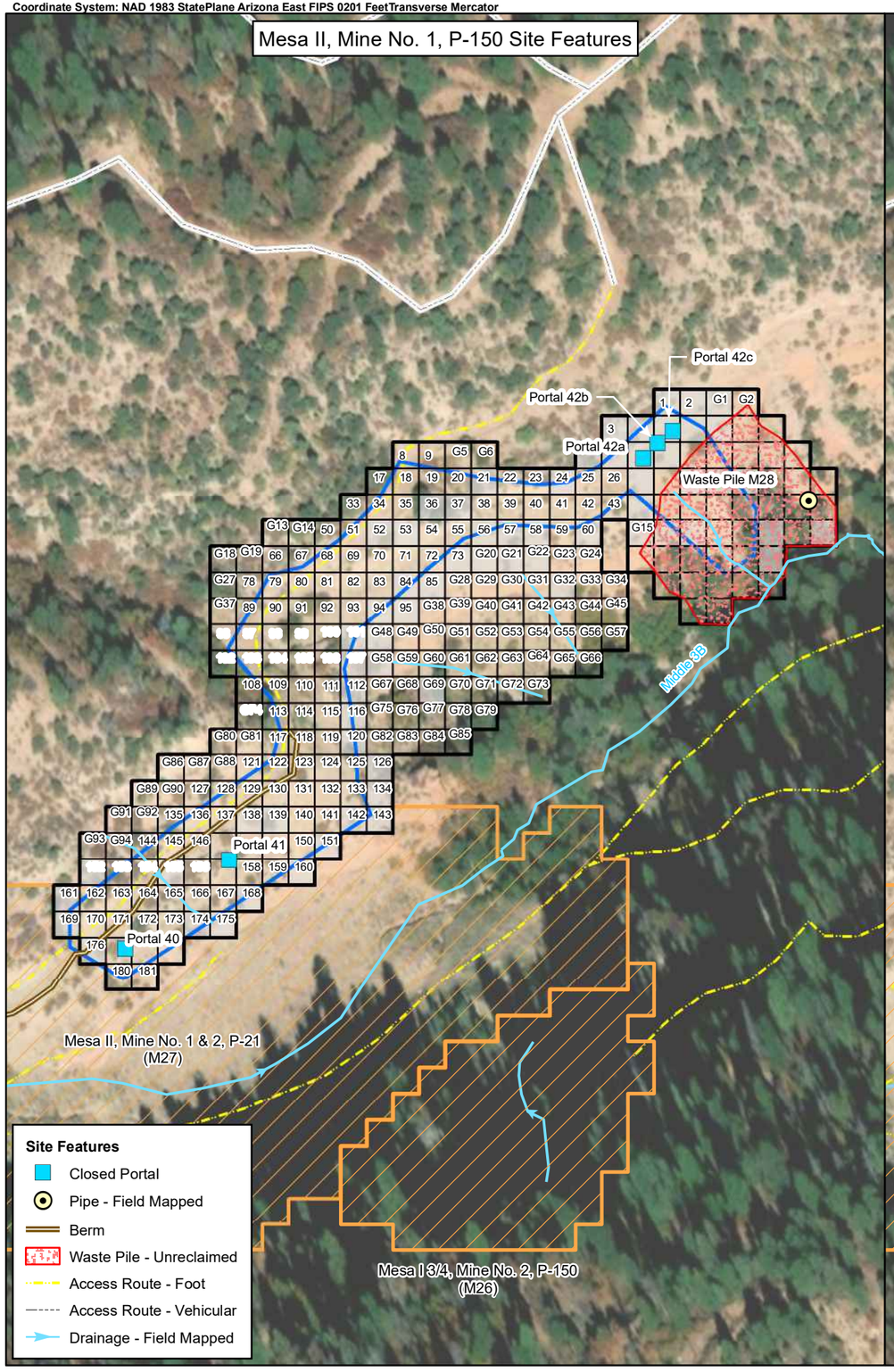


Figure H28-42. Box Plot of Surface Soil Selenium Concentrations

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

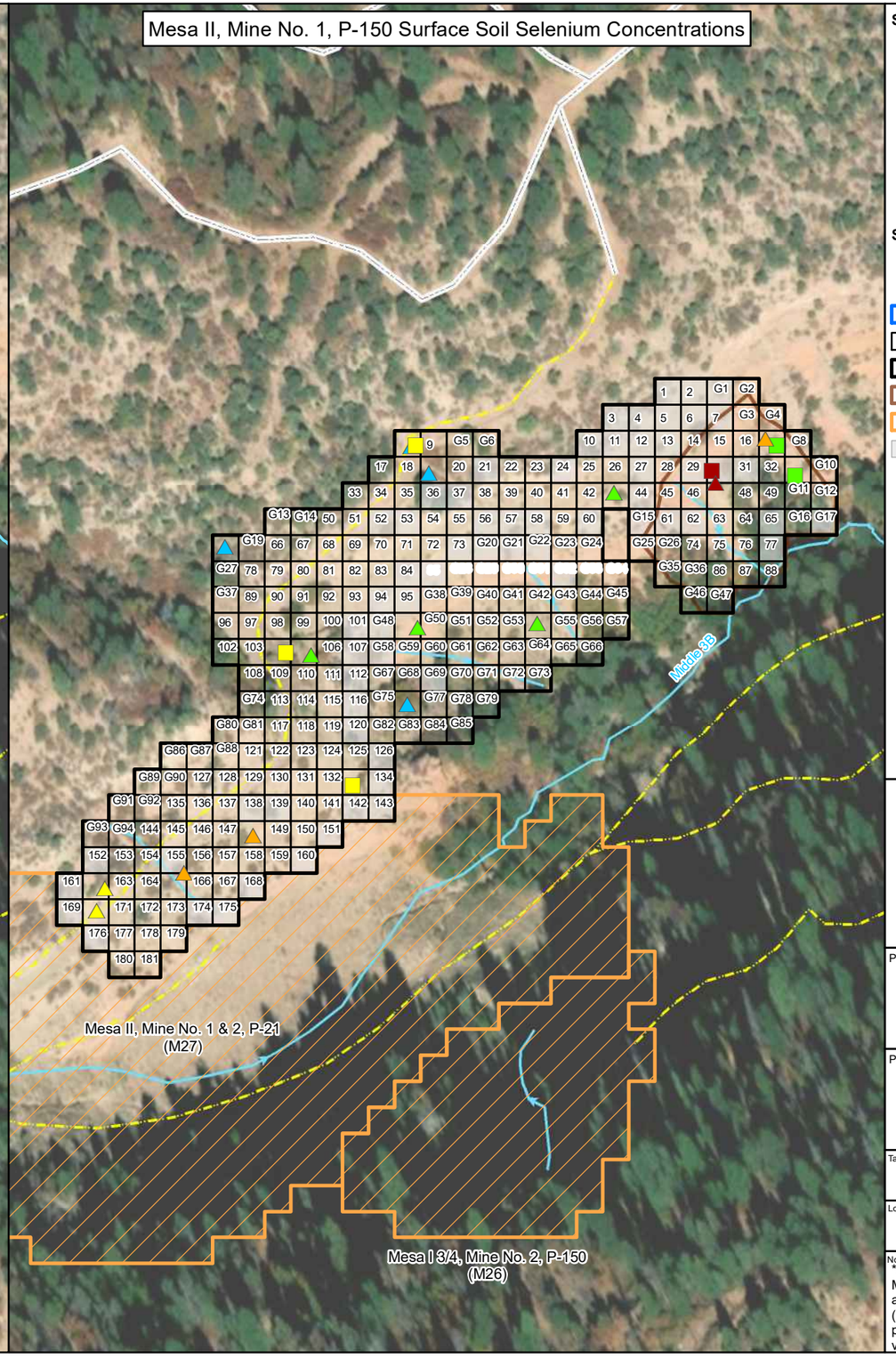
Mesa II, Mine No. 1, P-150 Site Features



Site Features

- Closed Portal
- Pipe - Field Mapped
- Berm
- Waste Pile - Unreclaimed
- Access Route - Foot
- Access Route - Vehicular
- Drainage - Field Mapped

Mesa II, Mine No. 1, P-150 Surface Soil Selenium Concentrations



Selenium Concentration Scale (mg/kg)*

≤ 0.54	≤ Avg. BG
0.54 - 0.92	Avg. BG - 1 x BTV
0.92 - 1.8	1 x BTV - 2 x BTV
1.8 - 2.8	2 x BTV - 3 x BTV
2.8 - 3.7	3 x BTV - 4 x BTV
3.7 - 9.2	4 x BTV - 10 x BTV
≥ 9.2	≥ 10 x BTV

Selenium Concentration Value Source

- XRF Confirmation Soil Sample
- Surface Soil Sample
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Waste Pile Boundary
- Other Survey Area
- Inaccessible To XRF Survey

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150
SURFACE SOIL
SELENIUM CONCENTRATION MAP

Prepared For:

Prepared By:

TETRA TECH
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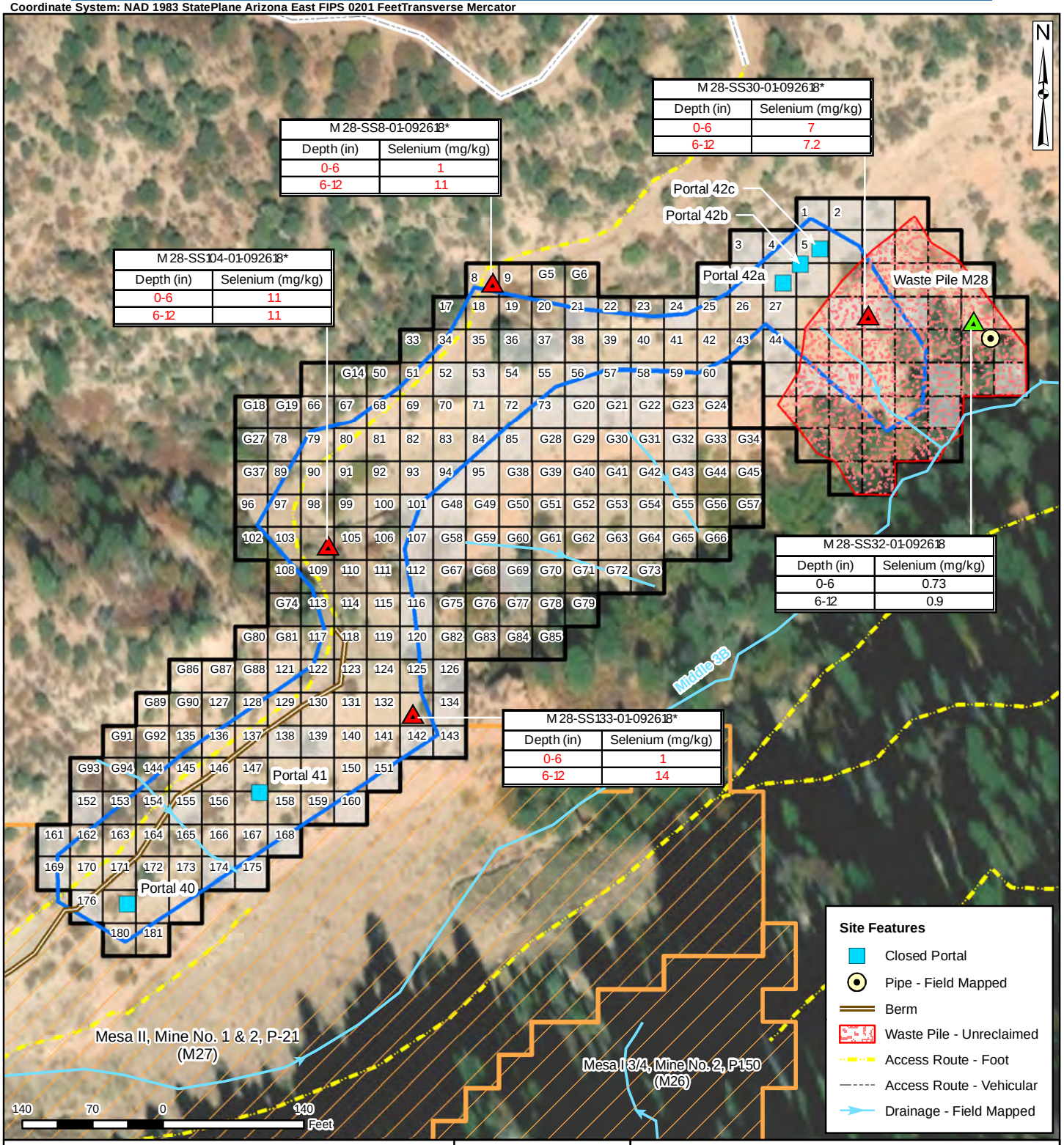
Oakland, CA 94612

Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	Date: 7/22/2019

Notes:
*Selenium concentration scale values for Mesa II, Mine No. 1, P-150 are based on an applied background threshold value (BTV) of 0.92 mg/kg derived from BSA-29 as presented in Appendix A. Avg. BG: Average value of the background data set.

Figure No.: **H28-43**

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



Subsurface Soil Samples

- Primary COPC Less Than Background Threshold Value
- Primary COPC In Exceedance of Background Threshold Value
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Other Survey Area
- Inaccessible To XRF Survey

*Red font indicates sample COPC concentration above BTV value of 0.92 mg/kg.

Prepared for: USEPA Region 9

Prepared By: TETRA TECH, 1999 Harrison Street, Suite 500, Oakland, CA 94612

MESA II, MINE NO. 1, P-150 SUBSURFACE SAMPLING SELENIUM RESULTS MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	H28-44
Location: COVE CHAPTER NAVAJO NATION	Date: 7/7/2019	

7.8 THORIUM

Thorium was identified as a COPC only in the surface soil environment. The applied BTV for thorium is 3.6 mg/kg for Mesa II Mine No. 1, P-150 as presented in Section 3.0. The analytical results for thorium for all the different scenarios (surface and subsurface) are provided in Attachment H28-1. Figure H28-45 presents an individual value plot of detectable thorium soil concentrations for the three different surface sample types. Figure H28-46 presents a box plot of detectable thorium soil concentrations for the three different sample types. Summary statistics for all sample types are provided in Section 5.0.

The thorium concentrations within surface soils at Mesa II Mine No. 1, P-150 ranged between 1.0 and 11 mg/kg with an average and standard deviation of 2.6 mg/kg and 1.3 mg/kg, respectively. The average thorium concentration observed in surface soils is below the applied BTV for thorium. A soil contaminant map showing the individual thorium concentrations observed at the site from the different surface sample types (that is, in situ XRF measurements, XRF confirmation samples, and surface soil samples) is provided in Figure H28-47.

The measurements of thorium exceeded the applied BTV in limited samples within the surface soil environment and in the subsurface soil environment. Figure H28-48 provides a map showing the subsurface results for thorium. The tables shown on Figure H28-48 provide the sample ID for the sample collected from 0 to 6 inches bgs at each boring location. The thorium concentrations within subsurface soils at Mesa II Mine No. 1, P-150 ranged between 1.3 and 4.0 mg/kg with an average and standard deviation of 2.4 mg/kg and 1.2 mg/kg, respectively. The average thorium concentration observed in subsurface soils is below the applied BTV for thorium. The thorium concentrations were below the applied BTV for thorium in four of the five subsurface soil samples. Thorium exceeded the applied BTV at boring M28-SB133, located away from Waste Pile M28.

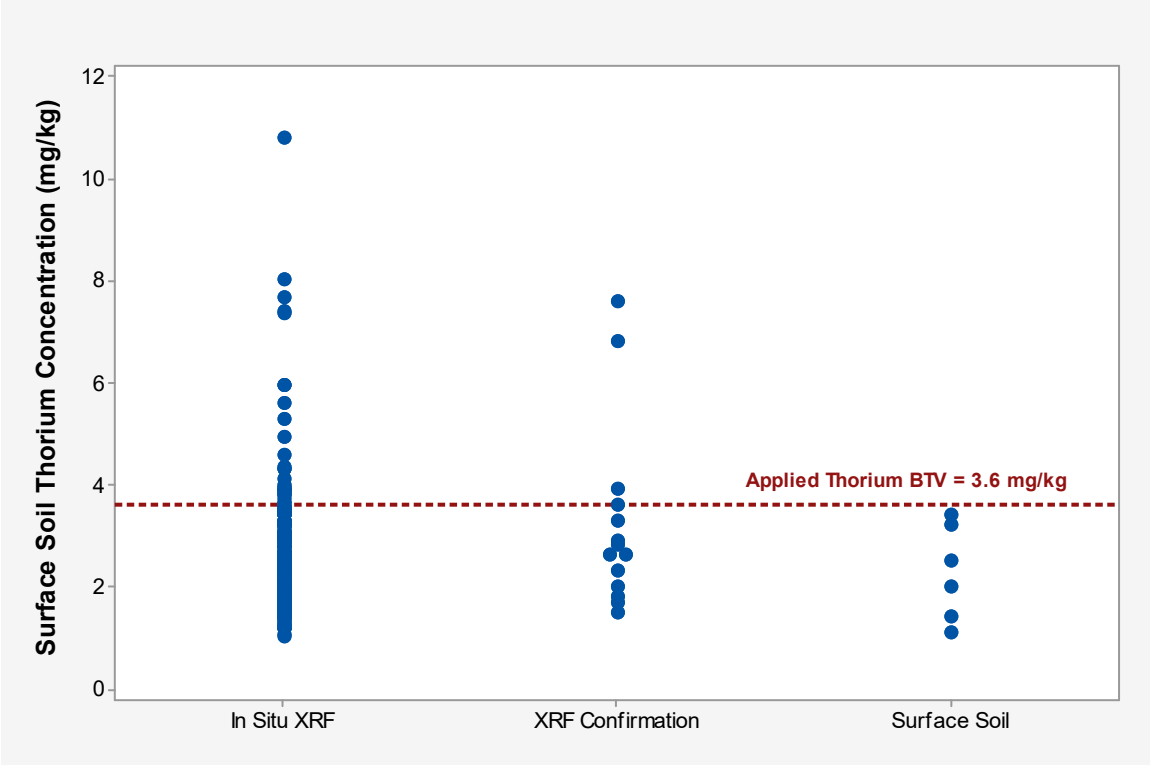


Figure H28-45. Individual Value Plot of Surface Soil Thorium Concentrations

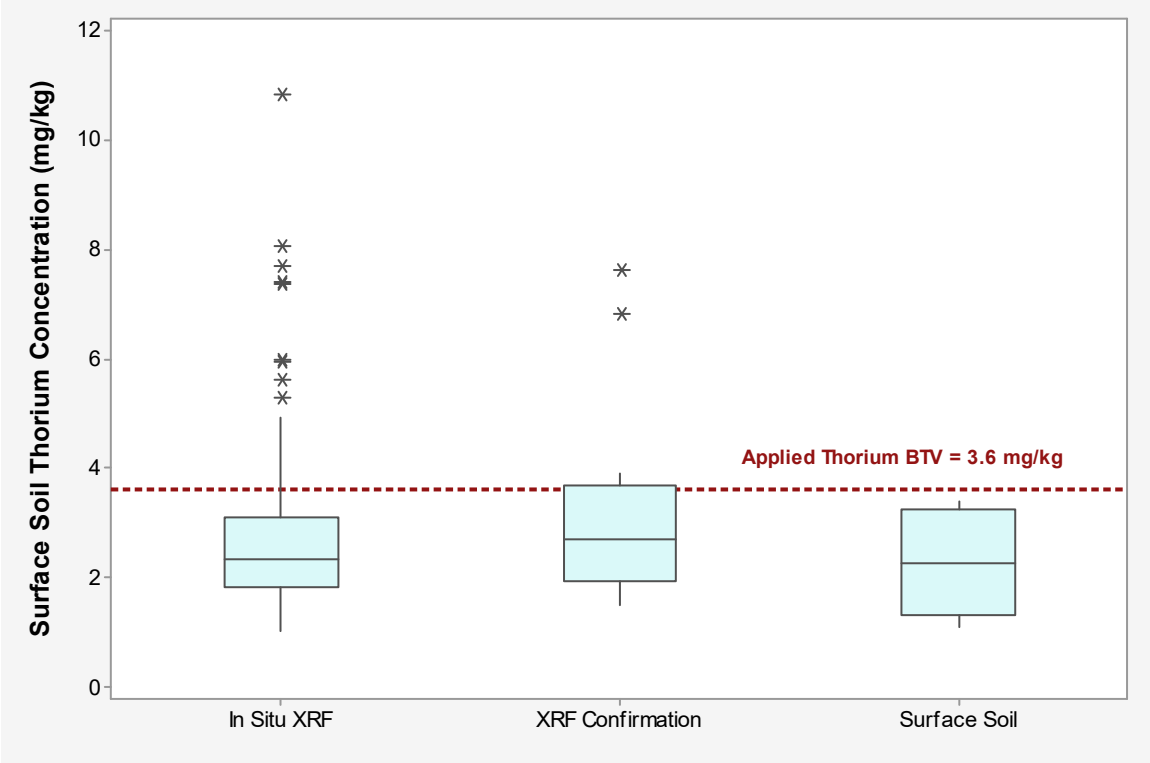
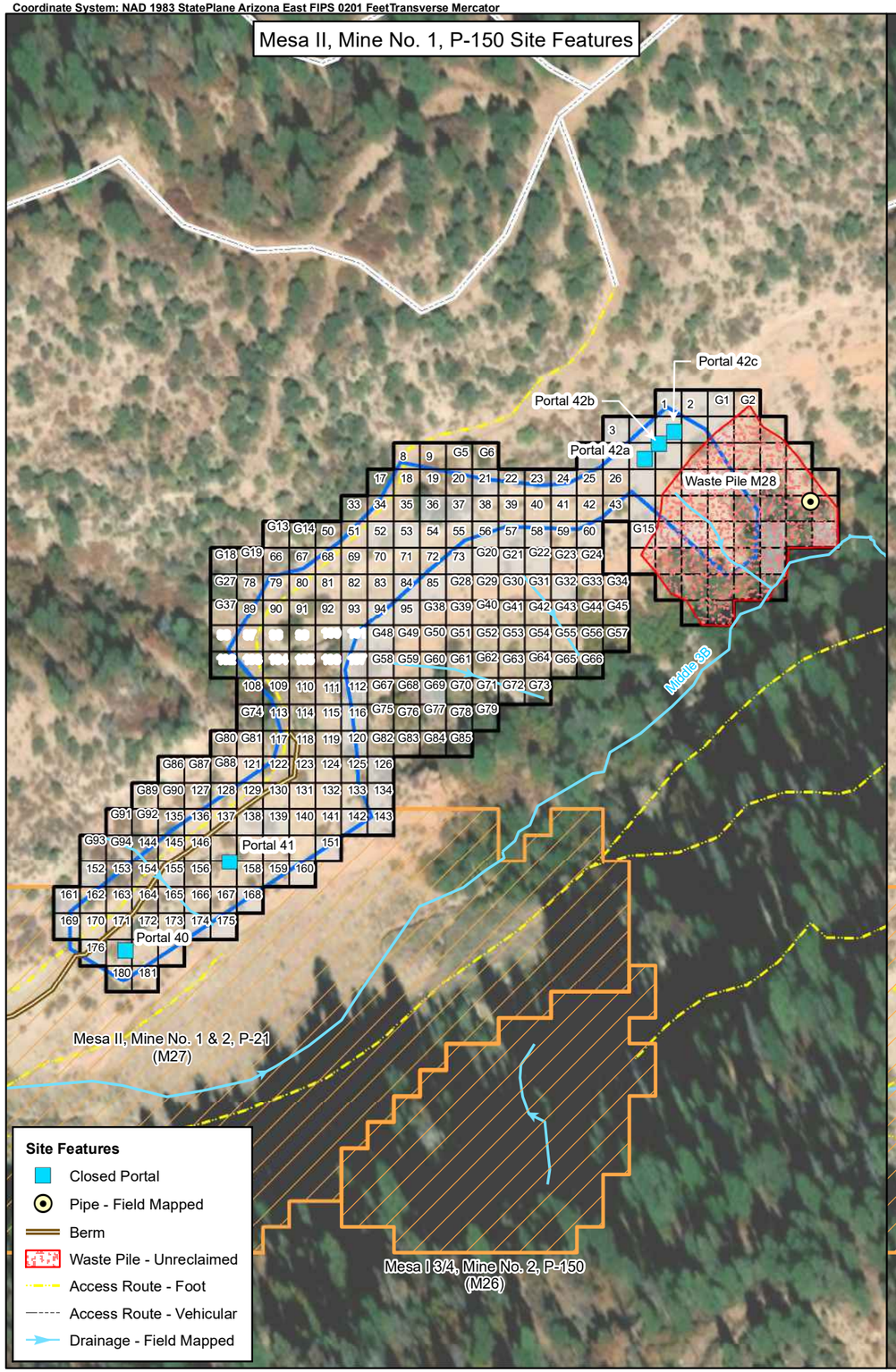


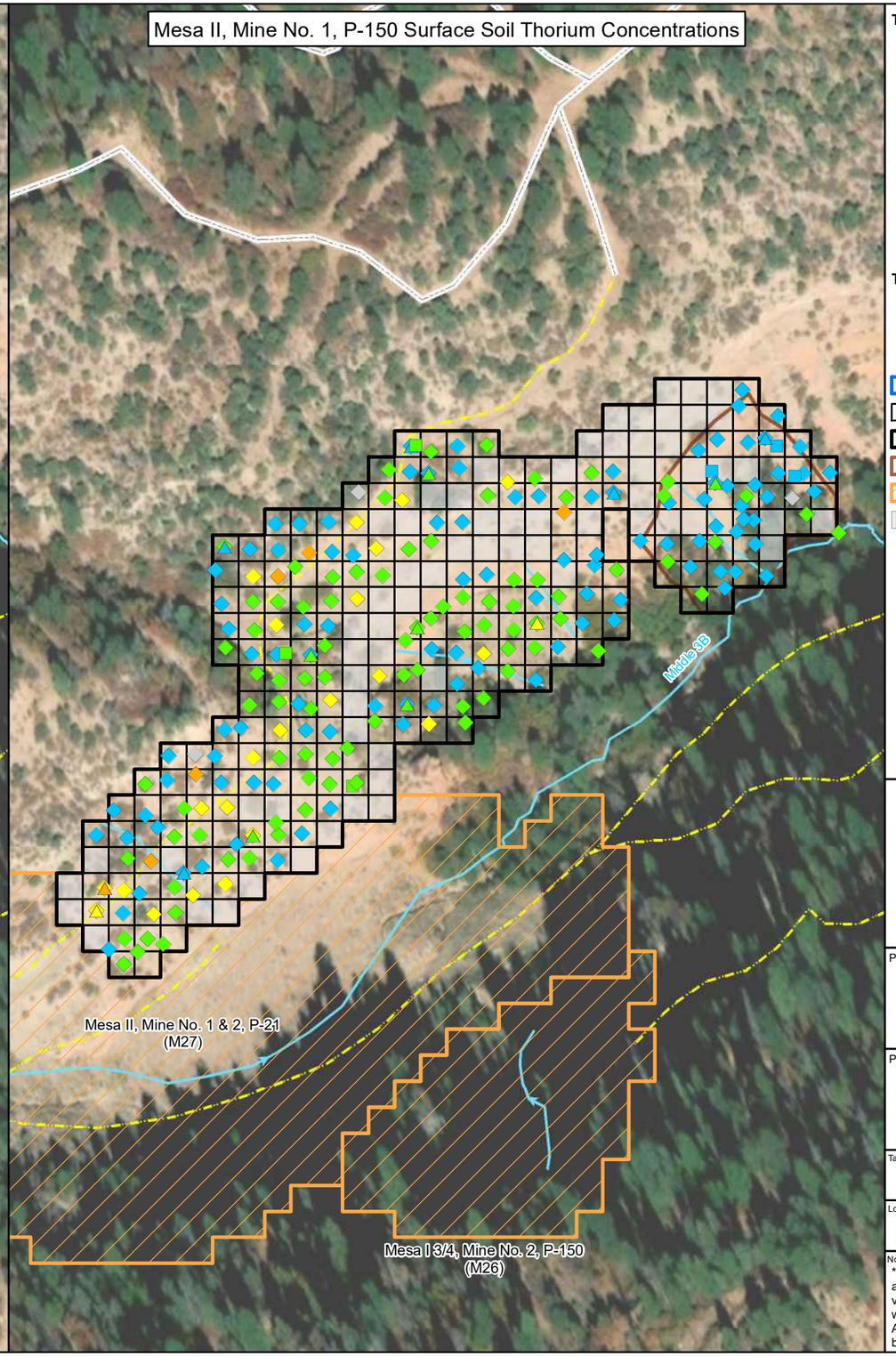
Figure H28-46. Box Plot of Surface Soil Thorium Concentrations

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

Mesa II, Mine No. 1, P-150 Site Features



Mesa II, Mine No. 1, P-150 Surface Soil Thorium Concentrations



Thorium Concentration Scale (mg/kg)*

≤ 2.3	≤ Avg. BG
2.3 - 3.6	Avg. BG - 1 x BTV
3.6 - 7.2	1 x BTV - 2 x BTV
7.2 - 11	2 x BTV - 3 x BTV
11 - 14	3 x BTV - 4 x BTV
14 - 36	4 x BTV - 10 x BTV
≥ 36	≥ 10 x BTV
Non-Detect (Less Than Limit of Detection)	

Thorium Concentration Value Source

- In Situ XRF Measurement
- XRF Confirmation Soil Sample
- Surface Soil Sample
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Waste Pile Boundary
- Other Survey Area
- Inaccessible To XRF Survey

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150 SURFACE SOIL THORIUM CONCENTRATION MAP

Prepared For:

Prepared By:

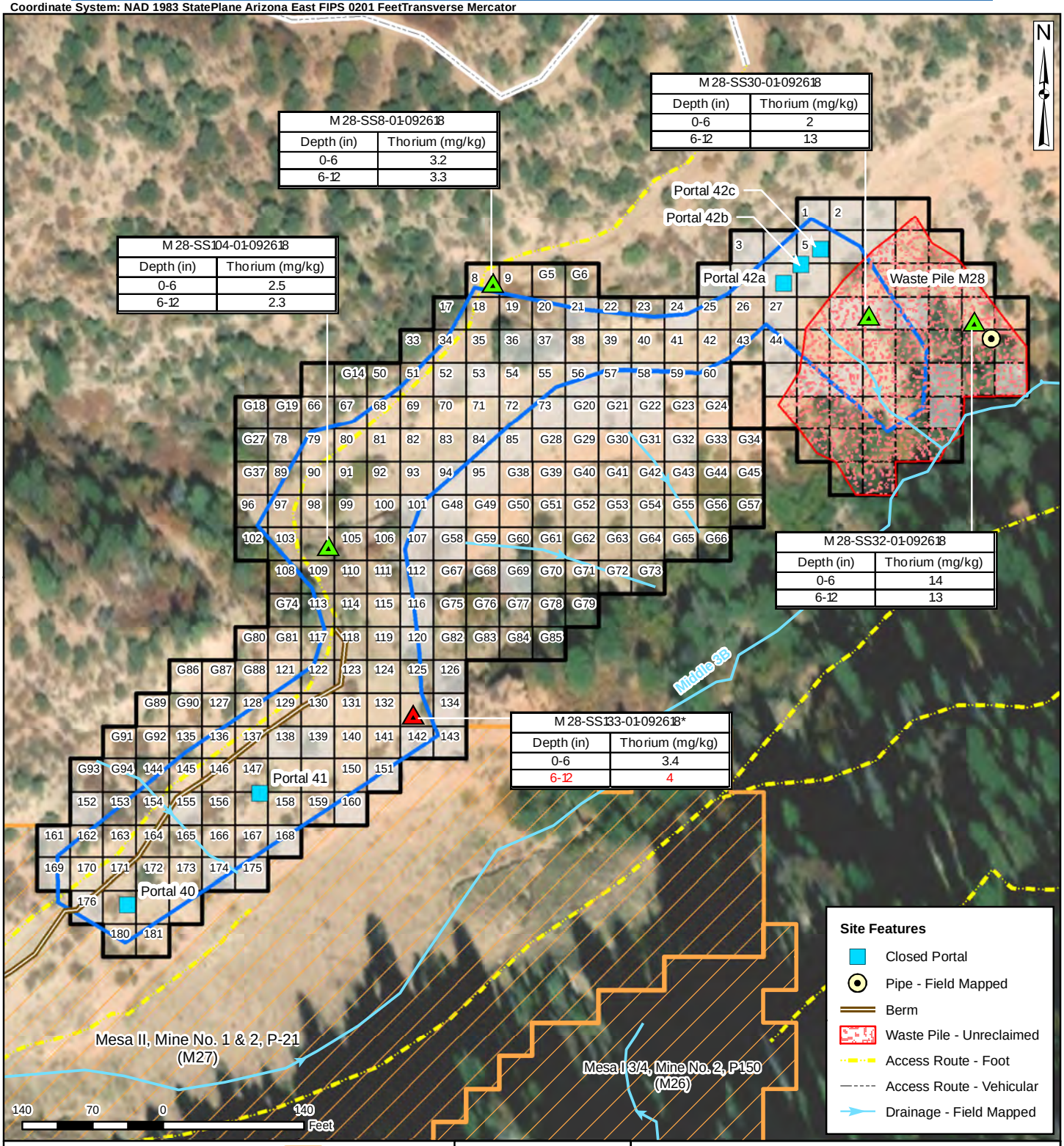
TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	Date: 7/22/2019

Notes:
*Thorium concentration scale values for Mesa II, are based on an applied background threshold value (BTV) of 3.6 mg/kg derived from BSAs within the Jse formation as presented in Appendix A. Avg. BG: Average value of the background data set.

