Section 26 (#1011, 1012, 1035)
Removal Site Evaluation Report

Final | September 21, 2018

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

Section 26 (#1011, 1012, 1035) Removal Site Evaluation Report - Final

September 21, 2018

Prepared for:

Navajo Nation AUM Environmental Response Trust – First Phase

Prepared by:

Stantec Consulting Services Inc.

Title and Approval Sheet

Title: Section 26 Removal Site Evaluation Report - Final

Approvals

This Removal Site Evaluation Report is approved for implementation without conditions.

Dr. Donald Benn Navajo Nation Environmental Protection Agency Executive Director	10/9/18 **Date**
Linda Reeves US Environmental Protection Agency, Region 9 Remedial Project Manager	10/9/18 **Date**
Sadie Hoskie Navajo Nation AUM Environmental Response Trust – First Phase Trustee	10/10/18 **Date**
Toby Leeson, P.G. Stantec Consulting Services, Inc. Project Technical Lead	10/10/18 **Date**

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Sign-off Sheet

This document entitled *Section 26 Removal Site Evaluation Report* was prepared by MWH, now part of Stantec Consulting Services Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase (the "Client") for submittal to the Navajo Nation Environmental Protection Agency (NNEPA) and United States Environmental Protection Agency (USEPA) (collectively, the "Agencies"). The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Per the *Navajo Nation AUM Environmental Response Trust Agreement – First Phase*, *Section 5.4.1,* (United States [US], 2015) the following certification must be signed by a person who supervised or directed the preparation of the Removal Site Evaluation report: "Under penalty of law, I certify that to the best of my knowledge, after appropriate inquiries of all relevant persons involved in the preparation of this report, the information submitted herein is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Prepared by Emily Yeager

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Emily Yeager, P.G.

Reviewed by Kelly Johnson

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Kelly Johnson, PhD, P.G.

Approved by Toby Leeson

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Toby Leeson, P.G.

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- Tabular database files
- 2017 Cooper aerial survey orthophotographs and data files
- Historical documents referenced in this RSE Report (refer to Section 7 for complete citation)
    - Anderson, 1980 – Abandoned or Inactive Uranium Mines in New Mexico. New Mexico Bureau of Mines and Mineral Resources
    - Chenoweth, 1985 – Historical Review of Uranium Production from the Todilto Limestone Cibola and McKinley Counties, New Mexico

- Ecology and Environment, INC, 2014 – Removal Assessment Report Tronox AUM Section 26 Baca/Haystack Chapter, Eastern Agency, Navajo Nation, Prewitt, McKinley County, New Mexico
- Green, 1982 – Origin of Intraformational Folds in the Jurassic Todilto Limestone, Ambrosia Lake Uranium Mining District, McKinley and Valencia Counties, New Mexico
- Hilpert, 1969 - Uranium Resources of Northwestern New Mexico
- McLemore and Chenoweth, 1991 – Uranium Mines and Deposits in the Grants District, Cibola and McKinley Counties, New Mexico. New Mexico Bureau of Mines and Mineral Resources Open-file Report 353
- McLemore, 1983 – Uranium and Thorium Occurrences in New Mexico, Distribution, Geology, Production, and Resources, with Selected Bibliography
- NSO, 1990 – Uranium and Thorium Occurrences in New Mexico, Distribution, Geology, Production, and Resources, with Selected Bibliography
- USEPA, 1991 – Preliminary Assessment Package for the Navajo-Desiderio Group Uranium Mines. Ambrosia Lake Subdistrict Grants Uranium District
- USEPA, 1992b – Aerial Photographic Analysis of the Brown-VanDever and Desidero Uranium Mines. Supplemental Report
- USEPA, n.d., - Bluewater Abandoned Uranium Mine Site Removal Action. A USEPA Superfund Success Story
- Rasor and Toren, 1952 – Certification of Hanosh Mines, Inc., Section 26, T. 13 N., R. 10 W. Grants Mining District, McKinley County, New Mexico
- USEPA, 2007a – Abandoned Uranium Mines and the Navajo Nation. Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data
- USEPA, 2011 – Aerial Radiological Surveys Ambrosia Lake Uranium Mines. Ambrosia, NM
- Weston Solutions, 2009 - Desidero Group Uranium Mines Navajo Abandoned Uranium Mine Site Screen Report

Executive Summary

Introduction

The Section 26 Desidero Group site (the Site) is located within the Navajo Nation, Eastern Navajo Bureau of Indian Affairs (BIA) Agency, Baca/Prewitt Chapter in northwestern New Mexico. The Site is also identified as an abandoned uranium mine (AUM) claim that consists of three mine sites with identifications of #1011, #1012, and #1035. The Site is one of 46 "priority" AUMs within the Navajo Nation selected by the United States Environmental Protection Agency (USEPA) in collaboration with the Navajo Nation Environmental Protection Agency (NNEPA) for further evaluation based on radiation levels and potential for water contamination (USEPA, 2013). Mining for uranium occurred prior to, during, and after World War II, when the United States (US) sought a domestic source of uranium located on Navajo lands (USEPA, 2007a).

On April 30, 2015, the *Navajo Nation AUM Environmental Response Trust Agreement – First Phase* (the *Trust Agreement*) became effective. The *Trust Agreement* was made by and among the US, as Settlor, and as Beneficiary on behalf of the USEPA, and the Navajo Nation, as Beneficiary, and the Trustee (Sadie Hoskie). The *Trust Agreement* was developed in accordance with a settlement on April 8, 2015 between the US and Navajo Nation for the investigation of 16 specified priority AUMs. The priority sites were selected by the US and Navajo Nation, as described in the *Trust Agreement*:

> "based on two primary criteria, specifically, demonstrated levels of Radium-226[1]: (a) at or in excess of 10 times the background levels and the existence of a potentially inhabited structure located within 0.25 miles of AUM features; or (b) at or in excess of two times background levels and the existence of a potentially inhabited structure located within 200 feet (ft)."

The purpose of this report is to summarize the objectives, field investigation activities, findings, and conclusions of Site Clearance and Removal Site Evaluation (RSE) activities conducted between August 2015 and September 2017 at the Site. The primary objectives of the RSE are to provide data (e.g., review relevant information and collect data related to historical mining activities) required to evaluate relevant Site conditions and to support future Removal or Remedial Action evaluations at the Site. It is not intended to establish cleanup levels or determine cleanup options or potential remedies. The purpose of the RSE data are to determine the volume of technologically enhanced naturally occurring radioactive material (TENORM) at the Site in excess of Investigation Levels (ILs) as a result of historical mining activities. ILs are based on the background gamma measurements (in counts per minute [cpm]), and Radium-226 (Ra-226) and metals concentrations, determined through statistical analyses, that are used to

[1] The Agencies selected the priority mines based on gamma radiation but the *Trust Agreement* erroneously states "levels of Radium -226".

evaluate potential mining-related impacts. The area inclusive of the Site has naturally occurring radioactive materials (NORM), which was the reason the area was prospected and mined.

Site History and Physical Characteristics

The Site is located within the Colorado Plateau physiographic province, which is an area of approximately 240,000 square miles in the Four Corners region of Utah, Colorado, Arizona, and New Mexico. Regionally the Site is located within the Ambrosia Lake Mining Sub-district and the ore host bedrock on-site was the Jurassic Todilto Limestone. From 1950 to 1978, mines located on 43 different properties in the Ambrosia Lake Mining Sub-district produced approximately 30,000 tons of U_3O_8 (uranium oxide) from Todilto orebodies (Green, 1982). The Site is also located within the Rio Grande-Elephant Butte watershed, an area of approximately 27,000 square miles spanning New Mexico. Topographically the Site is located on a mesa top and along a mesa sidewall at an elevation of approximately 7,100 ft above mean sea level. On-site overland surface water flow, when present, is controlled by a decrease in elevation either to the north or south from the edge of the mesa. Numerous parallel patterned ephemeral drainages are present on-site that drain either to the northeast (on the mesa top) or to the south (in the plains), where they then terminate.

The Site was in operation between 1952 to 1957. Historical mine workings on-site consisted of a 155-ft incline and several open pits. The United States Atomic Energy Commission (USAEC) reported total ore production attributable to the Site was 11,110 tons (approximately 22,220,000 pounds) of ore that contained 83,752 pounds of 0.38 percent U_3O_8 and 17,518 pounds of 0.12 percent V_2O_5 (vanadium oxide).

In 1991 the USEPA conducted an Emergency Removal Action (ERA) at the three AUMs (#1011, #1012, and #1035) associated with the Site. Remediation activities included filling existing pits and covering open adits, regrading reclaimed areas until they were consistent with the surrounding terrain, and grading areas to have proper water runoff. In 2009 Weston Solutions (Weston) performed site screening on behalf of the USEPA. In 2014 Ecology and Environment Inc. (E&E) performed a Removal Site Assessment (RSA) at the Site on behalf of the USEPA.

Summary of Removal Site Evaluation Activities

The Trust conducted Site Clearance activities prior to commencing the RSE tasks to obtain information necessary to develop the *Removal Site Evaluation Work Plan* ([*RSE Work Plan*] MWH, 2016b). Following Site Clearance activities, the Trust conducted RSE activities consisting of two separate tasks: Baseline Studies activities and Site Characterization Activities and Assessment. Details of the Site Clearance activities, Baseline Studies activities, and Site Characterization and Assessment activities are as follows:

- **Site Clearance activities** consisted of a desktop study of historical information, site mapping, potential background reference area evaluation, biological (vegetation and wildlife) surveys, and cultural resource survey. Results of the Site Clearance activities provided historical information, site access information, potential background reference area data, and vegetation, wildlife, and cultural clearance of the Site for the Baseline Studies activities and Site Characterization and Assessment activities to commence.

- **Baseline Studies activities** included a background reference area study, site gamma radiation surveys, and a Gamma Correlation Study. Results of the Baseline Studies were used to plan and prepare the Site Characterization Activities and Assessment. Data collected in the background reference area study (soil sampling, laboratory analyses, surface gamma surveying, and subsurface static gamma measurements) were used to establish ILs for the Site. Data collected from the site gamma radiation survey were the primary method to evaluate potential mining-related impacts or areas containing elevated radionuclides. The Gamma Correlation Study objectives were to determine the correlations between: (1) gamma measurements and concentrations of Ra-226 in surface soils; and (2) gamma measurements and exposure rates; to be used as screening tools for site assessments.

- **Site Characterization Activities and Assessment** included surface soil and sediment sampling, subsurface soil sampling, and a geophysical survey. The results of the surface and subsurface soil and sediment sampling analyses were used to evaluate mining impacts and define the lateral and vertical extent of TENORM at the Site. The results of the geophysical survey were used to inform the TENORM volume estimate.

Findings and Discussion

Surface and subsurface soil and sediment sampling results. Five background reference areas were selected to develop surface gamma, subsurface static gamma, Ra-226, and metals ILs for the Site. Arsenic, molybdenum, selenium, uranium, vanadium, and Ra-226 concentrations and gamma radiation measurements in soil/sediment exceeded their respective ILs and are confirmed constituents of potential concern (COPCs) for the Site. Based on the data analyses performed for this report along with the multiple lines of evidence, approximately 72.2 acres, out of the 101.3 acres of the Survey Area (i.e., the full areal of the Site surface gamma survey), were estimated to contain TENORM. Of the 72.2 acres that contain TENORM, 45.2 acres contain TENORM exceeding ILs. The volume of TENORM in excess of ILs was estimated to be 170,191 cubic yards (yd^3) (130,120 cubic meters) and the volume of potential TENORM exceeding ILs was estimated to be 14,055 yds^3 (10,745 cubic meters).

Gamma Correlation Study results. The Gamma Correlation Study indicated that surface gamma survey results correlate with Ra-226 concentrations in soil. Therefore, gamma surveys could be used during site assessments as a field screening tool to estimate Ra-226 concentrations in soil. Additional correlation studies may be needed to identify the relationship between gamma and Ra-226.

Based on the Site Clearance and RSE data collection and analyses for the Site, potential data gaps were identified and are presented in Section 4.9 of this RSE report. These potential data gaps can be taken into consideration for subsequent evaluations in support of future Removal or Remedial Action evaluations at the Site.

Acronyms/Abbreviations

cm^3	cubic centimeter
°F	degrees Fahrenheit
yd^3	cubic yard
e.g.	exempli gratia
et seq.	and what follows
etc.	et cetera
ft	feet
ft^2	square feet
i.e.	id est
mg/kg	milligram per kilogram
μR/hr	microRoentgens per hour
pCi/g	picocuries per gram
Adkins	Adkins Consulting Inc.
ags	above ground surface
amsl	above mean sea level
ATSDR	Agency for Toxic Substance and Disease Control Registry
AUM	abandoned uranium mine
bgs	below ground surface
BIA	Bureau of Indian Affairs
CCV	continuing calibration verification
Cooper	Cooper Aerial Surveys Company
CFR	Code of Federal Regulations
COPC	constituent of potential concern
cpm	counts per minute
cps	counts per second
Dinétahdóó	Dinétahdóó Cultural Resource Management
DMP	Data Management Plan
DQO	data quality objective
E&E	Ecology and Environment Inc.
ERG	Environmental Restoration Group, Inc.
ERA	Emergency Removal Action
ESA	Endangered Species Act
FSP	Field Sampling Plan
GIS	geographic information system
GPS	global positioning system
HASP	Health and Safety Plan
HGI	Hydrogeophysics Inc.

ICAL	initial calibration
ICB/CCB	initial/continuing calibration blank
ICV	initial calibration verification
IL	Investigation Level
LCS/LCSD	laboratory control sample/laboratory control sample duplicate
MARSSIM	Multi-agency Radiation Survey and Site Investigation Manual
MASW	multi-channel analysis of surface wave
MBTA	Migratory Bird Treaty Act
MS/MSD	matrix spike/matrix spike duplicate
MWH	MWH, now part of Stantec Consulting Services Inc. (formerly MWH Americas, Inc.)
NaI	sodium iodide
NAML	Navajo Abandoned Mine Lands Reclamation Program
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NNDFW	Navajo Nation Department of Fish and Wildlife
NNDOJ	Navajo Nation Department of Justice
NNDNR	Navajo Nation Division of Natural Resources
NNDWR	Navajo Nation Department of Water Resources
NNEPA	Navajo Nation Environmental Protection Agency
NNESL	Navajo Nation Endangered Species List
NNHP	Navajo Natural Heritage Program
NNHPD	Navajo Nation Historic Preservation Department
NORM	Naturally Occurring Radioactive Material
NSO	Navajo Superfund Office
PA	Preliminary Assessment
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
R^2	Pearson's Correlation Coefficient
RSA	Removal Site Assessment
Ra-226	Radium 226
RSE	Removal Site Evaluation
SOP	standard operating procedure
Stantec	Stantec Consulting Services Inc.
T&E	threatened and endangered
TENORM	Technologically Enhanced Naturally Occurring Radioactive Materials
Th-230	thorium-230
Th-232	thorium-232
U-235	uranium-235
U-238	uranium-238

U_3O_8	uranium oxide
UCL	upper confidence limit
US	United States
USAEC	US Atomic Energy Commission
USC	United States Code
USDA	US Department of Agriculture
USEPA	US Environmental Protection Agency
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
UTL	upper tolerance limit
V_2O_5	vanadium oxide
Weston	Weston Solutions

Glossary

Adit – a horizontal passage leading into a mine for the purposes of access (English Oxford Dictionary, 2018).

Alluvium – material deposited by flowing water.

Arroyo – a steep sided gully cut by running water in an arid or semiarid region.

Bin Range – as presented in the RSE report, a range of values to present surface gamma measurement data in relation to: (1) the surface gamma Investigation Level (IL); (2) multiples of the surface gamma IL; or (3) the mean and standard deviation of the predicted Radium-226 (Ra-226) concentrations for the Site based on the correlation equation.

Colluvium – unconsolidated, unsorted, earth material transported under the influence of gravity and deposited on lower slopes (Schaetzl and Thompson, 2015).

Composite sample – "Volumes of material from several of the selected sampling units are physically combined and mixed in an effort to form a single homogeneous sample, which is then analyzed" (USEPA, 2002a).

Constituent of potential concern (COPC) – analytes identified in the *RSE Work Plan* where their levels were confirmed based on the results of the RSE.

Data Validation – "an analyte- and sample-specific process that extends the evaluation of data beyond, method, procedural, or contractual compliance (i.e., data verification) to determine the analytical quality of a specific data set" (USEPA, 2002b).

Data Verification – "the process of evaluating the completeness, correctness and conformance/compliance of a specific data set against the method, procedural, or contractual requirements" (USEPA, 2002b).

Earthworks - human-caused disturbance of the land surface.

Electrical Resistivity – geophysical investigation method that measures a material's resistance to electrical current.

Eolian – a deposit that forms as a result of the accumulation of wind-driven products from the weathering of solid bedrock or unconsolidated deposits.

Ephemeral – ephemeral streams flow only in direct response to surface runoff precipitation or melting snow, and their channels are at all times above the water table (USGS, 2003). This concept also applies to ephemeral ponds that contain water in response to surface runoff precipitation or melting snow and are at all times above the water table.

Ethnographic – relating to the scientific description of peoples and cultures with their customs, habits, and mutual differences.

Gamma – a type of radiation that occurs as the result of the natural decay of uranium.

Geochemical – the chemistry of the composition and alterations of the solid matter of the earth (American Heritage Dictionary, 2016).

Geomorphology – the physical features of the surface of the earth and their relation to its geologic structures (English Oxford Dictionary, 2018).

Grab sample – a sample collected from a specific location (and depth) at a certain point in time.

Hogback – a long, narrow ridge or series of hills with a narrow crest and steep slopes of nearly equal inclination on both flanks. Typically, this term is restricted to a ridge created by the differential erosion of outcropping, steeply dipping (greater than 30 to 40 degrees), homoclinal, typically sedimentary strata. One side, the backslope, of a hogback consists of the surface (bedding plane) of steeply dipping rock stratum, which is called a "dip slope." The other side, the escarpment or "frontslope" or "scarp slope", is an erosion face that cuts through the dipping strata that comprises the hogback (Hugget, 2011).

Hummocky – a general geological term referring to a small knoll or mound above ground.

Incline – an entry to a mine that is not vertical (shaft) or horizontal (adit). Often incline is reserved for those entries that are too steep for a belt conveyor, in which case a hoist and guide rails are employed (Glossary of Mining Terms, 2018).

Investigation Level (IL) – based on the background gamma measurements (in counts per minute [cpm]) and, Radium-226 (Ra-226) and metals concentrations, determined through statistical analyses, that are used to evaluate potential mining-related impacts.

Isolated Occurrences – in relation to the Site Cultural Resource Survey: Any non-structural remains of a single event: alternately, any non-structural assemblage of approximately 10 or fewer artifacts within an area of approximately 10 square meters or less, especially if it is of questionable human origin or if it appears to be the result of fortuitous causes. The number and/or composition of observed artifact classes are a useful rule of thumb for distinguishing between a site and an isolate (NNHPD, 2016).

Leachate – a solution resulting from leaching, as of soluble constituents from soil, etc., by downward percolating groundwater.

Mineralized – economically important metals in the formation of ore bodies that have been geologically deposited. For example, the process of mineralization may introduce metals, such as uranium, into a rock. That rock may then be referred to as possessing uranium mineralization (World Heritage Encyclopedia, 2017).

Multi-channel analysis of surface wave (MASW) – geophysical investigation method that measures the elastic condition of the subsurface to produce an image based on differences in transmission time of the seismic wave.

Naturally occurring radioactive material (NORM) – "materials which may contain any of the primordial radionuclides or radioactive elements as they occur in nature, such as radium, uranium, thorium, potassium, and their radioactive decay products, that are undisturbed as a result of human activities" (USEPA, 2017).

Orthophotograph – an aerial photograph or image geometrically corrected such that the scale is uniform: the photograph has the same lack of distortion as a map. Unlike an uncorrected aerial photograph, an orthophotograph can be used to measure distances, because it is an accurate representation of the earth's surface, having been adjusted for topographic relief, lens distortion, and camera tilt.

Pan Evaporation – evaporative water losses from a standardized pan.

Portal – The surface entrance to a drift, tunnel, adit, or entry (US Bureau of Mines, 2017).

Radium-226 (Ra-226) – a radioactive isotope of radium that is produced by the natural decay of uranium.

Remedial Action (or remedy) – "those actions consistent with permanent remedy taken instead of, or in addition to, removal action in the event of a release or threatened release of a hazardous substance into the environment, to prevent or minimize the release of hazardous substances so that they do not migrate to cause substantial danger to present or future public health or welfare or the environment…For the purpose of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the term also includes enforcement activities related thereto" (USEPA, 1992a).

Remove or removal – "the cleanup or removal of released hazardous substances from the environment; such actions as may be necessary taken in the event of the threat of release of hazardous substances into the environment; such actions as may be necessary to monitor, assess, and evaluate the release or threat of release of hazardous substances; the disposal of removed material; or the taking of such other actions as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare of the United States or to the environment, which may otherwise result from a release or threat of release…" (USEPA, 1992a).

Respond or response – "remove, removal, remedy, or remedial action, including enforcement activities related thereto" (USEPA, 1992a).

Secular equilibrium – a type of radioactive equilibrium in which the half-life of the precursor (parent) radioisotope is so much longer than that of the product (daughter) that the radioactivity of the daughter becomes equal to that of the parent with time; therefore, the quantity of a radioactive isotope remains constant because its production rate is equal to its decay rate. In secular equilibrium the activity remains constant.

Static gamma measurement – stationary gamma measurement collected for a specific period of time (e.g., 60 seconds).

Technologically enhanced naturally occurring radioactive material (TENORM) – "naturally occurring radioactive materials that have been concentrated or exposed to the accessible environment as a result of human activities such as manufacturing, mineral extraction, or water processing", which includes disturbance from mining activities. Where "technologically enhanced means that the radiological, physical, and chemical properties of the radioactive material have been concentrated or further altered by having been processed, or beneficiated, or disturbed in a way that increases the potential for human and/or environmental exposures" (USEPA, 2017).

Thorium (Th) – "a naturally occurring radioactive metal found at trace levels in soil, rocks, water, plants and animals. Thorium (Th) is solid under normal conditions. There are natural and man-made forms of thorium, all of which are radioactive" (USEPA, 2017).

Th-230 – a radioactive isotope of thorium that is produced by the natural decay of thorium.

Th-232 – a radioactive isotope of thorium that is produced by the natural decay of thorium.

Upper Confidence Limit (UCL) – the upper boundary (or limit) of a confidence interval of a parameter of interest such as the population mean (USEPA, 2015).

Upper Tolerance Limit (UTL) – a confidence limit on a percentile of the population rather than a confidence limit on the mean. For example, a 95 percent one-sided UTL for 95 percent coverage represents the value below which 95 percent of the population values are expected to fall with 95 percent confidence. In other words, a 95 percent UTL with coverage coefficient 95 percent represents a 95 percent UCL for the 95^{th} percentile (USEPA, 2015).

Uranium (U) – a naturally occurring radioactive element that may be present in relatively high concentrations in the geologic materials in the southwest United States.

U-235 – a radioactive isotope of uranium that is produced by the natural decay of uranium.

U-238 – a radioactive isotope of uranium that is produced by the natural decay of uranium.

Walkover gamma radiation survey – referred to as a scanning survey in the Multi-agency Radiation Survey and Site Investigation Manual (*MARSSIM*; USEPA, 2000). A walkover gamma radiation survey is the process by which the operator uses a portable radiation detection instrument to detect the presence of radionuclides on a specific surface (i.e., ground, wall) while continuously moving across the surface at a certain speed and in a certain pattern (USEPA, 2000). Referred to in the RSE report as surface gamma survey after the first mention in the report.

Wind rose – a circular graph depicting average wind speed and direction.

1.0 INTRODUCTION

1.1 BACKGROUND

This report summarizes the purpose and objectives, field investigation activities, findings, and conclusions of Site Clearance and Removal Site Evaluation (RSE) activities conducted between August 2015 and September 2017 at the Section 26 Desidero Group site (the Site) located in northwestern New Mexico, as shown in Figure 1-1. The Site is also identified by the United States Environmental Protection Agency (USEPA) as an abandoned uranium mine (AUM) claim that consists of three mine sites with identifications of #1011, #1012, and #1035 in the *Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data* (the *2007 AUM Atlas*; USEPA, 2007a). The *2007 AUM Atlas* was prepared for the USEPA in cooperation with the Navajo Nation Environmental Protection Agency (NNEPA) and the Navajo Abandoned Mine Lands Reclamation Program (NAML). The mine site boundary polygons (refer to claim boundaries shown on Figure 2-1) used for the RSE encompassed an area of approximately 15.2 acres (662,112 square feet [ft^2]) and were provided as part of the *2007 AUM Atlas*. Per the *2007 AUM Atlas* these polygons and other factors represent the locations and surface extents of the AUMs.

Stantec Consulting Services Inc. (Stantec; formerly MWH), performed Site Clearance activities in accordance with the *Site Clearance Work Plan* (MWH, 2016a), and performed RSE activities in accordance with the *Removal Site Evaluation Work Plan* ([*RSE Work Plan*] MWH, 2016b). The *Site Clearance Work Plan* and the *RSE Work Plan* were approved in April and October 2016, respectively, by the NNEPA and the USEPA (collectively, the Agencies). Stantec conducted this investigation on behalf of Sadie Hoskie, Trustee pursuant to Section 1.1.21 of the *Navajo Nation AUM Environmental Response Trust Agreement – First Phase* (the *Trust Agreement*), effective April 30, 2015 (United States [US], 2015). The *Trust Agreement* is made by and among the US, as Settlor, and as Beneficiary on behalf of the USEPA, the Navajo Nation, as Beneficiary, and the Trustee. The *Trust Agreement* was developed in accordance with a settlement on April 8, 2015 between the US and Navajo Nation for the investigation of 16 specified "priority" AUMs.

A "Site" is defined in the *Trust Agreement* as:

> "each of the 16 AUMs listed on Appendix A to the Settlement Agreement, including the proximate areas where waste material associated with each such AUM has been deposited, stored, disposed of, placed, or otherwise come to be located." *Trust Agreement*, § 1.1.25.

The Site is one of 46 priority AUMs within the Navajo Nation selected by the USEPA in collaboration with the NNEPA for further evaluation based on radiation levels and potential for water contamination (USEPA, 2013). The 16 priority AUMs included in the *Trust Agreement* are located on Navajo Lands throughout southeastern Utah, northeastern Arizona, and western New

Mexico, as shown in Figure 1-1. The 16 priority AUMs were selected by the US and Navajo Nation, as described in the *Trust Agreement*:

> "based on two primary criteria, specifically, demonstrated levels of Radium-226[2]: (a) at or in excess of 10 times the background levels and the existence of a potentially inhabited structure located within 0.25 miles of AUM features; or (b) at or in excess of two times background levels and the existence of a potentially inhabited structure located within 200 feet (ft)." *Trust Agreement*, Recitals.

In addition, the 16 priority AUMs are, for the purposes of this investigation, a subset of priority mines for which a viable private potentially responsible party has not been identified. Mining for uranium occurred prior to, during, and after World War II, when the US sought a domestic source of uranium located on Navajo lands (USEPA, 2007a). *Trust Agreement*, Recitals.

1.2 OBJECTIVES AND PURPOSE OF THE REMOVAL SITE EVALUATION

The primary objectives of the RSE are to provide data (e.g., review relevant information and collect data related to historical mining activities) required to evaluate relevant Site conditions and to support future Removal or Remedial Action evaluations at the Site. It is not intended to establish cleanup levels or determine cleanup options or potential remedies. The purpose of the RSE data are to determine the volume of technologically enhanced naturally occurring radioactive material (TENORM) at the Site in excess of Investigation Levels (ILs) as a result of historical mining activities. ILs are based on the background gamma measurements (in counts per minute [cpm]), and Radium-226 (Ra-226) and metals concentrations, determined through statistical analyses, that are used to evaluate potential mining-related impacts. The USEPA (2017) defines TENORM as:

> "naturally occurring radioactive materials that have been concentrated or exposed to the accessible environment as a result of human activities such as manufacturing, mineral extraction, or water processing" (mine waste or other mining-related disturbance).
>
> "Technologically enhanced means that the radiological, physical, and chemical properties of the radioactive material have been concentrated or further altered by having been processed, or beneficiated, or disturbed in a way that increases the potential for human and/or environmental exposures."

An understanding of the extent and volume of TENORM that exceeds the ILs at the Site is key information for future Removal or Remedial Action evaluations, including whether, and to what extent, a Response Action is warranted under federal and Navajo law. Definitions presented in the glossary for "Removal", "Remedial Action", and "Response" are defined in 40 Code of

[2] The Agencies selected the priority mines based on gamma radiation but the *Trust Agreement* erroneously states "levels of Radium -226".

Federal Regulations (CFR) Section 300.5 of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP; USEPA, 1992a).

The Trust conducted Site Clearance activities prior to commencing the RSE tasks to obtain information necessary to develop the *RSE Work Plan*. Site Clearance activities consisted of two separate tasks: a "desktop" study (e.g., literature and historical documentation review) and field activities.

Desktop study – included review of readily available and reasonably ascertainable information including:

- Historical and current aerial photographs to identify any potential historical mining features, and to identify if buildings, homes and/or other structures, and potential haul roads were present within 0.25 miles of the Site
- Topographic and geologic maps
- Available data concerning perennial surface water features and water wells
- Previous studies and reclamation activities
- Meteorological data (e.g., predominant wind direction in the region of the Site)

Site Clearance field activities – included the following:

- Site reconnaissance to evaluate in the field: access routes to the Site, location of site boundaries, and observations presented in the Weston Solutions (Weston)(2009) report
- Mapping of site features and boundaries
- Evaluation of potential background reference areas
- Biological surveys (wildlife and vegetation)
- Cultural resource surveys

Following Site Clearance activities, RSE activities consisted of two separate tasks: Baseline Studies and Site Characterization and Assessment. Baseline Studies activities were completed to establish the basis for the Site Characterization and Assessment activities.

Baseline Studies activities – included the following:

- Background Reference Area Study – walkover gamma radiation survey (referred to hereafter as surface gamma survey), subsurface static gamma radiation measurements (referred to hereafter as subsurface static gamma measurements), surface and subsurface soil/sediment sampling, and laboratory analyses
- Site gamma survey – surface gamma survey

- Gamma Correlation Study – co-located surface static gamma measurements and exposure-rate measurements at fixed points, high-density surface gamma surveys (intended to cover 100 percent of the survey area), surface soil sampling, and laboratory analyses

Site Characterization Activities and Assessment – included the following:

- Characterization of surface soils and sediment – surface soil and sediment sampling and laboratory analyses.

- Characterization of subsurface soils – static gamma measurements (at surface and subsurface hand auger and drilling borehole locations), and subsurface sampling and laboratory analyses. Hand auger and drilling borehole locations are referred to hereafter as boreholes.

Details regarding the Site Clearance activities are provided in the *Section 26 (Desidero Group) Site Clearance Data Report* (*Site Clearance Data Report*; MWH, 2016c) and summarized in Section 3.2 of this report. Details regarding the Baseline Study activities are provided in the *Draft Section 26 (Desidero Group) Site Baseline Studies Field Report* (Stantec, 2017) and summarized in Section 3.3 of this report. Details regarding the Site Characterization Activities and Assessment are provided in Section 3.3 of this report. Findings are presented in Section 4.0 of this report.

1.3 REPORT ORGANIZATION

This report presents a comprehensive discussion of all RSE activities, including applicable aspects of the outline suggested in the *Multi-Agency Radiation Survey and Site Investigation Manual – Appendix A* ([*MARSSIM*] USEPA, 2000), and consists of the following sections:

Executive Summary – Presents a concise description of the principal elements of the RSE report.

Section 1.0 Introduction – Describes the purpose and objectives of the RSE process, and organization of this RSE report.

Section 2.0 Site History and Physical Characteristics – Presents the history, land use, and physical characteristics of the Site.

Section 3.0 Summary of Site Investigation Activities – Summarizes the Site Clearance and RSE activities.

Section 4.0 Findings and Discussion – Presents the results of the Site Clearance and RSE activities, areas that exceed ILs, areas of Naturally Occurring Radioactive Material (NORM) and TENORM, and the volume of TENORM that exceeds the ILs. Potential data gaps are also presented, as applicable.

Section 5.0 Summary and Conclusions – Summarizes data and presents conclusions based on results of the investigations completed to date.

Section 6.0 Estimate of Removal Site Evaluation Costs – A statement of actual or estimated costs incurred in complying with the *Trust Agreement*, as required by the *Trust Agreement*.

Section 7.0 References – Lists the reference documents cited in this RSE report.

Tables Included at the end of this RSE report.

Figures Included at the end of this RSE report.

Appendices – Appendices A through F.1 are included at the end of this RSE report and Appendix F.2 is provided as a separate electronic file due to its file size and length.

- **Appendix A** – Includes the radiological characterization report and the geophysical survey report for the Site
- **Appendix B** – Includes photographs of the Site
- **Appendix C** – Includes copies of RSE field activity forms
- **Appendix D** – Provides the potential background reference areas selection and the methods and results of the statistical data evaluation for the Site
- **Appendix E** – Includes the biological evaluation report and the biological and cultural resources compliance forms
- **Appendix F** – Includes the Data Usability Report, laboratory analytical data, and data validation reports for the RSE analyses

Attachments – Site-specific geodatabase, tabular database files, and available historical documents referenced in this RSE report.

2.0 SITE HISTORY AND PHYSICAL CHARACTERISTICS

2.1 SITE HISTORY AND LAND USE

2.1.1 Mining Practices and Background

A note to the reader: The Historical documentation for the Site is confusing and inconsistent. The Trust's AUM Section 26 Site (i.e., the Section 26 Desidero Group Site) is associated with two other AUMs, which have their own historical identification names: Hanosh Mines Inc. (also known as Indian Allotment [Rasor and Toren, 1952]) and Desidero (also known as Desidero Allotment [McLemore and Chenoweth, 1991]). However, the two other AUMs are not clearly distinguished in the historical documentation, and the terms are used interchangeably and inconsistently. For example, in1991 McLemore and Chenoweth reported the "Hanosh and Desidero Allotment" sites were combined together and referred to them collectively as Section 26. ***This reference to Section 26 is in conflict with the nomenclature for the Trust's AUM Section 26 Site***. The historical information presented in this RSE report may include just one of the AUM alternative names, or "aliases" or a combination of the AUM aliases, based on how the information was reported in the referenced historical documents. In addition, names in historical documents may not match current descriptions of the Site or surrounding mine areas. In the historical Sections 2.1.1 and 2.1.4 of this RSE report, to distinguish the Trust's AUM Site (called the Section 26 Desidero Group Site) from alternative names or aliases historically used, the Trust site will be referenced as the Trust Section 26 AUM where applicable.

The Trust Section 26 AUM is located on the Navajo Nation, in northwestern New Mexico, approximately 12.5 miles north of Grants, New Mexico, as shown in Figure 1-1 inset. The site is located within the Baca/Prewitt Chapter of the Navajo Nation. The Trust Section 26 AUM is also located in the Grants Uranium Mining District, Ambrosia Lake Sub-district. A summary of historical mining for the Trust Section 26 AUM is presented below.

In 1947 the US Atomic Energy Commission (USAEC) began a procurement program for uranium concentrate. In 1950 mineable uranium was first discovered in the Ambrosia Lake Sub-district by Navajo sheepherder Paddy Martinez (Chenoweth, 1985). Mr. Martinez collected samples of the Jurassic Luciano Mesa Member of the Todilto Limestone Formation (the Todilto Limestone) that contained yellow uranium minerals, from the foot of Haystack Butte. Though uranium was known to exist within the Gallup-Grants, New Mexico area for several years, this discovery indicated that there were vast mineable uranium resources. The news of this uranium discovery led to numerous prospectors arriving in the Gallup-Grants area. The additional prospecting led to the discovery of other deposits in the Todilto Limestone, as well as deposits in exposures of the Morrison and Dakota Formations. These discoveries triggered the uranium boom in west-central New Mexico. In 1951, leases for Hanosh Mines Inc. were granted to two Navajos who were also given allotments to the land associated with the mineral leases (Rasor and Toren, 1952). The leases (numbers I-149-Ind-8907 and I-149-Ind-8909) lasted for 15 years and authorized prospecting and mining uranium and other related materials. In 1952 mining began at the

Hanosh Mines from a small open pit, located on the mesa edge and corresponding with mine site #1012, refer to Figure 2-1 (Rasor and Toren, 1952). Mining continued until 1957, with additional mine workings consisting of a 155 ft incline and several open pits (Anderson, 1980 and McLemore, 1983). McLemore and Chenoweth (1991) reported that between 1952 and 1957 Hanosh Mines was listed as the producer and shipper of ore from "Section 26 (Hanosh) (Desidero Allotment)". The ore was shipped for processing to the Anaconda Minerals Company, located approximately six miles southwest of the Site (NSO, 1990). The USAEC reported total ore production from the "Section 26 (Hanosh) (Desidero Allotment)" between 1952 and 1957 was 11,110 tons (approximately 22,220,000 pounds) of ore that contained 83,752 pounds of 0.38 percent U_3O_8 (uranium oxide) and 17,518 pounds of 0.08 percent V_2O_5 (vanadium oxide) (McLemore and Chenoweth, 1991).

2.1.2 Ownership and Surrounding Land Use

The Site is located within the Navajo Nation, Eastern Navajo Bureau of Indian Affairs (BIA) Agency in Section 26 of Township 13 North, Range 10 West, New Mexico Principal Meridian. Land ownership where the Site is located falls under Allotted Trust lands. The Site is located within the Baca/Prewitt Chapter of the Navajo Nation, as shown in Figure 1-1, and is in Grazing Unit 16, as designated by the Navajo Nation Division of Natural Resources (NNDNR, 2006). Several home-sites are located within 0.25 miles of the Site to the west, north, and east, as shown in Figure 2-1.

2.1.3 Site Access

In 2015, the Navajo Nation Department of Justice (NNDOJ) provided the Trustee with legal access to all Navajo Trust lands to implement work in accordance with the *Trust Agreement*. The Trustee notified allotment owners via mail and also obtained individual written access agreements from residents living at or near the Site, or with an interest in lands at or near the Site, such as allotted land, home-site leases, and grazing rights, as applicable. In addition, the Trustee consulted with the Baca/Prewitt Chapter officials and nearby residents and notified them of the work.

2.1.4 Previous Work at the Site

2.1.4.1 1980 Abandoned or Inactive Mines Assessment

Between 1979 and 1980, the New Mexico Bureau of Mines and Mineral Resources assessed approximately 200 abandoned or inactive uranium mines in New Mexico (Anderson, 1980). The assessment included verifying the location, type and size of the mines, condition of the mines, ore host geologic formation, dimensions of remaining mine features, proximity to residences or towns, water quality data, and radiation levels (Anderson, 1980). The New Mexico Bureau of Mines and Mineral Resources assessed the AUMs associated with the Trust Section 26 AUM on January 15, 1980 and the following information was reported:

- The assessment included two AUMs with aliases associated with the Trust Section 26 AUM: the "Hanosh Mines" and "Section 26". The "Hanosh Mine" was located at N½ NE¼ Section 26 and "Section 26" was located at S¼ Section 23 and NE¼ Section 26. Based on these coordinate designations, and supporting photographs provided in Anderson (1980), it is believed that the "Hanosh Mine" was located in the vicinity of mine site #1035 and "Section 26" was located in the vicinity of mine site #1011 (refer to Figure 2-1). The "Section 26" designation in the 1980 assessment should not be confused with the 1991 Section 26 designation reported by McLemore and Chenoweth (1991), which was the combination of the "Hanosh and Desidero Allotment" aliases (refer to Section 2.1.1).

- The ore host geologic formation was the Todilto limestone.

- The Hanosh Mine was located within 0.5 miles of a home-site. Mine workings consisted of an incline and several open pits that extended north-westwards toward the Section 26 mine. The portal of the incline measured approximately 8 ft by 8 ft and was located at the bottom of a 75-ft-long by 20-ft-deep box cut. The 20-ft-deep box cut was entirely in unconsolidated overburden. Radiation levels were collected using a gamma ray scintillometer. Radiation readings inside the incline ranged up to 2,400 counts per second (cps) and mineralized bedrock readings inside the incline were up to 6,000 cps. The size of detector (i.e., 2-inch by 2-inch or 3-inch by 3-inch) used was not specified.

- Section 26 was located within 0.25 miles of a home-site. Mine workings consisted of an open pit complex used to mine an ore body or cluster of ore bodies in the middle and lower parts of the Todilto limestone. The pits were constructed as trenches up to 40 ft deep and 450 ft long. Radiation readings up to 5,000 cps were recorded in mineralized zones of bedrock. A small prospect pit with 8 ft high waste piles at each end was described as being present in an area of "undisturbed ground".

2.1.4.2 1990 Preliminary Assessment

In a memo dated January 1990, the Baca Chapter (the local community government that oversaw the community needs and resources) reported to the Navajo Superfund Office (NSO) that the "Desiderio Group Uranium Mines" were potentially contaminated with hazardous waste (NSO, 1990). In response to the memo, the NSO conducted a Preliminary Assessment (PA) to investigate the potentially contaminated Desiderio Group Uranium Mines. The PA was conducted at "The Desiderio Group Uranium Mines, also known as the Hanosh Mines Section 26", an area that occupied approximately 130 acres and extended into adjacent Section 23 and Section 25 (NSO, 1990). Of note, the 130 acres will be referred to as the PA site for the remainder of this RSE report section.

The PA findings identified the following known/potential problems for the PA site:

- The presence of 91,962 cubic yards (yd^3) of low grade, radioactive uranium ore and tooled mine waste piles that were exposed, uncontained, and unlined. The piles "were capable of producing leachate subject to migration into the atmosphere, groundwater and surface water systems."

- The presence of an unsecured155 ft inclined adit and unfenced open pits. The exposed surface of the adit and surface pits were also capable of "producing leachate similar in composition to that released from the mine waste piles".

- The possibility of exposure to local residents through: (1) radon gas emissions and ionizing radiation; and/or (2) direct contact of exposure through ingestion of windblown particulates contaminated with radioactive and heavy metal species. At the time of the PA, local residents were living less than 200 ft from the nearest mine waste pile.

The PA included a graphic representation of the PA site showing the locations of the residential area, mine waste piles, open pits, and adit. This graphic is presented in Figure 2-2 along with the approximate boundaries of Section 23, Section 25, and Section 26.

The PA concluded there was a potential for groundwater and surface water radioactive contamination at the PA site as a result of past uranium mining activities. The PA also concluded the soil surrounding the mines was contaminated by low grade uranium ore, abandoned after the mining ceased, and the persistent nature of radioactive and heavy metal species suggested that PA site exposure to residents was "potentially very high". The NSO submitted findings of the PA to the USEPA in a PA Package dated July 30, 1990 (NSO, 1990).

2.1.4.3 1991 Emergency Removal Action

Between August 11, 1991 and September 19, 1991, the USEPA Region 9 Emergency Response Section conducted an Emergency Removal Action (ERA) at the "Desidero mines" (USEPA, n.d.). It is unknown if the "Desidero mines" in the ERA were inclusive of the same areas, or were different areas, from the areas included as the Desidero aliases presented in Section 2.1.1. It is known, however, that the area of the Desidero mines in the ERA was inclusive of 130 acres, while the Trust Section 26 AUM claim boundaries for this RSE are inclusive of 15.2 acres (USEPA, 2007a). The ERA was in response to a health advisory (the Advisory) issued on November 21, 1990, by the US Agency for Toxic Substance and Disease Control Registry (ATSDR) (USEPA, n.d.), part of the US Center for Disease Control. The Advisory was the result of a request made by NSO to ATSDR for assistance in determining the health risk for residents living near the abandoned Desidero mines. The Advisory cited the following for the Desidero mines:

- Physical hazards which included open pits, open mine adits and ventilation shafts, all accessible by children
- Excessive gamma radiation exposure from mine tailing and low grade ore piles
- Potential leaching of heavy metals into the groundwater

Prior to ERAs occurring, well water samples from homes located near the Desidero mines were collected and analyzed. The analyses showed that heavy metals left by mining activities had not leached to the groundwater.

Based on the Advisory, USEPA Removal Action activities included the following:

- Filling existing pits and covering an open adit (it is unknown if the adit filled as part of the ERA was the 155 ft incline reported by Anderson (1980) and McLemore (1983); refer to Section 2.1.1).

- Re-grading reclaimed areas to match the surrounding terrain and ensure positive drainage.

According to the USEPA report, the ERA was completed using existing material on-site consisting of: ore piles, mine waste, and overburden that had been left behind at the mines (USEPA, n.d.). No clean topsoil or fill was brought to, nor was any contaminated material taken from the Desidero mine AUM site.

Once ERAs were completed, soil samples and radiation measurements were collected (USEPA, n.d.). Three soil samples and one background soil sample were also collected for the Desidero mines. The soil sample results for total uranium were less than 30 picocuries per gram (pCi/g) and Ra-226 concentrations were less than 5 pCi/g, for the first 15 centimeters. USEPA considered these levels acceptable for uranium mill tailing remediation under 40 CFR §192[3]. The radiation measurements were collected using a Ludlum 19 survey meter. Any area that had readings over 50 microRoentgens per hour (µR/hr), which was equal to the highest natural background reading, was reworked until the gamma reading was 50 µR/hr or less.

On September 20, 1991, USEPA prepared a post ERA summary report (USEPA, 1991). In the report USEPA stated the average gamma reading within the reclaimed area was 15 µR/hr. USEPA also stated the gamma emissions present at the Desidero mines were "within reclamation guideline levels and pose no significant health risks for long term exposures"… and "it does not appear that any mining enhanced increased indoor radon concentrations should be expected or have been measured at the homes on the Desiderio sites".

2.1.4.4 1992 Aerial Photographic Analysis

In July 1992, the USEPA Environmental Monitoring Systems Laboratory Office of Research and Development issued a report presenting a supplemental aerial photographic analysis of the Desidero mines (USEPA, 1992b). The Desidero mines appear to have included portions of mine sites #1011 #1035, as well as portions of adjacent mine sites within Sections 23 and 25, identified on Figure 2-1 as mine sites #364 and #363, respectively. The report presented volumetric data regarding piles that were removed[4], capped, or still remaining on the Desidero mines following the USEPA's ERA in 1991. The volumes were calculated by using a Carto AP190 Analytical Steroplotter to compare aerial images acquired on December 7, 1990 (prior to the ERA) to aerial images acquired on November 13, 1991 (while the ERA was underway). Results of the analysis for the Desidero mines were:

- Total volume of 24 piles removed or capped during the removal action was 53,200 yd^3
- Total volume of 15 piles that still remained after the removal action was 57,805 yd^3

[3] https://www.epa.gov/radiation/health-and-environmental-protection-standards-uranium-and-thorium-mill-tailings-40-cfr

[4] The USEPA, 1992b document stated that clean up activity had been done at the Desidero mines and some waste piles were removed and while others were not. This is in contradiction to the 1991 ERA report that no material was taken from the Desidero mine AUM site. It is unknown if in USEPA, 1992b the use of "removal" is referring to the 1991 ERA where the waste piles were used to fill in the existing pits and audit.

The report presented the volumetric data on a map showing the volumes and locations of "uranium piles, soil overburden, debris piles, and thin veneer" located within the aerial photographic analysis area (USEPA, 1992b). The report also presented photographs of the Desidero mines before, during, and after the ERA (refer to Section 2.1.4.2).

2.1.4.5 2009 Weston Solutions Site Screening

In 2009 Weston performed site screening on behalf of the USEPA (Weston, 2009). The site screening included: (1) recording site observations (i.e., number of homes and water sources around the Site); (2) recording the type, number, and reclamation status of mine features; and (3) performing a surface gamma survey. Weston reported the following: several home-sites were within 0.25 miles of the Site, no water features were within a one-mile radius of the Site, and the Site had 74,201.80 square meters (798,701 ft^2) of historical underground workings. Weston did not provide a reference for the underground workings information it reported. Based on the surface gamma survey, Weston determined that the highest gamma measurements were greater than three times the lowest site-specific background level it used for the gamma screening.

2.1.4.6 2011 Aerial Radiological Survey

In August 2011, the USEPA Aerial Spectrophotometric Environmental Collection Technology program conducted aerial radiological surveys of approximately 22,000 acres of land near Ambrosia Lake, New Mexico (USEPA, 2011). The area of the Site was included in the 22,000 acres aerial radiological survey area. The purpose of the radiological surveys was to identify areas of elevated surface uranium contamination. In addition, approximately 375 aerial and oblique photographs were taken as part of the surveys.

The surveys collected approximately 11,000 one-second radiological spectra data points. The data points were analyzed for total count rate, exposure rate, and uranium concentration. Radiological analyses results for the surveys indicated the following:

- Approximately 20 distinct areas within the aerial radiological survey area had exposure rates that exceeded 20 μR/hr
- Approximately 1,700 acres of land within the aerial radiological survey area exceeded 5 pCi/g of equivalent uranium (as measured by the gamma emission from Bismuth-214)
- Maximum exposure rates were measured at 435 μR/hr and maximum equivalent uranium concentrations at 350 pCi/g during the survey

The survey report (USEPA, 2011) included a figure showing exposure rates for the entire 22,000 acre survey area. On the Figure the Site was located just east of the area labeled Sec.25 SEQ 18 ac. As shown on the figure, the area inclusive of the Site had exposure rates that exceeded 20 μR/hr.

2.1.4.7 2014 Ecology and Environment Inc. Removal Assessment

In 2014 Ecology and Environment Inc. (E&E) performed a Removal Site Assessment (RSA) at the Site on behalf of the USEPA (E&E, 2014). The RSA included a surface gamma survey and collection of surface and subsurface soil samples at the RSA site and at a selected background reference area. The 2014 E&E RSA site area was different from the area of the Trust Section 26 AUM included in this RSE. It included the AUM mine site boundaries for #1011, #1035 and the northern portion of mine site #1012, plus additional areas to the southwest and southeast of #1011 and #1035 (refer to Figure 1 of the 2014 RA). E&E's objectives of the 2014RSA were:

1. Determine whether, and in what areas, the 2014RSA site concentrations of Ra-226 in surface soil require removal, further assessment, or no further action, including:
    - Determine whether gamma radiation measurements can be used to characterize the 2014RSA site or if further sampling to characterize the 2014RSA site is necessary
    - Determine a suitable background location for collecting data to calculate a 2014RSA site-specific action level or identify an alternate means of setting an action level
2. Determine whether 2014RSA site concentrations of Ra-226 in subsurface soil at locations where the surface levels of Ra-226 are elevated require removal, further assessment, or no further action

For the 2014RSA the Ra-226 action level and gamma radiation investigation level, as determined by E&E, was 2.29 pCi/g and twice the daily background gamma radiation level, respectively. Before E&E began gamma surveying using a 3-inch by 3-inch gamma detector, a one-minute surface gamma radiation measurement was collected daily from three locations in the background reference area. E&E then used these measurements to calculate the daily average background gamma radiation level. The daily average background level ranged from 20,425 to 22,005 cpm, and the gamma radiation investigation level used in the field by E&E was based on twice the daily average background level.

For the 2014 RA, E&E collected surface and subsurface soil samples based on the results of the gamma radiation surveys. Surface soil samples were collected at locations where gamma measurements were below, at, and above the E&E determined gamma radiation investigation level. Subsurface soil samples were collected from locations of the highest gamma measurements based on the gamma radiation surveys. To collect subsurface soil samples potholes were excavated, using a backhoe, at 1 ft depth bgs intervals. Subsurface soil samples were collected at each interval until gamma measurements were below the E&E gamma radiation investigation level, or a maximum depth of 4 ft bgs or refusal was reached. E&E collected static 1-minute gamma measurements and soil samples from the surface of excavated soil in the backhoe bucket.

Results of the 2014RSA as reported by E&E were:

- Rocks were observed in areas with elevated gamma measurements up to concentrations exceeding 999,000 cpm. It is unknown if E&E meant bedrock or rocks that are part of the unconsolidated deposit matrix.
- Ra-226 concentrations in soil were detected above the action level of 2.29 pCi/g in surface and subsurface soils. Sampling locations with elevated levels of Ra-226 in surface soil also contained subsurface Ra-226 at concentrations exceeding the action level. Ra-226 concentrations detected at the 2014RSA site generally decreased with depth except when subsurface rocks with elevated gamma measurements were present. Again, it is unknown if E&E meant bedrock or rocks that are part of the unconsolidated deposit matrix.

E&E used the results of the gamma radiation surveys and Ra-226 analyses to determine the relationship between gamma measurements and Ra-226 concentrations. Based on this, E&E proposed removal areas. E&Es results indicate there was a correlation and linear relationship between surface soil Ra- 226 sample results and co-located 1-minute gamma measurements. However, E&E determined the reported relationship to be weak and that the relationship may have been different at lower gamma measurements and lower Ra-226 concentrations. In addition, E&E determined that a prediction interval that can effectively predict Ra-226 concentrations in soil below the action level based on a measured co-located 1-minute gamma measurements needed to be established.

E&E used the results of the 2014RSA to define areas of the 2014RSA site for further action, such as source removal or institutional controls to protect human health. E&E determined the proposed lateral extent of areas for removal based on the surface gamma measurements levels and surface soil sample results exceeding the action level. E&E used the subsurface soil sample results exceeding the E&E action level to determine the vertical extent of soil for removal.

Based on the results, E&E reported that it "appears further action was necessary at AUM Section 26 to mitigate exposure threat posed by the [2014 RA] site". E&E proposed excavation of soil totaling approximately 9,737 yd^3 for the following 2014RSA site removal areas:

1. Mine claim ID 1011[5]
    - Excavation of soil to 1 ft bgs near the closest home-site to the east (AUM26-RA-01, -02, and -03). The proposed excavation included 29,488 ft^2 (0.63 acres) for a total of 1,091 yd^3.
2. Mine claim 1035
    - Excavation of soil to 4 ft bgs around areas AUM26-SS-04, -05, and -06 (AUM26-RA-05) which were located in the vicinity of the shaft. It is unknown if the shaft is the adit filled as part of the ERA (USEPA, n.d.) and/or the 155 ft incline reported by Anderson

[5] This is the claim identification nomenclature used by E&E in the 2014RSA (e.g. Mine claim ID 1011 instead of mine site #1011).

(1980) and McLemore (1993). The proposed excavation included 7,284 ft^2 (0.17 acres) for a total of 1,079 yd^3.

- Excavation of soil to 1 ft bgs in remaining areas with elevated gamma measurements (AUM26-RA-06). The proposed excavation included 178,618 ft^2 (4.1 acres) for a total of 6,615 yd^3.

3. Area Bounded by Mine claim 1011

   - Excavation of soil to 2 ft bgs around AUM26-SS-07 (AUM26-RA-04). The proposed excavation included 12,847 ft^2 (0.29 acres) for a total of 952 yd^3.

E&E recommended removal of loose rocks with elevated gamma measurements throughout the 2014RSA site, but did not provide a volume estimate for this material.

E&E reported that the area south of mine claim 1035 had gamma measurements up to 80,000 cpm, and that Ra-226 concentrations were not available for this area. The nearest location (AUM26-SS-10) with similar gamma measurements contained Ra-226 below the action level. E&E recommended additional assessment for this area, but did not include an area or volume estimate.

E&E reported that areas on the mesa had some surface soil that exceeded the Ra-226 E&E action level, but the primary source of elevated gamma measurements in these areas appeared to be bedrock. The Ra-226 concentrations in this area, except for AUM26-SS-01, were less than twice the E&E action level. E&E did not provide area or volume estimates for these locations, but recommended institutional controls, such as fencing to prevent access of these areas.

Refer to the 2014RSA figures, tables, and appendices for E&E sample locations, E&E proposed removal areas, and E&E estimated potential soil excavation volumes by removal area.

2.2 PHYSICAL CHARACTERISTICS

2.2.1 Regional and Site Physiography

The Site is located within the Colorado Plateau physiographic province, which is an area of approximately 240,000 square miles in the Four Corners region of Utah, Colorado, Arizona, and New Mexico. Figure 2-3 presents a current regional aerial photograph (BING® Maps, 2018) of the Site within a portion of the Colorado Plateau. The Colorado Plateau is typically high desert with scattered forests and varying topography having incised drainages, canyons, cliffs, buttes, arroyos, and other features consistent with a regionally uplifted, high-elevation, semi-arid plateau (Encyclopedia Britannica, 2017). The physiographic province landscape includes mountains, hills, mesas, foothills, irregular plains, alkaline basins, some sand dunes, and wetlands. This physiographic province is a large transitional area between the semi-arid grasslands to the east, the drier shrub-lands and woodlands to the north, and the lower, hotter, less-vegetated areas to the west and south.

The Colorado Plateau includes the area drained by the Colorado River and its tributaries: the Green, San Juan, and Little Colorado Rivers (Kiver and Harris, 1999). The physiographic province is composed of six sections: Uinta Basin, High Plateaus, Grand Canyon, Canyon Lands, Navajo, and Datil-Mogollon. The Site is located within the Navajo section.

Figure 2-4 presents the regional US Geological Survey (USGS) topographic map of a portion of the Colorado Plateau in the vicinity of the Site. Figure 2-5 presents the Site topography (Cooper Aerial Surveys Company [Cooper; refer to Section 3.2.2.1]) within a portion of the Colorado Plateau. The mine sites are located on a mesa top with mine site #1012 also located along a mesa sidewall. The elevation on-site is approximately 7,100 ft above mean sea level (amsl) (refer to Figure 2-5).

2.2.2 Geologic Conditions

2.2.2.1 Regional Geology

Regionally the Site is located within the Ambrosia Lake Mining Sub-district, in the southeastern portion of the Colorado Plateau and on the northeast flank of the Zuni uplift. The Ambrosia Lake Mining Sub-district consists of limestone and evaporates that were deposited in a near marine-environment that received both fresh and saline water (Green, 1982). The Colorado Plateau is a massive outcrop of generally flat-lying sedimentary rocks ranging in age from the Paleozoic Era to the Cenozoic Era (USGS, 2017). The plateau has very little regional structural deformation, compared with the mountainous basin-and-range region to the west, and the sedimentary beds range widely in thickness from less than 1 inch to hundreds of feet. Changes in paleoclimate and elevation produced alternating occurrences of deserts, streams, lakes, and shallow inland seas; and these changes contributed to the type of rock deposited in the region. The rock units of the plateau consist of shallow submarine or sub-aerially deposited rocks including sandstone, shale, limestone, mudstone, siltstone, and various other sedimentary rock subtypes. The Zuni uplift is a northwesterly trending uplift that is oval-shaped with a length of approximately 75 miles and a width of approximately 30 miles (Kelly, 1967). Precambrian rocks are exposed in several large areas along the crest of the uplift. Surrounding the Precambrian outcrops is a wide band of Permian strata that surfaces as the main portion of the uplift. Outside the Permian outcrops Mesozoic rocks form valleys, hogbacks, and mesas that mark the outer boundaries of the uplift.

The ore host bedrock on-site was the Jurassic Todilto Limestone (Hilpert, 1969). Regionally, within the Ambrosia Lake Mining Sub-district, the Todilto Limestone consists of two facies; a lower locally carbonaceous limestone facies that ranges in thickness from 0 to 40 ft and an overlying gypsum-anhydrite facies that ranges in thickness from 0 to 170 ft. Within the Ambrosia Lake Mining Sub-district, the Todilto Limestone was the host formation for numerous small- to medium-sized uranium deposits that occurred in joints, shear zones, and fractures within small to large scale intraformational folds (Green, 1982). A regional geology map is shown in Figure 2-3. With the exception of a few shallow underground mines, the majority of the Todilto ore deposits were mined from open pits on the Todilto outcrop bench. From 1950 to 1978, mines located on

43 different properties in the Ambrosia Lake Mining Sub-district produced approximately 30,000 tons of U_3O_8 from Todilto orebodies (Green, 1982).

2.2.2.2 Site Geology

Bedrock outcrops on the Site consist of the Jurassic Luciano Mesa Member of the Todilto Formation, the Jurassic Entrada Sandstone, and the Triassic Wingate Sandstone, as shown if Figure 2-7a. On-site uranium was located in Todilto Limestone (Chenoweth, 1985). The Todilto Formation consists of olive-gray to pale-yellow, thin-to thick-bedded limestone deposited in a lacustrine or saline environment. The Entrada Sandstone consists of reddish-orange to reddish-brown fine-to medium-grained eolian cross-bedded sandstone, and dark-reddish-brown clayey siltstone and very fine grained silty sandstone. The Wingate Sandstone consisted of reddish-brown, fine-to medium-grained, cross-bedded eolian sandstone. A geologic profile across the plains, mesa sidewall, and mesa top of the Site is shown in Figure 2-7a. A photograph of the primary bedrock outcrops at the Site is shown in Appendix B-1 photograph number 6. Exposed bedrock on-site is shown in Figure 2-7b.

Unconsolidated deposits on-site (i.e., Quaternary deposits) are eolian deposits, and alluvium and colluvium consisting of poorly and well graded sand and/or gravel, with varying amounts of silt, clay and cobbles, as shown on the borehole logs in Appendix C.2. Alluvium in the drainage channels consists of poorly graded sand with gravel and/or silt, and silt with fine sand. Drainage channels are shown in Figure 2-8. During the Site Characterization field activities, boreholes were advanced through the unconsolidated deposits using a hand auger or Geoprobe™ 8140LC rotary sonic drilling rig (refer to Section 3.3.2.2 and the borehole logs in Appendix C.2). The unconsolidated deposits ranged in depth from 0.2 to 20.0 ft below ground surface (bgs) at borehole locations.

Two cross-sections for the Site were produced using the subsurface borehole information, as shown in Figures 2-9a and 2-9b. The cross-sections show the extent and orientation of the consolidated and unconsolidated deposits in relation to the reclamation work that occurred on-site (refer to Section 2.1.4). The boreholes located closest to the cross-section lines were used to generate the cross-section figures and all boreholes were used to determine the average unconsolidated material depth to assist with projecting depth to bedrock in relation to the cross-sections.

According to the US Department of Agriculture (USDA) Soil Survey for McKinley County, New Mexico, soils on-site that have not been disturbed, are classified as Penistaja-San Mateo Series consisting of fine sandy loams that are deep and well drained (USDA, 1993).

2.2.3 Regional Climate

The Colorado Plateau is located in a zone of arid temperate climates characterized by periods of drought and irregular precipitation, relatively warm to hot growing seasons, and winters with sustained periods of freezing temperatures (National Park Service, 2017). The average monthly high temperature at weather station 298834, Thoreau 12 SE, New Mexico (Western Regional

Climate Center, 2017) located approximately 21 miles west of the Site, ranges between 41.8 degrees Fahrenheit (°F) in January to 83.2°F in July. Daily temperature extremes reach as high as 101°F in summer and as low as -24°F in winter. Thoreau 12 SE receives an average annual precipitation of 10.5 inches, with August being the wettest month, averaging 1.95 inches, and June being the driest month, averaging 0.47 inches.

Potential evaporation in the area is greater than the area's average annual precipitation. The potential evaporation noted at the Gallup Ranger Station weather station, located approximately 28 miles west of the Site, averages 62 inches of pan evaporation annually (Western Regional Climate Center, 2017). Average wind speeds in the area are generally moderate, although relatively strong winds often accompany occasional frontal activity, especially during late winter and spring months. Blowing dust, soil erosion, and local sand-dune migration/formation are common during dry months. The Grants, New Mexico airport, located approximately 12 miles to the south of the Site, had the most complete record of wind conditions. A wind rose for Grants airport is presented on Figure 1-1. The wind rose was produced using data contained in the *2007 AUM Atlas* for the years 1996 to 2006. Predominant winds were from the northwest (refer to the wind rose on Figure 1-1).

2.2.4 Surface Water Hydrology

The Site is located within the Rio Grande-Elephant Butte watershed, an area of approximately 27,000 square miles spanning New Mexico, as shown in Figure 1-1. On-site overland surface water flow, when present, is controlled by a decrease in elevation either to the north or south from the edge of the mesa (refer to Figures 2-5 and 2-8). Numerous parallel patterned ephemeral drainages are present on-site that drain either to the northeast (on the mesa top) or to the south (in the plains), where they then terminate, as shown in Figure 2-1.

Adkins Consulting Inc. (Adkins), under contract to Stantec, performed a wildlife evaluation as part of the Site Clearance field investigations and did not identify any wetlands, seeps, springs, or riparian areas within the Site (refer to Appendix E).

2.2.5 Vegetation and Wildlife

In the spring and summer of 2016, biological surveys were conducted as part of Site Clearance activities. In May 2016, Adkins conducted a wildlife survey. In July 2016, Redente Ecological Consultants (Redente), under contract to Stantec, conducted a summer vegetation survey. Information about each survey is provided in Appendix E, which includes the Site biological evaluation reports and the *Navajo Nation Department of Fish and Wildlife* (NNDFW) *Biological Resources Compliance Form*. A summary of the survey activities and findings are provided in Section 3.2.2.3.

Vegetation communities found within the physiographic transitional area described in Section 2.2.1 include shrublands with big sagebrush, rabbitbrush, winterfat, shadscale saltbush, and greasewood; and grasslands of blue grama, western wheatgrass, green needlegrass, and needle-and-thread grass. Higher elevations may support pinyon pine and juniper woodlands.

Vegetation communities on-site were sparsely vegetated grassland with sporadic shrubs and scattered pinyon/juniper in the eastern and southernmost areas (refer to Appendix E). During the surveys, Stantec and/or its subcontractors observed on-site wildlife including common raven, common nighthawk, cottontail rabbit, and mule deer (refer to Appendix E).

2.2.6 Cultural Resources

In May 2016, as part of Site Clearance activities, Dinétahdóó Cultural Resource Management (Dinétahdóó), under contract to Stantec, conducted a cultural resource survey, as well as ethnographic and historical data reviews, and interviewed local residents living near the Site (Dinétahdóó, 2016). The local residents recalled that mining occurred on-site through the 1950s and 1960s. The residents spoke about the Site as the southern area, the northwest area, and the northeast area. The residents recalled that in the southern area mining occurred from an open pit that was active from 1952 to 1953. The residents further recalled that in the northwest area mining occurred from an open pit with an incline, and in the northeast area, mining occurred from an open pit which extended east. The residents stated surface mining occurred from pits where a bull dozer driver stripped off the overburden and then miners would drill and set explosive charges. After the blasts were set off, a loader would put the ore into ore dump trucks. For underground mining the residents recalled mining occurred inside of inclines where miners would use a small mucking machine to load the ore into ore cars. A small engine would then pull the ore cars out of the mine and to the stockpile. Heavy equipment was used to move the ore out of the cars and onto the stockpile. The residents also recalled that around 1980, the open pit associated with the southern area was filled in by a company that was working at a mine located on Section 25. No historical documentation was found regarding a pit being filled in in 1980 (refer to Section 2.1.4).

During the 2016 cultural resource survey Dinétahdóó identified one archaeological site, two isolated occurrences, and one in-use site. Appendix E includes a copy of the *Cultural Resource Compliance Form,* and findings of the cultural resource survey are summarized in Section 3.2.2.4.

2.2.7 Observations of Potential Mining and Reclamation

During RSE activities, Stantec field personnel (field personnel) observed the following features indicative of potential mining or reclamation activities at the Site: a possible portal or storage area, potential haul roads, debris, excavation areas, potential mining disturbed areas, potential waste rock, waste piles, vertical mine shafts, graded/disturbed reclaimed areas, and historical boreholes. Details regarding these observations are presented in Section 3.2.2.1. These observations were used, along with additional lines of evidence (refer to Section 3.3.3), to identify areas at the Site where TENORM was present (refer to Section 4.6).

3.0 SUMMARY OF SITE INVESTIGATION ACTIVITIES

3.1 INTRODUCTION

This section summarizes Site Clearance and RSE activities conducted between August 2015 and September 2017. The purpose of the RSE activities was to review relevant information and collect data related to historical mining activities to support future Removal or Remedial Action evaluations for the Site. Site Clearance activities were conducted before RSE activities to obtain information necessary to develop the *RSE Work Plan*. Site Clearance activities were performed in accordance with the approved *Site Clearance Work Plan.* RSE activities were performed in accordance with the approved *RSE Work Plan.* The RSE is not intended to establish cleanup levels or determine cleanup options or potential remedies.

The *RSE Work Plan* is comprised of a Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPP), Health and Safety Plan (HASP), and a Data Management Plan (DMP). The FSP guided the fieldwork by defining sampling and data-gathering methods. The QAPP presented quality assurance/quality control (QA/QC) requirements designed to meet Data Quality Objectives (DQOs) for the environmental sampling activities. The HASP listed site hazards, safety procedures and emergency protocols. The DMP described the plan for the generation, management, and distribution of project data deliverables. The FSP, QAPP, HASP, and DMP provided the approved requirements and protocols to be followed for the RSE data collection, data management, and data analyses performed to develop this RSE report. Any deviations or modifications from the *RSE Work Plan* are described in the appropriate RSE report sections.

The RSE process followed applicable aspects of the USEPA DQO Process and *MARSSIM*, to verify that data collected during the RSE activities would be adequate to support reliable decision-making (USEPA, 2006). The USEPA DQO Process is a series of planning steps based on the scientific method for establishing criteria for data quality and developing survey designs. *MARSSIM* provides technical guidance on conducting radiation surveys and site investigations.

The USEPA DQO Process is a seven-step process[6] that was performed as part of the *RSE Work Plan* to identify RSE data objectives. The goal of the USEPA DQO Process is to minimize expenditures related to data collection by eliminating unnecessary, duplicate, or overly precise data and verifies that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application. It provides a systematic procedure for defining the criteria that the survey design should satisfy. This approach provides a more effective survey design combined with a basis for judging the usability of the data collected (USEPA, 2006).

[6] (1) State the problem; (2) Identify the goals of the study; (3) Identify the information inputs; (4) Define the boundaries of the study; (5) Develop the analytical approach; (6) Specify the tolerance on decision errors; and (7) Optimize sampling design (USEPA, 2006).

The USEPA DQO Process performed for the RSE is presented in the *RSE Work Plan*, Section 3, and identifies the purpose of the data collected as follows:

1. Background reference area soil/sediment sampling, laboratory analyses, surface gamma surveying, and subsurface static gamma measurements to establish background analyte concentrations and gamma measurements, which will be used as the ILs, for the Site.

2. Site sampling (soil and sediment), laboratory analyses, surface gamma surveying, and subsurface static gamma measurements for comparison with ILs, to define the lateral and vertical extent of contamination at the Site to characterize the Site to support future Removal or Remedial Action evaluations.

The USEPA DQO Process was used in conjunction with *MARSSIM* guidance for RSE planning and data collection. Per *MARSSIM* guidance, "planning radiation surveys, using the USEPA DQO Process, can improve radiation survey effectiveness and efficiency, and thereby the defensibility of decisions" (USEPA, 2000).

The applicable aspects of *MARSSIM* incorporated into the RSE process include:

- Historical site assessment
- Determining RSE DQOs
- Selecting background reference areas
- Selecting radiation survey techniques
- Site preparation
- Quality control
- Health and safety
- Survey planning and design
- Baseline surface gamma surveys and subsurface static gamma measurements
- Field measurement methods and instrumentation
- Media sampling and preparation for laboratory analyses

The RSE process also used applicable aspects of *MARSSIM* for interpretation of the RSE results, including:

- Data quality assessment through statistical analyses
- Evaluation of the analytical results
- Quality assurance and quality control

Sections 3.2 and 3.3 summarize the field investigation methods and procedures for data collection during the Site Clearance activities and the RSE activities, which are described in detail in the *RSE Work Plan,* Section 4. Appendix A.1 includes the radiological characterization report prepared by Environmental Restoration Group, Inc. (ERG), under contract to Stantec. Appendix B includes photographs of features at the Site and the surrounding area, Appendix C.1 includes field forms and Appendix C.2 includes borehole logs.

3.2 SUMMARY OF SITE CLEARANCE ACTIVITIES

The Site Clearance activities consisted of two tasks: a desktop study and field investigations. The desktop study was completed prior to field investigations, and the findings of the desktop study were used to guide field investigations. The Site Clearance activities are detailed in the *Site Clearance Data Report* and are described below.

3.2.1 Desktop Study

The desktop study included:

- Review of historical aerial photographs (USGS, 2016). Photographs were selected based on sufficient scale, quality, resolution, and whether the photograph met one or more of the following criteria:
    - Showed evidence of active mining or grading of the Site, or provided information on how the Site was developed or operated (e.g., haul roads and open pits).
    - Showed evidence of reclamation (e.g., soil covers).
    - Showed significant changes in ground cover compared to current photographs.
- Review of current aerial photographs for identification of buildings, homes and other structures, and potential haul roads within 0.25 miles of the Site.
- Review of topographic and geologic maps.
- Review of information related to surface water features and water wells on the Navajo Nation within a one-mile radius of the Site, provided by: (1) the Navajo Nation Department of Water Resources (NNDWR); and (2) ESRI Shapefiles data contained in the *2007 AUM Atlas*.
- Review of previous studies, information related to potential past mining, and reclamation activities.
- Identification of the predominant wind direction in the region of the Site.

Based on the list above, the following findings were identified during the desktop study:

- Historical photographs (USGS, 2016) for the Site were selected from 1952, 1956, 1991, 1997, and 2005 for comparison against a current 2017 image (Cooper, 2017). The selected historical photographs are shown in Figure 3-1a. Figure 3-1b compares the aerial photograph from 1956 and the current 2017 image. Figure 3-1c compares the aerial photograph from 1991 and the current 2017 image. Signs of mining activity, including piles of material and removal of overburden material, are present in the 1956 photograph in mine sites #1011 and #1035 (refer to Figure 3-1b). Signs of reclamation, including filling in of historical mining areas and regrading, are present in the 1991 photograph in mine sites #1011 and #1035 (refer to Figure 3-1c). From the 1991 photograph to the current 2017 photograph, the reclaimed areas appear re-vegetated, as shown in Figure 3-1c.

- The current aerial photograph review confirmed that several home-sites were located within 0.25 miles of the Site to the west, north, and east, as shown in Figure 2-1. Numerous dirt roads were identified within 0.25 miles of the Site, refer to Figure 2-1. The road type (i.e., potential haul road or road unrelated to historical mining) was identified by the current aerial photograph review, historical document review, and visual identification during the Site Clearance field investigations (refer to Section 3.2.2.1).

- Four water features were identified within a one-mile radius of the Site based on the review of information provided by the NNDWR and the *2007 AUM Atlas,* refer to Table 3-1and Figure 2-1.

- The predominant regional winds were from the northwest (refer to Section 2.2.3 and Figure 1-1).

As part of the desktop study a request was made by Stantec to NAML and New Mexico Mining and Mineral Division for any information regarding reclamation activities occurring on-site. The two departments contacted did not have any reclamation records for the Site. Previous studies and information related to past mining/exploration are discussed in Sections 2.1.1 and 2.1.4.

3.2.2 Field Investigations

3.2.2.1 Site Mapping

The *Site Clearance Work Plan* specified that the following features at and near the Site, if present, should be mapped, marked, and/or their presence confirmed:

- Claim boundaries and the 100-ft buffers of the claim boundaries

- Roads, fences/gates, utilities: haul roads to a distance of 0.25 miles or to the intersection with the next major road, whichever is closer

- Structures, homes, buildings, livestock pens, etc.

- Surface water and water well locations: surface water channels that drain the Site to a distance of 0.25 miles away from the Site or to the confluence with a major drainage, whichever is closer; surface water features and water wells identified within a one-mile radius of the Site

- Topographic features

- Potential background reference areas

- Type of ground cover, including rock, soil, waste rock, etc.
- Physical hazards

Based on the list above, the following site features were mapped during field investigations:

- Claim boundaries – 100-ft buffers of the claim boundaries, as shown in Figure 2-8, were marked in the field with stakes and/or flagging and mapped with a global positioning system (GPS).
- Topographic features – The mapped area can be divided into three primary topographic areas: the (1) mesa top; (2) mesa sidewall; and (3) plains. With the exception of the eastern portion of mine site #1035, the mesa top is a sub-horizontal surface that slopes gently to the northeast. The northeastern portion of mine site #1035 has a hummocky and irregular topography characterized by an undulating surface expression. The rim of the mesa is sinuous and dissected by gullies with several topographic prominences along the edge. The mesa sidewall is characterized by steep bedrock slopes near the top that have been undercut in areas near the base. The undercutting has created talus slopes at the transition between the mesa sidewall and the plains. The plains slope gently to the south. The topographic areas are shown in Figure 2-5 and in Appendix B-1 photograph numbers 6 and 15.
- Drainages – Numerous sub-parallel ephemeral drainages are present on-site that drained either to the northeast (on the mesa top) or to the south (in the plains), where they then terminated, as shown in Figures 2-1 and 2-8. Two of the drainages are shown in Appendix B-1 photograph number 7 and Appendix B-2 photograph number 16.
- Potential haul road – Potential haul roads were mapped, as shown in Figures 2-1 and 2-8. The potential haul roads provided access to mine sites #1011, #1012, and #1035. The potential haul roads are also shown as earthworks in Figure 2-7a and 2-7b.
- Road –Roads were mapped, as shown in Figure 2-8. The roads were dirt and provided access to home-sites or to the potential haul roads.
- Possible portal or storage area – One possible portal or storage area was mapped, as shown in Figure 2-8. The area was historically backfilled and covered with wood debris, as shown in Appendix B-1 photograph number 10. It was unknown if the possible portal or storage area was related to the historical 155 ft incline used to mine ore on-site (refer to Section 2.1.1)
- Historical boreholes – Nine historical boreholes were mapped, as shown in Figure 2-8. At least six historical boreholes were identified on mine site #1035 and were not plugged (i.e., open). The open boreholes ranged in diameter from 6 to 8 inches, and ranged in depth from 5 ft to 34 ft, based on measurements collected by field personnel with a weighted tape measure lowered into the borehole from ground surface. Some of the historical boreholes are shown in Appendix B-1 photograph numbers 13 and14. Because the boreholes were not plugged, the Agencies and Trustee decided this posed a safety risk. To mitigate the safety hazard the Trust conducted an interim closure, pursuant to the Trust provisions for interim actions. Prior to the interim closure the Trust contacted explosives experts suggested by the Agencies to investigate a potential storage area located on-site where the Agencies thought there might be unexploded munitions. On February 15, 2018, Stantec escorted three

representatives from the New Mexico State Police Bomb Squad on-site. The explosives experts assessed the potential storage area and the surrounding area and did not identify evidence of explosives or materials associated with explosives storage. After the munitions clearance, in May and July 2018, the Trust conducted the interim closure and backfilled the nine boreholes with soil. Because this work was completed separately from the RSE, it is not reported herein, and instead was reported to the Agencies in an interim action summary letter (Stantec, 2018).

- Utilities – A buried water line and a power line were mapped, as shown in Figure 2-8. The water line was not well marked and was difficult to identify. The power line connected to several home-sites and also ran across mine sites #1011 and #1035.

- Debris – Three debris piles were mapped, as shown in Figure 2-8. Contents of the center debris pile included cans, bottles, car parts/car frames, metal scraps, wood scraps pallets, wire, general construction debris, and miscellaneous trash. The center debris pile (shown in Appendix B-1 photograph number 4) filled a shallow, elongated excavation that appeared to be approximately 2 to 4 ft deep. It was not known if this excavation was related to historical mining. The northern pile contained approximately 30 to 40 tires and the southern debris pile contained more than 100 tires.

- Waste pile – Seven waste piles were mapped (Waste Pile 1 through Waste Pile 7), as shown in Figure 2-8 and Appendix B-1 photograph numbers 2, 3, 8 and Appendix B-2 photograph number 15. The waste piles consisted of gray limestone of the Todilto Formation.

- Excavation – Two excavation areas were mapped, as shown in Figure 2-8. The excavation areas were along the mesa edge, less than 10 ft deep, and were associated with Waste Pile 2 and Waste Pile 3. The excavation areas are shown as earthworks in Figures 2-7a and 2-7b. The excavation area associated with Waste Pile 2 is shown in Appendix B-1 photograph numbers 1 and 9.

- Graded/disturbed reclaimed area – Graded/disturbed reclaimed areas were mapped on mine sites #1011 and #1035, as shown in Figure 2-8. It is assumed that the areas were graded and reclaimed as part of the USEPA's 1991 ERA (refer to Section 2.1.4.2). The graded/disturbed reclaimed areas are shown as earthworks in Figures 2-7a and 2-7b.

- Potential mining disturbed areas – Four potential mining disturbed areas were mapped at, as shown in Figure 2-8. These areas are shown as earthworks in Figures 2-7a and 2-7b. Two of the disturbed areas were mapped by field personnel and were located along the mesa rim. The other two disturbed areas were identified using high resolution aerial images, and are located on the mesa top, in the central portion of the Site. Disturbed Area 3 is assumed to be the small prospect pit described in Section 2.1.4.1.

- Potential waste rock – Potential waste rock area was mapped near the mesa edge, as shown in Figure 2-8. The potential waste rock area is shown as earthworks in Figures 2-7a and 2-7b.

- Vertical mine shafts – Two unsecured vertical mine shafts were mapped, as shown in Figure 2-8. The two shafts were identified by field personnel as the primary shaft and secondary shaft. Field personnel collected measurements of the shafts using a weighted tape measure lowered into the shafts from ground surface. The primary shaft was square shaped at the surface and measured approximately 5 ft long by 5 ft wide by approximately 28 ft deep. The secondary shaft was square shaped at the surface and measured approximately 2.5 ft long by 2.5 ft wide by 8 ft deep. Field personnel did not detect water and/or air moving inside the shafts and neither shaft appeared to be connected to underground workings. Because the shafts were unsecured, the Agencies and Trustee decided this posed a safety risk to people and animals. To immediately and temporarily mitigate the safety risk, the two shafts were surrounded by a chain link fence that measured approximately 19 ft wide by 20 ft long by 8 ft tall, had a locked gate, and barbed wire at the top. To further mitigate the safety hazard the Trust conducted an interim closure, pursuant to the Trust provisions for interim actions. In May and July 2018, the Trust conducted the interim closure and backfilled the two shafts with soil. Once the shafts were backfilled the temporary fencing was removed. Because this work was completed separately from the RSE, it is not reported herein, and instead was reported to the Agencies in an interim action summary letter (Stantec, 2018). The vertical mine shafts are shown in Appendix B-1 photograph numbers 11 and 12. It is unknown if the shafts were related to the historical 155 ft incline used to mine ore on-site (refer to Section 2.1.1). It is also unknown if the shafts were excluded from reclamation during the 1991 ERA, or if the reclamation-related backfilling of the shafts had collapsed.

- Structures – Several home-sites were located within 0.25 miles of the Site to the west, north, and east, as shown in Figure 2-1.
- Water Features – Field personnel attempted to assess the four water features identified during the desk top study but were unable to access any of the four locations because they were located on private land and behind locked gates, as summarized in Table 3-1.
- Ground cover – Ground cover and vegetation observed on-site are discussed in Sections 2.2.2.2 and 2.2.5, respectively.

Field personnel did not observe evidence of the historical underground workings reported by Weston (2009) or the historical pits discussed in Section 2.1.1. The pits were not observed because they were reclaimed during the 1991 ERA. In addition, the *2007 AUM Atlas* identified a vertical mining feature and one pit located on each of the three mine sites. The vertical mining feature located in the *2007 AUM Atlas* was in the same area as the vertical mine shafts observed by field personnel. The pits identified in the *2007 AUM Atlas* were not observed by field personnel because the *2007 AUM Atlas* located the pits in either the graded/disturbed reclaimed area (for mine sites #1011 and #1035) or the potential mining disturbed area (for mine site #1012).

In June 2018, the USEPA provided the Trust with a copy of a NNDWR database that was generated in 2018. The USEPA stated that there were discrepancies between the NNDWR water feature locations in the 2018 database and those provided in the 2016 NNDWR database used by the Trust. The USEPA provided comment that the 2018 NNDWR database indicates well 16-2-6 is within one mile of mine site #1011 and that it may need to be addressed. The 2016 NNDWR database identified well 16-2-6 outside the one-mile buffer for the Site (refer to Figure 2-1) and it was not assessed during Site Characterization. This information about the 2018 database was provided after Site Characterization activities had occurred and was therefore not included in the RSE for the Site. Comparison of the 2018 NNDWR database against the 2016 NNDWR database and the *2007 AUM Atlas* will require additional field work and it is recommended that this be addressed in future studies for the Site.

On June 28, 2018, the USEPA provided a historical "Desidero waste piles map" that showed the locations and estimated area and volumes of uranium piles, soil overburden, and debris piles across the Site (refer to Section 2.1.4.4). The USEPA confirmed this map was part of previously received report presenting a supplemental aerial photographic analysis of the Desidero mines (USEPA, 1992b), but the map was not included in the previous copy of the report. Due to the late receipt of this document, it was not evaluated for this RSE report. A copy of the map is included with the historical documents attachment. Additional analysis of this map is warranted as part of future investigations at the Site.

In addition to the Site mapping activity, the Trust took high-resolution aerial photographs and collected topographic data at the Site. The objective of the high-resolution aerial photography survey was to develop orthophotographs and topographic data of the Site to:

- Assist with identifying ground cover (e.g., soil versus bedrock)
- Assist with delineating historical mine features (e.g., haul roads, portals, and waste piles)
- Allow additional evaluation of areas that were inaccessible due to steep or unsafe terrain
- Provide site base maps (high resolution imagery and elevation data) that could be used to support future Removal or Remedial Action evaluations at the Site

Stantec proposed to perform aerial photography in order to provide an overview of the Site and identify features that could not otherwise be accomplished safely on foot. USEPA is not authorized to allow drones on sites it oversees: therefore, drone use was not an option. Although aerial photography was not included in the approved *Scope of Work* (MWH, 2016d), the Trustee notified the Agencies and obtained approval prior to commencement of the work. The Trust also consulted with Baca/Prewitt Chapter officials and nearby residents and notified them of the aerial photography survey. On June 16, 2017 Cooper flew over the Site in a piloted fixed-wing aircraft and collected 3.5-centimeter digital color stereo photographs of the Site. Cooper provided the following data:

- Digital, high-resolution color orthophotograph imagery
- AutoCAD files (2-dimensional and 3-dimensional) that included elevation contours (refer to Figure 2-4) and plan features
- Elevation point files
- Triangular Irregular Network surface files

The site orthophotographs and supporting data files were used for data analyses, including estimating volumes of potentially mining-impacted material at the Site. They also were used as the base image for selected figures included in this RSE report, to the extent applicable.

3.2.2.2 Potential Background Reference Area Evaluation

The desktop study findings and field investigation observations were used to identify eight potential background reference areas (BG-1 through BG-8) for the Site, as shown in Figure 3-2 and described in Appendix D.1. BG-1 through BG-5 were selected as suitable surface background reference areas for the Site for the following reasons:

- BG-1 encompassed an area of 1,708 ft^2 (approximately 0.04 acres), was located 521 ft west of mine site #1011, and was upwind and hydrologically cross-gradient from the Site. The thin soils and bedrock outcrops represented the portions of the Site within the Todilto Limestone. The vegetation and ground cover at BG-1 were similar to the portions of the Site on the mesa edge.

- BG-2 encompassed an area of 2,328 ft^2 (approximately 0.05 acres), was located 557 ft northwest of mine site #1011, and was upwind and hydrologically cross-gradient from the Site. The thicker soils represented the portions of the Site that consisted of undifferentiated Quaternary deposits including residual soils, alluvium, and eolian deposits. The vegetation and ground cover at BG-2 were similar to the portions of the Site on the mesa top.

- BG-3 encompassed an area of 683 ft^2 (approximately 0.02 acres), was located 618 ft west of mine site #1011, and was upwind and hydrologically cross-gradient from the Site. The thin soils, colluvium-covered slopes, and bedrock outcrops represented the portions of the Site within the Entrada Sandstone. The vegetation and ground cover at BG-3 were similar to the portions of the Site on the mesa sidewall.

- BG-4 encompassed an area of 5,623 ft^2 (approximately 0.13 acres), was located 1,387 ft west of mine site #1012, and was upwind and hydrologically cross-gradient from the Site. The soils represented the portions of the Site that consisted of undifferentiated Quaternary deposits on the plains below the mine site boundaries. The vegetation and ground cover at BG-4 were similar to the areas of the Site on the plains.

- BG-5 encompasses an area of 1,151 ft^2 (approximately 0.03 acres), was located 1,447 ft southwest of mine site #1012, and was upwind and cross-gradient from the Site. The sediments represented the portions of the Site that consisted of Quaternary alluvium in the drainages. The vegetation and ground cover at BG-5 were similar to the alluvial drainages on the plains.

- BG-6 encompasses an area of 2,957 ft^2 (approximately 0.07 acres), was located 1,017 ft west of claim #1012, was upwind and hydrologically cross-gradient from the Site, and across multiple drainage divides. The thin soils, colluvium-covered slopes, and bedrock outcrops represented the portions of the survey areas within the Wingate Sandstone on the plains. The vegetation and ground cover at BG-6 were similar to the portions of the Site where the mesa sidewall transitions to the plains.

BG-7 and BG-8 were not selected as background reference areas for the Site for the reasons described in Appendix D.1. Separate background reference areas were identified for the Quaternary deposits (BG-4) in the plains area and the Quaternary alluvium in the drainages

(BG-5) within the plains area. The Agencies have suggested that additional study may be required to develop a background reference area for the plains area (NNEPA, 2018).

The potential background reference areas were selected based on *MARSSIM* guidance (i.e., similar geology and ground conditions, distance from the Site, etc.) to:

1. Represent undisturbed conditions at the Site (e.g., pre-mining conditions)
2. Provide a basis for establishing the ILs

The approved *RSE Work Plan* did not specify any minimum or maximum size criteria for these areas. Stantec does not view the size of the selected background reference areas as affecting the validity of the background concentrations. The sizes were based on professional judgment that the identified areas were generally representative of the Site.

The background reference areas were selected in areas outside of the Site that were considered to be representative of the general conditions observed at the Site. However, an important consideration is that the background gamma radiation and metals concentrations within soil and bedrock can be variable and often contain a wider range of concentrations than what was measured at the selected background reference areas. The ILs derived from the background reference areas provide a useful reference for comparison to the Site. However, it will be important to consider the variations in concentrations when conducting site assessment work and/or to support future Removal or Remedial Action evaluations at the Site.

3.2.2.3 Biological Surveys

The objective of the biological surveys was to determine if identified species of concern or potential federal or Navajo Nation Threatened and Endangered (T&E) species and/or critical habitat are present on or near the Site. Biological (vegetation and wildlife) clearance was required at the Site before RSE activities could begin to determine if the RSE activities could affect potential species of concern or federal or Navajo Nation listed T&E species and/or critical habitat. The Site biological evaluation reports, the *NNDFW Biological Resources Compliance Form*, and the US Fish and Wildlife Service (USFWS) consultation email are provided in Appendix E.

The Federal Endangered Species Act (ESA) of 1973, 16 United States Code (USC) §1531 et seq., requires that each Federal agency confer with the USFWS on any agency action that is likely to jeopardize the continued existence of any proposed T&E species or result in the destruction or adverse modification of critical habitat proposed to be designated for such species (15 USC §1531(a)(2); USFWS, 1998). An “action area”, as defined in the regulations implementing the ESA, includes “all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action” (50 CFR §402.2; USFWS, 1998).

The vegetation and wildlife surveys were conducted according to guidelines of the ESA and the NNDFW-Navajo Natural Heritage Program (NNHP), including the procedures set forth in the Biological Resource Land Use Clearance Policies and Procedures, RCS-44-08 (NNDFW, 2008), the

Species Accounts document (NNHP, 2008), and the USFWS survey protocols and recommendations (USFWS, 1996).

Based on the results of the vegetation and wildlife surveys, the NNDFW's opinion was that the RSE Baseline Studies and Site Characterization Activities,

> "with applicable conditions, [were] in compliance with Tribal and Federal laws protecting biological resources including the Navajo Endangered Species and Environmental Policy Codes, US Endangered Species, Migratory Bird Treaty, Eagle Protection and National Environmental Policy Acts".

A copy of the *NNDFW Biological Resources Compliance Form* is included in Appendix E. In addition, after the Trust submitted the results of the biological survey, USEPA consulted with John Nystedt of the USFWS on August 26, 2016, and received an email response on August 29, 2016 stating:

> "Based on the information you [Stantec] provided [i.e., there is no habitat for any Federally listed species in the action area], we [the USFWS] believe no endangered or threatened species or critical habitat will be affected by the project; nor is this project likely to jeopardize the continued existence of any proposed species or adversely modify any proposed critical habitat" (Nystedt, 2016).

A copy of the Nystedt email is included in Appendix E. In light of the results of the biological surveys described below, the USFWS recommended no further action from the USFWS for the project unless the project or regulations change, or a new species is listed.

Vegetation Survey - In July 2016, Redente performed a summer vegetation survey as part of the Site Clearance field investigations. Complete details of the vegetation survey, including the *NNDFW Biological Resources Compliance Form*, are included in Appendix E and summarized below.

In preparation for the vegetation survey, Redente submitted data requests for species of concern to the NNDFW and NNHP, and for Federal T&E species, to the USFWS. The NNDFW-NNHP responded to MWH by letter dated November 19, 2015. The letter provided a list of species of concern known to occur within the proximity of the Site and included their status as either Navajo Nation Endangered Species List (NNESL), and/or Federally Endangered, Federally Threatened, or Federal Candidate. The NNESL species were further classified as G2, G3, or G4[7]. A copy of this letter is included in Appendix E. A spring vegetation survey was not required for the Site because the species of concern data provided by NNDFW-NNHP did not include listed potential plant species that require a spring survey.

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[7] G2 classification includes endangered species or subspecies whose prospect of survival or recruitment are in jeopardy, G3 classification includes endangered species or subspecies whose prospect of survival or recruitment are likely to be in jeopardy in the foreseeable future, and G4 classification are "candidates" and includes those species or subspecies which may be endangered but for which sufficient information is lacking to support being listed (refer to Appendix E).

The NNDFW listed one T&E plant species that may occur on-site; Parish's alkali grass (G4). The USFWS also listed one T&E plant species that may occur on-site: Zuni fleabane (threatened). Parish's alkali grass is a native annual grass that grows in a series of widely discontinuous populations ranging from southern California to eastern Arizona and western New Mexico in alkaline seeps, springs and seasonally wet areas and washes at elevations from 5,000 ft to 7,200 ft amsl. Zuni fleabane is found on fine textured clay hillsides from clays derived from the Chinle Formation in the Zuni and Chuska Mountains, and in similar clays of the Baca Formation in the Datil and Sawtooth ranges in New Mexico, at mid to high elevations from 7,000 ft to 8,300 ft amsl.

Before beginning the Site vegetation surveys, Redente reviewed the ecologic and taxonomic information for the T&E species to understand ecological characteristics of the species, habitat requirements, and key taxonomic indicators for proper identification (Arizona Native Plant Society, 2000). Redente also reviewed currently accepted resource agency protocols and guidelines for conducting and reporting botanical inventories for special status plant species (USFWS, 1996). An experienced Redente botanist with local flora knowledge conducted the rare plant survey. The botanist walked transect lines on the Site with emphasis on areas with suitable habitat for Navajo sedge, specifically alkaline seeps and fine-textured clay hillsides.

The Redente botanist did not identify either of the two T&E species at the Site, based on observations they made during the on-site survey. The botanist concluded they did not identify any of the T&E species at the Site because the Site was not a likely habitat for the T&E species. Observed vegetation communities on-site are predominantly sparsely vegetated grassland with sporadic shrubs and scattered pinyon/juniper in the eastern and southernmost areas.

Wildlife Survey - In May 2016, Adkins performed a wildlife evaluation survey as part of the Site Clearance field investigations. The completed wildlife survey, including the *NNDFW Biological Resources Compliance Form*, are included in Appendix E and are summarized below.

Adkins performed the survey under a permit issued by NNDFW for the purpose of assessing habitat potential for ESA-listed or NNESL animal species. Adkins biologists with experience identifying local wildlife species led the field survey, which consisted of walking transects 10 ft apart throughout the Site, including a 100-ft buffer beyond the claim boundaries. The surrounding areas were visually inspected with binoculars for nests, raptors, or signs of raptor use.

The wildlife evaluation was performed for species listed as NNESL, Federally Endangered, Federally Threatened, or Federal Candidate, and species protected under the Migratory Bird Treaty Act (MBTA) that have the potential to occur on-site. Prior to the start of the wildlife survey, Adkins submitted data requests to USFWS and NNDFW for animal species listed under the ESA. The NNESL species were further classified as G2, G3, or G4. The USFWS included four ESA-species with the potential to occur in the area of the Site; three birds (southwestern willow flycatcher, Mexican spotted owl, and western yellow-billed cuckoo), and one fish (Zuni bluehead sucker). The NNDFW included: four birds (mountain plover [G4], western burrowing owl [G4], golden eagle [G3], and American peregrine falcon [G4]), and one mammal (black-footed ferret [endangered]). All species on the USFWS list and all species from the NNDFW list, with the exceptions of the golden eagle and American peregrine falcon, were eliminated from further evaluation because there was no potential for those species to occur on the Site due to lack of suitable habitat. Based on the preparation data, two birds remained as species of concern warranting further analysis during the survey: golden eagle and American peregrine falcon.

In addition, Adkins reviewed species protected under the MBTA that have the potential to occur in the area of the Site. The MBTA review resulted in the potential for identification of 16 bird species in addition to those listed above, known as priority birds of conservation concern with the potential to occur in the areas of the Site: black-throated sparrow, Brewer's sparrow, gray vireo, loggerhead shrike, mountain bluebird, mourning dove, sage sparrow, sage thrasher, scaled quail, Swainson's hawk, vesper sparrow, bald eagle, Bendire's thrasher, pinyon jay, prairie falcon, and ferruginous hawk. These 16 MBTA bird species were added for further analysis during the survey for effects to potential habitat.

The wildlife survey revealed two NNESL species of concern that had the potential to occur within or near the Site based on habitat suitability or actual recorded observation: golden eagle and American peregrine falcon. Based on these findings Adkins recommended the use of best management practices to protect potential habitat during RSE activities, specifically: (1) confining equipment travel to within the boundaries of the Site; (2) minimizing travel corridors as much as possible; (3) limiting truck and equipment travel within the Site when surfaces are wet and soil may become deeply rutted; and (4) using previously disturbed areas for travel when possible. The recommended best management practices were followed to protect potential habitat during RSE activities.

3.2.2.4 Cultural Resource Survey

In May 2016, Dinétahdóó conducted a cultural resource survey as part of the Site Clearance field investigations. Navajo Nation Historic Preservation Department (NNHPD) issued a Class B permit to Dinétahdóó to conduct the cultural resource survey. Following the cultural resource survey, the NNHPD issued a Cultural Resources Compliance Form that included a "Notification to Proceed" with RSE field work. A copy of the Cultural Resources Compliance Form is included in Appendix E. According to NNHPD, this form is the equivalent of a "permit" to conduct the work (NNHPD, 2018).

The survey included the areas of the claim boundaries and the 100-ft claim boundary buffer, as shown in Figure 2-8. Dinétahdóó did not survey areas on steep terrain due to safety concerns. The survey identified one archaeological site, two isolated occurrences, and one in-use site. For confidentiality reasons, details regarding the cultural resource survey findings are not provided herein NNHPD can be contacted for additional information. NNHPD contact information is located on the *Cultural Resource Compliance Form* included in Appendix E.

Based on the survey findings Dinétahdóó recommended archaeological clearance for the area surveyed, with the stipulation that testing and drilling would be halted if any cultural resources were encountered. Stantec complied with Dinétahdóó's recommendations while conducting RSE activities on–site and drilling did not need to be halted.

Dinétahdóó also escorted field personnel during: (1) the collection of subsurface soil/sediment samples at the background reference areas (refer to Section 3.3.1.1); and (2) during Site Characterization borehole subsurface soil/sediment sample collection in locations outside the 100-ft buffer (refer to Section 3.3.2.2). The Trust and NNHPD agreed that Dinétahdóó's archeologist would be present because the subsurface sample locations were outside of the area originally surveyed during the Site Clearance cultural resource survey.

3.3 SUMMARY OF REMOVAL SITE EVALUATION ACTIVITIES

The RSE activities consisted of two separate tasks: Baseline Studies and Site Characterization activities. The Baseline Studies included a Background Reference Area Study, Site gamma survey, and Gamma Correlation Study. The results of the Baseline Studies were used to plan and prepare the Site Characterization field investigations, which included surface and subsurface soil and sediment sampling. Results of the RSE activities are presented in Section 4.0 and Baseline Studies and Site Characterization activities are summarized in Sections 3.3.1 and 3.3.2, respectively.

3.3.1 Baseline Studies Activities

3.3.1.1 Background Reference Area Study

The Background Reference Area Study activities were completed at the background reference areas selected for the Site. Refer to Section 3.2.2.2 for an explanation of the selection of the background reference areas for the Site. The Background Reference Area Study included a surface gamma survey, static surface and subsurface gamma measurements, surface soil/sediment sampling, and subsurface soil/sediment sampling. The soil/sediment sample locations in the background reference areas were initially selected using a triangular grid, set on a random origin. Where possible, samples were collected at the center points of the triangles. However, in some instances, the actual sample locations had to be moved in the field if sampling was not possible (e.g., the location consisted of exposed bedrock or there was a large bush blocking access). In these cases, the closest accessible location was selected instead.

The background reference areas were selected based on a variety of factors, including *MARSSIM* criteria, which indicated whether the areas were representative of unmined locations, regardless of the sizes of the areas. These factors are described in this RSE report and accompanying appendices. The objectives of the background reference area study were to measure gamma radiation levels emitted by naturally occurring, undisturbed uranium-series radionuclides, and concentrations of other naturally occurring constituents. The results were used to establish background gamma levels and concentrations of Ra-226 and specific metals (uranium, arsenic, molybdenum, selenium, and vanadium). The soil/sediment sampling locations at the background reference areas are presented in Figures 3-3a and 3-3b. Field personnel performed the Background Reference Area Study in accordance with the *RSE Work Plan,* Sections 4.2, 4.4, and 4.5.

Initial surface gamma surveys at BG-1 and BG-2 were completed in May 2016 using a Ludlum Model 44-20 2-inch by 2-inch sodium iodide (NaI) high-energy gamma detector. Following discussions with the Agencies, it was identified that 3-inch by 3-inch NaI detectors (the detectors) would be used at the Site so the results could be more directly compared to the E&E Removal Assessment (refer to Section 2.1.4.7). Of note, 3-inch by 3-inch NaI detectors produce higher gamma count rates than 2-inch by 2-inch NaI detectors (when measuring an identical source) due to the higher volume of a 3-inch by 3-inch NaI detector (344.8 cubic centimeters [cm^3]) resulting in more gamma interactions when compared to the 2-inch by 2-inch NaI detector (104.2 cm^3). Gamma measurements from a 3-inch by 3-inch NaI detector are not directly comparable to measurements collected by a 2-inch by 2-inch NaI detector. BG-1 and BG-2 were re-surveyed using 3-inch by 3-inch detectors as described below. Each detector was coupled to a Ludlum Model 2221 ratemeter/scaler that in turn was coupled to a Trimble ProXRT GPS unit with a NOMAD 900 series datalogger. The detector tagged individual gamma measurements with associated geopositions recorded using the Universal Transverse Mercator Zone 12 North coordinate system. ERG matched and calibrated the detector to a National Institute of Standards and Technology-traceable cesium-137 check source, and function-checked the equipment prior-to and after each workday. ERG performed the surveys by walking the background reference areas with the detector carried by hand, along transects that varied depending on encountered topography. The gamma measurements were collected with the height of the detector varying from 1ft to 2 ft above ground surface (ags) with an average height of 1.5 ft ags to accommodate vegetation, rocks, or other surface features. If field personnel encountered an immovable obstruction (e.g., a tree) during the surface gamma surveys they went around the obstruction. Subsequent to each workday, ERG downloaded the gamma measurements to a computer and secure server. The surface gamma surveys at the background reference areas were completed using 3-inch by 3-inch NaI detectors in March, June, and September 2017 (refer to Appendix D.1).

ERG used Ludlum Model 44-10 2-inch by 2-inch NaI gamma detectors to collect static one-minute gamma measurements at the ground surface and down-hole (subsurface) at borehole locations S1011-BG1-011 (BG-1), S1011-BG2-011 (BG-2), S1011-BG2-011 (BG-3), S1011-BG4-011 (BG-4), and S1011-BG5-011 (BG-5). Refer to Appendix C.2 for borehole logs. These were different detectors than what was used for the surface gamma surveys. Static gamma measurements were categorized as surface measurements where they were collected at ground surface (0.0 ft) and as subsurface measurements where depths were below ground surface due to the influence of downhole geometric effects on subsurface static gamma measurements (refer to Section 4.1). Gamma measurements were collected according to the methods described in the *RSE Work Plan,* Section 4.2 and Appendix E.

Soil/sediment samples collected as part of the background study are detailed in Table 3-2 and sample locations are shown in Figures 3-3a and 3-3b. Soil/sediment samples were categorized as surface samples where sample depths ranged from 0.0 to 0.5 ft bgs and as subsurface samples where sample depths were greater than 0.5 ft bgs. Samples collected in drainages were classified as sediment samples. Field personnel collected the following samples from the background reference areas:

- BG-1 – In November 2016 and March 2017, 11 surface soil grab samples were collected from 11 locations and one subsurface soil grab sample was collected from borehole S1011-BG1-011.
- BG-2 – In November 2016 and March 2017, 11 surface soil grab samples were collected from 11 locations and one subsurface soil grab sample was collected from borehole S1011-BG2-011.
- BG-3 – In September 2017, 11 surface soil grab samples were collected from 11 locations. A borehole could not be advanced beyond 0.25 ft bgs at S1011-BG3-011, so no subsurface samples were collected at BG-3.
- BG-4 – In September 2017, 11 surface soil grab samples were collected from 11 locations and one subsurface soil composite sample was collected from borehole S1011-BG4-011.
- BG-5 – In September 2017, 11 surface sediment grab samples were collected from 11 locations and one subsurface sediment composite sample was collected from borehole S1011-BG5-011.

The lack of subsurface soil samples from BG-3 will not affect the derivation of Ra-226 or metal ILs because the Ra-226 and metals ILs (i.e., surface and subsurface) were based on surface soil samples (refer to Section 4.1).

A gamma survey was completed in BG-6 in June 2017; however, soil samples were not collected. Based on review of the RSE results it was determined that mining-related impacts extend onto the Wingate Sandstone along the base of the mesa sidewall. Because of these findings, the lack of soil samples from BG-6 in the Wingate Sandstone was identified as a data gap and is included in Section 4.9.

Samples were shipped to a USEPA approved laboratory, ALS Environmental Laboratories in Fort Collins, Colorado for analyses. Samples were collected according to the methods described in the *RSE Work Plan,* Section 3.8.1.1. The results of the surface gamma survey, static surface and subsurface gamma measurements, and surface and subsurface soil/sediment sample analytical results provided background reference data to guide the Site Characterization surface and subsurface soil/sediment sampling (refer to Section 3.3.2). The Background Reference Area Study results are presented in Section 4.1. The ERG survey report in Appendix A.1 provides further details on the gamma surveys. Field forms, including borehole logs, are provided in Appendix C.1 and C.2.

3.3.1.2 Site Gamma Radiation Surveys

Baseline Studies activities included a surface gamma survey of the Site in accordance with the *RSE Work Plan,* Section 4.2 and Appendix E. Approximately 10.1 acres of the Site were not surveyed during the surface gamma survey because field personnel were unable to safely access these areas, as shown on Figure 3-4. Field personnel also did not survey the area located in-between the northern most boundary of mine sites #1011 and #1035 and the northern most fence line because the landowner north of these mine sites did not allow access. These are identified as data gaps in Section 4.9. In addition, along the stretch of the northern potential haul road that extends between mine sites #1011 and #1035 (approximately 850 ft), only the approximate centerline of the road was surveyed, but the shoulders were not due to miscommunication with the field personnel. This is identified as a potential data gap in Section 4. 9.

Appendix E of the *RSE Work Plan* stated that gamma measurements would not be collected in the same areas where E&E had previously collected gamma measurements. However, Stantec decided to collect limited gamma measurements in the areas scanned by E&E to assess the potential variability between gamma measurements collected by E&E versus gamma measurements collected for this RSE. Based on the comparison, Stantec decided there was enough variability in the two gamma measurement sets that instead of using the gamma measurement data collected by E&E, Stantec would perform a gamma scan of the Site and also scan those areas previously scanned by E&E.

The surface gamma survey was used as the primary method to evaluate the extent of potential mining-related impacts or areas containing elevated radionuclides associated with uranium mineralization. In addition, surface and subsurface soil and sediment samples were also collected and used to evaluate mining-related impacts (refer to Section 3.3.2).

In March and September 2017, the surface gamma survey was performed using the methods and 3-inch by 3-inch detector equipment described in Section 3.3.1.1, with the exception that the detector was carried in a backpack when topographical features did not allow field personnel to carry the detector by hand for safety reasons. The surface gamma survey included the mine site areas (with the exception of areas on adjacent mine sites #364 and#363 located next to mine sites #1011 and #1035, respectively), and roads and drainages out to approximately 0.25 miles from the Site. The *RSE Work Plan* specified that the surface gamma survey would be an iterative process where the surface gamma survey would be extended laterally until gamma measurements appeared to be within background levels. Subsequent to each workday, the gamma measurements were evaluated by ERG and Stantec, and compared to the background reference areas to determine if additional surface gamma surveying was needed. The surface gamma survey was extended to include the areas between mine sites #1012 and #1035, additional areas along the mesa edge, the mesa sidewall, and the plains south of the Site.

The full extent of the surface gamma survey is referred to as the Survey Area, as shown in Figure 3-4. The Survey Area was 101.3 acres and was subdivided into five separate survey areas, as shown in Figure 3-4, based on *MARSSIM* criteria, including different geologic conditions on-site. Survey Area A is within the Todilto Limestone (based on BG-1), Survey Area B is within the Quaternary deposits on the mesa top (based on BG-2), Survey Area C is within the Entrada Sandstone (and Wingate Sandstone) on the mesa sidewall (based on BG-3), Survey Area D is within the Quaternary deposits on the plains (based on BG-4), and Survey Area E is within the Quaternary alluvium in the drainages (based on BG-5). Of note, the Wingate Sandstone is included in Survey Area C, but it is identified as a data gap that samples were not collected from the Wingate Sandstone and the background for the Wingate Sandstone needs to be further evaluated.

It was necessary to subdivide the Survey Area based on geologic conditions and present the findings in Section 4.0 based on the subdivision, because geologic formations can have different geochemical compositions (i.e., gamma levels and concentrations of Ra-226, uranium, arsenic, molybdenum, selenium, and vanadium). The surface gamma survey results are presented in Section 4.2. A photograph, showing elevated gamma measurements collected from the Todilto Formation, is provided in Appendix B-1 photograph number 5. The ERG survey report in Appendix A.1 provides further detailed information on the surface gamma survey.

3.3.1.3 Gamma Correlation Study

Baseline Studies activities included a Gamma Correlation Study in accordance with the *RSE Work Plan,* Section 4.3. The objectives of the Gamma Correlation Study were to determine correlations between the following constituents to be used as screening tools for site assessments:

- Gamma measurements (in cpm) and concentrations of Ra-226 in surface soils (in pCi/g)
- Gamma measurements (in cpm) and exposure rates (in µR/hr)

Two regression analyses were conducted for these correlations. The first regression analysis was performed using co-located high-density surface gamma measurements and laboratory concentrations of Ra-226 in surface soil to develop a correlation equation (refer to Section 4.2.2). The correlation equation allows for Ra-226 concentrations in soil and sediment to be estimated (predicted) based on gamma measurements in the field.

This correlation equation was not used in the field to estimate Ra-226 concentrations or to evaluate the extent of Ra-226 concentrations. The correlation was used to develop a site-specific prediction for Ra-226 concentrations from the actual gamma survey data, and was compared to actual concentrations from the soil/sediment samples to evaluate the usability of the correlation for future Removal or Remedial Action evaluations, as presented in Section 4.2.2. The correlation can be used as a site-specific field screening tool during site assessments, using the same gamma survey methods as in this RSE (e.g., walkover gamma survey) and based on site-specific conditions. The data related to the correlations are provided in Appendices A.1 and C.

The second regression analysis was performed using co-located static one-minute gamma measurements and exposure rates to develop an exposure-rate correlation equation. Exposure rates can be predicted, based on gamma measurements, using the developed exposure-rate correlation equation. The exposure rate correlation also provides a standard by which future gamma measurements can be compared to previous gamma measurements, if those previous gamma measurements were also correlated with exposure. In addition, exposure rates can be used to provide an estimate of gamma radiation levels when an exposure meter is used as a health and safety tool for field personnel working on-site. The exposure rate correlation was not used for Site Characterization. Because the exposure rates are used as a health and safety tool, and are not part of the data analyses for the RSE report, a summary of the exposure rate correlation is not presented in this report. Appendix A.1 provides a discussion of the correlations and the regression equations for both correlations.

In March 2017, field personnel identified five areas for the Gamma Correlation Study, as shown in Figure 3-5, by considering the results of the Site surface gamma survey (described in Section 3.3.1.2), field conditions (e.g., suitable terrain), and feasibility of sampling. To minimize variability when determining a correlation between gamma measurements (in cpm) and concentrations of Ra-226 in soil, the study area soils must: (1) represent a specific gamma measurement within the range of gamma measurements collected at the Survey Area; and (2) be as homogenous as possible with respect to soil type, and gamma measurement within the correlation area. At each area, field personnel completed a high-density surface gamma survey (intended to cover 100 percent of the survey area) and collected one five-point composite surface soil sample per area (refer to Table 3-2). Field personnel made a field modification from the *RSE Work Plan* by adjusting the size of the 900 ft^2 area smaller at four of the Gamma Correlation Study locations, to minimize the variability of gamma measurements observed. The area used for the Gamma Correlation Study is shown in Figure 3-5, where the box shown at the five study locations represents a 900 ft^2 area in comparison to the actual area covered for the study, as shown by the extent of the gamma measurements within each area.

Field personnel collected, logged, classified, packaged, and shipped the samples in accordance with the *RSE Work Plan,* Sections 4.4, 4.9, 4.11, and Appendix E. Soil samples were collected for analyses of Ra-226 and isotopic thorium, as described in the *RSE Work Plan,* Section 3.4.1.

The objectives of the thorium analyses were for site characterization and evaluation of potential effects of thorium on the correlation. The data can be used to assess the potential effects of thorium-232 (Th-232) series radioisotopes on the correlation of gamma measurements to concentrations of Ra-226 in surface soils (i.e., if gamma-emitting radioisotopes in the Th-232 series, such as actinium-228, lead-212, and thallium-208, are impacting gamma measurements at the Site), as discussed in Section 4.2.2. Uranium, radium, and thorium occur in three natural decay series (uranium-238 [U-238], Th-232, and U-235), each of which include significant gamma emitters (USEPA, 2007b). Therefore, in order to develop a correlation between gamma radiation and Ra-226 concentrations, the gamma radiation from each significant decay series present at the Site, may need to be taken into account. Typically, only U-238, and sometimes Th-232, are present in significant quantities. The contribution from the U-235 decay series can be excluded because U-235 is only approximately 0.72 percent of the total uranium concentration. If the Th-232 decay series is present in significant quantities, it should be accounted for in the correlation to accurately predict Ra-226 concentrations based on all significant sources of gamma radiation.

3.3.1.4 Secular Equilibrium

The Gamma Correlation Study soil samples (refer to Section 3.3.1.3) were also analyzed for thorium-230 (Th-230), in accordance with the *RSE Work Plan,* Section 3.4.1. The activities of Th-230 and Ra-226 can be compared to evaluate the status of secular equilibrium within the U-238 decay series (USEPA, 2007b). The U-238 decay series is in secular equilibrium when the radioactivity of a parent radionuclide (e.g., U-238) is equal to its decay products (refer to Appendix A.1). If the U-238 decay series is out of secular equilibrium, the quantities of the daughter products become depleted. This could be considered for potential site assessments (e.g., when evaluating the contribution of the daughter products to the total risk related to U-238 during a human health and/or ecological risk assessment). As part of the RSE, the secular equilibrium evaluation was a general indicator (e.g., screening level assessment) of the status of equilibrium at the sites. It was not used to characterize the extent of constituents of potential concern (COPCs) at the Site. The secular equilibrium evaluation is discussed here only because Th-230 was included in the isotopic thorium analysis.

3.3.2 Site Characterization Activities and Assessment

3.3.2.1 Surface Soil and Sediment Sampling

Site Characterization activities included surface soil and sediment sampling and associated laboratory analyses. The soil/sediment surface sampling locations within the Survey Area were selected based on professional judgment (i.e., non-randomly) to evaluate concentrations of Ra-226 and metals in relation to the surface gamma survey measurements and site features (e.g., historical mining features and geologic features). Based on the surface gamma survey results and site features, a limited number of samples were collected and analyzed where the gamma survey measurements were within background levels, mining and or exploration-related features were not present, and no ground disturbance was observed. The results were compared to the site-specific ILs and published regional concentrations to support the overall evaluation of potential mining impacts (refer to Section 4.3). Soil/sediment samples were categorized as surface samples where sample depths ranged from 0.0 to 0.5 ft bgs and as subsurface samples where sample depths were greater than 0.5 ft bgs. Samples collected in drainages were classified as sediment samples.

In December 2016 and May, June, and September 2017, samples were collected from the locations shown in Figure 3-6a and are summarized in Table 3-2. Sample locations and the locations of mining-related features are shown in Figure 3-6b. The number of surface samples collected within specific mine features are listed in Table 3-3. Fifty-nine surface soil/sediment grab samples were collected from 59 locations in the Survey Area (five from Survey Area A, 42 from Survey Area B, two from Survey Area C, three from Survey Area D, and seven from Survey Area E).

Field personnel collected, logged, classified, packaged, and shipped the samples in accordance with the *RSE Work Plan,* Sections 4.4, 4.9, 4.11, and Appendix E. Samples were shipped to ALS Environmental Laboratories in Fort Collins, Colorado for analyses of: Ra-226, uranium, arsenic, molybdenum, selenium, and vanadium, as described in the *RSE Work Plan,* Section 4.13.1. The surface soil/sediment analytical results are presented in Section 4.3. Field forms are provided in Appendix C.1 and the laboratory analytical data, data validation reports, and Data Usability Report for the analyses are provided in Appendix F.

3.3.2.2 Subsurface Soil and Sediment Sampling

Site Characterization activities included subsurface soil/sediment sampling and associated laboratory analyses. Similar to the surface soil/sediment sampling discussed in Section 3.3.2.1, subsurface sampling locations were selected based on professional judgment (i.e., non-randomly) to evaluate concentrations of Ra-226 and metals in relation to the surface gamma survey measurements and site features (e.g., historical mining features and geologic features). Grab samples were collected with the intent to characterize specific intervals of interest (e.g., material within zones with elevated static gamma measurements). Composite samples were collected to provide a screening level assessment across an interval (e.g., where historical mining features were located). The usefulness of a composite sample may be limited when the sample is collected over an interval with varying soil or rock types or is excessively long (e.g., greater than 5 ft), which tends to dilute the constituent concentrations or sample heterogeneity. Additionally, surface and subsurface static gamma measurements were collected in the boreholes using the 2-inch by 2-inch detector as described in Section 3.3.1.1. Static gamma measurements were collected by holding the detector in the borehole for a one-minute integrated count and are not comparable to the surface gamma survey measurements, which were collected as a walkover survey.

Subsurface samples were collected by advancing subsurface boreholes to a desired sample depth using either a 3-inch diameter hand auger or a Geoprobe™ 8140LC rotary sonic drilling rig. Field personnel advanced the hand auger to the desired sample depth manually, or the sonic drilling rig advanced the boreholes to the desired sample depth. The sonic drilling rig was equipped with a 4-inch diameter sonic core barrel that used cutting rotation and vibration to advance the boreholes. The sonic drilling method is ideal for use in rocky soils to obtain continuous samples in materials that are difficult to sample using other drilling methods (ASTM, 2016) and it recovers a continuous and relatively undisturbed core sample for review and analysis that is representative of the lithological column at that borehole location (refer to Appendix C.2).

Forty-four boreholes were advanced in the Survey Area (two in Survey Area A, 33 in Survey Area B, one in Survey Area C, three in Survey Area D, and five in Survey Area E). Boreholes were advanced until: (1) refusal at bedrock/hard surface; or (2) termination within bedrock; or (3) termination within undisturbed native material. Borehole depths ranged from 0.2 ft bgs to 22 ft bgs, and the depth of unconsolidated deposits to bedrock in boreholes ranged from 0.2 ft bgs to 20 ft bgs. The boreholes were advanced through poorly and well graded sand and/or gravel, with varying amounts of silt, clay and cobbles, mudstone, claystone, sandstone, shale, and limestone (refer to Appendix C.2 for borehole logs). Subsurface sampling was limited on the mesa sidewall due to unsafe terrain.

In December 2016 and May, June, and September 2017, samples were collected from the locations shown in Figure 3-6a and are summarized in Table 3-2. Sample locations and the locations of mining-related features are shown in Figure 3-6b. The number of subsurface samples collected within specific mine features are listed in Table 3-3. Sixty-four subsurface samples (61 soil/sediment and three soil/bedrock) were collected from 40 borehole locations in the Survey Area. Multiple samples were collected from many of the boreholes. Three subsurface samples were collected from Survey Area A, 50 from Survey Area B, one from Survey Area C, two from Survey Area D, and eight from Survey Area E.

Two cross-sections for the Site were produced using the subsurface borehole information, as shown in Figures 2-9a and 2-9b (refer to Section 2.2.2.2). Cross-section A-A' (refer to Figure 2-9a) is oriented roughly north-south. Lithological descriptions from seven boreholes (refer to Appendix C.2), in conjunction with surface geology observations made by field personnel, were used to model the north-south extent of unconsolidated earthworks and subsurface geology in the central area of mine site #1035. Cross-section B-B' (refer to Figure 2-9b) is also oriented roughly north-south. Lithological descriptions from six boreholes (refer to Appendix C.2) in conjunction with surface geology observations made by field personnel, were used to model the north-south extent of unconsolidated earthworks and subsurface geology in the eastern area of mine site #1035. The depth to bedrock along cross-section A-A' ranged from 3 ft bgs to 18 ft bgs and the average depth to bedrock increased from north to south. The depth to bedrock along cross-section B-B' ranged from 3 ft bgs to 20 ft bgs and the average depth to bedrock increased in the central portion of B-B'.

Field personnel logged, classified, packaged, and shipped the samples in accordance with the *RSE Work Plan,* Sections 4.5, 4.9, 4.11, and Appendix E. Samples were shipped to ALS Environmental Laboratories in Fort Collins, Colorado for analyses of Ra-226, uranium, arsenic, molybdenum, selenium, and vanadium, as described in the *RSE Work Plan,* Section 4.13.1. The subsurface analytical results are presented in Section 4.3. Field forms, including borehole logs showing static gamma measurements and Ra-226 analytical results, are provided in Appendix C.2. The laboratory analytical data, data validation reports, and Data Usability Report for the analyses are provided in Appendix F.

3.3.2.3 Water Sampling

According to the *RSE Work Plan*, Site Characterization activities were to include surface water and/or well water sampling, and associated laboratory analyses, of water features identified during the Site Clearance desktop study (refer to Section 3.2.1). The results of the analyses may be used to evaluate whether there are mining-related impacts to identified water feature(s). From the desktop study, four well water features were identified, as shown in Table 3-1 and Figure 2-1. Field personnel observed that the four identified water features were located behind locked gates and on private property (i.e. non-Navajo Nation lands). In addition, based on information provided by the USEPA Region 6, two of the water wells were never drilled (refer to Table 3-1). The other two identified water wells were not sampled because they were located behind locked gates on private property.

3.3.2.4 Geophysical Survey

Site Characterization activities included conducting the following geophysical surveys: (1) an electrical resistivity; and (2) a multi-channel analysis of surface waves (MASW). The geophysical surveys were performed in response to field personnel discovering open vertical shafts and boreholes at the Site (refer to Section 3.2.2.1). The geophysical surveys were conducted to assist with identifying any potential mine-related subsurface voids or tunnels, because open voids, tunnels, etc. could pose a safety risk at the Site. In addition, the results of the geophysical surveys can be used to support the identification of: (1) material type of unconsolidated deposits; and (2) depth of unconsolidated deposits to bedrock. A summary of the interpretation of the geophysical survey results is presented in Section 4.8.

Although geophysical surveys were not included in the *Scope of Work* (MWH, 2016d), the Trustee notified the Agencies and obtained approval prior to work commencing the survey. The Baca/Prewitt Chapter officials and nearby residents were consulted and notified of the additional field work. Between June 12 and June 19, 2017, Hydrogeophysics Inc. (HGI), under contract to Stantec, performed the geophysical surveys at mine sites #1011 and #1035. HGI's geophysical characterization report, included in Appendix A.2. The report provides a complete description of the geophysical survey objectives, theory, methods, and results and interpretation. The geophysical surveys conducted on-site are summarized as follows:

Electrical resistivity geophysical survey Electrical resistivity surveys are used to identify material types by measuring a material's resistance to electrical current. Materials with low electrical resistivity (high conductivity) will include materials with higher clay or moisture content, or conductive bedrock. Materials with high electrical resistivity (low conductivity) include air-filled voids or loose unconsolidated fill material, based on the assumption that the void space had increased resistivity compared to the surrounding bedrock or sediments. These assumptions also depended on other factors including sediment grain size, moisture content, chemical composition of the soil or bedrock, and the degree of compaction.

The electrical resistivity survey conducted on-site consisted of 13 electrical resistivity survey lines, as shown in Figure 3-7. Three parallel survey lines were laid out in an east-west orientation on mine site #1011, and ten survey lines on a grid pattern (three in an east-west orientation and seven in a north-south orientation) were laid out on mine site #1035. Resistivity data were collected using a multichannel electrical resistivity system consisting of cables, stainless steel electrodes, and a battery power supply, with an electrode spacing of approximately 10 ft. Electric current was transmitted into the earth through one pair of electrodes (transmitting dipole) that was in contact with the soil. The resultant voltage potential was then measured across another pair of electrodes (receiving dipole). Numerous electrodes were deployed along the survey lines. A complete set of measurements occurred when each electrode (or adjacent electrode pair) passed current, while all other adjacent electrode pairs were utilized for voltage measurements. Electrode locations were surveyed using a handheld GPS.

MASW geophysical survey The MASW geophysical surveys are used to identify material types by measuring contrasts in seismic velocity (i.e., the speed at which seismic energy travels through soil and rock). Seismic velocity typically correlates well with rock hardness and density, which in turn tends to correlate with changes in lithology, degree of fracturing, water content, and weathering. The MASW geophysical surveys measure the elastic condition of the subsurface, which produces an image based on differences in transmission time of induced seismic waves. Dense materials like competent bedrock and very dense soils tend to have increased seismic velocities, whereas voids or spaces filled with air or water display a decreased seismic velocity, compared to the native material. The contrast in seismic velocity between the native material and subsurface voids depends on a number of factors, including the depth of the feature, the fill material of a void (i.e., water, air, sediments, or a mixture of all three), void shape and dimensions, and the properties of and contrast to the native materials. Void spaces and fill materials generally display a measurable contrast in properties (lower shear wave velocities) to the surrounding materials.

The MASW survey conducted on-site also consisted of 13 survey lines, as shown in Figure 3-7. Geophones (ground motion transducers) were spaced approximately 10 ft apart along the survey lines, and their locations were surveyed using a handheld GPS. The induced seismic source was a 16 pound sledge hammer that was struck against a polyethylene strike plate. Each strike of the polyethylene strike plate is known as a shot. The locations where the seismic source was shot were spaced approximately 20 ft apart and in-between the midpoints of the geophone positions, along the survey line. Once the shot occurred, two Geode Ultra-Light Exploration 24 –Channel Seismographs were used to collect the data from the geophones, providing a total of 48 channels. The two Geodes were run from a laptop in order to view each shot to confirm acceptable data quality. Additional sledge hammer blows, forming a new "stack" of data, were added until the desired data quality was achieved. The shot record (seismogram) was saved to the computer and stored for subsequent processing. A real-time noise monitor showed all geophones were used during shots to verify that noise levels were at a minimum for each shot. This included waiting for breaks in wind noise, drilling activities, and other sources of noise.

3.3.3 Identification of TENORM Areas

Areas at the Site where TENORM is present were identified using multiple lines of evidence including:

1. Historical Data Review
    a. Aerial photographs
    b. USAEC records
    c. Reclamation records
    d. Other documents relevant to the Site, including those in the *2007 AUM Atlas*
    e. Interviews with residents living closest to the Site (for those sites where residents were available for interview)

   f. Consultation and site visits with NAML staff to identify reclamation features (for those sites reclaimed by NAML)

2. Geology/Geomorphology

   a. Hydrology/transport pathways with drainage delineation

   b. Site-specific geologic mapping including areas of mineralization

   c. Topography

3. Disturbance Mapping

   a. Exploration

   b. Mining

   c. Reclamation

4. Site Characterization

   a. Surface gamma surveys and subsurface static gamma measurements

   b. Soil/sediment sampling and analyses

Any areas where TENORM was not observed are considered to contain NORM, because soil and/or rock at the Site contain some amount of natural uranium and its daughter products. This area was mined because of the high levels of naturally occurring uranium ore. The areas containing NORM and/or TENORM are presented in Section 4.6. The volume of TENORM is presented in Section 4.7. The areas containing NORM and/or TENORM, along with additional findings of the RSE report, are identified to support future Removal or Remedial Action evaluations at the Site.

3.4 DATA MANAGEMENT AND DATA QUALITY ASSESSMENT

This section summarizes the data management and data quality assessment activities performed for the RSE.

3.4.1 Data Management

The DMP included in the *RSE Work Plan* describes the plan for the generation, validation, and distribution of project data deliverables. Successful data management comes from coordinating data collection, quality control, storage, access, reduction, evaluation, and reporting. A summary of the data management activities performed as part of the RSE process included:

- **Database** – Field-collected and laboratory analytical RSE data were stored in an Oracle SQL relational database, which increased data handling efficiency by using previously developed data entry, validation, and reporting tools. The Oracle SQL database was also used to export project data to a tabular format that can be used in a spreadsheet (e.g., Excel) and to the USEPA Scribe database format.

- **Scribe** – The Stantec Data Manager/Data Administrator was responsible for meeting the project data transfer requirements from the Oracle SQL database to Scribe, which is a software tool developed by the USEPA's Environmental Response Team to assist in the process of managing environmental data. Stantec maintained an Oracle SQL database and exported data from the Oracle SQL database to a Scribe compatible format following completion of each field investigation phase. Custom data queries and "crosswalk" export routines were built in Oracle SQL, to facilitate data export to the Scribe database format with the required frequency.

- **Geographic Information System (GIS)** – Spatial data collected during the RSE (e.g., sample locations and gamma measurements) were stored in a dedicated File Geodatabase for use in the project GIS. The geodatabase format enforces data integrity, version control, file size compression, and ease of sharing to preserve GIS output quality. Periodic geodatabase backups were performed to identify accidentally deleted or otherwise corrupt information that were then repaired or recovered, if applicable.

3.4.2 Data Quality Assessment

The QAPP, included in the *RSE Work Plan*, Appendix B, was followed for RSE data quality assessment, where the QAPP presents QA/QC requirements designed to meet the RSE DQOs. Data quality refers to the level of reliability associated with a particular data set or data point. The Data Usability Report included in Appendix F.1 provides a summary of the data quality assessment activities and qualified data for the RSE. A summary of findings, from the data quality assessment, are included below.

- **Data Verification** – The data were verified to confirm that standard operating procedures (SOPs) specified in the *RSE Work Plan* and *FSP* were followed and that the measurement systems were performed in accordance with the criteria specified in the QAPP. Any deviations or modifications from the *RSE Work Plan* are described in the appropriate RSE report sections. The USEPA definition (USEPA, 2002a) for data verification is provided in the glossary.

- **Data Validation** – The data were validated to confirm that the results of data collection activities support the objectives of the RSE as documented in the QAPP. The data quality assessment process was then applied using the validated data and determined that the quality of the data satisfies the intended use. The USEPA definition (USEPA, 2002a) for data validation is provided in the glossary. A copy of the Data Usability Report is included in Appendix F.1 and a summary of the validation results is presented below:

  - **Precision** Based on the matrix spike/matrix spike duplicate (MS/MSD) sample, laboratory control sample/laboratory control sample duplicate (LCS/LCSD) sample, laboratory duplicate sample, and field duplicate results, the data are precise as qualified.

  - **Accuracy** Based on the initial calibration (ICAL), initial calibration verification (ICV), continuing calibration verification (CCV), MS/MSD, and LCS, the data are accurate as qualified.

- **Representativeness** Based on the results of the sample preservation and holding time evaluation, the method and initial/continuing calibration blank (ICB/CCB) sample results, the field duplicate sample evaluation, and the reporting limit evaluation, the data are considered representative of the Site as reported.
- **Completeness** All media and QC sample results were valid and collected as scheduled (i.e., as planned in the *RSE Work Plan*); therefore, completeness for these is 100 percent.
- **Comparability** Standard methods of sample collection and standard units of measure were used during this project. The analyses performed by the laboratory were in accordance with current USEPA methodology and the QAPP.

Based on the results of the data validation, all data are considered valid as qualified.

4.0 FINDINGS AND DISCUSSION

4.1 BACKGROUND REFERENCE AREA STUDY RESULTS AND CALCULATION OF INVESTIGATION LEVELS

The results of the background reference area surface gamma survey are shown in Figures 4-1a through 4-1f. Sample locations in the background reference areas are shown for BG-1, BG-2, BG-3, BG-4, and BG-5 on Figures 4-1b, 4-1c, 4-1d, 4-1e and 4-1f, respectively. The surface gamma surveys in BG-2, BG-3, and BG-5 did not cover the areal extent of the sample locations; however, gamma survey measurements were within approximately 3 ft of sample locations that were outside of the survey area. Analytical results of the samples collected from the five background reference areas are summarized in Table 4-1. The gamma measurements and surface soil sample analytical results collected from BG-1, BG-2, BG-3, BG-4 and BG-5 were evaluated statistically to calculate ILs (refer to Appendix D.2) for each corresponding Survey Area (i.e., Survey Area A, Survey Area B, Survey Area C, Survey Area D and Survey Area E, respectively). As discussed in Section 3.3.1.2, the Survey Area was subdivided into five separate Survey Areas based on geologic conditions on-site where potential mining-related impacts were observed. After review of the RSE results it was determined that mining-related impacts extend onto the Wingate Sandstone along the base of the mesa sidewall. Based on these findings, the lack of soil samples from BG-6 in the Wingate Sandstone was identified as a data gap and is included in Section 4.9.

Statistical evaluation of the gamma measurements and soil sample analytical results included identifying potential outlier values, interpreting boxplots and probability plots, comparing group means between the background reference areas and the respective Survey Area data, and calculating descriptive statistics for each of the background reference areas. The descriptive statistics included the 95 percent upper confidence limit (UCL) on the mean gamma measurements and Ra-226/metals concentrations, and the 95-95 upper tolerance limits (UTLs). The data were analyzed using R statistical programming packages and ProUCL 5.1 software (USEPA, 2016).

The DQOs presented in the RSE Work Plan indicate that the ILs would be developed using the 95 percent UCL on the mean of the background sample results. However, the 95-95 UTL was used as the basis for the ILs instead because it better reflects the natural variability in the background data and lends itself to single-point comparisons to the Survey Area data; this was a change from the *RSE Work Plan*, as agreed upon with the Agencies. The UTL represents a 95 percent UCL for the 95th percentile of a background dataset whereby Survey Area results above this value are not considered representative of background conditions. The UTL is a statistical parameter for the entire population of the variable, whereas the actual results are from a sample of the population. UTLs were calculated in accordance with USEPA's *ProUCL 5.1 Technical Guidance,* Sections 3.4 and 5.3.3 (USEPA, 2015). Appendix D.2 presents a comprehensive discussion on the derivation of the ILs for the Site, which are presented below.

The *RSE Work Plan* also stated that gamma radiation measurements from the background surface and subsurface soil would be combined to develop the IL for surface gamma radiation at the Site. However, the surface gamma radiation ILs were instead developed from the surface gamma survey data only. The Agencies have commented that this should be noted as a deviation from the *RSE Work Plan*. The subsurface static gamma measurements were excluded for two reasons: (1) they were collected using a different method (static one-minute measurements versus a walkover gamma survey); and (2) because of the downhole geometric effects that influence subsurface static gamma measurements (refer to the discussion of geometric effects below).

The ILs for Survey Area A (i.e., Todilto Formation; refer to Figures 2-7a, 2-7b, and 3-4) were established using statistical analysis of background data collected from BG-1(refer to Figures 3-2 and 3-3a) and are as follows:

- Arsenic – 11.9 milligrams per kilogram (mg/kg)
- Molybdenum – 2.26 mg/kg
- Selenium – an IL for selenium was not identified because selenium sample results in BG-1 were all non-detect
- Uranium – 3.23 mg/kg
- Vanadium – 27.3 mg/kg
- Ra-226 – 2.13 pCi/g
- Surface gamma measurements – 16,829 cpm

The ILs for Survey Area B (i.e., the Quaternary deposits on the mesa top; refer to Figures 2-7a, 2-7b, and 3-4) were established using statistical analysis of background data collected from BG-2 (refer to Figures 3-2 and 3-3a) and are as follows:

- Arsenic – 2.34 mg/kg
- Molybdenum – 0.346 mg/kg
- Selenium – an IL for selenium was not identified because selenium sample results in BG-2 were all non-detect
- Uranium – 3.34 mg/kg
- Vanadium – 11.2 mg/kg
- Ra-226 – 2.96 pCi/g
- Surface gamma measurements – 23,320 cpm

The ILs for Survey Area C (i.e., the Entrada Sandstone and Wingate Sandstone; refer to refer to Figures 2-7a, 2-7b, and 3-4) were established using statistical analysis of background data collected from BG-3 (refer to Figures 3-2 and 3-3a) and are as follows:

- Arsenic – 4.99 mg/kg
- Molybdenum – 0.367 mg/kg
- Selenium – an IL for selenium was not identified because selenium sample results in BG-3 were all non-detect
- Uranium –1.91 mg/kg
- Vanadium – 17.4 mg/kg
- Ra-226 – 1.49 pCi/g
- Surface gamma measurements – 48,542 cpm

The ILs for Survey Area D (i.e., the Quaternary deposits on the plains; refer to Figures 2-7a, 2-7b, and 3-4) were established using statistical analysis of background data collected from BG-4 (refer to Figures 3-2 and 3-3a) and are as follows:

- Arsenic – 1.76 mg/kg
- Molybdenum – 0.210 mg/kg
- Selenium – an IL for selenium was not identified because selenium sample results in BG-4 were all non-detect
- Uranium – 0.554 mg/kg
- Vanadium – 11.0 mg/kg
- Ra-226 – 1.49 pCi/g
- Surface gamma measurements – 20,637 cpm

The ILs for Survey Area E (i.e., Quaternary alluvium in drainages on the plains; refer to Figures 2-7a, 2-7b, and 3-4) were established using statistical analysis of background data collected from BG-5 (refer to Figures 3-2 and 3-3b) and are as follows:

- Arsenic – 1.73 mg/kg
- Molybdenum – an IL for molybdenum was not identified because molybdenum sample results in BG-5 were all non-detect
- Selenium – an IL for selenium was not identified because selenium sample results in BG-5 were all non-detect

- Uranium –0.691 mg/kg
- Vanadium – 10.7 mg/kg
- Ra-226 – 0.839 pCi/g
- Surface gamma measurements – 21,864 cpm

Of note, the gamma survey in BG-3 was limited due to steep terrain, the sample size was low (80 measurements) and there is a notable difference between the UTL (48,542 cpm) and UCL (30,927) values (refer to Appendix D.1 Table D.1-2). Further evaluation of background for the Entrada Sandstone may be required in the future.

It is important to note that comparisons to the IL (i.e., 1.5 times the IL) are provided for context and evaluations of areas of the Site, samples, or TENORM that exceed the IL based on the statistically derived IL values.

In addition to the surface gamma survey performed in background reference areas, subsurface static gamma measurements were collected in the boreholes completed in the background reference areas. Where possible, these measurements were used to establish subsurface static gamma screening levels for Survey Areas A, B, C, D, and E. Where possible, the selected subsurface static gamma screening level measurement met the following criteria: (1) it was the lowest value measured at or below one ft bgs; and (2) it was not measured directly on bedrock.

These subsurface static gamma screening levels provide a comparison and assessment tool for Survey Areas A, B, C, D, and E, and are included as ILs for the Site. However, it is important to consider that the subsurface static gamma ILs are based on single measurements, and they are not statistically derived. For this reason, subsurface static gamma IL exceedances should be considered in conjunction with additional lines of evidence including: (1) down-hole trends of static gamma measurements; (2) changes in lithology within the borehole; and (3) a qualitative comparison of subsurface static gamma measurements to Ra-226 and/or metals concentrations in subsurface samples.

Subsurface static gamma measurements from the background reference areas are summarized in Table 4-2 and in Appendix C.2, and are described below.

- BG-1 – One subsurface static gamma measurement (7,963 cpm) was collected from borehole S1011-BG1-011 at a depth of 0.7 ft bgs. Therefore, 7,963 cpm was used as the subsurface static gamma IL for Survey Area A. This borehole was terminated at a depth of 0.9 ft bgs due to refusal on bedrock.
- BG-2 – Four subsurface static gamma measurements (12,551, 12,840, 13,268, and 12,669 cpm) were collected at down-hole depths of 0.5, 1.0, 1.5 and 2.0 ft bgs from borehole S1011-BG2-011, respectively. The lowest measured value, at or below 1 ft bgs and not directly measured on bedrock was12,669 cpm. This value was used as the subsurface static gamma IL for Survey Area B.

- BG-3 – One subsurface static gamma measurement (6,387 cpm) was collected from borehole S1001-BG3-011 at a down-hole depth of 0.25 ft bgs, therefore 6,387 cpm was used as the subsurface static gamma IL for Survey Area C. The total depth of the borehole was 0.25 ft bgs with refusal on sandstone.

- BG-4 – Six subsurface static gamma measurements (9,706, 10,481, 10,271, 10,313, 10,099, and 10,616 cpm) were collected from borehole S1011-BG4-011 at down-hole depths of 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 ft bgs, respectively. The lowest measured value, at or below 1 ft bgs and not directly measured on bedrock was 10,099 cpm. This value was used as the subsurface static gamma IL for Survey Area D.

- BG-5 – Four subsurface static gamma measurements (10,302, 11,450, 11,465, and 11,496 cpm) were collected from borehole S1011-BG5-011 at down-hole depths of 0.5, 1.0, 1.5 and 2.0 ft bgs, respectively. The lowest measured value of 10,302 cpm was measured at a depth of 0.5 ft bgs and did not meet the preferred depth criteria. The second lowest detection of 11,450 cpm was measured at 1.0 ft bgs and was used as the subsurface static gamma IL for Survey Area E.

It is important to consider that the subsurface static gamma IL measurements may be elevated relative to the surface gamma IL because increases in static gamma measurements with depth can result from the detector being in closer proximity to bedrock that has naturally elevated concentrations of radionuclides, and/or geometric effects.

Geometric effects are the result of the detector measuring gamma radiation from all directions, regardless of whether it is in a borehole or suspended in air. Gamma radiation measured with the detector held at the ground surface is primarily from the ground beneath the detector. As the detector is advanced down the borehole it measures gamma radiation from the surrounding material emanating from an increasing number of angles. Therefore, as the detector is lowered in the borehole it will generally measure increasingly higher values to a certain depth given a constant source. At approximately 1ft to 2 ft bgs, the detector is essentially surrounded by solid ground and further increases related to borehole geometry are not expected. Because downhole geometric effects influence static gamma measurements just below ground surface, static gamma measurements collected at or greater than 0.1 ft bgs are considered subsurface.

Due to the differing geometric effects, surface static gamma measurements at borehole locations may only be qualitatively compared to subsurface static gamma measurements, and the subsurface static gamma IL does not apply to the surface static gamma measurements. Instances where the surface static gamma measurement is greater than subsurface static gamma measurements suggest higher levels of radionuclides at the surface and may be indicative of the presence of TENORM at the surface. However, additional lines of evidence are generally needed to support that conclusion.

The Site gamma measurements, and soil and sediment sample analytical results were compared to their respective ILs to confirm the COPCs (refer to Section 4.4) and to identify areas of the Site where ILs are exceeded (refer to Section 4.5). The calculated ILs provide a line of evidence to evaluate potential mining-related impacts, and are provided to support considerations, as needed, for future Removal or Remedial Action evaluations at the Site.

4.2 SITE GAMMA RADIATION SURVEY RESULTS AND PREDICTED RADIUM-226 CONCENTRATIONS

4.2.1 Site Gamma Radiation Results

4.2.1.1 Surface Gamma Survey

Results of the Site surface gamma survey are shown in Figure 4-1a where the calculated ILs for each background reference area are used to set bin ranges with color coding to illustrate the spatial extent and patterns of surface gamma measurements within the entire Survey Area. The bin ranges were based on the Survey Area minimum site gamma measurements, the background reference area ILs, and the maximum site gamma measurement. The maximum gamma measurement for the Site was 749,127 cpm, which was more than 15 times the maximum IL (i.e., BG-3 IL of 48,542 cpm), and occurred in Survey Area C downgradient from Waste Pile 3 (compare Figure 2-7 with Figure 4-1a or 4-1d). Surface gamma measurements were generally highest in an area of the mesa sidewall downgradient of Waste Pile 3, on the mesa top coincident with Waste Pile 6, and in portions of Disturbed Area 1 (compare Figure 2-7 with Figure 4-1a). Descriptions and photographs of these areas are provided in Section 3.2.2.1 and Appendix B-1 photograph numbers 7, 9, 10, 11, 12, and 13.

The spatial distribution of surface gamma measurements and IL exceedances are shown in Figures 4-1b, 4-1c, 4-1d, 4-1e, and 4-1f for Survey Areas A, B, C, D, and E, respectively, and are described below:

- Survey Area A (refer to Figure 4-1b) – Surface gamma IL exceedances (greater than 16,829 cpm) occurred throughout Survey Area A except along the western-most portion of the mesa rim. The maximum measurement (654,837 cpm) occurred along the mesa rim within a central portion of Disturbed Area 1. Measurements greater than ten times the IL were observed in five locations along the mesa rim, including three locations within Disturbed Area 1, one location within Waste Pile 2, and one location west of Waste Pile 3.

- Survey Area B (refer Figure 4-1c) – Surface gamma IL exceedances (greater than 23,320 cpm) occurred throughout Survey Area B except for some southern portions of mine site #1011 and its 100-ft buffer, areas along the rim of the mesa west of Waste Pile 3, and in portions of the potential haul roads. The maximum measurement (633,057 cpm) occurred along the mesa rim within a central portion of Disturbed Area 1. Measurements greater than ten times the IL also occurred in Waste Pile 6 and in one location in the southwestern portion of mine site #1011.

- Survey Area C (refer to Figure 4-1d) – Surface gamma IL exceedances (greater than 48,542 cpm) occurred primarily in areas along the top of the mesa sidewall, and in areas downgradient from Waste Piles 2, 3, and 7. The maximum measurement (749,127 cpm) for Survey Area C (and the Site) occurred on the mesa sidewall downgradient of Waste Pile 3.

Measurements greater than ten times the IL occurred on the mesa sidewall downgradient of Waste Pile 3.

- Survey Area D (refer to Figure 4-1e) – Surface gamma IL exceedances (greater than 20,637 cpm) occurred throughout Survey Area D with the exception of three areas: 1) the majority of the southern-most portion of the area; 2) along the western boundary of Survey Area D; and 3) within an area at the base of the mesa sidewall, directly south of mine site #1012. The maximum measurement (62,220 cpm) was three times greater than the IL and occurred at the base of the mesa sidewall downgradient from Disturbed Area 1. The majority of Survey Area D surface gamma IL exceedances were less than two times the IL. In addition, the majority of the surface gamma IL exceedances in the central and western portions of the Survey Area were within ten-percent of the IL.

- Survey Area E (refer to Figure 4-1f) – Surface gamma IL exceedances (greater than 21,864 cpm) primarily occurred in portions of the central drainage and two eastern drainages. The maximum measurement (117,875 cpm) was greater than 5 times the IL and occurred downgradient from Disturbed Area 1 in the eastern-most drainage, near the base of the mesa sidewall.