Figure No.: **H28-47**

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



Subsurface Soil Samples

- Primary COPC Less Than Background Threshold Value
- Primary COPC In Exceedance of Background Threshold Value
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Other Survey Area
- Inaccessible To XRF Survey

*Red font indicates sample COPC concentration above BTV value of 3.6 mg/kg.

Prepared for: USEPA Region 9

Prepared By: TETRA TECH, 1999 Harrison Street, Suite 500, Oakland, CA 94612

MESA II, MINE NO. 1, P-150 SUBSURFACE SAMPLING THORIUM RESULTS MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	H28-48
Location: COVE CHAPTER NAVAJO NATION	Date: 7/7/2019	

7.9 URANIUM

Uranium was identified as a COPC in both the surface and subsurface soil environments as shown in Section 7.2. The applied BTV for uranium is 1.1 mg/kg for Mesa II, Mine No. 1, P-150 as presented in Section 3.0. The analytical results for uranium for all the different scenarios (surface and subsurface) are provided in Attachment H28-1. Figure H28-49 presents an individual value plot of detectable uranium soil concentrations for the three different surface sample types. Figure H28-50 presents a box plot of detectable uranium soil concentrations for the three different sample types. Summary statistics for all sample types are provided in Section 5.0.

The uranium concentrations within surface soils at Mesa II, Mine No. 1, P-150 ranged between 0.19 and 660 mg/kg with an average and standard deviation of 28 mg/kg and 77 mg/kg, respectively. The average uranium concentration observed in surface soils is significantly above the applied BTV for uranium. A soil contaminant map showing the individual uranium concentrations observed at the site from the different surface sample types (that is, in situ XRF measurements, XRF confirmation samples, and surface soil samples) is provided in Figure H28-51.

The measurements of uranium exceeded the applied BTV in the surface soil environment and were also found to be elevated above the applied BTV within the subsurface soil environment. Figure H28-52 provides a map showing the subsurface exceedances for uranium. The tables shown on Figure H28-52 provide the sample ID for the sample collected from 0 to 6 inches bgs at each boring location. The uranium concentrations within subsurface soils at Mesa II, Mine No. 1, P-150 ranged between 1.3 and 400 mg/kg with an average and standard deviation of 89 mg/kg and 174 mg/kg, respectively. Uranium was found to exceed the BTV in all five subsurface soil samples at Mesa II, Mine No. 1, P-150. The measurements of uranium that exceeded the applied BTV corresponded with elevated gamma measurements at the site.

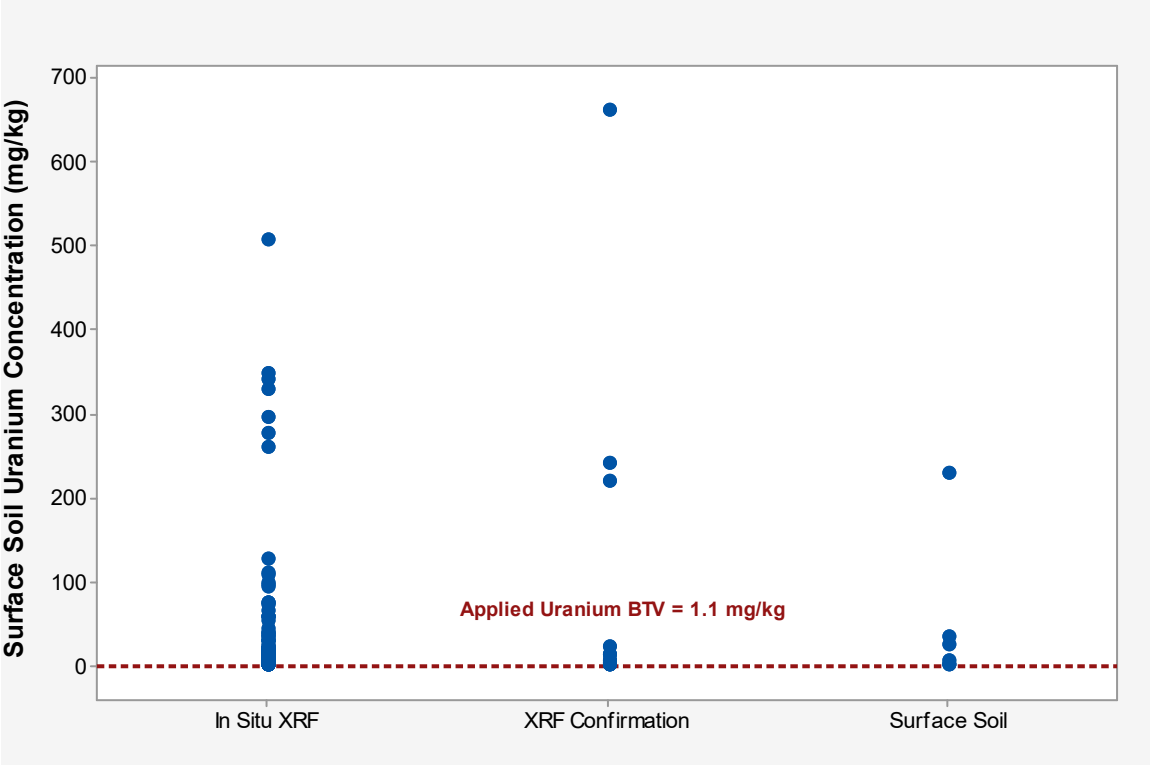


Figure H28-49. Individual Value Plot of Surface Soil Uranium Concentrations

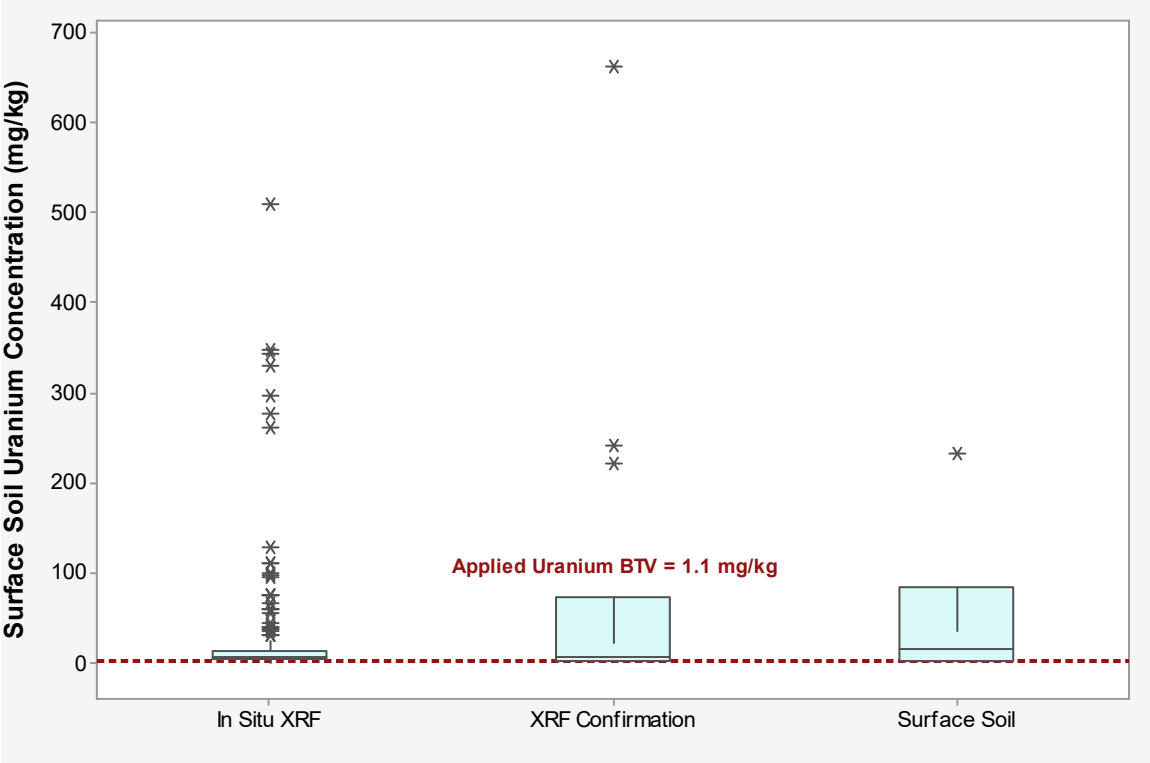
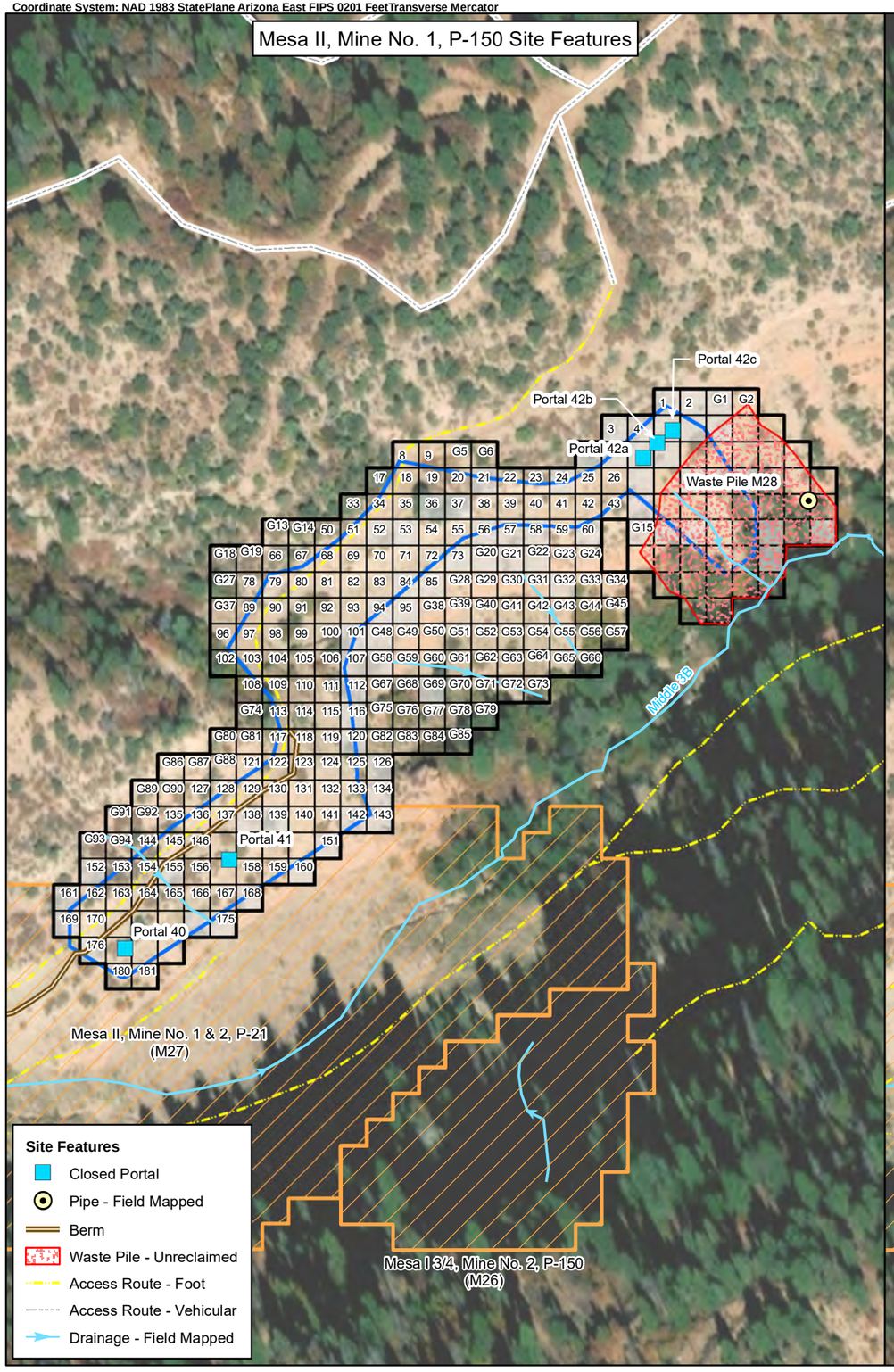


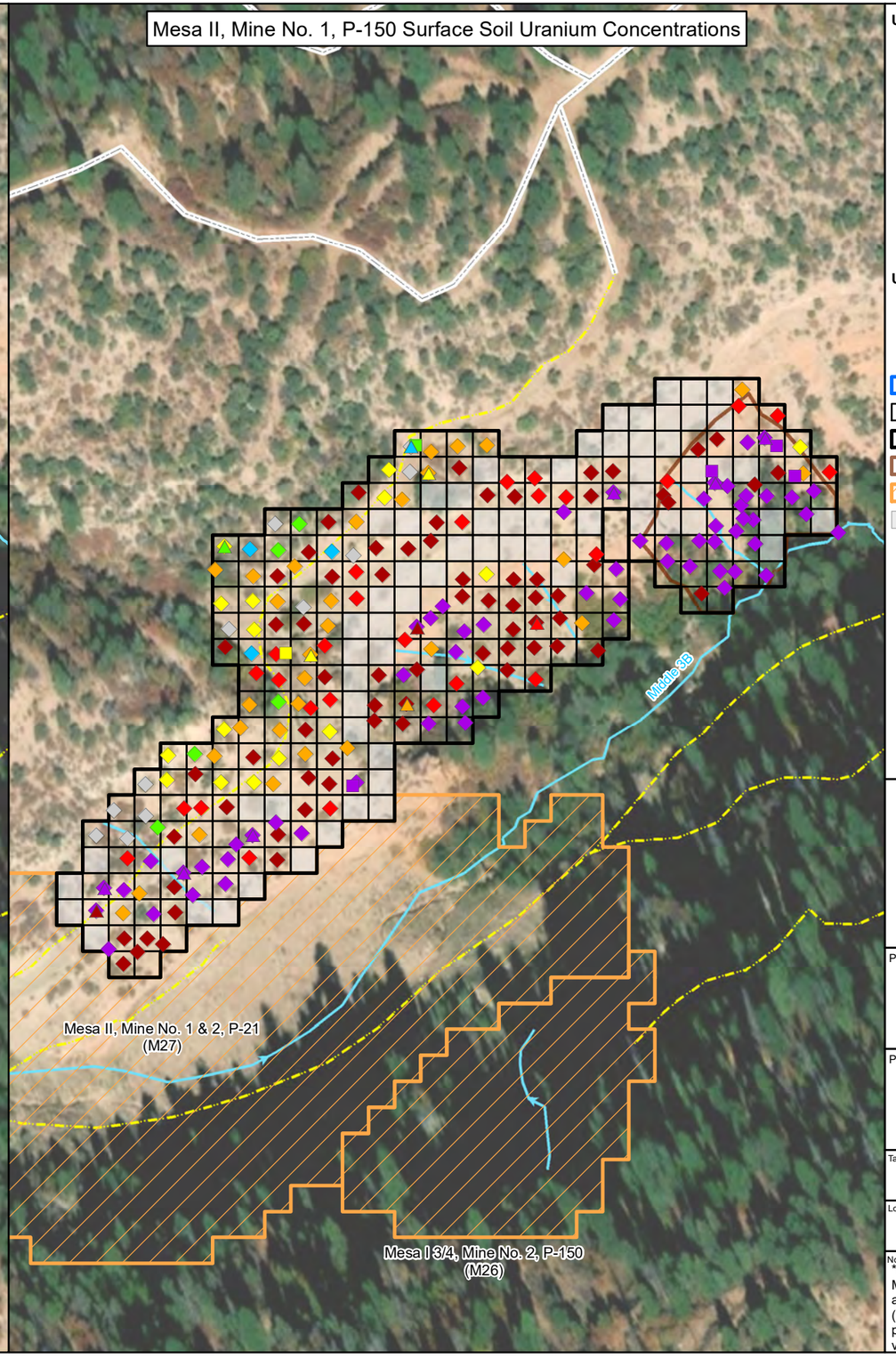
Figure H28-50. Box Plot of Surface Soil Uranium Concentrations

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

Mesa II, Mine No. 1, P-150 Site Features



Mesa II, Mine No. 1, P-150 Surface Soil Uranium Concentrations



Uranium Concentration Scale (mg/kg)*

≤ 0.34	≤ Avg. BG
0.34 - 1.1	Avg. BG - 1 x BTV
1.1 - 2.2	1 x BTV - 2 x BTV
2.2 - 3.3	2 x BTV - 3 x BTV
3.3 - 4.4	3 x BTV - 4 x BTV
4.4 - 11	4 x BTV - 10 x BTV
≥ 11	≥ 10 x BTV
Non-Detect (Less Than Limit of Detection)	

Uranium Concentration Value Source

- In Situ XRF Measurement
- XRF Confirmation Soil Sample
- Surface Soil Sample
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Waste Pile Boundary
- Other Survey Area
- Inaccessible To XRF Survey

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150 SURFACE SOIL URANIUM CONCENTRATION MAP

Prepared For:

Prepared By:

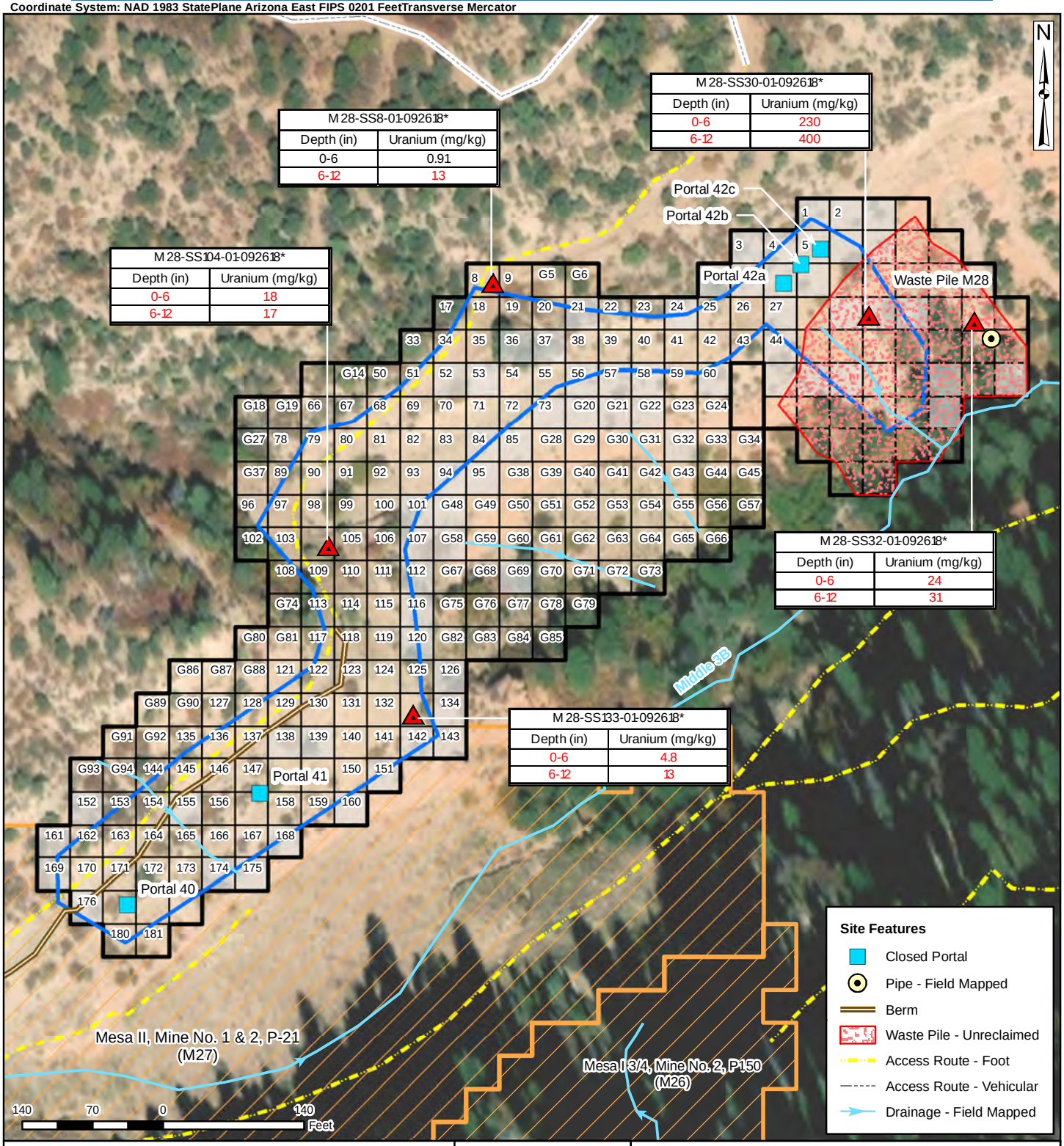
TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	**Date:** 7/7/2019

Notes:
*Uranium concentration scale values for Mesa II, Mine No. 1, P-150 are based on an applied background threshold value (BTV) of 1.1 mg/kg derived from BSA-29 as presented in Appendix A. Avg. BG: Average value of the background data set.

Figure No.: **H28-51**

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



Subsurface Soil Samples

- Primary COPC In Exceedance of Background Threshold Value
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Other Survey Area
- Inaccessible To XRF Survey

*Red font indicates sample COPC concentration above BTV value of 1.1 mg/kg.

Prepared for: USEPA Region 9

Prepared By: TETRA TECH, 1999 Harrison Street, Suite 500, Oakland, CA 94612

MESA II, MINE NO. 1, P-150 SUBSURFACE SAMPLING URANIUM RESULTS MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	H28-52
Location: COVE CHAPTER NAVAJO NATION	Date: 7/7/2019	

7.10 VANADIUM

Vanadium was identified as a COPC in both the surface and subsurface soil environments as shown in Section 7.2. The applied BTV for vanadium is 12 mg/kg for Mesa II, Mine No. 1, P-150 as presented in Section 3.0. The analytical results for vanadium for all the different scenarios (surface and subsurface) are provided in Attachment H28-1. Figure H28-53 presents an individual value plot of detectable vanadium soil concentrations for the three different surface sample types. Figure H28-54 presents a box plot of detectable vanadium soil concentrations for the three different sample types. Summary statistics for all sample types are provided in Section 5.0.

The vanadium concentrations within surface soils at Mesa II, Mine No. 1, P-150 ranged between 5.1 and 1,000 mg/kg with an average and standard deviation of 74 mg/kg and 144 mg/kg, respectively. The average vanadium concentration observed in surface soils is above the applied BTV for vanadium. A soil contaminant map showing the individual vanadium concentrations observed at the site from the different surface sample types (that is, in situ XRF measurements, XRF confirmation samples, and surface soil samples) is provided in Figure H28-55.

The measurements of vanadium exceeded the applied BTV in the surface soil environment and were also found to be elevated above the applied BTV within the subsurface soil environment. Figure H28-56 provides a map showing the subsurface exceedances for vanadium. The tables shown on Figure H28-56 provide the sample ID for the sample collected from 0 to 6 inches bgs at each boring location. The vanadium concentrations within subsurface soils at Mesa II, Mine No. 1, P-150 ranged between 9.3 and 820 mg/kg with an average and standard deviation of 190 mg/kg and 354 mg/kg, respectively. The average vanadium concentration observed in subsurface soils is substantially greater than the applied BTV. Vanadium exceeded the applied BTV in three of the five subsurface soil samples. Two exceedances at borings M28-SB30 and M28-32 were in unreclaimed Waste Pile M28.

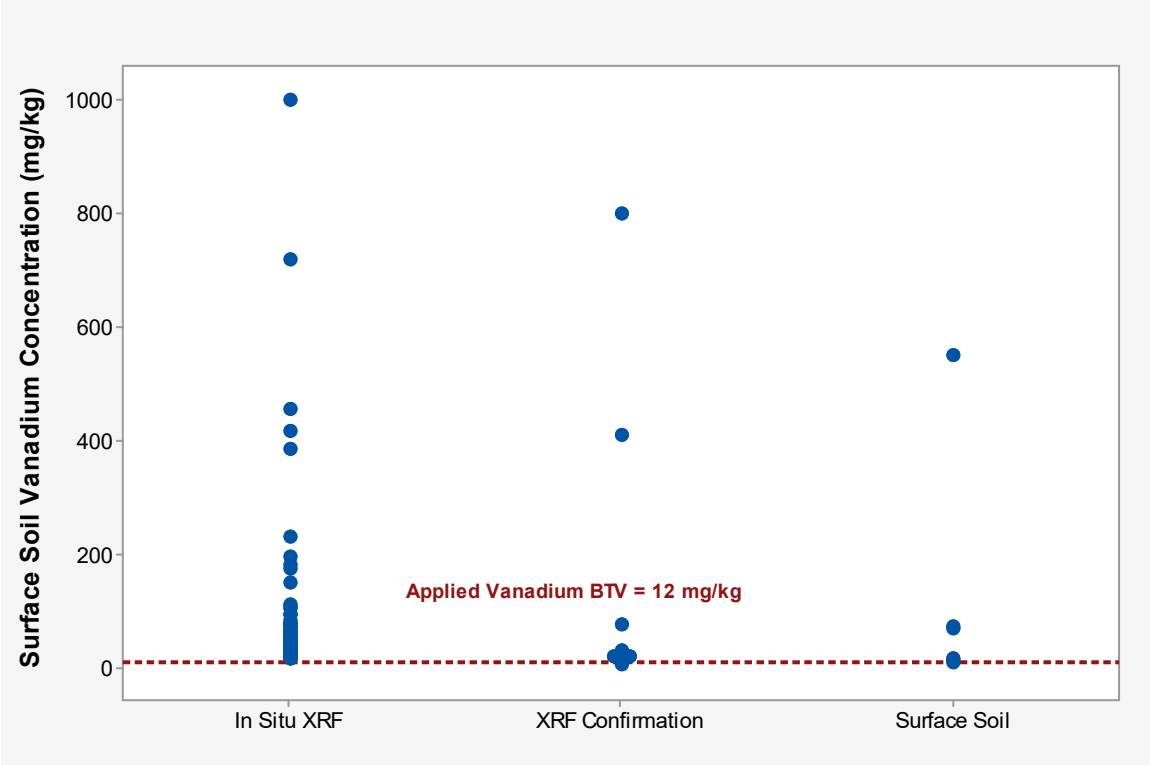


Figure H28-53. Individual Value Plot of Surface Soil Vanadium Concentrations

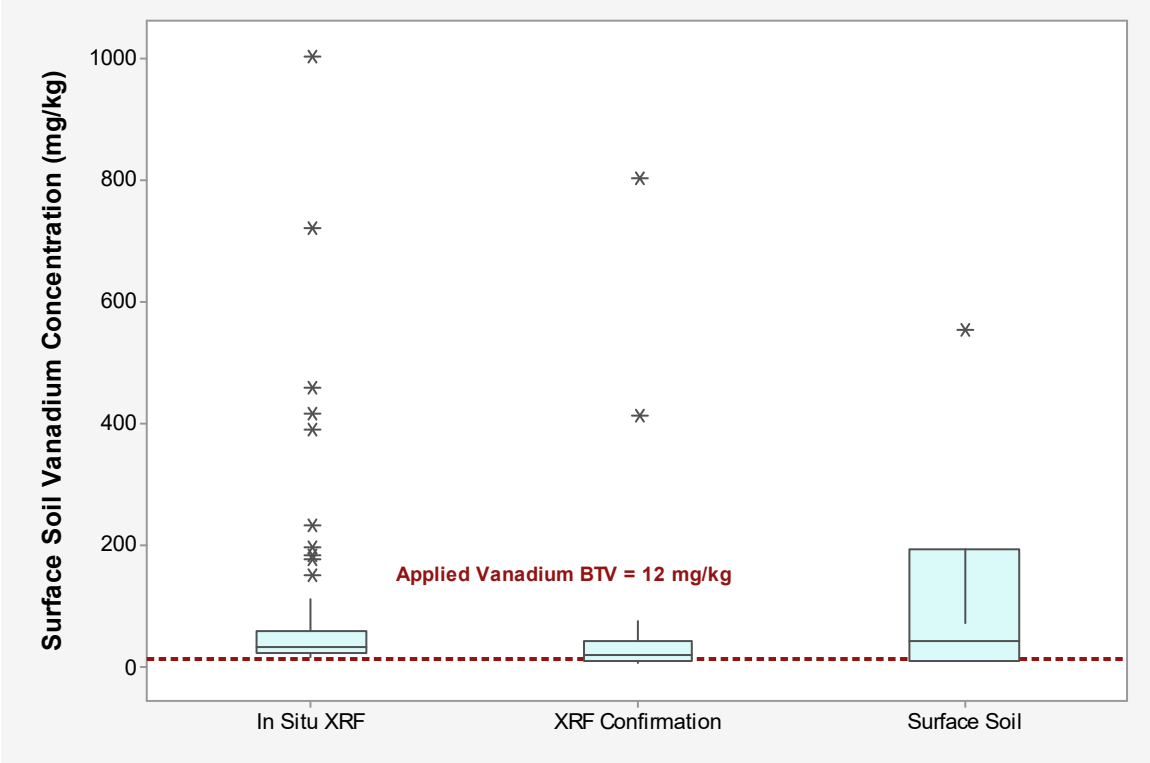
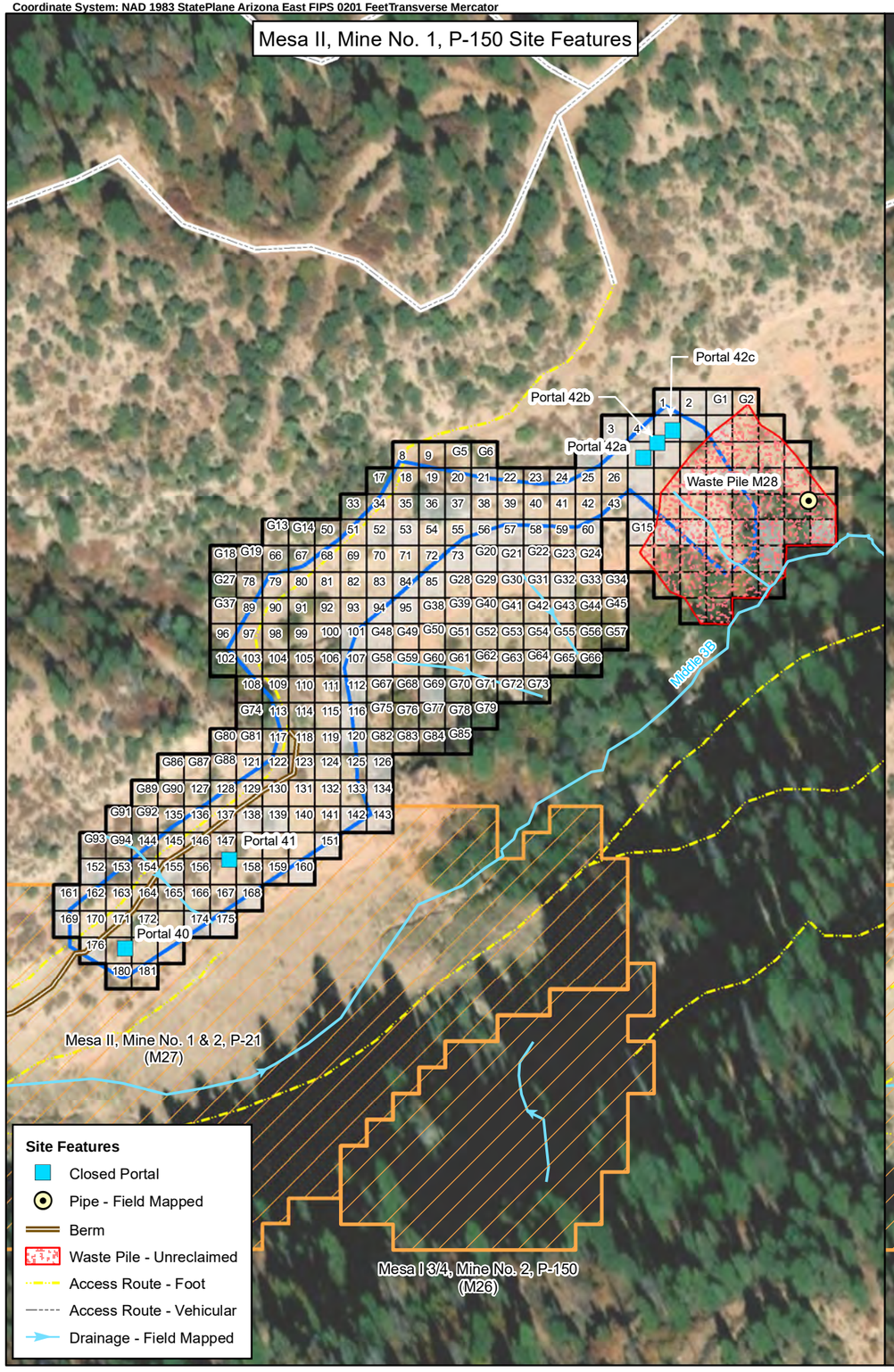