Figure 4-1d also compares Survey Area C to the surface gamma IL calculated for BG-6 (34,429 cpm; refer to Appendix D.1 and Table D.1-2), which represents the Wingate Sandstone portion of Survey Area C (refer to Section 2.2.2.2 and Figure 2-6a). Surface gamma measurements within the Wingate Sandstone that exceeded the BG-6 IL were detected downgradient from Disturbed Area 1 and in several discrete areas in the western portion of Survey Area C. Given that these areas did not exceed the Survey Area C IL (48,542 cpm)), these areas will be considered separately in the TENORM volume calculations (refer to Section 4.7).

Four potential data gaps were identified for the surface gamma survey, as listed below:

1. 10.1 acres of the Survey Area were not surveyed, because field personnel were unable to safely access these areas due to steep/unsafe terrain (refer to Figure 3-4).

2. The survey was not extended laterally from the potential haul roads where the gamma measurements were greater than the IL due to a miscommunication with field personnel.

3. The shoulders of some potential haul roads in the north-central portion of the Site were not surveyed due to a miscommunication with field personnel.

4. The gamma survey was not extended to the west of Survey Area B (the central portion of the mesa top) until gamma measurements reached background levels. This area was not surveyed based on professional judgement in the field that this area contained only NORM. However, review of high-resolution aerial images and historical documents following the survey suggested that some portions of this area (specifically Disturbed Area 4) may have been disturbed by mining-related activities. It is recommended that this data gap be addressed during future work.

4.2.1.2 Subsurface Gamma Survey

Surface and subsurface static gamma measurements were collected at all 44 borehole locations. Surface and subsurface static gamma measurement locations are shown in Figures 3-6a and 3-6b. Measurements and corresponding measurement depths are provided in Table 4-2 and are shown on the borehole logs in Appendix C.2. Subsurface static gamma ILs apply only to measurements from unconsolidated material; static gamma measurements detected within a bedrock interval are considered for informational purposes only. Surface and subsurface static gamma measurements from the boreholes are presented below by Survey Area:

- Survey Area A (refer to Figures 3-6a and 3-6b) – Two boreholes were completed in Survey Area A (S1011-SCX-008 and -SCX-017), one of which was terminated in bedrock (S1011-SCX-017). The highest subsurface static measurement from unconsolidated material (103,982 cpm) was detected in a borehole within Waste Pile 3 (S1011-SCX-008; 1.5 ft bgs). The highest measurement from bedrock (266,288 cpm in borehole S1011-SCX-017) was detected within a limestone interval at a depth of 1.0 ft bgs. Borehole S1011-SCX-017 was located within Disturbed Area 1. Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements in unconsolidated material increased in borehole S1011-SCX-008 from 57,060 at 0.5 ft bgs to 103,982 at the refusal depth of 1.5 ft bgs. When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole, static gamma measurements also increased with depth in both boreholes.

- Survey Area B (refer to Figures 3-6a and 3-6b) – 33 boreholes were completed in Survey Area B, of which 25 were terminated in bedrock. The Survey Area B subsurface static gamma IL (12,669 cpm) was exceeded in unconsolidated material in 28 boreholes. The highest subsurface static gamma measurement for Survey Area B and the Site (477,872 cpm) occurred in bedrock in a borehole that was within Disturbed Area 1 (S1011-SCX-019; 3.0 ft bgs). The highest subsurface static gamma measurement in unconsolidated material (352,526 cpm) for Survey Area B and the Site occurred in a borehole located within mine site #1035, approximately 100 feet southwest of the vertical mine shafts (S1011-SCX-028). Subsurface static gamma measurements and IL exceedances are considered with respect to mine site #1011, mine site #1035, Disturbed Area 1, and mine site #1012/Disturbed Area 2 within Survey Area B:

  - Mine site #1011 (refer to Figure 3-6b) – Nine boreholes were completed within the 100-ft buffer of mine site #1011 (S1011-SCX-009, -SCX-010, -SCX-011, -SCX-012, -SCX-013, -SCX-014, -SCX-039, -SCX-040, -SCX-044). Bedrock was encountered between 0.5 and 6.0 ft bgs, six of the nine boreholes terminated in bedrock, and the three others terminated due to hard material or refusal (unknown if it was bedrock). The Survey Area B IL (12,669 cpm) was exceeded in unconsolidated material in five boreholes. The highest subsurface static gamma measurement from unconsolidated material (72,575 cpm) was greater than five times the IL and was collected from borehole S1011-SCX-039 at the refusal depth of 0.2 ft bgs. The highest subsurface static gamma measurement from bedrock (41,294 cpm) was from borehole S1011-SCX-010 at a depth of 7.0 ft bgs. Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements in unconsolidated material generally decreased with depth in four boreholes

(S1011-SCX-009, -SCX-011, -SCX-012, and -SCX-014), increased with depth in one borehole (S1011-SCX-044) and fluctuated with depth in one borehole (S1011-SCX-010). When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole (0.5 to 1.0 ft bgs), static gamma measurements increased with depth in eight (out of nine) boreholes. One borehole (S1011-SCX-014) had static gamma measurements that decreased from 33,406 cpm at the surface to 10,820 cpm at 1.0 ft bgs, which was an indication of the potential presence of contaminated material near the surface in this area. Subsurface static gamma IL exceedances were observed in unconsolidated material to a maximum depth of 5 ft bgs (S1011-SCX-010).

- Mine site #1035 (refer to Figure 3-6b) – Eighteen boreholes were completed within mine site #1035 (S1011-SCX-021 through -SCX-038). Bedrock was encountered between 3.0 and 20.0 ft bgs and all boreholes terminated in bedrock. Subsurface static gamma measurements extended into bedrock in 15 of the 18 boreholes. The Survey Area B subsurface static gamma IL (12,669 cpm) was exceeded in unconsolidated material in all 18 boreholes, and exceedances in unconsolidated material extended to a maximum depth of 20 ft bgs. Subsurface static gamma measurements greater than two-times the IL were observed in unconsolidated material from six boreholes, of which two had measurements that were greater than five times the IL (S1011-SCX-028 and -SCX-031). The highest subsurface static gamma measurement from unconsolidated material (352,526 cpm) occurred in borehole S1011-SCX-028 (3.0 ft bgs), which was located approximately 100 ft southwest of the vertical mine shafts. The highest subsurface static gamma measurement from bedrock (39,254 cpm) occurred in borehole S1011-SCX-025 (8.0 ft bgs), which was located near the northern claim boundary. Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements in unconsolidated material increased with depth in two boreholes (S1011-SCX-022 and -SCX-029) and fluctuated with depth in the remaining 16 boreholes. When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole (0.5 to 1.0 ft bgs), static gamma measurements increased with depth in 14 boreholes, and decreased with depth in four boreholes (S1011-SCX-022, -SCX-024, -SCX-027 and -SCX-038).

- Disturbed Area 1 (refer to Figure 3-6b) – Three boreholes were completed within or near Disturbed Area 1 (S1011-SCX-018, -SCX-019, and -SCX-020). Bedrock was encountered between 2.5 and 5.0 ft bgs, and all three boreholes were terminated in bedrock. All subsurface static gamma measurements measured in unconsolidated material within the three boreholes exceeded the IL (12,669 cpm). Subsurface static gamma IL exceedances were observed in unconsolidated material to a maximum depth of 3 ft bgs (S1011-SCX-018) within Disturbed Area 1, and to a depth of 5.0 ft bgs in the borehole located just north of Disturbed Area 1(S1011-SCX-020). Subsurface static gamma measurements greater than ten times the IL were collected in unconsolidated material from boreholes S1011-SCX-018 and-SCX-019. The highest subsurface static gamma measurement from unconsolidated material (254,338 cpm) occurred in borehole S1011-SCX-019 (2.0 ft bgs). The highest subsurface static gamma measurement from bedrock for the Survey Area and the Site (477,872 cpm) also occurred in borehole S1011-SCX-019 (3.0 ft bgs). Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements in unconsolidated material increased with depth in two boreholes (S1011-SCX-019 and -SCX-020) and fluctuated with depth in borehole S1011-SCX-018. When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole (1.0 ft bgs), static gamma measurements increased with depth in all three boreholes.

- Mine site #1012 and Disturbed Area 2 (refer to Figure 3-6b) – Three boreholes were completed within mine site #1012 or Disturbed Area 2 (S1011-SCX-007, -SCX-015, and -SCX-016). Bedrock was encountered between 1.5 and 3.0 ft bgs. Two of the boreholes were terminated in bedrock, and one borehole (S1011-SCX-007) was terminated on a hard surface (it is unknown if this was bedrock). The Survey Area B subsurface static gamma IL (12,669 cpm) was exceeded in unconsolidated material in two boreholes (S1011-SCX-007 and -SCX-016) and exceedances in unconsolidated material were observed to a maximum depth of 3.0 ft bgs (S1011-SCX-016). The one borehole where subsurface static gamma measurements did not exceed the IL was located in the debris pile, just north of mine site #1012. The highest subsurface static gamma measurement from unconsolidated material (20,893 cpm) was less than two times the IL, and was detected in a borehole located in the northern portion of mine site #1012 (S1011-SCX-007). Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements in unconsolidated material increased with depth in one borehole (S1011-SCX-016) and decreased with depth in one borehole (S1011-SCX-007). When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole (0.5 to 1.0 ft bgs), static gamma measurements increased with depth in one borehole (S1011-SCX-015), and decreased with depth in the remaining two boreholes.

- Survey Area C (refer to Figure 3-6a) – One borehole was completed within Survey Area C (S1011-SCX-006) and was located downslope from Waste Pile 3 and in the southern debris pile. The borehole was terminated in unconsolidated material due to refusal on hard rock. All subsurface static gamma measurements collected in S1011-SCX-006 exceeded the Survey Area C IL (6,387 cpm), and the highest subsurface static gamma measurement (154,588 cpm) occurred at a depth of 0.25 ft bgs. Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements decreased with depth. When comparing the static gamma measurement collected at the surface to the first measurement collected down-hole (0.25 ft bgs), static gamma measurements increased with depth.

- Survey Area D (refer to Figure 3-6a) – Three boreholes were completed in Survey Area D (S1011-SCX-041, -SCX-042, and -SCX-043) and all three were terminated in unconsolidated material (S1011-SCX-041 and -SCX-042 did not meet refusal, S1011-SCX-043 met refusal on rock). The subsurface static gamma IL (10,099 cpm) was exceeded in two boreholes (S1011-SCX-041 and -SCX-043), and IL exceedances were observed to a maximum depth of 2.5 ft bgs (S1011-SCX-041). The maximum subsurface static gamma measurement (17,072 cpm) was less than two times the IL and occurred in the western-most Survey Area D borehole, and in the deepest interval (S1011-SCX-041; 2.5 ft bgs). Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements generally increased with depth in one borehole (S1011-SCX-041) and decreased with depth in one borehole (S1011-SCX-042). When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole (0.25 to 1.0 ft bgs), static gamma measurements increased with depth in all three Survey Area D borehole locations.

- Survey Area E (refer to Figure 3-6a) – Five boreholes were completed in Survey Area E (S1011-SCX-001 through -SCX-005), of which all five terminated on hard rock or hard surfaces in unconsolidated material. All subsurface static gamma measurements collected in unconsolidated material exceeded the Survey Area E IL (11,450 cpm), and exceedances were observed at a maximum depth of 2.25 ft bgs (S1011-SCX-003). The maximum subsurface static gamma measurement (42,405 cpm) was greater than three times the IL and occurred in a borehole located near the base of the mesa sidewall, in the eastern-most drainage (S1011-SCX-001; 1.0 ft bgs). Subsurface static gamma measurements greater than two times the IL were also detected in the deepest intervals from two other boreholes (S1011-SCX-003; 1.5 to 2.25 ft bgs and -SCX-005; 2.0 ft bgs). Borehole S1011-SCX-003 was located in the eastern drainage, downgradient from S1011-SCX-001, and borehole S1011-SCX-004 was located in west-central drainage and was the most southern (i.e., distal to potential mining-related disturbances) borehole location. Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements increased with depth in four boreholes (S1011-SCX-002, -SCX-003, -SCX-004, and -SCX-005) and fluctuated with depth in one borehole (S1011-SCX-001). When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole (0.5 ft bgs) static gamma measurements increased with depth in four borehole locations, and decreased with depth in borehole S1011-SCX-005.

4.2.2 Gamma Correlation Results

The high-density surface gamma measurements and concentrations of Ra-226 in surface soils obtained from the Gamma Correlation Study (refer to Section 3.3.1.3) were used to develop a correlation equation, using regression analysis, between the mean gamma measurements and Ra-226 concentrations measured in the co-located composite surface soil samples. This correlation is meant to be used as a general screening tool and provides approximate predicted Ra-226 concentrations.

The correlation was developed as a potential field screening tool for future Removal or Remedial Action evaluations. Analytical results of the correlation samples, which were used to develop the correlation equation, are presented in Table 4-3. The mean value of the gamma survey results from the correlation plots, with their corresponding Ra-226 concentrations and a graph showing the linear regression line and adjusted Pearson's Correlation Coefficient (R^2) value for the correlation, are shown in

Figure 4-2a. The regression produced an adjusted R^2 value of 0.93, which is within the acceptance criterion of 0.8 to 1.0 described in the *RSE Work Plan* and indicates that surface gamma results correlate with Ra-226 concentrations in soil. The correlation model may have been influenced by environmental conditions and the limited number of correlation sample locations. Users of the regression equation should be aware of the limitations of the dataset and be cautious when estimating radium-226 concentrations. The correlation equation to convert gamma measurements in cpm to predicted surface soil Ra-226 concentrations in pCi/g for the Site is:

$$\text{Gamma (cpm)} = 5{,}822 \times \text{Surface Soil Ra-226 (pCi/g)} + 13{,}201$$

The predicted Ra-226 concentrations in soil, as calculated from the gamma measurements using the developed correlation equation, are shown in Figure 4-2a. Ra-226 concentrations predicted using gamma measurements lower than the minimum (21,632 cpm) and greater than the maximum (165,200 cpm) mean gamma measurements from the Gamma Correlation Study are extrapolated from the regression model and are therefore uncertain. Using the correlation equation, the predicted Ra-226 concentration associated with the minimum mean gamma measurement is 1.4 pCi/g and the concentration associated with the maximum mean gamma measurement is 26.1 pCi/g. Therefore, predicted Ra-226 concentrations less than 1.4 pCi/g and greater than 26.1 pCi/g should be limited to qualitative use only.

The correlation equation predicted Ra-226 concentrations that were less than zero for gamma survey measurements below 13,201 cpm. The predicted concentrations are shown in Figure 4-2a and the values less than zero are located along the mesa edge, west of the Site. The elevated predicted Ra-226 concentrations shown in Figure 4-2a occur in the same areas where the elevated surface gamma measurements occur (refer to Section 4.2.1 and Figure 4-1a). This is because the predicted Ra-226 concentrations are based on a direct correlation with the gamma measurements. Predicted Ra-226 concentrations in the Survey Area range from -0.8 to 126.4 pCi/g, with a mean of 3.3 pCi/g, and a standard deviation, of 4.9 pCi/g. Bin ranges in Figure 4-2a are based on these mean and standard deviation values.

The gamma correlation was not used for the Site Characterization, which instead relied on actual gamma radiation measurements and soil analytical results. However, predicted Ra-226 concentrations were compared to the Ra-226 laboratory concentrations measured in surface soil samples collected at surface and borehole locations, to evaluate the accuracy of the correlation for the Site, as shown in Figure 4-2b. The correlation results were also compared to investigation levels, as shown in Figure 4-2c. Per the Agencies, these comparisons can be used for site characterization and are one of many analyses that can be used to interpret the data (NNEPA, 2018).

When comparing the predicted Ra-226 concentrations to the Ra-226 laboratory concentrations, soil/sediment sample locations are generally not co-located with specific gamma measurement locations (refer to Figure 4-2b). Therefore, the measured Ra-226 laboratory concentrations can only be qualitatively compared to the nearby predicted Ra-226 concentrations. With the exception of 15 (out of 59) sample locations, the measured Ra-226 laboratory concentrations were within the applicable predicted Ra-226 bin ranges. In 12 of the 15 sample locations where the predicted Ra-226 concentration and the Ra-226 concentration detected in the soil/sediment sample did not agree, the predicted concentration was higher than the reported laboratory concentration detected in the soil/sediment sample. The majority of these sample locations (seven out of 12) were within mine site #1035. Three soil sample locations had predicted Ra-226 concentrations that were slightly lower than the laboratory Ra-226 concentration; these two samples were both located in the vicinity of mine site #1012. The differences observed between the predicted and actual Ra-226 values are likely a function of the natural heterogeneity in Ra-226 concentrations and gamma radiation measurements, which affects the correlation based on the five Gamma Correlation Study areas, and the predicted values, based on the subsequent gamma measurements. However, the correlation may be useful as a screening tool as it provides a representative estimate of Ra-226 concentrations across the Site similar to the actual results.

The predicted Ra-226 concentrations were also compared to the Ra-226 ILs from each Survey Area, as shown in Figure 4-2c. The symbols for surface sample locations and boreholes where Ra-226 concentrations in surface soil/sediment samples exceeded the IL are highlighted with yellow halos. The predicted Ra-226 concentrations exceeded the Ra-226 ILs for approximately 60 to 70 percent of the Site. Sample locations where laboratory Ra-226 concentrations exceeded the ILs were generally co-located with predicted Ra-226 concentrations that exceeded the ILs. The exceptions were five samples collected in the northeastern portion of the Site where the laboratory Ra-226 was less than the IL but the predicted Ra-226 value exceeded the IL. The area of the Site where predicted Ra-226 values exceeded the ILs is compared to surface gamma IL exceedances in the surface gamma survey in Section 4.5.

The correlation soil samples were also analyzed for thorium isotopes Th-232 and Th-228. The objectives of the thorium analyses were to assess the potential effects of Th-232 series radioisotopes on the correlation of gamma measurements to concentrations of Ra-226 in surface soils (i.e., to evaluate whether gamma-emitting radioisotopes in the Th-232 series are impacting gamma measurements at the Site). The justification for the analysis is provided in Section 3.3.1.3. A multivariate linear regression (MLR) model was performed by ERG to relate the gamma count rate to multiple soil radionuclides simultaneously. The MLR and results are described extensively in Appendix A. ERG identified that the thorium series radionuclides do not affect the prediction of concentrations of Ra-226 from gamma survey measurements at the Site.

4.2.2.1 Secular Equilibrium Results

The activities of Th-230 and Ra-226 were compared to consider whether the uranium series is in secular equilibrium at the Site (refer to Section 3.3.1.4 and Appendix A). A linear regression was performed on the dataset (refer to Appendix A Figure 9). The p-value for the regression slope is significant (i.e., $p < 0.05$) and the adjusted R^2 meets the study DQO (adjusted $R^2 > 0.8$), indicating that Ra-226 and Th-230 exist in equilibrium. However, when compared to a y=x line (this line represents a perfect 1:1 ratio between Th-230 and Ra-226, indicating secular equilibrium), the y=x line falls partially outside of the 95% UCL bands of the Th-230/Ra-226 regression, indicating Ra-226 and Th-230 are not in secular equilibrium at the Site (refer to figures in Appendix A). This may be a consideration in the future if a human health and/or ecological risk assessment is performed.

4.3 SOIL METALS AND RADIUM-226 ANALYTICAL RESULTS

A total of 59 surface soil/sediment grab samples (48 soil and 11 sediment) from 59 locations, and 64 subsurface soil/sediment grab samples (47 soil, 3 soil/bedrock, and 14 sediment) from 40 borehole locations were collected at the Site (refer to Table 3-2). The three soil/bedrock subsurface samples were all collected from three borehole locations in Survey Area B (S1011-SCX-018; 1.0-3.5 ft bgs, -SCX-021; 19.0-20.0 ft bgs, and -SCX-027; 6.0-8.5 ft bgs). These three samples included the top 0.5 ft of bedrock and, therefore, the analytical results may, in part, reflect the composition of the bedrock interval. The metals and Ra-226 analytical results for each Survey Area are compared to their respective ILs and presented in Tables 4-4a through 4-4e. Figures 4-3a through 4-3d present the spatial patterns, both laterally and vertically, of metals and Ra-226 detections and IL exceedances in the soil/sediment samples.

With the exception of one subsurface soil sample collected in the Survey Area D plains area (S1011-SCX-042), Ra-226 and/or metals concentrations exceeded their respective ILs in all surface and/or subsurface soil/sediment samples collected from Survey Areas A, C, and D. With the exception of five surface and 13 subsurface soil/sediment samples, Ra-226 and/or metals concentrations exceeded their respective ILs in all surface and/or subsurface samples collected from Survey Area B. With the exception of one subsurface sediment sample, Ra-226 and/or metals concentrations exceeded their respective ILs in all other surface and/or subsurface samples collected from Survey Area E. The maximum molybdenum detection occurred within a surface soil sample from Survey Area B collected in the reclaimed area within mine site #1035.The maximum Ra-226 and metals concentrations (excluding molybdenum) were detected in subsurface soil or soil/bedrock samples collected in Disturbed Area 1 located within Survey Areas A and B. Presented sample counts do not include duplicate samples. Surface and subsurface soil/sediment concentrations and IL exceedances for each analyte, and within each Survey Area are described below:

- Ra-226
  - Survey Area A – The Ra-226 IL (2.13 pCi/g) was exceeded in all eight (five surface and three subsurface) soil samples. Ra-226 concentrations ranged from 5.39 to 66.4 pCi/g and the maximum concentration was greater than 64 times the IL and occurred in a subsurface soil sample collected from borehole S1011-SCX-017, located within Disturbed Area 1. Ra-226 concentrations varied with depth in borehole S1011-SCX-008 located in Waste Pile 3, and increased with depth in borehole S1011-SCX-017.
  - Survey Area B – The Ra-226 IL (2.96 pCi/g) was exceeded in 20 (out of 42) surface and 16 (out of 47) subsurface soil/sediment samples and two out three soil/bedrock samples. Ra-226 concentrations in Survey Area B ranged from 0.57 to 80.2 pCi/g and the maximum concentration for Survey Area B and the Site occurred in a subsurface soil/bedrock sample collected from Disturbed Area 1, (S1011-SCX-018; 1.0-3.5 ft bgs). The maximum concentration in an unconsolidated sample (47.1 pCi/g) was greater than 15 times the IL and occurred in a subsurface soil sample collected from borehole S1011-SCX-028, located within mine site #1035 southwest of the possible portal or storage area. Ra-226 concentrations greater than ten times the IL were detected in one additional sample location; borehole S1011-SCX-019, which was collected from Disturbed Area 1. Ra-226 IL exceedances within Survey Area B are described below with respect to mine site #1011, mine site #1035, Disturbed Area 1, and mine site #1012/Disturbed Area 2:
    - Mine site #1011 (refer to Figures 3-6b and 4-3b) – The Survey Area B Ra-226 IL (2.96 pCi/g) was exceeded in four (out of 11) surface soil samples and one (out of seven) subsurface samples. Ra-226 concentrations ranged from 0.78 to 7.8 pCi/g. The maximum concentration was less than three times the IL and occurred in a

surface soil sample from borehole S1011-SCX-044. Ra-226 concentrations increased with depth in one borehole, decreased with depth in four boreholes, and fluctuated with depth in one borehole. No distinct spatial patterns were observed with respect to IL exceedances or concentration changes with depth.

- Mine site #1035 (refer to Figures 3-6b and 4-3a) – The Survey Area B Ra-226 IL (2.96 pCi/g) was exceeded in nine (out of 22) surface soil/sediment samples, nine (out of 34) subsurface soil/sediment samples, and one bedrock sample. Ra-226 concentrations ranged from 0.57 to 47.1 pCi/g; the maximum concentration was greater than 15 times the IL and occurred in a subsurface soil sample located approximately 100-ft southwest of the vertical mine shafts (S1011-SCX-028; 0.5-5.0 ft bgs). All other exceedances ranged from less than two times the IL, to less than five times the IL. Ra-226 concentrations Increased with depth in two borehole locations, decreased with depth in seven borehole locations and fluctuated with depth in nine locations. No distinct spatial patterns were observed with respect to IL exceedances or Ra-226 concentration changes with depth. A notable concentration change with depth occurred in borehole S1011-SCX-028 where the Ra-226 concentration increased from 1.9 pCi/g in the surface sample (0-0.5 ft bgs) to 47.1 pCi/g in the next sample interval (0.5-5.0 ft bgs), decreased to 10.6 and 13.8 pCi/g at 5.0 and 10.0 ft bgs, respectively, and were below the IL deeper than 10 ft bgs.

- Disturbed Area 1 (refer to Figures 3-6b and 4-3c) – The Survey Area B Ra-226 IL (2.96 pCi/g) was exceeded in all four sample locations and included four surface and two subsurface soil/sediment samples. Ra-226 concentrations ranged from 5.54 to 80.2 pCi/g; the maximum concentration for the area, Survey Area B, and the Site was greater than 37 times the IL and occurred in a subsurface soil/bedrock sample from borehole S1011-SCX-018 at a depth of 1.0-3.5 ft bgs. Subsurface soil sample S1011-SCX-019 (0.5-2.5 ft bgs) had a Ra-226 concentration (37.2 pCi/g) that exceeded the IL by more than ten times and the remaining samples had Ra-226 concentrations that ranged from less than two times the IL to less than ten times the IL. Ra-226 concentrations increased with depth in boreholes S1011-SCX-018 and -SCX-019 and remained constant in borehole S1011-SCX-020.

- Mine site #1012 and Disturbed Area 2 (Figures 3-6b and 4-3d) – The Survey Area B Ra-226 IL (2.96 pCi/g) was exceeded three (out of five) surface soil samples, and all four subsurface soil samples. Ra-226 concentrations ranged from 2.27 to 11.3 pCi/g; the maximum concentration less than four times the IL and occurred in a surface soil sample located east of the mine site #1012 boundary (S1011-CX-005). Ra-226 concentrations increased with depth in two boreholes and fluctuated with depth in one borehole.

- Survey Area C – The Ra-226 IL (1.49 pCi/g) was exceeded in all three soil samples (two surface and one subsurface). Ra-226 concentrations ranged from 5.64 to 24.3 pCi/g. The maximum concentration was greater than 16 times the IL and occurred in a surface soil sample located downgradient from Waste Pile 3, and within the debris pile at the base of the mesa sidewall (S1011-SCX-006). Ra-226 concentrations decreased with depth.

- Survey Area D – The Ra-226 IL (1.49 pCi/g) was exceeded in one (out of three) surface soil samples and one (out of two) subsurface soil samples. Ra-226 concentrations ranged from 0.56 to 1.77 pCi/g. The maximum concentration was less than two times the IL and occurred in a surface soil sample located within the plains in the eastern portion of the Survey Area (S1011-SCX-043). Ra-226 concentrations increased with depth in one borehole and decreased with depth in the other borehole.

- Survey Area E – The Ra-226 IL (0.839 pCi/g) was exceeded in six (out of seven) surface sediment samples and in seven (out of eight) subsurface sediment samples. The two sediment samples that did not exceed the IL were both located in the eastern-central portion of the plains (S1011-CX-009; -SCX-002, 0.5-1.5 ft bgs). Ra-226 concentrations ranged from 0.54 to 3.51 pCi/g. The maximum concentration was less than five times the IL and occurred in a subsurface sediment sample located downgradient from Waste Piles 2 and 3, and the debris pile near the base of the mesa sidewall (S1011-SCX-004; 1.5 to 2.0 ft bgs). Ra-226 concentrations increased with depth in four out of five boreholes and decreased with depth in one borehole.

- Uranium

  - Survey Area A – The uranium IL (3.23 mg/kg) was exceeded in all eight (five surface and three subsurface) soil samples. Uranium concentrations ranged from 5.3 to 230 mg/kg; the maximum concentration, for the Survey Area and the Site, was greater than 71 times the IL and occurred in a surface soil sample collected from Disturbed Area 1 (S1011-SCX-017). In general, the highest concentrations were detected in surface and subsurface soil samples collected from Disturbed Areas 1 or 2. Uranium concentrations generally decreased with depth in both Survey Area A boreholes.

  - Survey Area B – The uranium IL (3.34 mg/kg) was exceeded in 19 (out of 42) surface soil/sediment samples, 15 (out of 47) subsurface soil/sediment samples, and in one (out of 2) subsurface soil/bedrock sample and the one subsurface bedrock sample. Survey Area B uranium concentrations ranged from 0.35 to 200 mg/kg. The maximum concentration occurred in a subsurface soil/bedrock sample collected from Disturbed Area 1 (S1011-SCX-018; 1.0-3.5 ft bgs). Uranium concentrations greater than ten times the IL were detected in three additional sample locations including 1) borehole S1011-SCX-007 located within mine site #1012 and within Disturbed Area 2; 2) borehole S1011-SCX-019 which was within Disturbed Area 1; and 3) borehole S1011-SCX-037 located within mine site #1035 in the vicinity of the vertical mine shafts. Uranium IL exceedances within Survey Area B are described below with respect to mine site #1011, mine site #1035, Disturbed Area 1, and mine site #1012/Disturbed Area 2.

    - Mine site #1011 (refer to Figures 3-6b and 4-3b) – The Survey Area B uranium IL (3.34 mg/kg) was exceeded in four (out of 11) surface soil samples and in one (out of seven) subsurface soil samples. Uranium concentrations ranged from 0.48 to 7.1 mg/kg. The maximum concentration was less than three times the IL and occurred in subsurface soil sample S1011-SCX-044 at a depth of 0.2-0.7 ft bgs. Uranium concentrations increased with depth in one borehole, decreased with depth in four boreholes, and fluctuated with depth in one borehole. No distinct spatial patterns were observed with respect to IL exceedances or concentration changes with depth.

- Mine site #1035 (refer to Figures 3-6b and 4-3a) – The Survey Area B uranium IL (3.34 mg/kg) was exceeded in ten sample locations and included six (out of 22) surface soil/sediment samples, eight (out of 34) subsurface soil/sediment samples and one subsurface soil/bedrock samples. Uranium concentrations ranged from 0.35 to 68 mg/kg. The maximum concentration was 20 times the IL and occurred in a surface sediment sample that was located approximately100 ft southwest of the vertical mine shafts (S1011-SCX-037). Uranium concentrations increased with depth in five borehole locations, decreased with depth in nine borehole locations, and fluctuated with depth in four borehole locations. No distinct patterns were observed with respect to IL exceedances or concentration changes with depth. Two boreholes had notable uranium concentration changes with depth: (1) uranium concentrations in soil samples from borehole S1011-SCX-028 increased from 2.1 mg/kg (less than the IL) at the surface, to 28 and 11 mg/kg in the next two sample intervals (0.5-5.0 ft and 5.0–8.0 ft bgs, respectively), and then decreased back down to less than the IL in the last three sample intervals; and (2) the uranium concentration in soil samples from borehole S1011-SCX-037 decreased from 68 mg/kg in the surface sample to 2.3 mg/kg in the next sample interval (0.5-3.0 ft bgs).

- Disturbed Area 1 (refer to Figures 3-6b and 4-3c) – The Survey Area B uranium IL (3.34 mg/kg) was exceeded in all four sample locations and included all four surface and both subsurface soil samples. Uranium concentrations ranged from 4.5 to 200 mg/kg. The maximum concentration occurred in subsurface soil/bedrock sample S1011-SCX-018 (1.0-3.5 ft bgs). Detections greater than ten times the IL were also observed in the surface sample from this borehole, as well as in the subsurface soil sample in borehole S1011-SCX-019 (0.5-2.5 ft bgs); the uranium concentration in S1011-SCX-019 (140 mg/kg) was the highest concentration measured in soil in Disturbed Area 1. Uranium concentrations increased with depth in all three boreholes, the increases were much more substantial in the boreholes within Disturbed Area 1 (S1011-SCX-018 and -SCX-019) relative to the borehole located just north of Disturbed Area 1 (S1011-SCX-020).

- Mine site #1012 and Disturbed Area 2 (Figures 3-6b and 4-3d) - The Survey Area B uranium IL (3.34 mg/kg) was exceeded in all surface and subsurface soil samples. Uranium concentrations ranged from 4.9 to 41 mg/kg. The maximum concentration was greater than 12 time the IL and occurred in a subsurface soil sample located in the northern portion of mine site #1012 (S1011-SCX-007; 1.5-2.0 ft bgs). Uranium concentrations increased with depth in one borehole and decreased with depth in two boreholes.

- Survey Area C – The uranium IL (1.91 mg/kg) was exceeded in all three soil samples (two surface and one subsurface). Uranium concentrations ranged from 7.1 to 24 mg/kg. The maximum concentration was greater than 12 times the IL and occurred in a surface soil sample located downgradient from Waste Pile 3, and within the debris pile at the base of the mesa sidewall (S1011-SCX-006). Uranium concentrations decreased with depth.

- Survey Area D – The uranium IL (0.554 mg/kg) was exceeded in all three surface soil samples and in one (out of 2) subsurface soil samples. Uranium concentrations ranged from 0.38 to 2 mg/kg. The maximum concentration was less than five times the IL and occurred in a surface soil sample located within the plains (S1011-SCX-043). Uranium concentrations decreased with depth.

- Survey Area E – The uranium IL (0.691 mg/kg) was exceeded four (out of seven) surface sediment samples and in seven (out of eight) subsurface sediment samples. The three sample locations where the IL was not exceeded were all located in the southeastern-most portion of the plains. Uranium concentrations ranged from 0.4 to 15 mg/kg. The maximum concentration was greater than 21 times the IL and occurred in a subsurface sediment sample located downgradient from Waste Piles 2 and 3, and the debris pile near the base of the mesa sidewall (S1011-SCX-004; 1.5-2.0 ft bgs). The remaining IL exceedances ranged from less than two times the IL to less than five times the IL. Uranium concentrations increased with depth in two boreholes, decreased with depth in one borehole, and varied in two boreholes.

As a broader point of reference, a regional study of the Western US documented uranium concentrations in soil that ranged from 0.68 to 7.9 mg/kg, with a mean value of 2.5 mg/kg (USGS, 1984). Uranium concentrations were within the typical range of regional values for all Survey Area D samples. Uranium concentrations in soil/sediment exceeded the maximum regional value in seven Survey Area A samples, 16 Survey Area B samples, two Survey Area C samples, and one Survey Area E sample. All samples that exceeded the maximum regional value were associated with or downgradient from potential mining- or reclamation-related features or disturbances.

- Arsenic
  - Survey Area A – The arsenic IL (11.9 mg/kg) was not exceeded in any surface or subsurface soil samples. Arsenic concentrations ranged from 2.3 to 4.1 mg/kg. The maximum concentration occurred in a surface soil sample that was collected from the Disturbed Area 1 (S1011-SCX-017). Arsenic concentrations decreased with depth in both borehole locations.

  - Survey Area B – The arsenic IL (2.34 mg/kg) was exceeded in 18 (out of 42) surface soil/sediment samples, in 12 (out of 47) subsurface soil/sediment samples and in one (out of two) subsurface soil/bedrock samples. Survey Area B arsenic concentrations ranged from 1.1 to 12 mg/kg. The maximum concentration (12 mg/kg) for the Survey Area and the Site occurred in a subsurface soil/bedrock sample collected from Disturbed Area 1 (S1011-SCX-018; 1.0-3.5 ft bgs). Arsenic IL exceedances within Survey Area B are described below with respect to mine site #1011, mine site #1035, Disturbed Area 1, and mine site #1012/Disturbed Area 2.

    - Mine site #1011 (refer to Figures 3-6b and 4-3b) – The Survey Area B arsenic IL (2.34 mg/kg) was exceeded in two (out of 11) surface samples and one (out of seven) subsurface soil samples. Arsenic concentrations ranged between 1.3 and 2.9 mg/kg. All IL exceedances were less than two times the IL. In general, arsenic concentrations decreased or remained constant with depth. No distinct spatial patterns were observed with respect to IL exceedances or concentration changes with depth.

- Mine site #1035 (refer to Figures 3-6b and 4-3a) – The Survey Area B arsenic IL (2.34 mg/kg) was exceeded in nine (out of 22) surface soil/sediment samples and five (out of 36) subsurface samples. Arsenic concentrations ranged from 1.1 to 4.2 mg/kg and all IL exceedances were less than two times the IL. The maximum concentration (4.2 mg/kg) occurred in a subsurface soil sample located near the eastern claim boundary (S1011-SCX-021; 17.0-18.0 ft bgs). Twelve boreholes generally had decreasing arsenic concentrations with depth and six had fluctuating concentrations with depth. No distinct spatial patterns were observed with respect to exceedances or concentration changes with depth.

- Disturbed Area 1(refer to Figures 3-6b and 4-3c) – The Survey Area B IL (2.34 mg/kg) was exceeded in three (out of four) surface soil sample locations and both subsurface soil samples. Arsenic concentrations ranged from 1.9 to 12 mg/kg. The maximum concentration (12 mg/kg) for Disturbed Area 1, Survey Area B and the Site occurred in subsurface soil/bedrock sample from borehole S1011-SCX-018 (1.0-3.5 ft bgs). Arsenic concentrations in soil samples were all less than two times the IL. Arsenic concentrations increased with depth in all three boreholes.

- Mine site #1012 and Disturbed Area 2 (Figures 3-6b and 4-3d) – The Survey Area B arsenic IL (2.34 mg/kg) was exceeded in four (out of five) surface soil samples and in all four subsurface soil samples. Arsenic concentrations ranged from 2.3 to 5.9 mg/kg with all but one sample exceeding the IL by less than two times. The maximum concentration occurred in a surface soil sample from borehole S1011-SCX-016, located within Waste Pile 3. Arsenic concentrations decreased with depth in two boreholes and fluctuated with depth in one borehole.

- Survey Area C – The arsenic IL (4.99 mg/kg) was not exceeded in any of the three soil samples (two surface and one subsurface). Arsenic concentrations ranged from 1.2 to 1.3 mg/kg. The maximum concentration was from both of the surface soil samples (S1011-CX-006 and -SCX-006).

- Survey Area D – The arsenic IL (1.76 mg/kg) was not exceeded in any of the five soil samples (three surface and two subsurface). Arsenic concentrations ranged from 1.1 to 1.5 mg/kg. The maximum concentration was from a subsurface soil sample located in the plains southwest of mine site #1012 (S1011-SCX-041; 0.2-2.5 ft bgs). Arsenic concentrations increased with depth in one borehole and were unchanged with depth in the other borehole.

- Survey Area E – The arsenic IL (1.73 mg/kg) was not exceeded in any of the seven surface or eight subsurface sediment samples. Arsenic concentrations ranged from 0.56 to 1.3 mg/kg. The maximum concentration occurred in a surface sediment sample located in a drainage in the eastern-central portion of the plains (S1011-CX-009). Arsenic concentrations increased with depth in two boreholes, were relatively unchanged with depth in two boreholes, and decreased with depth in one borehole.

As a broader point of reference, a regional study of the Western US documented arsenic concentrations in soil that ranged from less than 0.10 to 97 mg/kg, with a mean value of 5.5 mg/kg (USGS, 1984). All arsenic concentrations were within the typical range of regional values in the soil/sediment samples from all Survey Areas.

- Molybdenum
  - Survey Area A – The molybdenum IL (2.26 mg/kg) was not exceeded in any surface or subsurface soil samples. Molybdenum concentrations ranged from 0.27 to 0.4 mg/kg. The maximum concentration occurred in a surface soil sample that was collected from within Disturbed Area 1 (S1011-SCX-017). Molybdenum concentrations decreased with depth in one borehole and fluctuated with depth in the other.
  - Survey Area B – The molybdenum IL (0.346 mg/kg) was exceeded in seven (out of 42) surface sample locations and in four (out of 47) subsurface samples. Molybdenum IL exceedances did not occur in either of the two subsurface soil/bedrock samples or the bedrock sample. Molybdenum concentrations ranged from 0.2 to 11 mg/kg. The maximum concentration (11 mg/kg) for the Survey Area and the Site was greater than ten times the IL and occurred in a surface soil sample located within mine site #1035 (S1011-SCX-038). The remaining exceedances ranged from less than two times the IL to under five times the IL. Molybdenum IL exceedances within Survey Area B are described below with respect to mine site #1011, mine site #1035, Disturbed Area 1, and mine site #1012/Disturbed Area 2.
    - Mine site #1011 (refer to Figures 3-6b and 4-3b) – The Survey Area B molybdenum IL (0.346 mg/kg) was exceeded in one (out of 11) surface soil samples and was not exceeded in any of the seven subsurface samples. Molybdenum was not detected in eight sample locations. Measurable molybdenum concentrations ranged from 0.22 to 0.4 mg/kg. The maximum concentration was less than two times the IL and occurred in surface soil sample S1011-SCX-011.
    - Mine site #1035 (refer to Figures 3-6b and 4-3a) – The Survey Area B molybdenum IL (0.346 mg/kg) was exceeded in two (out of 22) surface samples and in two (out of 34) subsurface soil samples. Molybdenum was not detected in nine sample locations. Measurable molybdenum concentrations ranged from 0.2 to 11 mg/kg. The maximum concentration for the area, Survey Area B and the Site occurred in a surface soil sample located approximately 50 feet southwest of the vertical mine shafts (S1011-SCX-038). The remaining three IL exceedances were less than three times the IL. Four boreholes had increasing molybdenum concentrations with depth, five had decreasing molybdenum concentrations with depth, and four had fluctuating molybdenum concentrations with depth. No distinct spatial patterns were observed with respect to exceedances or concentration changes with depth.
    - Disturbed Area 1(refer to Figures 3-6b and 4-3c) – The Survey Area B molybdenum IL (0.346 mg/kg) was not exceeded in any surface or subsurface sample locations. Molybdenum concentrations were below the detection limit for six out

of seven samples. The one detection (0.22 mg/kg) occurred in subsurface soil/bedrock sample S1011-SCX-018 (1.0-3.5 ft bgs).

- Mine site #1012 and Disturbed Area 2 (Figures 3-6b and 4-3d) – The Survey Area B molybdenum IL (0.346 mg/kg) was exceeded in four (out of five) surface soil samples and in two (out of four) subsurface samples. Molybdenum concentrations ranged from 0.21 to 0.73 mg/kg; the maximum concentration was less than three times the IL and occurred in a surface soil sample located within the debris pile north of mine site #1012 (S1011-SCX-015). The remaining IL exceedances were all less than two times the IL. Molybdenum concentrations decreased with depth in two boreholes and fluctuated with depth in one borehole.

  - Survey Area C – Molybdenum was below detection limits in all surface and subsurface soil samples.
  - Survey Area D – Molybdenum was below detection limits in all surface and subsurface soil samples.
  - Survey Area E – An IL for molybdenum was not identified because molybdenum was not detected in the background reference area (BG-5). With the exception of one subsurface sediment sample, molybdenum was below detection limits in all surface and subsurface sediment samples. The one detection (0.2 mg/kg) occurred in a subsurface sediment sample located in the eastern-most drainage, near the base of the mesa sidewall (S1011-SCX-011; 0.5 to 1.5 ft bgs).

As a broader point of reference, a regional study of the Western US documented molybdenum concentrations in soil that ranged from less than 3 to 7 mg/kg, with a mean value of 0.85 mg/kg (USGS, 1984). Molybdenum concentrations were within the typical range of regional values in samples from Survey Areas A, C, D, and E. Molybdenum concentrations exceeded the maximum regional value in one Survey Area B soil sample.

- Selenium – ILs for selenium were not identified because selenium sample results were non-detect in all the background reference areas**.**
  - Survey Area A – With the exception of one subsurface soil sample, selenium was not detected in any surface soil samples or subsurface samples. The single selenium detection (1 mg/kg) occurred in a subsurface soil sample collected from Disturbed Area 1 (S1011-SCX-017; 0.5-1.0 ft bgs).
  - Survey Area B – With the exception of one subsurface sample, selenium was not detected in any surface or subsurface soil/sediment/bedrock samples. The single detection (1.2 mg/kg) occurred in a subsurface soil/bedrock sample collected from Disturbed Area 1 (S1011-SCX-018; 1.0-3.5 ft bgs).
  - Survey Area C – Selenium was below detection limits in all surface and subsurface soil samples.

- Survey Area D – Selenium was below detection limits in all surface and subsurface soil samples.

- Survey Area E – Selenium was below detection limits in all surface and subsurface sediment samples.

As a broader point of reference, a regional study of the Western US documented selenium concentrations in soil that typically ranged from less than 0.10 to 4.3 mg/kg, with a mean value of 0.23 mg/kg (USGS, 1984). Selenium concentrations were within the typical range of regional values in all Survey Areas.

- Vanadium
  - Survey Area A – The vanadium IL (27.3 mg/kg) was exceeded in three (out of five) surface soil samples and in one (out of three) subsurface samples. Survey Area A vanadium concentrations ranged from 16 to 310 mg/kg. The maximum concentration was 11 times greater than the IL and occurred in a surface soil sample collected from Waste Pile 2, located on the mesa sidewall (S1011-CX-012). Vanadium concentrations generally decreased with depth in one borehole location and remained unchanged with depth in the other borehole location.
  - Survey Area B – The vanadium IL (11.2 mg/kg) was exceeded in 34 (out of 42) surface soil/sediment samples and in 31 (out of 47) subsurface soil/sediment samples. Survey Area B vanadium concentrations ranged from 7.2 to 740 mg/kg. The highest concentration for the Survey Area and the Site (740 mg/kg) was detected in a subsurface soil/bedrock sample located in Disturbed Area 1 (S1011-SCX-018; 1.0 to 3.5 ft bgs). Approximately 81 percent of the vanadium exceedances (47 out of 58) were less than two times the Survey Area B IL. Vanadium IL exceedances within Survey Area B are described below with respect to mine site #1011, mine site #1035, Disturbed Area 1, and mine site #1012/Disturbed Area 2.
    - Mine site #1011 (refer to Figures 3-6b and 4-3b) – The vanadium IL (11.2 mg/kg) was exceeded in six (out of 11) surface soil samples and in six (out of seven) subsurface soil samples. Vanadium concentrations ranged from 7.2 to 17 mg/kg and IL exceedances were less than two times IL. The maximum concentration (17 mg/kg) occurred in a subsurface soil sample from borehole S1011-SCX-009 (0.5 to 2.0 ft bgs). Vanadium concentrations increased with depth in four boreholes, decreased with depth in one borehole, and fluctuated with depth in one borehole.
    - Mine site #1035 (refer to Figures 3-6b and 4-3a) – The vanadium IL (11.2 mg/kg) was exceeded in 19 (out of 22) surface soil or sediment samples and 19 (out of 34) subsurface soil or sediment samples. Vanadium concentrations ranged from 7.2 to 77 mg/kg. The maximum concentration was greater than six times the IL and occurred in a subsurface soil sample located near the eastern claim boundary (S1011-SCX-021; 12-13 ft bgs). Eighty percent (32 out of the 40) of the IL exceedances were less than two times the IL. Vanadium concentrations increased with depth in three boreholes, decreased with depth in seven boreholes, remained constant with depth in one borehole, and fluctuated with

depth in six boreholes. No distinct spatial patterns were observed with respect to exceedances or concentration changes with depth.

- Disturbed Area 1 (refer to Figures 3-6b and 4-3c) – The vanadium IL (11.2 mg/kg) was exceeded in all surface and subsurface soil samples with concentrations that ranged from 49 to 380 mg/kg; the maximum concentration in soil was greater than 10 times the IL and occurred in the surface sample collected from the S1011-SCX-018 borehole. The maximum concentration in Survey Area B and the Site (740 mg/kg) occurred in subsurface soil bedrock sample from borehole S1011-SCX-018 (1.0-3.5 ft bgs). The remaining soil samples all had vanadium exceedances between four and ten times the Survey Area B IL. Vanadium concentrations increased with depth in all three boreholes.

- Mine site #1012 and Disturbed Area 2 (Figures 3-6b and 4-3d) – The vanadium IL (11.2 mg/kg) was exceeded in all surface and subsurface soil samples from all five sample locations. Concentrations ranged from 15 to 88 mg/kg; the maximum concentration was greater than eight times the IL and occurred in a surface soil sample collected from Waste Pile 3 (S1011-SCX-016). Six out of the nine surface and subsurface soil samples exceeded the vanadium IL by more than two times. Vanadium concentrations decreased with depth in two boreholes and fluctuated with depth in one borehole.

- Survey Area C – The vanadium IL (17.4 mg/kg) was exceeded in one (out of two) surface soil samples and was not exceeded in the one subsurface sample. Vanadium concentrations ranged from 12 to 43 mg/kg. The maximum concentration was less than three times the IL and occurred in a surface soil sample located on the mesa sidewall, downgradient from Disturbed Area 1 (S1011-CX-006). The vanadium concentrations increased with depth.

- Survey Area D – The vanadium IL (11.0 mg/kg) was exceeded in two (out of three) surface soil samples and was not exceeded in the two subsurface soil samples. Vanadium concentrations ranged from 8.4 to 20 mg/kg. The maximum concentration was less than two times the IL and occurred in a surface soil sample collected within the plains (S1011-SCX-043). The vanadium concentrations increased with depth in one borehole, and decreased with depth in the other.

- Survey Area E – The vanadium IL (10.7 mg/kg) was exceeded in two (out of seven) surface sediment samples and four (out of eight) subsurface sediment samples. Vanadium concentrations ranged from 4.1 to 85 mg/kg. The maximum concentration was greater than seven times the IL and occurred in a surface sediment sample located in the eastern-most drainage, near the base of the mesa sidewall (S1011-SCX-011). Vanadium concentrations generally increased with depth in four boreholes and decreased with depth in one borehole.

As a broader point of reference, a regional study of the Western US documented vanadium concentrations in soil that ranged from 7 to 500 mg/kg, with a mean value of 70 mg/kg (USGS, 1984). Vanadium concentrations in soil and sediment were within the typical range of regional values in all Survey Areas.

4.4 CONSTITUENTS OF POTENTIAL CONCERN

Based on the results presented in Sections 4.2 and 4.3, gamma radiation and concentrations of Ra-226, uranium, and vanadium in soil/sediment exceeded their respective ILs in Survey Areas A, B, C, D and E. In addition, concentrations of arsenic and molybdenum exceeded their respective ILs in Survey Area B. Therefore, gamma radiation, Ra-226, arsenic, molybdenum, uranium, and vanadium were confirmed as COPCs for the Site. Selenium was also confirmed as a COPC, because it was detected in soil samples from Survey Areas A, B, and E, but was non-detect in all background reference area samples.

4.5 AREAS THAT EXCEED THE INVESTIGATION LEVELS

The approximate lateral extent of surface gamma IL exceedances in soil/sediment is 69.7 acres, as shown in Figure 4-4a. To estimate this area, polygons were contoured around portions of the Site that had multiple, contiguous surface gamma IL exceedances and then the total area within the polygons was calculated. This area estimate is also inclusive of all surface and subsurface soil/sediment sample locations with the exception of S1011-SCX-009 in mine site #1011. Figures 4-4b through 4-4f show the five Survey Areas separately to better display those areas with multiple, contiguous surface gamma IL exceedances and the sample locations.

Figure 4-5 shows the vertical extent of IL exceedances in each borehole by incorporating information from each location, including: (1) depth to bedrock; (2) total borehole depth; and (3) depth range of IL exceedances. Table 4-5 lists the IL exceedances identified at each borehole location and Figure 4-5 shows the surface gamma IL exceedances for reference.

IL exceedances in metals and Ra-226 concentrations at surface and subsurface sample locations were typically co-located with surface gamma survey measurements and/or subsurface static gamma measurements that also exceeded their ILs, but not always. Variations occur due to natural variability and the different field methods. For example, a small piece of mineralized rock or petrified wood may have been collected in a soil sample but may not have been detected by the gamma meter in the gamma survey due to distance from the meter, the depth below ground surface, or because the gamma meter measures radiation over a larger area than the discrete soil sample location.

The lateral extent of the IL exceedances for surface gamma data shown in Figure 4-4a were compared to the lateral extent of the predicted Ra-226 concentrations that exceeded ILs in Figure 4-2c. The areas of predicted Ra-226 concentrations that exceeded the Ra-226 ILs were generally similar to the areas of gamma measurements that exceeded the surface gamma survey ILs. However, there were notable differences within Survey Areas B and C. Predicted Ra-226 concentrations in Survey Area C exceeded the IL over a larger area than the actual surface gamma survey, while the opposite was true for Survey Area B. The inconsistency between the predicted Ra-226 exceedances and the surface gamma exceedances within Survey Areas B and C may be the result of the surface gamma ILs being high (Survey Area C) or low (Survey Areas B) relative to the Ra-226 IL.

4.6 AREAS OF TENORM AND NORM

A multiple lines of evidence approach was used to evaluate the Site and distinguish areas of TENORM from areas of NORM within the Survey Area, as described in Section 3.3.3. Based on this evaluation, 72.2 acres out of the 101.3 acres of the Survey Area were estimated to contain TENORM at the Site. This estimate was inclusive of three areas: (1) portions of the mesa top; (2) the mesa sidewall; and (3) the plains, which included three of the drainages. The area containing TENORM is shown in relation to the lateral extent of IL exceedances in Figure 4-6 and in relation to the gamma measurements in Figure 4-7.

The RSE data that supports the delineation of TENORM at the Site includes:

- Historical Data Review Conclusions
    - USAEC records show ore production from “Section 26 (Hanosh) (Desidero Allotment)” occurred between 1952 and 1957 and 11,110 tons (approximately 22,220,000 pounds) of ore were produced. The ore contained 83,752 pounds of 0.38 percent U3O8 and 17,518 pounds of 0.12 percent V2O5. Given that in the USAEC records “Section 26” appeared to have included the three AUM claims from the Site as well as additional AUM claims from Sections 23 and 25, it is not known what volume of ore was produced exclusively from the Section 26 claims.
    - Historical document review indicated that the portal of an incline was present at the bottom of a 75-ft-long by 20-ft-deep box cut in the northeast portion of the Site. In addition, several open pits were present. The open pits were constructed as trenches up to 40 ft deep and 450 ft long.
    - Historical document review indicated that a PA was conducted at “The Desiderio Group Uranium Mines, also known as the Hanosh Mines Section 26”, an area that occupied approximately 130 acres and extended into adjacent Section 23 and Section 25 (NSO, 1990). The PA findings identified the following known/potential problems for the PA site:(1) the presence of 91,962 cubic yards of low grade, radioactive uranium ore and tooled mine waste piles that were exposed, uncontained, and unlined;(2) the piles “were capable of producing leachate subject to migration into the atmosphere, groundwater and surface water systems.”; (3)the presence of an unsecured155 ft inclined adit and unfenced open pits; (4) the exposed surface of the adit and surface pits were also capable of “producing leachate similar in composition to that released from the mine waste piles”; and (5)The possibility of exposure to local residents through: (a) radon gas emissions and ionizing radiation; and/or (b) direct contact of exposure through ingestion of windblown particulates contaminated with radioactive and heavy metal species.
    - Historical document review indicated that in 1991 the USEPA conducted an ERA at the Desidero Mines that included portions of the Site. The ERA activities included filling existing pits, covering an open adit, and regrading. As part of the ERA, USEPA filled in and regraded open pits and the adit using existing material on-site including ore piles, mine waste, and overburden that had been left behind at the mines

- A follow-up 1992 USEPA study compared aerial images acquired just before the ERA started to aerial images acquired during remediation to provide volumetric data regarding the ERA. The study area included areas of claims #1011 and #1035 and portions of the adjacent claims north and east of the Site. The report indicated that 24 waste piles with a total volume of 53,200 yd^3 had been removed or recapped, and 15 piles with a volume of 57,805 yd^3 still remained.

- Review of the RSE report prepared in 2014 by E&E for the AUM Section 26 mines indicated that E&E proposed excavation of approximately 9,737 yd^3 of impacted soil from areas within or adjacent to claims #1011 and #1035. E&E also recommended removing loose rocks with elevated gamma from the 2014 RSE site but did not provide a volume estimate for this material. In addition, E&E reported that areas south of mine site #1035 had elevated gamma measurements in the surface soil, but that the primary source of elevated gamma appeared to be associated with bedrock. E&E did not provide area or volume estimates for these locations.

- Geology/geomorphology
  - Bedrock at the Site consisted of three geologic formations:
    (1) the Todilto Limestone; (2) the Entrada Sandstone; and (3) the Wingate Sandstone. The Todilto Limestone was known to contain natural enrichments of uranium mineralization. Therefore, the geology and geomorphology of the Site was conducive to the presence of NORM.
  - Numerous sub-parallel ephemeral drainages are present on-site that drain either to the northeast (on the mesa top) or to the south (in the plains), where they then terminate. These drainages could transport NORM/TENORM to the northeast or south.

- Disturbance Mapping – Stantec field personnel observed the following features either during field activities or during review of the high resolution imagery:
  - Graded/disturbed reclaimed areas were mapped on claims #1011 and #1035. It is assumed that the areas were graded/disturbed as part of the 1991 ERA.
  - Two unsecured vertical mine shafts were observed in the graded/disturbed reclaimed area within mine site #1035. The two shafts, referred to as the primary shaft and secondary shaft, were approximately 28 and 8 ft in depth, respectively. It is unknown if the shafts were excluded from reclamation during the 1991 ERA, or if the reclamation-related backfilling of the shafts had collapsed.
  - A possible portal or storage area that had been backfilled and covered with wood debris was observed in mine site #1035.
  - Seven waste piles were observed throughout the Site. The waste piles all consisted of gray limestone of the Todilto Formation.
  - Potential waste rock was mapped along the eastern portion of the mesa edge.
  - Four potential mining disturbed areas were mapped at the Site. Two of the disturbed areas were mapped by Stantec field personnel and were located along the mesa rim.

The other two disturbed areas were identified using the high resolution aerial images, and are located on the mesa top, in the central portion of the Site.

- Two excavation areas were mapped along the mesa edge that were less than 10 ft deep, and were associated with Waste Pile 2 and Waste Pile 3.
- Numerous historical boreholes were observed on the mesa top. Several of the historical boreholes, located on mine site #1035, were unplugged and ranged from 6 to 8 inches in diameter, and ranged in depth from 5 ft to 34 ft.
- Several potential haul roads were mapped on the mesa top. The roads provided various access routes between each of the three Section 26 claims, as well as off-site to the north.
- Three debris piles were mapped at the Site. One debris pile was located at the base of the mesa, downgradient from mine site #1012 and a large waste pile. The second debris pile was located near the mesa edge and debris was piled in a shallow excavation. It is unknown whether the excavation is related to historical mining activities. The third was in the north central portion of the mesa top.

- Site Characterization
  - The mesa top was comprised of portions of Survey Area A and all of Survey Area B and included mine site #1011, mine site #1035, and the northern half of mine site #1012. The majority of the mapped disturbances were located on the mesa top, with the exception of portions of Waste Pile 2, Waste Pile 3, Waste Pile 7, the southern debris pile and the potential waste rock. Surface gamma IL exceedances occurred in the majority of the surveyed areas on the mesa top, including nearly 100 percent of the eastern half of the mesa top survey areas. Surface gamma measurements did not exceed the IL in the southern portion of mine site #1011, along portions of the western potential haul roads, and in the area west of Waste Pile 2 along the rim of the mesa. With the exception of three sample locations within mine site #1011 and one sample location within mine site #1035, one or more IL was exceeded in every soil/sediment sample location. Excluding molybdenum, the highest Ra-226 and metals concentrations (greater than 10 times the ILs) for the Site were measured in surface and/or subsurface soil or soil/bedrock samples that were collected within Disturbed Area 1. The highest molybdenum concentration was measured in a sample from the graded/reclaimed area within mine site #1035.
  - The mesa sidewall was comprised of Survey Area C, the southern portions of Survey Area A, and included the southern half of mine site #1012. Portions of Waste Pile 2, Waste Pile 3, Waste Pile 7, the potential waste rock, and the southern debris pile were located on the mesa sidewall. The majority of surface gamma IL exceedances on the mesa sidewall were coincident with, or downgradient from the waste piles and debris pile, or in areas downgradient from the eastern portion of Disturbed Area 1. The greatest surface gamma IL exceedances were associated with Waste Pile 2. In addition, two or more ILs were exceeded in every sample location, with the greatest exceedances detected in sample locations within Waste Pile 2 or downgradient from Waste Pile 3.
  - The plains were comprised of Survey Area D, Survey Area E, and the southern portion of Survey Area C. Surface gamma IL exceedances occurred throughout the plains. The

greatest surface gamma IL exceedances were located downgradient from Disturbed Area 1 and in the eastern portion of the plains. One or more Ra-226 or metals ILs were exceeded in every surface or subsurface soil/sediment sample location, with the greatest surface soil exceedances detected from locations in the eastern portion of the plains. Ra-226 and metals concentrations in sediments collected from the drainages decreased with distance from the mesa sidewall, but generally increased with depth at four of the five locations. The greatest Ra-226 and metals IL exceedances in the drainages were detected in the deepest sediment sample in the southern-most sample location (S1011-SCX-004). As a result of the notable IL exceedances in the deepest sample in S1011-SCX-004, the southern extent of the drainage is assumed to contain TENORM. Surface gamma survey measurements did not exceed the IL to the southern extent of the drainage. The gamma survey extended to 0.25 miles from the closest claim boundary (#1012) per the *RSE Work Plan*.

- Areas within the plains and on the mesa sidewall that had surface gamma measurements that exceeded the IL were determined to contain NORM. These areas were characterized by fewer surface gamma exceedances relative to other areas in the plains, as well as gamma measurements that exceeded the IL by less than 10 percent. These areas were generally located within the western- and southern-most portions of the plains, as well as within a centrally located strip that extended south from the rim of the mesa to the southern extent of the Site. The area along the mesa sidewall that was considered to be NORM was not downgradient from any potential mining-disturbed areas or waste piles suggesting that this area was likely not impacted.

- A portion of the mesa top that was located between the three claims had surface gamma IL exceedances, but did not show signs of mining-related disturbances. This suggests that this area was not impacted and is considered to contain NORM. However, due to the uncertainty in the historical activities that have occurred at this Site, a volume of "potential TENORM" is provided for this area in Section 4.7.

- Seven waste piles were mapped at the Site. All waste piles are estimated to contain waste rock. Elevated Ra-226 and metals concentrations were detected in samples from Waste Pile 3 (S1011-SCX-008) and Waste Pile 6 (S1011-SCX-024). It is identified as a data gap that subsurface samples were not collected from Waste Piles 1, 2, 4, 5, and 7. Elevated Ra-226 and metals concentrations and subsurface static gamma measurements collected from the following locations also indicated the potential presence of waste rock: (1) S1011-SCX-006 collected on mesa sidewall and downslope from Waste Pile 3; (2) -SCX-017, -SCX-018, and -SCX-019 located within the potential mining disturbed area on the southwest portion of the mesa top; and (3) the variable elevated analytical results and subsurface static gamma measurements in -SCX-028 and -SCX-031 in the western portion of the eastern graded/disturbed reclaimed area may be indicative of waste rock mixed with reclamation material.

- Metals concentrations in samples collected outside the area of TENORM (S1011-CX-015 and -SCX-042) were less than or within the regional concentration values.

- It is important to consider that with the exception of one location, the subsurface static gamma ILs were not the only evidence used to delineate the vertical extent of TENORM that exceeded the IL in borehole locations at the Site. In borehole S1011-SCX-031, Ra-226 and metals concentrations did not exceed their respective ILs. However, a subsurface static gamma measurement of 112,936 was recorded at 7.0 ft bgs and was coincident with the presence of debris/refuse material (e.g., cans, paper, and bottle caps). TENORM was estimated to exceed the ILs to approximately 10 ft bgs in the area of S1011-SCX-031.

The area of the Site considered to contain TENORM (i.e., multiple lines of evidence indicated or suggested the presence of mining-related impacts) was 72.2 acres, as shown on Figure 4-8a. Portions of the TENORM area contained one or more IL exceedance. Of the 72.2 acres that contain TENORM, 45.2 acres contain TENORM that exceeded the surface gamma ILs and TENORM that exceeded the ILs at all but one of the soil/sediment sample locations. One location, S1011-SCX-009 in mine site #1011 was not included in the area of surface gamma IL exceedances. TENORM that exceeded the ILs in Survey Areas A through E is shown on Figures 4-8b through 4-8f, respectively, and is compared to mining-related features in Figure 4-8g.

4.7 TENORM VOLUME ESTIMATE

The volume of TENORM that exceeds one or more IL is approximately 170,191 yd^3, as shown in Figure 4-9a. The volume and area of TENORM associated with specific mine features is listed in Table 3-3. This estimate was calculated using ESRI ArcGIS Desktop 10.3.1 Spatial Analyst Extension cut/fill tool (ESRI, 2017). The volume analysis also utilized the ground surface elevation contours developed from the orthophotographs coupled with hand-derived contours based on field personnel observations, other field personnel observations and mapping, depth to bedrock in boreholes, gamma measurements, sample analytical data, and historical mining documentation. Field observations included observations of disturbance, changes in vegetation, estimating/projecting the slope of underlying bedrock, and estimating the shape and topography of waste piles and/or soil deposits.

In some portions of the Site, Stantec was unable to determine whether TENORM was present. Given this uncertainty, a second volume was calculated for areas of potential TENORM exceeding the ILs. This volume included: (1) Group 14 – an area in the central portion of the mesa top that were not sampled because mining-related ground disturbance was not observed; (2) Group 15 – areas on the mesa sidewall that could not be surveyed due to steep or unsafe terrain (portions of Survey Areas A and C); and (3) Group 16 – areas within the Wingate Sandstone portion of Survey Area C that exceeded the BG-6 (Wingate) surface gamma IL, but did not exceed the Survey Area C surface gamma IL. The volume of potential TENORM that exceeds the ILs is 14,055 yd^3.

TENORM and potential TENORM exceeding the ILs at the Site was split into groups based on the depth or type of material to aid in analysis and describing the basis of the volumes. The locations, volume, and areas of these groups are shown in Figure 4-9a. The assumptions that were used to calculate the volume of TENORM with IL exceedances were as follows

General Assumptions

- It was assumed that subsurface bedrock encountered in boreholes was not previously modified by human activity and is therefore NORM.
- For areas of TENORM at the Site containing large cobble- or boulder-sized rocks at the surface whose heights exceeded the assumed depth of TENORM in that area (e.g., a 3-ft-tall boulder in an area where TENORM was assumed to extend 1 ft bgs), the additional volume of the cobble- or boulder-sized rocks was assumed to be accounted for by the TENORM depth estimates.
- Portions of the areas delineated as exposed bedrock within the TENORM area on Figure 4-9a contain small amounts of colluvium.
- With the exception of S1011-SCX-031 (refer to last bullet in Section 4.6), the subsurface static gamma IL values were not used as the only evidence to delineate the vertical extent of TENORM that exceeded the ILs in borehole locations at the Site.

Group Assumptions

- Group 1 (69,028 yd^3) – Group 1 consists of the reclamation area in the northeast portion of mine site #1035 (refer to Figures 4-9a). The vertical extent of TENORM exceeding ILs was variable throughout Group 1; Figure 4-9b provides a contour map of the estimated vertical extent in Group 1. Vertical extent was estimated based on: (1) subsurface data from 18 boreholes; (2) elevation profiles developed using topographic contours from the orthophotographs (Cooper, 2017); and (3) historical documents, photographs, and aerial images that described or depicted the lateral and vertical extent of disturbances. In addition, results from the geophysical survey (refer to Section 4.8) were generally used to support these assumptions. The topographic contours and depth to bedrock information were used to generate cross-sections (refer to Figures 2-8a and 2-8b) that provided scaled representations of the subsurface that aided in the volume calculations performed in GIS. The depth to bedrock was directly observed in the central portions of Group 1 during the drilling investigation, and some areas had TENORM exceeding ILs to depths up to 15 feet. However subsurface data were not obtained in areas along the boundaries of Group 1, and therefore depth to bedrock was assumed based on field observations (including depth to bedrock in nearby boreholes) and mapping (including estimating the slope of the underlying bedrock surface, and the topographic shape of waste piles or soil deposits), as well as historical information about pit depths and locations. The vertical extent of TENORM exceeding ILs around boundaries of Group 1 was estimated to be 5.0 thick.
- Group 2 (6,831 yd^3) – Group 2 consists of a portion of the reclamation area in the western portion of mine site #1011. The Group 2 polygon was best fit around visible areas of surface disturbance observed in the 1956 historical aerial photograph (refer to Figure 3-1b), as well as current aerial images. The vertical extent of TENORM exceeding ILs was estimated to be 4.0 ft deep over the polygon area based on subsurface data from seven boreholes in mine site #1011 (S1011-SCX-009, -SCX-010, -SCX-011, -SCX-012, -SCX-039, -SCX-040, and -SCX-044). This assumption was generally supported by the results from the geophysical investigations within mine site #1011 (refer to Section 4.8). Of note, field personnel using hand augers met refusal on hard rock at less than 1.0 ft below ground surface for three of the boreholes

(S1011-SCX-039, -SCX-040, and -SCX-044), but boreholes advanced with the drill rig encountered bedrock between 2.5 and 5.0 ft bgs in the area.

- Group 3 (3,942 yd^3) – Group 3 consists of portions of the mesa top within and near mine site #1011 that appeared to have been disturbed based on current and historical (1991) aerial photos (refer to Figure 3-1c), limited subsurface investigations, and field observations including changes in vegetation spacing and density due to re-seeding and variation in soil type. TENORM exceeding ILs in this area was assumed to extend to 1.0 ft bgs. At borehole S1011-SCX-014, elevated Ra-226 and metals concentrations and static gamma measurements were present in the surface soil sample, but concentrations and static gamma measurements decreased in the subsurface.

- Group 4 (245 yd^3) – Based on field observations that the potential haul roads followed existing topography (i.e., fill material was not used to create the road), TENORM exceeding ILs in the areas of the potential haul roads was assumed to extend to 0.5 ft bgs. If a potential haul road was within another group, the volume of the road was not counted twice.

- Group 5 (23,301 yd^3) – Group 5 consists of portions of the mesa top that did not appear to have undergone major disturbance or mining activities based on limited subsurface investigations and field observations that vegetation and the ground surface appeared to be generally undisturbed. TENORM exceeding ILs in this area was assumed to extend to 1.0 ft bgs.

- Group 6 (7,213 yd^3) – Group 6 consists of the eastern portions of the mesa edge that appear to have been disturbed by mining activities, and more recently used as a corral. The volume of TENORM exceeding ILs in Group 6 was based on field observations (including disturbance of outcrops at the mesa edge and lack of vegetation) and subsurface data from four boreholes (S1011-SCX-017 through -SCX-020) and was assumed to be 3.5 ft thick over the area of the polygon.

- Group 7 (4,390 yd^3) – Group 7 consists of the portions of Waste Pile 2, Waste Pile 3, and Waste Pile 7 that extend down the sidewall, all of which are located on the edge of the mesa and extend down the mesa sidewall. TENORM that exceeded ILs was assumed to be 3.0 ft thick over the polygon areas based on field observations of the general thicknesses of the piles and limited subsurface soil sampling (S1011-SCX-008 and -SCX-016) and gamma radiation surveys. Portions of Group 7 could not be accessed safely on foot, and drill rig access was not possible.

- Group 8 (3,003 yd^3) – Group 8 includes the excavation area within mine site #1012, as well as areas to the north that also appeared to have been disturbed, based on review of recent and historical (1956) aerial photographs. The volume of TENORM that exceeded ILs in Group 8 was primarily based on field observations of ground disturbance and to a lesser extent, subsurface data from four boreholes (S1011-SCX-007, -SCX-008, -SCX-015, and -SCX-016 extending between 1.5 and 3.0 ft bgs to bedrock). TENORM exceeding the ILs was assumed to be 4.0 ft deep over the area of the polygon.

- Group 9 (4,602 yd^3) – Group 9 includes the excavation area located west of mine site #1012, as well as the western portions of Disturbed Area 2. Bedrock outcrops at the surface across much of the Group 9 area and the disturbance appeared to be mostly surficial (e.g., the ground appears scraped on the mesa point west of #1012, but stockpiles and pits are not present). The volume of TENORM exceeding ILs in Group 9 was based on field observations and was assumed to be 1.0 ft thick over the area of the polygon.

- Group 10 (4,148 yd^3) – Group 10 includes areas on the mesa sidewall that are downgradient of potential mining-disturbed areas located along the edge of the mesa that were: (1) within the Entrada Sandstone in Survey Area C; and (2) gamma surveyed and measurements exceeded the IL. The volume of TENORM that exceeded ILs in Group 10 was calculated using a depth assumption of 1.0 ft over the area of the polygons. The depth assumption was based on subsurface data from the S1011-SCX-006 borehole (refusal at 1.25 ft bgs) and field observations of the general depth of soil/sediments present on the mesa sidewall.

- Group 11 (39,218 yd^3) – Group 11 includes the plains at the base of the mesa. The volume of TENORM that exceeded ILs in Group 11 was calculated based on field observations of potential transport paths from waste piles and disturbed areas on the mesa edge and mesa sidewall and subsurface data from three boreholes (S1011-SCX-041 through -SCX-043). TENORM was assumed to extend to 2.0 ft bgs over the area of the polygons.

- Group 12 (3,796 yd^3) – Group 12 includes three drainages that originate near the base of the mesa, and extend southward into the plains. The drainages are downgradient from Disturbed Area 1, the excavation areas, and Waste Piles 2, 3 and 7, which are located along the edge of the mesa. The volume estimate was calculated by assuming the vertical extent of TENORM exceeding ILs was 2.0 ft over the total area of Group 12 polygons. This depth assumption was based on field observations of alluvium present in the drainages and subsurface data from five boreholes (S1011-SCX-001 through -SCX-005).

- Group 13 (474 yd^3) – Group 13 includes Disturbed Area 3 and is assumed to be the area of the small prospect pit described in Section 2.1.4.1. The area was identified based on the visible change in density and type of vegetation on the high resolution aerial photograph. TENORM in the area of the polygon was assumed to extend to 1.0 ft bgs based on the description of 4-ft tall waste piles being present at either end of the prospect pit. The volume estimate for Group 13 is likely conservative considering the disturbed area is approximately 230 ft by 50 ft.

- Groups 14 (8,900 yd^3) – Group 14 includes the central portions of the mesa top that may contain TENORM, but there were not clear lines of evidence to support that the area was disturbed during mining. The area was gamma surveyed and includes both areas where gamma survey measurements exceed the ILs (eastern polygon) and areas that did not exceed the ILs (western polygon). The area was not sampled. The volume of Group 14 is being provided for informational purposes should this area be considered TENORM in future Removal or Remedial Action evaluations at the Site. However, it is important to consider that historical documentation describes a portion of this area as "undisturbed ground" (refer to Section 2.1.4.1). A general assumption was made that potential TENORM may extend to 1.0 ft bgs over the area of the polygon based on subsurface conditions observed in nearby boreholes.

- Group 15 (3,360 yd^3) – Group 15 includes portions of the mesa sidewall located downgradient from potential mining-disturbed areas that could not be surveyed or sampled due to steep or unsafe terrain. Given that no subsurface information is available to estimate the vertical extent of potential TENORM exceeding ILs, the Group 10 (areas of the mesa sidewall that exceeded the ILs) assumption of 1.0 ft may provide the best estimate for Group

15. In addition, approximately 75 percent of Group 15 contains areas mapped as bedrock. Therefore, the volume estimate was calculated by assuming 25 percent of the Group 15 polygon area contains potential TENORM that exceeded the ILs to a depth of 1.0 ft.

- Group 16 (1,795 yd^3) – Group 16 includes the portions of the Wingate Sandstone that exceeded the surface gamma IL for BG-6, but did not exceed the BG-3 IL used for Survey Area C. The Wingate Sandstone occurs near the base of the mesa sidewall at the transition from the sidewall to the plains. The volume estimate was calculated by assuming a vertical extent of potential TENORM that exceeds the ILs of 1.5 ft bgs over the total area of the Group 16 polygons. The vertical extent was assumed based on subsurface data from nearby boreholes.

4.7.1 Comparison of TENORM Volume Estimate and Ecology and Environmental Inc. (E&E) 2014 Removal Assessment

Below is a comparison of the differences between the findings of the 2014 E&E RSE (E&E, 2014) performed on behalf of USEPA, and the Trust RSE, and how those findings resulted in different TENORM volume estimates. The 2014 E&E RSE was generally limited to Survey Areas A and B of the Trust RSE.

Based on the 2014 RSE results, E&E proposed excavation of soil totaling approximately 9,737 yd^3 from the mesa top, as summarized in Section 2.1.4.5. The E&E Ra-226 ILs (2.29 pCi/g) was generally similar to the ILs defined for the Trust RSE (2.13 and 2.96 pCi/g for Survey Areas A and B, respectively). While the daily average background gamma values identified by E&E (20,425 to 22,005 cpm) were similar to the BG-2 IL (23,320 cpm) and greater than the BG-1 IL (16,829 cpm), E&E's gamma radiation IL was twice the daily average background level (40,000 cpm). The gamma survey results observed by E&E were generally similar to gamma results observed by the Trust (e.g., elevated gamma measurements were observed in the same areas).

The 2014 RSE volume estimate determined by E&E differs from the volume estimate provided in this RSE report for the following reasons:

- The E&E gamma IL was nearly two times the Trust RSE gamma IL in Survey Area B.
- E&E evaluated Ra-226 as their primary laboratory COPC, the Trust RSE evaluated Ra-226, uranium, arsenic, molybdenum, selenium, and vanadium.
- The E&E subsurface investigation was limited to 4.0 ft bgs, the Trust RSE investigation extended up to 37.0 ft bgs.
- E&E did not recommend any material in the following areas on the mesa top and near the mesa edge be addressed (refer to Figure 2-8): Disturbed Areas 1 through 4, mine site #1012, Waste Piles 1, 2, 3, and 7.
- E&E did not evaluate the mesa sidewall or plains areas of the Site.
- E&E did not observe any signs of reclamation on the Site, they did not review historical documentation of mining or reclamation activities that took place at the Site (refer to

Section 2.1.4 of this RSE report), and their report did not include review of historical photographs of the Site.

The depth of material that E&E recommended for removal is compared to the Trust TENORM depth estimates below (refer to Figure 4-9a for the Trust TENORM depth estimates):

- In the general area of mine site #1011, E&E recommended material be removed in limited areas up to 1.0 and 2.0 ft bgs (AUM26-RA-01 through RA-04 on Figure 4 of the E&E report). The E&E recommended removal areas are encompassed by Groups 2 and 3 of TENORM, where TENORM is assumed to extend to 1.0 and 4.0 ft bgs, respectively.

In the general area of mine site #1035, E&E recommended material be removed in limited areas up to 4.0 ft bgs in AUM26-RA-05 and up to 1.0 ft bgs in AUM26-RA-06 on Figure 4 of the E&E report. The E&E recommended removal areas are encompassed by the Trust RSE Groups 1 and 5 of TENORM. The depth of TENORM in Group 1 varies (refer to Figure 4-9b), but it extends up to 15.0 ft bgs in some areas. TENORM is assumed to extend to 1.0 ft bgs in Group 5.

4.8 GEOPHYSICAL SURVEY RESULTS

The results of the geophysical survey are provided in Appendix A.2. A summary of the interpretation of the geophysical survey results is presented below.

- Results of the electrical resistivity survey displayed a similar structure for each of the 13 survey lines, with a near-surface conductive layer associated with soil material, overlying a deeper resistive layer interpreted as bedrock.
- In general, it was not possible to differentiate between fill soil and native material in the geophysical profiles. Soil deposits in areas known to be disturbed based on historic aerial photographs, typically had a greater thickness of soil, suggesting these areas contain fill material.
- Results of the two geophysical surveys did not identify significant features that would indicate the presence of air-filled voids or tunnels at the Site.
- Highly conductive features were observed in the electrical resistivity geophysical profiles within mine site #1035 that suggest the possibility of backfilled or collapsed mine workings. While the conductive nature of these features excludes air-filled voids, they could be associated with backfilled or collapsed mine workings associated with the open shaft. However, it is more likely that the open shaft is acting as a conduit for surface water infiltration, leading to increased moisture content in the soils surrounding the area. The increased moisture content would decrease the resistivity value of the infiltrated soils, compared to the surrounding materials
- The depth to bedrock interpreted from the geophysical surveys generally correlates with the depth to bedrock observed during drilling activities (refer to Section 3.3.2.2). In survey lines 1 through 3, competent bedrock is generally observed as flat and shallow, ranging from within 1 ft of the surface to 20 ft bgs, though depth to weathered bedrock is likely shallower than 10 ft bgs based on drilling data. The interpreted depth to competent bedrock in mine site

#1035 ranges from less than 1 ft to approximately 40 ft bgs. The geophysical data in mine site #1035 showed unconsolidated material thickness generally increased from south to north.

- In the northern and eastern portions of mine site #1035 the increasing unconsolidated material thickness, hummocky surface topography, and increased heterogeneity in the electrical resistivity and MASW profiles are consistent with areas of known disturbance and fill.
- The MASW profiles for the eastern portion of the Site did not extend the entire length of the electrical resistivity line, in some cases, because the undulating topography in this area of the Site hindered the generation and transmission of the seismic waves and resulted in unreliable model results.

An important consideration is that the interpretations of geophysical survey data are based on a number of assumptions and minor physical variations in subsurface properties. Therefore, interpretation results should be considered "suggestive" of subsurface conditions. Interpretation of geophysical survey data requires the consideration of multiple lines of evidence, including a comparison to subsurface data collected during drilling activities. An assessment of the geophysical data on its own, without additional supporting investigation techniques, can lead to false or misleading conclusions. In instances where the results of geophysical surveys contradict with direct observations collected during drilling and sampling, the drilling data should be considered more reliable.

Results of the geophysical survey were used to inform the TENORM volume estimate, specifically supporting the depth to bedrock and thicknesses of potential mine-impacted fill. These results are presented in Sections 4.6 through 4.8.

4.9 POTENTIAL DATA GAPS AND SUPPLEMENTAL STUDIES

4.9.1 Data Gaps

Seven potential data gaps were identified based on the Site Clearance and RSE data collection and analyses for the Site, as described in Sections 3.3, 4.1, 4.2, and 4.6. These data gaps can be considered for subsequent evaluations in support of future Removal or Remedial Action evaluations at the Site.

1. 10.1 acres of the Survey Area were not surveyed, because field personnel were unable to safely access these areas due to steep/unsafe terrain (refer to Figure 3-4).
2. The area located in-between the northern-most boundary of mine sites #1011 and #1035 and the northern most fence line were not surveyed because the landowner north of these mine sites did not allow access.
3. The survey was not extended laterally from the potential haul roads where the gamma measurements were greater than the IL due to a miscommunication with field personnel.
4. The shoulders of some potential haul roads in the north-central portion of the Site were not surveyed due to a miscommunication with field personnel.

5. The gamma survey was not extended to the west of Survey Area B (the central portion of the mesa top) until gamma measurements reached background levels. This area was not surveyed based on the professional judgement in the field that this area contained only NORM. However, review of high-resolution aerial images and historical documents following the survey suggested that some portions of this area (specifically Disturbed Area 4) may have been disturbed by mining-related activities. It is recommended that this data gap be addressed during future work.

6. The collection of soil samples within BG-6 is warranted to better evaluate potential mining-related impacts in the Wingate Sandstone at the base of the mesa sidewall.

7. Subsurface samples were not collected in Waste Piles 1, 2, 4, 5, and 7.

4.9.2 Supplemental Studies

Following review of the RSE report data and discussions with the Agencies, a limited number of items were identified for supplemental work to be considered for subsequent evaluations in support of future Removal or Remedial Action evaluations at the Site, as follows:

1. On June 28, 2018, the USEPA provided a historical "Desidero waste piles map" that showed the locations and estimated area and volumes of uranium piles, soil overburden, and debris piles across the Site. The USEPA confirmed this map was part of a previously received report presenting a supplemental aerial photographic analysis of the Desidero mines (USEPA, 1992b), but the map was not included in the previous copy of the report. Due to the late receipt of this document, it could not be evaluated for this RSE report. A copy of the map is included in the attachment. Additional analysis of this map is warranted as part of future investigations at the Site.

2. Contents of the center debris pile included cans, bottles, car parts/car frames, metal scraps, wood scraps pallets, wire, general construction debris, and miscellaneous trash. Additional evaluation of the debris may be warranted in the future (refer to the *Multi-Agency Radiation Survey and Site Investigation Manual* [USEPA, 2009]).

3. The USEPA identified that there were potential discrepancies between the NNDWR database used for this study (received from NNDWR in 2016) and a 2018 version of the NNDWR database that the USEPA reviewed. The USEPA provided comment that the 2018 NNDWR database indicates well 16-2-6 is within one mile of mine site #1011 and that it may need to be addressed (the 2016 NNDWR database shows it outside the one-mile buffer). It is recommended that the two databases be compared (with additional field work, if necessary) to confirm the locations of water features.

4. Separate background reference areas were identified for the Quaternary deposits (BG-4) in the plains area and the Quaternary alluvium in the drainages (BG-5) within the plains area. The Agencies have suggested that additional study may be required to develop a background reference area for the plains area (NNEPA, 2018).

5. The gamma survey in BG-3 was limited due to steep terrain that could not be safely accessed, the sample size was low (80 measurements) and there was a notable difference between the UTL (48,542 cpm) and UCL (30,927 cpm) values (refer to Appendix D.1

Table D.1-2). Further evaluation of background for the Entrada Sandstone may be required in the future.

6. Boulders located along or at the base of the mesa sidewall were included in the area of the surface gamma survey but were not otherwise evaluated. Additional characterization of the boulders may be required prior in the future.

7. Subsurface samples were not collected in Disturbed Areas 3 and 4. Further evaluation of the Disturbed Areas may be required in the future.

8. Comparison of Ra-226 and Th-230 concentrations indicated that Ra-226 and Th-230 are in equilibrium, but not in secular equilibrium. This may be an important consideration in the future and further evaluation may be required if a human health and/or ecological risk assessment is performed.

9. Additional correlation studies may be needed to identify the relationship between gamma and Ra-226.

5.0 SUMMARY AND CONCLUSIONS

This report details the purpose and objectives, field investigation activities, findings, and conclusions of the Site Clearance and RSE activities conducted for the Site between August 2015 and September 2017. The Site is known as the Section 26 Desidero Group site and is also identified by the USEPA as an AUM claim that consists of three mine sites with identifications of #1011, #1012, and #1035 in the *2007 AUM Atlas*.

The primary objectives of the RSE are to provide data (e.g., review relevant information and collect data related to historical mining activities) required to evaluate relevant Site conditions and to support future Removal or Remedial Action evaluations at the Site. It is not intended to establish cleanup levels or determine cleanup options or potential remedies. The purpose of the RSE data are to determine the volume of TENORM at the Site in excess of ILs as a result of historical mining activities. ILs are based on the background gamma measurements (in cpm), and Ra-226 and metals concentrations, determined through statistical analyses, that are used to evaluate potential mining-related impacts. To meet these objectives, the RSE included historical data review, visual observations, surface gamma surveys, surface and subsurface static gamma measurements, and soil/sediment sampling and analyses. An estimate of areas containing TENORM was made based on an evaluation of the RSE information/data and multiple lines of evidence. The correlation between gamma measurements (in cpm) and concentrations of Ra-226 in surface soils (pCi/g) was developed as a potential field screening tool for future Removal or Remedial Action evaluations. The gamma correlation was not used for the Site Characterization, which relied instead on the actual gamma radiation measurements and soil/sediment analytical results. However, predicted Ra-226 concentrations were compared to the actual Ra-226 laboratory results and ILs from the surface soil/sediment samples at the Agencies' request.

The Site was located in the Grants Uranium Mining District, Ambrosia Lake Sub-district, and was in operation from 1952 to 1957. Historical mine workings on-site consisted of a 155-ft incline and several open pits. The USAEC reported total ore production from the "Section 26 (Hanosh) (Desidero Allotment)" between 1952 and 1957 was 11,110 tons (approximately 22,220,000 pounds) of ore that contained 83,752 pounds of 0.38 percent U_3O_8 and 17,518 pounds of 0.12 percent V_2O_5.

Between August 11, 1991 and September 19, 1991, the USEPA Region 9 Emergency Response Section conducted an Emergency Response Action (ERA at the three AUMs #1011, #1012, and #1035). Remediation activities included the following:

- Filled existing pits and covered open adits
- Regraded reclaimed areas until they were consistent with the surrounding terrain
- Graded areas were made to have proper water runoff

Eight potential background reference areas (BG-1 through BG-8) were considered. Five background reference areas (BG-1 through BG-5) were selected to develop surface gamma, subsurface gamma, Ra-226, and metals ILs for the five Survey Areas (Survey Areas A through E) at the Site.

Arsenic, molybdenum, selenium, uranium, vanadium, and Ra-226 concentrations and gamma radiation measurements exceeded their respective ILs and are confirmed as COPCs for the Site.

Surface gamma measurements and Ra-226 and metals concentrations were generally highest in areas on the mesa sidewall immediately downgradient of Waste Pile 3, and on the mesa top within Disturbed Area 1. The maximum gamma survey measurement was 749,127 cpm, which was more than 15 times the maximum IL and occurred just downgradient from Waste Pile 3. The highest Ra-226 and metals concentrations, and subsurface static gamma measurements were detected in surface/subsurface soil samples collected from Disturbed Area 1.

Results of the Gamma Correlation Study indicated that surface gamma survey results correlate with Ra-226 concentrations in soil. Therefore, gamma surveys could be used during site assessments as a field screening tool to estimate Ra-226 concentrations in soil. Additional correlation studies may be needed to identify the relationship between gamma and Ra-226.

Based on the data analysis performed for this RSE report along with the multiple lines of evidence, approximately 72.2 acres out of the 101.3 acres of the Survey Area were estimated to contain TENORM. This estimate is inclusive of areas on the mesa top, the mesa sidewall, and in the plains. The areas outside of the TENORM boundary showed no signs of disturbance related to mining and, therefore, are considered NORM (i.e., naturally occurring). Of the 72.2 acres that contain TENORM, 45.2 acres contain TENORM exceeding the surface gamma ILs and TENORM that exceeded the ILs at all but one of the soil/sediment sample locations. The volume of TENORM in excess of ILs was estimated to be 170,191 yd^3 (130,120 cubic meters) plus the volume of potential TENORM exceeding ILs was estimated to be 14,055 yds^3. It should be noted that the COPC measurements and concentrations in the area that contains TENORM that exceeded the ILs are generally higher than the COPC measurements and concentrations in the area of NORM located outside the TENORM boundary.

Seven potential data gaps were identified based on the Site Clearance and RSE data collection and analyses for the Site, as listed in Section 4.9. These data gaps can be taken into consideration for subsequent evaluations in support of future Removal or Remedial Action evaluations at the Site.

6.0 ESTIMATE OF REMOVAL SITE EVALUATION COSTS

The Section 26 RSE was performed in accordance with the requirements of the *Trust Agreement* to characterize existing site conditions. Project costs related to the RSE include the planning and implementation of the scope of work stipulated in the *Site Clearance Work Plan* and *RSE Work Plan* and community outreach. Stantec's costs associated with the Section 26 RSE were $975,100. Stantec's costs associated with interim actions (backfilled two shafts and nine boreholes and installed signage) were $63,000. In addition, Administrative costs provided by the Trust were estimated currently at $191,500[8,9]. Administrative costs will change due to continued community outreach and close out activities.

[8] This cost is based on an approved budget of May 8, 2018; Administrative work, including community communications, are not yet complete.
[9] Administrative costs were averaged across all Sites.

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TABLES

Table 3-1
Identified Water Features
Section 26
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Navajo Nation AUM Environmental Response Trust - First Phase

Identified Water Feature	Source of Identified Water Feature	Water Feature Identification	USEPA Region 6 Provided Information[3]	Field Personnel Observations
Unknown	2007 AUM Atlas[1]	B01486[2]	USEPA Region 6 never sampled this well.	Field personnel were unable to assess this location because it was located on private land and access was behind a locked gate.
Unknown	2007 AUM Atlas[1]	B01486[2]	This well was drilled in December 2005 to a total depth of 460 feet.	Field personnel were unable to assess this location because it was located on private land and access was behind a locked gate.
Unknown	2007 AUM Atlas[1]	G01106	This location was a well permit application in 2000 that was then changed to B01486. The well was never drilled.	Field personnel were unable to assess this location because it was located on private land and access was behind a locked gate.
Unknown	2007 AUM Atlas[1]	B01480	Refer to water feature identification G01106.	Field personnel were unable to assess this location because it was located on private land and access was behind a locked gate.

Notes
USEPA - United States Environmental Protection Agency
[1] USEPA, 2007a
[2] This location is identified twice because it is associated with two different coordinates in USEPA, 2007a
[3] The USEPA provided this information to the Trust in an email dated September 12, 2017.

Table 3-2
Soil and Sediment Sampling Summary
Section 26
Removal Site Evaluation Report - Final
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Sample Location	Sample Depth (ft bgs)	Sample Media	Sample Category	Sample Collection Method	Survey Area	Sample Date	Easting [1]	Northing [1]	Sample Types: Metals, Total	Sample Types: Ra-226	Sample Types: Thorium
Background Reference Area Study - Background Area 1											
S1011-BG1-001	0 - 0.2	soil	SF	grab	NA	11/30/2016	784869.18	3914507.72	N	N	--
S1011-BG1-002	0 - 0.2	soil	SF	grab	NA	11/30/2016	784866.41	3914508.28	N	N	--
S1011-BG1-003	0 - 0.2	soil	SF	grab	NA	11/30/2016	784869.84	3914510.56	N	N	--
S1011-BG1-004	0 - 0.2	soil	SF	grab	NA	11/30/2016	784865.25	3914509.45	N	N	--
S1011-BG1-005	0 - 0.2	soil	SF	grab	NA	11/30/2016	784866.37	3914511.98	N;MS;MSD	N	--
S1011-BG1-006	0 - 0.2	soil	SF	grab	NA	11/30/2016	784868.91	3914512.18	N;FD	N;FD	--
S1011-BG1-007	0 - 0.2	soil	SF	grab	NA	11/30/2016	784862.31	3914509.37	N	N	--
S1011-BG1-008	0 - 0.2	soil	SF	grab	NA	11/30/2016	784860.86	3914511.96	N	N	--
S1011-BG1-009	0 - 0.2	soil	SF	grab	NA	11/30/2016	784862.03	3914514.07	N	N	--
S1011-BG1-010	0 - 0.2	soil	SF	grab	NA	11/30/2016	784864.52	3914514.51	N	N	--
S1011-BG1-011	0 - 0.2	soil	SF	grab	NA	3/25/2017	784866.57	3914510.88	N	N	--
S1011-BG1-011	0.5 - 0.7	soil	SB	grab	NA	3/25/2017	784866.57	3914510.88	N	N	--
Background Reference Area Study - Background Area 2											
S1011-BG2-001	0 - 0.2	soil	SF	grab	NA	11/30/2016	784865.63	3914687.31	N	N	--
S1011-BG2-002	0 - 0.2	soil	SF	grab	NA	11/30/2016	784864.84	3914691.41	N	N	--
S1011-BG2-003	0 - 0.2	soil	SF	grab	NA	11/30/2016	784863.17	3914693.72	N	N	--
S1011-BG2-004	0 - 0.2	soil	SF	grab	NA	11/30/2016	784860.43	3914691.53	N	N	--
S1011-BG2-005	0 - 0.2	soil	SF	grab	NA	11/30/2016	784859.56	3914688.46	N	N	--
S1011-BG2-006	0 - 0.2	soil	SF	grab	NA	11/30/2016	784862.40	3914686.99	N;FD	N;FD	--
S1011-BG2-007	0 - 0.2	soil	SF	grab	NA	11/30/2016	784857.33	3914687.17	N	N	--
S1011-BG2-008	0 - 0.2	soil	SF	grab	NA	11/30/2016	784854.66	3914688.03	N	N	--
S1011-BG2-009	0 - 0.2	soil	SF	grab	NA	11/30/2016	784854.81	3914691.78	N;MS;MSD	N	--
S1011-BG2-010	0 - 0.2	soil	SF	grab	NA	11/30/2016	784857.00	3914692.43	N	N	--
S1011-BG2-011	0 - 0.2	soil	SF	grab	NA	3/25/2017	784860.27	3914688.14	N	N	--
S1011-BG2-011	1.5 - 2.0	soil	SB	grab	NA	3/25/2017	784860.27	3914688.14	N	N	--
Background Reference Area Study - Background Area 3											
S1011-BG3-001	0 - 0.2	soil	SF	grab	NA	9/18/2017	784837.16	3914519.59	N	N	--
S1011-BG3-002	0 - 0.2	soil	SF	grab	NA	9/18/2017	784833.63	3914519.89	N;MS;MSD	N	--
S1011-BG3-003	0 - 0.2	soil	SF	grab	NA	9/18/2017	784836.97	3914517.15	N	N	--
S1011-BG3-004	0 - 0.2	soil	SF	grab	NA	9/18/2017	784836.97	3914514.72	N;FD	N;FD	--
S1011-BG3-005	0 - 0.2	soil	SF	grab	NA	9/18/2017	784838.15	3914513.01	N	N	--
S1011-BG3-006	0 - 0.2	soil	SF	grab	NA	9/18/2017	784834.69	3914516.25	N	N	--
S1011-BG3-007	0 - 0.2	soil	SF	grab	NA	9/18/2017	784836.55	3914513.30	N	N	--
S1011-BG3-008	0 - 0.2	soil	SF	grab	NA	9/18/2017	784838.01	3914511.30	N	N	--
S1011-BG3-009	0 - 0.2	soil	SF	grab	NA	9/18/2017	784839.32	3914511.42	N;FD	N;FD	--
S1011-BG3-010	0 - 0.2	soil	SF	grab	NA	9/18/2017	784840.38	3914509.61	N	N	--
S1011-BG3-011	0 - 0.2	soil	SF	grab	NA	9/19/2017	784840.05	3914512.82	N	N	--
Background Reference Area Study - Background Area 4											
S1011-BG4-001	0 - 0.2	soil	SF	grab	NA	9/19/2017	784829.11	3914106.05	N;MS;MSD	N	--
S1011-BG4-002	0 - 0.2	soil	SF	grab	NA	9/19/2017	784829.93	3914100.67	N	N	--
S1011-BG4-003	0 - 0.2	soil	SF	grab	NA	9/19/2017	784825.51	3914096.70	N;FD	N;FD	--
S1011-BG4-004	0 - 0.2	soil	SF	grab	NA	9/19/2017	784821.98	3914099.51	N	N	--
S1011-BG4-005	0 - 0.2	soil	SF	grab	NA	9/19/2017	784817.93	3914097.49	N	N	--
S1011-BG4-006	0 - 0.2	soil	SF	grab	NA	9/19/2017	784814.05	3914098.56	N	N	--
S1011-BG4-007	0 - 0.2	soil	SF	grab	NA	9/19/2017	784812.91	3914103.63	N	N	--
S1011-BG4-008	0 - 0.2	soil	SF	grab	NA	9/19/2017	784817.19	3914106.13	N	N	--
S1011-BG4-009	0 - 0.2	soil	SF	grab	NA	9/19/2017	784820.91	3914104.44	N;FD	N;FD	--
S1011-BG4-010	0 - 0.2	soil	SF	grab	NA	9/19/2017	784824.64	3914106.31	N	N	--
S1011-BG4-011	0 - 0.2	soil	SF	grab	NA	9/19/2017	784821.40	3914102.48	N	N	--
S1011-BG4-011	0.2 - 3.0	soil	SB	composite	NA	9/19/2017	784821.40	3914102.48	N	N	--

Notes

--	Not Sampled
N	Normal
FD	Field Duplicate
MS	Matrix Spike
MSD	Matrix Spike Duplicate
Ra-226	Radium 226
NA	Not Applicable
SB	Subsurface Sample
SF	Surface Sample
ft bgs	feet below ground surface

[1] Coordinate System: NAD 1983 UTM Zone 12N

Table 3-2
Soil and Sediment Sampling Summary
Section 26
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Sample Location	Sample Depth (ft bgs)	Sample Media	Sample Category	Sample Collection Method	Survey Area	Sample Date	Easting [1]	Northing [1]	Sample Types: Metals, Total	Sample Types: Ra-226	Sample Types: Thorium
Background Reference Area Study - Background Area 5											
S1011-BG5-001	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784827.40	3914010.80	N;MS;MSD	N	--
S1011-BG5-002	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784824.77	3914007.43	N;FD	N;FD	--
S1011-BG5-003	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784822.69	3914001.52	N	N	--
S1011-BG5-004	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784821.46	3913997.88	N	N	--
S1011-BG5-005	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784822.47	3913994.77	N	N	--
S1011-BG5-006	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784821.70	3913991.38	N	N	--
S1011-BG5-007	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784821.74	3913988.83	N	N	--
S1011-BG5-008	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784821.42	3913984.85	N	N	--
S1011-BG5-009	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784822.53	3913981.91	N;FD	N;FD	--
S1011-BG5-010	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784822.89	3913979.72	N	N	--
S1011-BG5-011	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784822.45	3913991.77	N	N	--
S1011-BG5-011	0.2 - 2.0	sediment	SB	composite	NA	9/19/2017	784822.45	3913991.77	N	N	--
Correlation											
S1011-C01-001	0 - 0.5	soil	SF	5-point composite	NA	3/29/2017	785155.24	3914549.34	--	N	N
S1011-C02-001	0 - 0.5	soil	SF	5-point composite	NA	3/29/2017	785451.96	3914219.56	--	N	N
S1011-C03-001	0 - 0.5	soil	SF	5-point composite	NA	3/29/2017	785562.35	3914331.94	--	N	N
S1011-C04-001	0 - 0.5	soil	SF	5-point composite	NA	3/29/2017	785495.24	3914439.54	--	N	N
S1011-C05-001	0 - 0.5	soil	SF	5-point composite	NA	3/29/2017	785545.94	3914561.09	--	N	N
Characterization											
S1011-CX-001	0 - 0.2	soil	SF	grab	B	12/1/2016	785057.48	3914553.45	N	N	--
S1011-CX-002	0 - 0.2	soil	SF	grab	B	12/1/2016	785566.35	3914507.02	N	N	--
S1011-CX-003	0 - 0.2	soil	SF	grab	B	12/1/2016	785611.36	3914470.83	N	N	--
S1011-CX-004	0 - 0.2	soil	SF	grab	B	12/1/2016	785658.94	3914560.17	N;FD	N;FD	--
S1011-CX-005	0 - 0.2	soil	SF	grab	B	12/1/2016	785313.02	3914225.47	N	N	--
S1011-CX-006	0 - 0.5	soil	SF	grab	C	5/13/2017	785562.58	3914271.68	N	N	--
S1011-CX-007	0 - 0.5	soil	SF	grab	A	5/13/2017	785654.39	3914300.90	N	N	--
S1011-CX-008	0 - 0.5	sediment	SF	grab	E	5/13/2017	785538.93	3913923.98	N	N	--
S1011-CX-009	0 - 0.5	sediment	SF	grab	E	5/13/2017	785449.78	3913960.65	N	N	--
S1011-CX-010	0 - 0.5	soil	SF	grab	B	5/13/2017	785060.57	3914573.54	N	N	--
S1011-CX-011	0 - 0.5	soil	SF	grab	B	5/13/2017	785141.69	3914248.75	N	N	--
S1011-CX-012	0 - 0.5	soil	SF	grab	A	5/13/2017	785166.10	3914207.05	N	N	--
S1011-CX-013	0 - 0.5	soil	SF	grab	A	5/13/2017	785278.83	3914192.94	N;FD	N;FD	--
S1011-CX-014	0 - 0.5	soil	SF	grab	B	5/13/2017	785433.54	3914230.44	N	N	--
S1011-CX-015	0 - 0.5	soil	SF	grab	B	5/13/2017	785482.08	3914412.33	N;MS;MSD	N	--
S1011-SCX-001	0 - 0.5	sediment	SF	grab	E	5/12/2017	785487.09	3914060.74	N	N	--
S1011-SCX-001	0.5 - 1.5	sediment	SB	grab	E	5/12/2017	785487.09	3914060.74	N	N	--
S1011-SCX-002	0 - 0.5	sediment	SF	grab	E	5/12/2017	785452.75	3914047.77	N	N	--
S1011-SCX-002	0.5 - 1.5	sediment	SB	grab	E	5/12/2017	785452.75	3914047.77	N	N	--
S1011-SCX-003	0 - 0.5	sediment	SF	grab	E	5/12/2017	785501.04	3913974.17	N;FD	N;FD	--
S1011-SCX-003	0.5 - 1.5	sediment	SB	grab	E	5/12/2017	785501.04	3913974.17	N	N	--
S1011-SCX-003	1.5 - 2.25	sediment	SB	grab	E	5/12/2017	785501.04	3913974.17	N	N	--
S1011-SCX-004	0 - 0.5	sediment	SF	grab	E	5/12/2017	785203.77	3913866.68	N	N	--
S1011-SCX-004	0.5 - 1.5	sediment	SB	grab	E	5/12/2017	785203.77	3913866.68	N	N	--
S1011-SCX-004	1.5 - 2.0	sediment	SB	grab	E	5/12/2017	785203.77	3913866.68	N	N	--
S1011-SCX-005	0 - 0.5	sediment	SF	grab	E	5/12/2017	785220.84	3914043.34	N	N	--
S1011-SCX-005	0.5 - 1.5	sediment	SB	grab	E	5/12/2017	785220.84	3914043.34	N	N	--
S1011-SCX-005	1.5 - 2.0	sediment	SB	grab	E	5/12/2017	785220.84	3914043.34	N	N	--
S1011-SCX-006	0 - 0.5	soil	SF	grab	C	5/12/2017	785219.68	3914156.28	N	N	--
S1011-SCX-006	0.5 - 1.25	soil	SB	grab	C	5/12/2017	785219.68	3914156.28	N	N	--
S1011-SCX-007	0 - 0.5	soil	SF	grab	B	5/13/2017	785278.26	3914225.39	N;MS;MSD	N	--
S1011-SCX-007	0.5 - 1.0	soil	SB	grab	B	5/13/2017	785278.26	3914225.39	N	N	--
S1011-SCX-007	1.0 - 1.5	soil	SB	grab	B	5/13/2017	785278.26	3914225.39	N	N	--
S1011-SCX-008	0 - 0.5	soil	SF	grab	A	5/13/2017	785261.82	3914202.15	N	N	--
S1011-SCX-008	0.5 - 1.0	soil	SB	grab	A	5/13/2017	785261.82	3914202.15	N	N	--
S1011-SCX-008	1.0 - 1.5	soil	SB	grab	A	5/13/2017	785261.82	3914202.15	N	N	--

Notes

--	Not Sampled
N	Normal
FD	Field Duplicate
MS	Matrix Spike
MSD	Matrix Spike Duplicate
Ra-226	Radium 226
NA	Not Applicable
SB	Subsurface Sample
SF	Surface Sample
ft bgs	feet below ground surface

[1] Coordinate System: NAD 1983 UTM Zone 12N

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Sample Location	Sample Depth (ft bgs)	Sample Media	Sample Category	Sample Collection Method	Survey Area	Sample Date	Easting [1]	Northing [1]	Sample Types: Metals, Total	Sample Types: Ra-226	Sample Types: Thorium
Characterization continued											
S1011-SCX-009	0 - 0.5	soil	SF	grab	B	6/9/2017	785079.03	3914548.27	N;MS;MSD	N	--
S1011-SCX-009	0.5 - 2.0	soil	SB	composite	B	6/9/2017	785079.03	3914548.27	N	N	--
S1011-SCX-010	0 - 0.5	soil	SF	grab	B	6/9/2017	785051.56	3914563.92	N	N	--
S1011-SCX-010	0.5 - 3.0	soil	SB	composite	B	6/9/2017	785051.56	3914563.92	N	N	--
S1011-SCX-011	0 - 0.5	soil	SF	grab	B	6/9/2017	785086.49	3914565.57	N;FD	N;FD	--
S1011-SCX-011	0.5 - 3.0	soil	SB	composite	B	6/9/2017	785086.49	3914565.57	N	N	--
S1011-SCX-011	3.0 - 4.0	soil	SB	grab	B	6/9/2017	785086.49	3914565.57	N	N	--
S1011-SCX-012	0 - 0.5	soil	SF	grab	B	6/9/2017	785054.80	3914579.57	N	N	--
S1011-SCX-012	3.0 - 4.0	soil	SB	grab	B	6/9/2017	785054.80	3914579.57	N	N	--
S1011-SCX-013	0 - 0.5	soil	SF	grab	B	6/9/2017	785237.75	3914584.49	N	N	--
S1011-SCX-014	0 - 0.5	soil	SF	grab	B	6/9/2017	785312.17	3914564.97	N	N	--
S1011-SCX-014	0.5 - 4.0	soil	SB	composite	B	6/9/2017	785312.17	3914564.97	N	N	--
S1011-SCX-015	0 - 0.5	soil	SF	grab	B	6/10/2017	785273.11	3914269.22	N;FD	N;FD	--
S1011-SCX-015	0.5 - 1.5	soil	SB	grab	B	6/10/2017	785273.11	3914269.22	N	N	--
S1011-SCX-016	0 - 0.5	soil	SF	grab	B	6/10/2017	785251.00	3914237.41	N	N	--
S1011-SCX-016	2.5 - 3.0	soil	SB	grab	B	6/10/2017	785251.00	3914237.41	N	N	--
S1011-SCX-017	0 - 0.5	soil	SF	grab	A	6/10/2017	785591.45	3914306.10	N	N	--
S1011-SCX-017	0.5 - 1.0	soil	SB	grab	A	6/10/2017	785591.45	3914306.10	N	N	--
S1011-SCX-018	0 - 0.5	soil	SF	grab	B	6/10/2017	785608.82	3914315.71	N	N	--
S1011-SCX-018	1.0 - 3.5	soil/bedrock	SB	composite	B	6/10/2017	785608.82	3914315.71	N	N	--
S1011-SCX-019	0 - 0.5	soil	SF	grab	B	6/10/2017	785584.20	3914327.38	N;MS;MSD	N	--
S1011-SCX-019	0.5 - 2.5	soil	SB	composite	B	6/10/2017	785584.20	3914327.38	N	N	--
S1011-SCX-020	0 - 0.5	soil	SF	grab	B	6/10/2017	785611.50	3914344.48	N	N	--
S1011-SCX-020	0.5 - 4.0	soil	SB	composite	B	6/10/2017	785611.50	3914344.48	N	N	--
S1011-SCX-021	0 - 0.5	soil	SF	grab	B	6/10/2017	785627.18	3914465.39	N	N	--
S1011-SCX-021	12.0 - 13.0	soil	SB	grab	B	6/10/2017	785627.18	3914465.39	N	N	--
S1011-SCX-021	14.0 - 15.0	soil	SB	grab	B	6/10/2017	785627.18	3914465.39	N;FD	N;FD	--
S1011-SCX-021	17.0 - 18.0	soil	SB	grab	B	6/10/2017	785627.18	3914465.39	N	N	--
S1011-SCX-021	19.0 - 20.0	soil/bedrock	SB	grab	B	6/10/2017	785627.18	3914465.39	N	N	--
S1011-SCX-022	0 - 0.5	soil	SF	grab	B	6/10/2017	785626.97	3914511.24	N	N	--
S1011-SCX-022	5.0 - 7.0	soil	SB	composite	B	6/10/2017	785626.97	3914511.24	N	N	--
S1011-SCX-023	0 - 0.5	soil	SF	grab	B	6/10/2017	785649.40	3914554.88	N;MS;MSD	N	--
S1011-SCX-023	0.5 - 5.0	soil	SB	composite	B	6/10/2017	785649.40	3914554.88	N	N	--
S1011-SCX-023	13.5 - 14.5	soil	SB	grab	B	6/10/2017	785649.40	3914554.88	N	N	--
S1011-SCX-024	0 - 0.5	soil	SF	grab	B	6/11/2017	785657.64	3914569.55	N;FD	N;FD	--
S1011-SCX-024	3.0 - 4.0	soil	SB	grab	B	6/11/2017	785657.64	3914569.55	N	N	--
S1011-SCX-025	0 - 0.5	sediment	SF	grab	B	6/11/2017	785580.09	3914579.84	N	N	--
S1011-SCX-025	0.5 - 3.0	sediment	SB	composite	B	6/11/2017	785580.09	3914579.84	N	N	--
S1011-SCX-026	0 - 0.5	sediment	SF	grab	B	6/11/2017	785534.47	3914533.88	N	N	--
S1011-SCX-026	0.5 - 5.0	sediment	SB	composite	B	6/11/2017	785534.47	3914533.88	N	N	--
S1011-SCX-026	5.0 - 6.0	sediment	SB	grab	B	6/11/2017	785534.47	3914533.88	N	N	--
S1011-SCX-027	0 - 0.5	soil	SF	grab	B	6/11/2017	785581.12	3914553.94	N	N	--
S1011-SCX-027	0.5 - 3.0	soil	SB	composite	B	6/11/2017	785581.12	3914553.94	N	N	--
S1011-SCX-027	6.0 - 8.5	soil/bedrock	SB	composite	B	6/11/2017	785581.12	3914553.94	N	N	--
S1011-SCX-028	0 - 0.5	soil	SF	grab	B	6/11/2017	785561.16	3914509.68	N;MS;MSD	N	--
S1011-SCX-028	0.5 - 5.0	soil	SB	composite	B	6/11/2017	785561.16	3914509.68	N;FD	N;FD	--
S1011-SCX-028	5.0 - 8.0	soil	SB	composite	B	6/11/2017	785561.16	3914509.68	N	N	--
S1011-SCX-028	8.0 - 10.0	soil	SB	composite	B	6/11/2017	785561.16	3914509.68	N	N	--
S1011-SCX-028	10.0 - 12.0	soil	SB	composite	B	6/11/2017	785561.16	3914509.68	N	N	--
S1011-SCX-028	12.0 - 14.0	soil	SB	composite	B	6/11/2017	785561.16	3914509.68	N	N	--
S1011-SCX-029	0 - 0.5	soil	SF	grab	B	6/11/2017	785628.22	3914490.57	N	N	--
S1011-SCX-029	0.5 - 3.0	soil	SB	composite	B	6/11/2017	785628.22	3914490.57	N	N	--
S1011-SCX-030	0 - 0.5	soil	SF	grab	B	6/11/2017	785580.15	3914467.81	N	N	--
S1011-SCX-030	0.5 - 5.0	soil	SB	composite	B	6/11/2017	785580.15	3914467.81	N	N	--

Notes

--	Not Sampled
N	Normal
FD	Field Duplicate
MS	Matrix Spike
MSD	Matrix Spike Duplicate
Ra-226	Radium 226
NA	Not Applicable
SB	Subsurface Sample
SF	Surface Sample
ft bgs	feet below ground surface

[1] Coordinate System: NAD 1983 UTM Zone 12N

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Sample Location	Sample Depth (ft bgs)	Sample Media	Sample Category	Sample Collection Method	Survey Area	Sample Date	Easting ¹	Northing ¹	Sample Types Metals, Total	Ra-226	Thorium
Characterization continued											
S1011-SCX-031	0 - 0.5	soil	SF	grab	B	6/11/2017	785554.61	3914489.47	N	N	--
S1011-SCX-031	0.5 - 5.0	soil	SB	composite	B	6/11/2017	785554.61	3914489.47	N	N	--
S1011-SCX-031	5.0 - 7.0	soil	SB	composite	B	6/11/2017	785554.61	3914489.47	N	N	--
S1011-SCX-031	7.0 - 10.0	soil	SB	composite	B	6/11/2017	785554.61	3914489.47	N	N	--
S1011-SCX-031	10.0 - 12.0	soil	SB	composite	B	6/11/2017	785554.61	3914489.47	N;FD	N;FD	--
S1011-SCX-032	0 - 0.5	soil	SF	grab	B	6/11/2017	785532.40	3914481.95	N	N	--
S1011-SCX-032	0.5 - 5.0	soil	SB	composite	B	6/11/2017	785532.40	3914481.95	N	N	--
S1011-SCX-032	5.0 - 9.0	soil	SB	composite	B	6/11/2017	785532.40	3914481.95	N	N	--
S1011-SCX-033	0 - 0.5	sediment	SF	grab	B	6/11/2017	785618.18	3914451.69	N;FD	N;FD	--
S1011-SCX-033	0.5 - 5.0	sediment	SB	composite	B	6/11/2017	785618.18	3914451.69	N	N	--
S1011-SCX-033	5.0 - 9.0	sediment	SB	composite	B	6/11/2017	785618.18	3914451.69	N	N	--
S1011-SCX-034	0 - 0.5	soil	SF	grab	B	6/12/2017	785596.46	3914489.26	N	N	--
S1011-SCX-034	0.5 - 5.0	soil	SB	composite	B	6/12/2017	785596.46	3914489.26	N	N	--
S1011-SCX-034	5.0 - 10.0	soil	SB	composite	B	6/12/2017	785596.46	3914489.26	N	N	--
S1011-SCX-035	0 - 0.5	soil	SF	grab	B	6/12/2017	785584.73	3914514.83	N;MS;MSD	N	--
S1011-SCX-035	0.5 - 5.0	soil	SB	composite	B	6/12/2017	785584.73	3914514.83	N	N	--
S1011-SCX-035	5.0 - 8.0	soil	SB	composite	B	6/12/2017	785584.73	3914514.83	N	N	--
S1011-SCX-036	0 - 0.5	soil	SF	grab	B	6/12/2017	785631.75	3914563.55	N;FD	N;FD	--
S1011-SCX-036	0.5 - 3.0	soil	SB	composite	B	6/12/2017	785631.75	3914563.55	N	N	--
S1011-SCX-037	0 - 0.5	soil	SF	grab	B	6/12/2017	785568.09	3914568.95	N	N	--
S1011-SCX-037	0.5 - 3.0	soil	SB	composite	B	6/12/2017	785568.09	3914568.95	N	N	--
S1011-SCX-038	0 - 0.5	soil	SF	grab	B	6/12/2017	785559.09	3914524.78	N	N	--
S1011-SCX-038	0.5 - 3.0	soil	SB	composite	B	6/12/2017	785559.09	3914524.78	N	N	--
S1011-SCX-038	3.0 - 10.0	soil	SB	composite	B	6/12/2017	785559.09	3914524.78	N	N	--
S1011-SCX-039	0 - 0.2	soil	SF	grab	B	9/19/2017	785066.82	3914558.93	N	N	--
S1011-SCX-040	0 - 0.2	soil	SF	grab	B	9/19/2017	785073.34	3914570.39	N	N	--
S1011-SCX-041	0 - 0.2	soil	SF	grab	D	9/19/2017	785168.70	3914011.94	N	N	--
S1011-SCX-041	0.2 - 2.5	soil	SB	composite	D	9/19/2017	785168.70	3914011.94	N	N	--
S1011-SCX-042	0 - 0.2	soil	SF	grab	D	9/19/2017	785343.45	3914012.62	N	N	--
S1011-SCX-042	0.2 - 2.0	soil	SB	composite	D	9/19/2017	785343.45	3914012.62	N;MS;MSD	N	--
S1011-SCX-043	0 - 0.2	soil	SF	grab	D	9/19/2017	785628.32	3914060.88	N;FD	N;FD	--
S1011-SCX-044	0 - 0.2	soil	SF	grab	B	9/19/2017	785065.46	3914556.94	N	N	--
S1011-SCX-044	0.2 - 0.7	soil	SB	grab	B	9/19/2017	785065.46	3914556.94	N	N	--

Notes

--	Not Sampled
N	Normal
FD	Field Duplicate
MS	Matrix Spike
MSD	Matrix Spike Duplicate
Ra-226	Radium 226
NA	Not Applicable
SB	Subsurface Sample
SF	Surface Sample
ft bgs	feet below ground surface

¹ Coordinate System: NAD 1983 UTM Zone 12N

Table 3-3
Mine Feature Samples and Area
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Mine Feature	Surface Samples	Subsurface Samples	Area (sq. ft)	Volume of TENORM exceeding ILs (yd^3)
Waste Pile 1	0	0	4,111	152
Waste Pile 2	1	0	15,302	1,063
Waste Pile 3	2	3	25,863	2,874
Waste Pile 4	0	0	207	8
Waste Pile 5	0	0	307	40
Waste Pile 6	1	1	581	108
Waste Pile 7	0	0	2,396	213
Central Debris Pile	0	0	5,719.3	847.0
Northern Debris Pile	0	0	498.6	*
Southern Debris Pile	1	1	29,915.6	*
Disturbed Area 1	3	3	73,217	5,690
Disturbed Area 2	5	3	146,811	7,906
Disturbed Area 3	1	0	12,789	474
Disturbed Area 4	0	0	**	**
Western Graded/Disturbed Reclaimed Area	10	5	146,081	16,817
Eastern Graded/Disturbed Reclaimed Area	19***	33***	242,120	70,512
Potential Waste Rock Area	2	0	119,405	8,647
Excavation 1	0	0	1,610	60
Excavation 2	1	2	283	37
Potential Haul Roads	5	9	**	--
Drainages	9	11	****	--

Notes

sq.ft	square feet
yd^3	cubic yards
TENORM	technologically enhanced naturally occurring radioactive material
--	Discrete volume was not identified for feature
*	Northern and southern debris piles contain car tires
**	Feature is not included in area of TENORM
***	Sample counts include samples collected within the potential haul roads and drainages mapped within the mining/reclaimed disturbed area
****	Area not determined because the width feature varies throughout the Site

Table 4-1
Background Reference Area Soil Sample Analytical Results
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Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification	S1011-BG1-001	S1011-BG1-002	S1011-BG1-003	S1011-BG1-004	S1011-BG1-005	S1011-BG1-006	S1011-BG1-006 Dup	S1011-BG1-007	S1011-BG1-008	S1011-BG1-009
Date Collected	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016
Depth (feet)	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2
Analyte (Units)										
Metals[1] (mg/kg)										
Arsenic	2	2.2	2.5	5.2	11 J-	3.4	12	2	5.8	6.1
Molybdenum	<0.21	0.33	0.32	0.54	1.4 J	0.62	1.7	<0.21	0.49	0.6
Selenium	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<0.99	<1.1	<1.1	<1.1
Uranium	1.6	2.4	1.7	2.5	2.4	2	2.5	2.8	2.5	1.9
Vanadium	5.5	6.7	7.8	11	26 J-	10	18	7.6	14	13
Radionuclides (pCi/g)										
Radium-226	1.05 ± 0.25	1.34 ± 0.3	1.43 ± 0.27	1.71 ± 0.34	1.86 ± 0.33	1.34 ± 0.29	1.29 ± 0.29	1.62 ± 0.33	1.43 ± 0.31	1.57 ± 0.3

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
< Result not detected above associated laboratory reporting limit
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Location Identification	S1011-BG1-010	S1011-BG1-011	S1011-BG1-011	S1011-BG2-001	S1011-BG2-002	S1011-BG2-003	S1011-BG2-004	S1011-BG2-005	S1011-BG2-006	S1011-BG2-006 Dup
Date Collected	11/30/2016	3/25/2017	3/25/2017	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016
Depth (feet)	0 - 0.2	0 - 0.2	0.5 - 0.7	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2
Analyte (Units)										
Metals[1] (mg/kg)										
Arsenic	4.3	3	2.4	1.4	1.3	1.8	1.6	1.9	2	2
Molybdenum	0.46	0.34	<0.2	<0.22	<0.22	<0.22	<0.21	<0.22	<0.2	0.23
Selenium	<1.1	<0.91	<1	<1.1	<1.1	<1.1	<1	<1.1	<1	<1.1
Uranium	2	2.1	2.9	1.5	1.6	1.9	1.5	1.5	1.6	1.6
Vanadium	14	11	11	7.7	7.6	9.6	8.6	10	9.2	9.1
Radionuclides (pCi/g)										
Radium-226	1.2 ± 0.29	1.62 ± 0.31 J-	1.51 ± 0.32	2.02 ± 0.37	2.7 ± 0.47	2.59 ± 0.43	1.89 ± 0.33	1.84 ± 0.36	1.92 ± 0.34	1.64 ± 0.34

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
< Result not detected above associated laboratory reporting limit
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Location Identification	S1011-BG2-007	S1011-BG2-008	S1011-BG2-009	S1011-BG2-010	S1011-BG2-011	S1011-BG2-011	S1011-BG3-001	S1011-BG3-002	S1011-BG3-003	S1011-BG3-004
Date Collected	11/30/2016	11/30/2016	11/30/2016	11/30/2016	3/25/2017	3/25/2017	9/18/2017	9/18/2017	9/18/2017	9/18/2017
Depth (feet)	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	1.5 - 2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2
Analyte (Units)										
Metals[1] (mg/kg)										
Arsenic	1.7	2	1.7	1.5	1.7	1.8	1.5	1	1	1.2
Molybdenum	<0.21	<0.22	0.22	0.33	<0.18	<0.2	0.37	<0.2	<0.18	<0.2
Selenium	<1.1	<1.1	<1.1	<1.1	<0.91	<0.99	<1	<1	<0.92	<0.98
Uranium	1.4	1.4	1.5 J+	3.4	1.3	1.2	1.4	0.82	0.75	0.82
Vanadium	8.8	9	8.6	6.7	7.9	9.6	15	10 J+	9.8	10
Radionuclides (pCi/g)										
Radium-226	1.73 ± 0.35	1.78 ± 0.37	2.15 ± 0.36	2.16 ± 0.39	2.03 ± 0.34	1.59 ± 0.32	1.21 ± 0.27	0.87 ± 0.25	0.82 ± 0.21 J-	0.88 ± 0.23

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
[1] Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
< Result not detected above associated laboratory reporting limit
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Location Identification	S1011-BG3-004 Dup	S1011-BG3-005	S1011-BG3-006	S1011-BG3-007	S1011-BG3-008	S1011-BG3-009	S1011-BG3-009 Dup	S1011-BG3-010	S1011-BG3-011	S1011-BG4-001
Date Collected	9/18/2017	9/18/2017	9/18/2017	9/18/2017	9/18/2017	9/18/2017	9/18/2017	9/18/2017	9/19/2017	9/19/2017
Depth (feet)	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2
Analyte (Units)										
Metals[1] (mg/kg)										
Arsenic	1.1	1.4	1.2	1.3	1	1.3	1.4	5.2	1.2	1.2
Molybdenum	<0.19	<0.2	<0.2	0.21	<0.2	<0.21	0.2	0.26	0.2	<0.2
Selenium	<0.96	<0.99	<1	<1	<0.99	<1	<1	<0.99	<0.97	<1
Uranium	0.7	1	1.2	1.6	0.6	1.1	1.1	0.9	1.3	0.36
Vanadium	8.4	9.2	12	9.6	9.6	11	10	13	15	7.7
Radionuclides (pCi/g)										
Radium-226	0.78 ± 0.24	1.23 ± 0.29	0.83 ± 0.2	1.14 ± 0.25	0.71 ± 0.22	0.99 ± 0.27	1.15 ± 0.26	1 ± 0.23	1.16 ± 0.25	0.84 ± 0.24

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
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< Result not detected above associated laboratory reporting limit
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Location Identification	S1011-BG4-002	S1011-BG4-003	S1011-BG4-003 Dup	S1011-BG4-004	S1011-BG4-005	S1011-BG4-006	S1011-BG4-007	S1011-BG4-008	S1011-BG4-009	S1011-BG4-009 Dup
Date Collected	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017
Depth (feet)	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2
Analyte (Units)										
Metals[1] (mg/kg)										
Arsenic	1.5	1.3	1.3	1.4	1.4	1.5	1.5	1.5	1.5	1.3
Molybdenum	<0.19	<0.2	<0.2	0.21	<0.2	<0.2	<0.2	<0.2	0.2	<0.19
Selenium	<0.96	<0.99	<1	<0.94	<1	<1	<0.99	<0.99	<0.97	<0.95
Uranium	0.42	0.39	0.41	0.47	0.47	0.46	0.49	0.47	0.45	0.43
Vanadium	9	8.2	8	9.3	9.8	9.2	9.8	9.7	9.3	8.5
Radionuclides (pCi/g)										
Radium-226	0.88 ± 0.23	0.72 ± 0.22	1.24 ± 0.27	1.14 ± 0.25	1.06 ± 0.24	1.27 ± 0.28	1.04 ± 0.27	1.11 ± 0.27	1.07 ± 0.25	0.9 ± 0.26

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
< Result not detected above associated laboratory reporting limit
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Location Identification	S1011-BG4-010	S1011-BG4-011	S1011-BG4-011	S1011-BG5-001	S1011-BG5-002	S1011-BG5-002 Dup	S1011-BG5-003	S1011-BG5-004	S1011-BG5-005	S1011-BG5-006
Date Collected	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017
Depth (feet)	0 - 0.2	0 - 0.2	0.2 - 3	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2
Analyte (Units)										
Metals[1] (mg/kg)										
Arsenic	1.3	1.6	1.3	1.2	1.3	1.1	1.5	1.1	1.1	1.3
Molybdenum	<0.2	<0.2	<0.19	<0.2	<0.2	<0.2	<0.2	<0.2	<0.19	<0.2
Selenium	<0.98	<1	<0.97	<0.98	<1	<1	<1	<1	<0.96	<1
Uranium	0.44	0.46	0.4	0.42 J	0.41	0.35	0.45	0.29	0.4	0.41
Vanadium	8.8	8.3	8.5	6.4	7.8	7	8.8	6.6	5.1	7.5
Radionuclides (pCi/g)										
Radium-226	1 ± 0.26	0.71 ± 0.23	0.56 ± 0.18	0.61 ± 0.24	0.55 ± 0.17	0.6 ± 0.25	0.52 ± 0.22	0.54 ± 0.17	0.65 ± 0.21	0.63 ± 0.19

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
< Result not detected above associated laboratory reporting limit
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J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Location Identification	S1011-BG5-007	S1011-BG5-008	S1011-BG5-009	S1011-BG5-009 Dup	S1011-BG5-010	S1011-BG5-011	S1011-BG5-011
Date Collected	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017
Depth (feet)	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0.2 - 2
Analyte (Units)							
Metals[1] (mg/kg)							
Arsenic	1.1	1.3	1.3	1.3	1.2	1.6	1.7
Molybdenum	<0.2	<0.19	<0.19	<0.2	<0.2	<0.2	<0.2
Selenium	<1	<0.96	<0.96	<0.98	<0.99	<0.99	<1
Uranium	0.68	0.35	0.39	0.36	0.35	0.41	0.43
Vanadium	8	6.7	7.6	7.3	6.6	9.4	9
Radionuclides (pCi/g)							
Radium-226	0.66 ± 0.2	0.79 ± 0.21	0.63 ± 0.18	0.72 ± 0.19	0.5 ± 0.19	0.63 ± 0.24	0.74 ± 0.22

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
< Result not detected above associated laboratory reporting limit
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Table 4-2
Static Gamma Measurement Summary
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Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-BG1-011	Background Area 1	*	0.0	soil	7,345
S1011-BG1-011	Background Area 1	*	0.7	soil	7,963**
S1011-BG2-011	Background Area 2	*	0.0	soil	10,200
S1011-BG2-011	Background Area 2	*	0.5	soil	12,551
S1011-BG2-011	Background Area 2	*	1.0	soil	12,840
S1011-BG2-011	Background Area 2	*	1.5	soil	13,268
S1011-BG2-011	Background Area 2	*	2.0	soil	12,669
S1011-BG3-011	Background Area 3	*	0.0	soil	6,390
S1011-BG3-011	Background Area 3	*	0.25	soil	6,387**
S1011-BG4-011	Background Area 4	*	0.0	soil	7,788
S1011-BG4-011	Background Area 4	*	0.5	soil	9,706
S1011-BG4-011	Background Area 4	*	1.0	soil	10,481
S1011-BG4-011	Background Area 4	*	1.5	soil	10,271
S1011-BG4-011	Background Area 4	*	2.0	soil	10,313
S1011-BG4-011	Background Area 4	*	2.5	soil	10,099
S1011-BG4-011	Background Area 4	*	3.0	soil	10,616
S1011-BG5-011	Background Area 5	*	0.0	sediment	8,008
S1011-BG5-011	Background Area 5	*	0.5	sediment	10,302
S1011-BG5-011	Background Area 5	*	1.0	sediment	11,450
S1011-BG5-011	Background Area 5	*	1.5	sediment	11,465
S1011-BG5-011	Background Area 5	*	2.0	sediment	11,496
S1011-SCX-008	A	--	0.0	soil	42,178
S1011-SCX-008	A	7,963	0.5	soil	57,060
S1011-SCX-008	A	7,963	1.0	soil	72,800
S1011-SCX-008	A	7,963	1.5	soil	103,982**
S1011-SCX-017	A	--	0.0	soil	105,490
S1011-SCX-017	A	7,963	1.0	soil	266,288
S1011-SCX-017	A	7,963	2.0	bedrock	102,426
S1011-SCX-017	A	7,963	3.0	unknown	16,794
S1011-SCX-017	A	7,963	3.5	unknown	15,000
S1011-SCX-007	B	--	0.0	soil	20,946
S1011-SCX-007	B	12,669	0.5	soil	20,893
S1011-SCX-007	B	12,669	1.0	soil	19,694
S1011-SCX-007	B	12,669	1.5	soil	16,236**

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
*	The subsurface gamma investigation levels are derived from the background area measurements, refer to Section 4.1 of the RSE report
**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-009	B	--	0.0	soil	8,544
S1011-SCX-009	B	12,669	1.0	soil	11,686
S1011-SCX-009	B	12,669	2.0	soil	10,692
S1011-SCX-009	B	12,669	3.0	bedrock	15,044
S1011-SCX-009	B	12,669	4.0	bedrock	17,232
S1011-SCX-009	B	12,669	5.0	bedrock	17,936
S1011-SCX-009	B	12,669	6.0	bedrock	19,196
S1011-SCX-010	B	--	0.0	soil	13,646
S1011-SCX-010	B	12,669	1.0	soil	27,136
S1011-SCX-010	B	12,669	2.0	soil	20,118
S1011-SCX-010	B	12,669	3.0	soil	25,594
S1011-SCX-010	B	12,669	4.0	soil	32,074
S1011-SCX-010	B	12,669	5.0	soil	42,308
S1011-SCX-010	B	12,669	6.0	bedrock	40,190
S1011-SCX-010	B	12,669	7.0	bedrock	41,294
S1011-SCX-010	B	12,669	8.0	bedrock	32,386
S1011-SCX-010	B	12,669	8.5	bedrock	29,706
S1011-SCX-011	B	--	0.0	soil	8,652
S1011-SCX-011	B	12,669	1.0	soil	11,026
S1011-SCX-011	B	12,669	2.0	soil	11,312
S1011-SCX-011	B	12,669	3.0	soil	10,428
S1011-SCX-011	B	12,669	4.0	soil	9,968
S1011-SCX-011	B	12,669	5.0	bedrock	16,896
S1011-SCX-011	B	12,669	6.0	bedrock	17,812
S1011-SCX-011	B	12,669	7.0	bedrock	13,242
S1011-SCX-011	B	12,669	8.0	bedrock	12,348
S1011-SCX-011	B	12,669	8.5	bedrock	13,386
S1011-SCX-012	B	--	0.0	soil	10,932
S1011-SCX-012	B	12,669	1.0	soil	14,594
S1011-SCX-012	B	12,669	2.0	soil	13,230
S1011-SCX-012	B	12,669	3.0	soil	11,274
S1011-SCX-012	B	12,669	4.0	soil	9,858
S1011-SCX-012	B	12,669	5.0	soil	12,308
S1011-SCX-012	B	12,669	6.0	bedrock	13,940
S1011-SCX-012	B	12,669	7.0	bedrock	11,776
S1011-SCX-012	B	12,669	8.0	bedrock	11,426
S1011-SCX-012	B	12,669	9.0	bedrock	10,814

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
*	The subsurface gamma investigation levels are derived from the background area measurements, refer to Section 4.1 of the RSE report
**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-013	B	--	0.0	soil	8,736
S1011-SCX-013	B	12,669	1.0	bedrock	14,258
S1011-SCX-013	B	12,669	2.0	bedrock	16,410
S1011-SCX-013	B	12,669	3.0	bedrock	16,580
S1011-SCX-013	B	12,669	4.0	bedrock	18,010
S1011-SCX-013	B	12,669	5.0	bedrock	13,298
S1011-SCX-014	B	--	0.0	soil	33,406
S1011-SCX-014	B	12,669	1.0	soil	10,820
S1011-SCX-014	B	12,669	2.0	soil	9,438
S1011-SCX-014	B	12,669	3.0	soil	9,166
S1011-SCX-014	B	12,669	4.0	soil	10,578
S1011-SCX-014	B	12,669	5.0	bedrock	10,380
S1011-SCX-014	B	12,669	5.5	bedrock	18,802
S1011-SCX-015	B	--	0.0	soil	8,296
S1011-SCX-015	B	12,669	1.0	soil	9,484
S1011-SCX-015	B	12,669	2.0	bedrock	8,832
S1011-SCX-016	B	--	0.0	soil	10,728
S1011-SCX-016	B	12,669	1.0	soil	9,288
S1011-SCX-016	B	12,669	2.0	soil	11,334
S1011-SCX-016	B	12,669	3.0	soil	15,094**
S1011-SCX-018	B	--	0.0	soil	45,908
S1011-SCX-018	B	12,669	1.0	soil	136,354
S1011-SCX-018	B	12,669	2.0	soil	252,986
S1011-SCX-018	B	12,669	3.0	soil	187,496
S1011-SCX-018	B	12,669	4.0	bedrock	130,140
S1011-SCX-019	B	--	0.0	soil	40,179
S1011-SCX-019	B	12,669	1.0	soil	107,138
S1011-SCX-019	B	12,669	2.0	soil	254,338
S1011-SCX-019	B	12,669	3.0	bedrock	477,872
S1011-SCX-020	B	--	0.0	soil	20,449
S1011-SCX-020	B	12,669	1.0	soil	25,622
S1011-SCX-020	B	12,669	2.0	soil	28,812
S1011-SCX-020	B	12,669	3.0	soil	45,588
S1011-SCX-020	B	12,669	4.0	soil	76,812
S1011-SCX-020	B	12,669	5.0	soil	79,874
S1011-SCX-020	B	12,669	6.0	bedrock	118,858

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
*	The subsurface gamma investigation levels are derived from the background area measurements, refer to Section 4.1 of the RSE report
**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-021	B	--	0.0	soil	11,964
S1011-SCX-021	B	12,669	1.0	soil	14,878
S1011-SCX-021	B	12,669	2.0	soil	16,610
S1011-SCX-021	B	12,669	3.0	soil	16,712
S1011-SCX-021	B	12,669	4.0	soil	17,798
S1011-SCX-021	B	12,669	5.0	soil	17,462
S1011-SCX-021	B	12,669	6.0	soil	17,212
S1011-SCX-021	B	12,669	7.0	soil	16,554
S1011-SCX-021	B	12,669	8.0	soil	14,260
S1011-SCX-021	B	12,669	9.0	soil	13,470
S1011-SCX-021	B	12,669	10.0	soil	14,074
S1011-SCX-021	B	12,669	11.0	soil	16,628
S1011-SCX-021	B	12,669	12.0	soil	25,502
S1011-SCX-021	B	12,669	13.0	soil	30,366
S1011-SCX-021	B	12,669	14.0	soil	26,570
S1011-SCX-021	B	12,669	15.0	soil	22,026
S1011-SCX-021	B	12,669	16.0	soil	15,886
S1011-SCX-021	B	12,669	17.0	soil	17,180
S1011-SCX-021	B	12,669	18.0	bedrock	29,628
S1011-SCX-021	B	12,669	19.0	bedrock	37,786
S1011-SCX-021	B	12,669	20.0	bedrock	29,272
S1011-SCX-022	B	--	0.0	soil	11,584
S1011-SCX-022	B	12,669	1.0	soil	10,014
S1011-SCX-022	B	12,669	2.0	soil	10,162
S1011-SCX-022	B	12,669	3.0	soil	10,390
S1011-SCX-022	B	12,669	4.0	soil	10,572
S1011-SCX-022	B	12,669	5.0	soil	10,538
S1011-SCX-022	B	12,669	6.0	soil	10,160
S1011-SCX-022	B	12,669	7.0	soil	10,124
S1011-SCX-022	B	12,669	8.0	soil	11,216
S1011-SCX-022	B	12,669	9.0	soil	14,474
S1011-SCX-022	B	12,669	10.0	soil	16,838
S1011-SCX-022	B	12,669	11.0	soil	19,754
S1011-SCX-022	B	12,669	12.0	soil	21,062
S1011-SCX-022	B	12,669	13.0	soil	22,684
S1011-SCX-022	B	12,669	14.0	soil	21,010
S1011-SCX-022	B	12,669	15.0	soil	23,160
S1011-SCX-022	B	12,669	16.0	soil	23,892
S1011-SCX-022	B	12,669	17.0	soil	23,822
S1011-SCX-022	B	12,669	18.0	soil	26,782
S1011-SCX-022	B	12,669	19.0	soil	29,084
S1011-SCX-022	B	12,669	20.0	soil	33,188

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
*	The subsurface gamma investigation levels are derived from the background area measurements, refer to Section 4.1 of the RSE report
**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Table 4-2
Static Gamma Measurement Summary
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Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-023	B	--	0.0	soil	11,194
S1011-SCX-023	B	12,669	1.0	soil	12,954
S1011-SCX-023	B	12,669	2.0	soil	13,554
S1011-SCX-023	B	12,669	3.0	soil	13,538
S1011-SCX-023	B	12,669	4.0	soil	13,460
S1011-SCX-023	B	12,669	5.0	soil	12,650
S1011-SCX-023	B	12,669	6.0	soil	11,678
S1011-SCX-023	B	12,669	7.0	soil	12,514
S1011-SCX-023	B	12,669	8.0	soil	13,054
S1011-SCX-023	B	12,669	9.0	soil	13,532
S1011-SCX-023	B	12,669	10.0	soil	13,714
S1011-SCX-023	B	12,669	11.0	soil	14,780
S1011-SCX-023	B	12,669	12.0	soil	14,028
S1011-SCX-023	B	12,669	13.0	soil	13,874
S1011-SCX-023	B	12,669	14.0	soil	18,286
S1011-SCX-023	B	12,669	15.0	bedrock	26,014
S1011-SCX-024	B	--	0.0	soil	32,082
S1011-SCX-024	B	12,669	1.0	soil	26,124
S1011-SCX-024	B	12,669	2.0	soil	16,190
S1011-SCX-024	B	12,669	3.0	soil	15,480
S1011-SCX-024	B	12,669	4.0	soil	18,898
S1011-SCX-024	B	12,669	5.0	bedrock	22,238
S1011-SCX-024	B	12,669	6.0	bedrock	25,878
S1011-SCX-024	B	12,669	7.0	bedrock	27,094
S1011-SCX-025	B	--	0.0	sediment	14,636
S1011-SCX-025	B	12,669	1.0	sediment	23,846
S1011-SCX-025	B	12,669	2.0	sediment	18,968
S1011-SCX-025	B	12,669	3.0	sediment	17,256
S1011-SCX-025	B	12,669	4.0	sediment	17,846
S1011-SCX-025	B	12,669	5.0	sediment	17,792
S1011-SCX-025	B	12,669	6.0	sediment	20,898
S1011-SCX-025	B	12,669	7.0	bedrock	29,730
S1011-SCX-025	B	12,669	8.0	bedrock	39,254
S1011-SCX-026	B	--	0.0	sediment	11,826
S1011-SCX-026	B	12,669	1.0	sediment	16,592
S1011-SCX-026	B	12,669	2.0	sediment	18,044
S1011-SCX-026	B	12,669	3.0	sediment	16,534
S1011-SCX-026	B	12,669	4.0	sediment	16,388
S1011-SCX-026	B	12,669	5.0	sediment	15,326
S1011-SCX-026	B	12,669	6.0	sediment	15,000
S1011-SCX-026	B	12,669	7.0	bedrock	12,426
S1011-SCX-026	B	12,669	8.0	bedrock	12,886
S1011-SCX-026	B	12,669	8.5	bedrock	13,314

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
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**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-027	B	--	0.0	soil	14,552
S1011-SCX-027	B	12,669	1.0	soil	13,266
S1011-SCX-027	B	12,669	2.0	soil	13,404
S1011-SCX-027	B	12,669	3.0	soil	10,856
S1011-SCX-027	B	12,669	4.0	soil	9,462
S1011-SCX-027	B	12,669	5.0	soil	8,428
S1011-SCX-027	B	12,669	6.0	soil	8,884
S1011-SCX-027	B	12,669	7.0	soil	9,148
S1011-SCX-027	B	12,669	8.0	soil	8,580
S1011-SCX-027	B	12,669	9.0	bedrock	8,958
S1011-SCX-028	B	--	0.0	soil	13,424
S1011-SCX-028	B	12,669	1.0	soil	47,276
S1011-SCX-028	B	12,669	2.0	soil	208,490
S1011-SCX-028	B	12,669	3.0	soil	352,526
S1011-SCX-028	B	12,669	4.0	soil	103,780
S1011-SCX-028	B	12,669	5.0	soil	85,838
S1011-SCX-028	B	12,669	6.0	soil	123,720
S1011-SCX-028	B	12,669	7.0	boulder	174,166
S1011-SCX-028	B	12,669	8.0	boulder	223,904
S1011-SCX-028	B	12,669	9.0	soil	72,022
S1011-SCX-028	B	12,669	10.0	soil	34,166
S1011-SCX-028	B	12,669	11.0	soil	27,028
S1011-SCX-028	B	12,669	12.0	soil	24,992
S1011-SCX-028	B	12,669	13.0	soil	24,632
S1011-SCX-028	B	12,669	14.0	soil	21,364
S1011-SCX-028	B	12,669	15.0	bedrock	17,048
S1011-SCX-028	B	12,669	16.0	bedrock	16,304
S1011-SCX-028	B	12,669	17.0	bedrock	17,316
S1011-SCX-028	B	12,669	18.0	bedrock	24,485
S1011-SCX-028	B	12,669	18.5	bedrock	39,182
S1011-SCX-029	B	--	0.0	soil	11,734
S1011-SCX-029	B	12,669	1.0	soil	15,084
S1011-SCX-029	B	12,669	2.0	soil	20,564
S1011-SCX-029	B	12,669	3.0	soil	33,810**

Notes

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**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-030	B	--	0.0	soil	10,412
S1011-SCX-030	B	12,669	1.0	soil	11,078
S1011-SCX-030	B	12,669	2.0	soil	10,834
S1011-SCX-030	B	12,669	3.0	soil	11,048
S1011-SCX-030	B	12,669	4.0	soil	11,634
S1011-SCX-030	B	12,669	5.0	soil	12,246
S1011-SCX-030	B	12,669	6.0	soil	13,378
S1011-SCX-030	B	12,669	7.0	soil	14,020
S1011-SCX-030	B	12,669	8.0	soil	14,542
S1011-SCX-030	B	12,669	9.0	soil	16,164
S1011-SCX-030	B	12,669	10.0	soil	14,666
S1011-SCX-030	B	12,669	11.0	bedrock	14,218
S1011-SCX-030	B	12,669	12.0	bedrock	16,740
S1011-SCX-030	B	12,669	13.0	bedrock	17,184
S1011-SCX-030	B	12,669	13.5	bedrock	18,014
S1011-SCX-031	B	--	0.0	soil	10,658
S1011-SCX-031	B	12,669	1.0	soil	11,560
S1011-SCX-031	B	12,669	2.0	soil	12,288
S1011-SCX-031	B	12,669	3.0	soil	12,194
S1011-SCX-031	B	12,669	4.0	soil	13,318
S1011-SCX-031	B	12,669	5.0	soil	14,170
S1011-SCX-031	B	12,669	6.0	soil	23,174
S1011-SCX-031	B	12,669	7.0	soil	112,936
S1011-SCX-031	B	12,669	8.0	soil	46,570
S1011-SCX-031	B	12,669	9.0	soil	14,706
S1011-SCX-031	B	12,669	10.0	soil	12,666
S1011-SCX-031	B	12,669	11.0	soil	12,820
S1011-SCX-031	B	12,669	12.0	soil	13,212
S1011-SCX-031	B	12,669	13.0	soil	13,678
S1011-SCX-031	B	12,669	14.0	soil	14,856
S1011-SCX-031	B	12,669	15.0	soil	16,104
S1011-SCX-031	B	12,669	16.0	soil	16,732
S1011-SCX-031	B	12,669	17.0	soil	17,160**
S1011-SCX-032	B	--	0.0	soil	10,570
S1011-SCX-032	B	12,669	1.0	soil	14,382
S1011-SCX-032	B	12,669	2.0	soil	16,332
S1011-SCX-032	B	12,669	3.0	soil	14,894
S1011-SCX-032	B	12,669	4.0	soil	13,608
S1011-SCX-032	B	12,669	5.0	soil	13,554
S1011-SCX-032	B	12,669	6.0	soil	14,296
S1011-SCX-032	B	12,669	7.0	soil	14,250
S1011-SCX-032	B	12,669	8.0	soil	14,892
S1011-SCX-032	B	12,669	9.0	soil	17,310
S1011-SCX-032	B	12,669	10.0	bedrock	21,916
S1011-SCX-032	B	12,669	11.0	bedrock	23,336