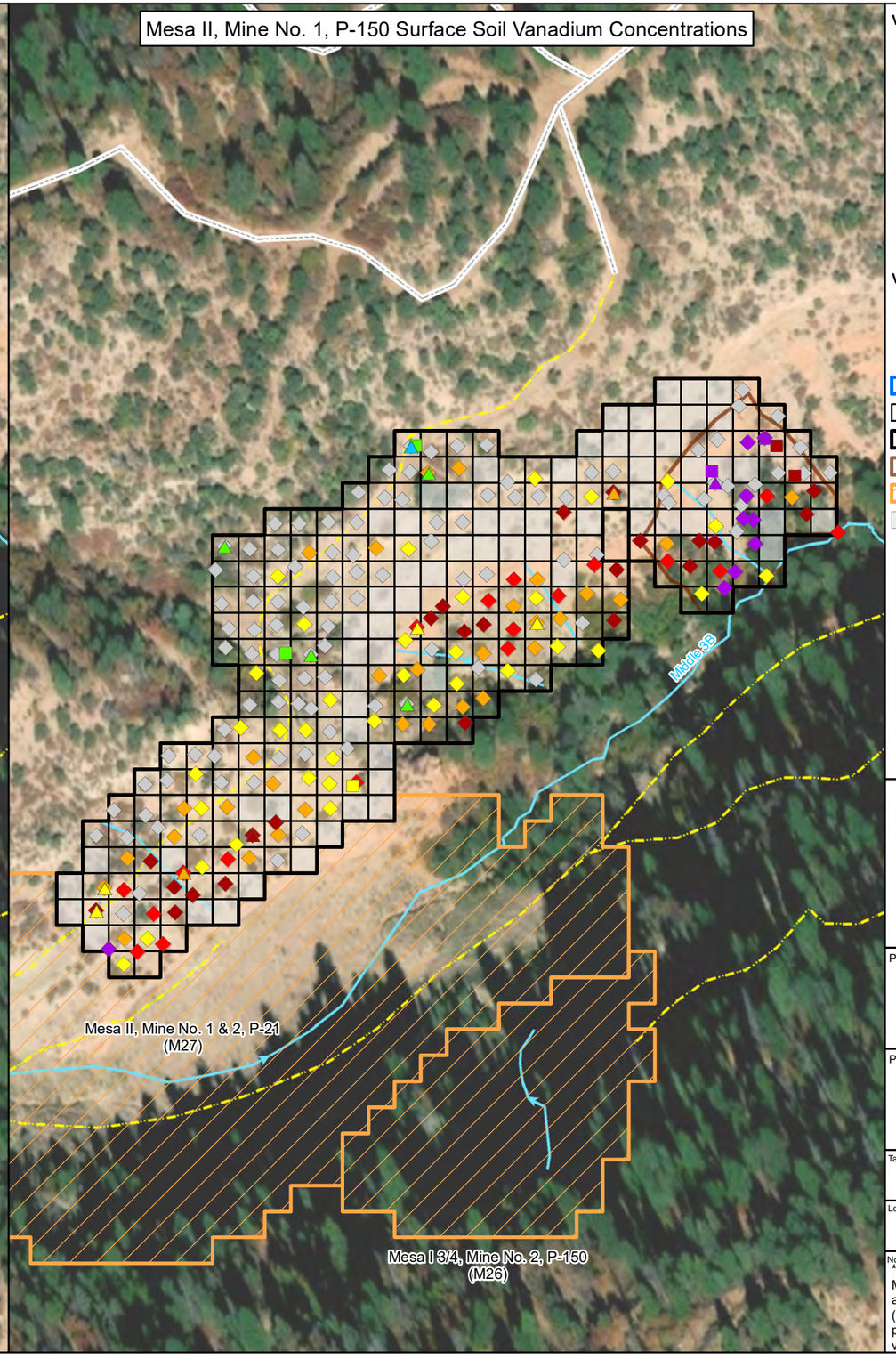
Figure H28-54. Box Plot of Surface Soil Vanadium Concentrations

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

Mesa II, Mine No. 1, P-150 Site Features



Mesa II, Mine No. 1, P-150 Surface Soil Vanadium Concentrations



Vanadium Concentration Scale (mg/kg)*

≤ 7.0	≤ Avg. BG
7.0 - 12	Avg. BG - 1 x BTV
12 - 24	1 x BTV - 2 x BTV
24 - 36	2 x BTV - 3 x BTV
36 - 48	3 x BTV - 4 x BTV
48 - 120	4 x BTV - 10 x BTV
≥ 120	≥ 10 x BTV
Non-Detect (Less Than Limit of Detection)	

Vanadium Concentration Value Source

- In Situ XRF Measurement
- XRF Confirmation Soil Sample
- Surface Soil Sample
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Waste Pile Boundary
- Other Survey Area
- Inaccessible To XRF Survey

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150 SURFACE SOIL VANADIUM CONCENTRATION MAP

Prepared For:

Prepared By:

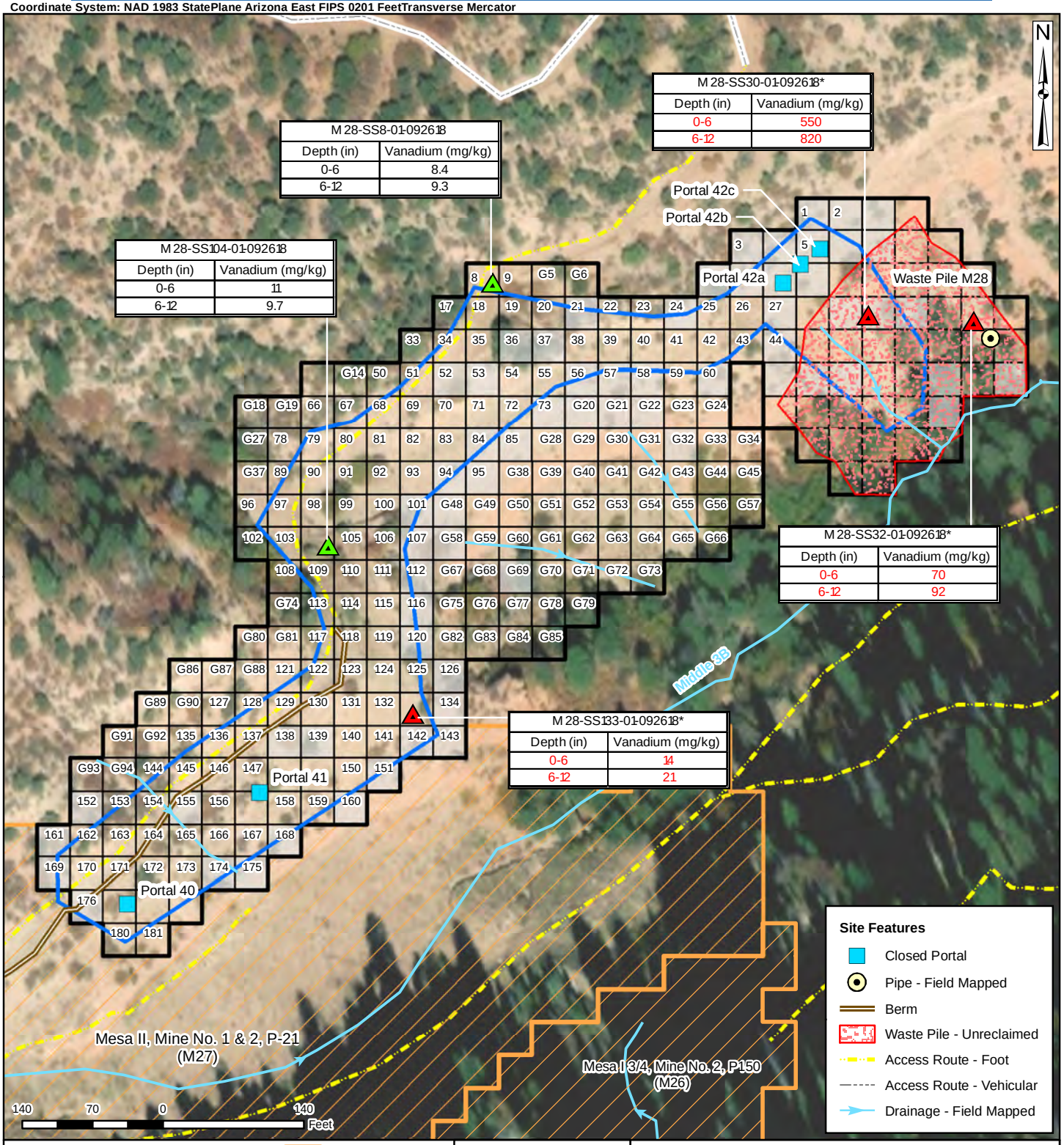
TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	Date: 7/7/2019

Notes:
*Vanadium concentration scale values for Mesa II, Mine No. 1, P-150 are based on an applied background threshold value (BTV) of 12 mg/kg derived from BSA-29 as presented in Appendix A. Avg. BG: Average value of the background data set.

Figure No.: **H28-55**

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



Subsurface Soil Samples

- Primary COPC Less Than Background Threshold Value
- Primary COPC In Exceedance of Background Threshold Value
- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Other Survey Area
- Inaccessible To XRF Survey

*Red font indicates sample COPC concentration above BTV value of 12 mg/kg.

Prepared for: USEPA Region 9

Prepared By: TETRA TECH, 1999 Harrison Street, Suite 500, Oakland, CA 94612

MESA II, MINE NO. 1, P-150 SUBSURFACE SAMPLING VANADIUM RESULTS MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	H28-56
Location: COVE CHAPTER NAVAJO NATION	Date: 7/7/2019	

8.0 LATERAL AND VERTICAL EXTENT OF WASTE

This section presents the mine waste volume estimation and discusses surface water and groundwater migration pathways.

8.1 VOLUME OF MINE WASTE

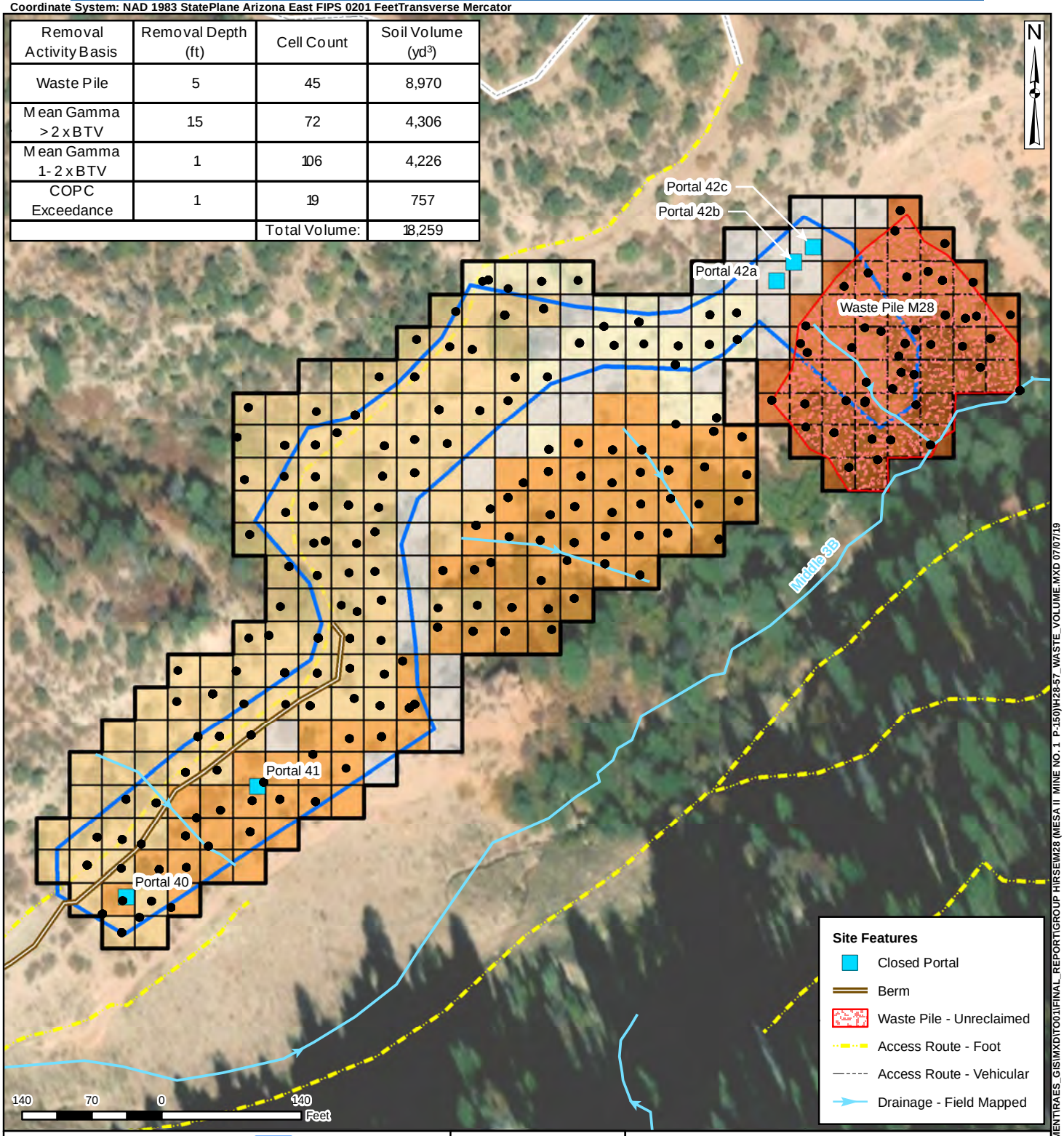
The volume of mine waste remaining at Mesa II, Mine No. 1, P-150 was estimated using multiple lines of evidence, including site mapping, subsurface soil sampling, and historical records. The volume of material was estimated for soils exceeding background conditions for primary analytes. The approach assumed that the removal action would address the waste pile and any survey units containing exceedances that were outside of the waste pile. The following assumptions were made:

- A depth of 5 feet was applied to the survey units intersecting Waste Pile M28. This depth was based on the observed depths from waste pile mapping. The total removal volume for Waste Pile M28 is 8,970 yd^3.
- A depth of 1 foot was applied to survey units outside of the waste pile that contained an average gamma radiation level between one to two times the applied gamma BTV. This depth was based on the subsurface soil sampling results. The total removal volume for these survey units is 4,226 yd^3.
- A depth of 1.5 feet was applied to survey units outside of the waste pile or burial cell with an average gamma radiation level exceeding two times the applied BTV. This depth was based on subsurface sampling results and refusal at bedrock because of the shallow nature of soil at the site. The total removal volume for these survey units is 4,306 yd^3.
- A depth of 1 foot was applied to all survey units that did not meet any of the criteria above and contained a minimum of one individual surface measurement (XRF or soil) above the applied BTV for any of the primary analytes, except for molybdenum because of the potential variability at such a low concentration. The total removal volume for these survey units is 757 yd^3.

Using this approach, the total mine waste volume at Mesa II, Mine No. 1, P-150 is 18,259 yd^3. Figure H28-57 presents a detailed breakdown of the removal action criteria for the site and a table with the different excavation depths for each criterion. Weston (2010) made an estimate of remaining mine waste at Mesa II, Mine No. 1, P-150 to be 463 yd^3. The RSE investigation removal volume estimate is conservative because it assumes a uniform excavation of the entire affected survey unit rather than a more precise potential underestimate of where lateral extent may extend within a survey unit.

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

Removal Activity Basis	Removal Depth (ft)	Cell Count	Soil Volume (yd^3)
Waste Pile	5	45	8,970
Mean Gamma > 2 x BTV	1.5	72	4,306
Mean Gamma 1- 2 x BTV	1	106	4,226
COPC Exceedance	1	19	757
		Total Volume:	18,259



COPC Exceedance

Removal Activity Basis

- Waste Pile (Removal depth = 5 feet)
- Mean Gamma > 2 x BTV (Removal depth = 1.5 feet)
- Mean Gamma 1-2 x BTV (Removal depth = 1 foot)
- COPC Exceedance (Removal depth = 1 foot)

- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Inaccessible

Prepared for: USEPA Region 9

Prepared By: TETRA TECH, 1999 Harrison Street, Suite 500, Oakland, CA 94612

MESA II, MINE NO. 1, P-150
WASTE VOLUME ESTIMATION MAP

Task Order No.:	Contract No.:	Figure No.:
TO0001	EP-S9-17-03	H28-57
Location: COVE CHAPTER NAVAJO NATION	Date: 7/7/2019	

C:\USERS\JIM.HERNING\DOCUMENTS\EMIFIELD DEPLOYMENT\RAES_GIS\MXD\T001\FINAL_REPORT\GROUP HIRSE\M28 (MESA II MINE NO. 1 P-150)\H28-57_WASTE_VOLUME.MXD 07/07/19

8.2 OFFSITE MIGRATION

An evaluation was performed as part of the RSE investigation to assess potential offsite migration pathways for contaminants at Mesa II, Mine No. 1, P-150. Mesa II, Mine No. 1, P-150 is situated on a slope directly above the Middle 3B drainage and contributes surface water runoff directly to the Middle 3B. Drainage pathways were identified throughout the survey area boundary, some of which channelize directly through waste material remaining at the site. Additionally, the Middle 3B drainage flows directly through the toe of Waste Pile M28.

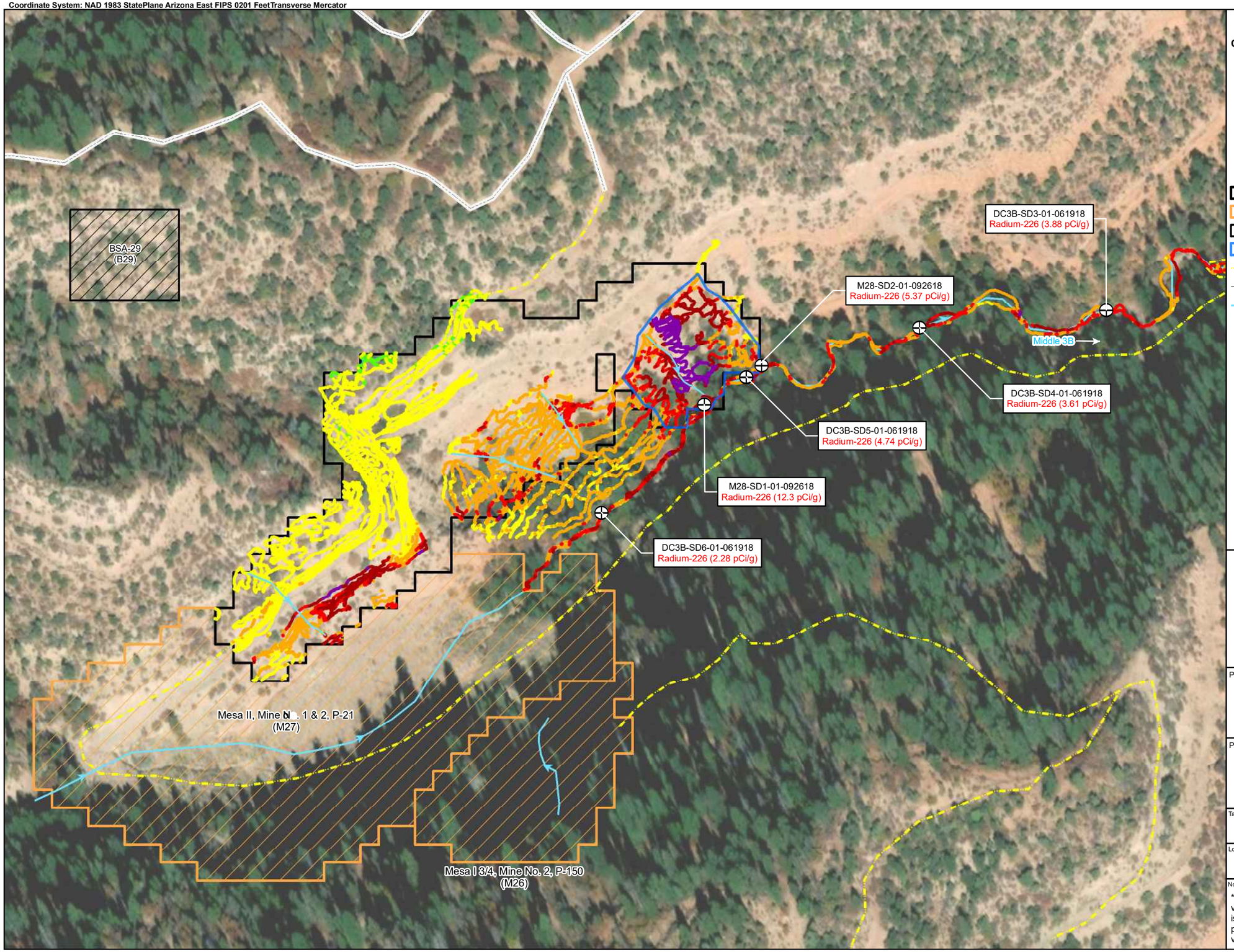
The Middle 3B drainage was investigated as part of the drainage investigation study, which is included in Appendix J of the RSE Report. Figure H28-58 provides a map of sediment sample locations and Ra-226 concentrations from the 2018 RSE investigation. A sediment sample was collected within Waste Pile M28 in the Middle 3B drainage and the Ra-226 concentration for that sample was 12.3 pCi/g. Offsite migration of waste material from Mesa II, Mine No. 1, P-150 was confirmed, though the extent of eroded material and sediment that Mesa II, Mine No. 1, P-150 contributes to downstream areas is unknown.

There is potential for aeolian transport. The surficial contamination is extensive at that Mesa II, Mine No. 1, P-150, and some areas where potential mine waste is found exceed 10 times the applied gamma BTV.

The depth to groundwater is unknown at Mesa II, Mine No. 1, P-150; however, Weston (2010) indicated that the closest groundwater well is within 1.76 miles of the site and could be potentially affected by Mesa II, Mine No. 1, P-150. Further investigation would be required to understand the impacts to groundwater from this mine.

In summary, offsite migration of mine waste via surface water was confirmed, and there is a potential for offsite migration of mine waste materials via windborne and groundwater transport pathways at the site.

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



Sediment Sample Location*

Gamma Reading (cpm)**

≤ 8,123	≤ Avg. BG
8,123 - 9,703	Avg. BG - 1 x BTV
9,703 - 19,406	1 x BTV - 2 x BTV
19,406 - 29,109	2 x BTV - 3 x BTV
29,109 - 38,812	3 x BTV - 4 x BTV
38,812 - 97,030	4 x BTV - 10 x BTV
≥ 97,030	≥ 10 x BTV

- Survey Area Boundary
- Other Survey Area
- Background Location
- Waste Pile - Unreclaimed
- Access Route - Foot
- Access Route - Vehicular
- Drainage - Field Mapped

Note:
*Red font indicates Radium-226 concentration above drainage background BTV value of 1.16 pCi/g.

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150
SEDIMENT SAMPLE LOCATION MAP

Prepared For:

Prepared By:

TETRA TECH
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Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	Date: 7/22/2019

Notes:
**The applied gamma background threshold value (BTV) for Mesa II, Mine No. 1, P-150 is 9,703 cpm derived from BSA-24 as presented in Appendix A. Avg. BG: Average value of the background data set.

Figure No.: **H28-58**

8.3 EVALUATION OF GAMMA-RADIUM CORRELATION

Tetra Tech performed GPS-based gamma radiation surveys and collected nine-point composite samples of surface soils in 21 correlation plots within the Jse and Jste geologies. This methodology is described in Section 4.5.1. These areas were selected using criteria established in the RSE Work Plan (Tetra Tech 2018). No DQO was established for homogeneity of the correlation plots; therefore, homogeneity of the correlation plots was evaluated qualitatively in the field. The activities were performed contemporaneously by area and on the same day such that variations in the gamma count rate measurements could be limited largely to those posed by the soils and rocks at the mine. The soil samples were analyzed by ALS Environmental in Fort Collins, Colorado, as described in Section 4.5.1. A detailed analysis of the gamma-radium correlation developed for Mesa II, Mine No. 1, P-150 is provided in Appendix C of the RSE Report. Equations 1a and 1b (see Section 4.5.1) provide the correlation model for the relationship between the gamma count rate and soil concentration of Ra-226; the correlation itself is provided in Section 4.5.2.

The predicted results of the gamma-radium correlation in the form of soil Ra-226 concentrations across Mesa II, Mine No. 1, P-150 are provided in Section 7.6. Figure H28-38 provides a map of the individual gamma survey measurements converted into estimated Ra-226 concentrations and color coded to the Ra-226 concentration. Figure H28-39 presents a similar map showing the average Ra-226 concentration within each survey unit estimated from the converted gamma survey measurement data, as well as the actual soil samples collected and their respective values.

An analysis was performed to see how well the gamma-radium correlation predicts soil Ra-226 concentrations across the survey area of Mesa II, Mine No. 1, P-150. Two types of analysis were performed for each observed Ra-226 soil sample as follows:

- **Grid average gamma:** all gamma survey measurements within the survey unit are averaged, and this value is converted to a Ra-226 soil concentration and compared to the observed Ra-226 soil concentration.
- **Closest gamma:** all gamma survey measurements within a 2-meter buffer zone are averaged, and this value is converted to a Ra-226 soil concentration and compared to the observed Ra-226 soil concentration.

A visual example of these two approaches is provided in Figure H28-59. The results of both approaches are shown in Figure H28-60 and Figure H28-61. The black line on these figures indicates a 1:1 relationship (unity line) if the model was perfect. The blue line shows the regression line for the observed versus predicted Ra-226 soil concentrations. If the blue line is below the black line, the model underestimates Ra-226 concentrations from the gamma-radium correlation. If the blue is over the black line, the model overpredicts Ra-226 concentrations from the gamma-radium correlation. In general, the model, using either a 2-meter buffer approach or grid average approach overpredicts the Ra-226 soil concentrations at lower levels and under predicts at higher levels. The cutoff between overprediction and underprediction using the grid averaged approach is at 18.5 pCi/g. According to the model, the average Ra-226 concentration within the survey area of Mesa II, Mine No. 1, P-150 is 13.1 pCi/g; the average based only on surface soil samples is 21.6 pCi/g. The equivalent gamma count rate associated with the applied Ra-226 BTV (0.85 pCi/g) is 13,517 cpm versus the applied gamma BTV of 9,703 cpm. Therefore, it would be more conservative to base the cleanup on the applied gamma BTV provided in Section 3.0 rather than an estimated gamma BTV using Equation 1a in Section 4.5.1.

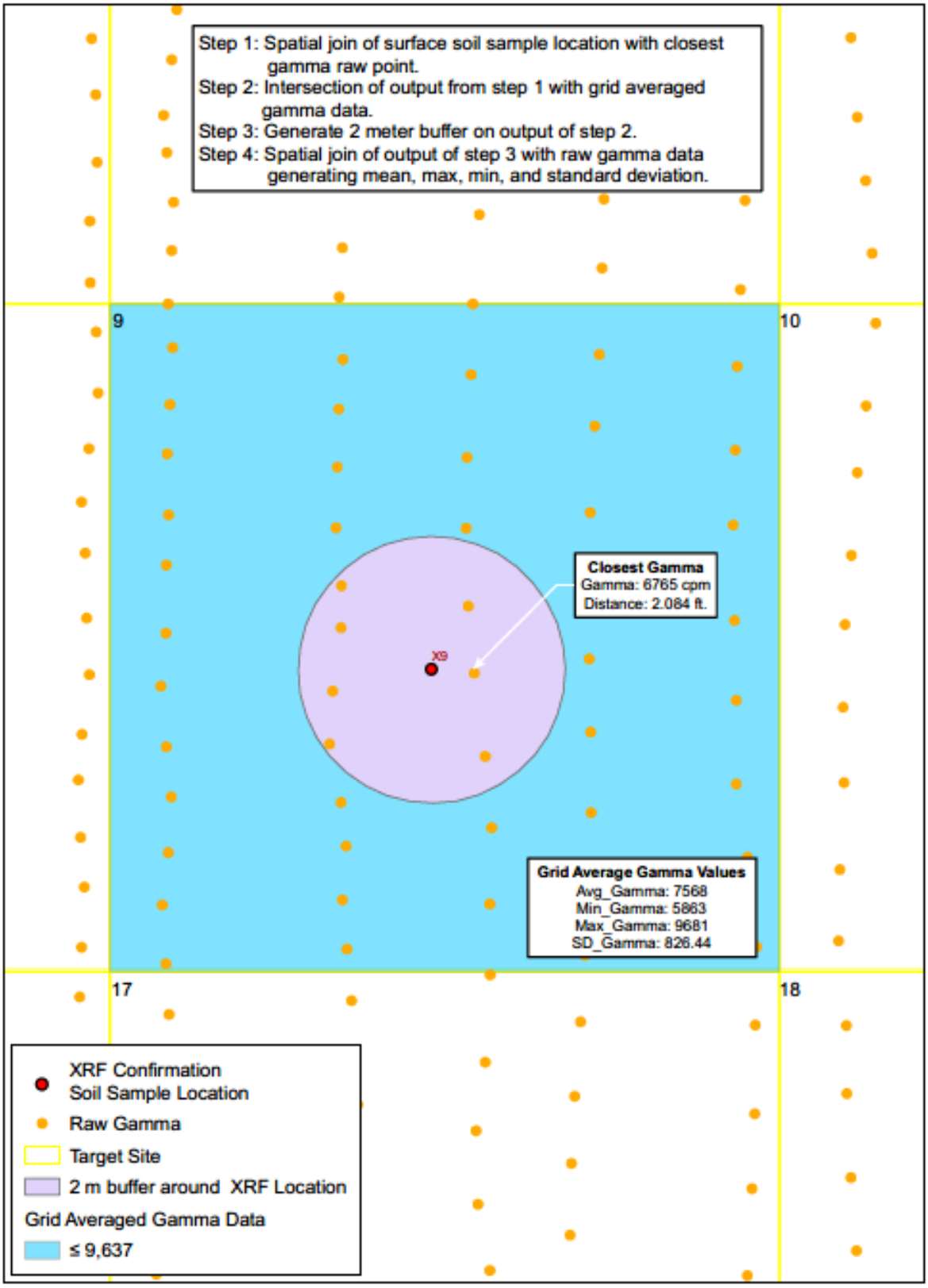

Figure H28-59. Gamma-Radium Correlation Validation Approaches

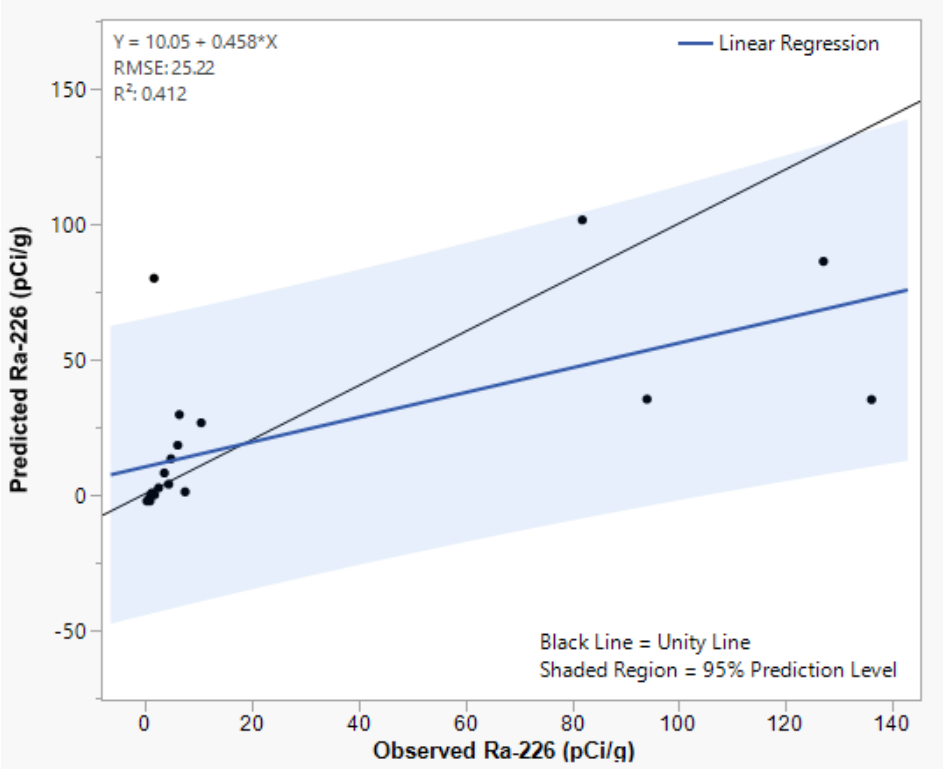

Figure H28-60. Observed versus Predicted Surface Soil Radium-226 Concentrations (Blue Line) for Grid Averaged Gamma Data within the Survey Unit

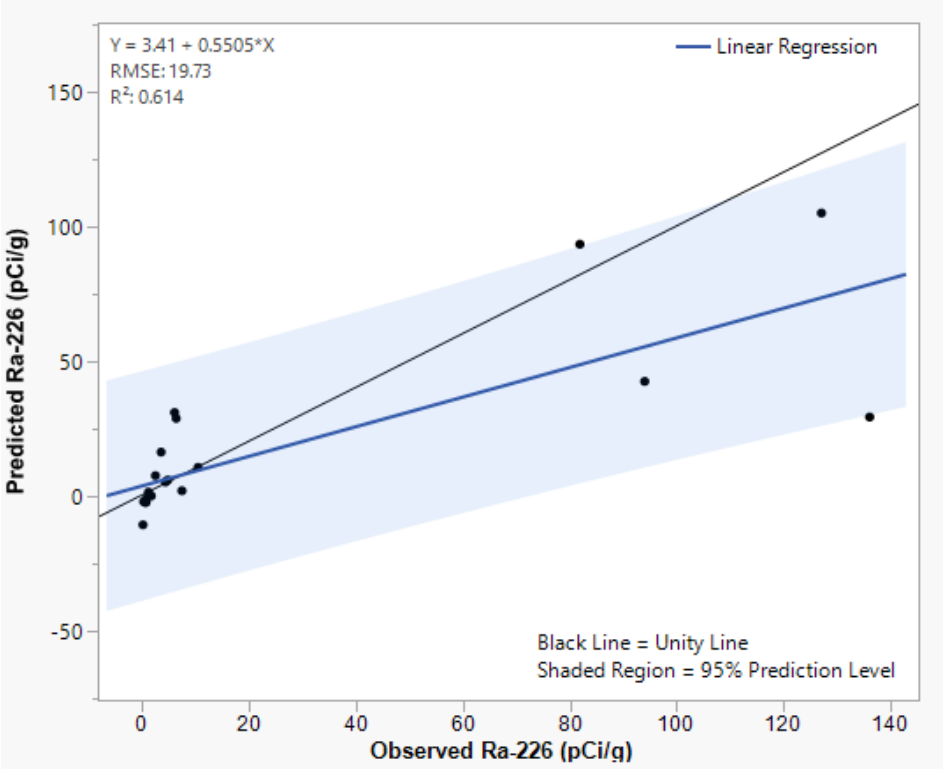

Figure H28-61. Observed versus Predicted Surface Soil Radium-226 Concentrations (Blue Line) for Grid Averaged Gamma Data within the 2-Meter Buffer

9.0 CONCLUSIONS

An RSE investigation was performed at Mesa II, Mine No. 1, P-150 during the 2018 field season by Tetra Tech. There were several field mobilizations to the site as part of the Baseline Study and the Site Characterization Study. A comprehensive gamma radiation survey was performed at Mesa II, Mine No. 1, P-150 (see Attachment H28-4 for comparative purposes). Similarly, many soil samples were collected from both the surface and subsurface soils and analyzed for metals, radionuclides, geochemical parameters, and geotechnical parameters. Not all DQOs identified in Section 1.2 have been achieved through the RSE investigations. The remaining data gaps for Mesa II, Mine No. 1, P-150 are discussed below. The conclusions from the RSE investigation at Mesa II, Mine No. 1, P-150 are:

- There are physical hazards at the site that include vertical cliffs resulting in inaccessible areas in the center of the site and also near the closed portals in the northern portion of the site.
- The five portals at the site were confirmed to be closed and stable during the RSE investigation. However, the cover material located on Portal 40 was observed to be eroded. The polyurethane foam was intact at Portal 40 and the portal remains closed, but there is potential for deterioration in the future.
- Waste Pile M28 (formerly Waste Pile 42) was characterized by the field team. Contamination associated with the unreclaimed Waste Pile M28 appeared to extend outside of the original boundary provided in the USEPA geodatabase (Neptune and TSG 2018), which was then confirmed using multiple lines of evidence (see Section 2.6). Based on these findings, the extent of the Waste Pile M28 boundary was expanded and is estimated to contain approximately 50 percent of the waste remaining at the site.
- There are areas of mine waste that contain radionuclides and chemicals above background concentrations throughout the site. The volume of waste from the unreclaimed waste pile and other areas of mine waste is estimated at 18,259 yd^3.
- The potential for offsite migration through the surface water pathway was confirmed. The greatest potential source of offsite contaminant migration to the canyon below is Waste Pile M28, a portion of which sits within the Middle 3B drainage.
- The lateral extent of radiological contamination at the site was well documented through gamma radiation surveys, and the full extent of areas containing elevated gamma measurements above the applied BTV levels has been characterized except for the northwest area; this survey area was not extended far enough outside of the existing elevated region because of topography and safety concerns.
- A total of 26 analytes were identified as COPCs at Mesa II, Mine No. 1, P-150 (all 26 in the surface environment and 22 in the subsurface environment).

In general, the RSE investigation was successful at fulfilling the DQOs, and few data gaps remain for Mesa II, Mine No. 1, P-150. The remaining data gaps for Mesa II, Mine No. 1, P-150 are the depth to groundwater and the existing groundwater quality as well as radon gas concentrations. The data generated during this investigation greatly expanded upon previous investigations and will be used to assist in developing and evaluating cleanup options in the EE/CA.

10.0 REFERENCES

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ATTACHMENT H28-1

XRF FIELD SURVEY AND SOIL SAMPLING RESULT TABLES

Table H28-1-1. Summary of Geospatial Locations of Soil Samples for Mesa II, Mine No. 1, P-150

Sample ID	Survey Unit	Depth (inches)	Analyses	Sample Type	Sample QC	Date Sampled	Latitude	Longitude	Laboratory ID						
M28-XS8-01-062018	8	0-3	XRF Conf Short	XRF Confirmation	Primary	6/20/2018	36.51316173	-109.2339951	1806558-21	1806561-21	-	-	-	-	-
M28-XS19-01-092918	19	0-3	XRF Conf Short	XRF Confirmation	Primary	9/29/2018	36.51306817	-109.2339206	1810122-15	1810123-15	-	-	-	-	-
M28-XS29-01-092618	29	0-3	XRF Conf Long2	XRF Confirmation	Primary	9/26/2018	36.51302416	-109.2326913	1810032-6	1810033-6	-	-	-	-	-
M28-XS43-01-062018	43	0-3	XRF Conf Short	XRF Confirmation	Primary	6/20/2018	36.5129952	-109.233127	1806558-20	1806561-20	-	-	-	-	-
M28-XS105-01-062018	105	0-3	XRF Conf Short	XRF Confirmation	Primary	6/20/2018	36.51244386	-109.2344323	1806558-16	1806561-16	-	-	-	-	-
M28-XS148-01-062018	148	0-3	XRF Conf Long	XRF Confirmation	Primary	6/20/2018	36.51182127	-109.2346887	1806558-17	1806561-17	-	-	-	-	-
M28-XS155-01-062018	155	0-3	XRF Conf Short	XRF Confirmation	Primary	6/20/2018	36.51169223	-109.2349881	1806558-18	1806561-18	-	-	-	-	-
M28-XS162-01-092818	162	0-3	XRF Conf Long2	XRF Confirmation	Primary	9/28/2018	36.51164222	-109.2353277	1810122-14	1810123-14	-	-	-	-	-
M28-XS170-01-062018	170	0-3	XRF Conf Short	XRF Confirmation	Primary	6/20/2018	36.51156525	-109.235363	1806558-19	1806561-19	-	-	-	-	-
M28-XSG7-01-092618	G7	0-3	XRF Conf Long2	XRF Confirmation	Primary	9/26/2018	36.51317787	-109.2324746	1810032-8	1810033-8	-	-	-	-	-
M28-XSG18-01-092918	G18	0-3	XRF Conf Short	XRF Confirmation	Primary	9/29/2018	36.51282172	-109.2347977	1810122-16	1810123-16	-	-	-	-	-
M28-XSG49-01-092618	G49	0-3	XRF Conf Short	XRF Confirmation	Primary	9/26/2018	36.51253516	-109.233975	1810032-7	1810033-7	-	-	-	-	-
M28-XSG54-01-092918	G54	0-3	XRF Conf Short	XRF Confirmation	Primary	9/29/2018	36.5125458	-109.233462	1810122-17	1810123-17	-	-	-	-	-
M28-XSG76-01-092918	G76	0-3	XRF Conf Short	XRF Confirmation	Primary	9/29/2018	36.51226993	-109.2340229	1810122-18	1810123-18	-	-	-	-	-
M28-SS8-01-092618	8	0-6	Soil Short	Soil Sampling	Primary	9/26/2018	36.51316603	-109.2339744	1810024-43	1810025-34	-	-	-	-	-
M28-SB8-0612-01-092618	8	6-12	Soil Short	Soil Sampling	Primary	9/26/2018	36.51316603	-109.2339744	1810024-36	1810025-27	-	-	-	-	-
M28-SS8-02-092618	8	0-6	Soil Short	Soil Sampling	Duplicate	9/26/2018	36.51316603	-109.2339744	1810024-44	1810025-35	-	-	-	-	-
M28-SS30-01-092618	30	0-6	Soil Long	Soil Sampling	Primary	9/26/2018	36.51306666	-109.232705	1810024-41	1810024-55	1810024-56	1810024-57	1810025-32	1810025-43	T1801766-007
M28-SB30-0612-01-092618	30	6-12	Soil Long	Soil Sampling	Primary	9/26/2018	36.51306666	-109.232705	1810024-34	1810024-52	1810024-53	1810024-54	1810025-25	1810025-42	T1801766-006

Table H28-1-1. Summary of Geospatial Locations of Soil Samples for Mesa II, Mine No. 1, P-150 (Continued)

Sample ID	Survey Unit	Depth (inches)	Analyses	Sample Type	Sample QC	Date Sampled	Latitude	Longitude	Laboratory ID						
M28-SS32-01-092618	32	0-6	Soil Short	Soil Sampling	Primary	9/26/2018	36.51304722	-109.2323486	1810024-42	1810025-33	-	-	-	-	-
M28-SB32-0612-01-092618	32	6-12	Soil Short	Soil Sampling	Primary	9/26/2018	36.51304722	-109.2323486	1810024-35	1810025-26	-	-	-	-	-
M28-SS104-01-092618	104	0-6	Soil Short	Soil Sampling	Primary	9/26/2018	36.5124514	-109.2345402	1810024-39	1810025-30	-	-	-	-	-
M28-SB104-0612-01-092618	104	6-12	Soil Short	Soil Sampling	Primary	9/26/2018	36.5124514	-109.2345402	1810024-32	1810025-23	-	-	-	-	-
M28-SS133-01-092618	133	0-6	Soil Short	Soil Sampling	Primary	9/26/2018	36.5119898	-109.2342584	1810024-40	1810025-31	-	-	-	-	-
M28-SB133-0612-01-092618	133	6-12	Soil Short	Soil Sampling	Primary	9/26/2018	36.5119898	-109.2342584	1810024-33	1810025-24	-	-	-	-	-
M28-SSG7-01-092618	G7	0-6	Soil Long	Soil Sampling	Primary	9/26/2018	36.51315192	-109.2324262	1810024-45	1810024-58	1810024-59	1810024-60	1810025-36	1810025-44	T1801766-008

Notes:
Laboratory ID is presented for metals and radionuclide data, but not for geochemical and geotechnical data; please see individual reports for that information.
QC Quality control
XRF X-ray fluorescence

Table H28-1-2. XRF Field Survey Results for Mesa II, Mine No. 1, P-150

Survey Unit	Unique_X[1]	Date Collected	Survey Unit Classification	Arsenic (mg/kg)	Q	Iron (mg/kg)	Q	Lead (mg/kg)	Q	Manganese (mg/kg)	Q	Molybdenum (mg/kg)	Q	Thorium (mg/kg)	Q	Uranium (mg/kg)	Q	Vanadium (mg/kg)	Q	Zinc (mg/kg)	Q
X8	M28X8	6/20/2018	Class 2	< 1.8	QU	5,527		7.1		158		1.8		1.9		< 0.077	QU	< 16	QU	13	
X17	M28X17	6/20/2018	Class 1	3.0		8,736		3.9		333		< 0.038	QU	2.9		1.4		< 16	QU	22	
X18	M28X18	6/20/2018	Class 1	< 1.8	QU	4,160		4.1		130		< 0.038	QU	1.2		< 0.077	QU	< 16	QU	10	
X22	M28X22	6/20/2018	Class 3	3.5		12,886		6.1		290		< 0.038	QU	4.0		3.9		< 16	QU	38	
X23	M28X23	6/20/2018	Class 3	2.3		10,541		4.5		598	QH	< 0.038	QU	2.4		3.7		17		33	
X25	M28X25	6/20/2018	Class 3	3.9		7,798		6.2		217		2.1		3.4		8.8		< 16	QU	21	
X26	M28X26	6/20/2018	Class 3	4.6		8,690		6.5		227		0.74		1.7		10		< 16	QU	26	
X34	M28X34	6/20/2018	Class 1	2.2		10,249		7.9		242		< 0.038	QU	3.3		1.7		< 16	QU	27	
X35	M28X35	6/20/2018	Class 1	3.0		11,848		8.3		361		1.2		3.7		3.1		< 16	QU	29	
X38	M28X38	6/20/2018	Class 3	6.0		7,835		4.8		225		< 0.038	QU	2.5		4.8		< 16	QU	24	
X39	M28X39	6/20/2018	Class 3	2.9		6,001		5.1		159		< 0.038	QU	1.9		6.2		< 16	QU	16	
X40	M28X40	6/20/2018	Class 3	< 1.8	QU	6,934		5.9		167		< 0.038	QU	2.1		4.2		< 16	QU	17	
X41	M28X41	6/20/2018	Class 3	2.1		6,425		6.2		157		< 0.038	QU	2.9		4.2		< 16	QU	19	
X42	M28X42	6/20/2018	Class 3	3.3		6,037		3.9		151		< 0.038	QU	2.2		6.5		21		17	
X43	M28X43	6/20/2018	Class 3	35		4,535		5.8		115		< 0.038	QU	1.2		295		75		12	
X51	M28X51	6/20/2018	Class 1	3.5		14,018		8.0		302		< 0.038	QU	4.3		2.7		< 16	QU	37	
X54	M28X54	6/20/2018	Class 1	6.6		7,595		6.8		169		< 0.038	QU	2.3		6.9		< 16	QU	22	
X55	M28X55	6/20/2018	Class 3	2.2		5,975		4.7		152		< 0.038	QU	1.6		4.4		< 16	QU	18	
X59	M28X59	6/20/2018	Class 3	7.1		16,879		8.6		235		< 0.038	QU	7.3		14		94		51	
X67	M28X67	6/20/2018	Class 1	5.7		20,179		19		297		< 0.038	QU	11		7.6		36		48	
X68	M28X68	6/20/2018	Class 1	< 1.8	QU	6,193		5.9		199		< 0.038	QU	1.9		0.28		< 16	QU	15	
X69	M28X69	6/20/2018	Class 1	< 1.8	QU	4,037		3.1		83	QL	< 0.038	QU	1.4		< 0.077	QU	< 16	QU	10	
X70	M28X70	6/20/2018	Class 1	15		15,088		7.9		364		< 0.038	QU	5.6		6.0		26		41	
X71	M28X71	6/20/2018	Class 1	15		11,151		7.8		217		< 0.038	QU	3.2		6.2		16		30	
X72	M28X72	6/20/2018	Class 1	13		8,596		5.4		181		< 0.038	QU	2.6		5.0		< 16	QU	23	
X78	M28X78	6/20/2018	Class 1	2.5		10,453		6.4		271		< 0.038	QU	3.9		2.6		< 16	QU	26	
X79	M28X79	6/20/2018	Class 1	6.2		17,541		10		408		< 0.038	QU	7.7		5.1		22		45	
X80	M28X80	6/20/2018	Class 1	2.9		7,870		7.3		175		0.082		3.3		2.7		< 16	QU	20	
X81	M28X81	6/20/2018	Class 1	4.7		10,453		9.8		195		0.90		3.5		5.8		< 16	QU	26	
X82	M28X82	6/20/2018	Class 1	5.1		10,532		6.6		174		< 0.038	QU	3.4		4.0		< 16	QU	24	
X83	M28X83	6/20/2018	Class 1	8.6		8,206		6.3		159		< 0.038	QU	2.6		4.7		< 16	QU	24	
X89	M28X89	6/20/2018	Class 1	< 1.8	QU	7,703		7.1		242		< 0.038	QU	2.9		1.5		< 16	QU	19	
X90	M28X90	6/20/2018	Class 1	< 1.8	QU	7,509		6.3		198		2.2		3.0		3.2		< 16	QU	21	
X91	M28X91	6/20/2018	Class 1	< 1.8	QU	8,403		7.2		181		< 0.038	QU	3.2		< 0.077	QU	< 16	QU	21	
X92	M28X92	6/20/2018	Class 1	4.0		7,584		4.9		206		< 0.038	QU	2.5		2.7		< 16	QU	20	
X93	M28X93	6/20/2018	Class 1	3.6		9,835		5.5		257		< 0.038	QU	3.9		4.1		< 16	QU	24	
X96	M28X96	6/20/2018	Class 1	< 1.8	QU	4,353		4.1		215		< 0.038	QU	1.2		< 0.077	QU	< 16	QU	10	

Table H28-1-2. XRF Field Survey Results for Mesa II, Mine No. 1, P-150 (Continued)

Survey Unit	Unique_X[1]	Date Collected	Survey Unit Classification	Arsenic (mg/kg)	Q	Iron (mg/kg)	Q	Lead (mg/kg)	Q	Manganese (mg/kg)	Q	Molybdenum (mg/kg)	Q	Thorium (mg/kg)	Q	Uranium (mg/kg)	Q	Vanadium (mg/kg)	Q	Zinc (mg/kg)	Q
X97	M28X97	6/20/2018	Class 1	< 1.8	QU	5,774		6.6		190		1.5		2.4		1.6		< 16	QU	16	
X98	M28X98	6/20/2018	Class 1	15		12,389		10		237		0.039		4.9		5.7		< 16	QU	30	
X99	M28X99	6/20/2018	Class 1	3.6		8,756		3.1		436		< 0.038	QU	1.5		7.6		20		24	
X100	M28X100	6/20/2018	Class 1	2.9		7,601		6.9		179		< 0.038	QU	1.8		3.2		< 16	QU	20	
X102	M28X102	6/20/2018	Class 1	< 1.8	QU	6,000		4.7		508	QH	5.4		2.8		4.7		< 16	QU	28	
X103	M28X103	6/20/2018	Class 1	< 1.8	QU	6,105		7.3		218		0.24		2.1		0.19		< 16	QU	16	
X104	M28X104	6/20/2018	Class 1	2.7		7,672		6.3		243		< 0.038	QU	2.3		4.0		< 16	QU	22	
X105	M28X105	6/20/2018	Class 1	2.2		5,823		6.4		180		< 0.038	QU	1.8		2.3		< 16	QU	15	
X106	M28X106	6/20/2018	Class 1	3.0		7,805		7.8		219		1.4		3.0		3.7		< 16	QU	18	
X108	M28X108	6/20/2018	Class 1	2.9		8,641		7.3		234		< 0.038	QU	3.0		3.6		18		21	
X109	M28X109	6/20/2018	Class 1	3.0		9,116		8.3		269		< 0.038	QU	3.6		4.1		< 16	QU	23	
X110	M28X110	6/20/2018	Class 1	3.9		7,530		5.2		195		< 0.038	QU	2.9		2.5		< 16	QU	18	
X111	M28X111	6/20/2018	Class 1	3.5		8,499		7.6		251		0.18		2.6		5.6		< 16	QU	23	
X113	M28X113	6/20/2018	Class 1	< 1.8	QU	6,661		5.7		309		< 0.038	QU	2.5		0.73		< 16	QU	18	
X114	M28X114	6/20/2018	Class 1	< 1.8	QU	7,015		6.1		254		< 0.038	QU	1.7		2.3		< 16	QU	17	
X114A	M28X114A	6/20/2018	Class 1	2.9		9,092		8.6		208		< 0.038	QU	3.5		4.3		< 16	QU	23	
X115	M28X115	6/20/2018	Class 1	4.6		9,632		7.1		236		0.80		4.1		4.3		16		27	
X117	M28X117	6/20/2018	Class 1	7.8		11,234		8.2		245		< 0.038	QU	4.6		3.2		19		27	
X118	M28X118	6/20/2018	Class 1	2.7		6,970		6.8		174		< 0.038	QU	2.1		5.1		18		19	
X119	M28X119	6/20/2018	Class 1	4.6		7,212		6.0		193		< 0.038	QU	1.9		2.0		< 16	QU	20	
X121	M28X121	6/20/2018	Class 1	2.0		11,566		7.6		238		< 0.038	QU	3.8		4.8		30		29	
X122	M28X122	6/20/2018	Class 1	2.1		8,689		6.9		207		< 0.038	QU	2.6		1.3		< 16	QU	21	
X123	M28X123	6/20/2018	Class 1	3.2		8,698		6.6		237		< 0.038	QU	2.6		3.2		< 16	QU	23	
X124	M28X124	6/20/2018	Class 1	11		9,506		6.4		219		< 0.038	QU	3.4		8.6		23		27	
X125	M28X125	6/20/2018	Class 1	4.5		7,880		7.0		193		1.4		3.2		3.2		< 16	QU	22	
X128	M28X128	6/20/2018	Class 1	< 1.8	QU	6,027		5.0		140		< 0.038	QU	1.8		1.3		< 16	QU	41	
X129	M28X129	6/20/2018	Class 1	1.8		6,678		4.5		304		< 0.038	QU	1.7		1.8		< 16	QU	16	
X130	M28X130	6/20/2018	Class 1	4.7		10,954		6.2		283		< 0.038	QU	2.2		3.2		31		28	
X131	M28X131	6/20/2018	Class 1	6.4		7,465		4.6		182		< 0.038	QU	3.2		9.8		23		20	
X132	M28X132	6/20/2018	Class 1	2.3		9,428		6.5		199		< 0.038	QU	3.4		5.3		24		28	
X133	M28X133	6/20/2018	Class 1	9.8		8,470		8.3		229		0.93		3.4		38		39		25	
X135	M28X135	6/20/2018	Class 1	3.5		9,162		6.2		213		0.43		3.3		3.4		26		23	
X136	M28X136	6/20/2018	Class 1	3.4		11,443		7.4		182		< 0.038	QU	4.0		3.7		19		26	
X137	M28X137	6/20/2018	Class 1	11		10,496		7.8		211		0.39		3.7		5.1		29		27	
X139	M28X139	6/20/2018	Class 1	19		7,717		6.6		149		7.0		2.3		74		76		20	
X140	M28X140	6/20/2018	Class 1	5.4		10,158		6.0		227		< 0.038	QU	3.0		8.4		27		27	

Table H28-1-2. XRF Field Survey Results for Mesa II, Mine No. 1, P-150 (Continued)

Survey Unit	Unique_X[1]	Date Collected	Survey Unit Classification	Arsenic (mg/kg)	Q	Iron (mg/kg)	Q	Lead (mg/kg)	Q	Manganese (mg/kg)	Q	Molybdenum (mg/kg)	Q	Thorium (mg/kg)	Q	Uranium (mg/kg)	Q	Vanadium (mg/kg)	Q	Zinc (mg/kg)	Q
X141	M28X141	6/20/2018	Class 1	2.8		8,905		6.7		250		< 0.038	QU	2.3		3.8		18		24	
X144	M28X144	6/20/2018	Class 1	< 1.8	QU	5,516		6.2		167		< 0.038	QU	1.4		1.1		< 16	QU	29	
X145	M28X145	6/20/2018	Class 1	9.1		8,012		6.2		195		< 0.038	QU	2.5		5.3		26		49	
X146	M28X146	6/20/2018	Class 1	2.2		6,439		6.0		157		< 0.038	QU	3.0		2.5		< 16	QU	27	
X147	M28X147	6/20/2018	Class 1	24		6,139		4.4		154		25		2.1		21		19		13	
X148	M28X148	6/20/2018	Class 1	35		9,581		7.8		170		58		4.3		259		69		26	
X149	M28X149	6/20/2018	Class 1	4.8		12,465		6.6		383		< 0.038	QU	3.2		6.7		31		31	
X153	M28X153	6/20/2018	Class 1	2.9		9,767		7.7		286		< 0.038	QU	2.8		3.5		25		52	
X154	M28X154	6/20/2018	Class 1	104	QH	25,531	QH	22		355		2.8		8.0		21		65		90	QH
X155	M28X155	6/20/2018	Class 1	4.9		6,571		3.3		148		0.76		1.8		20		39		17	
X156	M28X156	6/20/2018	Class 1	< 1.8	QU	2,598		3.1		101		< 0.038	QU	1.1		20		21		10	
X157	M28X157	6/20/2018	Class 1	4.6		7,751		5.4		283		< 0.038	QU	2.3		21		41		22	
X158	M28X158	6/20/2018	Class 1	4.4		6,891		4.8		164		< 0.038	QU	2.5		3.9		31		18	
X163	M28X163	6/20/2018	Class 1	14		14,396		8.4		508	QH	< 0.038	QU	5.3		13		46		65	QH
X164	M28X164	6/20/2018	Class 1	3.2		7,571		6.0		201		< 0.038	QU	2.2		2.3		< 16	QU	39	
X165	M28X165	6/20/2018	Class 1	6.8		8,055		6.1		208		< 0.038	QU	2.3		7.7		57		24	
X166	M28X166	6/20/2018	Class 1	10		13,359		9.3		312		< 0.038	QU	3.8		12		103		35	
X167	M28X167	6/20/2018	Class 1	12		8,147		6.7		199		4.9		3.8		65		110		23	
X170	M28X170	6/20/2018	Class 1	17		17,426		9.9		375		1.3		6.0		20		60		87	QH
X171	M28X171	6/20/2018	Class 1	3.6		6,075		3.2		203		< 0.038	QU	2.0		2.3		< 16	QU	44	
X172	M28X172	6/20/2018	Class 1	17		10,943		7.6		294		< 0.038	QU	3.9		12		38		32	
X173	M28X173	6/20/2018	Class 1	5.5		10,686		7.0		260		< 0.038	QU	3.1		5.5		50		28	
X176	M28X176	6/20/2018	Class 1	6.5		7,594		5.7		227		< 0.038	QU	1.7		16		175		21	
X177	M28X177	6/20/2018	Class 1	4.1		9,252		7.4		192		< 0.038	QU	3.3		4.8		32		26	
X178	M28X178	6/20/2018	Class 1	7.5		8,142		3.7		228		< 0.038	QU	3.6		6.9		23		21	
X179	M28X179	6/20/2018	Class 1	6.5		9,499		6.3		262		< 0.038	QU	2.6		9.0		41		27	
X180	M28X180	6/20/2018	Class 1	4.2		7,393		6.3		203		< 0.038	QU	2.4		9.2		21		22	
X181	M28X181	6/20/2018	Class 1	7.8		9,592		4.8		267		< 0.038	QU	3.0		7.0		43		26	
X14	M28X14	9/26/2018	Class 1	< 1.8	QU	< 1335	QU	< 0.27	QU	< 81	QU	8.4		1.5		6.6		< 16	QU	< 7.8	QU
X15	M28X15	9/26/2018	Class 1	< 1.8	QU	< 1335	QU	< 0.27	QU	< 81	QU	6.9		1.8		5.8		< 16	QU	< 7.8	QU
G3	M28G3	9/26/2018	Class 1	< 1.8	QU	< 1335	QU	< 0.27	QU	< 81	QU	6.5		1.5		3.4		< 16	QU	< 7.8	QU
G2	M28G2	9/26/2018	Class 1	< 1.8	QU	< 1335	QU	< 0.27	QU	< 81	QU	6.0		1.8		3.0		< 16	QU	< 7.8	QU
G4	M28G4	9/26/2018	Class 1	< 1.8	QU	< 1335	QU	< 0.27	QU	< 81	QU	7.6		2.0		4.0		< 16	QU	< 7.8	QU
X16	M28X16	9/26/2018	Class 1	5.2		6,317		3.9		164		0.25		2.1		98		195		17	
G7	M28G7	9/26/2018	Class 1	6.5		3,589		7.1		123		3.0		1.5		507	QH	718		8.1	
G8	M28G8	9/26/2018	Class 1	< 1.8	QU	< 1335	QU	< 0.27	QU	< 81	QU	6.8		1.4		1.8		< 16	QU	< 7.8	QU

Table H28-1-2. XRF Field Survey Results for Mesa II, Mine No. 1, P-150 (Continued)