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
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**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-033	B	--	0.0	sediment	12,994
S1011-SCX-033	B	12,669	1.0	sediment	18,482
S1011-SCX-033	B	12,669	2.0	sediment	18,922
S1011-SCX-033	B	12,669	3.0	sediment	18,392
S1011-SCX-033	B	12,669	4.0	sediment	20,686
S1011-SCX-033	B	12,669	5.0	sediment	23,166
S1011-SCX-033	B	12,669	6.0	sediment	24,122
S1011-SCX-033	B	12,669	7.0	sediment	22,206
S1011-SCX-033	B	12,669	8.0	sediment	22,044
S1011-SCX-033	B	12,669	9.0	sediment	23,926
S1011-SCX-033	B	12,669	10.0	bedrock	31,118
S1011-SCX-034	B	--	0.0	soil	10,216
S1011-SCX-034	B	12,669	1.0	soil	12,334
S1011-SCX-034	B	12,669	2.0	soil	10,874
S1011-SCX-034	B	12,669	3.0	soil	10,392
S1011-SCX-034	B	12,669	4.0	soil	10,602
S1011-SCX-034	B	12,669	5.0	soil	11,044
S1011-SCX-034	B	12,669	6.0	soil	11,470
S1011-SCX-034	B	12,669	7.0	soil	11,290
S1011-SCX-034	B	12,669	8.0	soil	12,642
S1011-SCX-034	B	12,669	9.0	soil	13,500
S1011-SCX-034	B	12,669	10.0	soil	13,430
S1011-SCX-034	B	12,669	11.0	soil	14,888
S1011-SCX-034	B	12,669	13.0	bedrock	18,172
S1011-SCX-034	B	12,669	14.0	bedrock	19,656
S1011-SCX-034	B	12,669	14.5	bedrock	21,210
S1011-SCX-035	B	--	0.0	soil	11,674
S1011-SCX-035	B	12,669	1.0	soil	14,782
S1011-SCX-035	B	12,669	2.0	soil	16,220
S1011-SCX-035	B	12,669	3.0	soil	16,496
S1011-SCX-035	B	12,669	4.0	soil	14,548
S1011-SCX-035	B	12,669	5.0	soil	13,084
S1011-SCX-035	B	12,669	6.0	soil	13,386
S1011-SCX-035	B	12,669	7.0	soil	13,298
S1011-SCX-035	B	12,669	8.0	soil	13,728
S1011-SCX-035	B	12,669	9.0	soil	13,652
S1011-SCX-035	B	12,669	10.0	soil	14,074
S1011-SCX-035	B	12,669	11.0	soil	13,990
S1011-SCX-035	B	12,669	12.0	soil	15,622
S1011-SCX-035	B	12,669	13.0	soil	15,690
S1011-SCX-035	B	12,669	14.0	soil	15,844
S1011-SCX-035	B	12,669	15.0	soil	17,532
S1011-SCX-035	B	12,669	16.0	soil	18,100
S1011-SCX-035	B	12,669	17.0	soil	17,820
S1011-SCX-035	B	12,669	18.0	bedrock	17,452

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
*	The subsurface gamma investigation levels are derived from the background area measurements, refer to Section 4.1 of the RSE report
**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Table 4-2
Static Gamma Measurement Summary
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Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-035 continued					
S1011-SCX-035	B	12,669	19.0	bedrock	29,954
S1011-SCX-035	B	12,669	20.0	bedrock	31,690
S1011-SCX-036	B	--	0.0	soil	13,564
S1011-SCX-036	B	12,669	1.0	soil	15,048
S1011-SCX-036	B	12,669	2.0	soil	14,742
S1011-SCX-036	B	12,669	3.0	soil	12,738
S1011-SCX-036	B	12,669	4.0	soil	11,068
S1011-SCX-036	B	12,669	5.0	bedrock	13,984
S1011-SCX-036	B	12,669	6.0	bedrock	21,554
S1011-SCX-036	B	12,669	7.0	bedrock	25,802
S1011-SCX-036	B	12,669	7.5	bedrock	22,384
S1011-SCX-037	B	--	0.0	sediment	14,226
S1011-SCX-037	B	12,669	1.0	sediment	18,620
S1011-SCX-037	B	12,669	2.0	sediment	13,508
S1011-SCX-037	B	12,669	3.0	sediment	13,690
S1011-SCX-037	B	12,669	4.0	bedrock	12,558
S1011-SCX-037	B	12,669	5.0	bedrock	13,066
S1011-SCX-038	B	--	0.0	soil	24,372
S1011-SCX-038	B	12,669	1.0	soil	17,094
S1011-SCX-038	B	12,669	2.0	soil	12,736
S1011-SCX-038	B	12,669	3.0	soil	16,092
S1011-SCX-038	B	12,669	4.0	soil	13,244
S1011-SCX-038	B	12,669	5.0	soil	11,722
S1011-SCX-038	B	12,669	6.0	soil	12,444
S1011-SCX-038	B	12,669	7.0	soil	13,204
S1011-SCX-038	B	12,669	8.0	soil	14,028
S1011-SCX-038	B	12,669	9.0	soil	14,446
S1011-SCX-038	B	12,669	10.0	soil	15,148
S1011-SCX-038	B	12,669	11.0	soil	14,630
S1011-SCX-038	B	12,669	12.0	soil	15,030
S1011-SCX-038	B	12,669	13.0	soil	15,232
S1011-SCX-038	B	12,669	14.0	soil	14,684
S1011-SCX-038	B	12,669	15.0	soil	13,868
S1011-SCX-038	B	12,669	16.0	soil	13,826
S1011-SCX-038	B	12,669	17.0	bedrock	14,336
S1011-SCX-038	B	12,669	18.0	bedrock	13,668
S1011-SCX-038	B	12,669	19.0	bedrock	12,206
S1011-SCX-038	B	12,669	19.5	bedrock	14,560
S1011-SCX-039	B	--	0.0	soil	25,341
S1011-SCX-039	B	12,669	0.2	soil	72,575**
S1011-SCX-040	B	--	0.0	soil	16,404
S1011-SCX-040	B	12,669	0.5	soil	24,374**

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
*	The subsurface gamma investigation levels are derived from the background area measurements, refer to Section 4.1 of the RSE report
**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-044	B	--	0.0	soil	18,638
S1011-SCX-044	B	12,669	0.5	soil	32,807
S1011-SCX-044	B	12,669	0.8	soil	37,173**
S1011-SCX-006	C	--	0.0	soil	154,022
S1011-SCX-006	C	6,387	0.25	soil	154,588
S1011-SCX-006	C	6,387	1.0	soil	75,424
S1011-SCX-006	C	6,387	1.25	soil	47,582**
S1011-SCX-041	D	--	0.0	soil	8,725
S1011-SCX-041	D	10,099	0.5	soil	11,463
S1011-SCX-041	D	10,099	1.0	soil	14,067
S1011-SCX-041	D	10,099	1.5	soil	14,704
S1011-SCX-041	D	10,099	2.0	soil	16,358
S1011-SCX-041	D	10,099	2.5	soil	17,072
S1011-SCX-042	D	10,099	0.5	soil	9,653
S1011-SCX-042	D	10,099	1.0	soil	10,000
S1011-SCX-042	D	10,099	1.5	soil	9,725
S1011-SCX-042	D	10,099	2.0	soil	9,365
S1011-SCX-043	D	--	0.0	soil	10,128
S1011-SCX-043	D	10,099	0.25	soil	12,081**
S1011-SCX-001	E	--	0.0	sediment	18,116
S1011-SCX-001	E	11,450	0.5	sediment	40,869
S1011-SCX-001	E	11,450	1.0	sediment	42,405
S1011-SCX-001	E	11,450	1.5	sediment	34,807**
S1011-SCX-002	E	--	0.0	sediment	9,941
S1011-SCX-002	E	11,450	0.5	sediment	11,730
S1011-SCX-002	E	11,450	1.0	sediment	12,136
S1011-SCX-002	E	11,450	1.5	sediment	13,372**
S1011-SCX-003	E	--	0.0	sediment	10,529
S1011-SCX-003	E	11,450	0.5	sediment	16,417
S1011-SCX-003	E	11,450	1.0	sediment	21,117
S1011-SCX-003	E	11,450	1.5	sediment	27,011
S1011-SCX-003	E	11,450	2.0	sediment	30,415
S1011-SCX-003	E	11,450	2.25	sediment	34,453**
S1011-SCX-004	E	--	0.0	sediment	9,633
S1011-SCX-004	E	11,450	0.5	sediment	13,991
S1011-SCX-004	E	11,450	1.0	sediment	17,635
S1011-SCX-004	E	11,450	1.5	sediment	20,059
S1011-SCX-004	E	11,450	2.0	sediment	29,039**
S1011-SCX-005	E	--	0.0	sediment	14,559
S1011-SCX-005	E	11,450	0.5	sediment	12,706
S1011-SCX-005	E	11,450	1.0	sediment	13,934
S1011-SCX-005	E	11,450	1.5	sediment	17,422
S1011-SCX-005	E	11,450	2.0	sediment	22,217**

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
*	The subsurface gamma investigation levels are derived from the background area measurements, refer to Section 4.1 of the RSE report
**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Table 4-3
Gamma Correlation Study Soil Sample Analytical Results
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Location Identification	S1011-C01-001	S1011-C02-001	S1011-C03-001	S1011-C04-001	S1011-C05-001
Date Collected	3/29/2017	3/29/2017	3/29/2017	3/29/2017	3/29/2017
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Analyte (Units)					
Radionuclides (pCi/g)					
Radium-226	1.26 ± 0.3	25.2 ± 3.1	11 ± 1.4	1.83 ± 0.33	9 ± 1.2
Thorium-228	0.48 ± 0.1	0.341 ± 0.081	0.359 ± 0.084	0.52 ± 0.11	0.372 ± 0.085
Thorium-230	0.9 ± 0.17	15.5 ± 2.4	4.95 ± 0.79	1.4 ± 0.25	4.07 ± 0.66
Thorium-232	0.451 ± 0.092	0.335 ± 0.075	0.368 ± 0.08	0.48 ± 0.1	0.356 ± 0.078

Notes
Bold Bolded result indicates positively identified compound
pCi/g picocuries per gram

Table 4-4a
Site Characterization Soil Sample Analytical Results for Survey Area A
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Location Identification		S1011-CX-007	S1011-CX-012	S1011-CX-013	S1011-CX-013 Dup	S1011-SCX-008	S1011-SCX-008	S1011-SCX-008	S1011-SCX-017	S1011-SCX-017
Date Collected		5/13/2017	5/13/2017	5/13/2017	5/13/2017	5/13/2017	5/13/2017	5/13/2017	6/10/2017	6/10/2017
Depth (feet)		0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.0	1.0 - 1.5	0 - 0.5	0.5 - 1.0
Sample Category		surface	surface	surface	surface	surface	subsurface	subsurface	surface	subsurface
Sample Collection Method		grab	grab	grab	grab	grab	grab	grab	grab	grab
Media		soil	soil	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)										
Metals[1] (mg/kg)	Investigation Level									
Arsenic	11.9	2.3	3.4	2.8	3.2	3.4	2.4	2.3	4.1	3.8
Molybdenum	2.26	0.27	0.27	0.32	0.37	0.35	0.34	0.36	0.4	0.32
Selenium	NA	<1	<0.94	<0.96	<0.94	<1	<1	<1	<1	1
Uranium	3.23	5.3	120	28	34	29	19	20	230 D	220 D
Vanadium	27.3	16	310	20	23	26	16	17	210	210
Radionuclides (pCi/g)										
Radium-226	2.13	5.39 ± 0.75	12.1 ± 1.5 J-	8.6 ± 1.1	8.3 ± 1.1	12 ± 1.5	6.61 ± 0.91	8.9 ± 1.2	64.4 ± 7.6 J-	66.4 ± 7.9

Bold Bolded result indicates positively identified compound
Shaded Shaded result indicates result greater than or equal to the investigation level
Shaded Shaded result indicates analyte detected, where that analyte does not have an investigation level
mg/kg milligrams per kilogram
pCi/g picocuries per gram
NA An investigation level is not identified because in BG-1 selenium sample results were all non-detect
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< Result not detected above associated laboratory reporting limit
D Sample dilution required for analysis; reported values reflect the dilution
J- Data are estimated and are potentially biased low due to associated quality control data

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Table 4-4b
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area B
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	Location Identification	S1011-CX-001	S1011-CX-002	S1011-CX-003	S1011-CX-004	S1011-CX-004 Dup	S1011-CX-005	S1011-CX-010	S1011-CX-011	S1011-CX-014	S1011-CX-015	S1011-SCX-007	S1011-SCX-007	S1011-SCX-007	S1011-SCX-009
	Date Collected	12/1/2016	12/1/2016	12/1/2016	12/1/2016	12/1/2016	12/1/2016	5/13/2017	5/13/2017	5/13/2017	5/13/2017	5/13/2017	5/13/2017	5/13/2017	6/9/2017
	Depth (feet)	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.0	1.0 - 1.5	0 - 0.5
	Sample Category	surface	surface	surface	surface	surface	surface	surface	surface	surface	surface	surface	subsurface	subsurface	surface
	Sample Collection Method	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
	Media	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)															
Metals[1] (mg/kg)	Investigation Level														
Arsenic	2.34	1.8	2.3	2.8	2.6	2.6	3.2	1.9	2.3	1.9	1.9	3.5	2.8	3.9	2.3 J
Molybdenum	0.346	0.23	<0.21	<0.21	<0.26	0.27	0.4	<0.19	0.21	<0.19	<0.19	0.38	0.35	0.36	<0.21
Selenium	NA	<1.1	<1.1	<1	<1.3	<1.2	<1.1	<0.96	<0.96	<0.96	<0.96	<1	<1.1	<1.1	<1
Uranium	3.34	1.8	2.3	9.9	3.5	3.5	23	1.6	7.1	7.7	1.6 J	24 J	28	41	0.56
Vanadium	11.2	9.8	13	14	20	20	22	11	60	52	19	26 J-	22	33	13
Radionuclides (pCi/g)															
Radium-226	2.96	2.18 ± 0.38	2.35 ± 0.39	10.6 ± 1.4	4.24 ± 0.69 J+	4.81 ± 0.76 J+	11.3 ± 1.5 J+	2.39 ± 0.42	3.39 ± 0.5	5.54 ± 0.76 J-	1.66 ± 0.34	5.34 ± 0.76	3.74 ± 0.58	4.69 ± 0.67	0.88 ± 0.26

Bold Bolded result indicates positively identified compound
Shaded Shaded result indicates result greater than or equal to the investigation level
mg/kg milligrams per kilogram
pCi/g picocuries per gram
NA An investigation level is not identified because in BG-2 selenium sample results were all non-detect
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< Result not detected above associated laboratory reporting limit
D Sample dilution required for analysis; reported values reflect the dilution.
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Location Identification		S1011-SCX-009	S1011-SCX-010	S1011-SCX-010	S1011-SCX-011	S1011-SCX-011	S1011-SCX-011	S1011-SCX-011 Dup	S1011-SCX-012	S1011-SCX-012	S1011-SCX-013	S1011-SCX-014	S1011-SCX-014	S1011-SCX-015
Date Collected		6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/10/2017
Depth (feet)		0.5 - 2.0	0 - 0.5	0.5 - 3.0	0 - 0.5	0.5 - 3.0	3.0 - 4.0	0 - 0.5	0 - 0.5	3.0 - 4.0	0 - 0.5	0 - 0.5	0.5 - 4.0	0 - 0.5
Sample Category		subsurface	surface	subsurface	surface	subsurface	subsurface	surface	surface	subsurface	surface	surface	subsurface	surface
Sample Collection Method		composite	grab	composite	grab	composite	grab	grab	grab	grab	grab	grab	composite	grab
Media		soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)														
Metals[1] (mg/kg)	Investigation Level													
Arsenic	2.34	2.2	2.1	2	2.9	2.1	2.6	2.9	2.1	2.1	1.3	2.1	1.8	3.6
Molybdenum	0.346	<0.2	0.23	<0.21	0.4	<0.21	<0.2	0.43	<0.2	0.25	<0.2	<0.2	<0.2	0.73
Selenium	NA	<1	<1	<1	<0.99	<1.1	<1	<1	<0.99	<1	<1	<1	<1	<1
Uranium	3.34	0.48	3.6	2.4	0.8	0.49	1.2	0.93	2.2	1.4	2.3	6.8	0.81	7.6
Vanadium	11.2	17	11	12	15	13	14	16	11	12	7.2	12	15	53
Radionuclides (pCi/g)														
Radium-226	2.96	0.92 ± 0.24 J+	5.11 ± 0.73	2.36 ± 0.42	1.53 ± 0.33	0.78 ± 0.27 J+	1 ± 0.23	1.58 ± 0.31	2.6 ± 0.46	1.12 ± 0.27	2.5 ± 0.4	3.21 ± 0.52	0.81 ± 0.23	2.27 ± 0.39

Bold — Bolded result indicates positively identified compound
Shaded — Shaded result indicates result greater than or equal to the investigation level
mg/kg — milligrams per kilogram
pCi/g — picocuries per gram
NA — An investigation level is not identified because in BG-2 selenium sample results were all non-detect
1 — Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< — Result not detected above associated laboratory reporting limit
D — Sample dilution required for analysis; reported values reflect the dilution.
J — Data are estimated due to associated quality control data
J- — Data are estimated and are potentially biased low due to associated quality control data
J+ — Data are estimated and are potentially biased high due to associated quality control data

Table 4-4b
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area B
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	Location Identification	S1011-SCX-015	S1011-SCX-015 Dup	S1011-SCX-016	S1011-SCX-016	S1011-SCX-018	S1011-SCX-018	S1011-SCX-019	S1011-SCX-019	S1011-SCX-020	S1011-SCX-020	S1011-SCX-021	S1011-SCX-021	S1011-SCX-021
	Date Collected	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017
	Depth (feet)	0.5 - 1.5	0 - 0.5	0 - 0.5	2.5 - 3.0	0 - 0.5	1.0 - 3.5	0 - 0.5	0.5 - 2.5	0 - 0.5	0.5 - 4.0	0 - 0.5	12.0 - 13.0	14.0 - 15.0
	Sample Category	subsurface	surface	surface	subsurface	surface	subsurface	surface	subsurface	surface	subsurface	surface	subsurface	subsurface
	Sample Collection Method	grab	grab	grab	grab	grab	composite	grab	composite	grab	composite	grab	grab	grab
	Media	soil	soil	soil	soil	soil	soil/bedrock	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)														
Metals[1] (mg/kg)	Investigation Level													
Arsenic	2.34	2.5	2.9	5.9	3.6	3.5	12	3 J	3.9	2.4	2.9	1.5	2	1.5
Molybdenum	0.346	0.23	0.39	0.58	0.28	<0.19	0.22	<0.2	<0.21	<0.21	<0.2	<0.2	<0.2	0.3
Selenium	NA	<1	<1	<1	<1	<0.97	1.2	<1	<1	<1	<1	<0.98	<1	<1
Uranium	3.34	4.9	5.9	7	6.5	50	200 D	26	140 D	4.5	4.8	2.6	4.3	7.4
Vanadium	11.2	50	63	88	15	380	740	92 J	110	49	51	19	77	48
Radionuclides (pCi/g)														
Radium-226	2.96	3.59 ± 0.56	2.05 ± 0.34	2.93 ± 0.46	3.85 ± 0.54	19.8 ± 2.5 J-	80.2 ± 9.5	13.6 ± 1.8	37.2 ± 4.6	6.24 ± 0.88	6.23 ± 0.86 J+	3.02 ± 0.48	5.59 ± 0.74	3.99 ± 0.59

Bold — Bolded result indicates positively identified compound
Shaded — Shaded result indicates result greater than or equal to the investigation level
mg/kg — milligrams per kilogram
pCi/g — picocuries per gram
NA — An investigation level is not identified because in BG-2 selenium sample results were all non-detect
1 — Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< — Result not detected above associated laboratory reporting limit
D — Sample dilution required for analysis; reported values reflect the dilution.
J — Data are estimated due to associated quality control data
J- — Data are estimated and are potentially biased low due to associated quality control data
J+ — Data are estimated and are potentially biased high due to associated quality control data

Table 4-4b
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area B
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Location Identification		S1011-SCX-021	S1011-SCX-021	S1011-SCX-021 Dup	S1011-SCX-022	S1011-SCX-022	S1011-SCX-023	S1011-SCX-023	S1011-SCX-023	S1011-SCX-024	S1011-SCX-024	S1011-SCX-024 Dup	S1011-SCX-025	S1011-SCX-025
Date Collected		6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017
Depth (feet)		17.0 - 18.0	19.0 - 20.0	14.0 - 15.0	0 - 0.5	5.0 - 7.0	0 - 0.5	0.5 - 5.0	13.5 - 14.5	0 - 0.5	3.0 - 4.0	0 - 0.5	0 - 0.5	0.5 - 3.0
Sample Category		subsurface	subsurface	subsurface	surface	subsurface	surface	subsurface	subsurface	surface	subsurface	surface	surface	subsurface
Sample Collection Method		grab	grab	grab	grab	composite	grab	composite	grab	grab	grab	grab	grab	composite
Media		soil	soil/bedrock	soil	soil	soil	soil	soil	soil	soil	soil	soil	sediment	sediment
Analyte (Units)														
Metals[1] (mg/kg)	Investigation Level													
Arsenic	2.34	4.2	1.4	1.4	1.9	1.7	1.7	1.9	1.1	2.6	2.5	2.9	1.6	1.5
Molybdenum	0.346	0.28	0.3	0.34	1	0.24	<0.2	<0.21	<0.2	0.31	0.45	0.3	<0.2	<0.21
Selenium	NA	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Uranium	3.34	8.3	10	7.2	4.4	0.6	1.1	0.97	0.76	8.9	8.8	9.1	3.3	7.3
Vanadium	11.2	54	34	49	38	8.1	21 J-	14	9.3	23	23	25	10	9.6
Radionuclides (pCi/g)														
Radium-226	2.96	5.76 ± 0.81	6.75 ± 0.91	4.15 ± 0.61	3.64 ± 0.54	0.78 ± 0.23	1.44 ± 0.31	0.84 ± 0.24	1.22 ± 0.3	9 ± 1.2 J+	10.2 ± 1.3	6.67 ± 0.95 J+	6.08 ± 0.84	3.32 ± 0.52

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
NA	An investigation level is not identified because in BG-2 selenium sample results were all non-detect
1	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit
D	Sample dilution required for analysis; reported values reflect the dilution.
J	Data are estimated due to associated quality control data
J-	Data are estimated and are potentially biased low due to associated quality control data
J+	Data are estimated and are potentially biased high due to associated quality control data

Table 4-4b
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area B
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Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification		S1011-SCX-026	S1011-SCX-026	S1011-SCX-026	S1011-SCX-027	S1011-SCX-027	S1011-SCX-027	S1011-SCX-028	S1011-SCX-028	S1011-SCX-028 Dup	S1011-SCX-028	S1011-SCX-028	S1011-SCX-028	S1011-SCX-028
Date Collected		6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017
Depth (feet)		0 - 0.5	0.5 - 5.0	5.0 - 6.0	0 - 0.5	0.5 - 3.0	6.0 - 8.5	0 - 0.5	0.5 - 5.0	0.5 - 5.0	5.0 - 8.0	8.0 - 10.0	10.0 - 12.0	12.0 - 14.0
Sample Category		surface	subsurface	subsurface	surface	subsurface	subsurface	surface	subsurface	subsurface	subsurface	subsurface	subsurface	subsurface
Sample Collection Method		grab	composite	grab	grab	composite	composite	grab	composite	composite	composite	composite	composite	composite
Media		sediment	sediment	sediment	soil	soil	bedrock	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)	Investigation Level													
Metals[1] (mg/kg)														
Arsenic	2.34	1.8	2.5	2.1	2.1	2.2	1.7	2.9 J	2.6	2.6	2.4	1.7	1.7	1.8
Molybdenum	0.346	<0.2	0.22	0.27	<0.19	<0.2	0.34	0.27	0.33	0.25	0.4	<0.19	<0.2	<0.2
Selenium	NA	<0.98	<1	<1	<0.97	<1	<1	<1	<0.97	<0.98	<1	<0.97	<1	<0.98
Uranium	3.34	0.97	1.1	1.3	1	0.88	1.6	2.1 J-	28	11	11	1.1	2.4	1.5
Vanadium	11.2	9.5	16	14	14	14	17	14	18	14	15	9.1	12	9.8
Radionuclides (pCi/g)														
Radium-226	2.96	1.26 ± 0.29	1.48 ± 0.28	1.12 ± 0.28	1.74 ± 0.36	1.15 ± 0.32 J+	1.2 ± 0.25	1.91 ± 0.37	47.1 ± 5.6	45.8 ± 5.5	10.6 ± 1.4	13.8 ± 1.7	0.63 ± 0.22	1.36 ± 0.32

Bold Bolded result indicates positively identified compound
Shaded Shaded result indicates result greater than or equal to the investigation level
mg/kg milligrams per kilogram
pCi/g picocuries per gram
NA An investigation level is not identified because in BG-2 selenium sample results were all non-detect
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< Result not detected above associated laboratory reporting limit
D Sample dilution required for analysis; reported values reflect the dilution.
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Table 4-4b
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area B
Section 26
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification		S1011-SCX-029	S1011-SCX-029	S1011-SCX-030	S1011-SCX-030	S1011-SCX-031	S1011-SCX-031	S1011-SCX-031	S1011-SCX-031	S1011-SCX-031	S1011-SCX-031 Dup	S1011-SCX-032	S1011-SCX-032	S1011-SCX-032
Date Collected		6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017
Depth (feet)		0 - 0.5	0.5 - 3.0	0 - 0.5	0.5 - 5.0	0 - 0.5	0.5 - 5.0	5.0 - 7.0	7.0 - 10.0	10.0 - 12.0	10.0 - 12.0	0 - 0.5	0.5 - 5.0	5.0 - 9.0
Sample Category		surface	subsurface	surface	subsurface	surface	subsurface	subsurface	subsurface	subsurface	subsurface	surface	subsurface	subsurface
Sample Collection Method		grab	composite	grab	composite	grab	composite	composite	composite	composite	composite	grab	composite	composite
Media		soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)														
Metals[1] (mg/kg)	Investigation Level													
Arsenic	2.34	1.8	1.6	2.2	2.1	1.8	1.9	1.7	1.5	1.7	1.7	2.3	1.8	1.7
Molybdenum	0.346	0.2	<0.21	<0.2	<0.2	<0.2	<0.2	<0.19	<0.2	<0.19	<0.2	0.21	<0.2	0.28
Selenium	NA	<0.96	<1	<1	<1	<0.98	<1	<0.96	<1	<0.97	<1	<1	<1	<0.99
Uranium	3.34	2.2	2.1	0.62	0.58	0.89	0.8	1	0.49	0.61	0.58	0.76	0.81	1.1
Vanadium	11.2	20	13	12	14	11	11	8.7	7.6	8	7.4	13	9	12
Radionuclides (pCi/g)														
Radium-226	2.96	1.73 ± 0.3	2.87 ± 0.51 J+	1.16 ± 0.26	0.79 ± 0.22	0.98 ± 0.24	0.92 ± 0.24	0.69 ± 0.19	0.67 ± 0.22	0.57 ± 0.18	0.61 ± 0.2	1.44 ± 0.3	0.81 ± 0.2	1.01 ± 0.28

Bold Bolded result indicates positively identified compound
Shaded Shaded result indicates result greater than or equal to the investigation level
mg/kg milligrams per kilogram
pCi/g picocuries per gram
NA An investigation level is not identified because in BG-2 selenium sample results were all non-detect
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< Result not detected above associated laboratory reporting limit
D Sample dilution required for analysis; reported values reflect the dilution.
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Table 4-4b
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area B
Section 26
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification		S1011-SCX-033	S1011-SCX-033	S1011-SCX-033	S1011-SCX-033 Dup	S1011-SCX-034	S1011-SCX-034	S1011-SCX-034	S1011-SCX-035	S1011-SCX-035	S1011-SCX-035	S1011-SCX-036	S1011-SCX-036	S1011-SCX-036 Dup
Date Collected		6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/12/2017	6/12/2017	6/12/2017	6/12/2017	6/12/2017	6/12/2017	6/12/2017	6/12/2017	6/12/2017
Depth (feet)		0 - 0.5	0.5 - 5.0	5.0 - 9.0	0 - 0.5	0 - 0.5	0.5 - 5.0	5.0 - 10.0	0 - 0.5	0.5 - 5.0	5.0 - 8.0	0 - 0.5	0.5 - 3.0	0 - 0.5
Sample Category		surface	subsurface	subsurface	surface	surface	subsurface	subsurface	surface	subsurface	subsurface	surface	subsurface	surface
Sample Collection Method		grab	composite	composite	grab	grab	composite	composite	grab	composite	composite	grab	composite	grab
Media		sediment	sediment	sediment	sediment	soil	soil	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)	Investigation Level													
Metals[1] (mg/kg)														
Arsenic	2.34	2.1	2.2	1.5	2.2	2.8	1.7	1.5	3	2	1.9	2.8	2	2.9
Molybdenum	0.346	0.21	<0.2	0.31	0.25	<0.2	<0.2	0.3	0.22	<0.21	<0.2	0.22	<0.21	0.24
Selenium	NA	<1	<1	<1	<1	<1	<0.98	<0.99	<1	<1	<1	<1	<1	<1
Uranium	3.34	1.2	1.8	8.4	1.4	0.68	0.38	0.35	0.99 J	0.41	0.73	2.7	2	2.9
Vanadium	11.2	17	18	49	18	19	8.8	7.2	21	11	12	20	16	20
Radionuclides (pCi/g)														
Radium-226	2.96	1.75 ± 0.35	1.59 ± 0.35	3.31 ± 0.51	1.54 ± 0.29	1.26 ± 0.29	0.66 ± 0.18	0.65 ± 0.19	1.51 ± 0.3	0.94 ± 0.26	1.33 ± 0.3	3.79 ± 0.59	2.11 ± 0.42	3.74 ± 0.6

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
NA	An investigation level is not identified because in BG-2 selenium sample results were all non-detect
1	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit
D	Sample dilution required for analysis; reported values reflect the dilution.
J	Data are estimated due to associated quality control data
J-	Data are estimated and are potentially biased low due to associated quality control data
J+	Data are estimated and are potentially biased high due to associated quality control data

Table 4-4b
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area B
Section 26
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Analyte (Units)	Location Identification / Date Collected / Depth (feet) / Sample Category / Sample Collection Method / Media	S1011-SCX-037	S1011-SCX-037	S1011-SCX-038	S1011-SCX-038	S1011-SCX-038	S1011-SCX-039	S1011-SCX-040	S1011-SCX-044	S1011-SCX-044
	Date Collected	6/12/2017	6/12/2017	6/12/2017	6/12/2017	6/12/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017
	Depth (feet)	0 - 0.5	0.5 - 3.0	0 - 0.5	0.5 - 3.0	3.0 - 10.0	0 - 0.2	0 - 0.2	0 - 0.2	0.2 - 0.7
	Sample Category	surface	subsurface	surface	subsurface	subsurface	surface	surface	surface	subsurface
	Sample Collection Method	grab	composite	grab	composite	composite	grab	grab	grab	grab
	Media	soil	soil	soil	soil	soil	soil	soil	soil	soil
Metals[1] (mg/kg)	Investigation Level									
Arsenic	2.34	2.6	2.1	3.3	1.8	1.8	2.4	2.1	2.1	2.1
Molybdenum	0.346	<0.2	<0.19	11	0.28	<0.2	0.25	<0.19	0.22	0.22
Selenium	NA	<1	<0.97	<0.99	<1	<1	<1	<0.97	<1	<1
Uranium	3.34	68	2.3	8.7	1.6	1.1	5.2	2.3	6.5	7.1
Vanadium	11.2	15	13	12	9.3	10	12	12	12	11
Radionuclides (pCi/g)										
Radium-226	2.96	7.8 ± 1	1.28 ± 0.3	8.2 ± 1.1	0.73 ± 0.2	0.68 ± 0.19	6.9 ± 0.94	2.91 ± 0.47	7.8 ± 1	7.01 ± 0.94

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
NA	An investigation level is not identified because in BG-2 selenium sample results were all non-detect
1	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit
D	Sample dilution required for analysis; reported values reflect the dilution.
J	Data are estimated due to associated quality control data
J-	Data are estimated and are potentially biased low due to associated quality control data
J+	Data are estimated and are potentially biased high due to associated quality control data

Table 4-4c
Site Characterization Soil Sample Analytical Results for Survey Area C
Section 26
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase
Page 1 of 1

	Location Identification	S1011-CX-006	S1011-SCX-006	S1011-SCX-006
	Date Collected	5/13/2017	5/12/2017	5/12/2017
	Depth (feet)	0 - 0.5	0 - 0.5	0.5 - 1.25
	Sample Category	surface	surface	subsurface
	Sample Collection Method	grab	grab	grab
	Media	soil	soil	soil
Analyte (Units)				
Metals[1] (mg/kg)	Investigation Level			
Arsenic	4.99	1.3	1.3	1.2
Molybdenum	0.367	<0.19	<0.2	<0.21
Selenium	NA	<0.95	<1	<1
Uranium	1.91	7.1	24	16
Vanadium	17.4	43	12	17
Radionuclides (pCi/g)				
Radium-226	1.49	5.64 ± 0.78	24.3 ± 3	23.8 ± 2.9

Bold — Bolded result indicates positively identified compound
Shaded — Shaded result indicates result greater than or equal to the investigation level
mg/kg — milligrams per kilogram
pCi/g — picocuries per gram
NA — An investigation level is not identified because in BG-3 selenium sample results were all non-detect
[1] — Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< — Result not detected above associated laboratory reporting limit
J- — Data are estimated and are potentially biased low due to associated quality control data

Table 4-4d
Site Characterization Soil Sample Analytical Results for Survey Area D
Section 26
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

	Location Identification	S1011-SCX-041	S1011-SCX-041	S1011-SCX-042	S1011-SCX-042	S1011-SCX-043	S1011-SCX-043 Dup
	Date Collected	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017
	Depth (feet)	0 - 0.2	0.2 - 2.5	0 - 0.2	0.2 - 2.0	0 - 0.2	0 - 0.2
	Sample Category	surface	subsurface	surface	subsurface	surface	surface
	Sample Collection Method	grab	grab	grab	composite	grab	grab
	Media	soil	soil	soil	soil	soil	soil
Analyte (Units)							
Metals[1] (mg/kg)	Investigation Level						
Arsenic	1.76	1.3	1.5	1.4	1.4	1.1	1.3
Molybdenum	0.210	<0.2	<0.2	<0.2	<0.2	<0.2	<0.19
Selenium	NA	<0.99	<0.98	<0.98	<0.99	<1	<0.97
Uranium	0.554	1.3	0.79	0.57	0.38	2	0.71
Vanadium	11.0	8.4	10	15	11 J+	20	13
Radionuclides (pCi/g)							
Radium-226	1.49	0.72 ± 0.22	1.66 ± 0.33	1.11 ± 0.28	0.56 ± 0.19	1.77 ± 0.32	1.99 ± 0.34

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
NA	An investigation level is not identified because in BG-4 selenium sample results were all non-detect
1	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit
J+	Data are estimated and are potentially biased high due to associated quality control data

	Location Identification	S1011-CX-008	S1011-CX-009	S1011-SCX-001	S1011-SCX-001	S1011-SCX-002	S1011-SCX-002	S1011-SCX-003	S1011-SCX-003	S1011-SCX-003	S1011-SCX-003 Dup	S1011-SCX-004
	Date Collected	5/13/2017	5/13/2017	5/12/2017	5/12/2017	5/12/2017	5/12/2017	5/12/2017	5/12/2017	5/12/2017	5/12/2017	5/12/2017
	Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.5	0 - 0.5	0.5 - 1.5	0 - 0.5	0.5 - 1.5	1.5 - 2.25	0 - 0.5	0 - 0.5
	Sample Category	surface	surface	surface	subsurface	surface	subsurface	surface	subsurface	subsurface	surface	surface
	Sample Collection Method	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
	Media	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment
Analyte (Units)												
Metals[1] (mg/kg)	Investigation Level											
Arsenic	1.73	0.84	1.3	1	1.2	0.94	0.85	0.81	0.87	0.94	0.97	0.56
Molybdenum	NA	<0.2	<0.23	<0.19	0.2	<0.19	<0.2	<0.2	<0.21	<0.21	<0.2	<0.19
Selenium	NA	<0.98	<1.1	<0.97	<1	<0.94	<1	<1	<1.1	<1	<1	<0.97
Uranium	0.691	0.58	0.68	1.1	1.3	0.48	0.4	0.72	0.7	2	1.5	0.81
Vanadium	10.7	9.9	52	85	13	8.3	9.3	8.7	13	21	28	4.1
Radionuclides (pCi/g)												
Radium-226	0.839	1.18 ± 0.25	0.72 ± 0.21	1.93 ± 0.35	2.48 ± 0.39	0.95 ± 0.23	0.54 ± 0.2	1.64 ± 0.28	2.23 ± 0.37	3.41 ± 0.5	1.55 ± 0.32	1.53 ± 0.31

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
Shaded	Shaded result indicates analyte detected, where that analyte does not have an investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
NA	An investigation level is not identified because in BG-5 selenium and molybdenum sample results were all non-detect
1	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit

Table 4-4e
Site Characterization Sediment Sample Analytical Results for Survey Area E
Section 26
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

	Location Identification	S1011-SCX-004	S1011-SCX-004	S1011-SCX-005	S1011-SCX-005	S1011-SCX-005
	Date Collected	5/12/2017	5/12/2017	5/12/2017	5/12/2017	5/12/2017
	Depth (feet)	0.5 - 1.5	1.5 - 2.0	0 - 0.5	0.5 - 1.5	1.5 - 2.0
	Sample Category	subsurface	subsurface	surface	subsurface	subsurface
	Sample Collection Method	grab	grab	grab	grab	grab
	Media	sediment	sediment	sediment	sediment	sediment
Analyte (Units)						
Metals[1] (mg/kg)	Investigation Level					
Arsenic	1.73	0.73	0.83	0.98	0.97	1
Molybdenum	NA	<0.2	<0.21	<0.19	<0.2	<0.2
Selenium	NA	<0.99	<1	<0.96	<0.98	<1
Uranium	0.691	2.9	15	1.9	1.7	1.9
Vanadium	10.7	5.8	35	6.8	6	9.2
Radionuclides (pCi/g)						
Radium-226	0.839	2.26 ± 0.39	3.51 ± 0.51	1.59 ± 0.31	1.9 ± 0.35	3.1 ± 0.46

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
Shaded	Shaded result indicates analyte detected, where that analyte does not have an investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
NA	An investigation level is not identified because in BG-5 selenium and molybdenum sample results were all non-detect
1	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit

Table 4-5
Summary of Investigation Level Exceedances in Soil at Borehole Locations
Section 26
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Sample Location	Survey Area	Investigation Level Exceedances
S1011-SCX-001[1]	E	Mo, U, V, Ra-226, Static Gamma
S1011-SCX-002	E	Ra-226, Static Gamma
S1011-SCX-003	E	U, V, Ra-226, Static Gamma
S1011-SCX-004	E	U, V, Ra-226, Static Gamma
S1011-SCX-005	E	U, Ra-226, Static Gamma
S1011-SCX-006	C	U, Ra-226, Static Gamma
S1011-SCX-007	B	As, Mo, U, V, Ra-226, Static Gamma
S1011-SCX-008	A	U, Ra-226, Static Gamma
S1011-SCX-009	B	V
S1011-SCX-010	B	U, V, Ra-226, Static Gamma
S1011-SCX-011	B	As, Mo, V
S1011-SCX-012	B	V, Static Gamma
S1011-SCX-014	B	U, V, Ra-226
S1011-SCX-015	B	As, Mo, U, V, Ra-226
S1011-SCX-016	B	As, Mo, U, V, Ra-226, Static Gamma
S1011-SCX-017[1]	A	Se, U, V, Ra-226, Static Gamma
S1011-SCX-018[1,2]	B	As, Se, U, V, Ra-226, Static Gamma
S1011-SCX-019	B	As, U, V, Ra-226, Static Gamma
S1011-SCX-020	B	As, U, V, Ra-226, Static Gamma
S1011-SCX-021	B	As, U, V, Ra-226, Static Gamma
S1011-SCX-022	B	Mo, U, V, Ra-226, Static Gamma
S1011-SCX-023	B	V, Static Gamma
S1011-SCX-024	B	As, Mo, U, V, Ra-226, Static Gamma
S1011-SCX-025	B	U, Ra-226, Static Gamma
S1011-SCX-026	B	As, V, Static Gamma
S1011-SCX-027[2]	B	Mo, V, Static Gamma
S1011-SCX-028	B	As, Mo, U, V, Ra-226, Static Gamma
S1011-SCX-029	B	V, Static Gamma
S1011-SCX-030	B	V, Static Gamma
S1011-SCX-031	B	Static Gamma
S1011-SCX-032	B	V, Static Gamma
S1011-SCX-033	B	U, V, Ra-226, Static Gamma
S1011-SCX-034	B	As, V, Static Gamma
S1011-SCX-035	B	As, V, Static Gamma
S1011-SCX-036	B	As, V, Ra-226, Static Gamma
S1011-SCX-037	B	As, U, V, Ra-226, Static Gamma
S1011-SCX-038	B	As, Mo, U, V, Ra-226, Static Gamma
S1011-SCX-039	B	As, U, V, Ra-226, Static Gamma
S1011-SCX-040	B	V, Static Gamma
S1011-SCX-041	D	U, Ra-226, Static Gamma
S1011-SCX-042	D	U, V
S1011-SCX-043	D	U, V, Ra-226, Static Gamma
S1011-SCX-044	B	U, V, Ra-226, Static Gamma

Notes
[1] Detections of Se and/or Mo included for reference, no IL was established for Se and/or Mo
[2] Includes a sample that crosses the soil to bedrock contact
IL - Investigation Level
As - Arsenic
Mo - Molybdenum
Ra-226 - Radium 226
Se - Selenium
U - Uranium
V - Vanadium

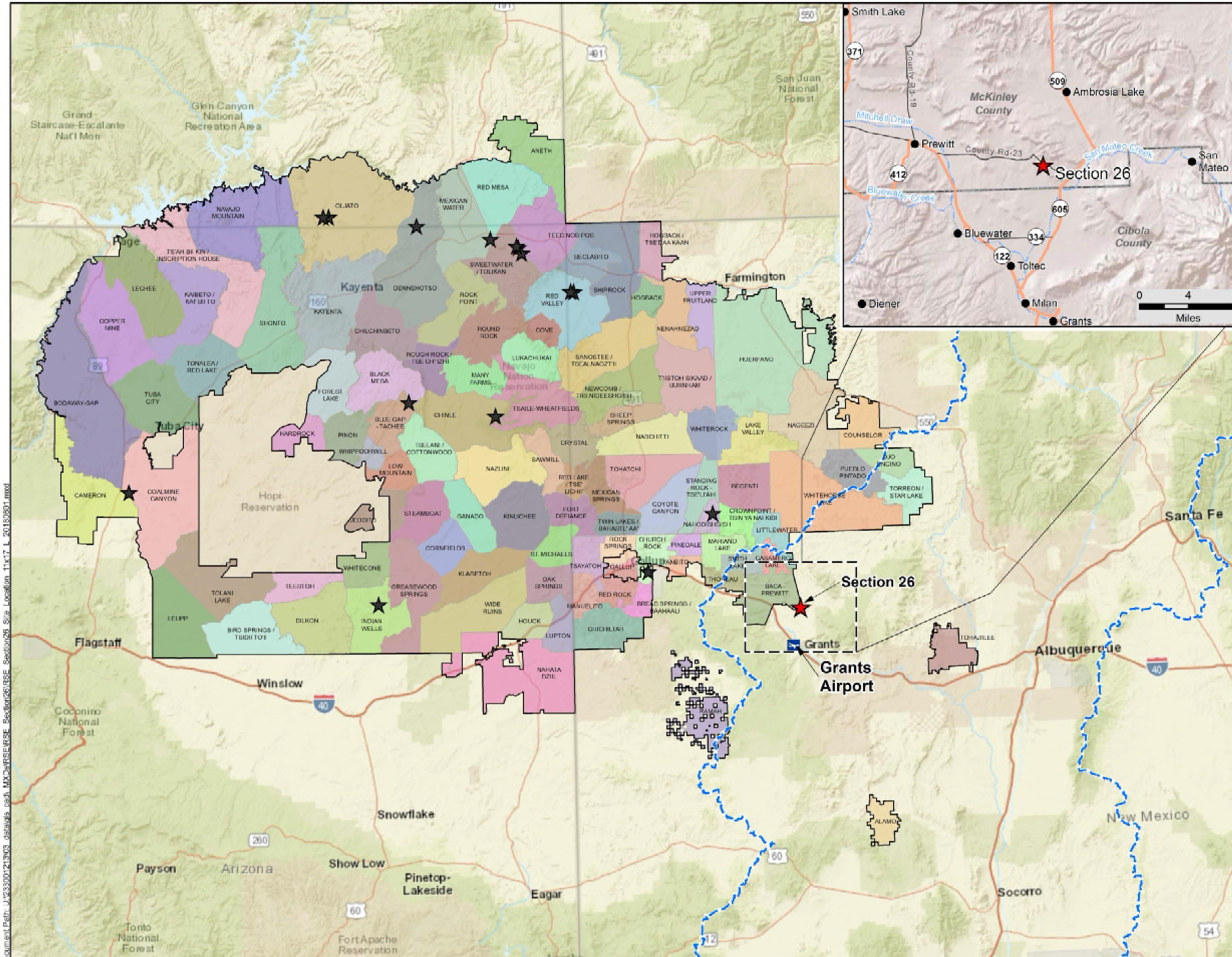
FIGURES

FIGURE ACRONYMS/ABBREVIATIONS

As	arsenic
BG	potential background reference area
bgs	below ground surface
cpm	counts per minute
ft	feet
IL	investigation level
mg/kg	milligrams per kilogram
Mo	molybdenum
NA	not applicable
NAD	North American Datum
NAVD88	North American Vertical Datum of 1988
pCi/g	picocuries per gram
Ra	radium-226
Ra-226	radium-226
Se	selenium
TENORM	Technologically Enhanced Naturally Occurring Radioactive Materials
uk	unknown
U	uranium
UTL	upper tolerance limit
UTM	Universal Transverse Mercator
V	vanadium

NOTE FOR FIGURES

Section 26 is located just within UTM Zone 13 North, but was projected and displayed in NAD 83 UTM Zone 12 North (meters) for data management and figure display purposes because the other 15 priority AUMs are located in UTM Zone 12 North

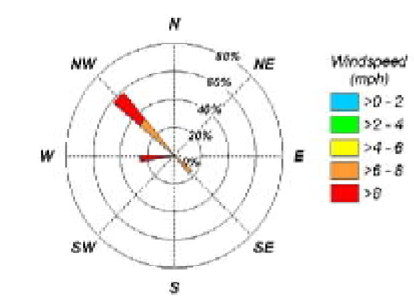


NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Section 26 Mine Site
- Priority Abandoned Uranium Mine (AUM) Site
- Populated Place
- State Highway
- Major Road
- Intermittent Stream
- Rio Grande-Elephant Butte Watershed
- Navajo Nation Boundary
- Navajo Nation Chapter

Grants Airport, New Mexico Wind Rose (KGNT), 1996-2006



REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap: ESRI World Street Map and World Shaded Relief accessed 08/2018.

Wind Rose: USEPA, 2007a

0 25 50
Miles

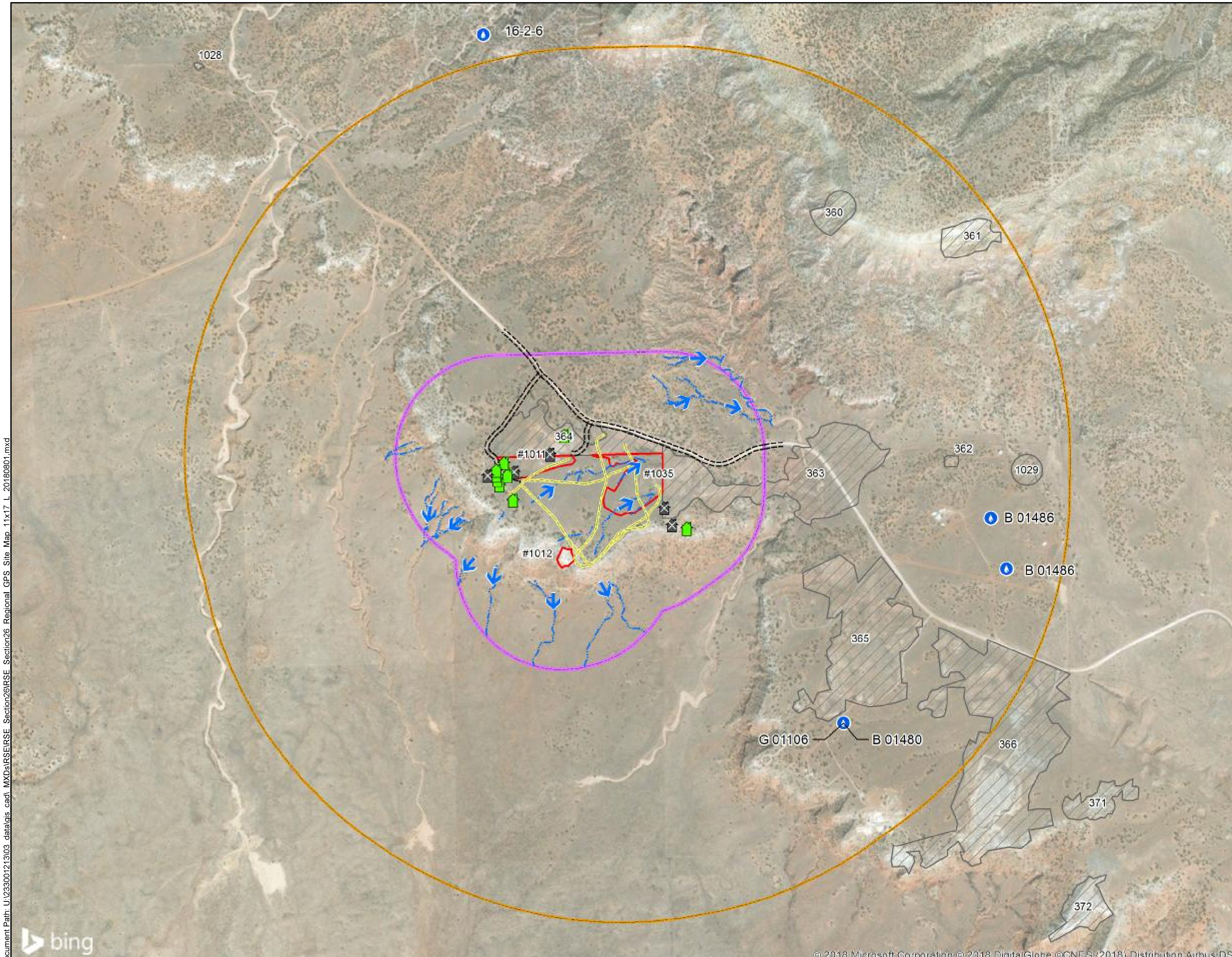
TITLE:

Site Location

PROJECT:

Removal Site Evaluation
Section 26 Mine Site

DATE: 8/2/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 1-1	



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Site Clearance Identified Water Feature[1]
- Habitable Building
- Uninhabitable Building
- Flow Direction
- Drainage
- Potential Haul Road
- Road
- Claim Boundary
- 1/4-Mile Claim Boundary Buffer
- 1-Mile Claim Boundary Buffer
- Other Claim Boundary

NOTES:

1. Water features and identification names identified in 2007 AUM Atlas.

2. Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S

0 1,250 2,500
Feet

TITLE: Site Features

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 9/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

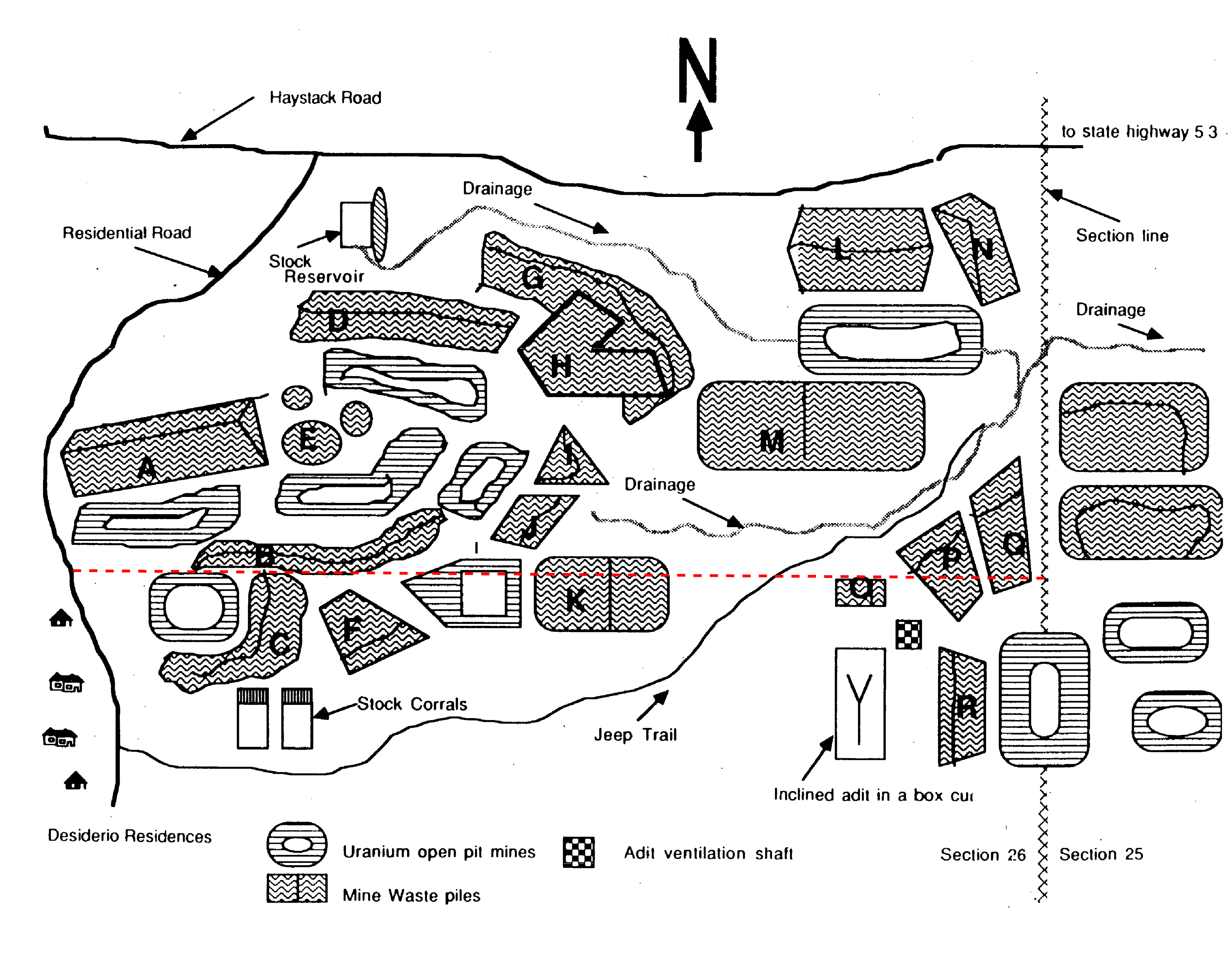
AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 2-1

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Regional_GPS_Site_Map_11x17_L_20180801.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Approximate Northern Boundaries of the Section 26 Mines #1011 and #1035

Mine Waste Pile	Volume (cubic yards)
A	21,600
B	600
C	1,575
D	8000
E	2,709
F	187
G	5,000
H	3,150
I	300
J	300
K	18,750
L	7,000
M	21,000
N	625
O	30
P	140
Q	120
R	875

REFERENCES:
Navajo Superfund Office (NSO), 1990. Preliminary Assessment Package for the Navajo-Desiderio Group Uranium Mines. Worksheet # 1 Estimation of Hazardous Waste

TITLE: Historical Mine Drawing

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 8/2/2018

DOCUMENT NAME: Removal Site Evaluation Report

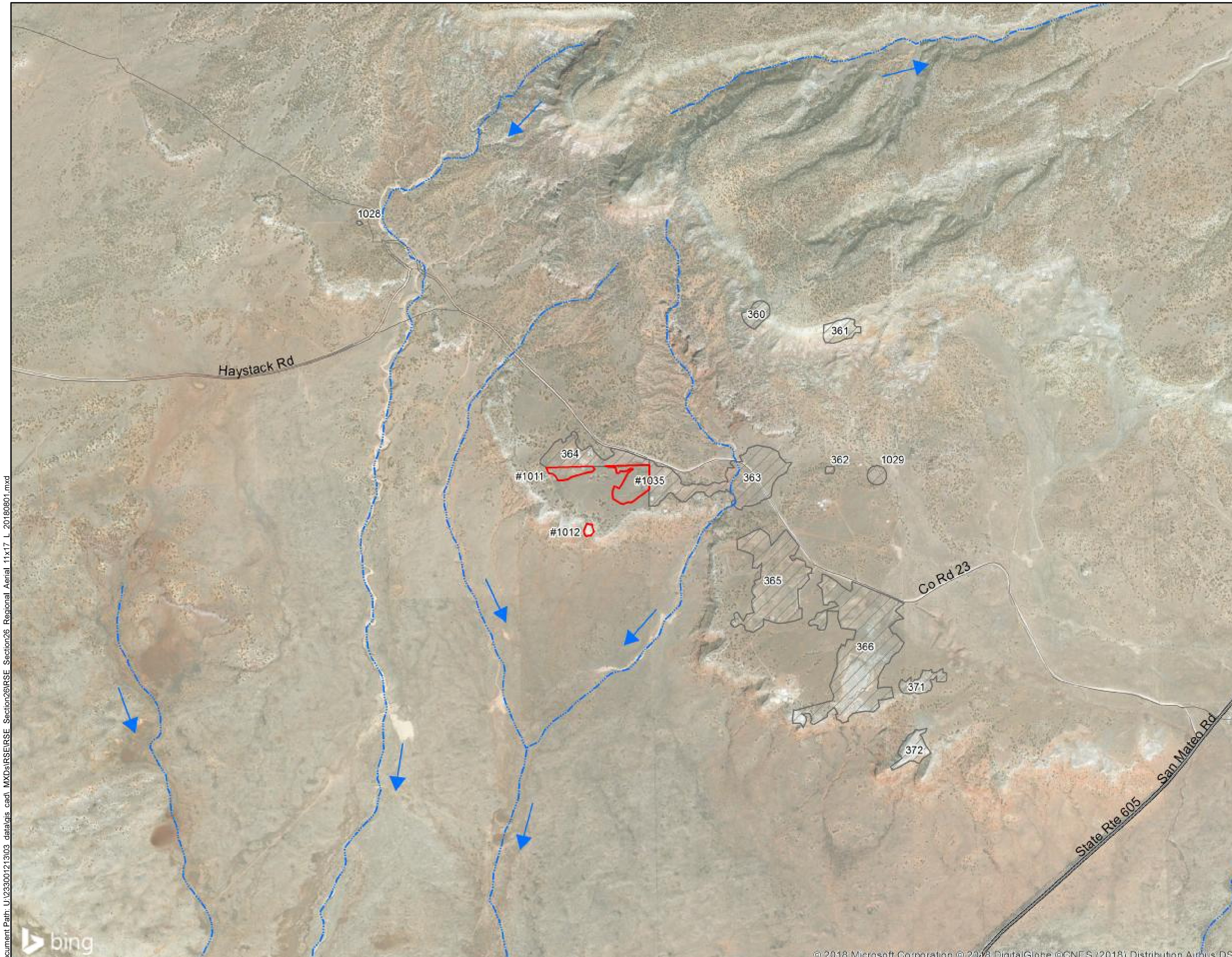
AUTHOR: CBB

REVIEWER: KJJ

Stantec

FIGURE: 2-2

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_HistoricalDrawing_11x17_L_20180801.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Flow Direction
- Intermittent Stream/River
- State Highway
- County Road
- Local Road
- Claim Boundary
- Other Claim Boundary

NOTE:
Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

N W E S

0 2,000 4,000
Feet

TITLE:
Regional Aerial Photograph

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 8/1/2018

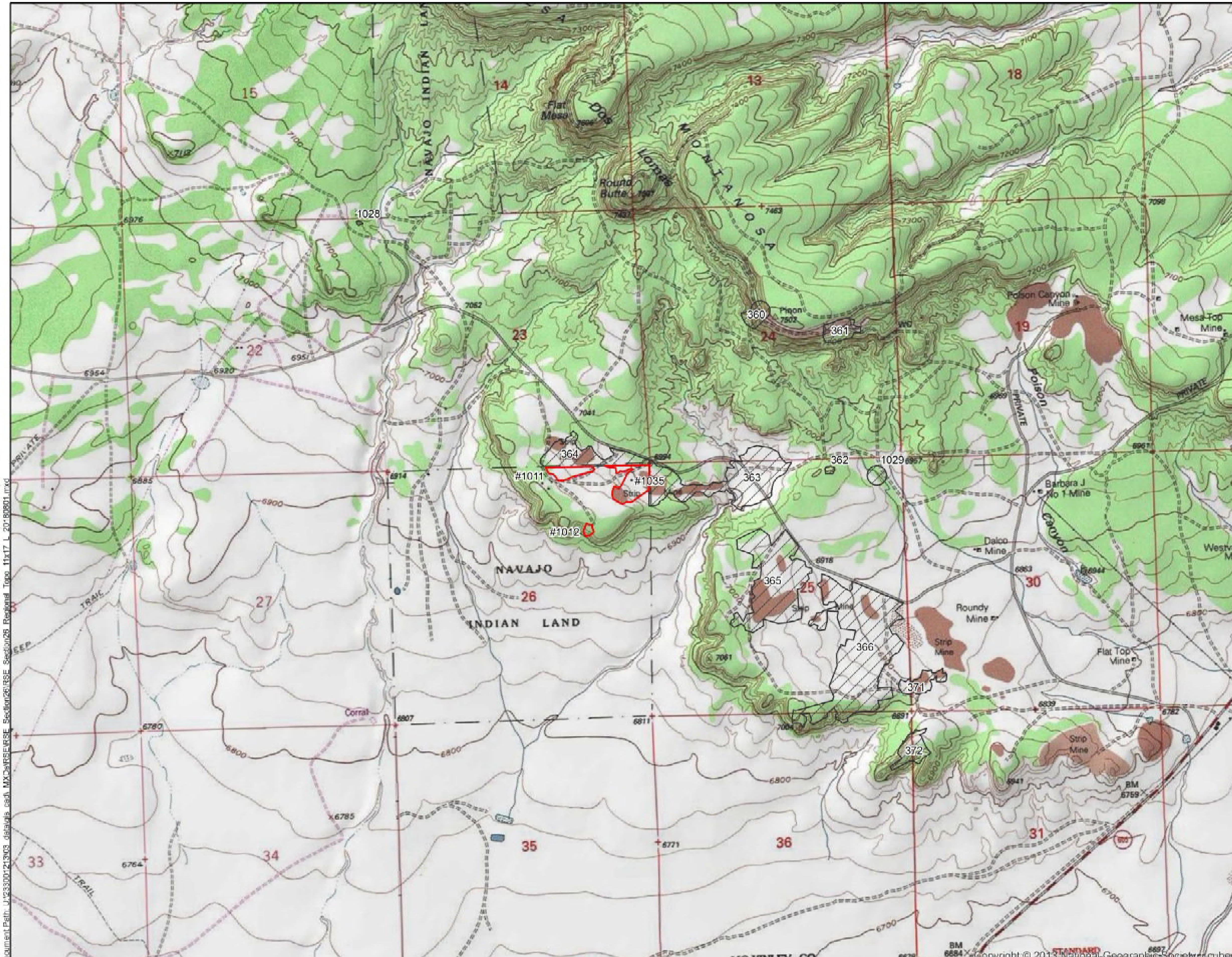
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 2-3



NAVAJO NATION

AUM Environmental Response Trust-First Phase

LEGEND

Claim Boundary

Other Claim Boundary

NOTE:

Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap: ESRI USA Topo Maps service accessed 08/2018.

N

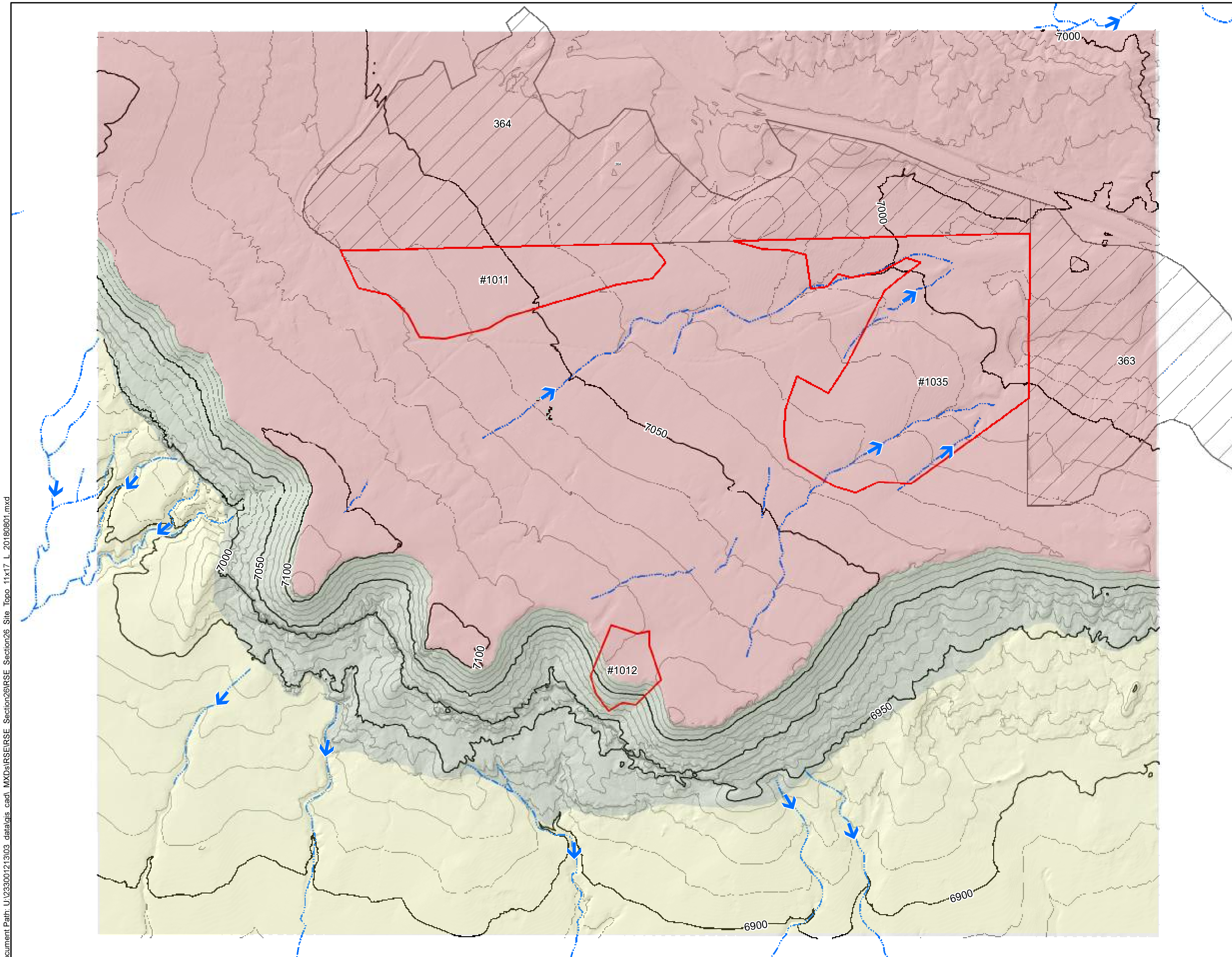
W E

S

0 2,000 4,000

Feet

TITLE:	Regional Topographic Map
PROJECT:	Removal Site Evaluation Section 26 Mine Site
DATE: 8/1/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: EDZ REVIEWER: CBB
	FIGURE: 2-4



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Flow Direction
- Drainage
- Index Contour (50 ft Interval)
- Intermediate Contour (10 ft Interval)
- Claim Boundary
- Other Claim Boundary

Geomorphology Features

- Mesa Top
- Mesa Sidewall
- Plains

NOTES:

The extent of the basemap is based on the Cooper aerial surveys conducted on June 16, 2017.

Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:

Site-specific contours were generated as part of aerial surveys conducted on June 16, 2017.

Coordinate System: NAD 1983 UTM Zone 12N

N W E S

0 300 600 Feet

TITLE: Site Topography

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 8/1/2018

DOCUMENT NAME: Removal Site Evaluation Report

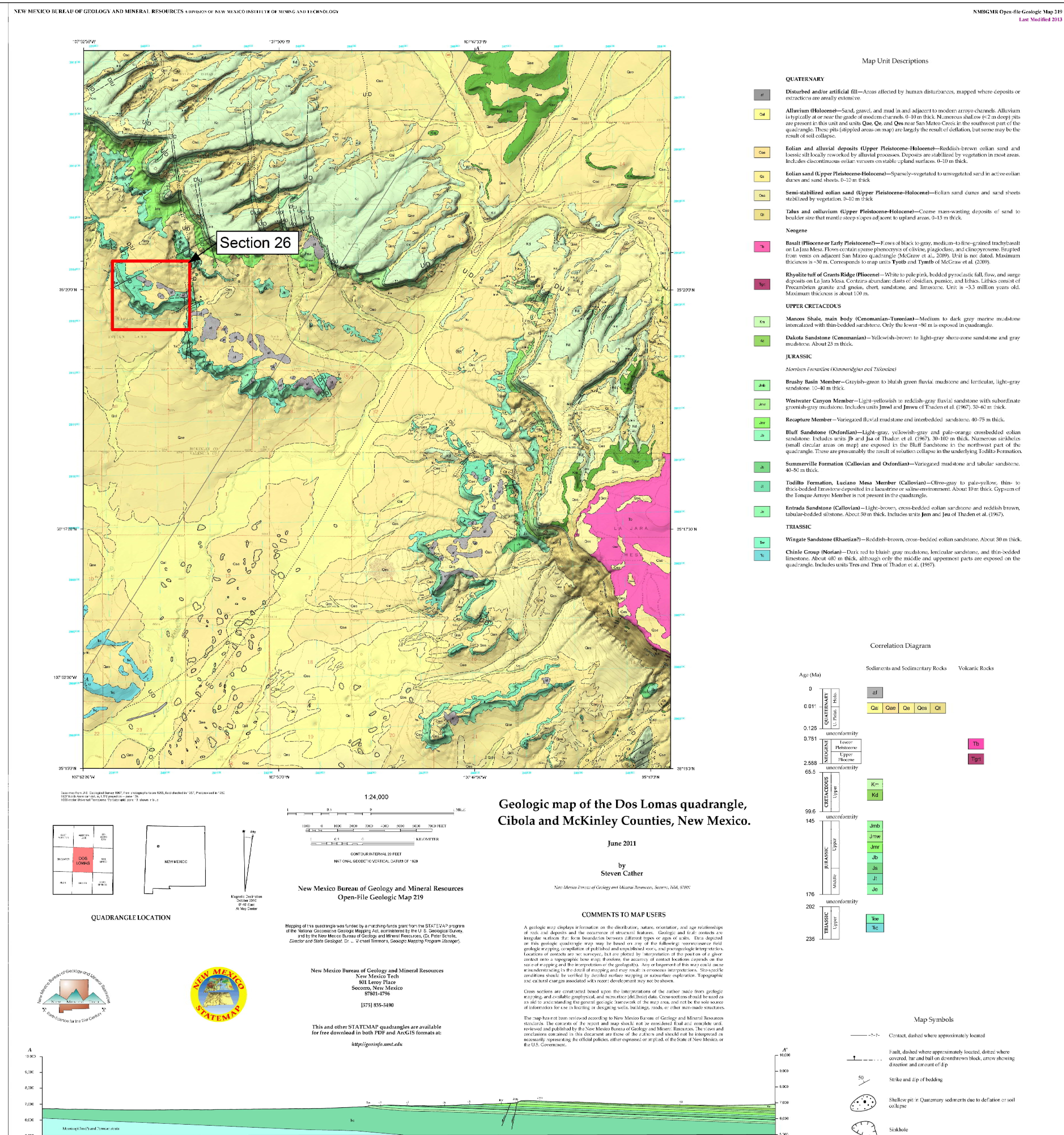
Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 2-5

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Site_Topo_11x17_L_20180801.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

TITLE:
Regional Geology

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 8/1/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 2-6

NOTES:
Based on field observations at the Site, bedrock units shown are near surface (typically within 1 foot), but do not necessarily outcrop and may be overlain by minor Q deposits.

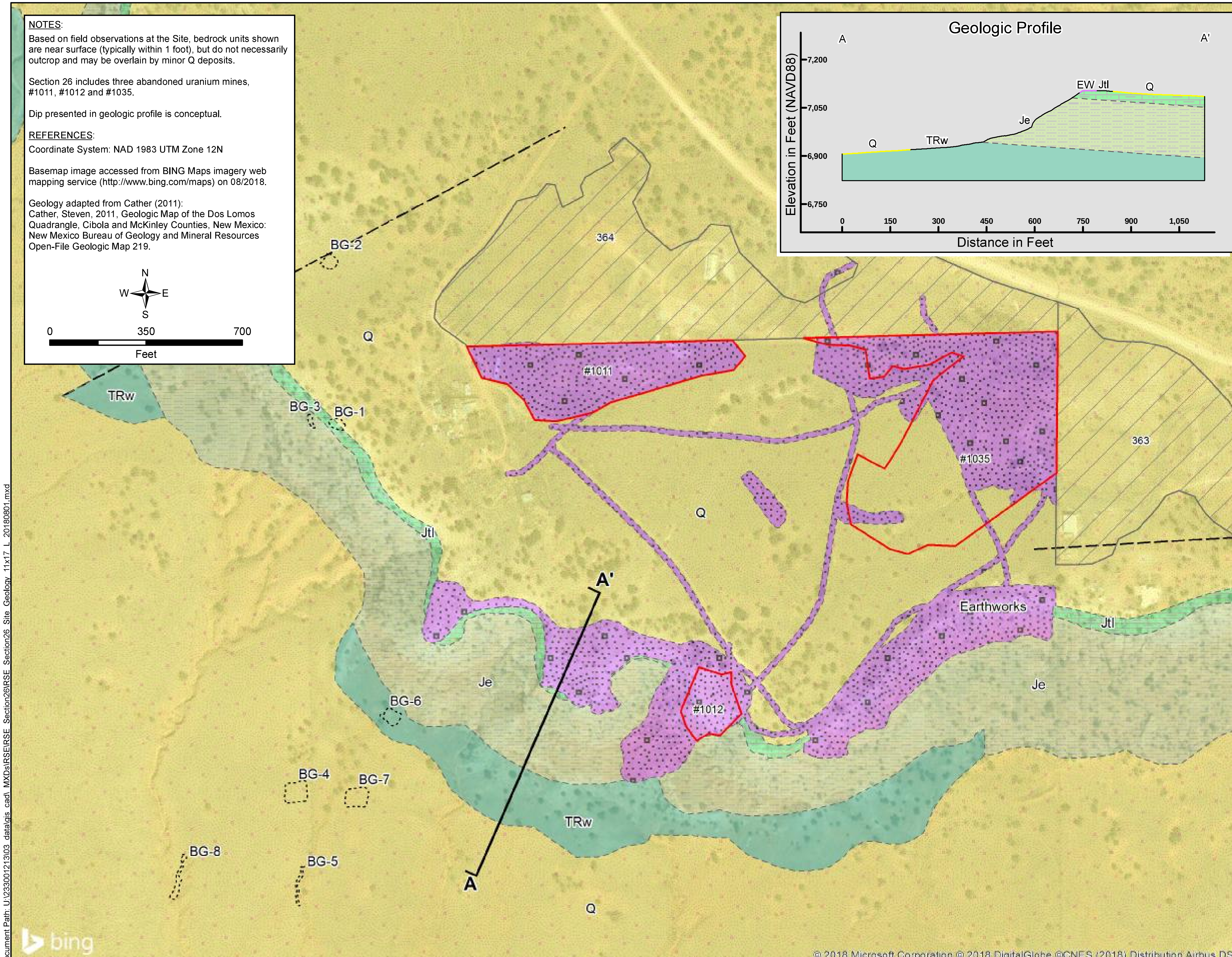
Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

Dip presented in geologic profile is conceptual.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

Geology adapted from Cather (2011):
Cather, Steven, 2011, Geologic Map of the Dos Lomos Quadrangle, Cibola and McKinley Counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-File Geologic Map 219.



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Geologic Profile
Potential Background Reference Area
Claim Boundary
Other Claim Boundary
Geology Contact (Inferred)
Fault

Site Geology

HOLOCENE

Earthworks: Human-caused disturbance of the land surface potentially related to mining or reclamation.

Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly colluvial and alluvial deposits, and eolian sand deposits.

JURASSIC

Jtl: Luciano Mesa Member of the Todilto Formation (Upper Jurassic) – Olive-gray to pale-yellow, thin- to thick-bedded limestone deposited in a lacustrine or saline environment.

Je: Entrada Sandstone – (Upper and Middle Jurassic) – Reddish-orange to reddish-brown fine- to medium-grained eolian crossbedded sandstone and dark-reddish-brown clayey siltstone and very fine grained silty sandstone.

TRIASSIC

TRw: Wingate Sandstone (Upper Triassic) – Reddish-brown, fine- to medium-grained, cross-bedded eolian sandstone.

TITLE: Site Geology

PROJECT: Removal Site Evaluation
Section 26 Mine Site

DATE: 8/23/2018

DOCUMENT NAME: Removal Site Evaluation Report

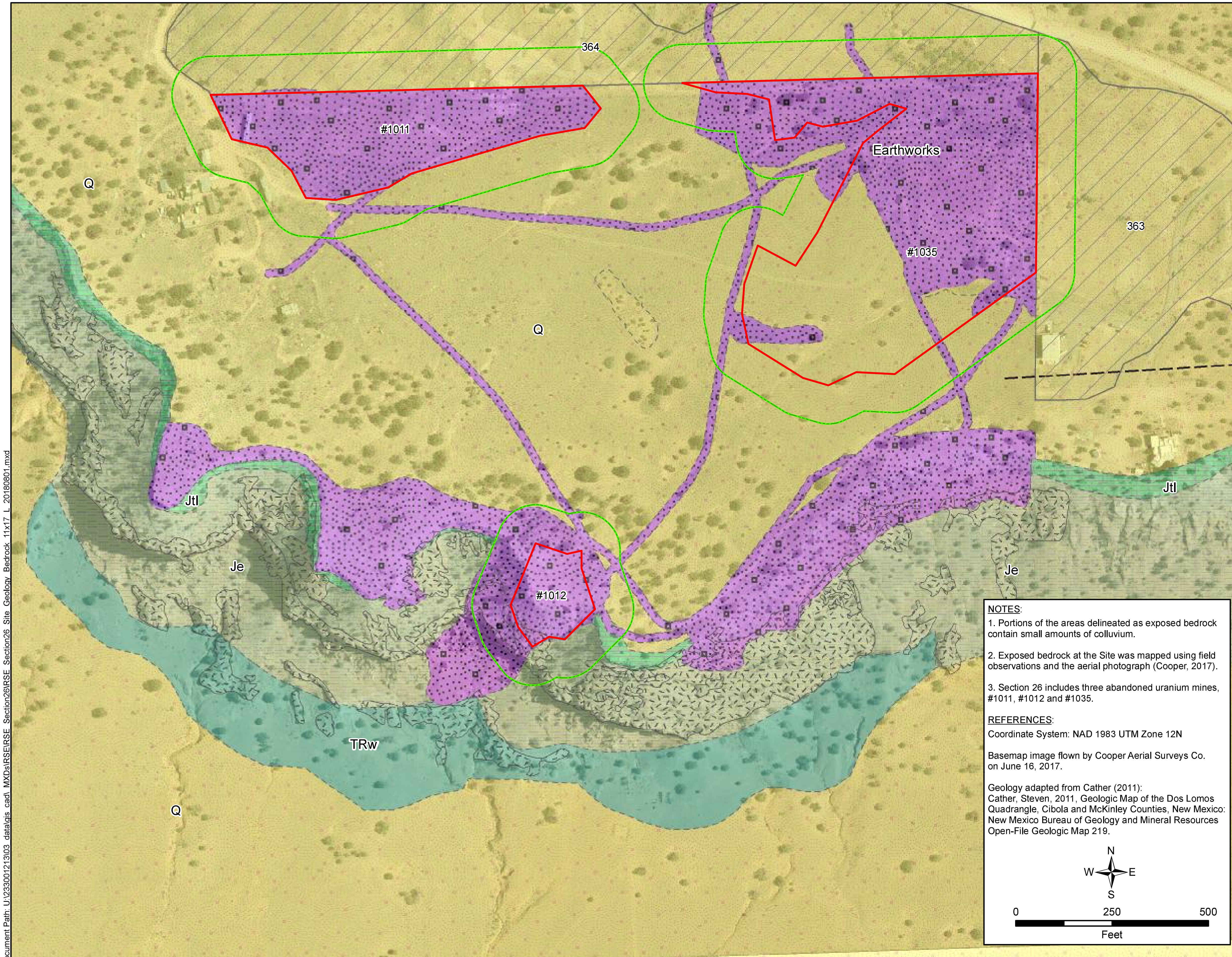
Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 2-7a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Site_Geology_11x17_L_20180801.mxd



NOTES:

1. Portions of the areas delineated as exposed bedrock contain small amounts of colluvium.

2. Exposed bedrock at the Site was mapped using field observations and the aerial photograph (Cooper, 2017).

3. Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

Geology adapted from Cather (2011):
Cather, Steven, 2011, Geologic Map of the Dos Lomos Quadrangle, Cibola and McKinley Counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-File Geologic Map 219.

N
W E
S

0 250 500
Feet

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Claim Boundary
- 100-Foot Claim Buffer
- Other Claim Boundary
- Geology Contact (Inferred)
- Fault
- Exposed Bedrock[1]

Site Geology

HOLOCENE

Earthworks: Human-caused disturbance of the land surface potentially related to mining or reclamation.

Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly colluvial and alluvial deposits, and eolian sand deposits.

JURASSIC

Jtl: Luciano Mesa Member of the Todilto Formation (Upper Jurassic) – Olive-gray to pale-yellow, thin- to thick-bedded limestone deposited in a lacustrine or saline environment.

Je: Entrada Sandstone – (Upper and Middle Jurassic) – Reddish-orange to reddish-brown fine- to medium-grained eolian crossbedded sandstone and dark-reddish-brown clayey siltstone and very fine grained silty sandstone.

TRIASSIC

TRw: Wingate Sandstone (Upper Triassic) – Reddish-brown, fine- to medium-grained, cross-bedded eolian sandstone.

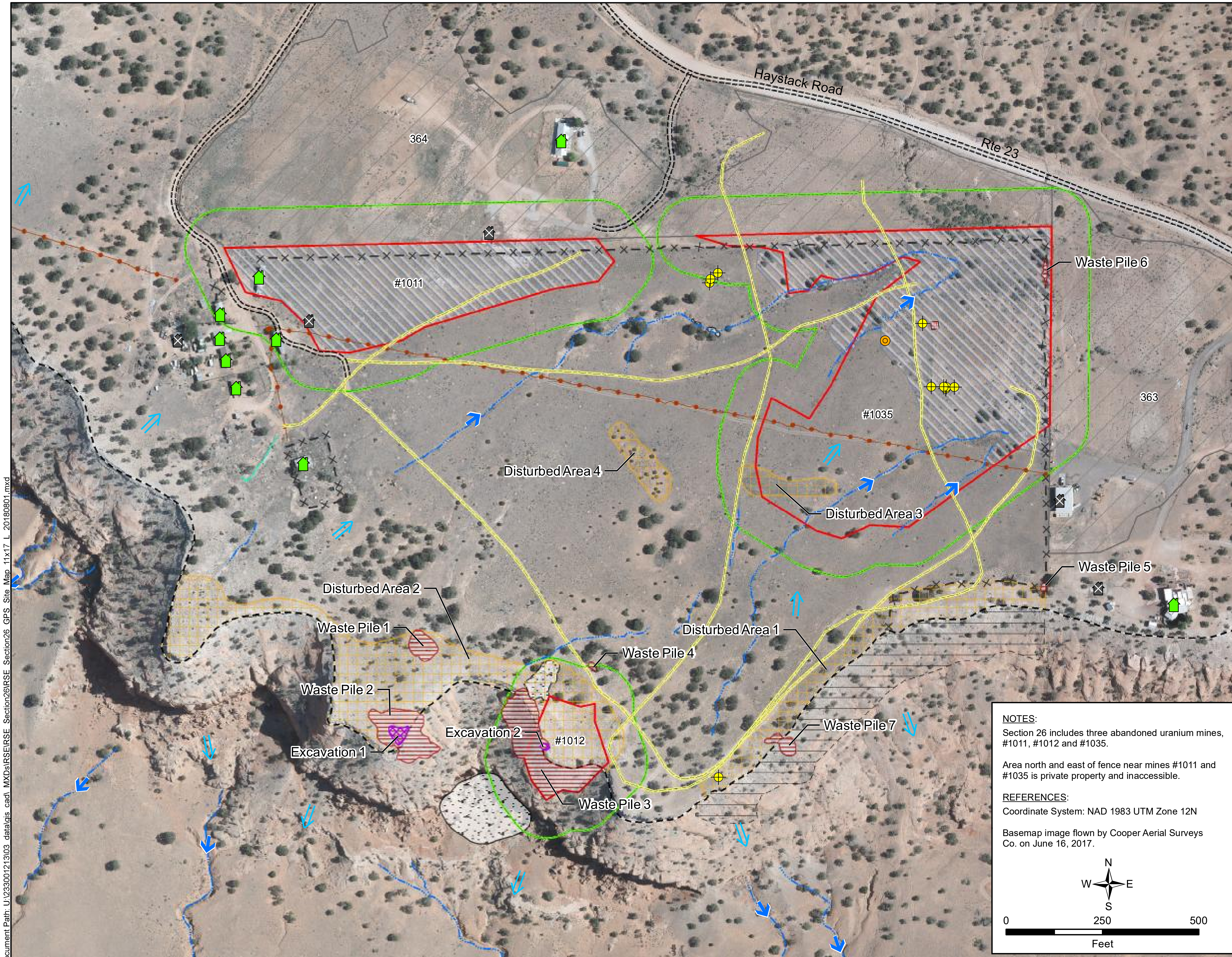
TITLE:

Site Exposed Bedrock

PROJECT:

Removal Site Evaluation
Section 26 Mine Site

DATE:	DOCUMENT NAME:	
8/1/2018	Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 2-7b	



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Habitable Building
- Uninhabitable Building
- Possible Portal or Storage Area
- Historical Borehole
- Flow Direction
- Approximate Overland Water Flow Direction
- Drainage
- Fence
- Potential Haul Road
- Power Line
- Road
- Water Line
- Approximate Edge of Mesa
- Debris
- Excavation
- Graded / Disturbed Reclaimed Area
- Potential Mining Disturbed Area
- Potential Waste Rock
- Waste Pile
- Vertical Mine Shafts
- Claim Boundary
- 100-Foot Claim Buffer
- Other Claim Boundary

NOTES:

Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

Area north and east of fence near mines #1011 and #1035 is private property and inaccessible.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

TITLE: Site Map

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 8/2/2018

DOCUMENT NAME: Removal Site Evaluation Report

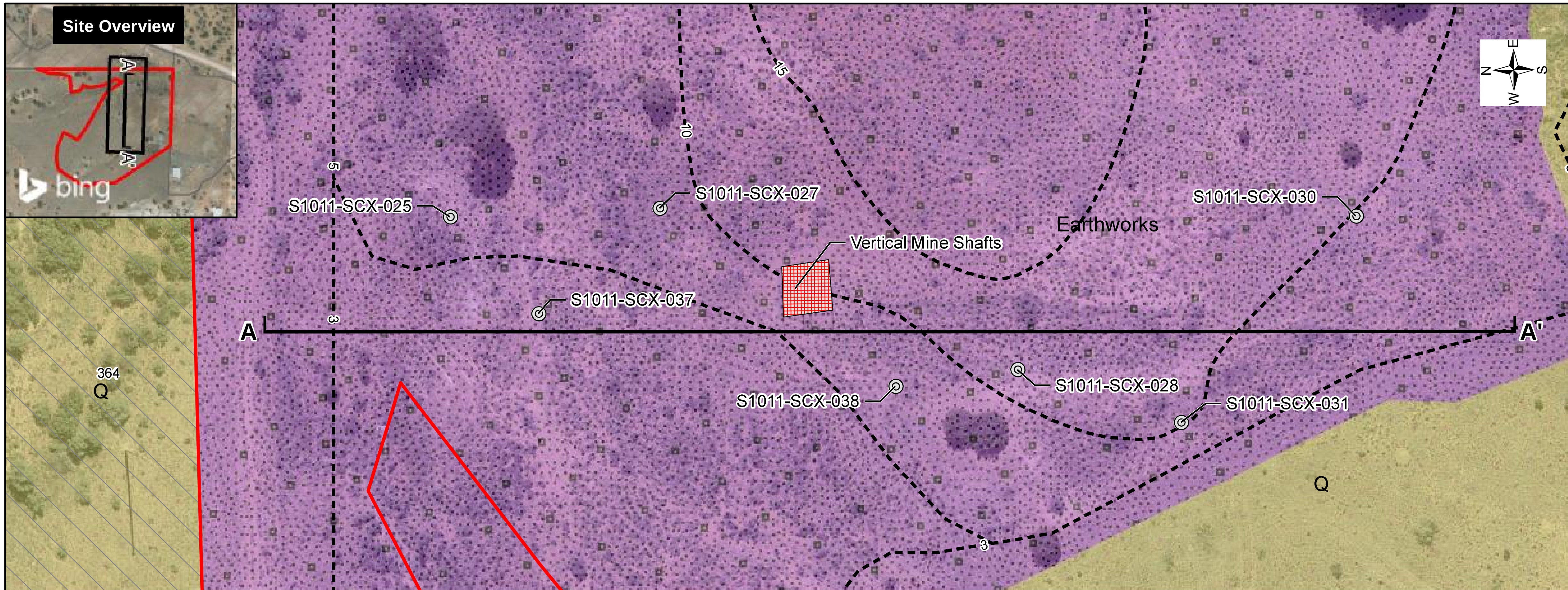
AUTHOR: EDZ

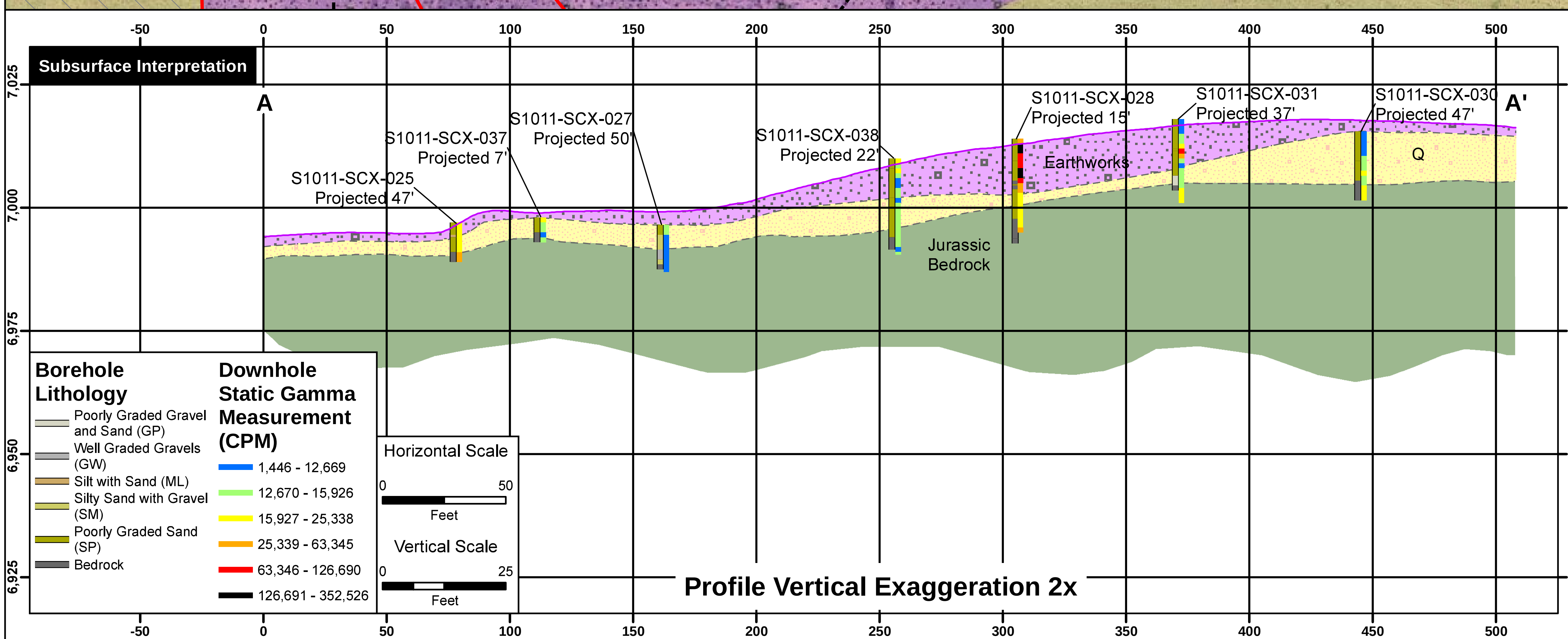
REVIEWER: CBB

Stantec

FIGURE: 2-8

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_GPS_Site Map_11x17_L_20180801.mxd





NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Subsurface Borehole Location
- Cross Section
- Approximate Waste Pile Contour (thickness in feet)
- Vertical Mine Shafts
- Claim Boundary
- Other Claim Boundary
- Geologic Contact (Inferred)
- Earthworks: Human-caused disturbance of the land surface potentially related to mining or reclamation.
- Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly colluvial and alluvial deposits, and eolian sand deposits.
- J: Jurassic Bedrock - Luciano Mesa Member of the Todilto Formation (Upper Jurassic) – Olive –gray to pale -yellow, thin- to thick-bedded limestone and Entrada Sandstone – (Upper and Middle Jurassic) – Reddish-orange to reddish-brown fine - to medium –grained eolian cross bedded sandstone.

NOTES:

1. Projected distance indicates the distance the borehole was offset from the cross-section line in plan view (not depth) for boreholes that are not located on the cross-section line.

2. Surface and subsurface static gamma measurements were collected using a 2 x 2 inch NaI detector.

REFERENCES:

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017

Geology adapted from Cather (2011): Cather, Steven, 2011, Geologic Map of the Dos Lomos Quadrangle, Cibola and McKinley Counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-File Geologic Map 219.

TITLE: Cross Section A - A'

PROJECT: Removal Site Evaluation Section 26 Mine Site

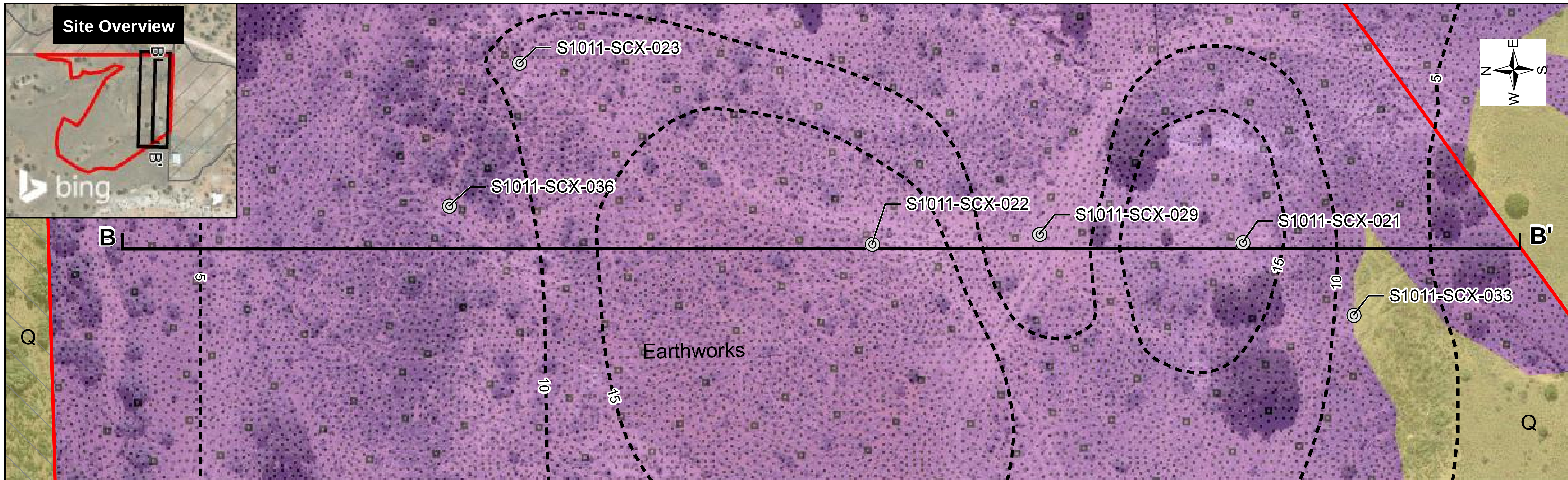
DATE:	DOCUMENT NAME:
8/1/2018	Removal Site Evaluation Report

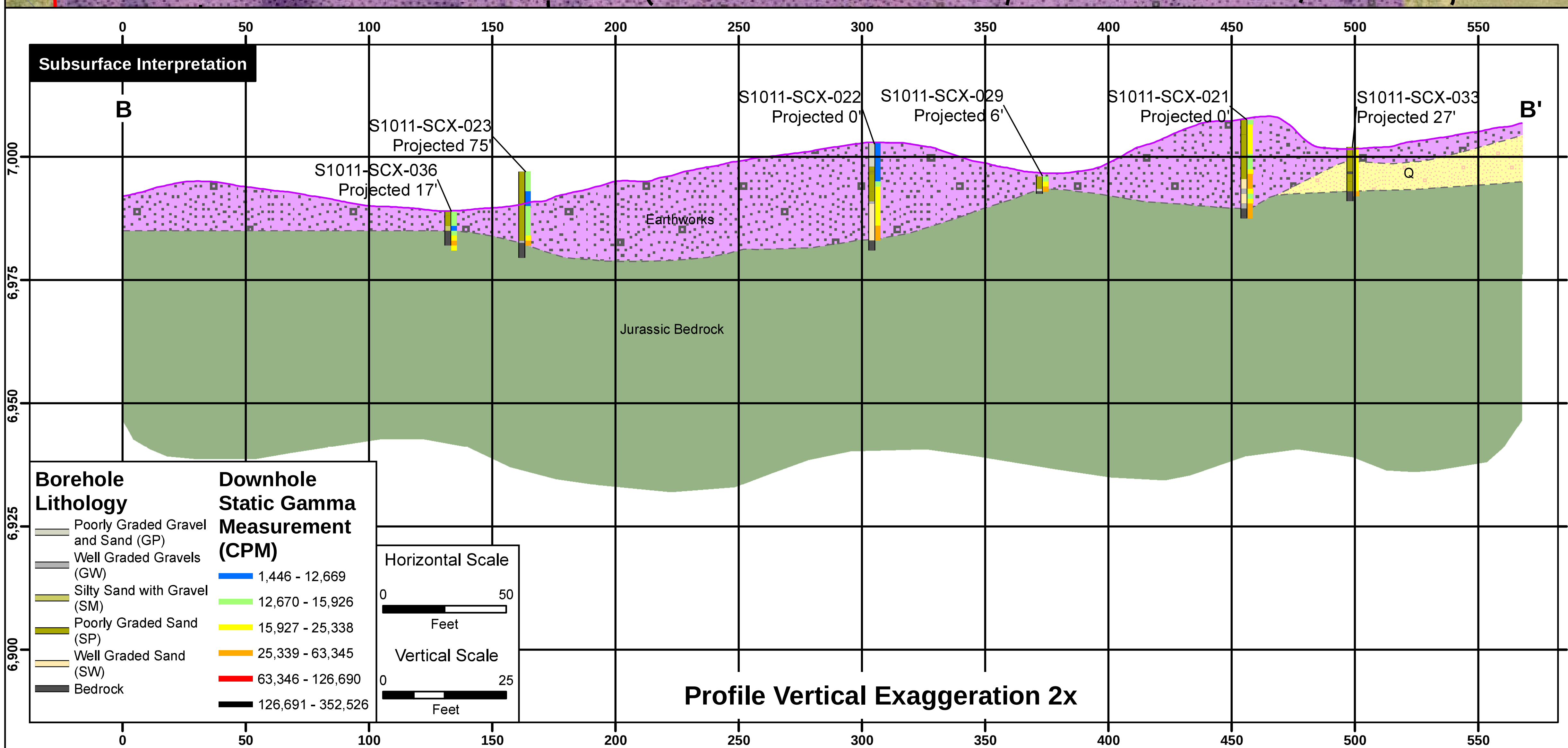
Stantec

AUTHOR:	REVIEWER:
EDZ	CBB

FIGURE: 2-9a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section_26_SectionA_Gamma_11x17_L_20180801.mxd





NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Subsurface Borehole Location
- Cross Section
- Approximate Waste Pile Contour (thickness in feet)
- Claim Boundary
- Other Claim Boundary
- Geologic Contact (Inferred)
- Earthworks: Human-caused disturbance of the land surface potentially related to mining or reclamation.
- Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly colluvial and alluvial deposits, and eolian sand deposits.
- J: Jurassic Bedrock - Luciano Mesa Member of the Todilto Formation (Upper Jurassic) – Olive –gray to pale -yellow, thin- to thick-bedded limestone and Entrada Sandstone – (Upper and Middle Jurassic) – Reddish-orange to reddish-brown fine - to medium –grained eolian cross bedded sandstone.

NOTES:

1. Projected distance indicates the distance the borehole was offset from the cross-section line in plan view (not depth) for boreholes that are not located on the cross-section line.

2. Surface and subsurface static gamma measurements were collected using a 2 x 2 inch NaI detector.

REFERENCES:

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet

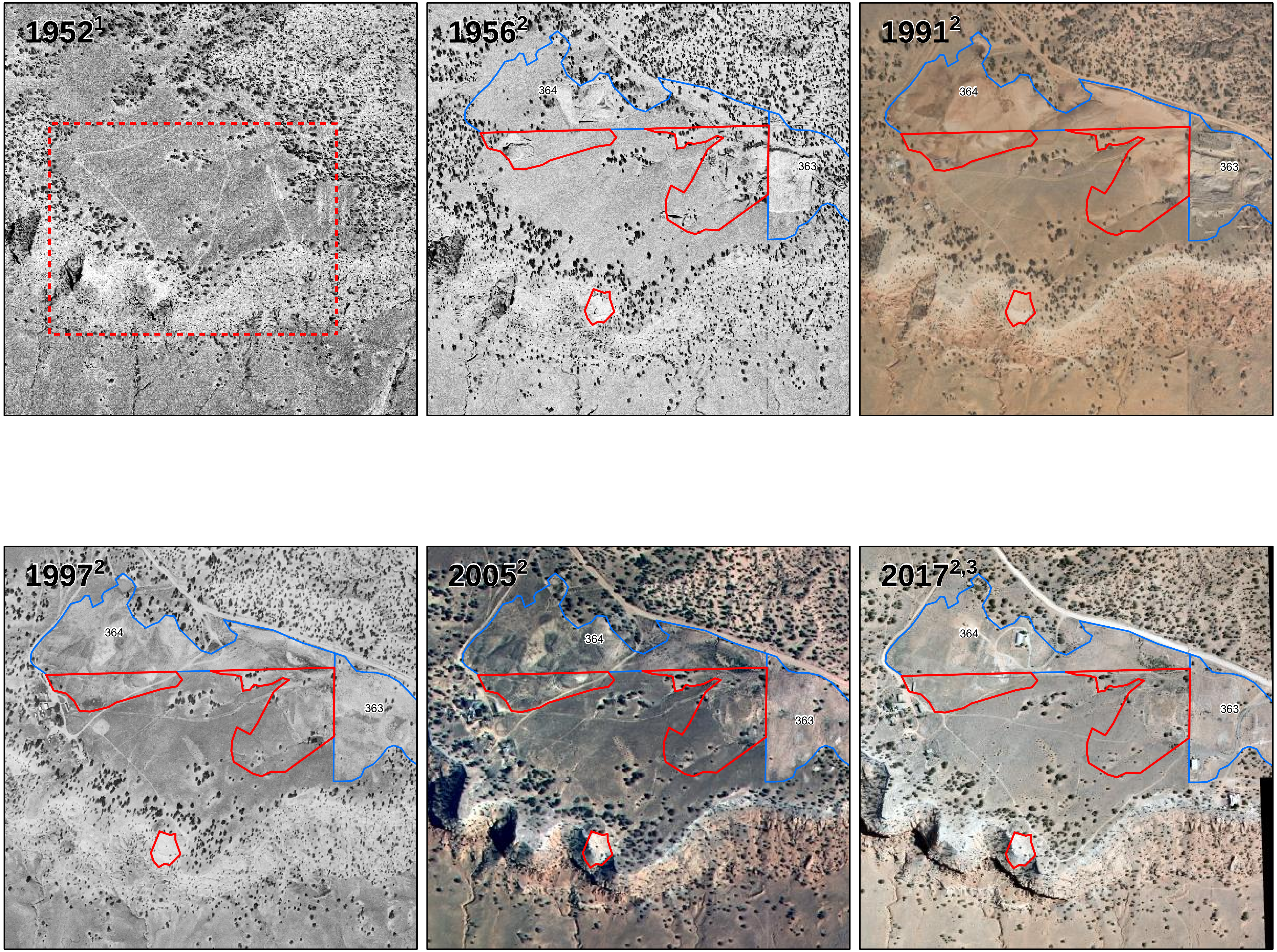
Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017

Geology adapted from Cather (2011): Cather, Steven, 2011, Geologic Map of the Dos Lomos Quadrangle, Cibola and McKinley Counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-File Geologic Map 219.

TITLE:	Cross Section B - B'
PROJECT:	Removal Site Evaluation Section 26 Mine Site
DATE:	8/1/2018
DOCUMENT NAME:	Removal Site Evaluation Report
AUTHOR:	EDZ
REVIEWER:	CBB
FIGURE:	2-9b

Stantec

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section_26_SectionB_Gamma_11x17_L_20180801.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Section 26 Claim Boundary
- Other Claim Boundary
- Approximate Site Location, not georeferenced

NOTES:
1. Image is not georeferenced, scale not available.

2. Image is georeferenced. Scale bar applies to these image frames only.

3. Site-specific imagery flown by Cooper Aerail Surveys Co. on June 16, 2017.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Historical Aerial Imagery downloaded from https://earthexplorer.usgs.gov/ (01/2016)

N
W E
S

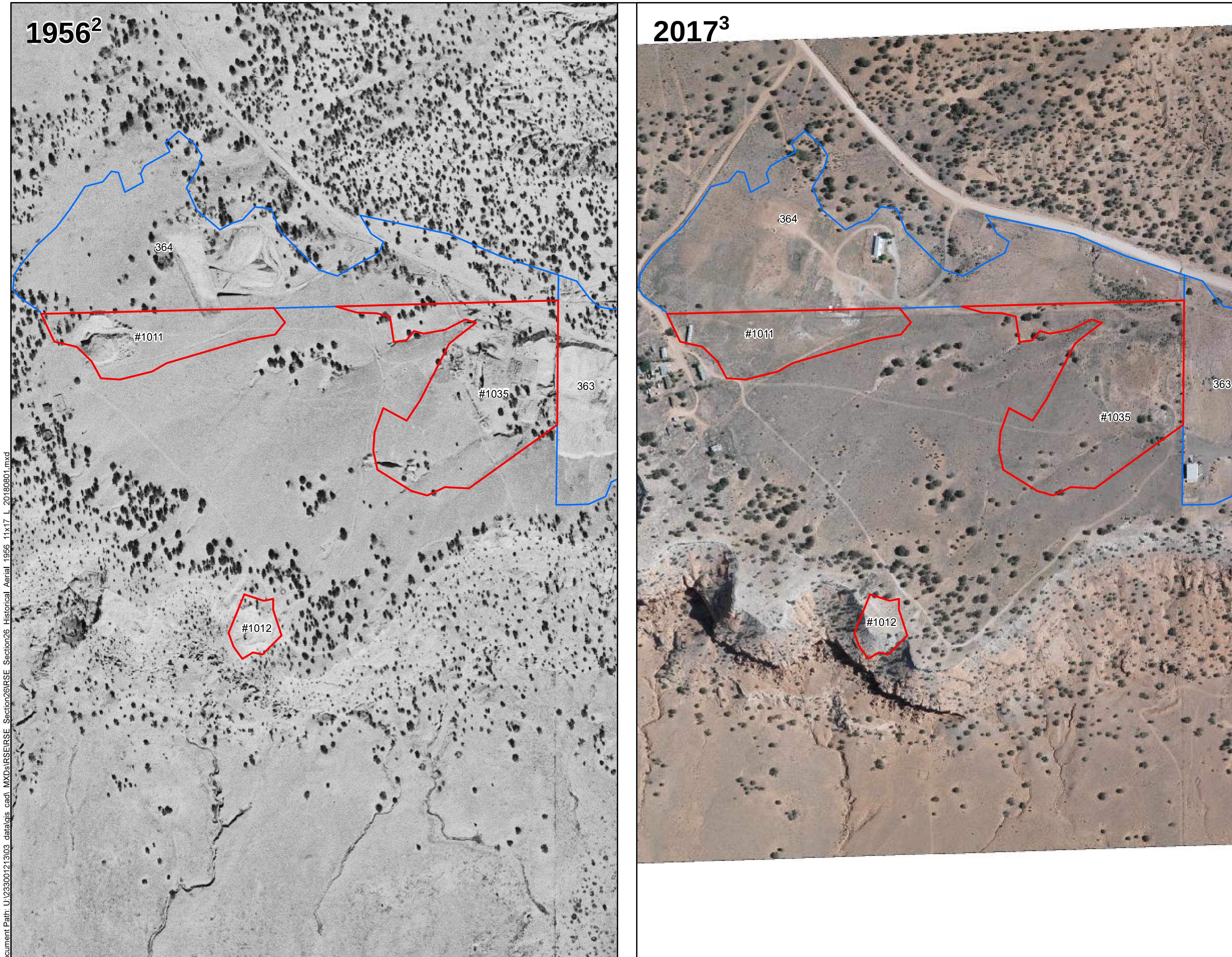
0 1,500 3,000
Feet

TITLE:
Historical Aerial Photograph Comparison

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 8/1/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 3-1a	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Historical_Aerial_Compilation_11x17_L_20180801.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Claim Boundary
- Other Claim Boundary

NOTE:
Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:
1. Coordinate System: NAD 1983 UTM Zone 12N

2. 1956 aerial image downloaded from https://earthexplorer.usgs.gov/ (01/2016) and georeferenced using current image from BING (03/2016).

3. Site-specific imagery flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

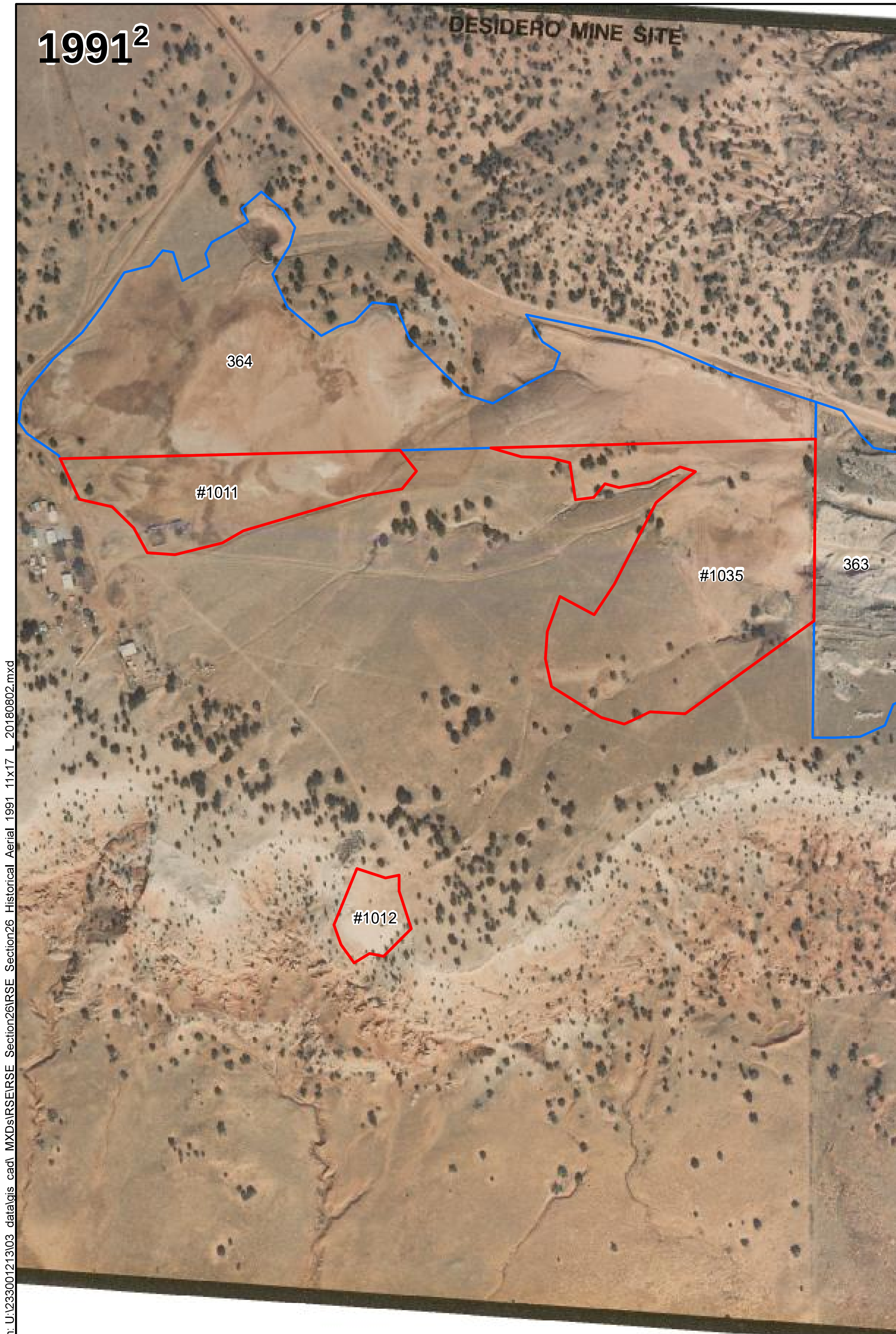
0 400 800
Feet

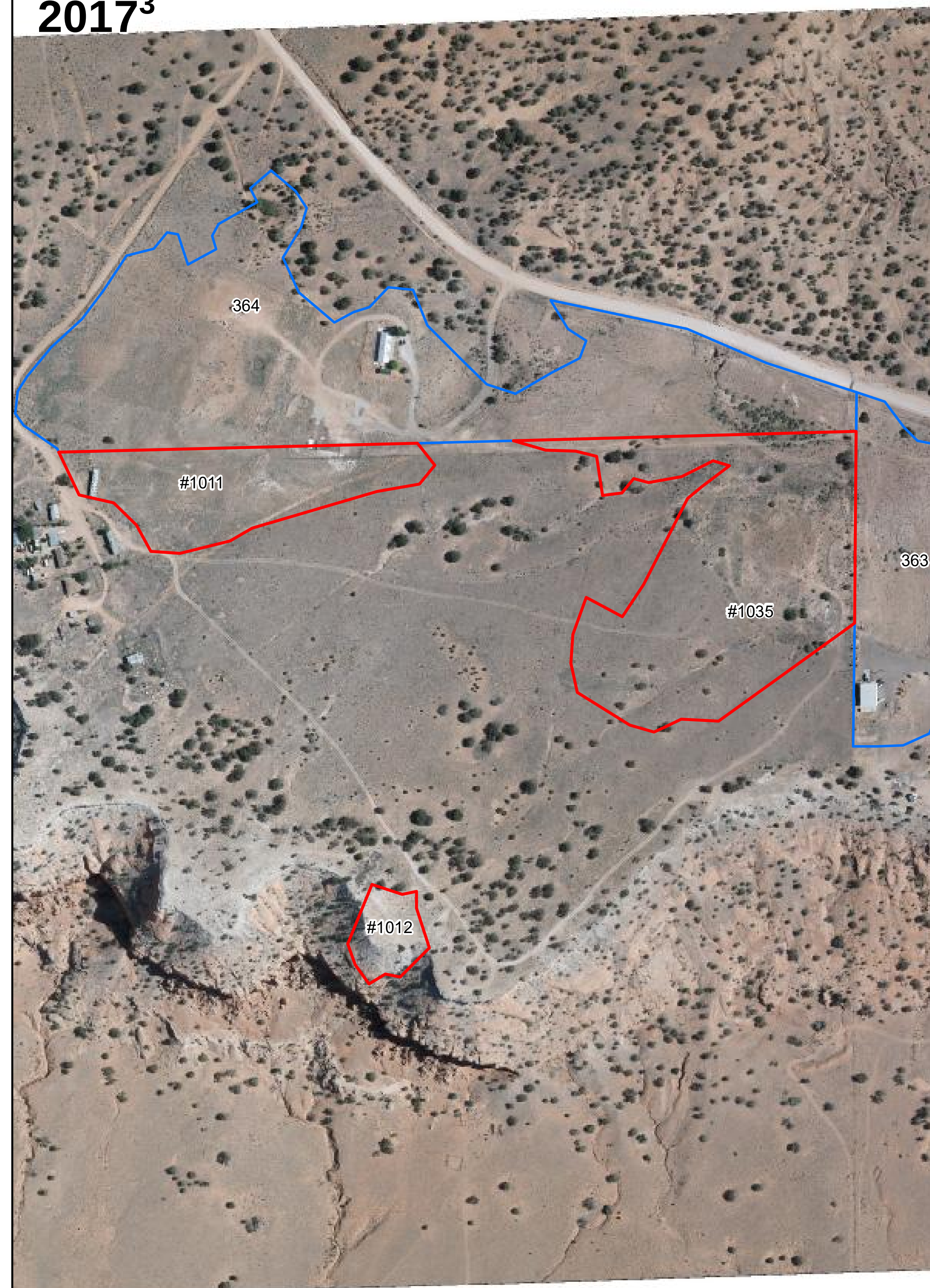
TITLE:
1956 Historical Aerial Photograph Comparison

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 8/1/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 3-1b	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Historical_Aerial_1956_11x17_L_20180801.mxd





NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Claim Boundary
- Other Claim Boundary

NOTE:
Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:
1. Coordinate System: NAD 1983 UTM Zone 12N

2. 1991 aerial image downloaded from https://earthexplorer.usgs.gov/ (01/2016) and georeferenced using current image from BING (03/2016).

3. Site-specific imagery flown by Cooper Aerial Surveys Co. on June 16, 2017.

N
W E
S

0 400 800
Feet

TITLE:
1991 Historical Aerial Photograph Comparison

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 8/2/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 3-1c

Stantec

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Historical_Aerial_1991_11x17_L_20180802.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Potential Background Reference Area
- Claim Boundary
- Other Claim Boundary

NOTE:
Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 300 600
Feet

TITLE:
Potential Background Reference Areas

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 8/23/2018

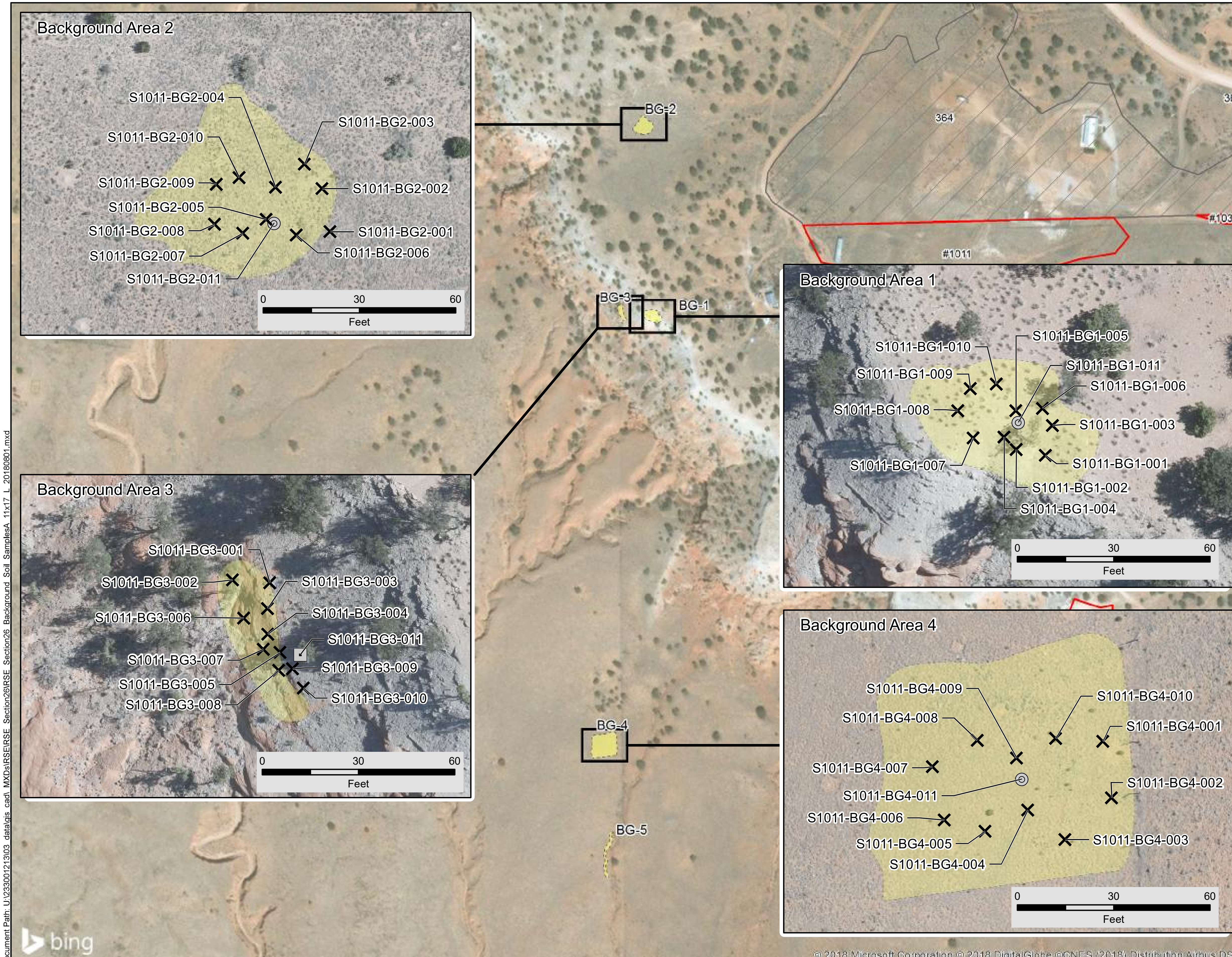
DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 3-2



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Background Reference Area
- Claim Boundary
- Other Claim Boundary

NOTE:
Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Main display basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

Inset basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 300 600
Feet

TITLE:
Background Reference Areas (1-4) - Sample Locations

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 8/23/2018

DOCUMENT NAME: Removal Site Evaluation Report

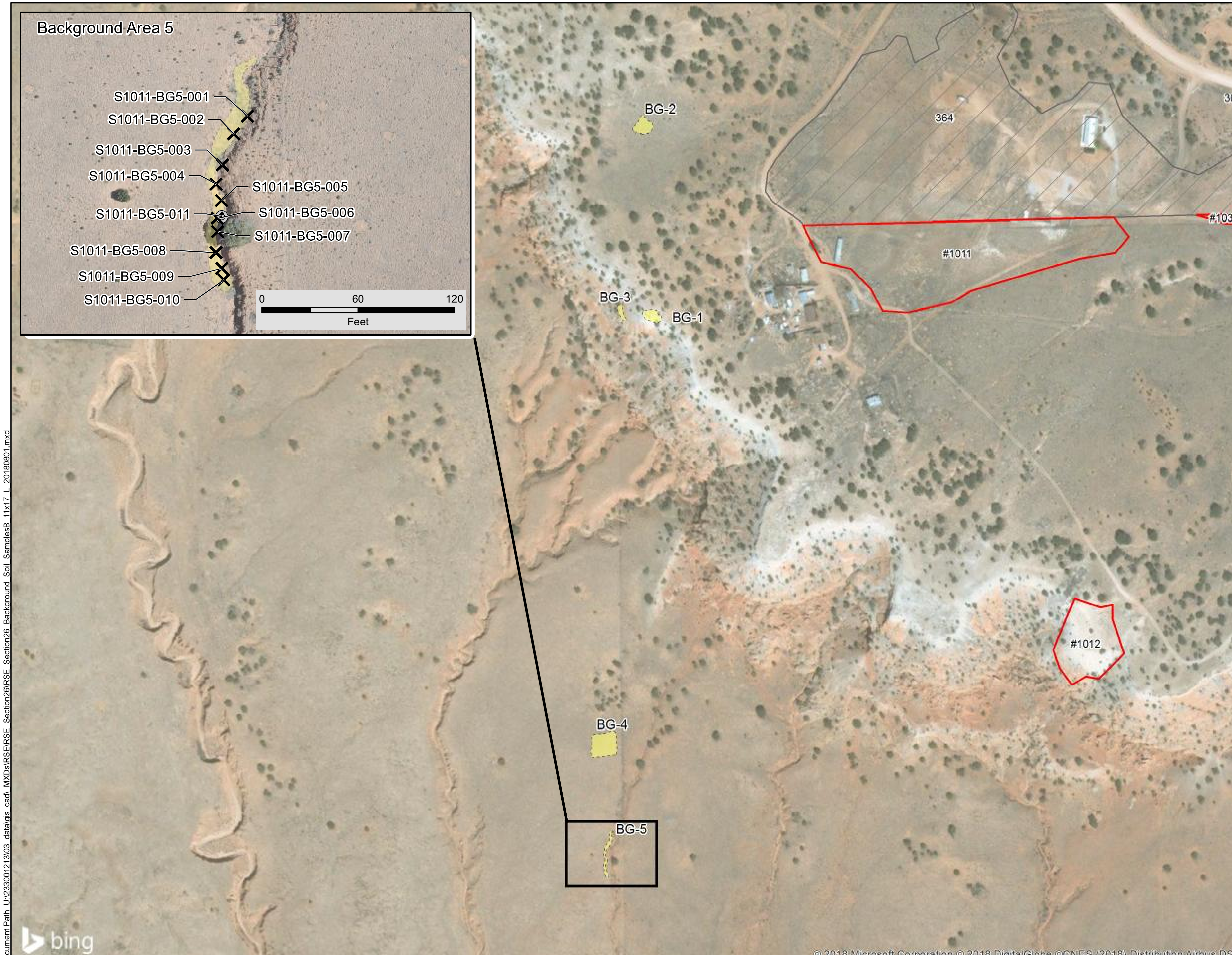
AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 3-3a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Background_Soil_SamplesA_11x17_L_20180801.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- ◎ Borehole Location - Surface and Subsurface Samples
- Background Reference Area
- Claim Boundary
- Other Claim Boundary

NOTE:
Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Main basemap image inset accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

Inset basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N
W E
S

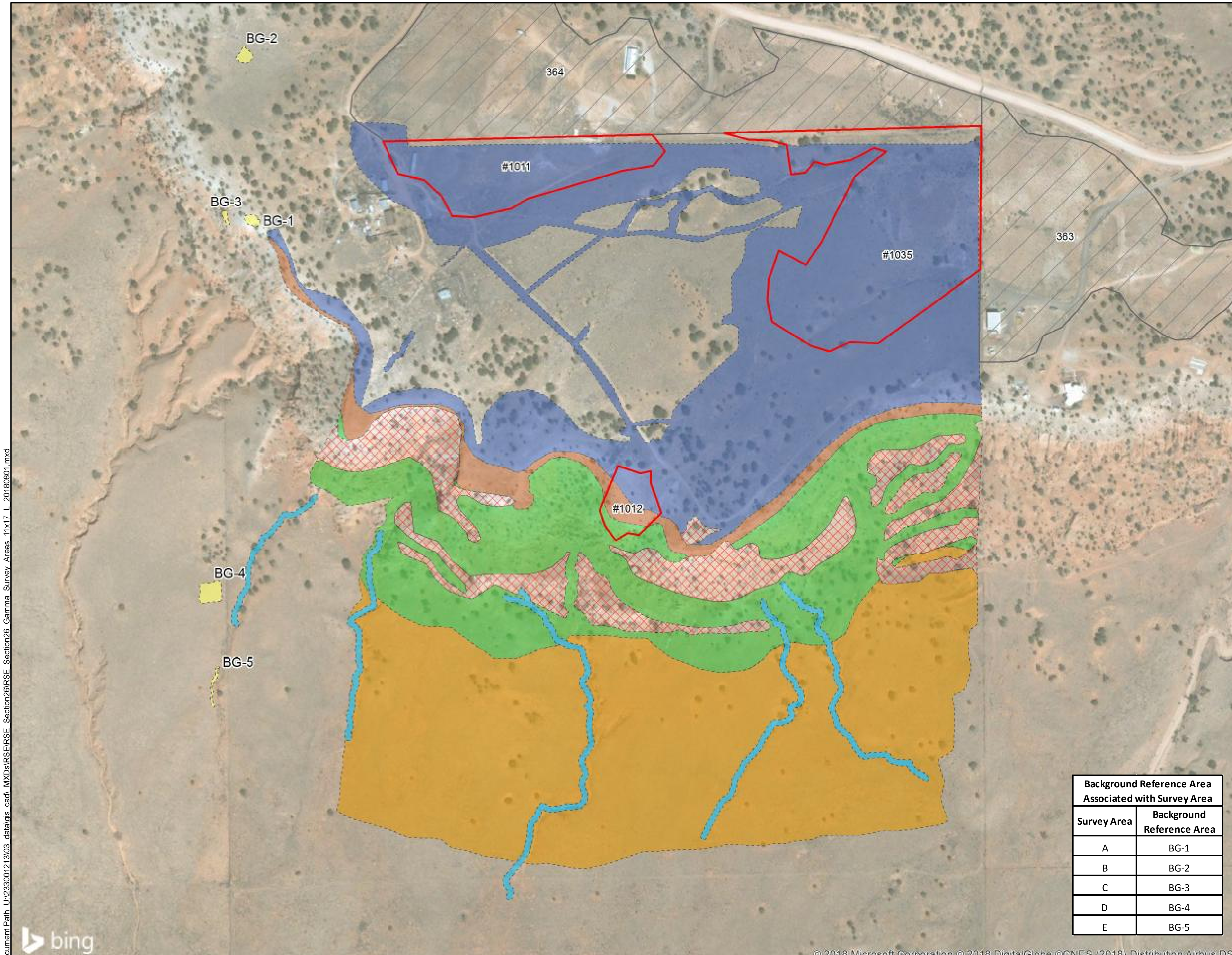
0 300 600
Feet

TITLE:
Background Reference Area 5 - Sample Locations

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 8/23/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 3-3b	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Background_Soil_SamplesB_11x17_L_20180801.mxd



Background Reference Area Associated with Survey Area	
Survey Area	Background Reference Area
A	BG-1
B	BG-2
C	BG-3
D	BG-4
E	BG-5

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Background Reference Area
- Survey Area A
- Survey Area B
- Survey Area C
- Survey Area D
- Survey Area E
- Unsurveyed Area[1]
- Claim Boundary
- Other Claim Boundary

NOTES:

1. Areas within Survey Areas that were not surveyed (10.1 acres) due to steep/unsafe terrain.
2. Gamma survey area is approximately 101.3 acres.
3. Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.
4. Area north and east of fence near mines #1011 and #1035 is private property and inaccessible.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

N W E S

0 350 700
Feet

TITLE:
Gamma Radiation Survey Areas

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 8/23/2018

DOCUMENT NAME: Removal Site Evaluation Report

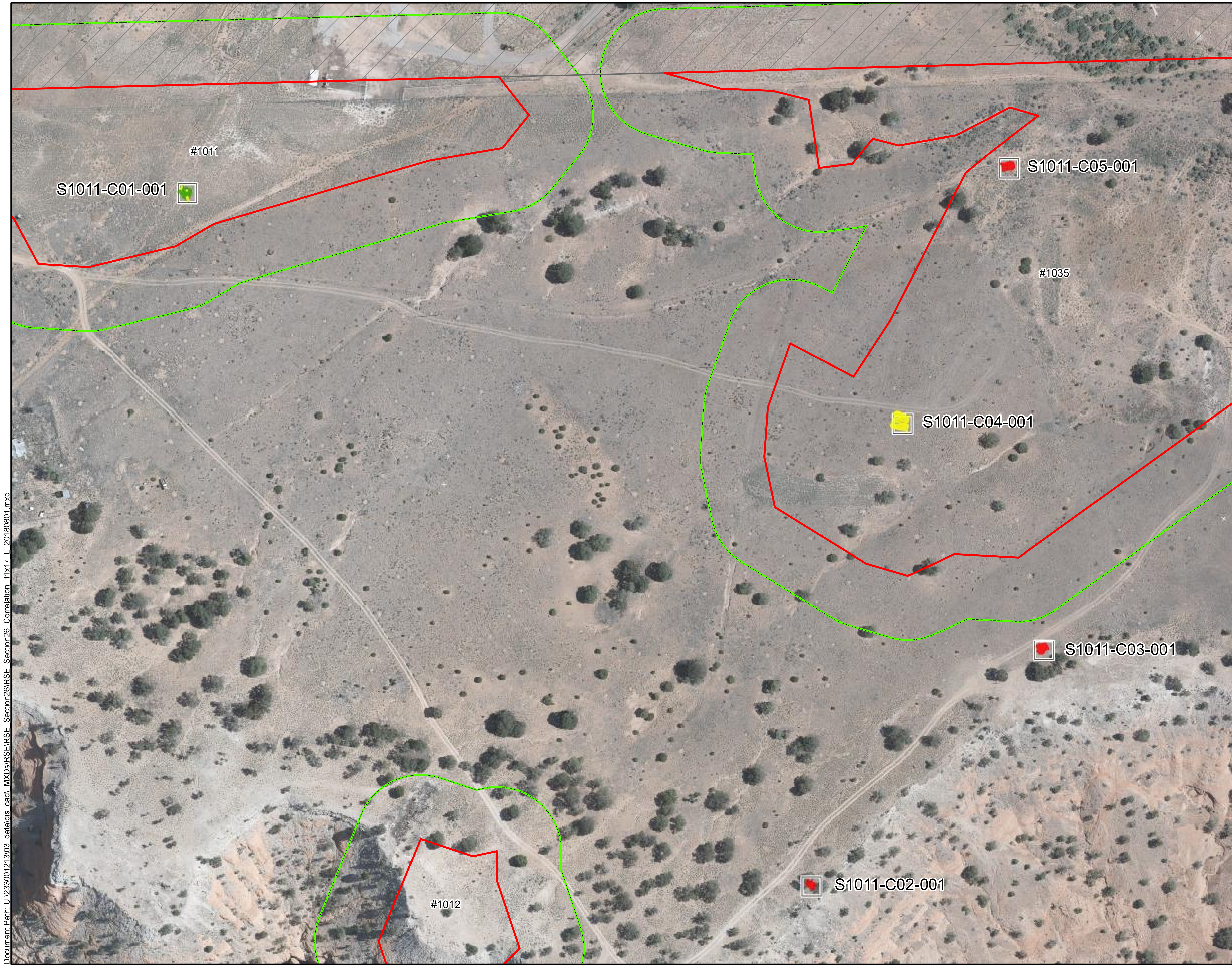
Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 3-4

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Gamma_Survey_Areas_11x17_L_20180801.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

S1011-C01-001 Correlation Location (30'x30')

Claim Boundary

100-Foot Claim Buffer

Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

19,390 - 23,320 (Minimum to BG-2 UTL)

23,321 - 46,640 (>BG-2 UTL to 2x BG-2 UTL)

46,641 - 190,264 (>2x BG-2 UTL to Maximum)

NOTES:

Surface gamma measurements were collected using a 3 x 3 inch detector.

Each correlation sample consists of five grab samples collected from 0.0 - 0.5 feet below ground surface, composited together for laboratory analysis.

Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 150 300 Feet

TITLE: Gamma Correlation Study Locations

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 8/2/2018

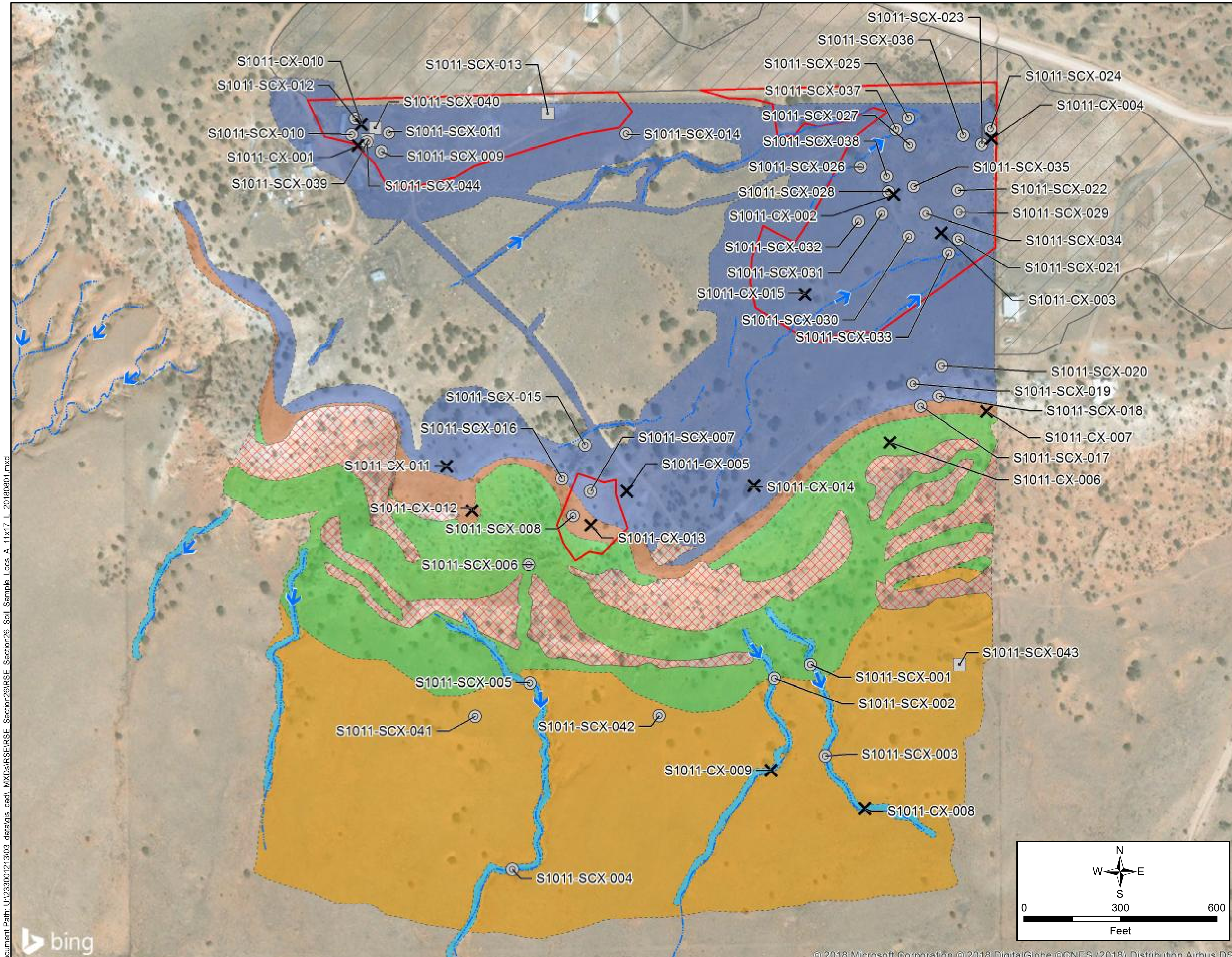
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 3-5



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Flow Direction
- Drainage
- Survey Area A
- Survey Area B
- Survey Area C
- Survey Area D
- Survey Area E
- Unsurveyed Area
- Claim Boundary
- Other Claim Boundary

NOTES:

Surface and subsurface static gamma measurements were collected at all borehole locations with one exception; only subsurface static gamma measurements were collected at S1011-SCX-042.

Surface soil samples range from 0.0 - 0.5 feet below ground surface (ft bgs)

Subsurface soil samples range from 0.0 - 20.0 ft bgs

Static gamma measurements range from 0.0 - 20.0 ft bgs

Area north and east of fence near mines #1011 and #1035 is private property and inaccessible.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

TITLE:

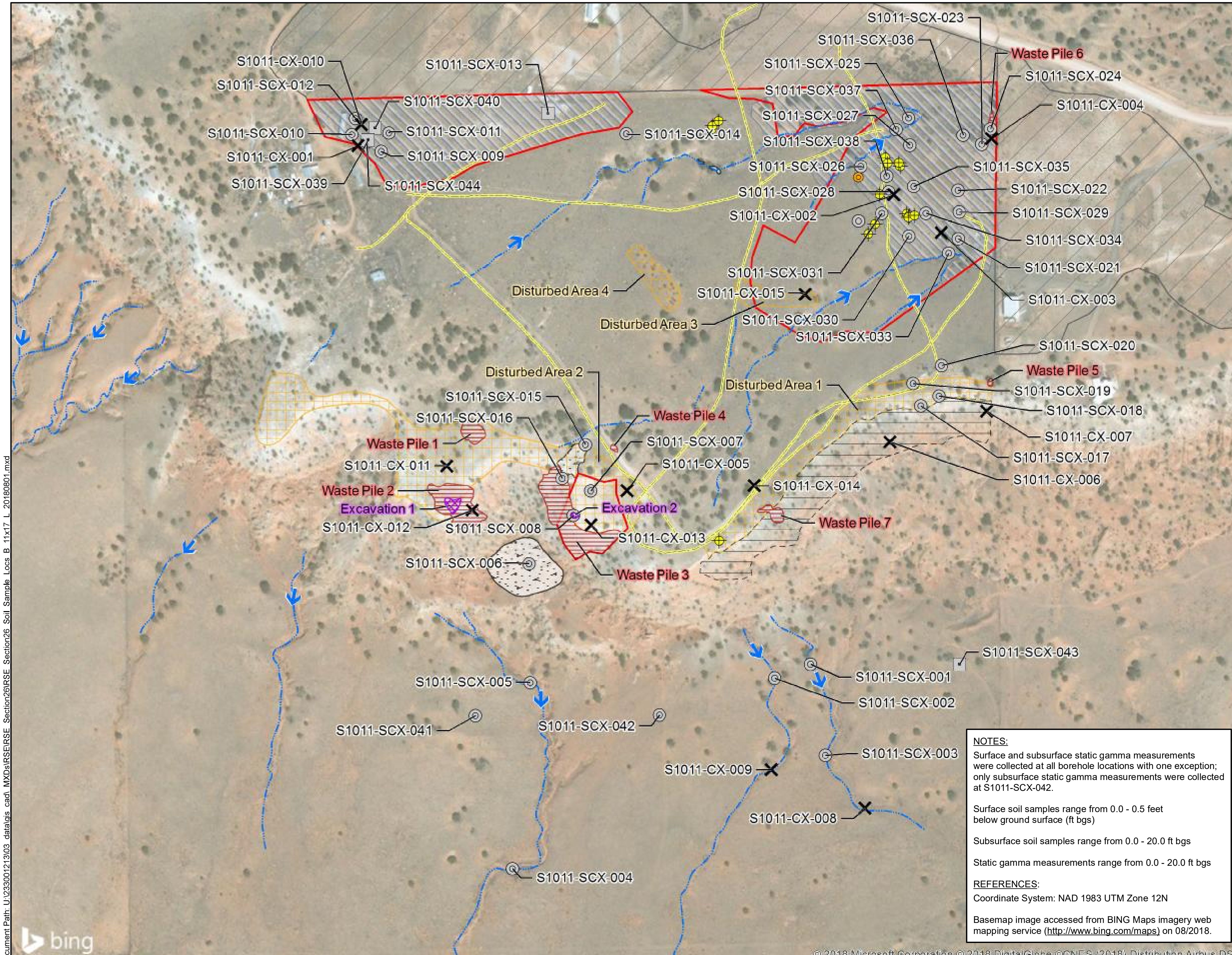
Site Characterization Surface and Subsurface Sample Locations

PROJECT:

Removal Site Evaluation
Section 26 Mine Site

DATE:	DOCUMENT NAME:	
8/23/2018	Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 3-6a	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE_Section26\RSE_Section26_Soil_Sample_Locs_A_11x17_L_20180801.mxd



NOTES:

Surface and subsurface static gamma measurements were collected at all borehole locations with one exception; only subsurface static gamma measurements were collected at S1011-SCX-042.

Surface soil samples range from 0.0 - 0.5 feet below ground surface (ft bgs)

Subsurface soil samples range from 0.0 - 20.0 ft bgs

Static gamma measurements range from 0.0 - 20.0 ft bgs

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

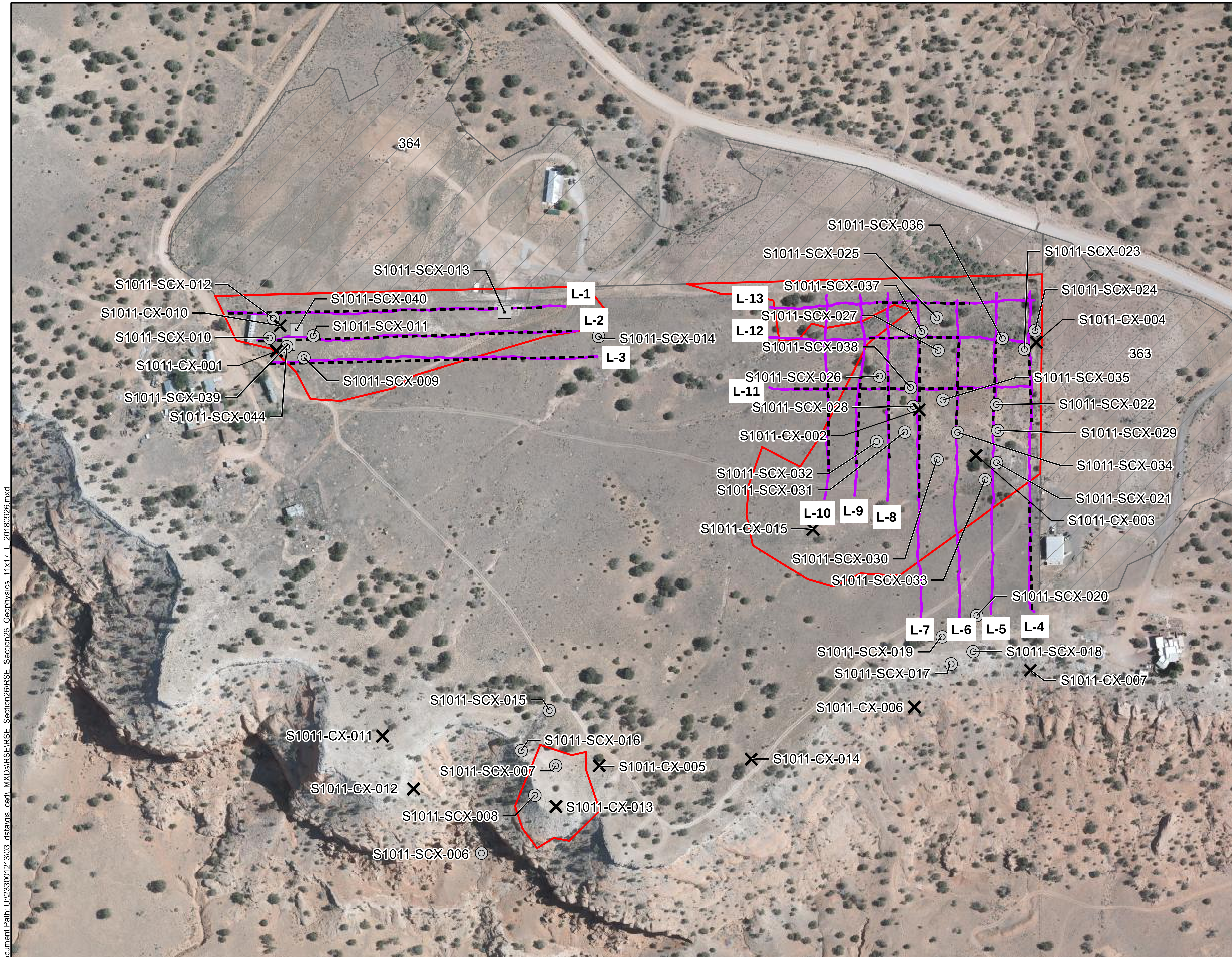
- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Flow Direction
- Possible Portal or Storage
- Historical Borehole
- Potential Haul Road
- Drainage
- Debris
- Excavation
- Graded / Disturbed Reclaimed Area
- Potential Mining Disturbed
- Potential Waste Rock
- Waste Pile
- Vertical Mine Shafts
- Claim Boundary
- Other Claim Boundary

N W E S

0 300 600
Feet

TITLE: Site Characterization Mining Features and Surface and Subsurface Sample Locations	
PROJECT: Removal Site Evaluation Section 26 Mine Site	
DATE: 8/23/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: EDZ / REVIEWER: CBB
	FIGURE: 3-6b

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE_Section26\RSE_Section26_Soil_Sample_Locs_B_11x17_L_20180801.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- ◎ Borehole Location - Surface and Subsurface Samples
- ▣ Borehole Location - Surface Samples Only
- MASW Survey Line
- Resistivity Survey Line
- Claim Boundary
- Other Claim Boundary

NOTES:
MASW: multi-channel analysis of surface waves

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

Geophysical surveys were performed by Hydrogeophysics, Inc. The geophysical survey report is presented in Appendix A.