Survey Unit	Unique_X[1]	Date Collected	Survey Unit Classification	Arsenic (mg/kg)	Q	Iron (mg/kg)	Q	Lead (mg/kg)	Q	Manganese (mg/kg)	Q	Molybdenum (mg/kg)	Q	Thorium (mg/kg)	Q	Uranium (mg/kg)	Q	Vanadium (mg/kg)	Q	Zinc (mg/kg)	Q
G9	M28G9	9/26/2018	Class 1	< 1.8	QU	< 1335	QU	< 0.27	QU	< 81	QU	6.9		1.7		2.9		< 16	QU	< 7.8	QU
X32	M28X32	9/26/2018	Class 1	< 1.8	QU	< 1335	QU	< 0.27	QU	< 81	QU	6.4		1.5		5.1		< 16	QU	< 7.8	QU
X48B	M28X48B	9/26/2018	Class 1	< 1.8	QU	< 1335	QU	< 0.27	QU	< 81	QU	6.5		1.4		7.9		< 16	QU	< 7.8	QU
X47	M28X47	9/26/2018	Class 1	< 1.8	QU	< 1335	QU	< 0.27	QU	< 81	QU	7.5		1.5		73		< 16	QU	< 7.8	QU
X29	M28X29	9/26/2018	Class 1	< 1.8	QU	< 1335	QU	< 0.27	QU	< 81	QU	9.0		1.8		54		< 16	QU	< 7.8	QU
X48A	M28X48A	9/26/2018	Class 1	< 1.8	QU	< 1335	QU	< 0.27	QU	< 81	QU	9.0		1.7		95		< 16	QU	< 7.8	QU
X64A	M28X64A	9/26/2018	Class 1	< 1.8	QU	< 1335	QU	< 0.27	QU	< 81	QU	7.5		1.7		59		< 16	QU	< 7.8	QU
X63	M28X63	9/26/2018	Class 1	< 1.8	QU	< 1335	QU	< 0.27	QU	< 81	QU	6.9		1.7		35		19		< 7.8	QU
X46	M28X46	9/26/2018	Class 1	< 1.8	QU	< 1335	QU	< 0.27	QU	< 81	QU	6.3		1.9		12		< 16	QU	< 7.8	QU
X45	M28X45	9/26/2018	Class 1	< 1.8	QU	6,672		5.3		201		< 0.038	QU	2.9		5.1		< 16	QU	18	
X28	M28X28	9/26/2018	Class 1	6.7		11,086		7.1		233		< 0.038	QU	3.5		4.2		20		29	
X75A	M28X75A	9/26/2018	Class 1	13		5,962		4.7		154		5.1		2.7		347		1000		19	
X76	M28X76	9/26/2018	Class 1	6.7		4,017		6.0		128		< 0.038	QU	1.5		275		386		13	
X64B	M28X64B	9/26/2018	Class 1	14		5,573		6.8		137		1.1		1.5		328		415		17	
X64	M28X64	9/26/2018	Class 1	8.8		5,265		7.9		128		1.4		2.1		341		455		17	
X48	M28X48	9/26/2018	Class 1	4.2		6,018		5.4		169		< 0.038	QU	2.4		126		230		19	
X49	M28X49	9/26/2018	Class 1	< 1.8	QU	4,184		3.6		145		< 0.038	QU	1.2		24		46		12	
G11	M28G11	9/26/2018	Class 1	< 1.8	QU	4,009		5.0		153		< 0.038	QU	< 1.0	QU	18		35		13	
G10	M28G10	9/26/2018	Class 1	2.0		4,568		4.5		155		< 0.038	QU	2.1		4.3		< 16	QU	15	
G12	M28G12	9/26/2018	Class 1	< 1.8	QU	4,833		3.6		143		< 0.038	QU	2.0		12		106		14	
G17	M28G17	9/26/2018	Class 1	< 1.8	QU	6,743		5.4		222		3.5		2.7		18		38		19	
G16	M28G16	9/26/2018	Class 1	3.9		5,617		8.0		289		< 0.038	QU	2.5		43		61		22	
X88	M28X88	9/26/2018	Class 1	3.5		6,224		5.4		158		< 0.038	QU	2.2		12		22		18	
G47	M28G47	9/26/2018	Class 1	6.2		4,989		6.7		197		< 0.038	QU	1.8		108		182		15	
G46	M28G46	9/26/2018	Class 1	2.6		7,207		5.5		191		2.6		2.6		6.0		19		17	
X86	M28X86	9/26/2018	Class 1	2.3		4,468		3.2		121		1.3		1.9		11		39		9.5	
X87	M28X87	9/26/2018	Class 1	3.8		5,215		3.3		217		4.3		2.1		93		150		22	
G36	M28G36	9/26/2018	Class 1	3.5		4,690		3.5		192		< 0.038	QU	1.9		34		62		13	
X75	M28X75	9/26/2018	Class 1	3.9		5,802		6.9		173		2.3		2.2		29		61		15	
X74	M28X74	9/26/2018	Class 1	3.9		4,309		5.3		126		< 0.038	QU	1.5		58		93		12	
G35	M28G35	9/26/2018	Class 1	< 1.8	QU	5,754		4.7		177		< 0.038	QU	2.4		19		41		14	
G26	M28G26	9/26/2018	Class 1	3.5		5,811		3.8		158		< 0.038	QU	2.1		12		30		14	
G25	M28G25	9/26/2018	Class 1	3.1		4,301		4.4		129		0.064		1.8		29		72		12	
G34	M28G34	9/26/2018	Class 1	7.9		6,749		4.0		157		< 0.038	QU	2.5		36		59		18	
G33	M28G33	9/26/2018	Class 1	4.0		6,940		3.1		237		< 0.038	QU	1.6		8.9		38		17	
G24	M28G24	9/26/2018	Class 3	2.9		6,276		4.0		200		0.62		1.8		3.6		< 16	QU	17	

Table H28-1-2. XRF Field Survey Results for Mesa II, Mine No. 1, P-150 (Continued)

Survey Unit	Unique_X[1]	Date Collected	Survey Unit Classification	Arsenic (mg/kg)	Q	Iron (mg/kg)	Q	Lead (mg/kg)	Q	Manganese (mg/kg)	Q	Molybdenum (mg/kg)	Q	Thorium (mg/kg)	Q	Uranium (mg/kg)	Q	Vanadium (mg/kg)	Q	Zinc (mg/kg)	Q
G32	M28G32	9/26/2018	Class 1	1.9		5,074		2.9		122		< 0.038	QU	1.6		2.7		< 16	QU	13	
G31	M28G31	9/26/2018	Class 1	6.1		6,977		5.9		180		< 0.038	QU	2.4		10		28		20	
G42	M28G42	9/26/2018	Class 1	2.7		5,743		5.6		180		< 0.038	QU	1.3		9.1		19		18	
G41	M28G41	9/26/2018	Class 1	10		9,471		5.9		220		< 0.038	QU	3.5		10		33		24	
G30	M28G30	9/26/2018	Class 1	7.9		9,934		6.8		267		< 0.038	QU	2.8		9.6		43		27	
G40	M28G40	9/26/2018	Class 1	12		10,751		6.8		227		1.1		3.0		11		41		30	
G39	M28G39	9/26/2018	Class 1	3.7		7,739		5.9		163		< 0.038	QU	2.5		8.9		23		20	
G28	M28G28	9/26/2018	Class 3	2.8		4,444		1.2		129		1.8		1.4		4.4		< 16	QU	11	
G29	M28G29	9/26/2018	Class 1	< 1.8	QU	3,888		2.1		113		< 0.038	QU	1.8		2.0		< 16	QU	11	
G38	M28G38	9/26/2018	Class 1	6.0		8,465		6.5		186		< 0.038	QU	3.5		39		78		22	
G50	M28G50	9/26/2018	Class 1	4.3		8,636		4.2		171		< 0.038	QU	2.8		58		61		24	
G49	M28G49	9/26/2018	Class 1	5.0		8,822		8.0		225		< 0.038	QU	3.2		110		46		23	
X162	M28X162	9/28/2018	Class 1	59	QH	14,927		9.0		795	QH	< 0.038	QU	5.9		19		28		53	
G94	M28G94	9/28/2018	Class 1	< 1.8	QU	6,026		4.8		198		< 0.038	QU	1.4		< 0.077	QU	< 16	QU	20	
G93	M28G93	9/28/2018	Class 1	< 1.8	QU	4,989		2.8		143		< 0.038	QU	1.4		< 0.077	QU	< 16	QU	14	
G91	M28G91	9/28/2018	Class 1	< 1.8	QU	5,192		4.3		136		< 0.038	QU	2.1		< 0.077	QU	< 16	QU	14	
G92	M28G92	9/28/2018	Class 1	< 1.8	QU	5,062		4.4		141		< 0.038	QU	1.9		< 0.077	QU	< 16	QU	14	
G89	M28G89	9/28/2018	Class 1	< 1.8	QU	7,413		4.8		174		< 0.038	QU	2.5		< 0.077	QU	< 16	QU	18	
X159	M28X159	9/28/2018	Class 1	2.4		4,485		3.1		168		0.69		1.6		9.9		< 16	QU	14	
X150	M28X150	9/28/2018	Class 1	< 1.8	QU	5,970		3.6		191		< 0.038	QU	1.3		17		< 16	QU	18	
G85	M28G85	9/28/2018	Class 1	3.5		9,749		8.5		277		0.23		2.8		73		70		30	
G78	M28G78	9/28/2018	Class 1	4.2		8,791		6.7		269		1.2		3.0		19		25		26	
G70	M28G70	9/28/2018	Class 1	2.9		8,333		8.1		240		< 0.038	QU	2.0		4.3		22		28	
G61	M28G61	9/28/2018	Class 1	< 1.8	QU	5,649		5.9		159		< 0.038	QU	1.7		13		19		18	
G51	M28G51	9/28/2018	Class 1	6.2		10,174		7.2		260		< 0.038	QU	3.5		14		56		31	
G52	M28G52	9/28/2018	Class 1	4.1		7,583		5.8		261		2.4		2.6		21		83		38	
G53	M28G53	9/28/2018	Class 1	5.5		9,582		6.7		259		< 0.038	QU	2.7		7.8		40		27	
X45A	M28X45A	9/29/2018	Class 1	3.5		6,619		4.9		186		< 0.038	QU	2.1		5.0		< 16	QU	22	
G57	M28G57	9/29/2018	Class 1	3.1		4,534		6.3		172		< 0.038	QU	1.9		30		53		21	
G45	M28G45	9/29/2018	Class 1	2.8		4,490		4.2		141		< 0.038	QU	1.6		16		25		18	
G44	M28G44	9/29/2018	Class 1	6.9		5,828		5.3		165		< 0.038	QU	1.5		21		31		20	
G43	M28G43	9/29/2018	Class 1	4.5		6,097		5.0		221		2.2		2.5		7.7		42		19	
G54	M28G54	9/29/2018	Class 1	5.0		8,576		5.7		218		< 0.038	QU	3.1		7.3		34		28	
G64	M28G64	9/29/2018	Class 1	7.5		8,216		5.2		207		< 0.038	QU	2.9		9.9		30		27	
G65	M28G65	9/29/2018	Class 1	2.9		4,899		3.0		191		< 0.038	QU	1.9		6.0		19		16	
G66	M28G66	9/29/2018	Class 1	5.8		6,782		4.5		198		< 0.038	QU	2.8		8.2		24		21	

Table H28-1-2. XRF Field Survey Results for Mesa II, Mine No. 1, P-150 (Continued)

Survey Unit	Unique_X[1]	Date Collected	Survey Unit Classification	Arsenic (mg/kg)	Q	Iron (mg/kg)	Q	Lead (mg/kg)	Q	Manganese (mg/kg)	Q	Molybdenum (mg/kg)	Q	Thorium (mg/kg)	Q	Uranium (mg/kg)	Q	Vanadium (mg/kg)	Q	Zinc (mg/kg)	Q
G58	M28G58	9/29/2018	Class 1	< 1.8	QU	3,397		1.9		109		0.13		1.2		2.8		< 16	QU	14	
G55	M28G55	9/29/2018	Class 1	3.4		5,967		5.3		198		0.11		2.4		9.1		25		23	
G73	M28G73	9/29/2018	Class 1	2.8		4,910		4.9		154		< 0.038	QU	2.2		3.9		< 16	QU	19	
G72	M28G72	9/29/2018	Class 1	2.1		5,962		6.1		202		< 0.038	QU	2.4		8.5		17		19	
G63	M28G63	9/29/2018	Class 1	5.1		7,389		4.7		231		< 0.038	QU	3.2		8.7		37		26	
G71	M28G71	9/29/2018	Class 1	< 1.8	QU	3,445		5.2		128		< 0.038	QU	1.9		1.5		< 16	QU	15	
G79	M28G79	9/29/2018	Class 1	4.4		8,837		6.1		292		0.22		3.2		12		27		29	
G62	M28G62	9/29/2018	Class 1	7.1		10,827		5.8		265		< 0.038	QU	3.9		8.8		25		34	
G84	M28G84	9/29/2018	Class 1	6.8		10,521		6.8		219		< 0.038	QU	4.4		12		33		33	
G83	M28G83	9/29/2018	Class 1	6.4		8,050		6.1		206		< 0.038	QU	2.1		8.8		36		30	
G82	M28G82	9/29/2018	Class 1	7.9		8,702		5.4		221		< 0.038	QU	3.2		7.2		18		28	
G75	M28G75	9/29/2018	Class 1	< 1.8	QU	4,120		4.5		130		< 0.038	QU	2.3		8.9		< 16	QU	18	
G76	M28G76	9/29/2018	Class 1	2.8		6,119		4.5		171		< 0.038	QU	2.0		5.1		< 16	QU	17	
G77	M28G77	9/29/2018	Class 1	3.3		6,518		4.1		194		0.31		1.3		3.5		19		27	
G69	M28G69	9/29/2018	Class 1	4.3		8,556		7.5		200		1.1		2.5		9.7		29		25	
G68	M28G68	9/29/2018	Class 1	< 1.8	QU	6,664		6.2		277		3.7		2.3		18		24		27	
G67	M28G67	9/29/2018	Class 1	5.3		9,708		6.1		200		0.076		3.7		8.7		35		29	
G59	M28G59	9/29/2018	Class 1	7.0		5,896		3.4		170		1.2		2.4		3.6		20		19	
G60	M28G60	9/29/2018	Class 1	3.0		4,352		3.1		149		< 0.038	QU	1.4		2.2		< 16	QU	13	
G90	M28G90	9/29/2018	Class 1	< 1.8	QU	4,359		3.8		113		< 0.038	QU	2.0		1.1		< 16	QU	17	
G86	M28G86	9/29/2018	Class 1	< 1.8	QU	2,454		3.0		< 81	QU	< 0.038	QU	1.0		1.9		< 16	QU	10	
X127	M28X127	9/29/2018	Class 1	5.2		17,310		14		261		< 0.038	QU	7.4		4.7		21		44	
G87	M28G87	9/29/2018	Class 1	< 1.8	QU	2,392		2.2		321		< 0.038	QU	< 1.0	QU	0.44		< 16	QU	10	
G88	M28G88	9/29/2018	Class 1	< 1.8	QU	4,655		3.4		128		1.4		1.7		3.1		< 16	QU	17	
G80	M28G80	9/29/2018	Class 1	< 1.8	QU	4,109		5.6		168		< 0.038	QU	1.7		2.1		< 16	QU	14	
G81	M28G81	9/29/2018	Class 1	4.0		7,470		4.4		409		< 0.038	QU	2.3		2.4		20		18	
G74	M28G74	9/29/2018	Class 1	< 1.8	QU	6,068		7.3		182		< 0.038	QU	2.7		3.0		< 16	QU	16	
G37	M28G37	9/29/2018	Class 1	< 1.8	QU	4,451		4.9		228		0.31		2.1		2.0		< 16	QU	12	
G27	M28G27	9/29/2018	Class 1	< 1.8	QU	6,333		5.9		166		< 0.038	QU	2.2		2.8		< 16	QU	19	
G18	M28G18	9/29/2018	Class 1	< 1.8	QU	4,067		5.4		163		0.30		2.5		1.2		< 16	QU	18	
G19	M28G19	9/29/2018	Class 1	< 1.8	QU	4,210		6.1		142		< 0.038	QU	2.0		0.20		< 16	QU	15	
X66	M28X66	9/29/2018	Class 1	< 1.8	QU	3,118		4.6		135		0.28		1.6		0.61		< 16	QU	13	
G13	M28G13	9/29/2018	Class 2	< 1.8	QU	2,921		4.6		108		< 0.038	QU	1.5		< 0.077	QU	< 16	QU	10	
G14	M28G14	9/29/2018	Class 1	< 1.8	QU	3,116		4.1		118		< 0.038	QU	1.5		0.75		< 16	QU	11	
X50	M28X50	9/29/2018	Class 1	< 1.8	QU	4,472		7.2		144		1.2		1.7		4.6		< 16	QU	13	
X33	M28X33	9/29/2018	Class 1	< 1.8	QU	3,726		3.5		113		0.57		< 1.0	QU	5.6		< 16	QU	12	

Table H28-1-2. XRF Field Survey Results for Mesa II, Mine No. 1, P-150 (Continued)

Survey Unit	Unique_X[1]	Date Collected	Survey Unit Classification	Arsenic (mg/kg)	Q	Iron (mg/kg)	Q	Lead (mg/kg)	Q	Manganese (mg/kg)	Q	Molybdenum (mg/kg)	Q	Thorium (mg/kg)	Q	Uranium (mg/kg)	Q	Vanadium (mg/kg)	Q	Zinc (mg/kg)	Q
X19	M28X19	9/29/2018	Class 1	< 1.8	QU	6,397		4.6		176		3.8		2.3		2.3		25		18	
X20	M28X20	9/29/2018	Class 1	2.1		8,107		7.8		305		0.90		1.8		5.4		27		24	
G5	M28G5	9/29/2018	Class 3	< 1.8	QU	7,376		6.9		222		0.64		2.3		2.7		< 16	QU	24	
G6	M28G6	9/29/2018	Class 3	< 1.8	QU	6,225		6.3		213		< 0.038	QU	2.4		3.0		< 16	QU	21	
X9	M28X9	9/29/2018	Class 3	< 1.8	QU	7,440		6.3		202		< 0.038	QU	3.0		2.7		< 16	QU	24	

Notes:

Each measurement location is classified as Class 1, Class 2, or Class 3 based on which survey unit the point is located within, the radiological characteristics, and the known historical mine features in relation to that survey unit.

[1] Unique_X is a unique identification for an in situ XRF measurement, which is the mine site ID and the sample ID.

mg/kg Milligrams per kilogram
QU Qualifier is given to a reported value where the XRF reported value is detected but is less than XRF_{MIN} and also less than XRF_O. This value is no nondetect and reported as the maximum observed laboratory method detection limit for that analyte.
XRF X-ray fluorescence
XRF_{MIN} Minimum XRF value used in the development of the correlation for the given analyte
XRF_O XRF value that would equal a laboratory concentration of zero

Table H28-1-3. Laboratory Analytical Results for XRF Confirmation Soil Samples (0 to 3 inches bgs) (1of 2)

Analyte	Units	Sample ID													
		M28-XS8-01-062018		M28-XS19-01-092918		M28-XS29-01-092618		M28-XS43-01-062018		M28-XS105-01-062018		M28-XS148-01-062018		M28-XS155-01-062018	
		Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Survey Unit		8		19		29		43		105		148		155	
Classification		Class 2		Class 1		Class 1		Class 3		Class 1		Class 1		Class 1	
Aluminum	mg/kg	2,300		5,200		5,800		4,600		3,600		6,300		4,400	
Antimony	mg/kg	0.036	J	0.04	J	0.13		0.32		0.046	J	0.35		0.04	J
Arsenic	mg/kg	0.96		1.6		10		53		1.5		42		2.9	
Barium	mg/kg	65		140		69		16		110		53		47	
Beryllium	mg/kg	0.22		0.39		0.27		0.19		0.27		0.27		0.22	
Cadmium	mg/kg	<0.2	U	0.032	J	0.95		0.71		0.046	J	0.14	J	0.037	J
Calcium	mg/kg	12,000	J	18,000		16,000		4,500		11,000		12,000		17,000	
Chromium	mg/kg	1.6		3		4.2		2.9		2.1		3.8		2.7	
Cobalt	mg/kg	1.5		3.6		3.4		2.4		2.2		3.4		2.4	
Copper	mg/kg	3.3		10		8.9		6		5.1		8.9		5.6	
Iron	mg/kg	3,700		6,800		6,700		6,800		5,400		8,800		5,300	
Lead	mg/kg	3.3		6.2		7		9.8		4.6		7.4		4.5	
Lithium	mg/kg	2.9		8.1		18		11		4.4		14		10	
Magnesium	mg/kg	1,200		4,400		4,800		3,400		2,000		4,700		5,400	
Manganese	mg/kg	210	J	200		110		86		220		140		150	
Mercury	mg/kg	-		-		-		-		-		0.0065	J-	-	
Molybdenum	mg/kg	0.06	J	0.083	J	1		7.9		0.14	J	60		0.87	
Nickel	mg/kg	1.7	J	4.3		5.9		3.7		2.3		5.1		3	
Potassium-40	pCi/g	11.9		17.6		15.7		17.8		15.9		16.5		15.4	
Radium-226	pCi/g	<0.37	UJ	1.02		81.9	M3	25.4		1.36		94	M3	3.71	
Radium-228	pCi/g	<0.61	U	<0.51	U	<1.47	UJ	<0.98	U	<0.82	U	<1.3	UJ	<0.71	U
Selenium	mg/kg	0.31	J	0.46	J	7.5		0.65	J	0.74	J	2.7		2.1	
Silver	mg/kg	0.0098	J	0.024	J-	0.21		0.045	J	0.025	J	0.057		0.028	J
Sodium	mg/kg	<98	U	36	J	38	J	<100	U	<97	U	24	J	2500	
Thallium	mg/kg	0.022		0.043		0.12		0.54		0.034		0.55		0.043	
Thorium	mg/kg	1.8	J	3.6		2.6		2.3		2.6		2.8		2	
Uranium	mg/kg	0.27		1.3		220		22		1.2		240		13	
Vanadium	mg/kg	5.1		9.6		410		30		11		75		27	
Zinc	mg/kg	8.4	J	18		21		15		14		23		14	

Table H28-1-3. Laboratory Analytical Results for XRF Confirmation Soil Samples (0 to 3 inches bgs) (2 of 2)

Analyte	Units	Sample ID													
		M28-XS162-01-092818		M28-XS170-01-062018		M28-XSG7-01-092618		M28-XSG18-01-092918		M28-XSG49-01-092618		M28-XSG54-01-092918		M28-XSG76-01-092918	
		Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Survey Unit		162		170		G7		G18		G49		G54		G76	
Classification		Class 1		Class 1		Class 1		Class 1		Class 1		Class 1		Class 1	
Aluminum	mg/kg	12,000		14,000		3,100		3,200		5,800		6,600		4,900	
Antimony	mg/kg	0.062	J	0.074	J	0.12		0.041	J	0.07	J	0.047	J	0.033	J
Arsenic	mg/kg	44		15		6.1		1.1		2.7		4.7		5.1	
Barium	mg/kg	160		99		66		60		60		96		100	
Beryllium	mg/kg	0.75		0.72		0.13		0.2		0.35		0.38		0.29	
Cadmium	mg/kg	0.12	J	0.096	J	0.099	J	0.048	J	0.063	J	0.064	J	0.037	J
Calcium	mg/kg	49,000		35,000		12,000		4,100		33,000		29,000		17,000	
Chromium	mg/kg	7.1		7		1.9		2.8		5.2		5.3		2.9	
Cobalt	mg/kg	15		8.1		2.3		1.7		3.8		4.6		3.2	
Copper	mg/kg	23		19		7.2		4.2		9.9		12		8.8	
Iron	mg/kg	16,000		15,000		4,100		3,800		7,700		8,600		6,500	
Lead	mg/kg	16		12		4.4		4.8		5.7		6.7		5.7	
Lithium	mg/kg	29		28		7		4.6		13		13		8.8	
Magnesium	mg/kg	13,000		13,000		2,400		2,100		5,500		6,200		4,100	
Manganese	mg/kg	500		320		81		120		220		220		160	
Mercury	mg/kg	-		-		-		-		-		-		-	
Molybdenum	mg/kg	1.9		0.7		0.089	J	0.085	J	0.15	J	0.33		0.29	
Nickel	mg/kg	13		11		2.7		2.5		6.8		6.7		3.8	
Potassium-40	pCi/g	18.5		20.1		11.8		11		15		17.1		16.1	
Radium-226	pCi/g	7.6		4.52		136	M3	0.83	LT	4.96		2.65		1.79	
Radium-228	pCi/g	<0.91	UJ	<0.58	UJ	<2.23	UJ	<0.58	UJ	<0.86	U	<0.82	U	<0.4	UJ
Selenium	mg/kg	1		1.1		2.2		0.31	J	0.87	J	0.61	J	0.51	J
Silver	mg/kg	0.022	J-	0.035	J	0.11		0.023	J-	0.035	J	0.023	J-	0.015	J-
Sodium	mg/kg	130		120		22	J	20	J	99		56	J	33	J
Thallium	mg/kg	0.54		0.22		0.3		0.024		0.049		0.066		0.058	
Thorium	mg/kg	7.6		6.8		1.7		1.5		3.3		3.9		2.9	
Uranium	mg/kg	12		6.2		660		1		5		3.7		2.3	
Vanadium	mg/kg	18		19		800		8.1		18		17		12	
Zinc	mg/kg	50		45		<9.5	U	12		22		27		17	

Notes:
Each measurement location is classified as Class 1, Class 2, or Class 3 based on which survey unit the point is located within, the radiological characteristics, and the known historical mine features in relation to that survey unit.

- Not analyzed
bgs Below ground surface
J Estimated value
J- Estimated value, may be biased low.
LT Result less than requested minimum detectable concentration, but greater than sample-specific minimum detectable concentration.
M3 The requested minimum detected concentration was not met, but the reported activity is greater than the reported minimum detected concentration.
mg/kg Milligrams per kilogram
pCi/g Picocuries per gram
Q Qualifier
U Not detected. The associated value is the reporting limit.
UJ Not considered detected. The associated value is the reported concentration, which is estimated.
XRF X-ray fluorescence

Table H28-1-4. Laboratory Analytical Results for Surface Soil Samples (0 to 6 inches bgs)

Analyte	Units	Sample ID											
		M28-SS8-01-092618		M28-SS30-01-092618		M28-SS32-01-092618		M28-SS104-01-092618		M28-SS133-01-092618		M28-SSG7-01-092618	
		Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Survey Unit		8		30		32		104		133		G7	
Classification		Class 2		Class 1		Class 1		Class 1		Class 1		Class 1	
Aluminum	mg/kg	4,600		3,900		2,500		4,300		5,600		2,600	
Antimony	mg/kg	0.047	J	0.18		0.053	J	0.04	J	0.047	J	0.044	J
Arsenic	mg/kg	2.2		12		2.1		3.4		8.4		2.3	
Barium	mg/kg	120	J	85		35		95		79		40	
Beryllium	mg/kg	0.39		0.19		0.16		0.33		0.38		0.14	
Cadmium	mg/kg	0.043	J	0.83		0.11	J	0.053	J	0.058	J	0.064	J
Calcium	mg/kg	18,000		14,000		7,200		12,000		20,000		13,000	
Chromium	mg/kg	2.5		2.7		1.9		2.1		3		2.1	
Cobalt	mg/kg	3.5		2.9		1.4		2.9		3.9		1.4	
Copper	mg/kg	15		8.9		2.6		8.4		12		3	
Iron	mg/kg	5,800		5,400		2,900		5,500		7,400		2,200	
Lead	mg/kg	6.1		5.8		3.1		5.2		8.2	J	2	
Lithium	mg/kg	7.7		12		5.6		7		12		7.2	
Magnesium	mg/kg	4,200		3,200		2,100		3,300		5,400		2,800	
Manganese	mg/kg	200		110		76		190		190		110	
Mercury	mg/kg	-		-		-		-		-		-	
Molybdenum	mg/kg	0.068	J	2.7		0.18	J	0.18	J	0.64		0.099	J
Nickel	mg/kg	4.4		4.4		2.1		3.4		5.3		2	
Potassium-40	pCi/g	18.9		9	LT	13.7		17.8		16.1		10.8	
Radium-226	pCi/g	0.91	LT	127	M3	10.6		1.88		6.52		6.23	
Radium-228	pCi/g	<0.56	UJ	<2	UJ	<0.48	U	<0.59	U	<0.81	U	<0.38	U
Selenium	mg/kg	1		7		0.73	J	1.1		1		0.7	J
Silver	mg/kg	0.039	J	0.32		0.023	J	0.028	J	0.033	J	0.021	J
Sodium	mg/kg	39	J	30	J	<97	U	26	J	47	J	21	J
Thallium	mg/kg	0.045		0.19		0.031		0.044		0.078		0.029	
Thorium	mg/kg	3.2		2		1.4		2.5		3.4		1.1	
Uranium	mg/kg	0.91		230		24		1.8		4.8	J	34	
Vanadium	mg/kg	8.4		550		70		11		14	J	73	
Zinc	mg/kg	19		16		7.9	J	16		21		7.7	J

Notes:
Each measurement location is classified as Class 1, Class 2, or Class 3 based on which survey unit the point is located within, the radiological characteristics, and the known historical mine features in relation to that survey unit.

- Not analyzed
bgs Below ground surface
J Estimated value.
LT Result less than requested minimum detectable concentration, but greater than sample-specific minimum detectable concentration.
mg/kg Milligrams per kilogram
M3 The requested minimum detected concentration was not met, but the reported activity is greater than the reported minimum detected concentration.
pCi/g Picocuries per gram
Q Qualifier
U Not detected. The associated value is the reporting limit.
UJ Not considered detected. The associated value is the reported concentration, which is estimated.

Table H28-1-5. Laboratory Analytical Results for Subsurface Soil Samples (1 of 2)

Analyte	Units	Sample ID							
		M28-SS8-01-092618		M28-SB8-0612-01-092618		M28-SS30-01-092618		M28-SB30-0612-01-092618	
		Result	Q	Result	Q	Result	Q	Result	Q
Survey Unit		8				30			
Depth (inches)		0-6		6-12		0-6		6-12	
Classification		Class 2		Class 2		Class 1		Class 1	
Aluminum	mg/kg	4,600		5,100		3,900		2,400	
Antimony	mg/kg	0.047	J	0.05	J	0.18		0.23	
Arsenic	mg/kg	2.2		2.3		12		15	
Barium	mg/kg	120	J	120		85		51	
Beryllium	mg/kg	0.39		0.41		0.19		0.11	
Cadmium	mg/kg	0.043	J	0.051	J	0.83		1.2	
Calcium	mg/kg	18,000		24,000		14,000		8,200	
Chromium	mg/kg	2.5		2.8		2.7		1.6	
Cobalt	mg/kg	3.5		4.2		2.9		2.1	
Copper	mg/kg	15		12		8.9		5.2	
Iron	mg/kg	5,800		6,500		5,400		4,400	
Lead	mg/kg	6.1		6.3		5.8		6	
Lithium	mg/kg	7.7		9.2		12		8.1	
Magnesium	mg/kg	4,200		5,200		3,200		1,700	
Manganese	mg/kg	200		250		110		82	
Mercury	mg/kg	-		-		-		-	
Molybdenum	mg/kg	0.068	J	0.056	J	2.7		3.3	
Nickel	mg/kg	4.4		5.2		4.4		2.4	
Potassium-40	pCi/g	18.9		19.1		9	LT	<6.7	U
Radium-226	pCi/g	0.91	LT	1.5		127	M3	175	M3
Radium-228	pCi/g	<0.56	UJ	<0.65	UJ	<2	UJ	<3	UJ
Selenium	mg/kg	1		1.1		7		7.2	
Silver	mg/kg	0.039	J	0.055		0.32		0.28	
Sodium	mg/kg	39	J	65	J	30	J	<96	U
Thallium	mg/kg	0.045		0.048		0.19		0.36	
Thorium	mg/kg	3.2		3.3		2		1.3	
Uranium	mg/kg	0.91		1.3		230		400	
Vanadium	mg/kg	8.4		9.3		550		820	
Zinc	mg/kg	19		23		16		9.3	J

Table H28-1-5. Laboratory Analytical Results for Subsurface Soil Samples (2 of 2)

Analyte	Units	Sample ID											
		M28-SS32-01-092618		M28-SB32-0612-01-092618		M28-SS104-01-092618		M28-SB104-0612-01-092618		M28-SS133-01-092618		M28-SB133-0612-01-092618	
		Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Survey Unit		32				104				133			
Depth (inches)		0-6		6-12		0-6		6-12		0-6		6-12	
Classification		Class 1		Class 1		Class 1		Class 1		Class 1		Class 1	
Aluminum	mg/kg	2,500		2,400		4,300		4,000		5,600		6,300	
Antimony	mg/kg	0.053	J	0.064	J	0.04	J	0.046	J	0.047	J	0.07	J
Arsenic	mg/kg	2.1		2.3		3.4		3.3		8.4		8.7	
Barium	mg/kg	35		39		95		92		79		79	
Beryllium	mg/kg	0.16		0.16		0.33		0.31		0.38		0.47	
Cadmium	mg/kg	0.11	J	0.14	J	0.053	J	0.045	J	0.058	J	0.086	J
Calcium	mg/kg	7,200		18,000		12,000		11,000		20,000		26,000	
Chromium	mg/kg	1.9		1.8		2.1		1.9		3		4.1	
Cobalt	mg/kg	1.4		1.4		2.9		2.9		3.9		5	
Copper	mg/kg	2.6		2.9		8.4		8.7		12		15	
Iron	mg/kg	2,900		2,600		5,500		5,200		7,400		9,000	
Lead	mg/kg	3.1		3.1		5.2		5.1		8.2	J	7.5	
Lithium	mg/kg	5.6		5.7		7		6.7		12		16	
Magnesium	mg/kg	2,100		2,100		3,300		3,100		5,400		6,600	
Manganese	mg/kg	76		140		190		190		190		210	
Mercury	mg/kg	-		-		-		-		-		-	
Molybdenum	mg/kg	0.18	J	0.22		0.18	J	0.24		0.64		1.1	
Nickel	mg/kg	2.1		2.1		3.4		3.2		5.3		7	
Potassium-40	pCi/g	13.7		13.6		17.8		13.9		16.1		14.4	
Radium-226	pCi/g	10.6		10.6		1.88		2.14		6.52		50.7	M3
Radium-228	pCi/g	<0.48	U	<0.68	U	<0.59	U	<0.84	U	<0.81	U	<1.59	UJ
Selenium	mg/kg	0.73	J	0.9	J	1.1		1.1		1		1.4	
Silver	mg/kg	0.023	J	0.025	J	0.028	J	0.023	J	0.033	J	0.043	J
Sodium	mg/kg	<97	U	<100	U	26	J	23	J	47	J	59	J
Thallium	mg/kg	0.031		0.037		0.044		0.044		0.078		0.12	
Thorium	mg/kg	1.4		1.3		2.5		2.3		3.4		4	
Uranium	mg/kg	24		31		1.8		1.7		4.8	J	13	
Vanadium	mg/kg	70		92		11		9.7		14	J	21	
Zinc	mg/kg	7.9	J	8.3	J	16		16		21		27	

Table H28-1-5. Laboratory Analytical Results for Subsurface Soil Samples (Continued)

Notes:
Each measurement location is classified as Class 1, Class 2, or Class 3 based on which survey unit the point is located within, the radiological characteristics, and the known historical mine features in relation to that survey unit.

-	Not analyzed
J	Estimated value
LT	Result less than requested minimum detectable concentration, but greater than sample-specific detectable concentration.
mg/kg	Milligrams per kilogram
M3	The requested minimum detected concentration was not met, but the reported activity is greater than the reported minimum detected concentration.
pCi/g	Picocuries per gram
Q	Qualifier
U	Not detected. The associated value is the reporting limit.
UJ	Not considered detected. The associated value is the reported concentration, which is estimated.

Table H28-1-6. Laboratory Analytical Results for Toxicity Characteristic Leaching Procedure

Analyte	TCLP Permissible Limit	Units	Sample ID					
			M28-SSG7-01-092618		M28-SS30-01-092618		M28-SB30-0612-01-092618	
			Result	Q	Result	Q	Result	Q
Survey Unit			G7		30		30	
Depth (inches)			0-6		0-6		6-12	
Classification			Class 1		Class 1		Class 1	
Arsenic	5	mg/L	<0.1	U	<0.1	U	0.033	J
Barium	100	mg/L	0.58	J-	1.1		0.73	J-
Cadmium	1	mg/L	<0.05	UJ	0.0024	J-	0.011	J-
Chromium	5	mg/L	<0.1	U	<0.1	U	<0.1	U
Lead	5	mg/L	<0.04	U	<0.04	U	<0.04	U
Selenium	1	mg/L	0.034	J-	<0.06	UJ	0.017	J-
Silver	5	mg/L	<0.1	U	<0.1	U	<0.1	U

Notes:
Each measurement location is classified as Class 1, Class 2, or Class 3 based on which survey unit the point is located within, the radiological characteristics, and the known historical mine features in relation to that survey unit.

J Estimated value
J- Estimated value, may be biased low.
mg/L Milligrams per liter
Q Qualifier
TCLP Toxicity characteristic leaching potential
U Not detected. The associated value is the reporting limit.
UJ Not considered detected. The associated value is the reported concentration, which is estimated.

Table H28-1-7. Metals Laboratory Analytical Results for Synthetic Precipitation Leaching Procedure

Analyte	Range of Background Concentrations within the Cove Wash[1]	Units	Sample ID					
			M28-SSG7-01-092618		M28-SS30-01-092618		M28-SB30-0612-01-092618	
			Result	Q	Result	Q	Result	Q
Survey Unit			G7		30		30	
Depth (inches)			0-6		0-6		6-12	
Classification			Class 1		Class 1		Class 1	
Aluminum	-	mg/L	1.5		1.5		1.6	
Antimony	-	mg/L	<0.01	U	<0.01	U	<0.01	U
Arsenic	<0.003 to 0.018	mg/L	0.0048	J	0.018	J	0.024	
Barium	-	mg/L	0.021	J	0.044	J	0.027	J
Beryllium	-	mg/L	<0.005	U	<0.005	U	<0.005	U
Cadmium	-	mg/L	<0.02	U	<0.02	U	<0.02	U
Calcium	-	mg/L	<10	U	<10	U	<10	U
Chromium	-	mg/L	<0.1	U	<0.1	U	<0.1	U
Cobalt	-	mg/L	<0.05	U	<0.05	U	<0.05	U
Copper	-	mg/L	<0.2	UJ	<0.2	U	<0.2	UJ
Iron	-	mg/L	<1	U	1.1		1.8	
Lead	< 0.0022 to 0.0074	mg/L	<0.02	U	<0.02	U	<0.02	U
Lithium	-	mg/L	<0.2	U	<0.2	U	<0.2	U
Magnesium	-	mg/L	1.7		1		1.4	
Manganese	-	mg/L	<0.05	U	<0.05	U	<0.05	U
Molybdenum	< 0.0003 to 0.0033	mg/L	<0.02	U	0.0009	J	0.0016	J
Nickel	-	mg/L	<0.2	U	<0.2	U	<0.2	U
Selenium	<0.0015 to 0.015	mg/L	<0.1	U	<0.1	U	<0.1	U
Silver	-	mg/L	<0.005	U	<0.005	U	0.0006	J
Sodium	-	mg/L	<10	U	<10	U	<10	U
Thallium	-	mg/L	<0.001	U	0.0001	J	0.0001	J
Thorium	-	mg/L	0.0003	J	0.0005	J	0.0006	J
Uranium	0.0015 to 0.18	mg/L	0.0035		0.027		0.034	
Vanadium	0.0027 to 0.13	mg/L	0.36		1.4		2.1	
Zinc	-	mg/L	<1	U	<1	U	<1	U

Notes:
Each measurement location is classified as Class 1, Class 2, or Class 3 based on which survey unit the point is located within, the radiological characteristics, and the known historical mine features in relation to that survey unit.
[1] The range of primary analyte concentrations observed in surface water and groundwater as reported in the Cove Wash Watershed Assessment (Weston 2018). No background concentrations were reported for thorium.
- Not applicable
J Estimated value
mg/L Milligrams per liter
Q Qualifier
U Not detected. The associated value is the reporting limit.
UJ Not considered detected. The associated value is the reported concentration, which is estimated.

References:
Weston Solutions, Inc. (Weston). 2018. “Cove Wash Watershed Assessment.” DCN 0100-08-AAYN. April.

Table H28-1-8. Radionuclides Laboratory Analytical Results for Synthetic Precipitation Leaching Procedure

Decay Series	Analyte	Units	Sample ID								
			M28-SSG7-01-092618			M28-SS30-01-092618			M28-SB30-0612-01-092618		
			Result	TPU	Q	Result	TPU	Q	Result	TPU	Q
Survey Unit			G7			30			30		
Depth (inches)			0-6			0-6			6-12		
Classification			Class 1			Class 1			Class 1		
Uranium	Uranium-238[1]	pCi/L	0.48	0.21	J	5.5	1.2	J	0.33	0.13	J
	Uranium-234	pCi/L	0.45	0.2	J	4.5	1	J	0.25	0.11	J
	Thorium-230	pCi/L	0.234	0.082		7.1	1.1		0.322	0.098	
	Radium-226[2]	pCi/L	2.29	0.95		15.9	4.2		7.7	2.3	
	Lead-210	pCi/L	<0.63	0.39	U	7	1.8		<0.64	0.38	U
	Polonium-210	pCi/L	1.09	0.44		13	2.5		0.66	0.35	
Actinide	Uranium-235	pCi/L	0.045	0.075	J	0.32	0.14	J	<0.079	0.053	UJ
Thorium	Thorium-232[1]	pCi/L	<0.031	0.015	U	0.06	0.029		<0.042	0.022	U
	Radium-228	pCi/L	<0.87	0.42	U	<0.96	0.54	UJ	<0.88	0.45	U
	Thorium-228	pCi/L	<0.081	0.052	U	<0.084	0.051	U	<0.111	0.06	U

Notes:
Each measurement location is classified as Class 1, Class 2, or Class 3 based on which survey unit the point is located within, the radiological characteristics, and the known historical mine features in relation to that survey unit.

[1] Measured via alpha spectroscopy.

[2] The range of reported background concentrations for Ra-226 and Ra-228 in surface water and groundwater within the Cove Wash is 0.21 to 2.1 pCi/L as reported in the Cove Wash Watershed Assessment (Weston 2018).

J Estimated value
pCi/L Picocuries per liter
Q Qualifier
TPU Total propagated uncertainty
U Not detected. The associated value is the reporting limit.
UJ Not considered detected. The associated value is the reported concentration, which is estimated.

References:
Weston Solutions, Inc. (Weston). 2018. “Cove Wash Watershed Assessment.” DCN 0100-08-AAYN. April.

Table H28-1-9. Laboratory Analytical Results for Acid-Base Accounting

Analyte	Units	Sample ID		
		M28-SSG7-01-092618	M28-SS30-01-092618	M28-SB30-0612-01-092618
		Result	Result	Result
Survey Unit		G7	30	30
Depth (inches)		0-6	0-6	6-12
Classification		Class 1	Class 1	Class 1
Paste pH	pH	7.9	7.7	8
Total Moisture	Weight Percent	0.69	1.13	1.35
Total Sulfur	Moisture Free Weight Percent	0 U	0 U	0 U
Acid Potential	ppt $CaCO_3$	0 U	0 U	0 U
Neutralization Potential	ppt $CaCO_3$	36	39	30
Acid-Base Accounting	ppt $CaCO_3$	36	39	30

Notes:
Each measurement location is classified as Class 1, Class 2, or Class 3 based on which survey unit the point is located within, the radiological characteristics, and the known historical mine features in relation to that survey unit.
ppt CaCO3 Tons of calcium carbonate equivalent per 1,000 tons of material
U Not detected. The associated value is the reporting limit.

Table H28-1-10. Extended Radionuclides Laboratory Analytical Results

Decay Series	Analyte	Units	Sample ID																			
			M28-XSG7-01-092618			M28-XS29-01-092618			M28-XS148-01-062018			M28-XS162-01-092818			M28-SSG7-01-092618			M28-SS30-01-092618			M28-SB30-0612-01-092618		
			Activity	TPU	Q	Activity	TPU	Q	Activity	TPU	Q	Activity	TPU	Q	Activity	TPU	Q	Activity	TPU	Q	Activity	TPU	Q
Survey Unit			G7			29			148			162			G7			30			30		
Sample Type			XRF Confirmation			XRF Confirmation			XRF Confirmation			XRF Confirmation			Soil Sampling			Soil Sampling			Soil Sampling		
Depth (inches)			0-3			0-3			0-3			0-3			0-6			0-6			6-12		
Classification			Class 1			Class 1			Class 1			Class 1			Class 1			Class 1			Class 1		
Uranium	Uranium-238[1]	pCi/g	193	35	M3	51.9	8.7		92	15		5.27	0.95		14.6	2.4		141	24	M3	173	30	M3
	Uranium-234	pCi/g	150	27	M3	45.5	7.6		100	17		5.7	1		12.7	2.1		132	23		157	28	M3
	Thorium-230	pCi/g	138	21	M3	47.7	7.4	M3	84	13	M3	4.77	0.85	M3	7.2	1.2	M3	109	17	M3	143	22	M3
	Radium-226	pCi/g	136	16	M3	81.9	9.7	M3	94	11	M3	7.6	1		6.23	0.78		127	15	M3	175	21	M3
	Lead-210	pCi/g	68	16		36.4	8.8		61	15		3.23	0.93	J+	4	1.1		70	17		112	27	
Actinide	Uranium-235	pCi/g	9.2	1.9	M3	2.36	0.52		3.57	0.73		0.2	0.097		0.68	0.2		5.7	1.2	M3	7.4	1.5	
Thorium	Thorium-232[1]	pCi/g	0.54	0.12		0.46	0.11		0.78	0.16		1.28	0.28		0.177	0.064		0.49	0.11		0.391	0.093	
	Radium-228	pCi/g	<2.23	0.96	UJ	<1.47	0.9	UJ	<1.3	0.82	UJ	<0.91	0.69	UJ	<0.38	0.23	U	<2	1	UJ	<3	1.8	UJ
	Thorium-228	pCi/g	0.42	0.11		0.42	0.12	M3	0.61	0.15	M3	1.23	0.29	M3	0.3	0.1	M3	0.5	0.14	M3	0.42	0.11	

Notes:
Each measurement location is classified as Class 1, Class 2, or Class 3 based on which survey unit the point is located within, the radiological characteristics, and the known historical mine features in relation to that survey unit.

[1]	Measured via alpha spectroscopy.
J+	Estimated value, may be biased high
M3	The requested minimum detected concentration was not met, but the reported activity is greater than the reported minimum detected concentration.
pCi/g	Picocuries per gram
Q	Qualifier
TPU	Total propagated uncertainty
U	Undetected value. The associated value is the reporting limit.
UJ	Not considered detected. The associated value is the reported concentration, which is estimated.

ATTACHMENT H28-2

FIELD DOCUMENTATION

Attachment H28-2-1. Site Mapping
Attachment H28-2-2. XRF Field Forms
Attachment H28-2-3. Soil Sampling and Boring Logs

ATTACHMENT H28-2-1
SITE MAPPING

Completed 9/26/18
M 26

Site Mapping
Field Sampling Plan 34 Mesa II, Mine No. 1, P-150 AUM Site

Date: 9/26/18

Time: 1100

Weather: Sunny 80°F

GPS Color: Green

Personnel: AO, SK, MH

Site Name: Mesa II, Mine No. 1, P-150

Tetra Tech ID: M28

Site Mapping Objectives: Site mapping will consist of recording the geospatial locations of key site features using a handheld GPS unit and recorded in the mobile data collection devices. Site mapping will focus on (1) gathering geospatial data generated during the Baseline Study gamma and XRF surveys; (2) gathering geospatial data that will inform the Site Characterization Study; and (3) gathering geospatial data to populate the Tronox NAUM Risk Prioritization metric (Section 3.4). The following key site features will be mapped:

- Location of nearest access road/paths
- Location of visible mine features
- Boundaries of mine reclamation features
- Location of nearest surface water body
- Differentiation and mapping of NORM/TENORM boundaries
- Changes and deviations to planned data collection locations. Changes and deviations during XRF surveys will be noted in the XRF field forms.

Access Roads: Describe the route taken and time taken to reach the site

Access by foot from Mesa II Base Camp and walking down foot path from upper level of the mine.

Location of Mine Features

A map showing the expected and existing mine features is provided in Figure FSP34-3. According to the USEPA geodatabase (TSG 2018), there are five closed portals, and one unreclaimed 0.34-acre waste pile present at Mesa II, Mine No. 1, P-150. In summary, the following mine features are documented for Mesa II, Mine No. 1, P-150 in the geodatabase and loaded in the GPS:

- Portals 40, 41, 42a, 42b, 42c (closed)
- Waste Pile 42 (unreclaimed)

Note the location and condition of mine features in the table below:

Mine Feature	Is the location in Geodatabase accurate? If not, record new coordinates and note.	Condition of Mine Feature/Notes
Portal 40 (closed)	Yes; photo visited by AO 9/26/18	Closed; but slope has eroded reclanation but PUF is still intact drainage above and below.
Portal 41 (closed)	Yes; photo/video by AO 9/26/18	Closed; no sign of timbers of portal all dirt on top drainage below to sandstone ledges access to below
Portal 42a (closed)	Most likely	No access
Portal 42b (closed)	Most likely	No access

Mine Feature	Is the location in Geodatabase accurate? If not, record new coordinates and note.	Condition of Mine Feature/Notes
Portal 42c (closed)	Most likely	No access
Waste Pile 42 (unreclaimed)	Yes	However, rock pile added to EAST/NORTHEAST

Boundaries of mine reclamation features

The Roux liability assessment (Roux 2011) indicated that the Mesa II, Mine No.1, P-150 had been reclaimed by NAMLRP. Five portals (Portals 40, 41, 42a, 42b, and 42c) were excavated, stablized, and closed with PUF (Neptune and TSG 2017).

Record notes about the boundaries of reclamation features and GPS the perimeter of reclamation features, if applicable.

Portal 40/41 - closed and documented. See video 9/26/18 by AO. Waste pile is unreclaimed and was photo documented.

Location of Nearest Surface Water

There is a drainage channel southeast of Mesa II, Mine No. 1, P-150. Site reconnaissance is necessary to verify the likelihood for presence of this drainage pathway and off-site migration. There are no wells identified within the vicinity of this AUM site and associated Target sites. The nearest registered well is 09K-223, which is located 1.76 miles from the AUM site according to the USEPA geodatabase (TSG 2018).

Record notes about surface water bodies present and the likelihood for off-site migration via surface water.

A number of drainages on west, and on east/NW were noted on MOBILIZATION #9.

Differentiation and mapping of NORM/TENORM boundaries

NORM/TENORM will be differentiated and verified during the Baseline Study and if necessary, confirmed and adjusted in the Site Characterization Study. A combination of geologic engineering judgement, visual assessment of mining-disturbed areas, and comparison of Ra-226 and metals concentrations in soils to background will be used to differentiate between NORM and TENORM. Additionally, Tetra Tech will follow USEPA guidance for using multiple lines of evidence to evaluate NORM and TENORM.

Is there a clear demarcation between waste rock piles from mining versus naturally-occurring rocks in the area? Describe the conditions and GPS the waste rock piles, if applicable.

Maybe/Yes waste piles are evident.
09288 appeared as waste pile but may not be actual waste pile.

Is natural outcropping of the Salt Wash Member of the Morrison Formation apparent at the site? If so, where?

Yes, along geologic divide there is evidence of salt wash outcrops.

How do open adits, portals, haul shafts, or boreholes at the site impact NORM/TENORM boundaries?

N/A; ALL PORTALS ARE CLOSED.

Tronox NAUM Risk Prioritization Ranking

Radiation Level Above Background

1. Greater than 100 X Above Background
2. 10-100 X Above Background
3. 2-10 X Above Background
4. Less than 2 X Above Background
5. At Background level

- Waste Material Characteristics

1. High mobility (fine) > 1 acre (8 to -1 0)
2. High mobility (fine) < 1 acre (8 to -1 φ)
3. Moderate mobility (-1 to -6 φ)
4. Low mobility (-6 to -1 φ)
5. None

- Migration to Surface Water

1. Surface water flowing through the site or mine waste located in a surface water body
2. Likely (mobile material or surface water within 200 foot)
3. Potential (surface water within 0.25 miles)
4. Unlikely (based on distance and material)
5. None

- Land-Use Scenario

1. Residential
2. Cultural
3. Agricultural
4. Grazing
5. Recreational

- Accessibility

1. Mine is readily accessible from a maintained road using a standard two-wheel drive passenger vehicle or by walking

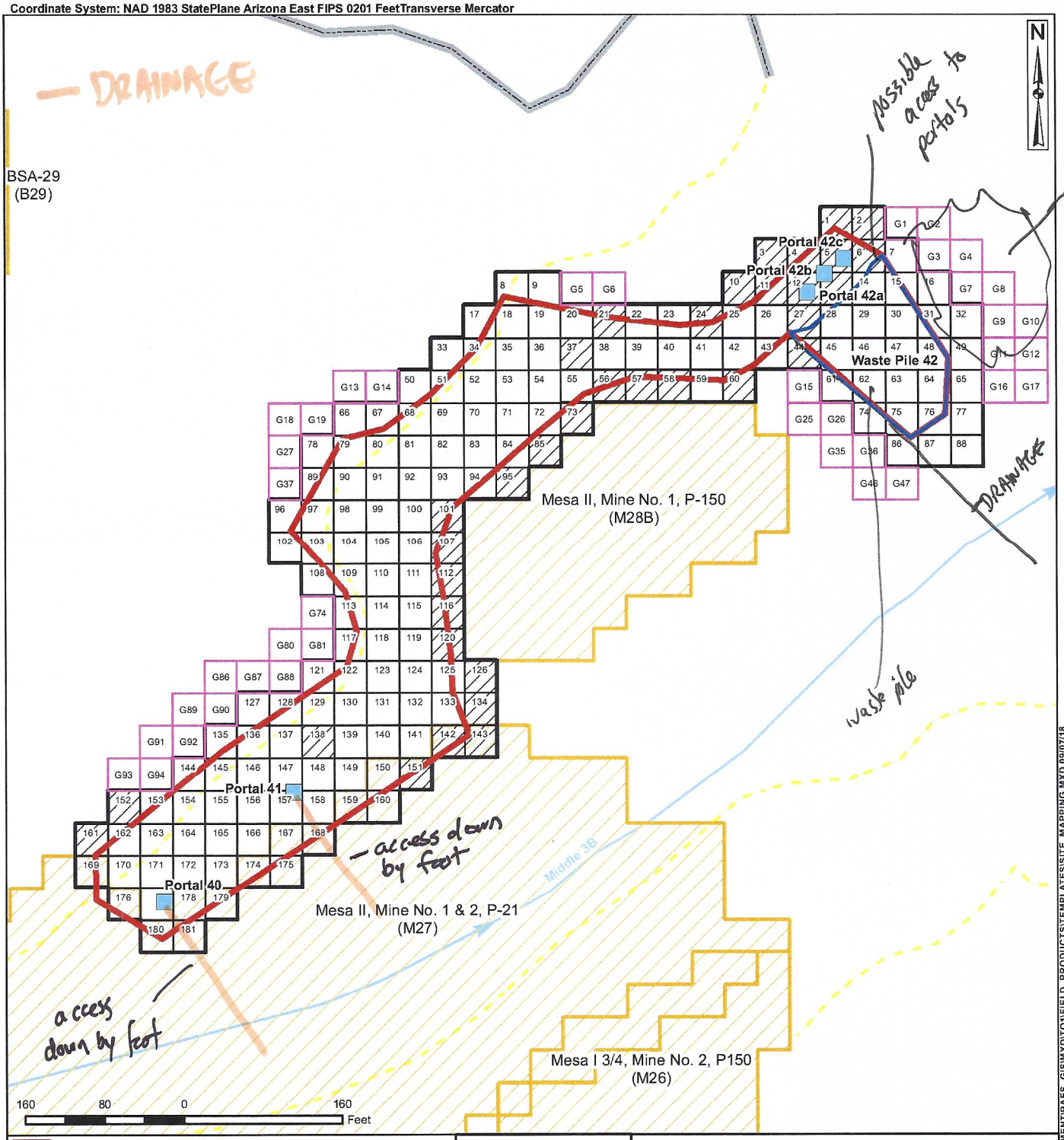
2. Not accessible by standard two-wheel drive passenger vehicle; accessible by four-wheel drive vehicle or a utility task vehicle
3. Mine is inaccessible to a four-wheel drive vehicle or a utility task vehicle
4. Mine access requires a moderate hike across relatively flat terrain of less than 1 mile
5. Mine access requires a hard hike (e.g. heavy vegetation, grade greater than 10% slope, no defined trail, etc.) of greater than 1 mile to access the mine

- Reclamation Status
  1. Un-reclaimed
  2. Reclamation deteriorating
  3. Reclamation performed/status unknown (waste inaccessible)
  4. Reclamation action stable/effective

- Impacts to Ground Water
  1. Yes ground water may be impacted by mine workings *Maybe from mine workings. *
  2. No ground water is likely not impacted by mine workings

- Surface Area of Contamination
  1. Greater than 40 acres
  2. 20 to 40 acres
  3. 10 to 20 acres
  4. Less than 10 acres
  5. None

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



AUM Site
Initial Survey Boundary
Survey Grid Unit (100 m²)
Other Survey Boundary
Inaccessible
Access Route - Foot
Access Route - Vehicular

Reclaimed Features
Closed Portal

Unreclaimed Features
Waste Pile

Prepared for: USEPA Region 9

Prepared By:
TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

MESA II, MINE NO. 1, P-150
PROPOSED SITE CHARACTERIZATION SAMPLING PLAN

Task Order RSE Report No.:	Contract No.:	Figure No.:
TO 001	EP-S9-17-03	M28
Location: COVE CHAPTER NAVAJO NATION	Date: 9/7/2018	

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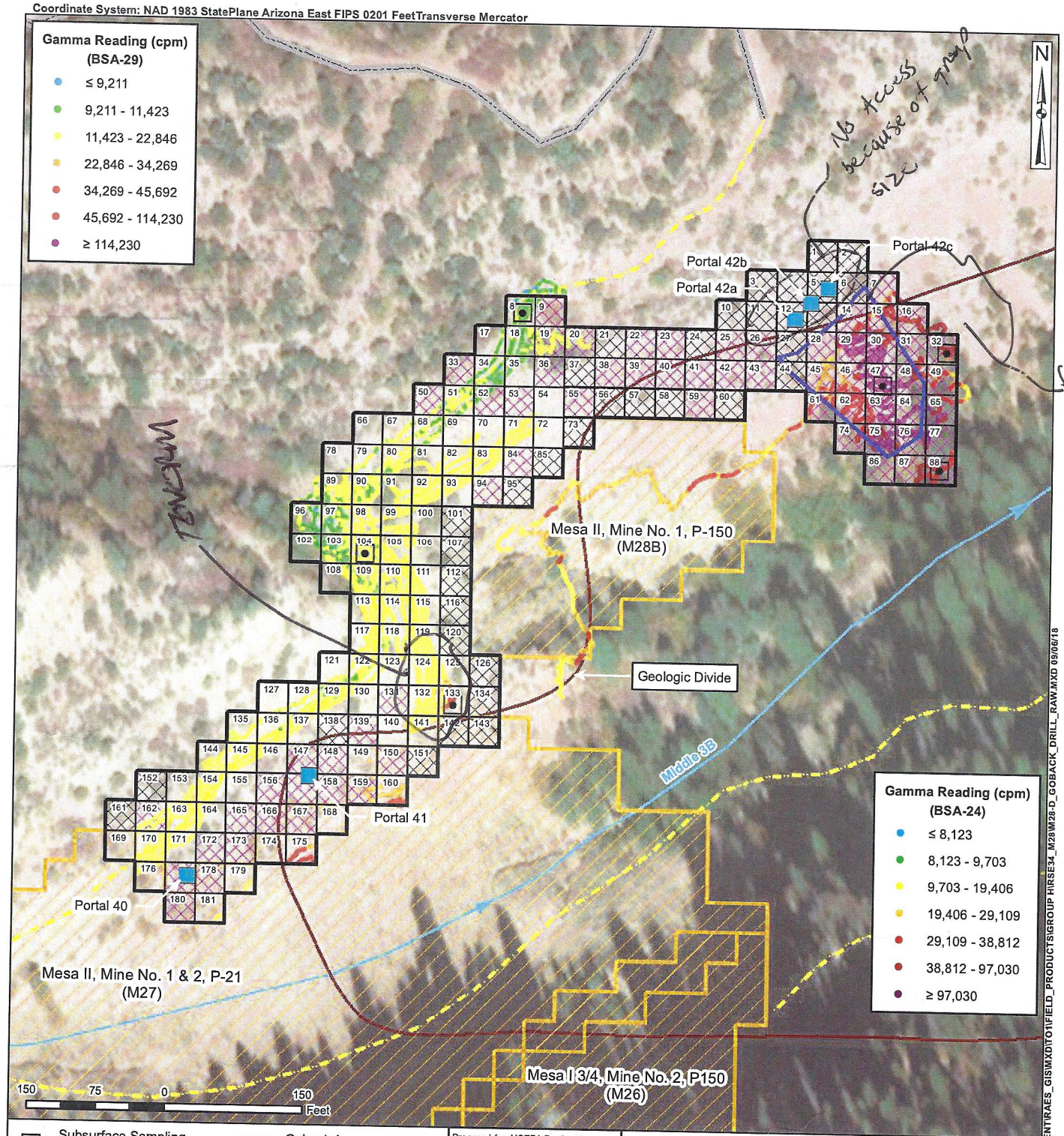

Subsurface Sampling Location
Closed Portal
Waste Pile - Unreclaimed
Initial Survey Boundary
Survey Grid Unit (100 m²)
Inaccessible
Goback Access Reevaluation
Other Survey Boundary
Access Route - Foot
Access Route - Vehicular
Geologic Divide
Drainage

Note: Mesa II, Mine No. 1, P-150 has a geologic divide and is represented by two background study areas (BSAs). The investigation Level (IL) for BSA-24 is 9,703 cpm. The IL for BSA-29 is 11,423 cpm. Both of the ILs are the UTL 95-95 calculated from gamma radiation levels at the respective BSAs.

Prepared for: USEPA Region 9

Prepared By:

TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

MESA II, MINE NO. 1, P-150
PROPOSED SITE CHARACTERIZATION SAMPLING PLAN

Task Order RSE Report No.:	Contract No.:	Figure No.:
TO 001	EP-S9-17-03	M28-D
Location: COVE CHAPTER NAVAJO NATION	Date: 9/6/2018	

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DRAFT

Waste Pile Observation Form

Date/Time: 9/26/18

Weather: 80°F SUNNY

GPS Color: GREEN

Personnel: AO, SK, MH

Site Name: Mesa II, Mine No. 1 P-150

Tetra Tech ID: M28

Waste Pile ID: 42

☒ Photographed? ☒ Subsurface sampling performed? First interval sample ID: GRIDS G7; 30

Waste Pile Observation Objectives: *The objective of the unreclaimed waste pile observation is to document the physical location characteristics, mine waste material characteristics, and provide visual estimates of the depth of mine waste.*

Physical Location Description: Describe the topography of the unreclaimed waste pile(s) location. Note proximity to drainages, vegetation, erosional features and proximity to mine features. Also note if mining debris is present.

Main waste pile is fine grained w/ gravel and some cobbles
grayish green - approx 5' deep at 45° slope.
No vegetation; drainage on south side
Vegetation & native soil separates this waste pile
from large rock slide and/or waste pile
further to NORTHEAST.

Access Description: Describe the access route to the unreclaimed waste pile. Does foot access require a different route than nearby mine features? Is there evidence of haul roads? Note time required for foot access from UTV parking.

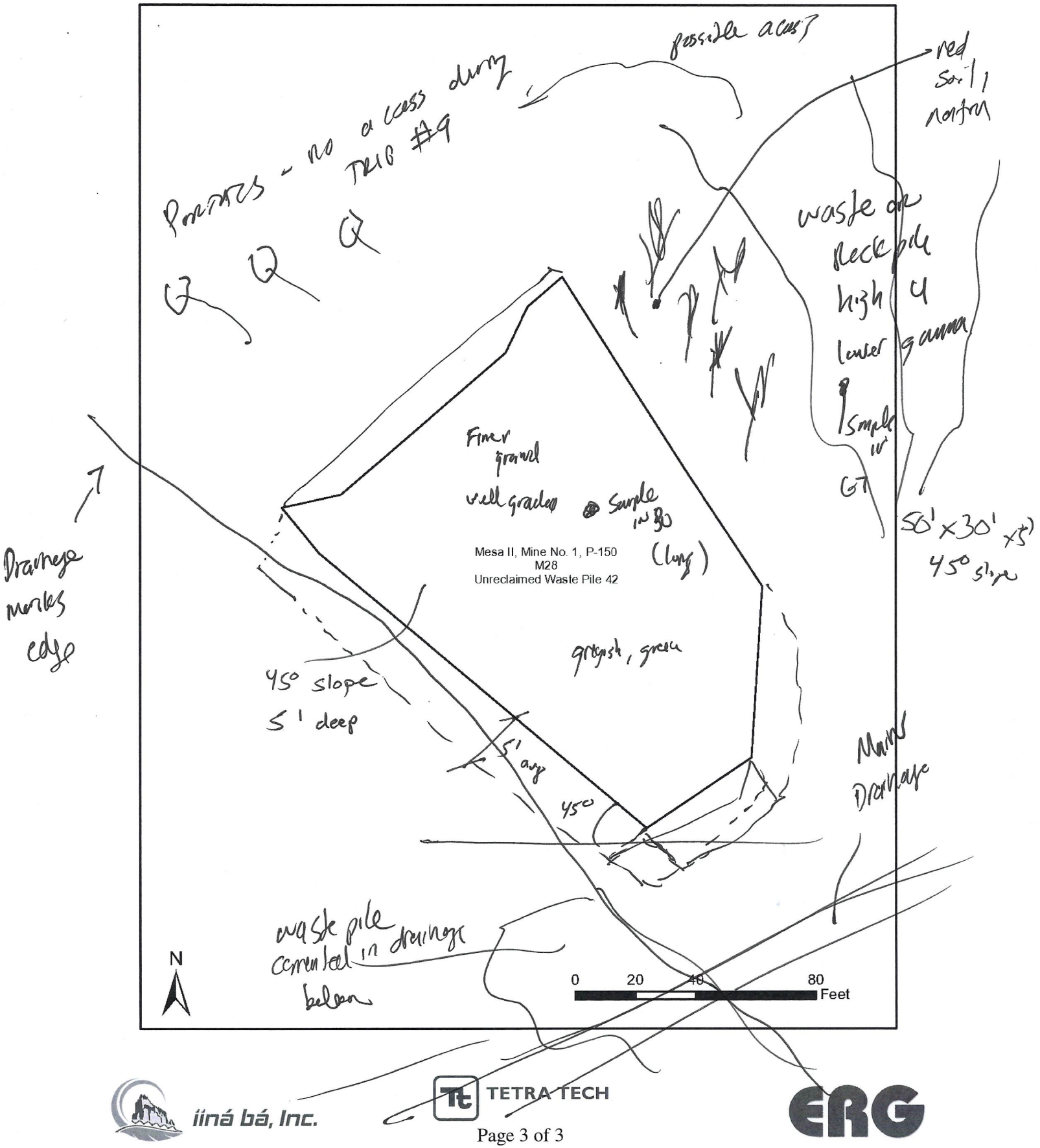
Access is from MW8 through MW7 down drainage or along cliff trail. Difficult access.

Material Characteristics: Describe the general soil characteristics (texture, color, grain size) of the mine waste.

WP1 - Fine grained, greyish, green, w/sand, gravel, and cobbles.

WP2 - Large cobbles w/ carnotite deposits scattered.

Waste Pile Sketch – Where possible note visual estimate of mine waste depth.



ATTACHMENT H28-2-2
XRF FIELD FORMS

XRF Form

Site Type: ~~Target~~ AUM
AUM Site: Mesa II Site
Tetra Tech ID: M28
Sampling team: Minc AO.1, R150 Bryan, Patrick Mark
XRF Color: Blue

Date: 6/20th/18
Weather:
Page No.: 1 of 5
GPS Color: Blue

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
X180	6/20/18	1038	No	49, 14	57, 11	NO				
X181		1049	YES	77, 27		NO				OFFSET DUE TO CLIFF DATA BLOCK XRF WAS NOT WIPED READING #92
X178		1051	NO	52, 11		NO				OFFSET DUE TO CLIFF
X179		1054	YES	74, 14		NO				
X177		1058	NO	62, 8		NO				
X176		1100	YES	242, 22		NO				OFFSET CLIFF FACE
X172		1103	NO	70, 17		NO				
X173		1105	NO	85, 9		NO				
X165		1107	NO	94, 12		NO				
X166		1112	YES	152, 17		NO				OFFSET DUE TO CLIFF

Notes to field team:
If the location of an in situ XRF measurement is adjusted by more than 1 foot, make a note of the direction of the adjustment in the notes seciton and record new coordinates in the GPS.
If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

XRF Form

Site Type: AUM SITE
AUM Site: MESA II Mine no. 4, P-950
Tetra Tech ID: M28
Sampling team: BRYAN, PATRICK, MARK
XRF Color: BLUE

Date: 6/20/18
Weather:

Page No.: 2 of 5
GPS Color: BLUE

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
X155	6/20/18	1114	YES	72, 27	75, 31	YES	M28-XS155-01-062018	NO		SAMPLE TIME 1118
X156		1134	YES	49, 27		NO				OFFSET DUE TO CLIFF
X157		1136	NO	74, 28		NO				
X167		1138	NO	160, 84		NO				
X158		1142	YES	61, 7		NO				OFFSET DUE TO BRUSH
X147		1144	YES	46, 28		NO				OFFSET DUE TO CLIFF
X148		1146	NO	109, 37	142, 148	YES	M28-XS148-01-062018	NO		SAMPLE TIME 1149
X149		1201	NO	62, 11		NO				
X139		1204	YES	119, 96		NO				OFFSET DUE TO CLIFF
X140		1210	NO	56, 13		NO				

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XRF Form

Site Type: AUM SITE
AUM Site: MESA II MINE NO. 1, P-150
Tetra Tech ID: M28
Sampling team: BRYAN, PATRICK, MARK
XRF Color: BLUE

Date: 6/20/18
Weather:

Page No.: 3 of 5
GPS Color: BLUE

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
X141	6/20/18	1212	NO	45, 7		NO				
X133		1216	NO	71, 50		NO				
X132		1218	NO	52, 9		NO				
X133		1222	YES	51, 15		NO				OFFSET CLIFF SIDE/ROCKS
X124		1224	NO	52, 13		NO				
X118		1229	NO	45, 9		NO				
X123		1232	NO	27, 6		NO				
X108		1334	NO	45, 7		NO				
X109		1336	NO	41, 7		NO				
X110	↓	1338	NO	36, 5		NO				

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XRF Form

Site Type: AUM SITE
AUM Site: MESA II MINE no. 1, P-150
Tetra Tech ID: M28
Sampling team: BRYAN, PATRICK, MARK
XRF Color: BLUE

Date: 6/20/18
Weather:

Page No.: 4 of 5
GPS Color: BLUE

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
X113	6/20/18	1340	NO	27, 083 LOD		NO				
X114		1342	YES	38, 5		NO				
X117		1344	NO	46, 6		NO				
X122		1347	NO	37, 4		NO				
X121		1349	NO	60, 0		NO				
X129		1351	NO	38, 5		NO				OFFSET 1M DUE TO CLIFF
X130		1353	YES	61, 6		NO				
X137		1355	NO	59, 9		NO				
X136		1357	NO	47, 7		NO				
X135		1400	YES	55, 7		NO				OFFSET 2M CLIFF EDGE/BIG BUSH

Notes to field team:
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XRF Form

Site Type: AUM SITE
AUM Site: MESA II MINE NO. 1, P-150
Tetra Tech ID: M28
Sampling team: BRYAN, PATRICK, MARK
XRF Color: BLUE

Date: 6/20/18
Weather:

Page No.: 5 of 5
GPS Color: BLUE

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
X141	6/20/18	1403	YES	30, 4		NO		NO		OFFSET 4M DUE TO BIG BUSH
X145		1405	NO	56, 9		NO		NO		
X146		1407	NO	31, 5		NO		NO		
X154		1409	NO	104, 29		NO		NO		
X153		1412	YES	53, 7		NO		NO		OFFSET 3M DUE TO TREES/BRUSH
X163		1414	NO	80, 18		NO		NO		
X164		1416	YES	39, 5		NO		NO		OFFSET 4M DUE TO CLIFF
X171		1418	NO	34, 5		NO		NO		
X170		1420	NO	98, 27	73, 22	YES	M28-XS170-01-062018	NO		SAMPLE TIME 1423
X128		1434	YES	31, 4		NO		NO		OFFSET 2M / BRUSH

Notes to field team:
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*Select metals TBD in field, note the metal on logsheet.

XRF Field Form

Site Type: AUM
Site Name: Mesa II, Mine No. 1, P-150
Tetra Tech ID: M28
Sampling team: KD, KR, AB
XRF Color: Yellow

Date: 20 June 2018
Weather: Sunny 80s
Page No.: p.1
GPS Color: ~~Yellow~~ Yellow

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
X 26	20 June 208	1040		V 40 U ~~6~~ 15		N		N		XRF data was not cleared 1st Rdg # will be found and noted.
X 25		1042	~~Yes~~ ~~1M~~	V 40 U 13		N		N		
X43		1044	Yes 1M	V 116 U 384		Y	M1-XS43-01-062018	N		offset due to tree 1046
X42		1055		V 49 U 10	~~V~~ 52 U 10	N		N		Trip Rdg.# is "170"
X41		1104		V 33 U 8		N		N		
X59		1106		V 141 U ~~1~~ 20		N		N		offset due to cliff
X40		1108		V 39 U 8		N		N		
X39		1111		V 38 U 10		N		N		
X23		1114		V 44 U 07		N		N		offset due to cliff
X22	↓	1117		V 33 U 07						

Notes to field team:
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XRF Field Form

Site Type: AUM-Nose II, Mine No. 4, P-150
Site Name:
Tetra Tech ID: M28
Sampling team: KD, KR, AB
XRF Color: Yellow

Date: 20 June 2018
Weather: Sunny

Page No.: p 2
GPS Color: Yellow

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
x38	20 June 2018	1121		V 40 U 08		N		N		
x55		1125		V 33 U 08		N		N		
x54		1128		V 32 U 11		N		N		
x72		1131		V 36 U 09		N		N		offset due to obvious cliff
x71		1133		V 43 U 10		N		N		
x83		1136		V 34 U 08		N		N		
x70		1140		V 55 U 10		N		N		offset due to rock pile
x69		1142		V 17 U ~~<3~~ 3		N		N		
x81		1145		V 36 U 10		N		N		
x82	↓	1147		V 36 U 07		N		N		

Notes to field team:
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XRF Field Form

Site Type: AUM-Mesa II, Mine No. 1, P-150
Site Name: N28
Tetra Tech ID: KD, KR, AB
Sampling team:
XRF Color: Yellow

Date: 20 June 2018
Weather: Sunny
Page No.: P.3
GPS Color: Yellow

28 062018
Example Sample ID: M1-XS1-01-~~042218~~
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
x93	~~1150~~ 20 June 2018	1150	N	V 35 @ U 7		N		N		
x92	20 June 2018	1152	N	V 31 U 06		N		N		
x91		1155	Yes 1M	V 34 U ~~<3~~ <3		N		N		offset, slightly due to brush
x99		1157	N	V 48 U 12		N		N		
x100		1200	N	V 30 U 06		N		N		#197-Misshoot
x105		1202	N	V 26 U 05	V 24 U 04	Y	N28-XS105-01-062018	N		1210 KR
x106		1210	Yes 2M	V 35 U 07		N		N		offset due to cliff
x111		1212	N	V 37 U 09		N		N		~~1210KR~~ offset due to cliff
x115		1215	N	V 43 U 08		N		N		
x114	↓	1219	Yes 2M	V 31 U 08		N		N		offset due to brush

Notes to field team:
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*Select metals TBD in field, note the metal on logsheet.

XRF Field Form

Site Type: AUM - Mesa II, Mine No. 1, P-150
Site Name: M 28
Tetra Tech ID:
Sampling team: KD, KR, AB
XRF Color: Yellow

Date: 20 June 2018
Weather: Sunny 80s

Page No.: P. 6 of 6
GPS Color: Yellow

Example Sample ID: M1-XS1-01-~~042218~~ 062018
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
x119	20 June 2018	1223	No	V 30 U 05		N		N		
x125		1226	Yes 3M	V 34 U 06		N		N		offset due to cliff
x103		1233	N	V 29 U ~~<3~~ <3		N		N		
x104		1234	N	V 39 U 07		N		N		
x102		13:42 ~~13:32~~		V 32 U 8						13:42 is correct sampling time KR
x96		13:34		V 25 U <3						
x97		13:36		V 29 U 4						
x98		13:38		V 33 U 9						#212 misfire
~~x~~		13:32		V 32 U						KR
x99	✓	13:44		V 33 U 4						

Notes to field team:
If the location of an in situ XRF measurement is adjusted by more than 1 foot, make a note of the direction of the adjustment in the notes seciton and record new coordinates in the GPS.
If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

XRF Field Form

Site Type: AUM
Site Name: Mesa II, Mine No. 1, P-150
Tetra Tech ID: M28
Sampling team: KR, KD, AB
XRF Color: Yellow

Date: 6/20/18
Weather: Sunny, 80's
Page No.: 5
GPS Color: Yellow

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
X 78	6/20/18	13:47 ~~13:44~~	No	V 39 U 6						
X 96		13:50		V 28 U 6						
X 79		13:52		V 51 U 9						
X 80		13:55		V 40 U 6						offset by boulder, cliff ~3m
X 67		13:58		V 66 U 12						66 inaccessible due to rock cliff
X 68		14:01		V 21 U <3						
X 51		14:03		V 40 U 6						50 inaccessible, cliff 52 slope > 45°, loose material
X 34		14:05		V 30 U 4						33 inaccessible - rock cliff
X 35		14:07		V 30 U 6						offset ~2m due to cliff
X 18	↓	14:09		V 18 U <3						

Notes to field team:
If the location of an in situ XRF measurement is adjusted by more than 1 foot, make a note of the direction of the adjustment in the notes seciton and record new coordinates in the GPS.
If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

XRF Field Form

Site Type:
Site Name:
Tetra Tech ID:
Sampling team: KD, KR, AB
XRF Color: Yellow

Date: 6/20/18
Weather: Sunny 80s
Page No.: 6
GPS Color: Yellow

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
X17	06/20/18	14:11		V 32 u 4						
X8	06/20/18	14:13		V 25 u <3	V 22 u 3	Yes	M28-XS8-01-062018	N		14:14
				V u						

Notes to field team:
If the location of an in situ XRF measurement is adjusted by more than 1 foot, make a note of the direction of the adjustment in the notes seciton and record new coordinates in the GPS.
If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

XRF Field Form

Site Type: AUM Site
AUM Site: Mesa II, Mine No. 1, P-150
Tetra Tech ID: M2S
Sampling team: AB, KS, PM
XRF Color: Blue

Date: 26 Sept. 2018
Weather: Sunny.
Page No.: 1/6
GPS Color: Blue

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
										NOT GREY WASTE MATERIAL
X14	9/26/18	1059	N	V 23 U 11	V 25 U 10	N	—	N	—	Top of waste rock pile, adjacent to cliff. offset slightly due to cliff
X29		1207	N	V <LOD U 70	V <LOD U 87	Y	M28-XS29-01-092618	N	—	Duplicate, triplicate, soil pinched from rock face ST: 1209
X15		1111	N	V 10 U 10	—	N	—	N	—	
G3		1114	N	V <lod U 7	—	N	—	N	—	
G2		1116	Y	V <lod U 6	—	N	—	N	—	offset due to Cliff
G4		1122	N	V <LOD U 7	—	N	—	N	—	ADJACENT TO METAL RAIL
X16		1129	N	V 267 U 128	—	N	—	N	—	ADJACENT TO METAL RAIL
G7		1132	Y	V 1009 U 716	V 924 U 661	N	M28-XSG7-01-092618	N	—	1st Rdg V: 924 U: 661 | WASTE ROCK PILE ADJACENT TO RAIL 2nd Rdg V: 1009 U: 716 ST: 1138 (YELLOW DUST NOTED IN SAMPLE
G8		1146	N	V <LOD U 5	—	N	—	N	—	
~~G3~~		1109	N	V <LOD U 7	OMIT	—		N	OMIT	

Notes to field team:
If the location of an in situ XRF measurement is adjusted by more than 1 foot, make a note of the direction of the adjustment in the notes seciton and record new coordinates in the GPS.
If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

XRF Field Form

Site Type: AUM Site
AUM Site: Mesa II, Mine No. 1, P-150
Tetra Tech ID: M28
Sampling team: KSPM, AB
XRF Color: Blue

Date: 26 Sept 2018
Weather: Sunny
Page No.: 2/6
GPS Color: Blue

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
G9	9/26/18	1151	Y	V: <LOD U: 6	—	N	—	N	—	~~Heavily~~ offset Bottom of waste rock pile above cliff edge
X32		1153	N	V: <LOD U: 9	—	N	—	N	—	NATIVE SOIL, Pink-reddish brown
X31		1155	Y	V: <LOD U: 12	—	N	—	N	—	offset due to cliff
X30		1200	N	V: <LOD U: 94	—	N	—	N	—	FINE GREY WASTE MATERIAL
X47		1216	Y	V: <7 U: 123	—	N	—	N	—	offset due to dress East edge of Waste Rock
X63		1221	Y	V: <LOD U: 76	—	N	—	N	—	OFSET @ TOE OF WASTEPILE
X62		1224	N	V: 46 U: 46	—	N	—	N	—	IN DRAINAGE
X46		1227	N	V: <LOD U: 17	—	N	—	N	—	OFFSET BECAUSE OF ROCK
X45		1246	N	V: 39 U: 9	—	N	—	N	—	~~OFFSE~~
X28		1249	N	V: 47 U: 8	—	N	—	N	—	OFFSET DUE TO CLIFF & LOW ACCURACY

Notes to field team:
If the location of an in situ XRF measurement is adjusted by more than 1 foot, make a note of the direction of the adjustment in the notes seciton and record new coordinates in the GPS.
If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

XRF Field Form

Site Type: AUM SITE
AUM Site: MESA II, Mine No. 1, P-150
Tetra Tech ID: M28
Sampling team: KS, PM, AB
XRF Color: Blue

Date: 26 Sept. 2018
Weather: Sunny
Page No.: 3 / 6
GPS Color: Blue

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
X76	9/24/18	1304	N	V 1278 U 451	—	N	—	N	—	Collected in waste rock pile on side of drainage going through waste pile.
X77		1308	N	V 507 U 358	—	N	—	N	—	BELOW WASTEROCK PILE IN TREES.
X65		1310	N	V 543 U 427	—	N	—	N	—	OFFSET DUE TO TREES GREY SILTY SAND MATERIAL ~~WASTE PILE MATERIAL~~
X64		1312	N	V 594 U 444	—	N	—	N	—	OFFSET DUE TO VEGETATION
X48		1316	N	V 311 U 163	—	N	—	N	—	TINY WASTE ROCK MATERIAL SILTY SAND BELOW BUSHES
X49		1318	N	V 81 U 32	—	N	—	N	—	OFFSET ½ M due to ledge NATIVE RED/BROWN SOIL
*XG11		1320	N	V 66 U 24	—	N	—	N	—	offset due to rock ENTERED AS XG11
*XG10		1323 ~~1322~~	Y	V 42 U 8	—	N	—	N	—	OFFSET DUE TO VEGETATION ENTERED AS XG10
*XG12		1327	N	V ~~155~~ 18 U 18	—	N	—	N	—	IN WASTE ROCK ENTERED AS XG12
G17	↓	1334	Y	V 70 U 25	—	N	—	N	—	OFFSET SLOPE IN DRAINAGE

Notes to field team:
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If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

*Sediment notes on back

XRF Field Form

Site Type: AUM SITE
AUM Site: MESA II, Mine No. 1, P-150
Tetra Tech ID: M28
Sampling team: KS, PM, AB
XRF Color: Blue

Date: 26 Sept. 2018
Weather: Sunny
Page No.: 4/6
GPS Color: Blue

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
G17A	9/26/18			V: U:						~~X~~
G16		1349	N	V: 99 U: 56	—	N	—	N	—	
X89		1355	N	V: 50 U: 17	—	N	—	N	—	~~Bias~~ In drainage below fine grain waste pile
G47		1401	Y	V: 251 U: 140	—	N	—	N	—	OFFSET DUE TO TREES IN DRAINAGE
G46		1405	N	V: 46 U: 10	—	N	—	N	—	In drainage
X86		1406	Y	V: 71 U: 16	—	N	—	N	—	OFFSET DUE TO FALLEN TREE (SLIGTLY) IN DRAINAGE
X87		1409	Y	V: 211 U: 121	—	N	—	N	—	SHIFTED FOR SAFETY FROM FALLEN TREE IN DRAINAGE
G36		1423	N	V: 101 U: 44	—	N	—	N	—	
X75		1426	Y	V: 99 U: 34	—	N	—	N	—	offset due to rocks
X74		1428	N	V: 139 U: 75	—	N	—	N	—	

Notes to field team:
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If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

XRF Field Form

Site Type: AUM SITE
AUM Site: MESA II, Mine No. 1
Tetra Tech ID: M28
Sampling team: KS AB DM
XRF Color: Blue

Date: 26 Sept. 2018
Weather: Sunny
Page No.: 5/6
GPS Color: Blue

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
G35	9/26/18	1429	N	V 75 U 24	—	N	—	N	—	
G26		1438	N	V 61 U 17	—	N	—	N	—	
G25		1445	Y	V 113 U 39	—	N	—	N	—	OFFSET BECAUSE OF CLIFF
G34		1446	N	V 97 U 47	—	N	—	N	—	
G33		1450	Y	V 70 U 13	—	N	—	N	—	OFFSET DUE TO TREE
G24		1453	Y	V 34 U 7	—	N	—	N	—	OFFSET DUE TO CLIFF
G32		~~1501~~ 1459	N	V 39 U 6	—	N	—	N	—	*Changed battery*
G31		~~1513~~ ~~1505~~	N	V 58 U 15	—	N	—	N	—	2.2M Accuracy ONLY 6 SATALITES
G42		1514	N	V 46 U 14	—	N	—	N	—	
G41		1516	N	V 64 U 15	—	N	—	N	—	2.5M Accuracy 6 SATALITES

Notes to field team:
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If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

XRF Form

Site Type: AUM SITE
AUM Site: MESA II, MINE NO-1
Tetra Tech ID: M28
Sampling team: KS, AB, PM
XRF Color: BLUE

Date: 26 SEPT 2018
Weather: Sunny
Page No.: 6/6
GPS Color: BLUE

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
G30	~~9/26~~ 9/26/18 ~~9/27~~	1520	Y	V: 76 U: 14	—	N	—	N	—	OFFSET DUE TO LOW ACCURACY
G40		1526	N	V: 74 U: 16	—	N	—	N	—	
G39		1529	N	V 52 U 13	—	N	—	N	—	
G28		1530	Y	V 36 U 8	—	N	—	N	—	OFFSET DUE TO CLIFF
G29		1532	N	V 31 U 5	—	N	—	N	—	
G38		1537	Y	V 120 U 51	—	N	—	N	—	OFFSET DUE TO TREE & CLIFF
G50		1540	~~N~~	V 99 U 75	—	N	—	N	—	OFFSET DUE TO CLIFF
G49		1544	Y	~~V 71 U 12~~	~~V 78 U 171~~	Y	M28-XSG49-01-092418	N	—	OFFSET DUE TO CLIFF
				V 80 U 143	V 78 U 171		Rdg #66, 67, 68 labled G49 XRF Moved after 66, 67 & 68 shown to the left. Grey silty sand in potential waste pile			
				V U			disregard reading #66 due to moving XRF during shot			

Notes to field team:
If the location of an in situ XRF measurement is adjusted by more than 1 foot, make a note of the direction of the adjustment in the notes seciton and record new coordinates in the GPS.
If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

XRF Field Form

Site Type: AUM
AUM Site: Mesa 11, Mine No. 1, P-156
Tetra Tech ID: M28
Sampling team: MS, CA, JM
XRF Color: Black

Date: 9/28/18
Weather: Clear, 80°F
Page No.: 1/
GPS Color: Black

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
X159	9/28/18	1543	N	V 37 U 15	—	N	—	N	—	below cliff
X150	9/28/18	1545	N	V 29 U 23	—	N	—	N	—	Reading 1/1 below cliff
G85	9/28/18	1551	N	V 111 U 95	—	N	—	N	—	Slope
G78	9/28/18	1553	N	V 54 U 26	—	N	—	N	—	Slope
G70	9/28/18	1557	N	V 50 U 8	—	N	—	N	—	SLOPE
G61	9/28/18	1559	N	V 46 U 19	—	N	—	N	—	SLOPE
G51	9/28/18	1600	N	V 93 U 20	—	N	—	N	—	SLOPE
G52	9/28/18	1602	N	V 124 U 28	—	N	—	N	—	SLOPE
G53	9/28/18	1604	N	V 73 U 12	—	N	—	N	—	SLOPE

Notes to field team:
If the location of an in situ XRF measurement is adjusted by more than 1 foot, make a note of the direction of the adjustment in the notes seciton and record new coordinates in the GPS.
If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

XRF Field Form

Site Type: M28
AUM Site: Mesa 11, Mine No. 1, P-150
Tetra Tech ID:
Sampling team: AD, JS, MP
XRF Color: Black

Date: 9/28/18
Weather: Sunny, high of 85°F

Page No.: 1
GPS Color: Orange

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
										Reading 54
X162	9/28/18	1551	Yes	V 58 U 26		Yes	M28-XS162-01-092818	No		Steep unstable slope Time: 1558
G94	"	1558	No	V 29 U <5						Reading #56
G93	"	1603	No	V 23 U <5						
G91	"	1607	Yes	V 26 U <3						snags, brush/sand
G92	"	1610	slightly	V 22 U <3						Reading #59
G89	"	1614	No	V 37 U <5						

Notes to field team:
If the location of an in situ XRF measurement is adjusted by more than 1 foot, make a note of the direction of the adjustment in the notes seciton and record new coordinates in the GPS.
If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

XRF Field Form

AUM

Site Type: MESA 2 MINE 1 P.150
AUM Site: M28
Tetra Tech ID: MEGAN, RONEN, MITCH
Sampling team:
XRF Color: WHITE

9/29/18

Date:
Weather: SUNNY 70°F LIGHT BREEZE
Page No.: 1/6
GPS Color: WHITE

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID READING NO.	Notes
~~X45A~~ ~~G45A~~	9/29/18	0934		V 34 U 9	V 36 U 6		~~M28-XSG45-01-092918~~ ~~SOIL SAMPLED 9:45~~		R=3 R=4	GPS LIBRARY NOT ON GPS – NOTE MINE & GRID ONLY * REDUNDANT X45 GRID
G57		948		V 90 U 40						
G45		952		V 54 U 22						
G44		955	Y	V 61 U 29					R=12	OFF-SET – BRUSH
G43		958		V 76 U 12						
G54		1001		V 122 U 11	V 63 U 12	Y	M28-XSG54-01-092918			SOIL SAMPLE 10:05
G64		1009		V 60 U 15						G64
G65		1013		V 46 U 10						G G5
G66 ~~G73~~		1016		V 53 U 13						G66
G58		1018		V 30 U 6						

Notes to field team:
If the location of an in situ XRF measurement is adjusted by more than 1 foot, make a note of the direction of the adjustment in the notes seciton and record new coordinates in the GPS.
If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

XRF Field Form

Site Type: AUM
AUM Site: MINE 2 MINE No. 2 P-150
Tetra Tech ID: M25
Sampling team: MEGAN, RONAN, MITCH
XRF Color: WHITE

Date: 9/29/18
Weather: SUNNY 70°F SLT BRZ
Page No.: 2/
GPS Color: WHITE

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
G55	9/29/18	1020		V 54 U 14						
G73		1023		V 24 U 7						
G72		1024		V 43 U 13						
G63		1026		V 69 U 13						
G71		1029		V 22 U 4						
G79		1032		V 57 U 18						
G62		1044	Y	V 54 U 13						OFFSET - UNSTABLE SLOPE
G84		1056		V 64 U 17						
G83		1058		V 67 U 13						
G82		1102		V 45 U 11						

Notes to field team:
If the location of an in situ XRF measurement is adjusted by more than 1 foot, make a note of the direction of the adjustment in the notes seciton and record new coordinates in the GPS.
If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

(2)

XRF Field Form

Site Type: AUM
AUM Site: M28 2 MINE No. 1 P-150
Tetra Tech ID: M28
Sampling team: MEGAN, RONEN, MITCH
XRF Color: WHITE

Date: 9/22/18
Weather: SEE PAGE 1
Page No.: 3/6
GPS Color: WHITE

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID / READING No.	Notes
G75	9/22/18			V 38 u 13						
~~G76~~ G67		1112		V 39 u 9	V 35 u 8	Y	M28-XSG76-01-092218		R=31	SOIL SAMPLED AT 11:15
G77		1119		V 46 u 7						
~~G69~~ ~~G76~~		1122		V 59 u 14						G69
G68		1124		V 52 u 25						
G67		1127		V 66 u 13						
G59		1131		V 47 u 7						G59
G60		1133		V 41 u 5						
~~X55~~				V u						X55 NOT ACCESSIBLE
G90		1202		V 29 u 4						

Notes to field team:
If the location of an in situ XRF measurement is adjusted by more than 1 foot, make a note of the direction of the adjustment in the notes seciton and record new coordinates in the GPS.
If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

XRF Field Form

Site Type: AUM
AUM Site: MESA 2 MINE No 1 P-150
Tetra Tech ID: M28
Sampling team: MIZHAN, RONAN, MITCH
XRF Color: WHITE

Date: 9/29/18
Weather: SUNNY 75° CLEAR, WINDY
Page No.: 4/6
GPS Color: WHITE

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
G86	9/29/18	1204		V 26 u 5						
X127		1209		V 49 u 8						
G87		1212		V 30 u 3						
G88		1215	Y	V 17 u 6						OFFSET - CLIFF
G80		1217		V 37 u 5						
G81		1219	Y	V 48 u 5						OFFSET - CLIFF
G74		1221		V 37 u 6						
G37		1226		V 30 u 5						
G27		1300		V 31 u 6						
G18		1303		V 38 u 4	V 33 u 3	Y	M28-XSG18-01-092918			SOIL SAMPLE 13:05

Notes to field team:
If the location of an in situ XRF measurement is adjusted by more than 1 foot, make a note of the direction of the adjustment in the notes seciton and record new coordinates in the GPS.
If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

XRF Field Form

Site Type: AUM
AUM Site: MESA 2 MINE No 1 P-150
Tetra Tech ID: M-28
Sampling team: MEGAN, RONAN, MITCH
XRF Color: WHITE

Date: 9/29/18
Weather: SUNNY 75 SCT BRZ
Page No.: 5/6
GPS Color: WHITE

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
G19	9/29/18	1310		V 27 U <3						
X66	"	1314		V 24 U 3						
G13	"	1316		V 29 U <3						
G14	"	1319	Y	V 35 U 3						OFFSET - ROCK OUTCROP
X50	"	1321	"	V 23 U 8						X50
X33	"	1324	"	V 41 U 9						
X19	"	1338	"	V 54 U 5	V 45 U 8	Y	M28-XS19-01-092918			SOIL SAMPLE AT 13:45
X20	"	1343	"	V 57 U 9						
G5	"	1346	"	V 36 U 6						
G6	"	1347	"	V 38 U 6						

Notes to field team:
If the location of an in situ XRF measurement is adjusted by more than 1 foot, make a note of the direction of the adjustment in the notes seciton and record new coordinates in the GPS.
If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

5

XRF Field Form

Site Type: AUM
AUM Site: MESA 2 MINE No 1 P-150
Tetra Tech ID: M28
Sampling team: MEGAN, RONAN, MITCH
XRF Color: WHITE

Date: 9/29/18
Weather: SUNNY 75°F SLT BRZ
Page No.: 6/6
GPS Color: WHITE

Example Sample ID: M1-XS1-01-042218
Example Duplicate ID: M1-XS1-02-042218

XRF Sample ID	Date (M/D/Y)	Time (MST)	Adjusted Location by >1 ft? (Yes or No)	Metal Concentration* (In Situ XRF Measurement, ppm)	Duplicate Metal Concentration (In Situ XRF Measurement, ppm)	Lab Sample Collected? (Yes or No)	Lab Sample ID	Lab Sample Duplicate Collected? (Yes or No)	Duplicate ID	Notes
X9	9/29/18	1352	Y	V 40 U 6						OFFSET DUE TO BRUSH

Notes to field team:
If the location of an in situ XRF measurement is adjusted by more than 1 foot, make a note of the direction of the adjustment in the notes seciton and record new coordinates in the GPS.
If a grid cannot be accessed, make a note and describe the reason.
XRF confirmation samples are collected with in situ XRF measurements.
XRF confirmation samples are collected from 0" to 3" bgs.
*Select metals TBD in field, note the metal on logsheet.

6

ATTACHMENT H28-2-3
SOIL SAMPLING AND BORING LOGS

Subsurface Sample by Hand Field Form

Site Name: Mesa II, Mine No. 1, P-150
Tetra Tech Site ID: M28
Grid Location No.: 8
Date: 9/26/18

Weather: 80°F Sunny
GPS Color: Green
Sampling Team: AO, SK, MH
Page No.: 1

Example Sample IDs: Surface Sample (0-6 inches) M1-SS1-01-090518
Subsurface Sample (6-12 inches) M1-SB1-0612-01-090518
Subsurface Sample (12-18 inches) M1-SB1-1218-01-090518

Field Sample ID	Time (MST)	Duplicate Collected? (Yes or No)	Depth Range (inches)	Duplicate ID	Analysis (Long/Short)	Field Notes
M28-SS8-01-092618	1030	Yes	0"-6"	M28-SS8-02-092618	Short	located on roadway down to Canyon 10,000 cpm silty sand gravel w/gravel
M28-SB8-0612-01-092618	1040	NO	6"-12"	—	Short	greyish brown near drainage from road
~~M28-SB8-1218-01-~~					Short	

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Subsurface Sample by Hand Field Form

Site Name: Mesa II, Mine No. 1, P-150
Tetra Tech Site ID: M28
Grid Location No.: ~~47~~ 30
Date: 9/26/18

Weather: 80°F Sunny
GPS Color: Green
Sampling Team: AG, SK, MH
Page No.: 1

Example Sample IDs:

Surface Sample (0-6 inches) M1-SS1-01-090518

Subsurface Sample (6-12 inches) M1-SB1-0612-01-090518

Subsurface Sample (12-18 inches) M1-SB1-1218-01-090518

Field Sample ID	Time (MST)	Duplicate Collected? (Yes or No)	Depth Range (inches)	Duplicate ID	Analysis (Long/Short)	Field Notes
M28-SS~~47~~30-01-092618	1235	NO	0"-6"	—	Long (extra bag)	130,000 cpm in area; located on waste pile grey, green, purple silty sand w/ gravel
M28-SB~~47~~30-0612-01-092619	1240	NO	6"-12"		Long (extra bag)	Sandstone gravel only to 12"
M28-SB47-1218-01-					Long (extra bag)	

iiná bá, Inc.

TETRA TECH

ERG

Subsurface Sample by Hand Field Form

Site Name: Mesa II, Mine No. 1, P-150
Tetra Tech Site ID: M28
Grid Location No.: 32
Date: 9/26/18
Example Sample IDs: Surface Sample (0-6 inches) M1-SS1-01-090518
Subsurface Sample (6-12 inches) M1-SB1-0612-01-090518
Subsurface Sample (12-18 inches) M1-SB1-1218-01-090518

Weather: 80°F Sunny
GPS Color:
Sampling Team:
Page No.:

Field Sample ID	Time (MST)	Duplicate Collected? (Yes or No)	Depth Range (inches)	Duplicate ID	Analysis (Long/Short)	Field Notes
M28-SS32-01-092618	1205		0'-6"	-	Short	Located at base of pt. pile (large rock) above sandstone drop. silty sand, reddish brown some gravel; adjacent to pile
M28-SB32-0612-01-092618	1210		6"-12"	-	Short	may be native. NO GEOTECH
~~M28-SB32-1218-01-~~					Short	

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ERG

Subsurface Sample by Hand Field Form

Site Name: Mesa II, Mine No. 1, P-150
Tetra Tech Site ID: M28
Grid Location No.: 104
Date: 9/26/18
Example Sample IDs: Surface Sample (0-6 inches) M1-SS1-01-090518
Subsurface Sample (6-12 inches) M1-SB1-0612-01-090518
Subsurface Sample (12-18 inches) M1-SB1-1218-01-090518

Weather: 80°F Sunny
GPS Color: green
Sampling Team: AG, SK, MH
Page No.: 1

Field Sample ID	Time (MST)	Duplicate Collected? (Yes or No)	Depth Range (inches)	Duplicate ID	Analysis (Long/Short)	Field Notes
M28-SS104-01-092618	1045	NO	0"-6"	—	Short	silty sand, brown, moist, grass below road bank
M28-SB104-0612-01-	1055	NO		—	Short	appears to be on old road but now vegetated bed 12,000 cpm
M28-SB104-1218-01-					Short	Geotech collected 8"-15"

Subsurface Sample by Hand Field Form

Site Name: Mesa II, Mine No. 1, P-150
Tetra Tech Site ID: M28
Grid Location No.: 133
Date: 9/26/18

Weather: Sunny
GPS Color: Green
Sampling Team: AD, SK, MH
Page No.: 1

Example Sample IDs: Surface Sample (0-6 inches) M1-SS1-01-090518
Subsurface Sample (6-12 inches) M1-SB1-0612-01-090518
Subsurface Sample (12-18 inches) M1-SB1-1218-01-090518

Field Sample ID	Time (MST)	Duplicate Collected? (Yes or No)	Depth Range (inches)	Duplicate ID	Analysis (Long/Short)	Field Notes
M28-SS133-01-092618	1100	-	0"-6"	—	Short	56,000 cpm; area below drastic previously scanned; Greyish tan; weathered shale silty loam;
M28-SB133-0612-01-092618	1105	-	6"-12"	—	Short	↓ Refusal at 12" This area is possible rimstone or exploration area.
~~M28-SB133-1218-01-~~					Short	
						* GEOTECH Sample collected. *

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Subsurface Sample by Hand Field Form

Site Name: Mesa II, Mine No. 1, P-150
Tetra Tech Site ID: M28
Grid Location No.: ~~88~~ GT
Date: 9/26/18
Example Sample IDs: Surface Sample (0-6 inches) M1-SS1-01-090518
Subsurface Sample (6-12 inches) M1-SB1-0612-01-090518
Subsurface Sample (12-18 inches) M1-SB1-1218-01-090518

Weather: Sunny 80°F
GPS Color: Green
Sampling Team: AO, SK, MH
Page No.: 1

Field Sample ID	Time (MST)	Duplicate Collected? (Yes or No)	Depth Range (inches)	Duplicate ID	Analysis (Long/Short)	Field Notes
M28-SS~~88~~-01- GT	1215	NO	0"-6"	—	LONG AO ~~Short~~	on RT waste pile; greyish poorly graded sand w/ silt and gravel;
M28-SB88-0612-01-					~~Short~~	on drained path
M28-SB88-1218-01-					Short	

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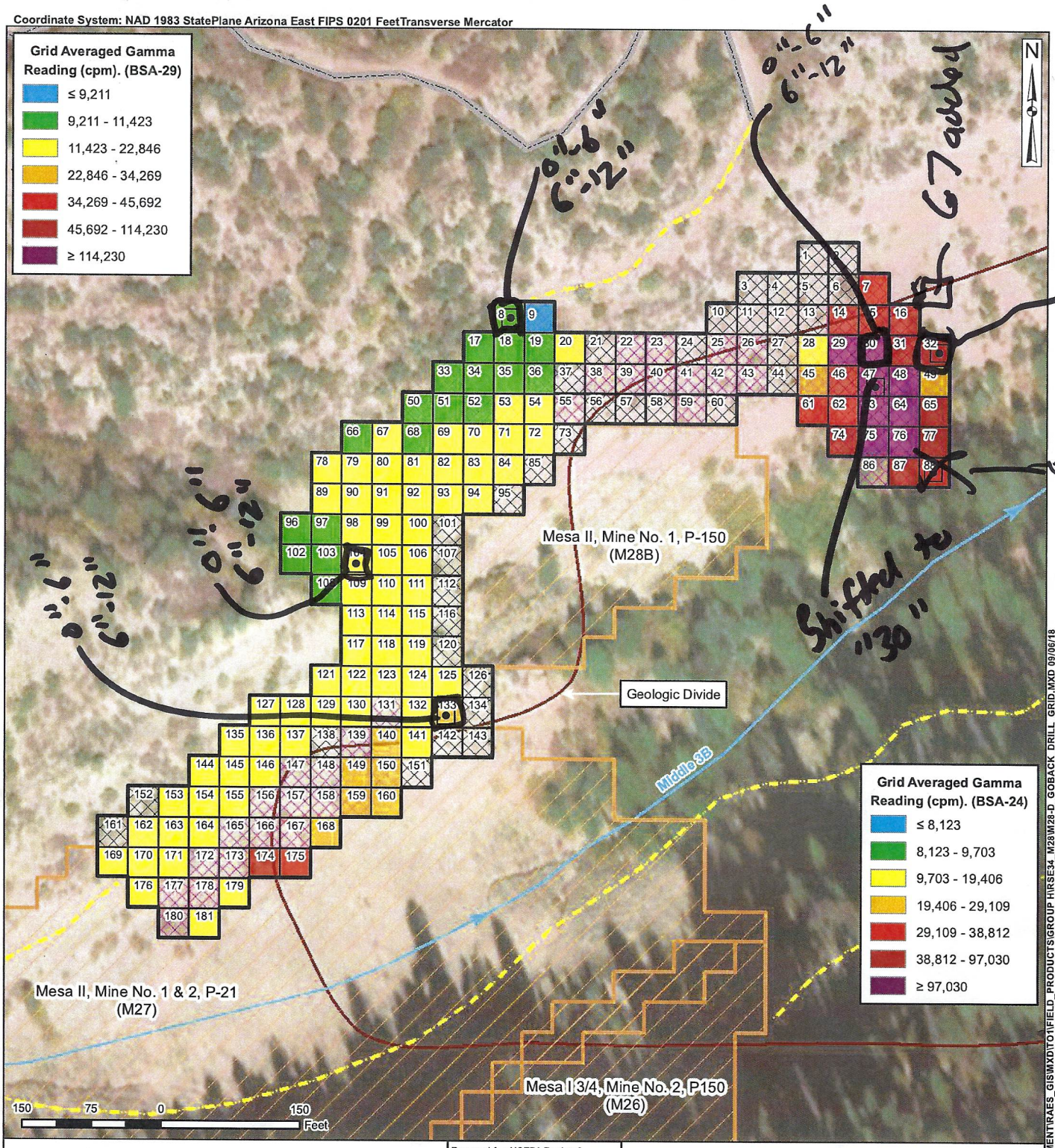


Subsurface Sampling Location
Initial Survey Boundary
Survey Grid Unit (100 m²)
Inaccessible
Goback Access Reevaluation
Access Route - Foot
Access Route - Vehicular
Geologic Divide
Drainage

Note: Mesa II, Mine No. 1, P-150 has a geologic divide and is represented by two background study areas (BSAs). The investigation Level (IL) for BSA-24 is 9,703 cpm. The IL for BSA-29 is 11,423 cpm. Both of the ILs are the UTL 95-95 calculated from gamma radiation levels at the respective BSAs.

Prepared for: USEPA Region 9

Prepared By:

TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

MESA II, MINE NO. 1, P-150
PROPOSED SITE CHARACTERIZATION SAMPLING PLAN

Task Order No.:	Contract No.:	Figure No.:
TO 001	EP-S9-17-03	M28-E
Location: COVE CHAPTER NAVAJO NATION	Date: 9/6/2018	

G:\USERS\JM.HERNING\DOCUMENTS\EM\FIELD DEPLOYMENTRAES_GIS\MXD\TO1\FIELD_PRODUCTS\GROUP HIRSE34_M28\M28-D_GOBACK_DRILL_GRID.MXD 09/06/18

ATTACHMENT H28-3

PHOTOGRAPHIC LOG OF FIELD ACTIVITIES

The following photos were taken during the RAES Task Order 0001 visit to the Mesa II, Mine No. 1, P-150 site (Tetra Tech ID M28) in September 2018.

PHOTOGRAPH 1

Date/Time: 9/26/18 10:55

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: Field personnel at waste pile boundary below cliff.

PHOTOGRAPH 2

Date/Time: 9/26/18 10:58

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: Field personnel on Waste Pile M28.

PHOTOGRAPH 3

Date/Time: 9/26/18 11:06

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: Field personnel at inaccessible cliff area of M28.

PHOTOGRAPH 4

Date/Time: 9/26/18 16:14

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: Field team at M28.

PHOTOGRAPH 5

Date/Time: 9/26/18 11:37

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: Field personnel collecting a surface soil sample at survey unit G7.

PHOTOGRAPH 6

Date/Time: 9/26/18 11:38

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: Field personnel collecting a surface soil sample at survey unit G7.

PHOTOGRAPH 7

Date/Time: 9/26/18 12:32

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: Waste Pile M28 below cliff.

PHOTOGRAPH 8

Date/Time: 9/26/18 13:06

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: Drainage through waste pile.

PHOTOGRAPH 9

Date/Time: 9/26/18 15:34

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: Cliff above survey unit G38.

PHOTOGRAPH 10

Date/Time: 9/26/18 10:46

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: Subsurface soil sampling location in survey unit 104.

PHOTOGRAPH 11

Date/Time: 9/26/18 11:09

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: Closed Portal 40.

PHOTOGRAPH 12

Date/Time: 9/26/18 11:46

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: Steep slope of Waste Pile M28 below cliff.

PHOTOGRAPH 13

Date/Time: 9/26/18 11:55

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: Drainage that cuts through Waste Pile M28.

PHOTOGRAPH 14

Date/Time: 9/26/18 12:12

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: Survey unit 32.

PHOTOGRAPH 15

Date/Time: 9/26/18 12:28

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: Inaccessible cliff area at M28.

PHOTOGRAPH 16

Date/Time: 9/26/18 12:39

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: Collecting a subsurface soil sample at survey unit 30.

PHOTOGRAPH 17

Date/Time: 9/26/18 12:28

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: View facing southwest up the Mesa II valley.

PHOTOGRAPH 18

Date/Time: 9/26/18 13:04

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: View from M28, facing southwest looking at the drainage pathway through mine waste at M27.

PHOTOGRAPH 19

Date/Time: 9/26/18 14:15

Location: Mesa II, Mine No. 1, P-150 (M28)

Description: View from M26, facing northwest, of waste piles at M28.

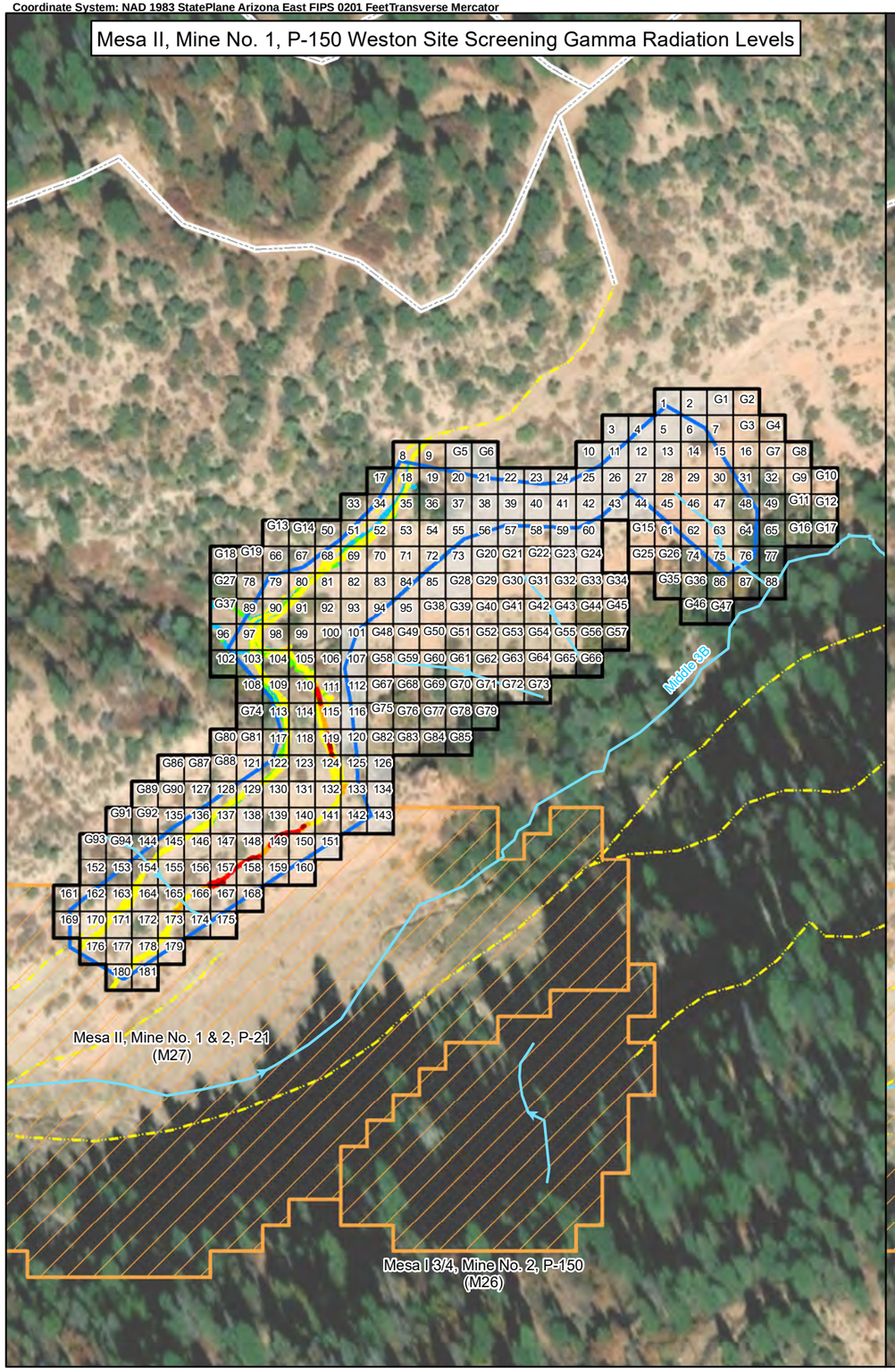
ATTACHMENT H28-4

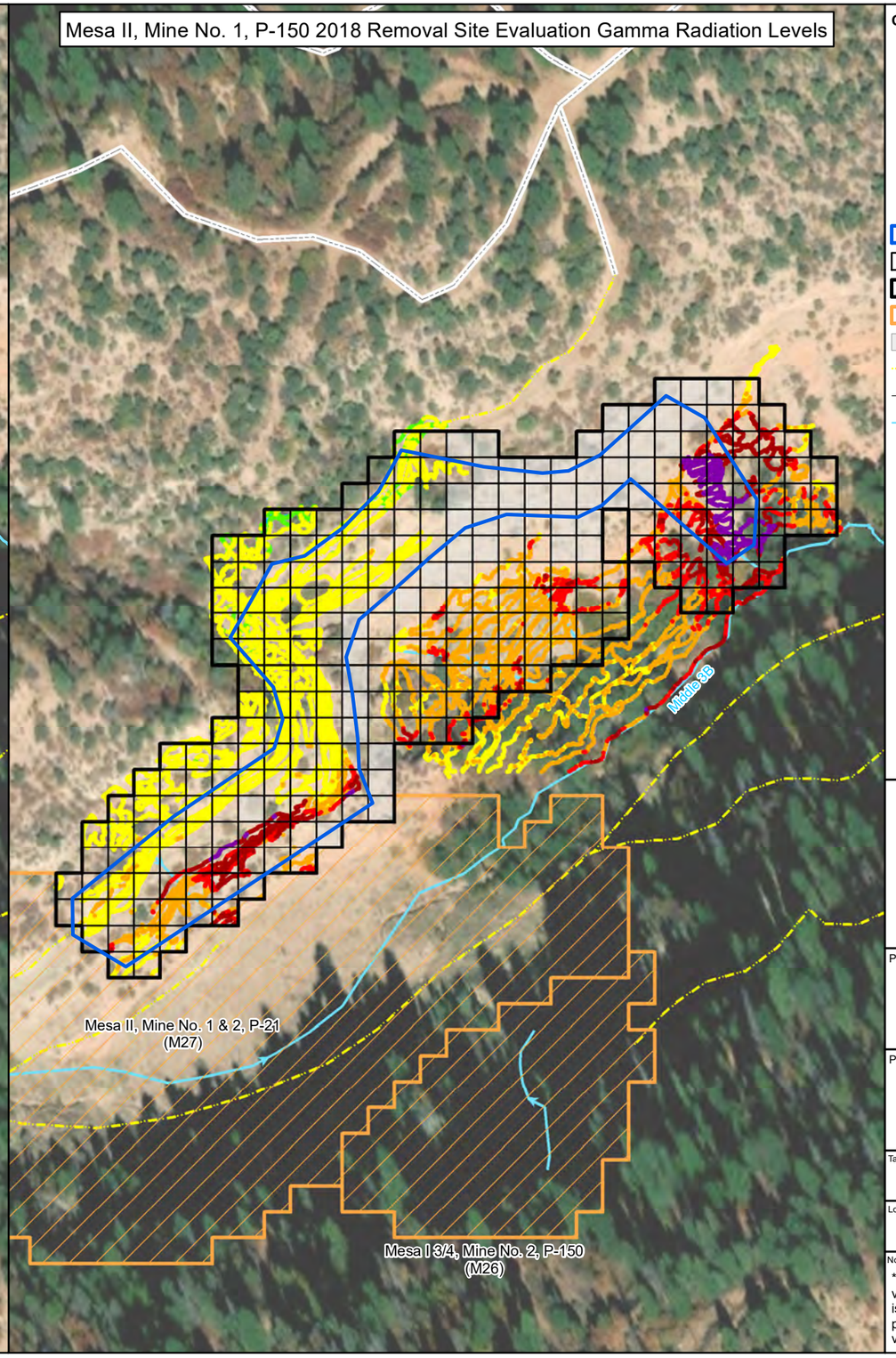
GAMMA RADIATION SURVEY COMPARISON MAPS

Figure H28-4-1. Mesa II, Mine No. 1, P-150 2018 Removal Site Evaluation and Weston Site Screening Gamma Radiation Levels Survey Map

Figure H28-4-2. Mesa II, Mine No. 1, P-150 2018 Removal Site Evaluation and ASPECT Contour Map

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator





Gamma Reading (cpm)*

≤ 8,123	≤ Avg. BG
8,123 - 9,703	Avg. BG - 1 x BTV
9,703 - 19,406	1 x BTV - 2 x BTV
19,406 - 29,109	2 x BTV - 3 x BTV
29,109 - 38,812	3 x BTV - 4 x BTV
38,812 - 97,030	4 x BTV - 10 x BTV
≥ 97,030	≥ 10 x BTV

- AUM Site Boundary
- Survey Unit (100 m²)
- Survey Area Boundary
- Other Survey Area
- Inaccessible To Gamma Survey
- Access Route - Foot
- Access Route - Vehicular
- Drainage - Field Mapped

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150
2018 REMOVAL SITE EVALUATION AND WESTON SITE SCREENING GAMMA RADIATION LEVELS SURVEY MAP

Prepared For:

Prepared By:

TETRA TECH
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Oakland, CA 94612

Task Order No.:	Contract No.:
TO0001	EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	**Date:** 7/7/2019

Notes:

*The applied gamma background threshold value (BTV) for Mesa II, Mine No. 1, P-150 is 9,703 cpm derived from BSA-24 as presented in Appendix A. Avg. BG: Average value of the background data set.

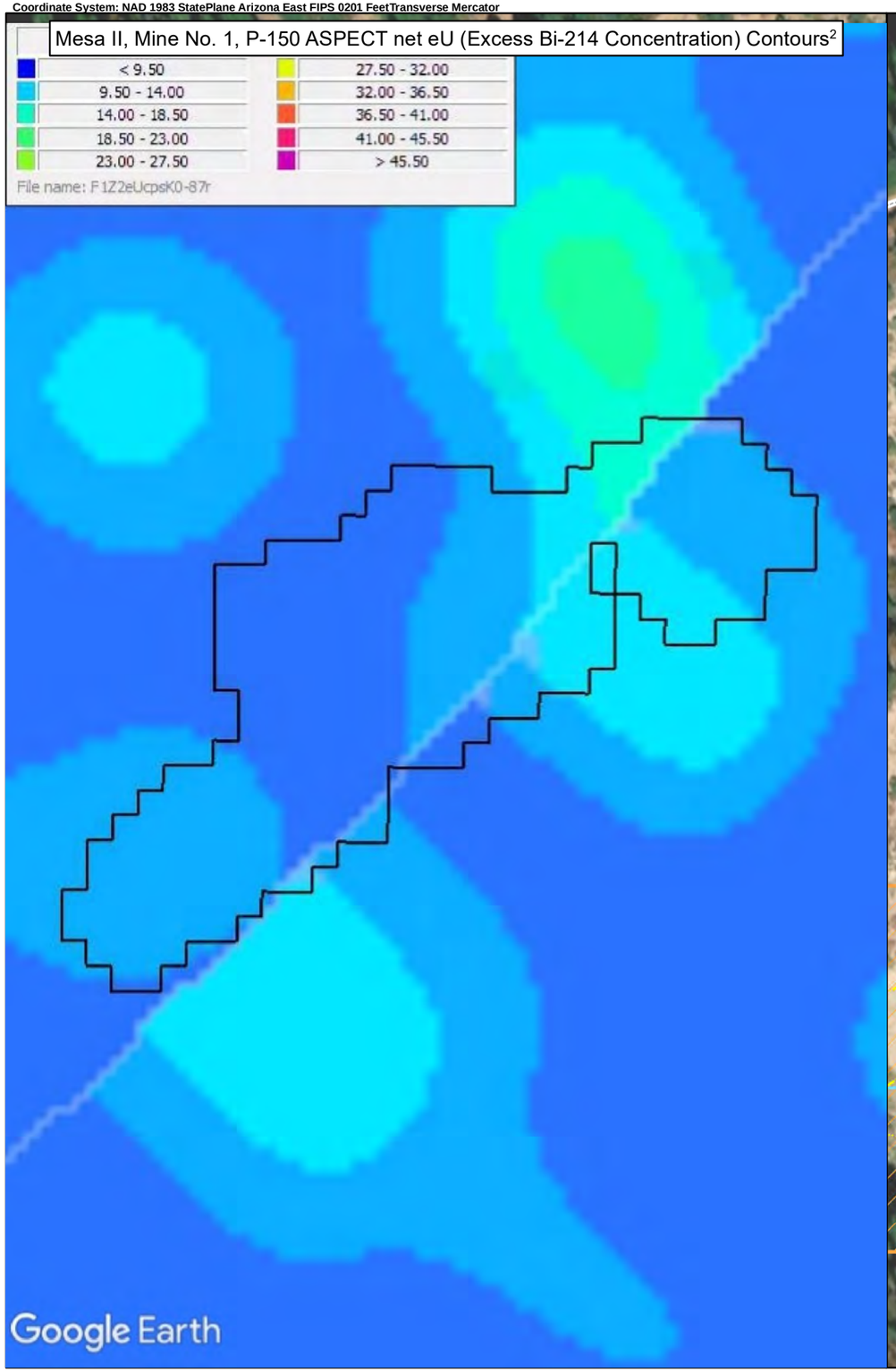
Figure No.: **H28-4-1**

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator

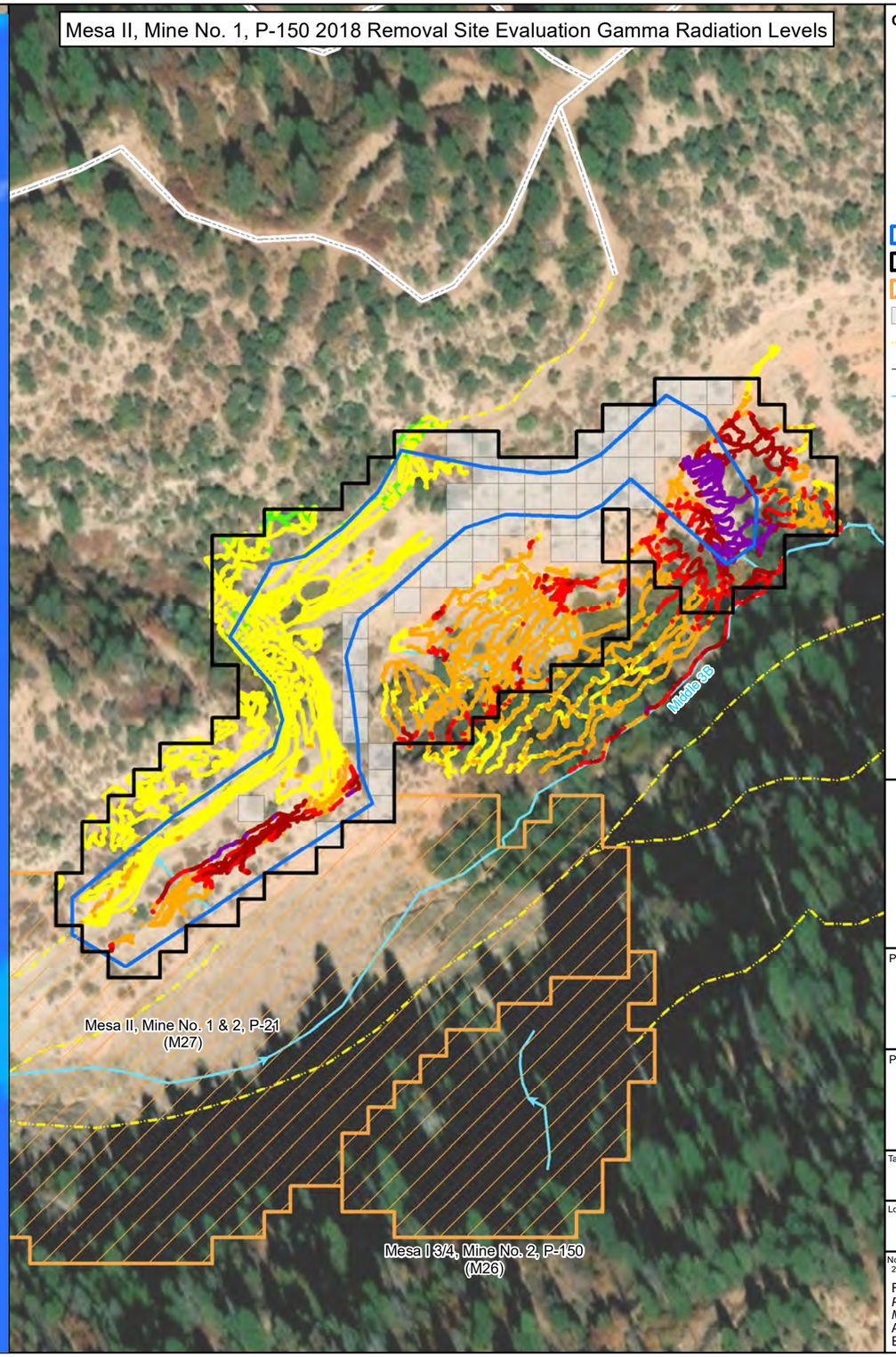
Mesa II, Mine No. 1, P-150 ASPECT net eU (Excess Bi-214 Concentration) Contours[2]

< 9.50	27.50 - 32.00
9.50 - 14.00	32.00 - 36.50
14.00 - 18.50	36.50 - 41.00
18.50 - 23.00	41.00 - 45.50
23.00 - 27.50	> 45.50

File name: F1Z2eUcpsK0-87r



Mesa II, Mine No. 1, P-150 2018 Removal Site Evaluation Gamma Radiation Levels



Gamma Reading (cpm)[1]

≤ 8,123	≤ Avg. BG
8,123 - 9,703	Avg. BG - 1 x BTV
9,703 - 19,406	1 x BTV - 2 x BTV
19,406 - 29,109	2 x BTV - 3 x BTV
29,109 - 38,812	3 x BTV - 4 x BTV
38,812 - 97,030	4 x BTV - 10 x BTV
≥ 97,030	≥ 10 x BTV

- AUM Site Boundary
- Survey Area Boundary
- Other Survey Area
- Inaccessible To Gamma Survey
- Access Route - Foot
- Access Route - Vehicular
- Drainage - Field Mapped

[1]The applied gamma background threshold value (BTV) for Mesa II, Mine No. 1, P-150 is 9,703 cpm derived from BSA-24 as presented in Appendix A. Avg. BG: Average value of the background data set.

1 in = 170 ft

1:2,040

N W E S

0 85 170 340 Feet

MESA II, MINE NO. 1, P-150
2018 REMOVAL SITE EVALUATION AND ASPECT CONTOUR MAP

Prepared For:

Prepared By:

TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.: TO0001	Contract No.: EP-S9-17-03
Location: COVE CHAPTER NAVAJO NATION	Date: 7/10/2019

Notes:
[2]U.S Environmental Protection Agency, Region 9, Superfund Program, *An Aerial Radiological Survey of Abandoned Uranium Mines in the Navajo Nation.* May, 2015. ASPECT - Airborn Spectral Photometric Environmental Collection Technology.

Figure No.: **H28-4-2**