N
W E
S

0 250 500
Feet

TITLE:
Geophysical Surveys

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

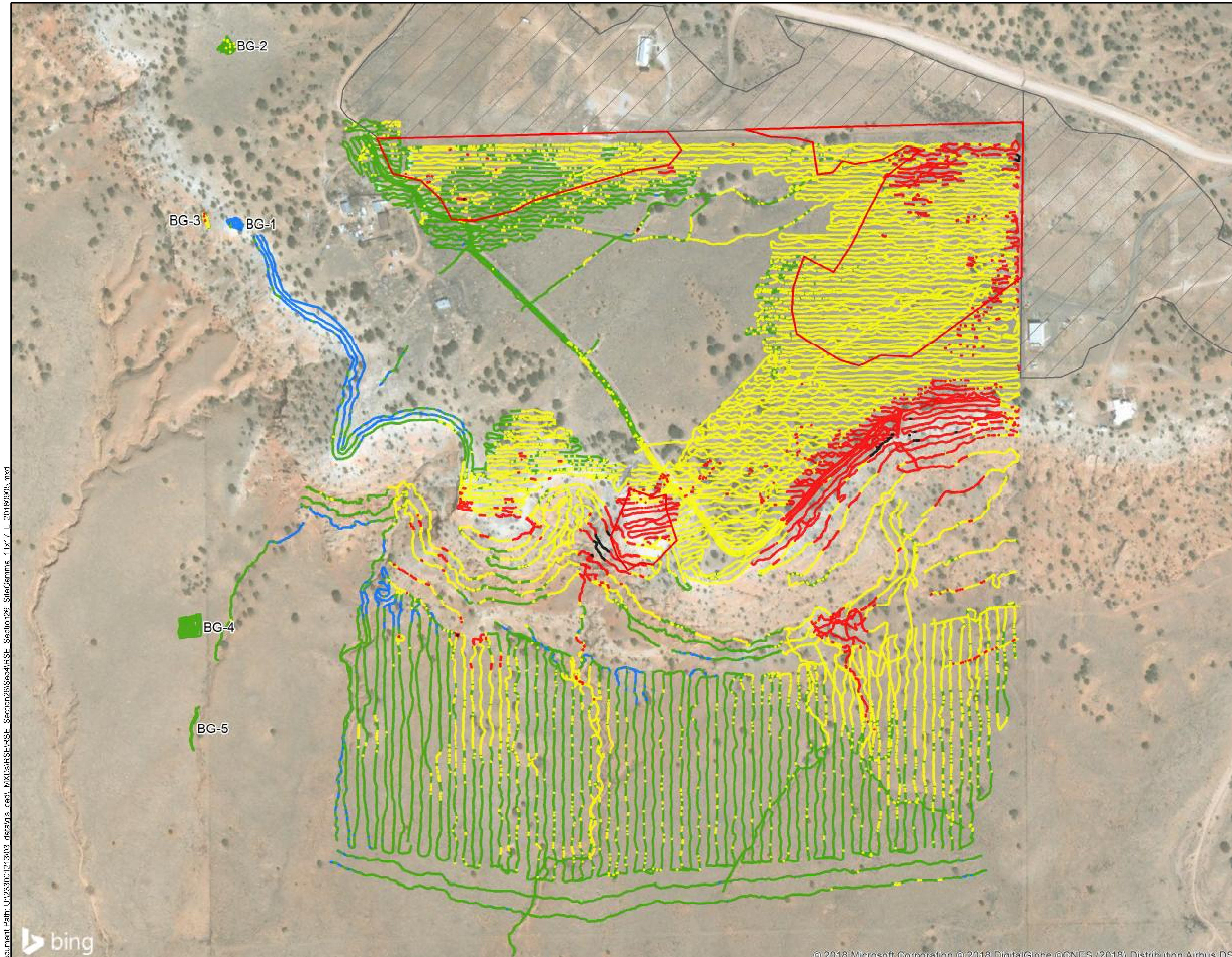
DATE:	DOCUMENT NAME:
9/26/2018	Removal Site Evaluation Report

Stantec

AUTHOR:	REVIEWER:
EDZ	CBB

FIGURE:
3-7

Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_Section26\RSE_Section26_Geophysics_11x17_L_20180926.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Claim Boundary
Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)
- 8,652 - 16,829 (Minimum to BG-1 IL)
- 16,830 - 23,320 (>BG-1 IL to BG-2 IL)
- 23,321 - 46,640 (>BG-2 IL to 2x BG-2 IL)
- 46,641 - 233,200 (>2x BG-2 IL to 10x BG-2 IL)
- 233,201 - 749,127 (>10x BG-2 IL to Maximum)

NOTES:
Surface gamma measurements were collected using a 3 x 3 inch detector.

Refer to Figure 3-4 for Survey Area delineation.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S

0 320 640
Feet

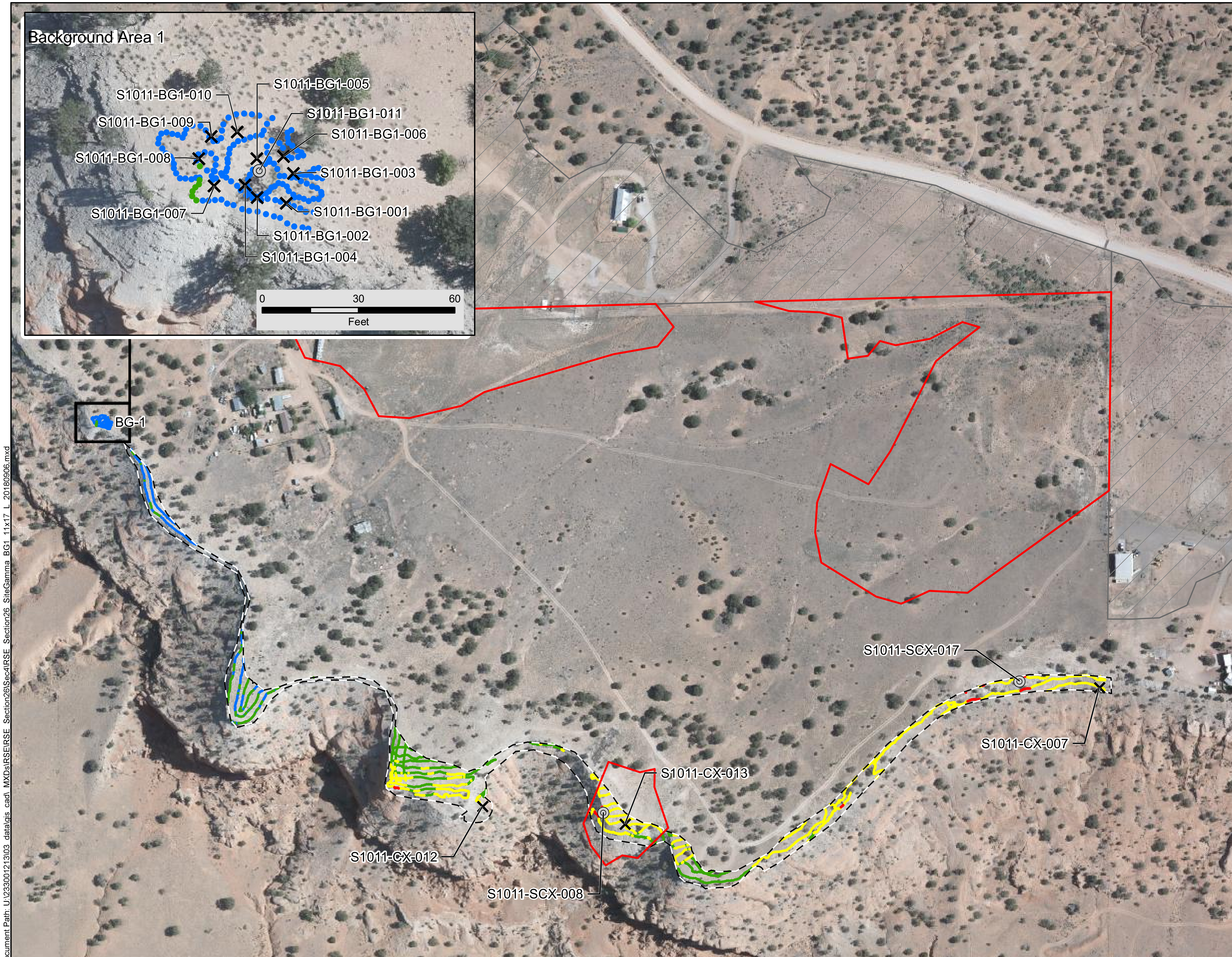
TITLE:
Gamma Radiation Survey Results for Site

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/14/2018
DOCUMENT NAME: Removal Site Evaluation Report
AUTHOR: EDZ
REVIEWER: CBB
FIGURE: 4-1a

Stantec

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_SiteGamma_11x17_L_20180905.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Survey Area A
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 11,058 - 16,829 (Minimum to BG-1 IL)
- 16,830 - 33,658 (>BG-1 IL to 2x BG-1 IL)
- 33,659 - 168,290 (>2x BG-1 IL to 10x BG-1 IL)
- 168,291 - 654,837 (>10x BG-1 IL to Maximum)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

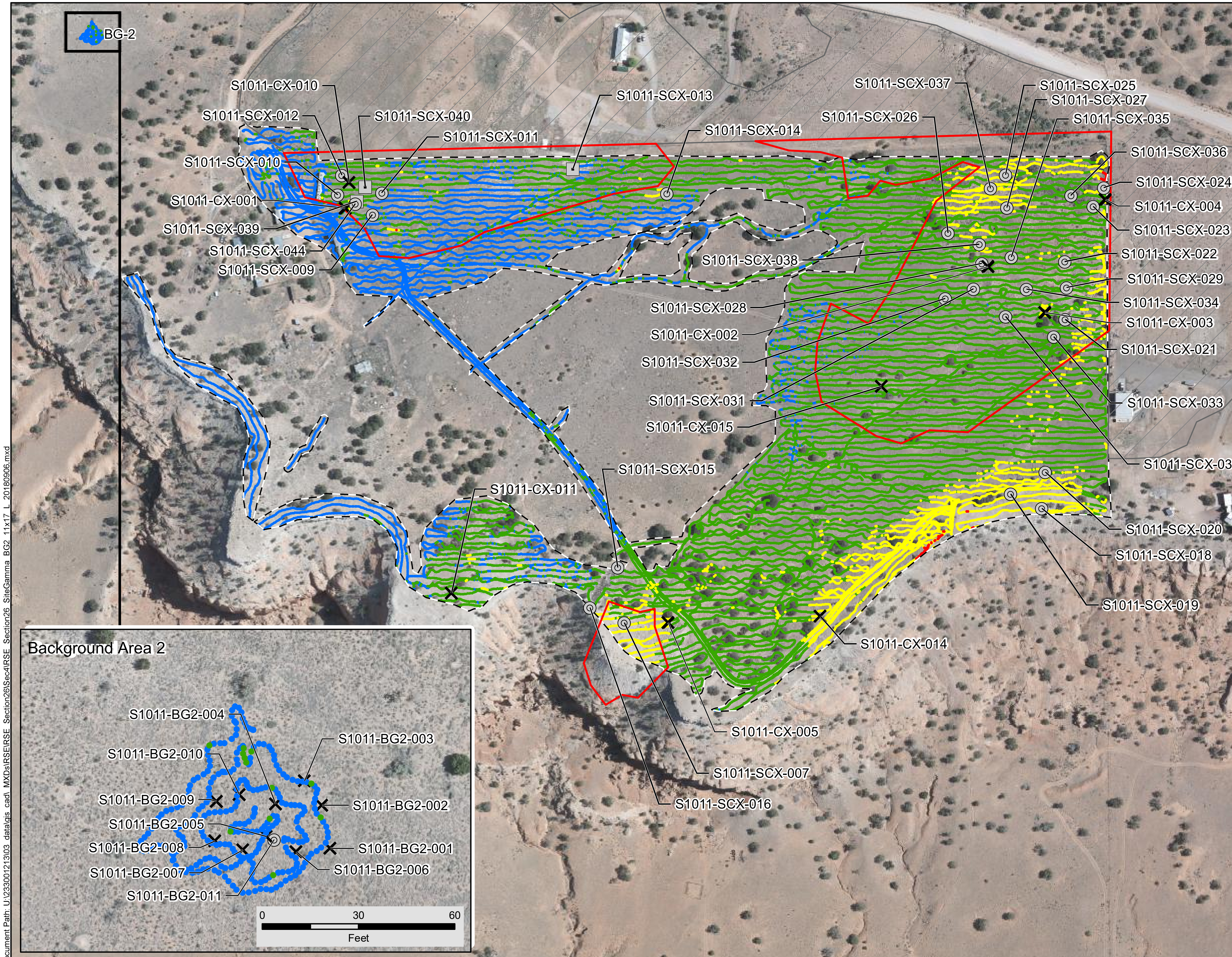
0 250 500
Feet

TITLE:
Gamma Radiation Survey Results for Survey Area A

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE:	DOCUMENT NAME:	
9/14/2018	Removal Site Evaluation Report	
	AUTHOR: EDZ	REVIEWER: CBB
Stantec	FIGURE: 4-1b	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_SiteGamma_BG1_11x17_L_20180906.mxd



Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_SiteGamma_BG2_11x17_L_20180906.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Survey Area
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 8,652 - 23,320 (Minimum to BG-2 IL)
- 23,321 - 46,640 (>BG-2 IL to 2x BG-2 IL)
- 46,641 - 233,200 (>2x BG-2 IL to 10x BG-2 IL)
- 233,201 - 633,057 (>10x BG-2 IL to Maximum)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

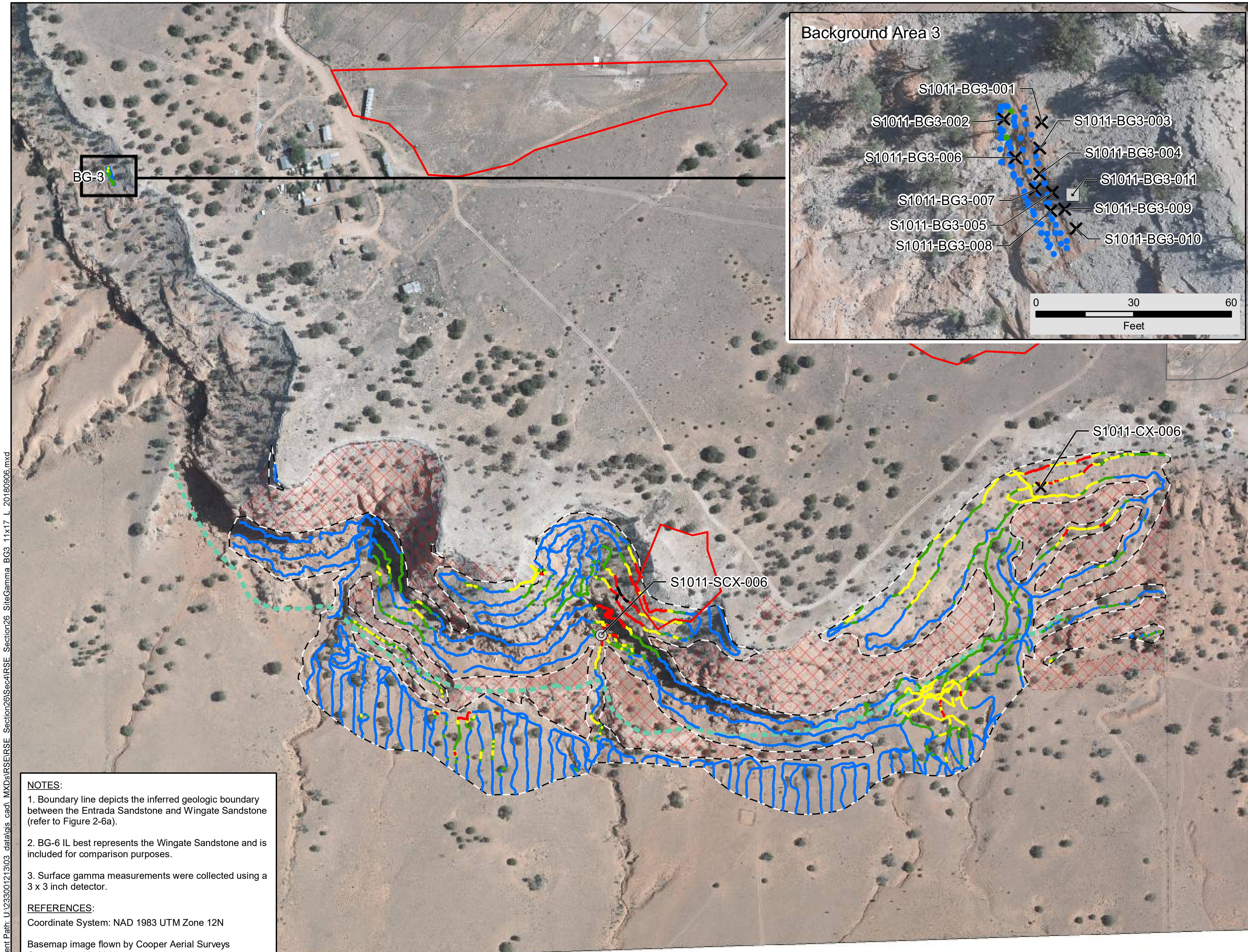
N W E S

0 250 500
Feet

TITLE:
Gamma Radiation Survey Results for Survey Area B

PROJECT:
Removal Site Evaluation Section 26 Mine Site

DATE: 9/6/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-1c	



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Wingate / Entrada Geologic Contact (inferred)[1]
- Unsurveyed Area
- Survey Area C
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 11,527 - 34,429 (Minimum to BG-6[2] IL)
- 34,430 - 48,542 (>BG-6 IL to BG-3 IL)
- 48,543 - 97,084 (>BG-3 IL to 2x BG-3 IL)
- 97,085 - 485,420 (>2x BG-3 IL to 10x BG-3 IL)
- 485,421 - 749,127 (>10x BG-3 IL to Maximum)

N W E S

0 250 500
Feet

NOTES:

1. Boundary line depicts the inferred geologic boundary between the Entrada Sandstone and Wingate Sandstone (refer to Figure 2-6a).

2. BG-6 IL best represents the Wingate Sandstone and is included for comparison purposes.

3. Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_SiteGamma_BG3_11x17_L_20180906.mxd

TITLE: Gamma Radiation Survey Results for Survey Area C

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 9/14/2018

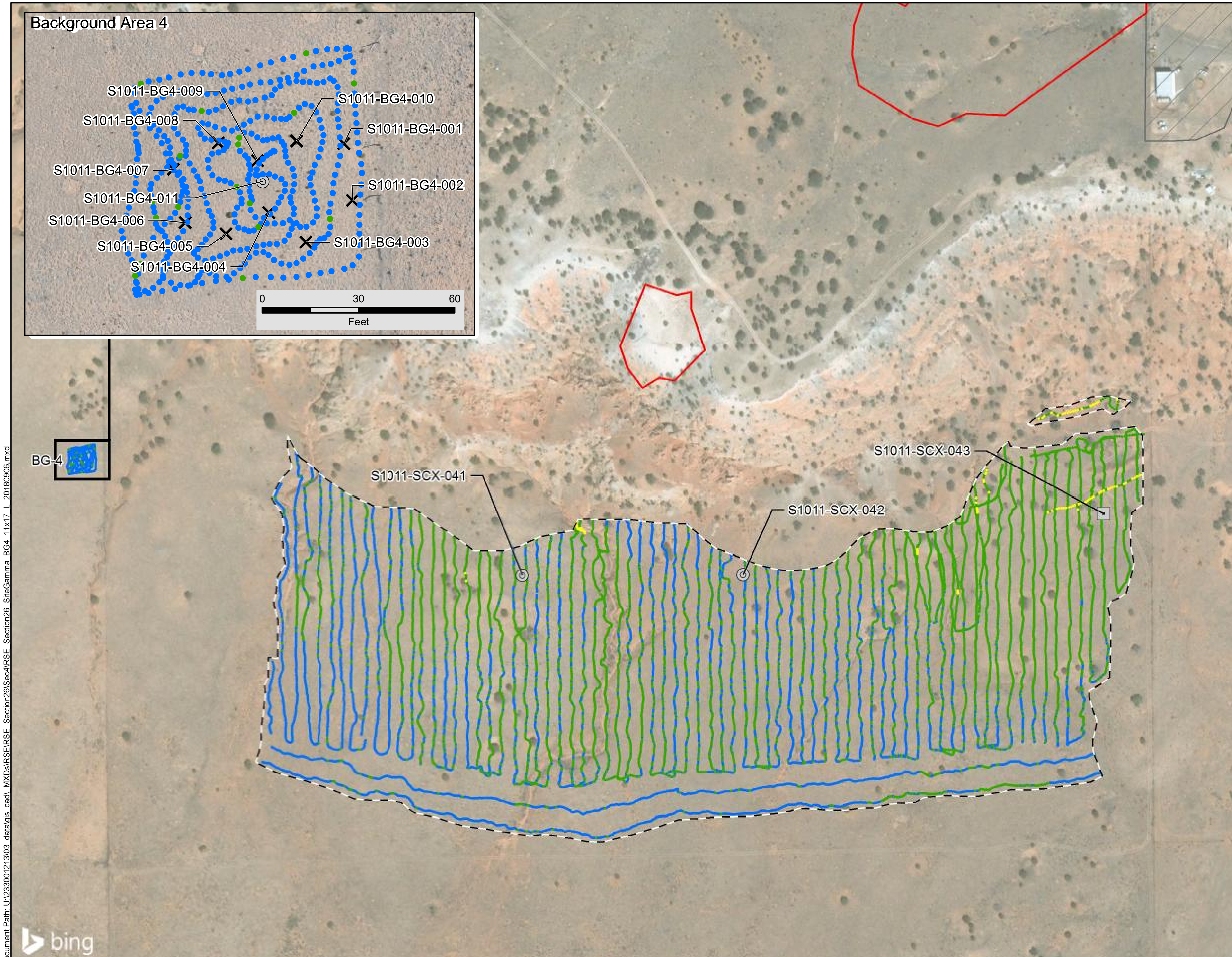
DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 4-1d



Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_SiteGamma_BG4_11x17_L_20180906.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Survey Area
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 12,476 - 20,637 (Minimum to BG-4 IL)
- 20,638 - 41,274 (>BG-4 IL to 2x BG-4 IL)
- 41,275 - 62,220 (>2x BG-4 IL to Maximum)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Main display basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

Inset basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 250 500
Feet

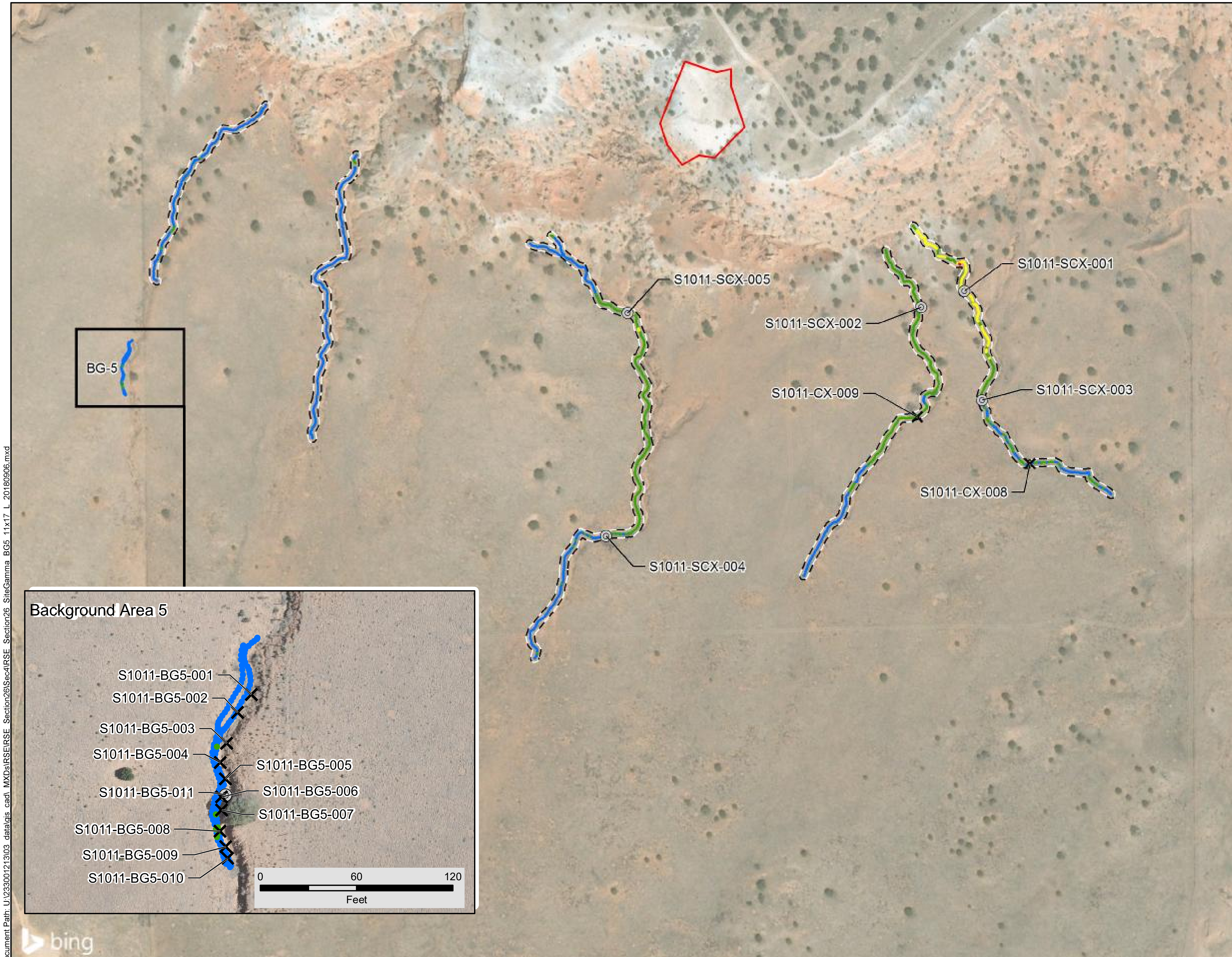
TITLE:
Gamma Radiation Survey Results for Survey Area D

PROJECT:
Removal Site Evaluation Section 26 Mine Site

DATE: 9/14/2018
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ
REVIEWER: CBB
FIGURE: 4-1e



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample
- Borehole Location - Surface and Subsurface Samples
- Survey Area
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 12,054 - 21,864 (Minimum to BG-5 IL)
- 21,865 - 43,728 (>BG-5 IL to 2x BG-5 IL)
- 43,729 - 109,320 (>2x BG-5 IL to 5x BG-5 IL)
- 109,321 - 117,875 (>5x BG-5 IL to Maximum)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Main display basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

Inset basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 250 500
Feet

TITLE:
Gamma Radiation Survey Results for Survey Area E

PROJECT:
Removal Site Evaluation Section 26 Mine Site

DATE: 9/14/2018

DOCUMENT NAME: Removal Site Evaluation Report

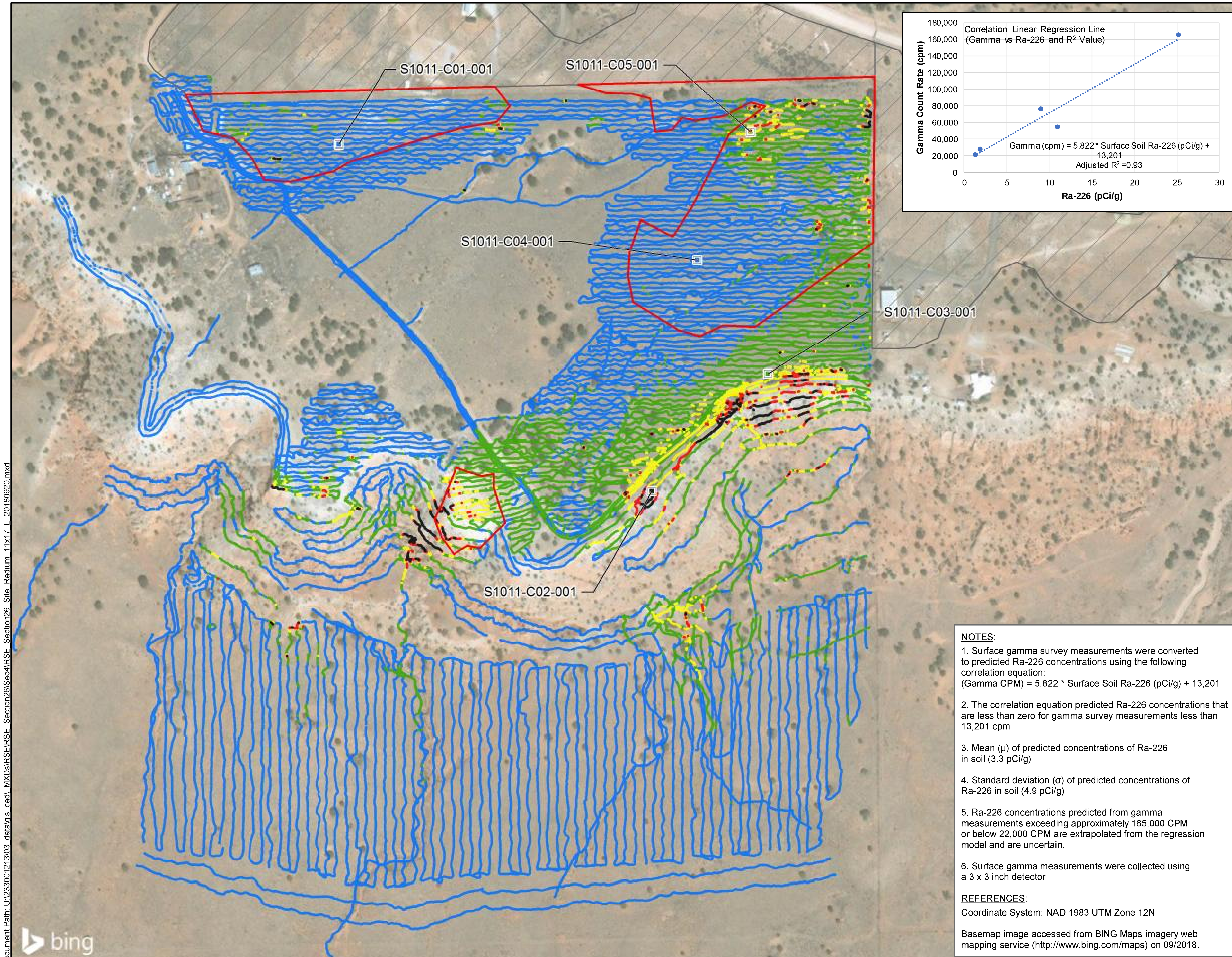
Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-1f

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_SiteGamma_BG5_11x17_L_20180906.mxd



NOTES:

1. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
(Gamma CPM) = 5,822 * Surface Soil Ra-226 (pCi/g) + 13,201

2. The correlation equation predicted Ra-226 concentrations that are less than zero for gamma survey measurements less than 13,201 cpm

3. Mean (μ) of predicted concentrations of Ra-226 in soil (3.3 pCi/g)

4. Standard deviation (σ) of predicted concentrations of Ra-226 in soil (4.9 pCi/g)

5. Ra-226 concentrations predicted from gamma measurements exceeding approximately 165,000 CPM or below 22,000 CPM are extrapolated from the regression model and are uncertain.

6. Surface gamma measurements were collected using a 3 x 3 inch detector

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

S1011-C01-001 Correlation Location (30'x30')

Claim Boundary

Other Claim Boundary

Predicted Ra-226 Concentration[1](pCi/g)

- Less than 0[2]
- 0 - 3.3 (μ)[3]
- 3.4 - 8.2 (μ + 1σ[4])
- 8.3 - 13.1 (μ + 2σ)
- 13.2 - 18.0 (μ + 3σ)
- 18.1 - 126.4[5]

Correlation Data		
Sample ID	Ra-226 (pCi/g)	Mean Gamma Count Rate (cpm)[1]
S1011-C01-001	1.26	21,632
S1011-C02-001	25.2	165,200
S1011-C03-001	11	55,042
S1011-C04-001	1.83	28,422
S1011-C05-001	9	76,851

1 Average gamma count rate for a correlation

N
W E
S

0 300 600
Feet

TITLE:
Predicted Concentrations of Ra-226 in Soil using the Correlation Equation

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/20/2018

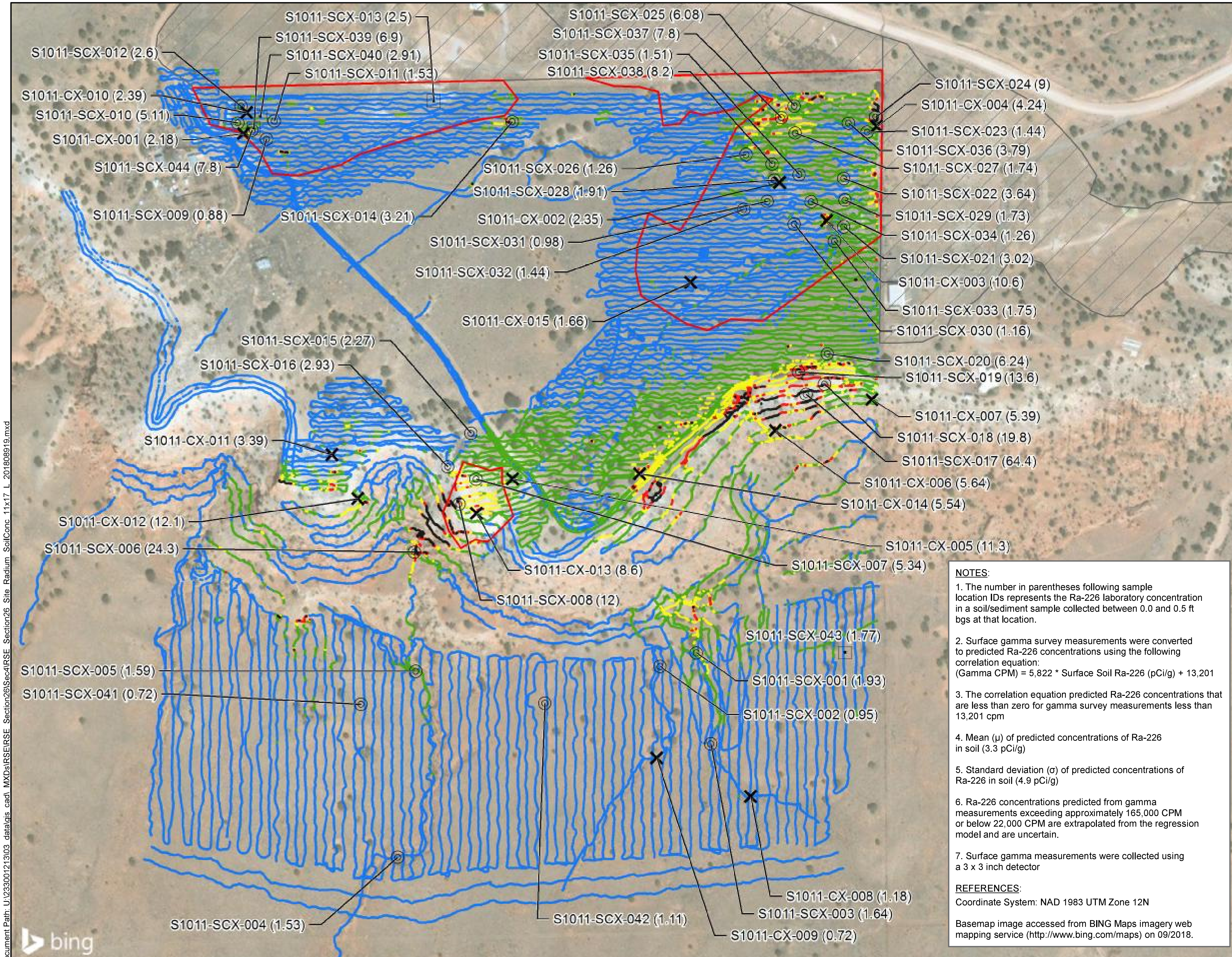
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-2a



NOTES:

1. The number in parentheses following sample location IDs represents the Ra-226 laboratory concentration in a soil/sediment sample collected between 0.0 and 0.5 ft bgs at that location.

2. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
(Gamma CPM) = 5,822 * Surface Soil Ra-226 (pCi/g) + 13,201

3. The correlation equation predicted Ra-226 concentrations that are less than zero for gamma survey measurements less than 13,201 cpm

4. Mean (μ) of predicted concentrations of Ra-226 in soil (3.3 pCi/g)

5. Standard deviation (σ) of predicted concentrations of Ra-226 in soil (4.9 pCi/g)

6. Ra-226 concentrations predicted from gamma measurements exceeding approximately 165,000 CPM or below 22,000 CPM are extrapolated from the regression model and are uncertain.

7. Surface gamma measurements were collected using a 3 x 3 inch detector

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Claim Boundary
- Other Claim Boundary

Predicted Ra-226 Concentration[2] (pCi/g)

- Less than 0[3]
- 0 - 3.3 (μ)[4]
- 3.4 - 8.2 (μ + 1σ[5])
- 8.3 - 13.1 (μ + 2σ)
- 13.2 - 18.0 (μ + 3σ)
- 18.1 - 126.4[6]

N
W E
S

0 300 600
Feet

TITLE:
Predicted Ra-226 Concentrations in Soil Compared to Ra-226 Concentrations in Surface Soil/Sediment

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/20/2018

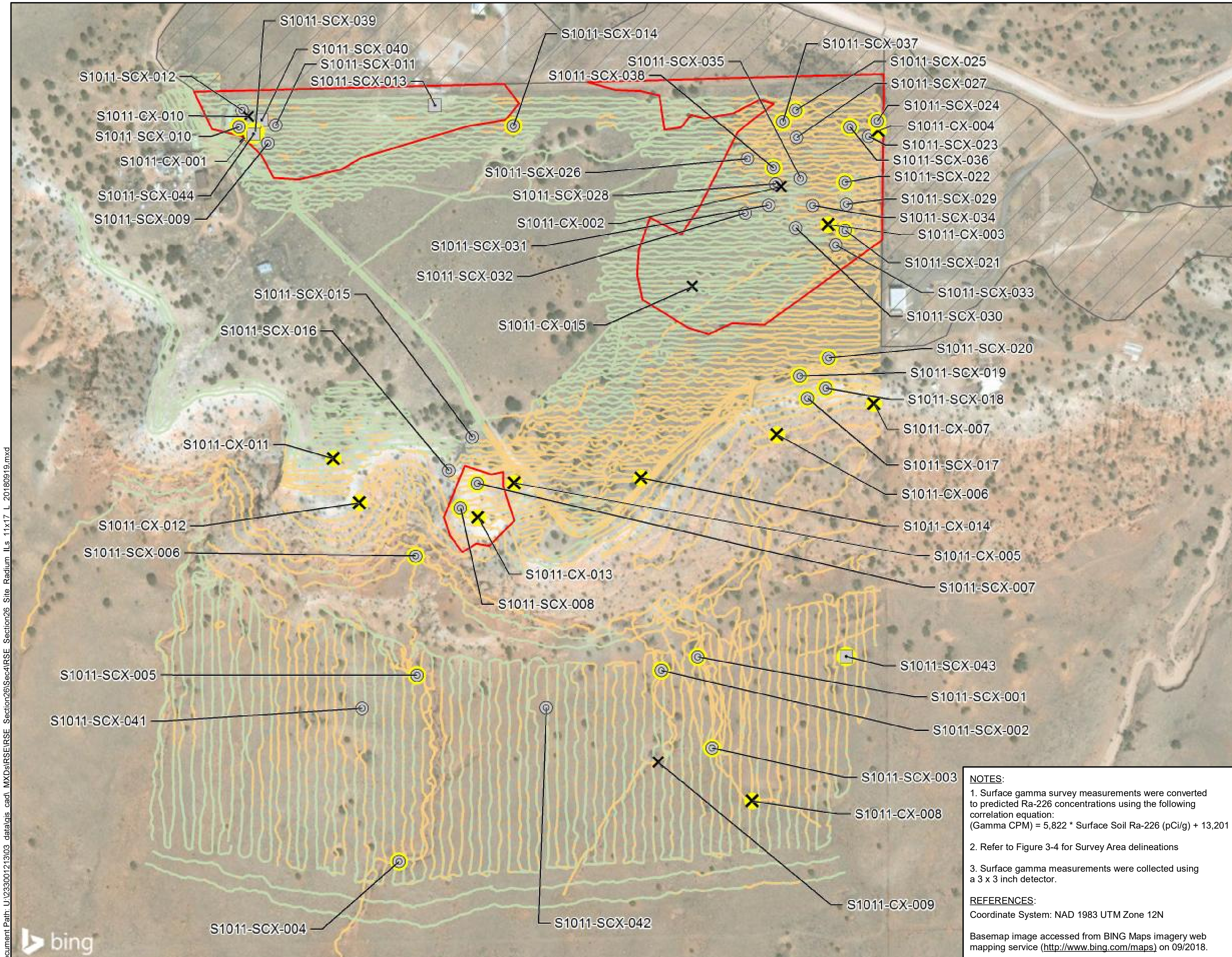
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-2b



NOTES:
1. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
(Gamma CPM) = 5,822 * Surface Soil Ra-226 (pCi/g) + 13,201

2. Refer to Figure 3-4 for Survey Area delineations

3. Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Ra-226 IL Exceedance in Surface Soil
- Claim Boundary
- Other Claim Boundary

Predicted RA-226 Concentration[1] (pCi/g)

IL Not Exceeded
Survey Area A: -0.37 - 2.13
Survey Area B: -0.78 - 2.96
Survey Area C: -0.29 - 1.49
Survey Area D: -0.12 - 1.49
Survey Area E: -0.21 - 0.84

IL Exceeded
Survey Area A: 2.14 - 110.21
Survey Area B: 2.97 - 106.47
Survey Area C: 1.50 - 126.40
Survey Area D: 1.50 - 8.42
Survey Area E: 0.85 - 17.98

N
W E
S

0 300 600
Feet

TITLE:
Predicted Ra-226 Concentrations in Surface Soil Compared to Ra-226 ILs

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

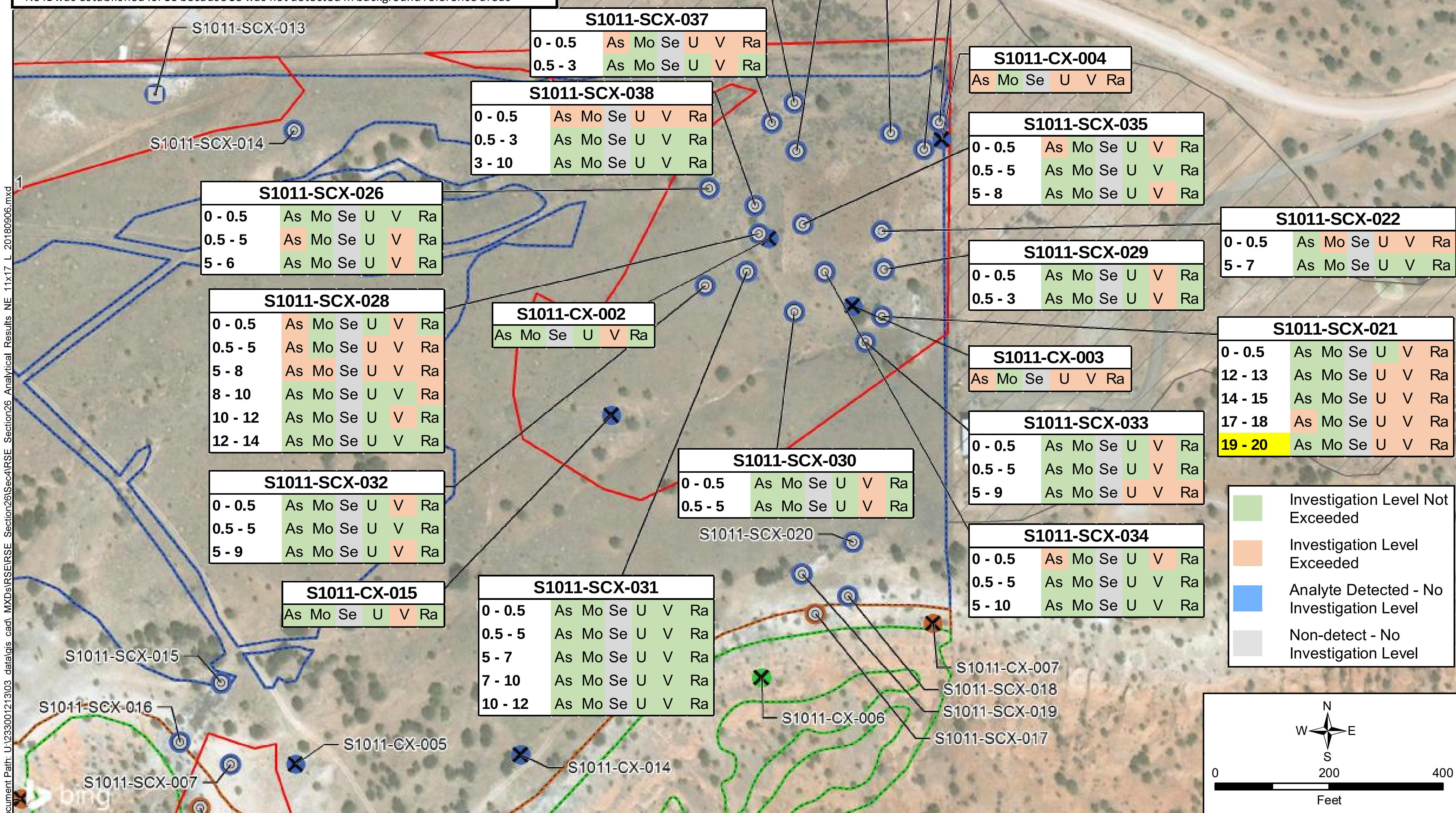
FIGURE: 4-2c

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_Radium_ILs_11x17_L_20180919.mxd

Soil and Sediment Investigation Levels					
	Investigation Level				
Analyte (Units)	Survey Area A	Survey Area B	Survey Area C	Survey Area D	Survey Area E
Metals (mg/kg)					
Arsenic	11.9	2.34	4.99	1.76	1.73
Molybdenum	2.26	0.346	0.367	0.210	NA[1]
Selenium	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
Uranium	3.23	3.34	1.91	0.554	0.691
Vanadium	27.3	11.2	17.4	11.0	10.7
Radionuclides (pCi/g)					
Radium-226	2.13	2.96	1.49	1.49	0.839

[1] No IL was established for Mo in Survey Area E because Mo was not detected in background reference area 5 (BG-5)

[2] No IL was established for Se because Se was not detected in background reference areas



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Survey Area A - Surface Sample Location
- Survey Area A - Borehole Location - Surface and Subsurface Samples
- Survey Area B - Surface Sample Location
- Survey Area B - Borehole Location - Surface and Subsurface Samples
- Survey Area B - Borehole Location - Surface Samples Only
- Survey Area C - Surface Sample Location
- Survey Area A
- Survey Area B
- Survey Area C
- Claim Boundary
- Other Claim Boundary

NOTES:

Sample Intervals (e.g. 0 - 0.5) are in ft bgs.

Surface gamma measurements were collected using a 3 x 3 inch detector.

Highlighted sample intervals are partially or completely within bedrock

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

TITLE: Surface and Subsurface Metals and Ra-226 Analytical Results Northeast Quadrant

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 9/14/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 4-3a

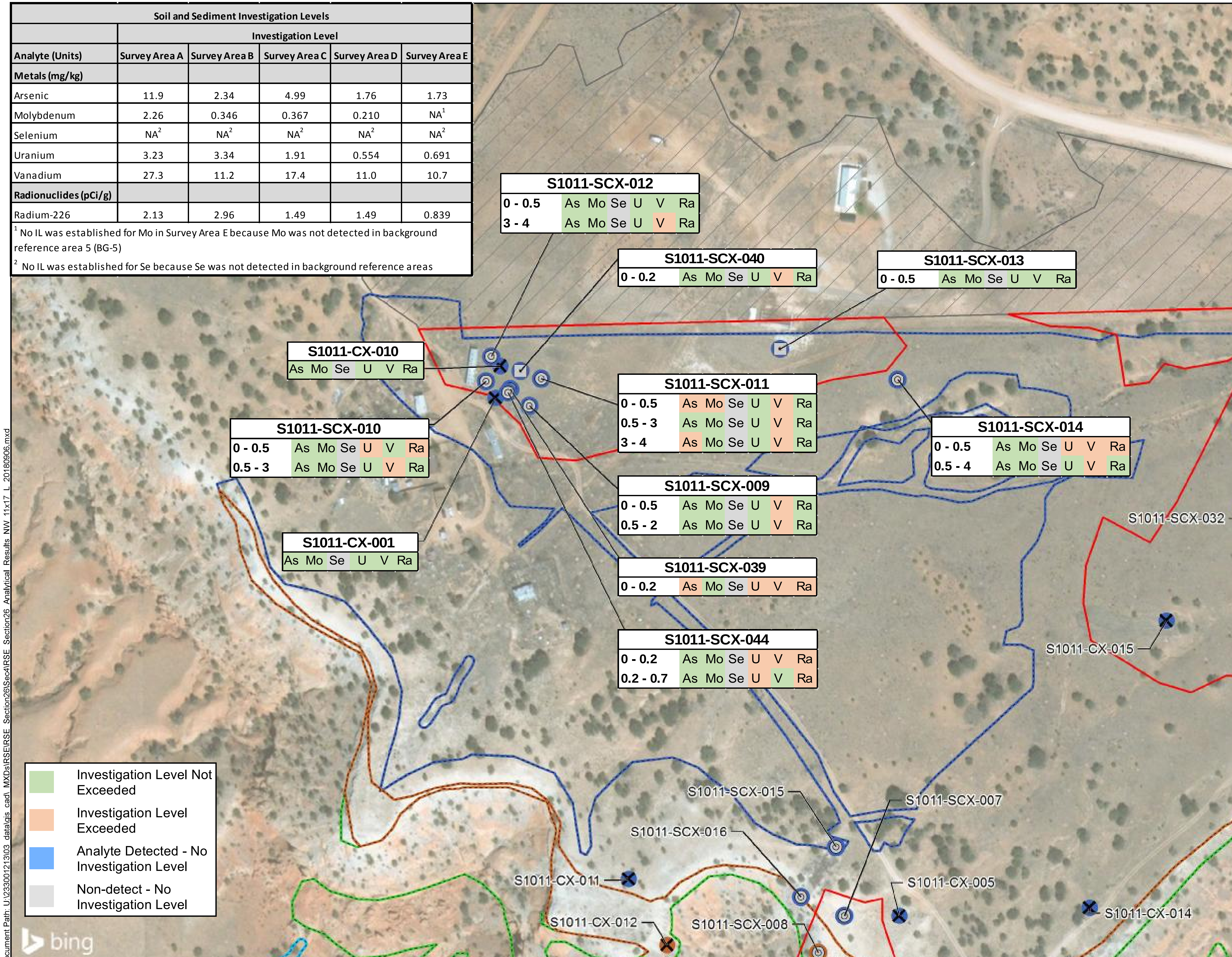
Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26\Sec4\RSE_Section26_Analytical_Results_NE_11x17_L_20180906.mxd

Soil and Sediment Investigation Levels

Analyte (Units)	Investigation Level				
	Survey Area A	Survey Area B	Survey Area C	Survey Area D	Survey Area E
Metals (mg/kg)					
Arsenic	11.9	2.34	4.99	1.76	1.73
Molybdenum	2.26	0.346	0.367	0.210	NA[1]
Selenium	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
Uranium	3.23	3.34	1.91	0.554	0.691
Vanadium	27.3	11.2	17.4	11.0	10.7
Radionuclides (pCi/g)					
Radium-226	2.13	2.96	1.49	1.49	0.839

[1] No IL was established for Mo in Survey Area E because Mo was not detected in background reference area 5 (BG-5)

[2] No IL was established for Se because Se was not detected in background reference areas



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NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Survey Area A - Surface Sample Location
- Survey Area A - Borehole Surface and Subsurface Sample Location
- Survey Area B - Surface Sample Location
- Survey Area B - Borehole Surface and Subsurface Sample Location
- Survey Area B - Borehole Surface Sample Location
- Survey Area A
- Survey Area B
- Survey Area C
- Survey Area E
- Claim Boundary
- Other Claim Boundary

NOTES:

Sample Intervals (e.g. 0 - 0.5) are in ft bgs.

Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S

0 200 400
Feet

TITLE: Surface and Subsurface Metals and Ra-226 Analytical Results Northwest Quadrant

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 9/6/2018

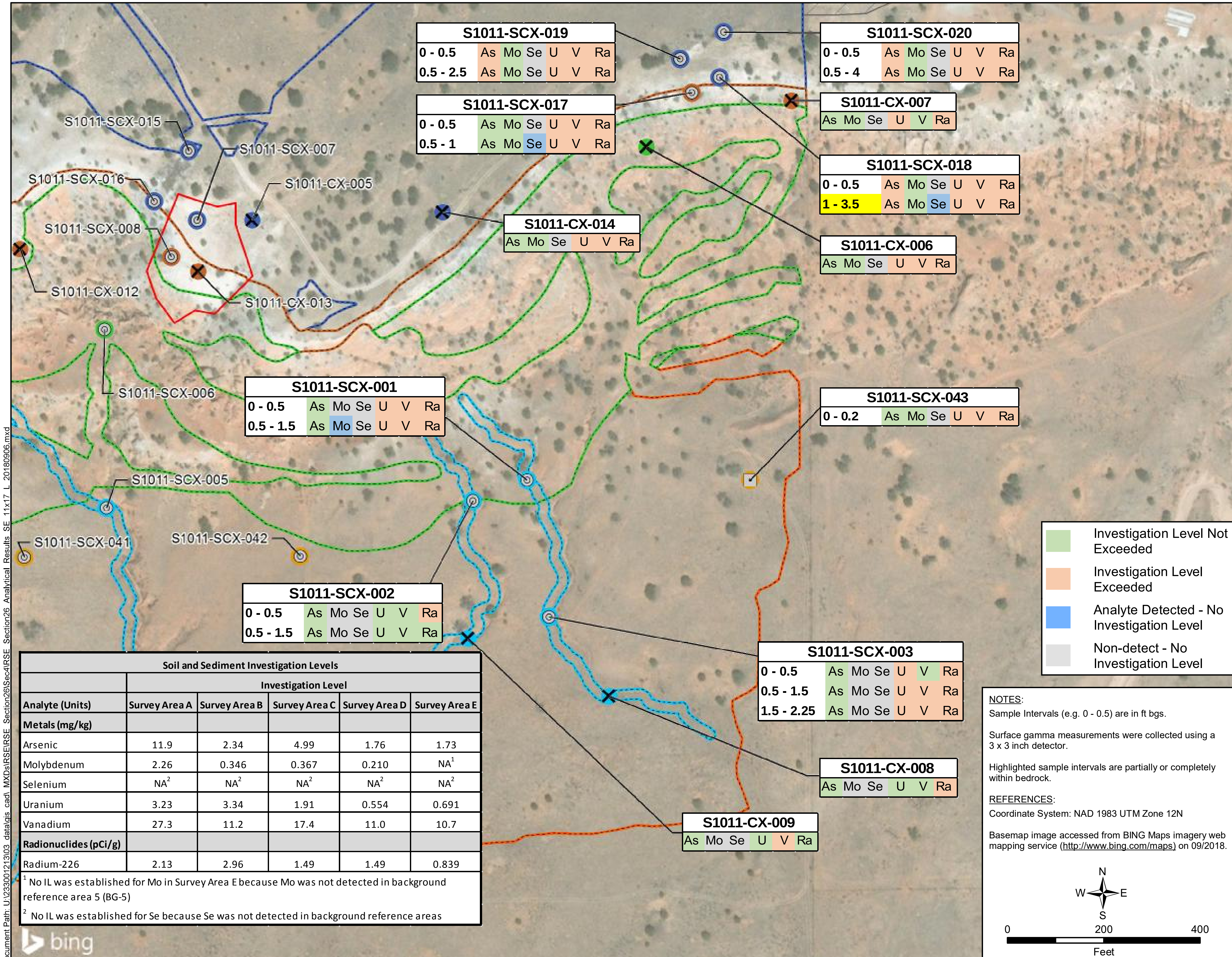
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-3b



Soil and Sediment Investigation Levels

	Investigation Level				
Analyte (Units)	Survey Area A	Survey Area B	Survey Area C	Survey Area D	Survey Area E
Metals (mg/kg)					
Arsenic	11.9	2.34	4.99	1.76	1.73
Molybdenum	2.26	0.346	0.367	0.210	NA[1]
Selenium	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
Uranium	3.23	3.34	1.91	0.554	0.691
Vanadium	27.3	11.2	17.4	11.0	10.7
Radionuclides (pCi/g)					
Radium-226	2.13	2.96	1.49	1.49	0.839

[1] No IL was established for Mo in Survey Area E because Mo was not detected in background reference area 5 (BG-5)

[2] No IL was established for Se because Se was not detected in background reference areas

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Survey Area A - Surface Sample Location
- Survey Area A - Borehole Location - Surface and Subsurface Samples
- Survey Area B - Surface Sample Location
- Survey Area B - Borehole Location - Surface and Subsurface Samples
- Survey Area C - Surface Sample Location
- Survey Area C - Borehole Location - Surface and Subsurface Samples
- Survey Area D - Borehole Location - Surface and Subsurface Samples
- Survey Area D - Borehole Location - Surface Samples Only
- Survey Area E - Surface Sample Location
- Survey Area E - Borehole Location - Surface and Subsurface Samples
- Survey Area A
- Survey Area B
- Survey Area C
- Survey Area D
- Survey Area E
- Claim Boundary
- Other Claim Boundary

NOTES:
Sample Intervals (e.g. 0 - 0.5) are in ft bgs.

Surface gamma measurements were collected using a 3 x 3 inch detector.

Highlighted sample intervals are partially or completely within bedrock.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S

0 200 400
Feet

TITLE: Surface and Subsurface Metals and Ra-226 Analytical Results Southeast Quadrant

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 9/17/2018

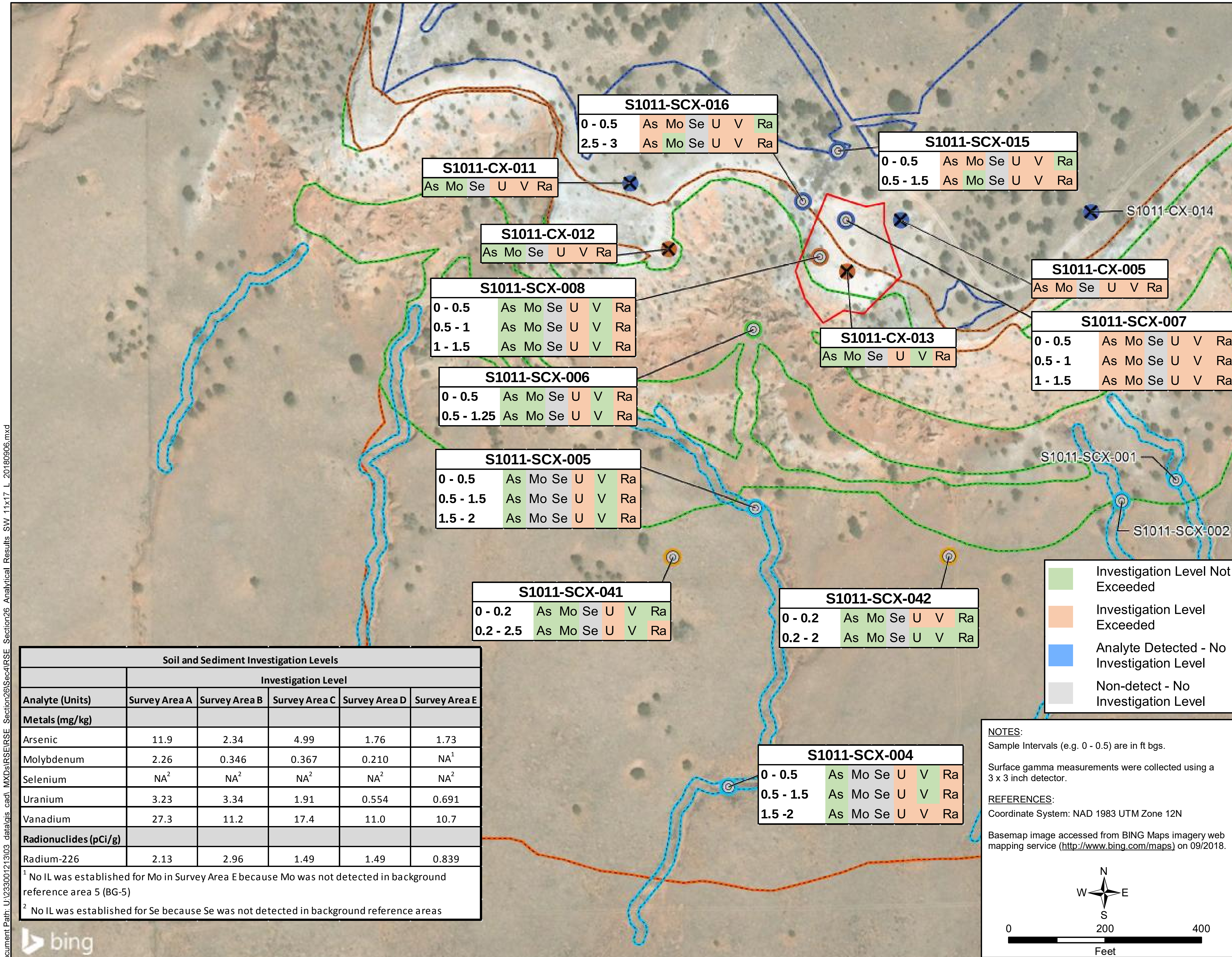
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-3c



Soil and Sediment Investigation Levels

Analyte (Units)	Investigation Level				
	Survey Area A	Survey Area B	Survey Area C	Survey Area D	Survey Area E
Metals (mg/kg)					
Arsenic	11.9	2.34	4.99	1.76	1.73
Molybdenum	2.26	0.346	0.367	0.210	NA[1]
Selenium	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
Uranium	3.23	3.34	1.91	0.554	0.691
Vanadium	27.3	11.2	17.4	11.0	10.7
Radionuclides (pCi/g)					
Radium-226	2.13	2.96	1.49	1.49	0.839

[1] No IL was established for Mo in Survey Area E because Mo was not detected in background reference area 5 (BG-5)

[2] No IL was established for Se because Se was not detected in background reference areas

Investigation Level Not Exceeded
Investigation Level Exceeded
Analyte Detected - No Investigation Level
Non-detect - No Investigation Level

NOTES:
Sample Intervals (e.g. 0 - 0.5) are in ft bgs.

Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S
0 200 400
Feet

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Survey Area A - Surface Sample Location
- Survey Area A - Borehole Location - Surface and Subsurface Samples
- Survey Area B - Surface Sample Location
- Survey Area B - Borehole Location - Surface and Subsurface Samples
- Survey Area C - Borehole Location - Surface and Subsurface Samples
- Survey Area D - Borehole Location - Surface and Subsurface Samples
- Survey Area E - Surface Sample Location
- Survey Area E - Borehole Location - Surface and Subsurface Samples
- Survey Area A
- Survey Area B
- Survey Area C
- Survey Area D
- Survey Area E
- Claim Boundary

TITLE: Surface and Subsurface Metals and Ra-226 Analytical Results Southwest Quadrant

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 9/17/2018

DOCUMENT NAME: Removal Site Evaluation Report

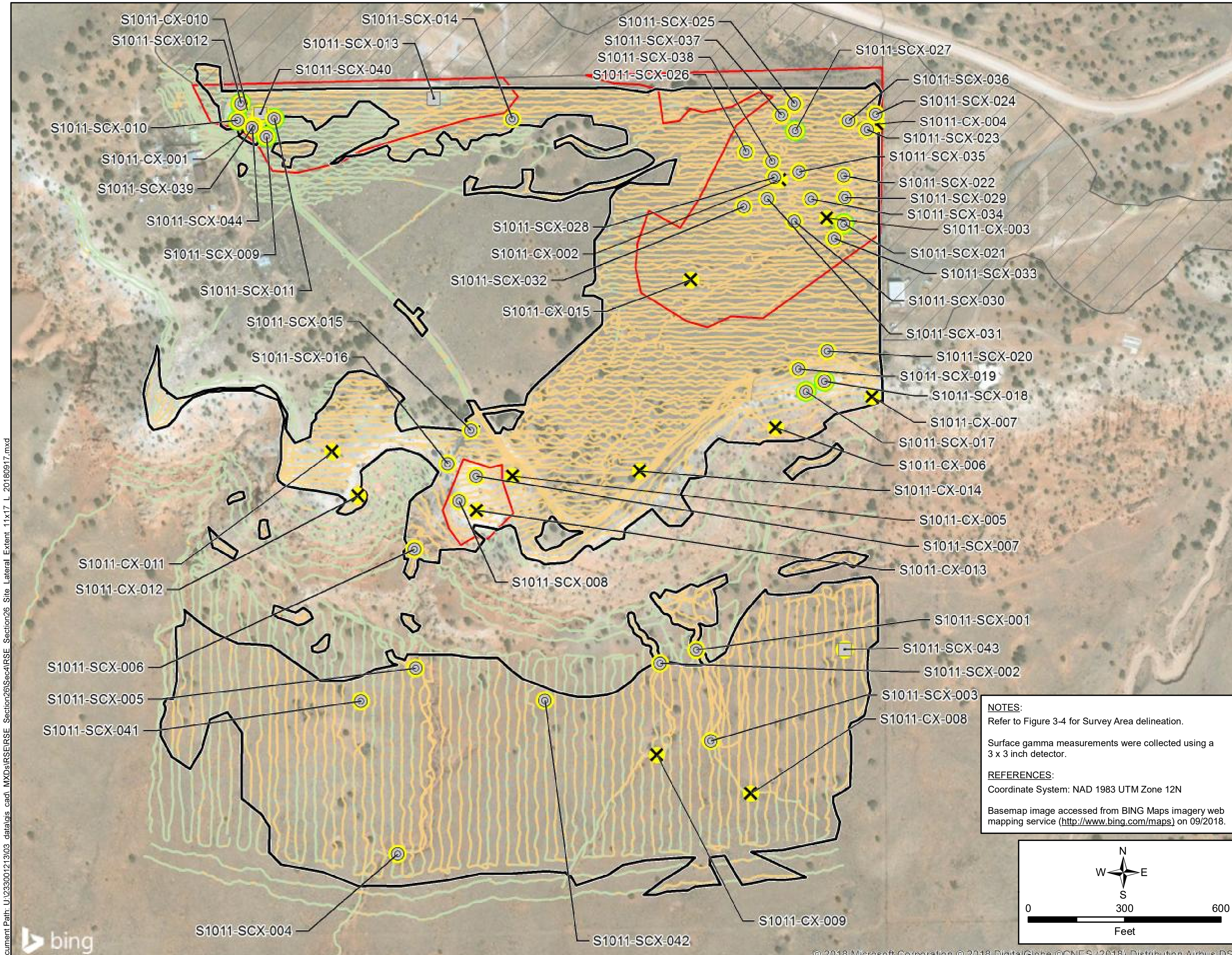
Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-3d

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Analytical_Results_SW_11x17_L_20180906.mxd



NOTES:
Refer to Figure 3-4 for Survey Area delineation.

Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- IL Exceedance in Unconsolidated Material at Location
- IL Exceedance in Bedrock in Borehole
- Approximate Area where Surface Gamma ILs are Exceeded (69.7 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

IL Not Exeeded
Survey Area A: 11,058 - 16,829
Survey Area B: 8,652 - 23,320
Survey Area C: 11,527 - 48,542
Survey Area D: 12,476 - 20,637
Survey Area E: 12,001 - 21,864

IL Exceeded
Survey Area A: 16,830 - 654,837
Survey Area B: 23,321 - 633,057
Survey Area C: 48,543 - 749,127
Survey Area D: 20,638 - 62,220
Survey Area E: 21,865 - 117,575

TITLE:
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation Section 26 Mine Site

DATE: 9/17/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 4-4a

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- IL Exceedance in Unconsolidated Material at Location
- IL Exceedance in Bedrock in Borehole
- Approximate Area where Surface Gamma IL is Exceeded (3.0 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 11,058 - 16,829 (IL Not Exeeded)
- 16,830 - 654,837 (IL Exceeded)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

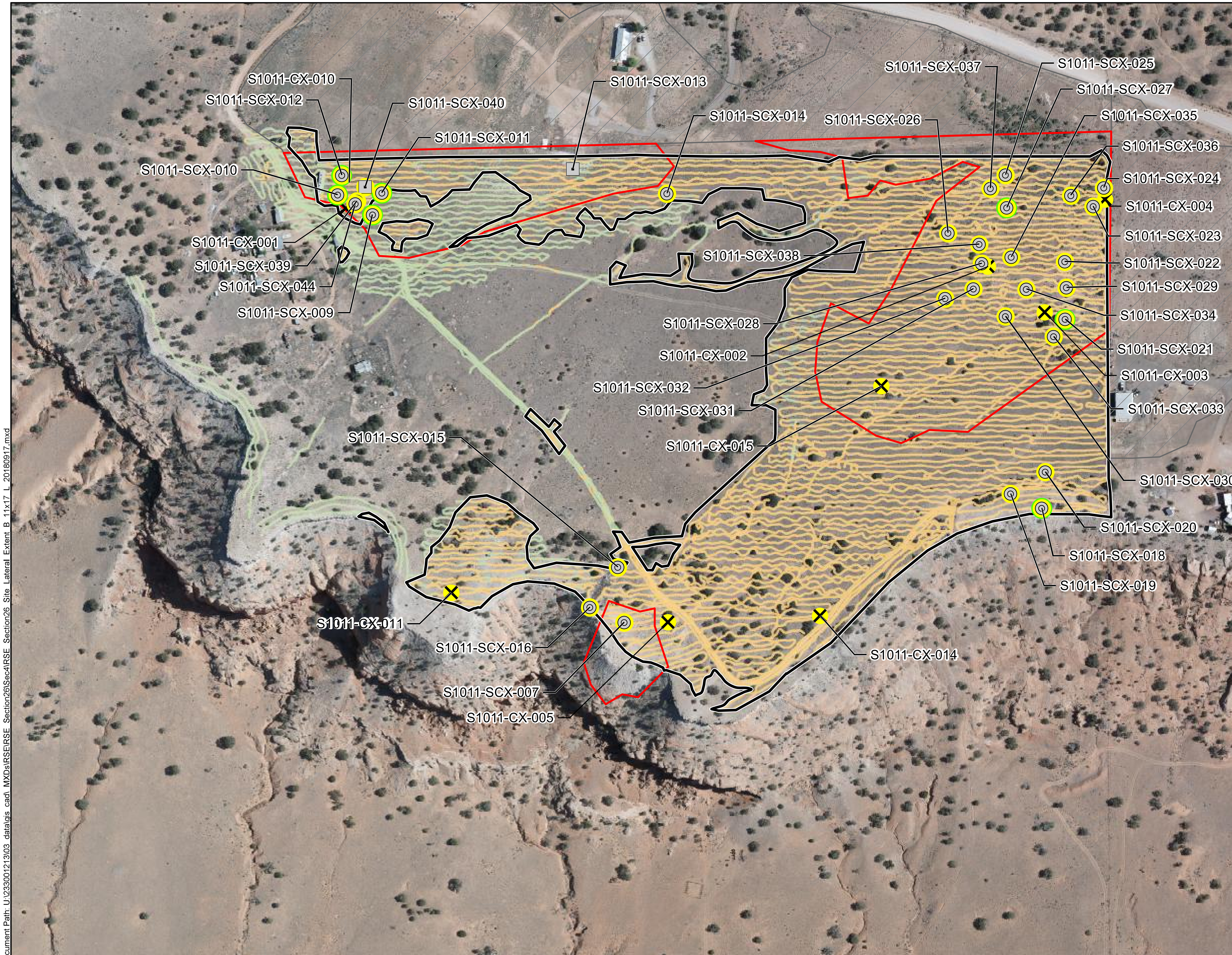
0 200 400
Feet

TITLE:
Survey Area A
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/17/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-4b	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_Lateral_Extent_A_11x17_L_20180917.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- IL Exceedance in Unconsolidated Material at Location
- IL Exceedance in Bedrock in Borehole
- Approximate Area where Surface Gamma IL is Exceeded (30.9 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)
- 8,652 - 23,320 (IL Not Exeeded)
- 23,321 - 633,057 (IL Exceeded)

NOTE: Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

TITLE: Survey Area B
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT: Removal Site Evaluation
Section 26 Mine Site

DATE: 9/17/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-4c

Stantec

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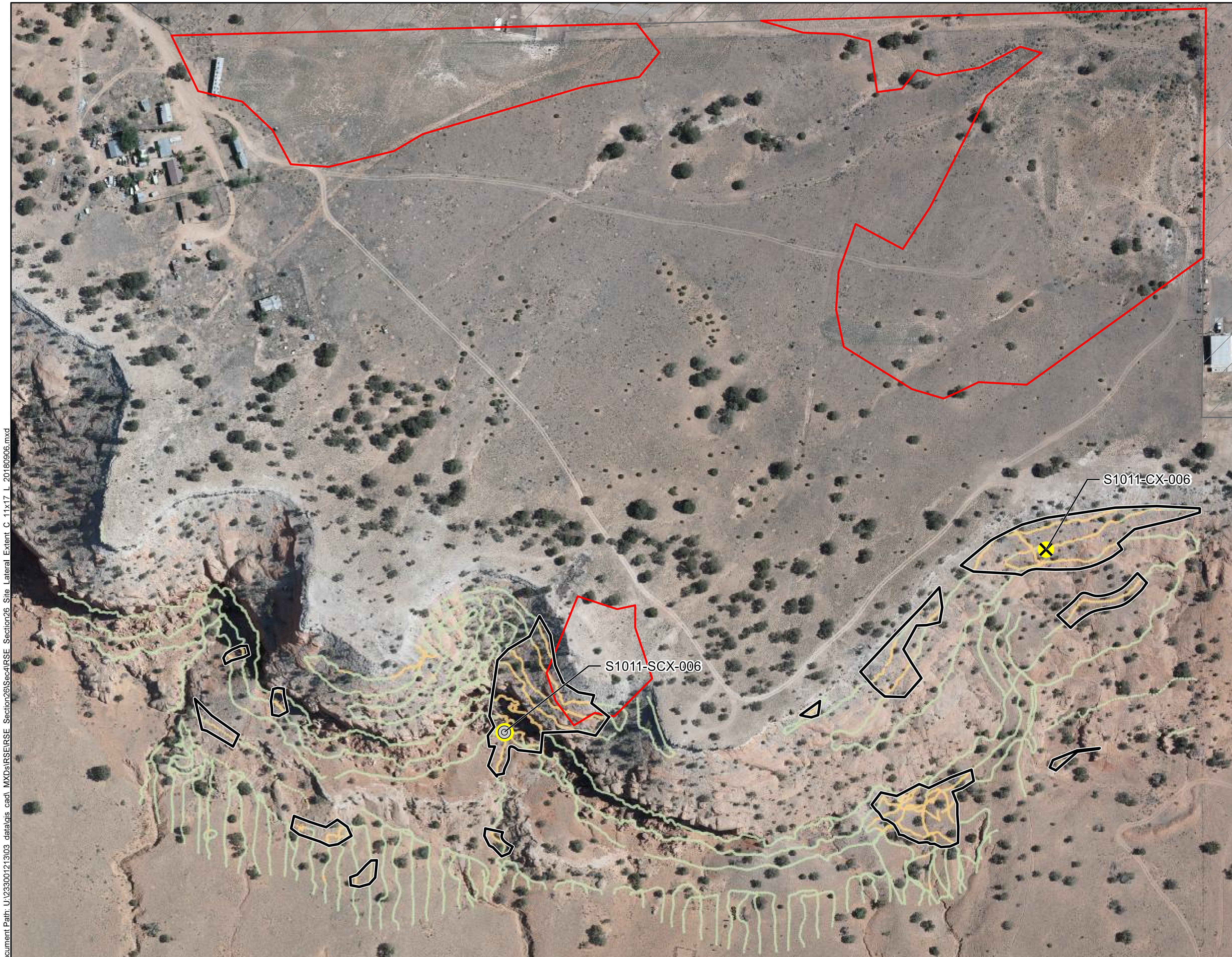

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma IL is Exceeded (2.9 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 11,527 - 48,542 (IL Not Exeeded)
- 48,543 - 749,127 (IL Exceeded)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 200 400
Feet

TITLE:
Survey Area C
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/17/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-4d	

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma IL is Exceeded (31.6 acres)
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)
- 12,476 - 20,637 (IL Not Exeeded)
- 20,638 - 62,220 (IL Exceeded)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S

0 200 400
Feet

TITLE: Survey Area D Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 9/18/2018

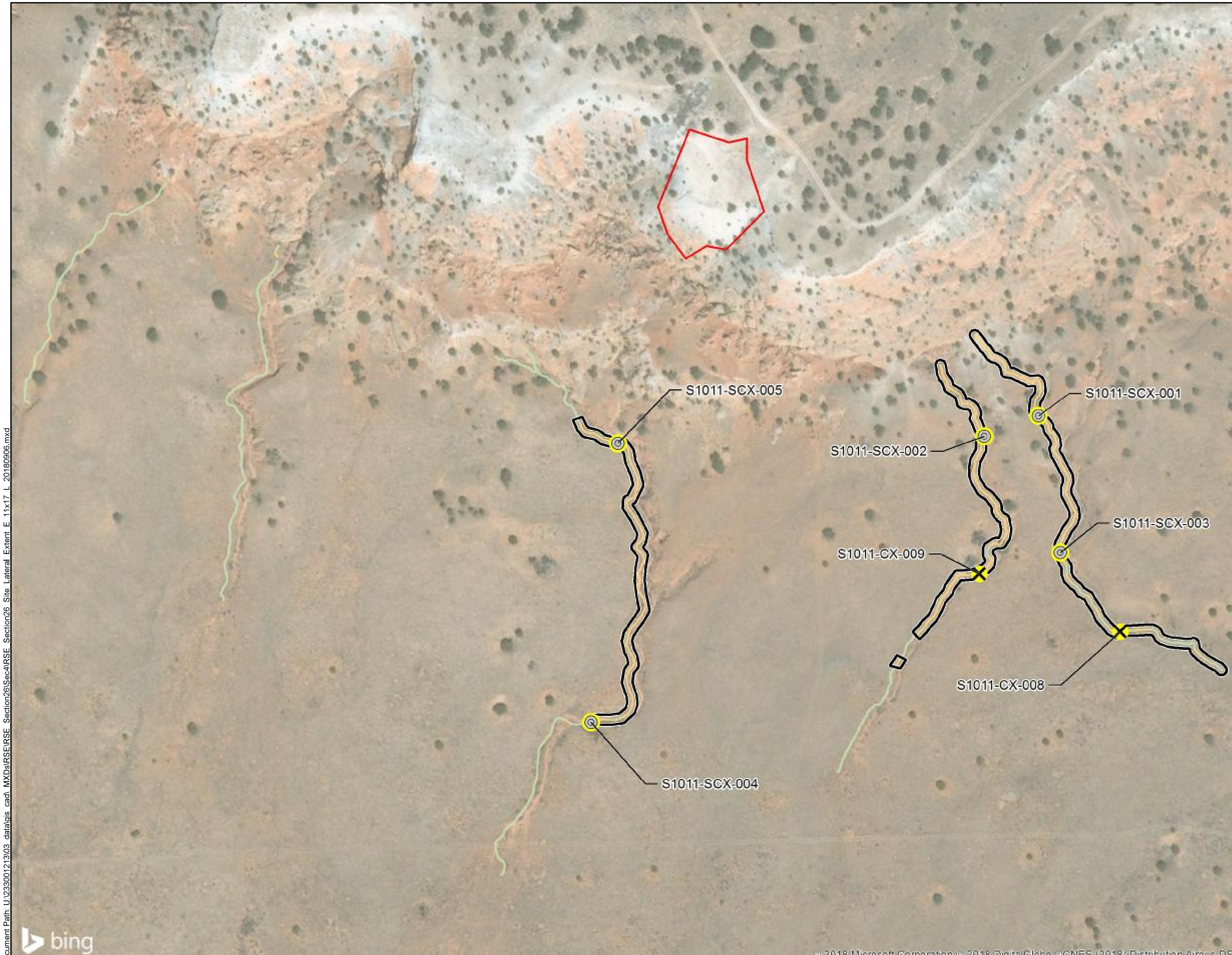
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-4e



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma IL is Exceeded (1.3 acres)
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 12,001 - 21,864 (IL Not Exeeded)
- 21,865 - 117,575 (IL Exceeded)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S

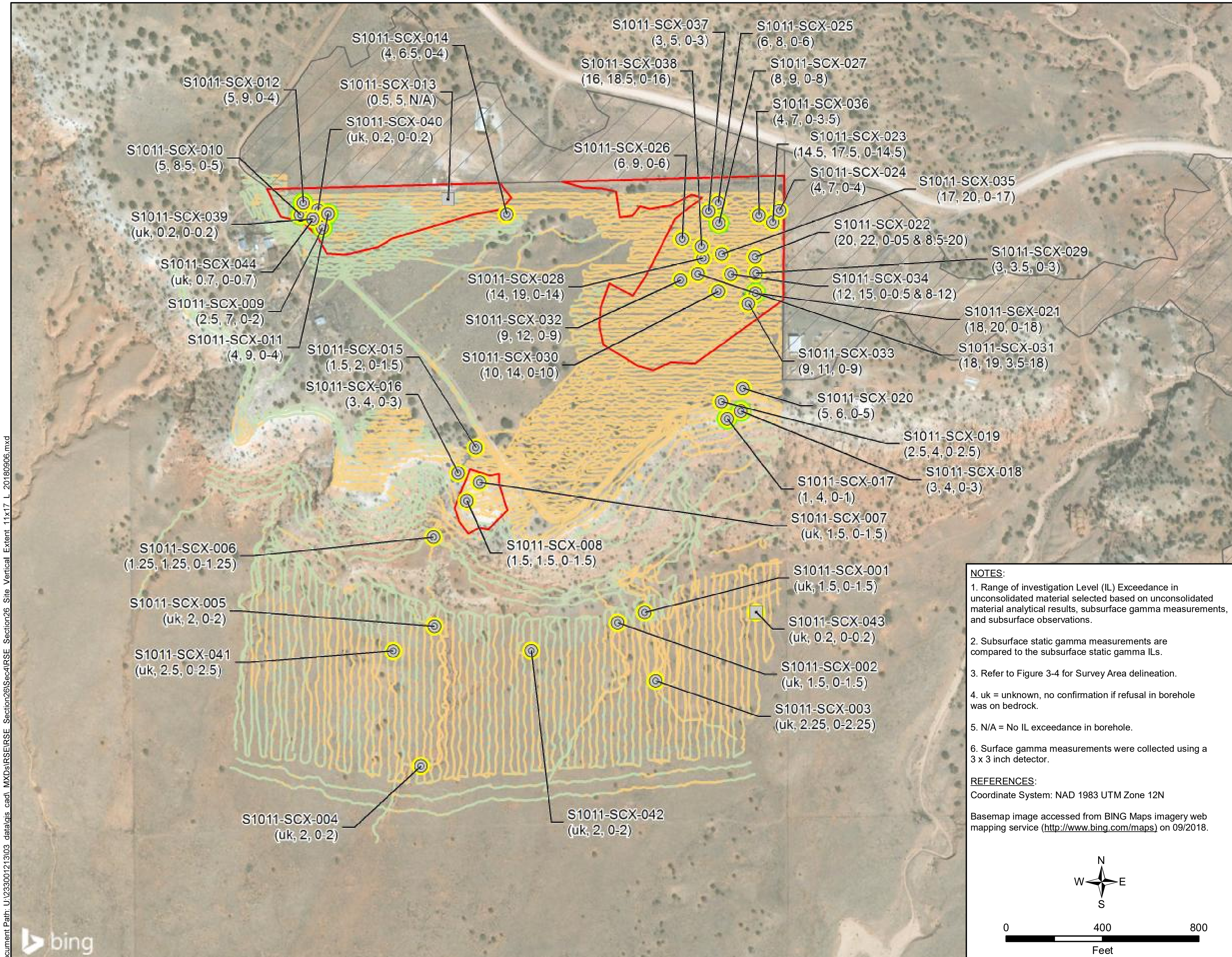
0 200 400
Feet

TITLE:
Survey Area E
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/18/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-4f	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_Lateral_Extent_E_11x17_L_20180906.mxd



NOTES:

1. Range of investigation Level (IL) Exceedance in unconsolidated material selected based on unconsolidated material analytical results, subsurface gamma measurements, and subsurface observations.

2. Subsurface static gamma measurements are compared to the subsurface static gamma ILs.

3. Refer to Figure 3-4 for Survey Area delineation.

4. uk = unknown, no confirmation if refusal in borehole was on bedrock.

5. N/A = No IL exceedance in borehole.

6. Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Borehole Surface and Subsurface Sample Location (Depth of Bedrock, Borehole Depth, Depth Range of IL Exceedance in Unconsolidated Material[1])
- Borehole Surface Sample Location (Depth of Bedrock, Borehole Depth, Depth Range of IL Exceedance in Unconsolidated Material[1])
- IL Exceedance in Unconsolidated Material at Location
- IL Exceedance in Bedrock in Borehole
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

IL Not Exeeded
Survey Area A: 11,058 - 16,829
Survey Area B: 8,652 - 23,320
Survey Area C: 11,527 - 48,542
Survey Area D: 12,476 - 20,637
Survey Area E: 12,001 - 21,864

IL Exceeded
Survey Area A: 16,830 - 654,837
Survey Area B: 23,321 - 633,057
Survey Area C: 48,543 - 749,127
Survey Area D: 20,638 - 62,220
Survey Area E: 21,865 - 117,575

TITLE:
Vertical Extent of IL Exceedances in Unconsolidated Material

PROJECT:
Removal Site Evaluation Section 26 Mine Site

DATE: 9/20/2018

DOCUMENT NAME: Removal Site Evaluation Report

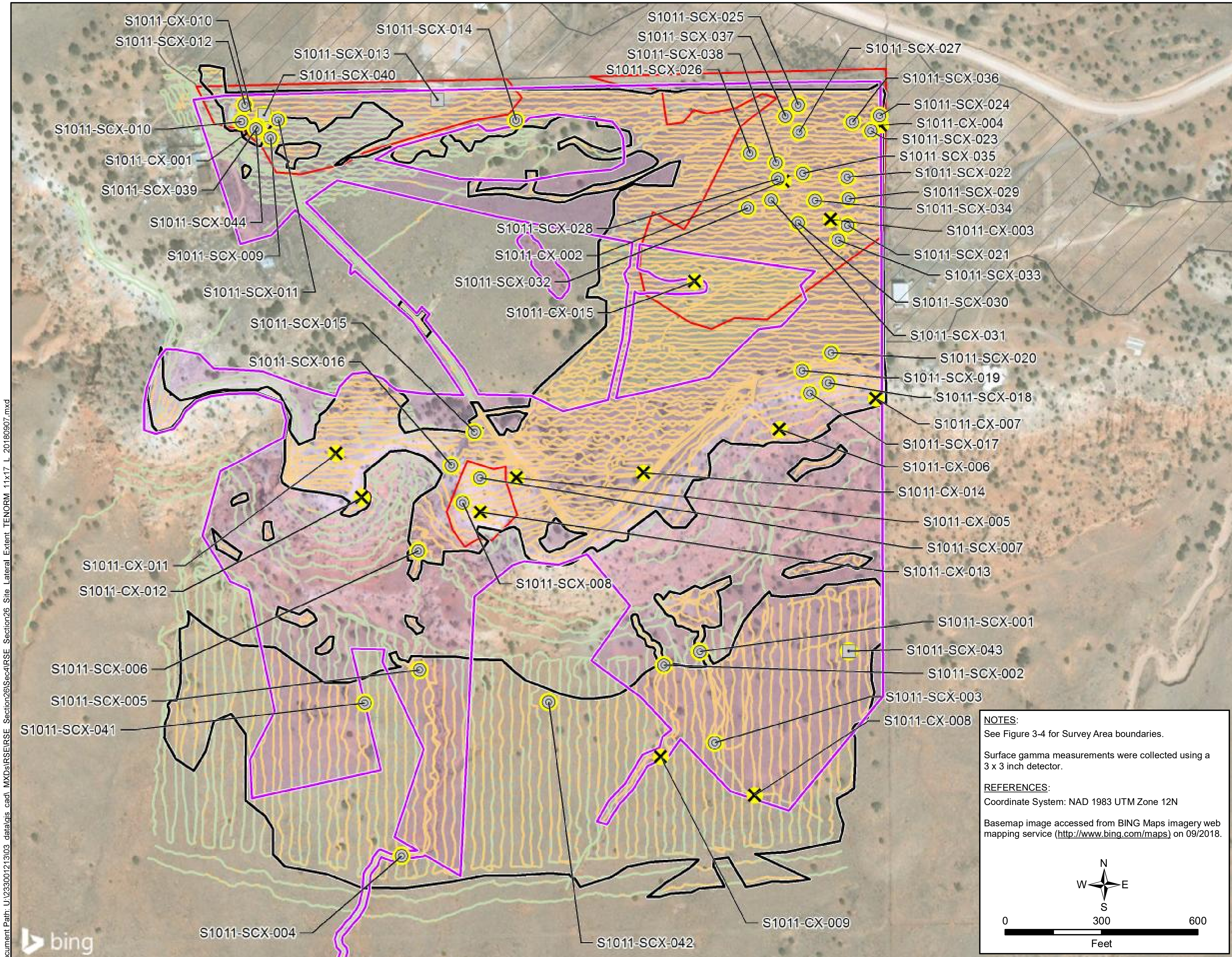
Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-5

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_Vertical_Extent_11x17_L_20180906.mxd



NOTES:
See Figure 3-4 for Survey Area boundaries.

Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N
W E
S
0 300 600
Feet

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- IL Exceedance in Unconsolidated Material at Location
- TENORM (72.2 acres)
- Approximate Area where Surface Gamma IL is Exceeded (69.7 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

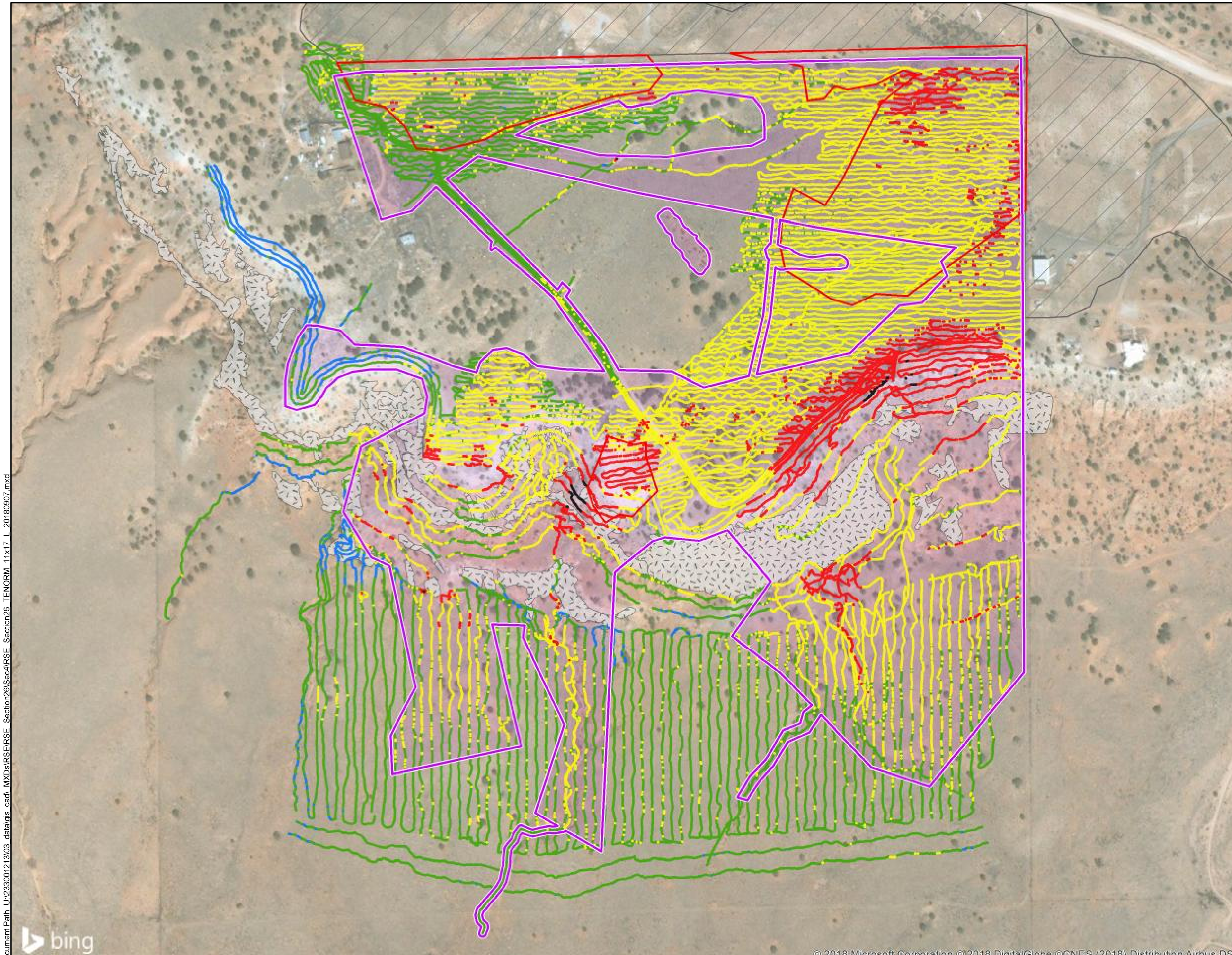
IL Not Exeeded
Survey Area A: 11058 - 16829
Survey Area B: 8652 - 23320
Survey Area C: 11527 - 48542
Survey Area D: 12476 - 20637
Survey Area E: 12001 - 21864

IL Exceeded
Survey Area A: 16830 - 654837
Survey Area B: 23321 - 633057
Survey Area C: 48543 - 749127
Survey Area D: 20638 - 62220
Survey Area E: 21865 - 117575

TITLE:
TENORM Compared to Lateral Extent of IL Exceedances

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/20/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-6	



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NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- TENORM (72.2 acres)
- Exposed Bedrock[1]
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 8,652 - 16,829 (Minimum to BG-1 IL)
- 16,830 - 23,320 (>BG-1 IL to BG-2 IL)
- 23,321 - 46,640 (>BG-2 IL to 2x BG-2 IL)
- 46,641 - 233,200 (>2x BG-2 IL to 10x BG-2 IL)
- 233,201 - 749,127 (>10x BG-2 IL to Maximum)

NOTES:

1. Portions of the areas delineated as exposed bedrock contain small amounts of colluvium.

2. Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S

0 300 600
Feet

TITLE: TENORM Compared to Gamma Radiation Survey Results

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 9/20/2018

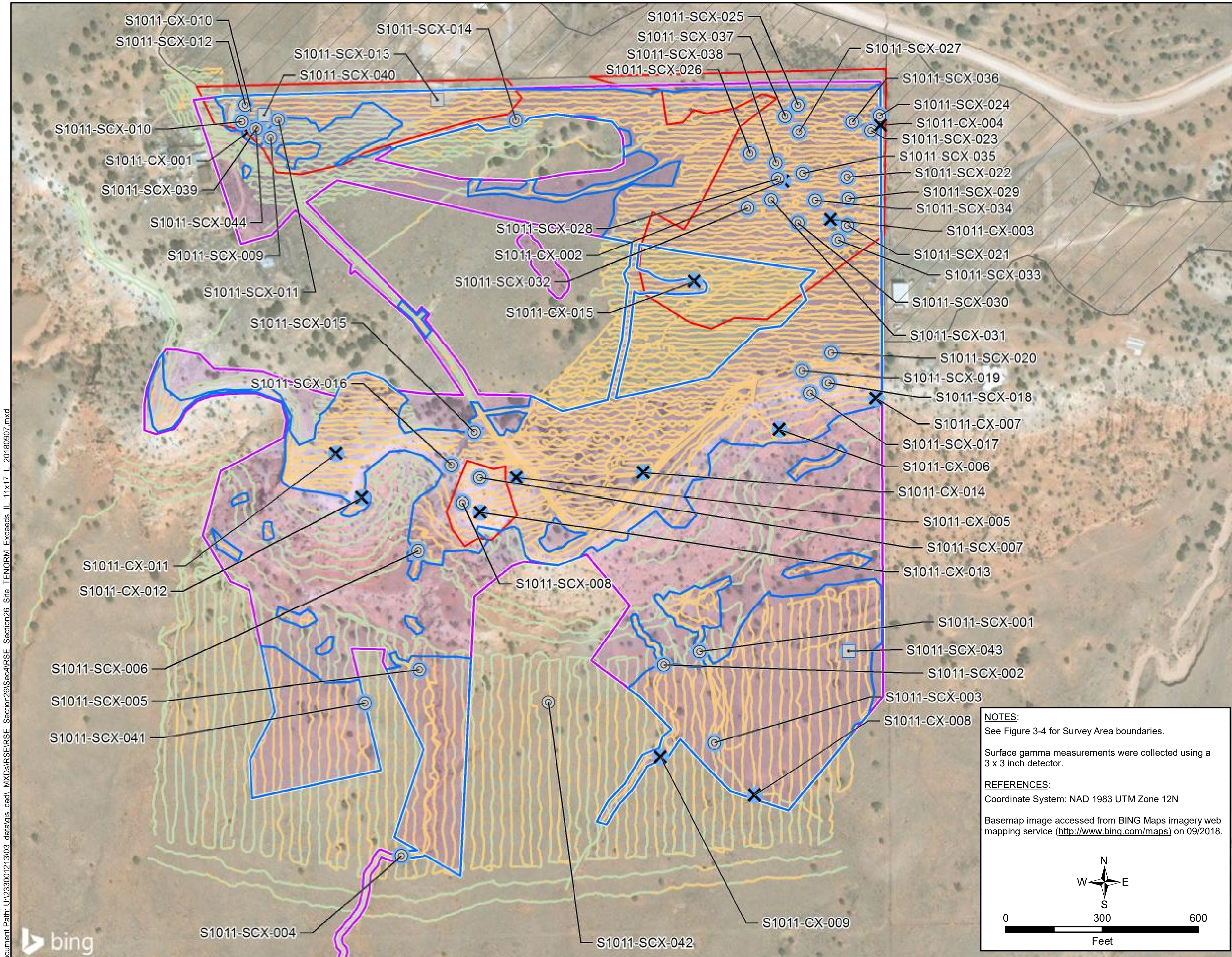
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-7



NOTES:
See Figure 3-4 for Survey Area boundaries.

Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S

0 300 600
Feet

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (45.2 acres)
- TENORM (72.2 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

IL Not Exeeded
Survey Area A: 11058 - 16829
Survey Area B: 8652 - 23320
Survey Area C: 11527 - 48542
Survey Area D: 12476 - 20637
Survey Area E: 12001 - 21864

IL Exceeded
Survey Area A: 16830 - 654837
Survey Area B: 23321 - 633057
Survey Area C: 48543 - 749127
Survey Area D: 20638 - 62220
Survey Area E: 21865 - 117575

TITLE: TENORM that Exceed ILs

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 9/20/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: EDZ / REVIEWER: CBB
	FIGURE: 4-8a

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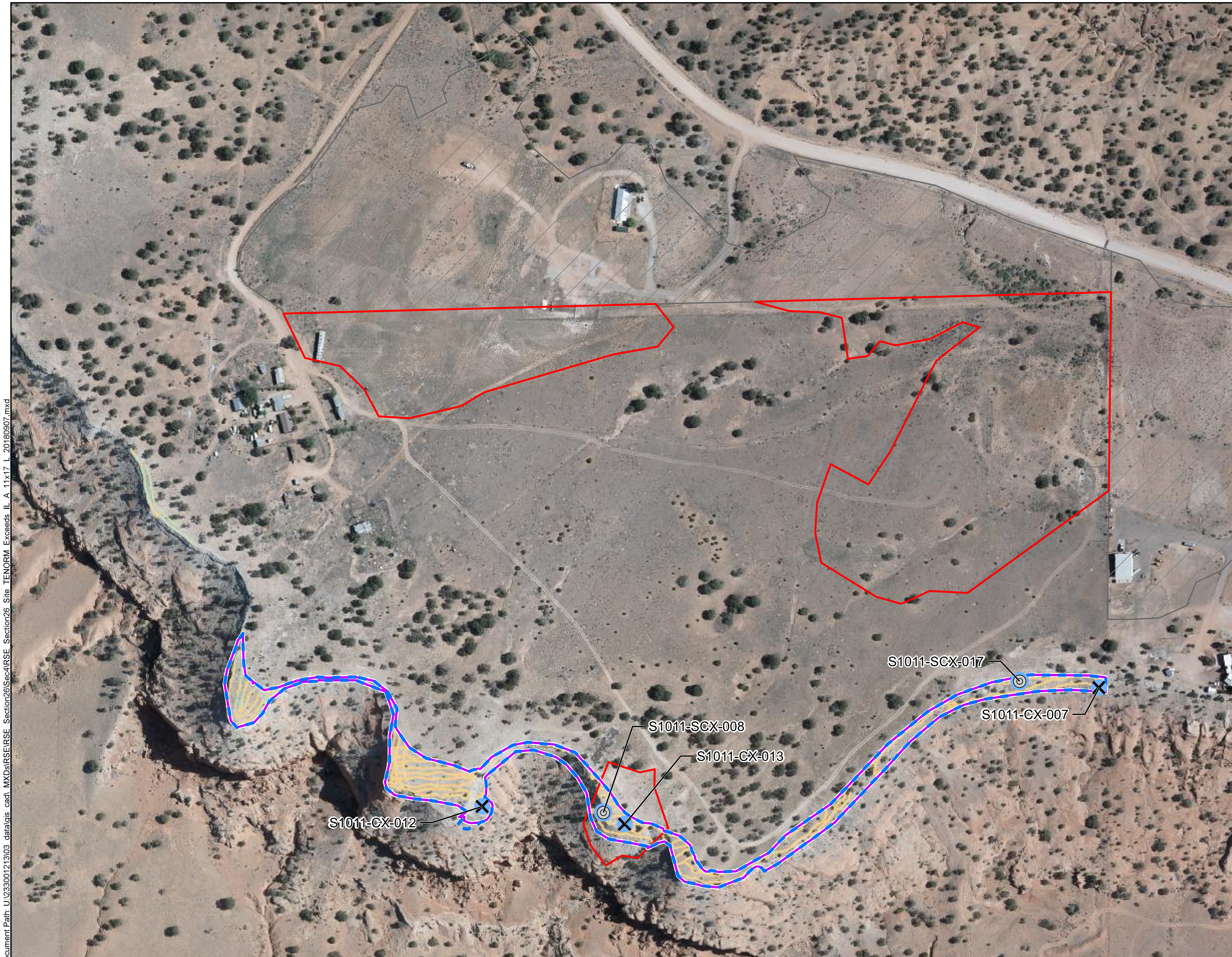

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (3.0 acres)
- Area of Survey Area A that is TENORM (3.0 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 11,058 - 16,829 (IL Not Exeeded)
- 16,830 - 654,837 (IL Exceeded)

NOTES:
1. Gamma Survey Area A is approximately 3.3 acres.
2. Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 250 500
Feet

TITLE:
Survey Area A
TENORM that Exceed ILs

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/19/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-8b	

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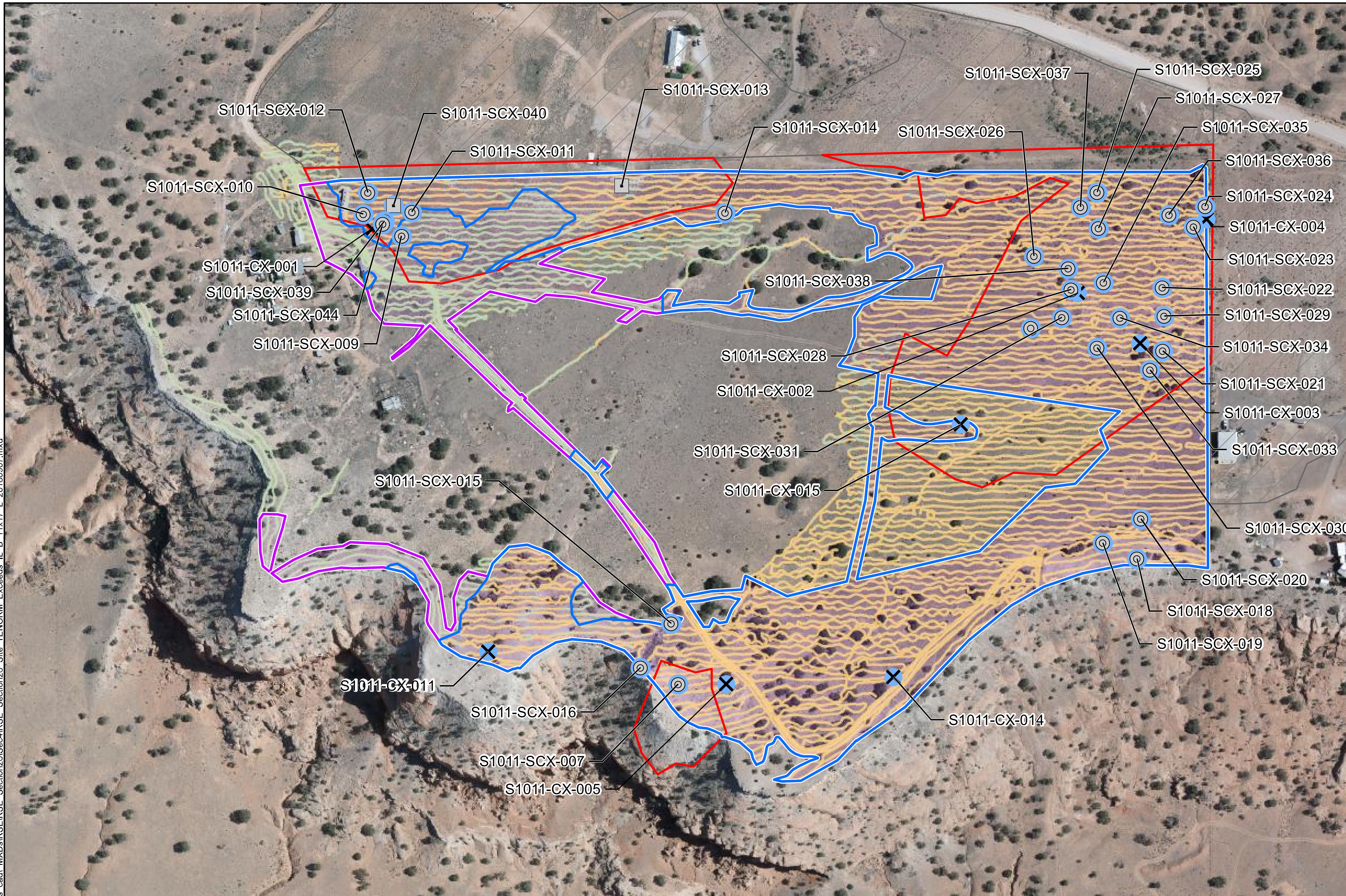


NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (24.7 acres)
- Area of Survey Area B that is TENORM (28.9 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 8,652 - 23,320 (IL Not Exeeded)
- 23,321 - 633,057 (IL Exceeded)

TITLE:
Survey Area B
TENORM that Exceed ILs

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE:	DOCUMENT NAME:	
9/20/2018	Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-8c	

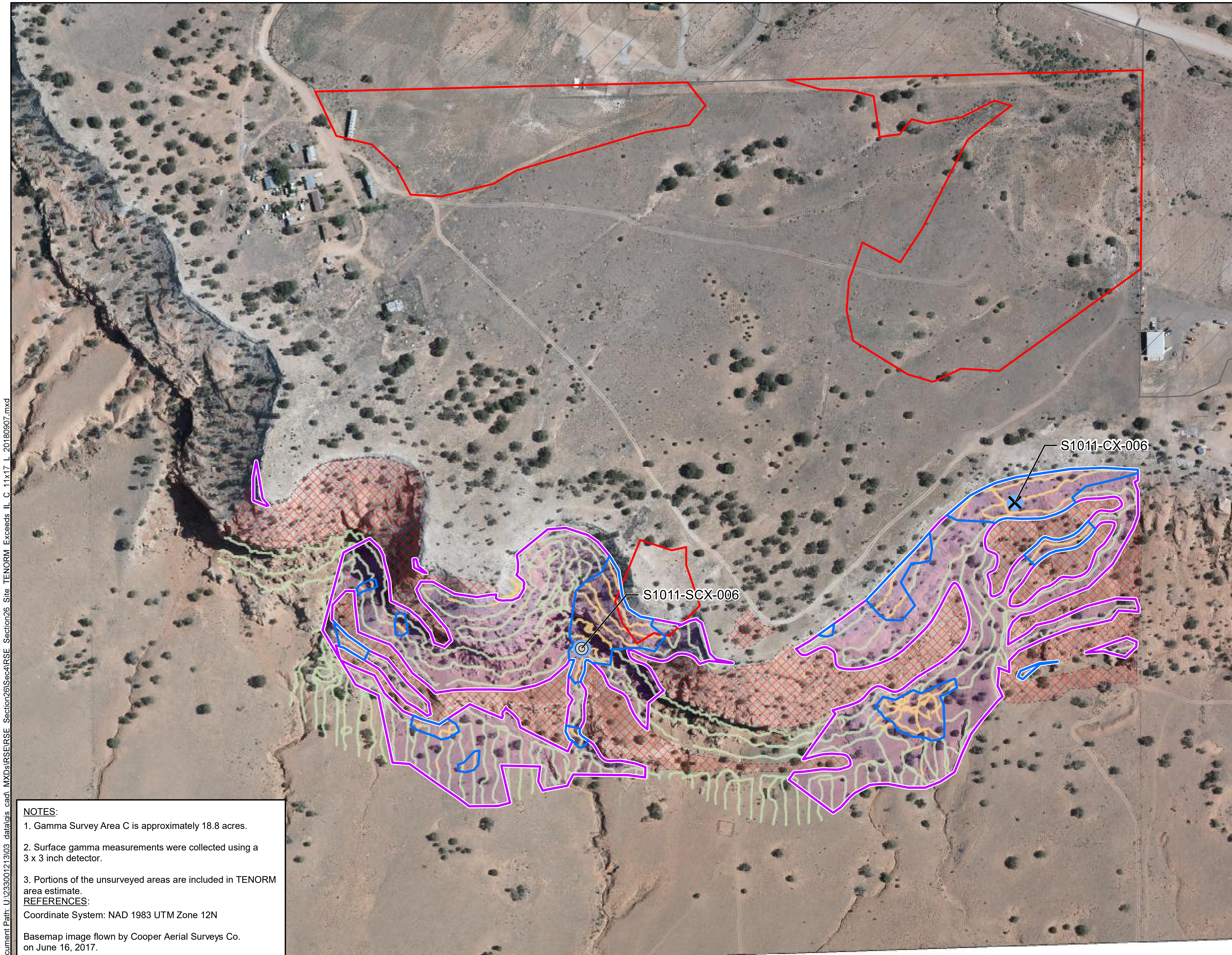
NOTES:
1. Gamma Survey Area B is approximately 37.4 acres.

2. Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_TENORM_Exceeds_IL_B_11x17_L_20180907.mxd



NOTES:
1. Gamma Survey Area C is approximately 18.8 acres.

2. Surface gamma measurements were collected using a 3 x 3 inch detector.

3. Portions of the unsurveyed areas are included in TENORM area estimate.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Surface Sample Location

Borehole Location - Surface and Subsurface Samplea

TENORM Exceeding IL in Unconsolidated Material at Location

TENORM Area Exceeding Surface Gamma ILs (2.9 acres)

Area of Survey Area C that is TENORM (15.0 acres)

Unsurveyed Area (10.1 acres)

Claim Boundary

Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

11,527 - 48,542 (IL Not Exeeded)

48,543 - 749,127 (IL Exceeded)

N W E S

0 250 500
Feet

TITLE:
Survey Area C
TENORM that Exceed ILs

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/20/2018

DOCUMENT NAME: Removal Site Evaluation Report

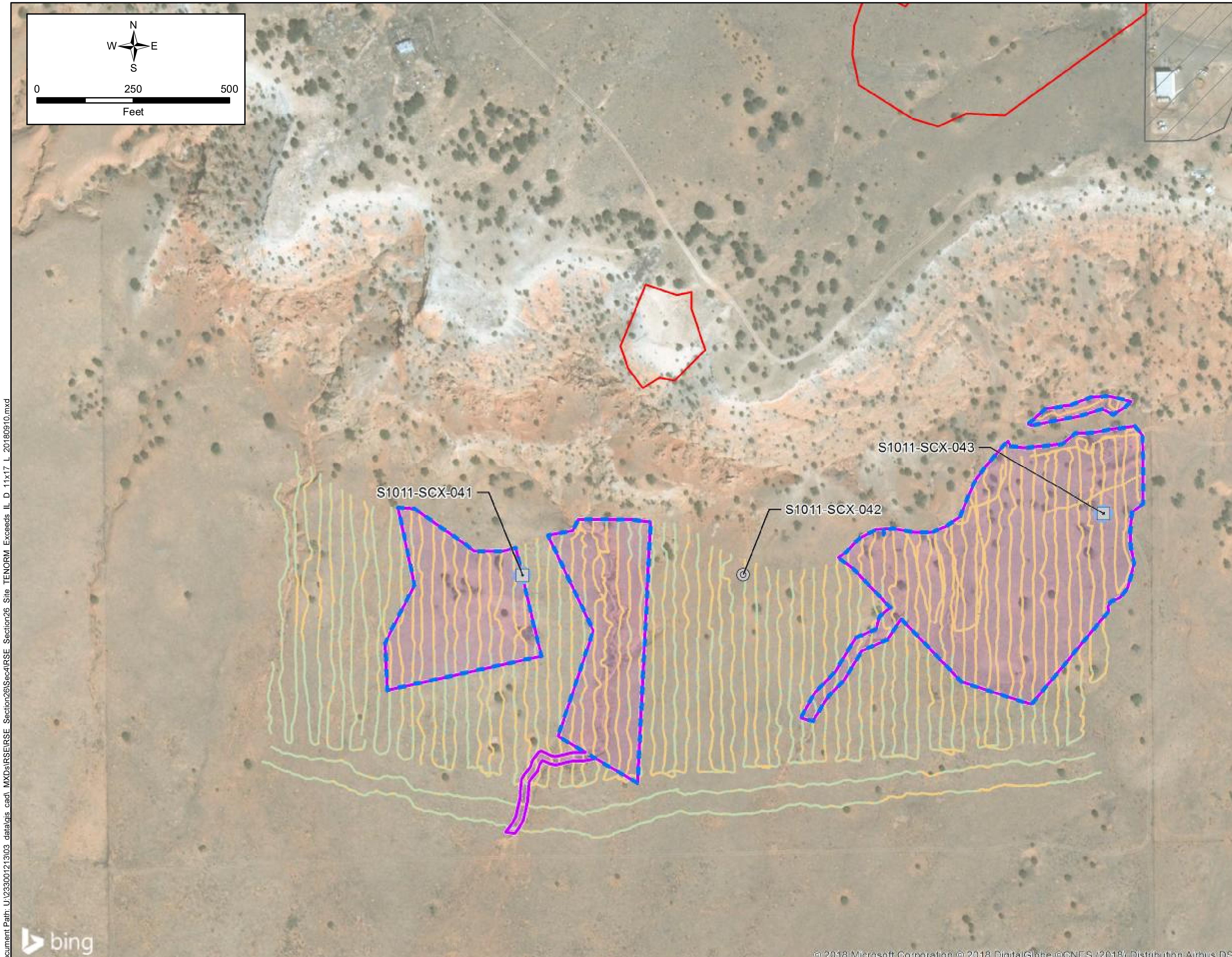
Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-8d

Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_TENORM_Exceeds_IL_C_11x17_L_20180907.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (13.4 acres)
- Area of Survey Area D that is TENORM (13.6 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 12,476 - 20,637 (IL Not Exeeded)
- 20,638 - 62,220 (IL Exceeded)

NOTES:

1. Gamma Survey Area D is approximately 38.8 acres.
2. Surface gamma measurements were collected using a 3 x 3 inch detector.

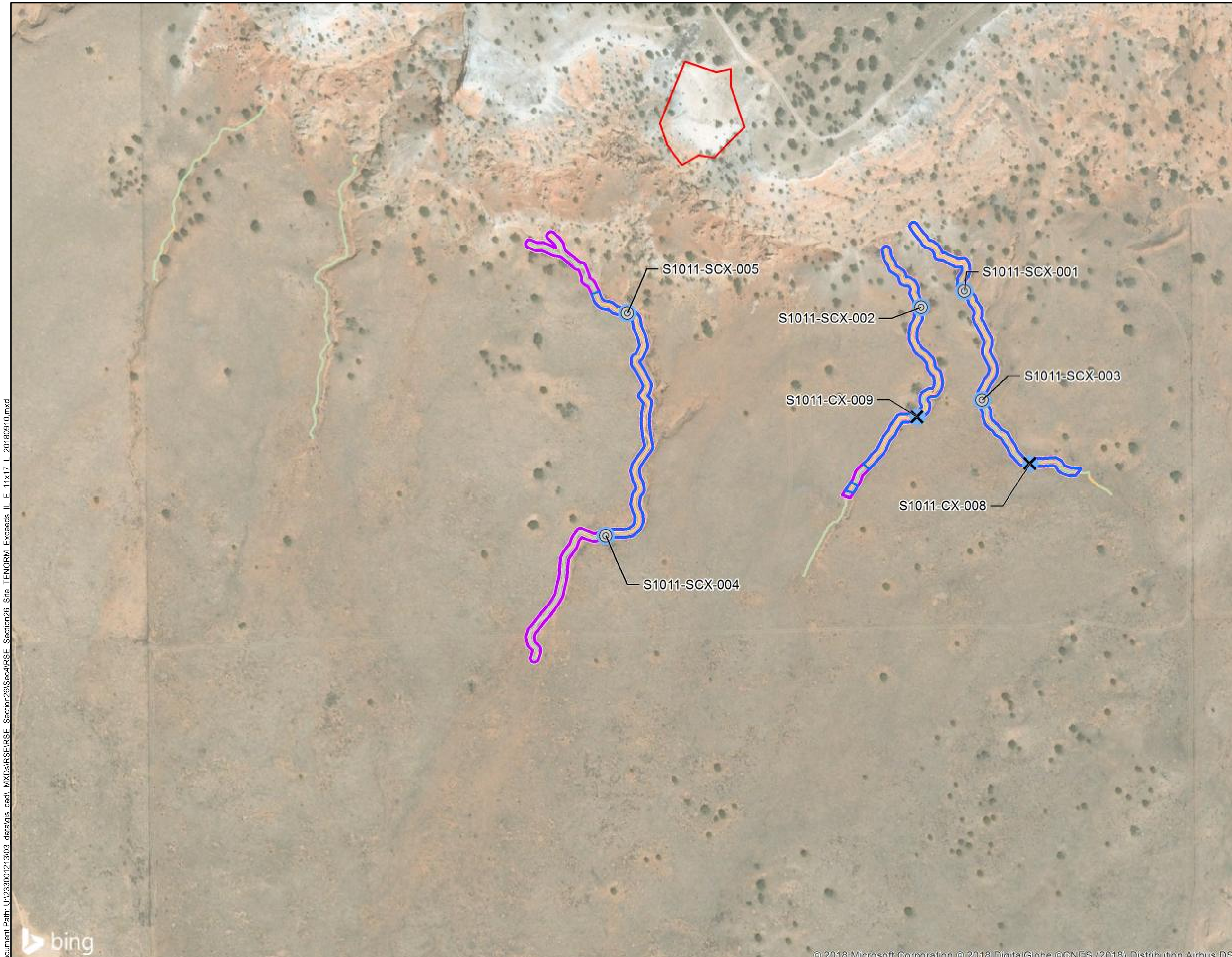
REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

TITLE:	Survey Area D TENORM that Exceed ILs
PROJECT:	Removal Site Evaluation Section 26 Mine Site
DATE: 9/20/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: EDZ / REVIEWER: CBB
	FIGURE: 4-8e

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_TENORM_Exceeds_IL_D_11x17_L_20180910.mxd



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NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (1.2 acres)
- Area of Survey Area E that is TENORM (1.6 acres)
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 12,001 - 21,864 (IL Not Exeeded)
- 21,865 - 117,575 (IL Exceeded)

NOTES:

1. Gamma Survey Area E is approximately 2.1 acres.
2. Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S

0 250 500
Feet

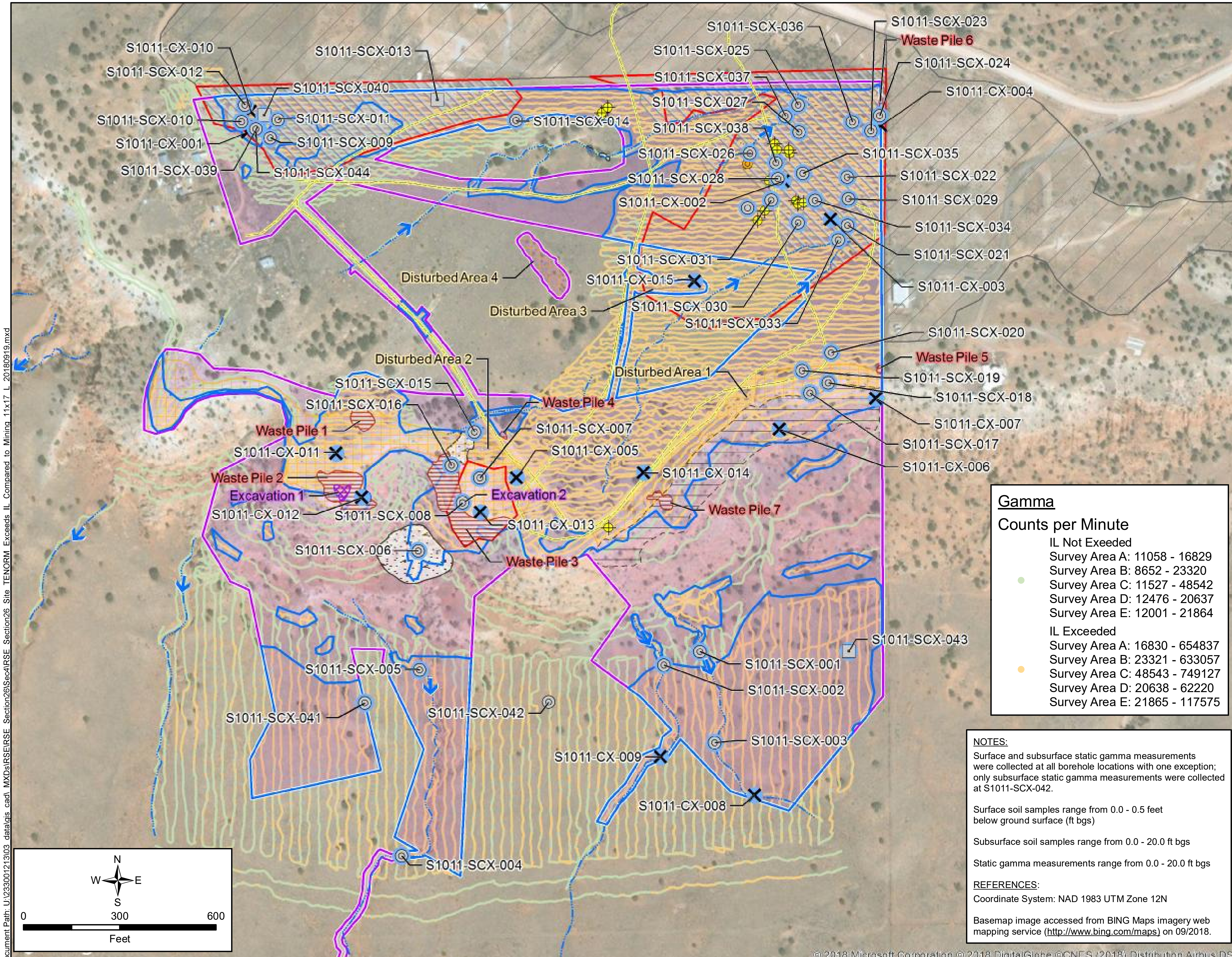
TITLE:

Survey Area E
TENORM that Exceed ILs

PROJECT:

Removal Site Evaluation
Section 26 Mine Site

DATE: 9/20/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: EDZ / REVIEWER: CBB
	FIGURE: 4-8f



NOTES:

Surface and subsurface static gamma measurements were collected at all borehole locations with one exception; only subsurface static gamma measurements were collected at S1011-SCX-042.

Surface soil samples range from 0.0 - 0.5 feet below ground surface (ft bgs)

Subsurface soil samples range from 0.0 - 20.0 ft bgs

Static gamma measurements range from 0.0 - 20.0 ft bgs

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

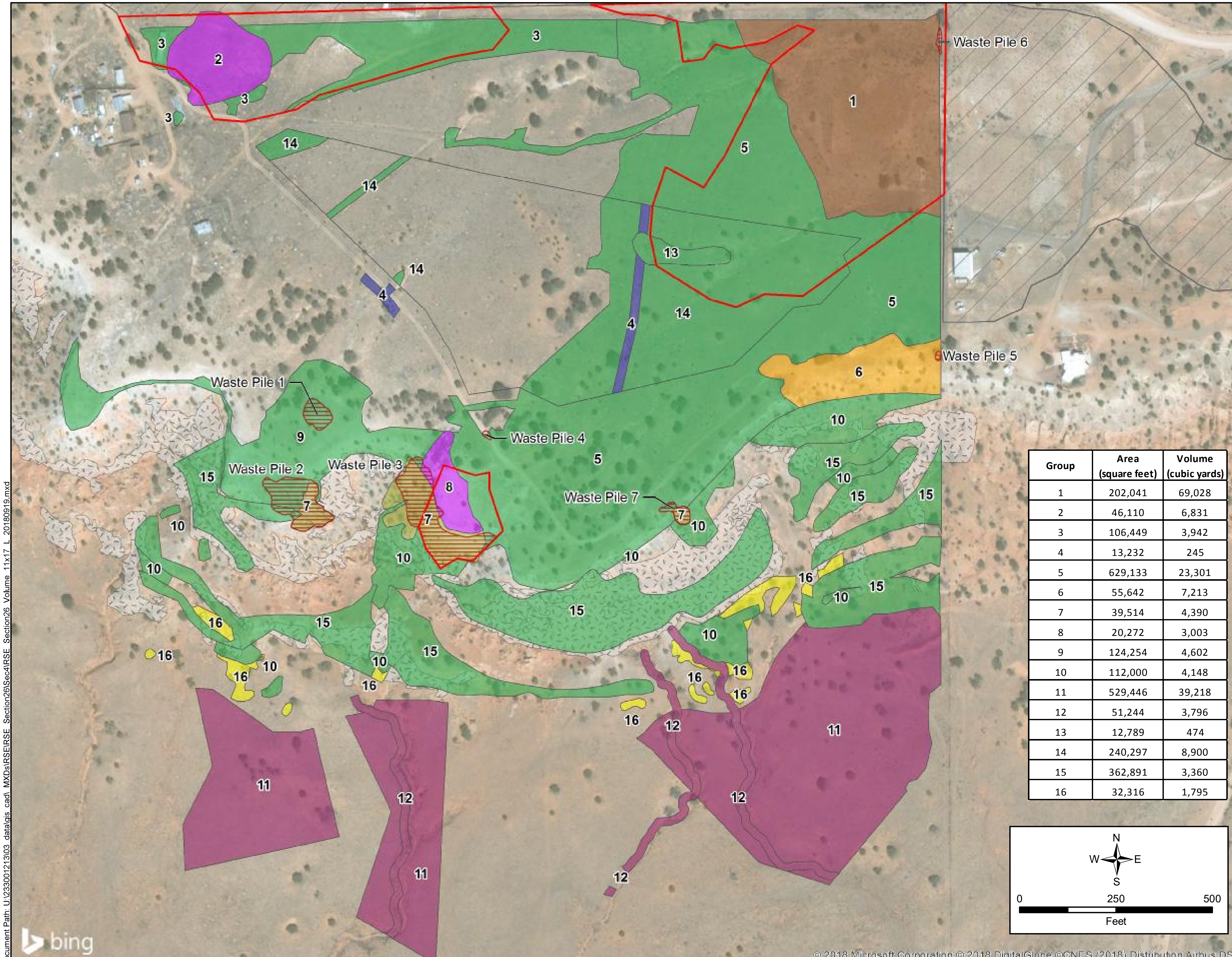
LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- TENORM Exceeding IL in Unconsolidated Material at Location
- Flow Direction
- Possible Portal or Storage
- Historical Borehole
- Potential Haul Road
- Drainage
- Debris
- Excavation
- Graded / Disturbed Reclaimed Area
- Potential Mining Disturbed
- Potential Waste Rock
- Waste Pile
- Vertical Mine Shafts
- TENORM Area Exceeding Surface Gamma ILs (45.2 acres)
- TENORM (72.2 acres)
- Claim Boundary
- Other Claim Boundary

TITLE:
TENORM that Exceed ILs Compared to Mining-Related Features

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/20/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-8g	



Group	Area (square feet)	Volume (cubic yards)
1	202,041	69,028
2	46,110	6,831
3	106,449	3,942
4	13,232	245
5	629,133	23,301
6	55,642	7,213
7	39,514	4,390
8	20,272	3,003
9	124,254	4,602
10	112,000	4,148
11	529,446	39,218
12	51,244	3,796
13	12,789	474
14	240,297	8,900
15	362,891	3,360
16	32,316	1,795

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Waste Pile
- Claim Boundary
- Other Claim Boundary
- Exposed Bedrock[1]

Average Depth by Group (feet below ground surface)

- Variable[2] - Group 1
- 0.5 ft - Group 4
- 1.0 ft - Groups 3, 5, 9, 10, 13, 14, 15[3]
- 1.5 ft - Group 16
- 2.0 ft - Groups 11, 12
- 3.0 ft - Group 7
- 3.5 ft - Group 6
- 4.0 ft - Groups 2, 8

NOTES:

1. Portions of the areas delineated as exposed bedrock contain small amounts of colluvium.

2. See Figure 4-9b

3. Volume was calculated with the assumption that 75% of the area that could not be surveyed was exposed bedrock.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

TITLE: Volume Estimate of TENORM that Exceed ILs

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 9/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

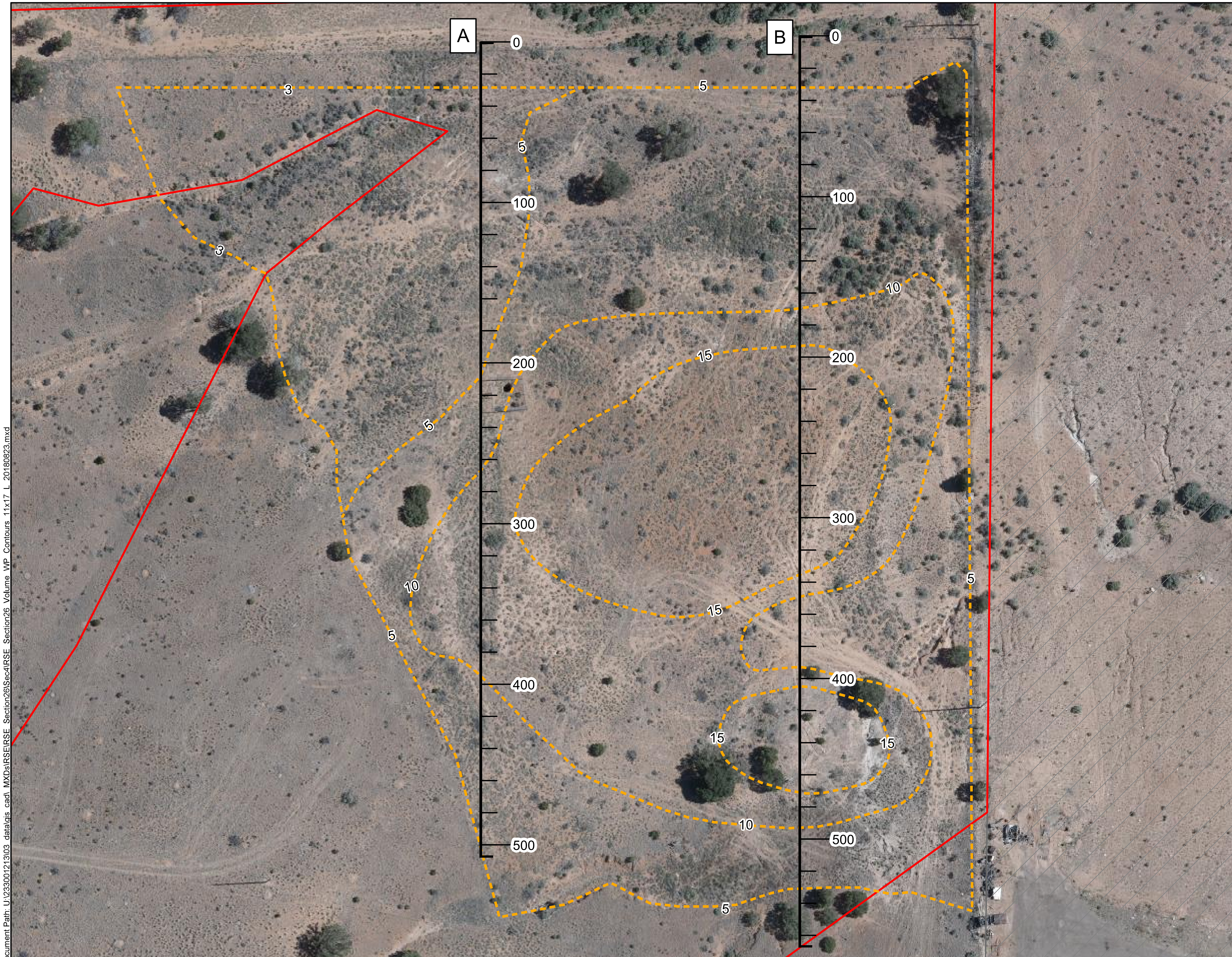
AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 4-9a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Volume_11x17_L_20180919.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Cross Section
Approximate Waste Pile Contour (thickness in feet)
Claim Boundary
Other Claim Boundary

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 60 120
Feet

TITLE:
Group 1 Contours for Volume Estimates

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 8/23/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-9b

APPENDICES

Appendix A Subcontractor Reports

A.1 Radiological Characterization of the Section 26 Abandoned Uranium Mine

A.2 Geophysical Characterization of the Navajo Nation Section 26 Site

Radiological Characterization of the Section 26 (Desidero Group) Abandoned Uranium Mines

September 19, 2018

prepared for:

Stantec Consulting Services Inc.

2130 Resort Drive, Suite 350
Steamboat Springs, CO 80487

prepared by:

Environmental Restoration Group, Inc.

8809 Washington St. NE
Suite 150
Albuquerque, NM 87113

Contents

Tables

Figures

Appendices

Acronyms

ANSI	American National Standards Institute
AUM	abandoned uranium mine
BG1	Background Reference Area 1
BG2	Background Reference Area 2
BG3	Background Reference Area 3
BG4	Background Reference Area 4
BG5	Background Reference Area 5
cpm	counts per minute
DQOs	data quality objectives
ERG	Environmental Restoration Group, Inc.
ft	foot
GPS	global positioning system
m	meter
MDL	method detection limit
µR/h	microRoentgens per hour
pCi/g	picocuries per gram
R^2	Pearson's Correlation Coefficient
RSE	removal site evaluation
σ	standard deviation
Stantec	Stantec Consulting Services Inc.

Executive Summary

This report addresses the radiological characterization of the Section 26 (Desidero Group) abandoned uranium mines (AUMs) located in the Baca/Haystack Chapter of the Navajo Nation north of Milan, New Mexico. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. (ERG) of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase.

This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of the gamma count rates at these AUMs to exposure rates and concentrations of radium-226 in surface soils, and 3) an assessment of equilibrium in the uranium series. The field activities addressed in this report were conducted on March 25, 26, 28, and 29; June 29, and September 18 and 19, 2017. They included a GPS-based radiological survey of land surfaces over a Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, areas where the survey was extended; and correlation studies.

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in the "Section 26 Removal Site Evaluation Report" (Stantec, 2018).

The findings of the RSE pertaining to these activities are:

- The horizontal extent and magnitude of mining-related materials were delineated sufficiently to support additional characterization of the subsurface.
- Elevated count rates were associated with waste rock in each of the mine claims; i.e., in several small areas of the northwestern claim, the north and east edges of the northeastern claim, and the center of the southern claim. Elevated count rates also were observed outside the northeastern and southern claims along the edge of the mesa and continuing onto the valley floor below.
- Five potential Background Reference Areas were established.
- The relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface) is described by a linear regression model:

$$\text{Gamma Count Rate (cpm)} = 5822*[\text{Radium-226 (pCi/g)}] + 13201$$

- The distribution of concentrations of radium-226 in surface soils predicted using this model resembles a lognormal distribution. Using the correlation equation, the values in the Survey Area range from -0.8 to 126.4 pCi/g, with a central tendency (median) of 2.2 pCi/g.

- The thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226 from gamma count rates.

- There is evidence that radium-226 and thorium-230 are in equilibrium, but not secular equilibrium, at the site.

- The relationship between gamma count rates and exposure rates is described by a linear regression model:

Exposure Rate (microRoentgens per hour [µR/h]) = 2.66×10^{-4} x [Gamma Count Rate (cpm)] + 5.355

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 7.7 to 204.6 µR/h, with a central tendency (median) of 12.3 µR/h.

1.0 Introduction

This report addresses the radiological characterization of the Section 26 (Desidero Group) abandoned uranium mines (AUMs) located in the Baca/Haystack Chapter of the Navajo Nation north of Milan, New Mexico. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. (ERG) of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase.

This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of the gamma count rates at this AUM to exposure rates and concentrations of radium-226 in surface soils, and 3) an assessment of equilibrium in the uranium series. The field activities addressed in this report were conducted on March 25, 26, 28, and 29; June 29, and September 18 and 19, 2017. They included a GPS-based radiological survey of land surfaces over an approximately 101.3-acre Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, areas where the survey was extended, five potential Background Reference Areas; and correlation studies. Section 3.0 of the RSE Workplan provides the data quality objectives (DQOs) for the project.

A salient deviation to the RSE Work Plan was the use of 3-inch by 3-inch sodium iodide (NaI) detectors in lieu of the 2-inch by 2-inch detectors that were specified in the plan. The change was made such that the gamma count rate measurements could be compared to those made previously by others using 3-inch by 3-inch sodium iodide detectors (Ecology and Environment, 2014). A 3-inch by 3-inch will exhibit higher count rates and therefore higher sensitivity to gamma-emitting radionuclides in the soil as compared to a 2-inch by 2-inch detector i.e.; the volume of a 3-inch by 3- inch NaI detector is 344.8 cm3; the volume of a 2-inch by 2-inch NaI detector is 104.2 cm3. The larger volume, results in more gamma interactions within the 3-inch by 3-inch detector compared to the 2x2 inch detector for an identical source.

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in the “Section 26 Removal Site Evaluation Report” (Stantec, 2018).

Figure 1 shows the location of the AUM. Background information that is pertinent to the characterization of these AUMs is presented in the “Section 26 Removal Site Evaluation Report” (Stantec, 2018).

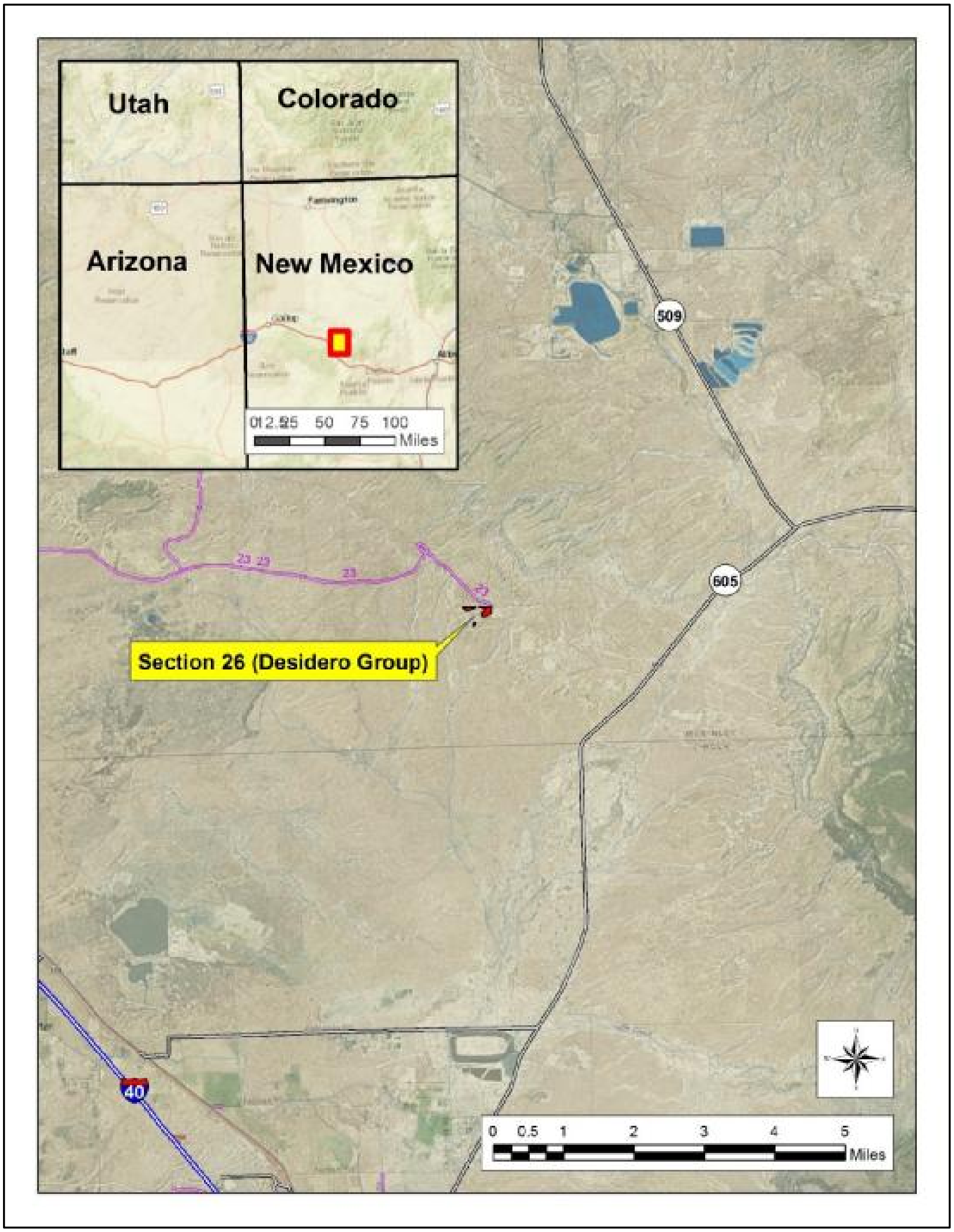


Figure 1. Location of the Section 26 (Desidero Group) Abandoned Uranium Mines

2.0 GPS-Based Gamma Survey

This section addresses the GPS-based surveys conducted in five potential Background Reference Areas and the Survey Area. The survey was extended to bound areas in which elevated count rates were observed. Table 1 lists the detection systems used in the survey. Pursuant to the approved RSE Workplan, detectors were function checked each day to ensure the instruments were stable to the limits prescribed by the Workplan. Detector normalization was not performed as it was not addressed by the RSE Workplan. Appendix A presents the completed function check forms and calibration certificates for the instruments. Standard operating procedures (SOPs) are discussed in Section 4.2 of the RSE Workplan and are provided in Appendix E therein.

The 3-inch by 3-inch NaI detectors used in this investigation are sensitive to sub-surface radium-226 decay products and other gamma emitting radionuclides. The purpose of the gamma correlation was to estimate radium-226 concentrations in the upper 15 cm of soil. Per the RSE Workplan, ERG selected correlation plots based on the range of gamma radiation levels observed. If subsurface soil concentrations of gamma emitting radionuclides were variable between correlation locations, this variability would be included in the regression model, and if the magnitude of the effect were sufficiently large, it would result in failure of the DQOs related to the regression analysis.

Table 1. Detection systems used in the GPS-Based gamma surveys.

Survey Area	Ludlum Model 44-20	Ludlum Model 2221 Ratemeter/Scaler
Potential Background Reference Areas	PR202073[a]	190166[a]
	PR213432	271435
	051517S	218564
Survey Area	051517P	262334
	PR202073[a]	190166[a]
	PR213432	271435
	PR269880	254772
	PR269985	254772
	PR262406	196086

Notes:
[a]Detection system used in the correlation studies described in Sections 3.1 and 3.3.

2.1 Potential Background Reference Areas

Five potential Background Reference Areas were surveyed, the locations and results of which are depicted on Figure 2. BG1, BG2, BG3, BG4, and BG5 in the figure are Background Reference Areas 1 through 5, respectively. Table 2 lists a summary of the gamma count rates, which in:

- BG1 ranged from 11,464 to 20,015 counts per minute (cpm), with a mean and median of 14,082 and 14,041 cpm, respectively.

- BG2 ranged from 18,508 to 25,542 cpm, with a mean and median of 21,269 and 21,227 cpm, respectively.

- BG3 ranged from 13,202 to 57,059 cpm, with a mean and median of 29,080 and 26,603 cpm, respectively.

- BG4 ranged from 15,868 to 22,772 cpm, with a mean and median of 18,804 and 18,780 cpm, respectively.

- BG5 ranged from 16,299 to 22,914 cpm, with a mean and median of 19,213 and 19,101 cpm, respectively.

Figure 3 depicts histograms of the gamma count rates in the potential Background Reference Areas. The red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could be expected if the distributions were normal or lognormal.

Table 2. Summary statistics for gamma count rates in the potential Background Reference Areas.

			Gamma Count Rate (cpm)			
Potential Background Reference Area	**n**	**Minimum**	**Maximum**	**Mean**	**Median**	**Standard Deviation**
1	171	11,464	20,015	14,082	14,041	1,483
2	288	18,508	25,542	21,269	21,227	1,139
3	80	13,202	57,059	29,080	26,603	9,927
4	442	15,868	22,772	18,804	18,780	1,035
5	138	16,299	22,914	19,213	19,101	1,412

Notes:
cpm = counts per minute

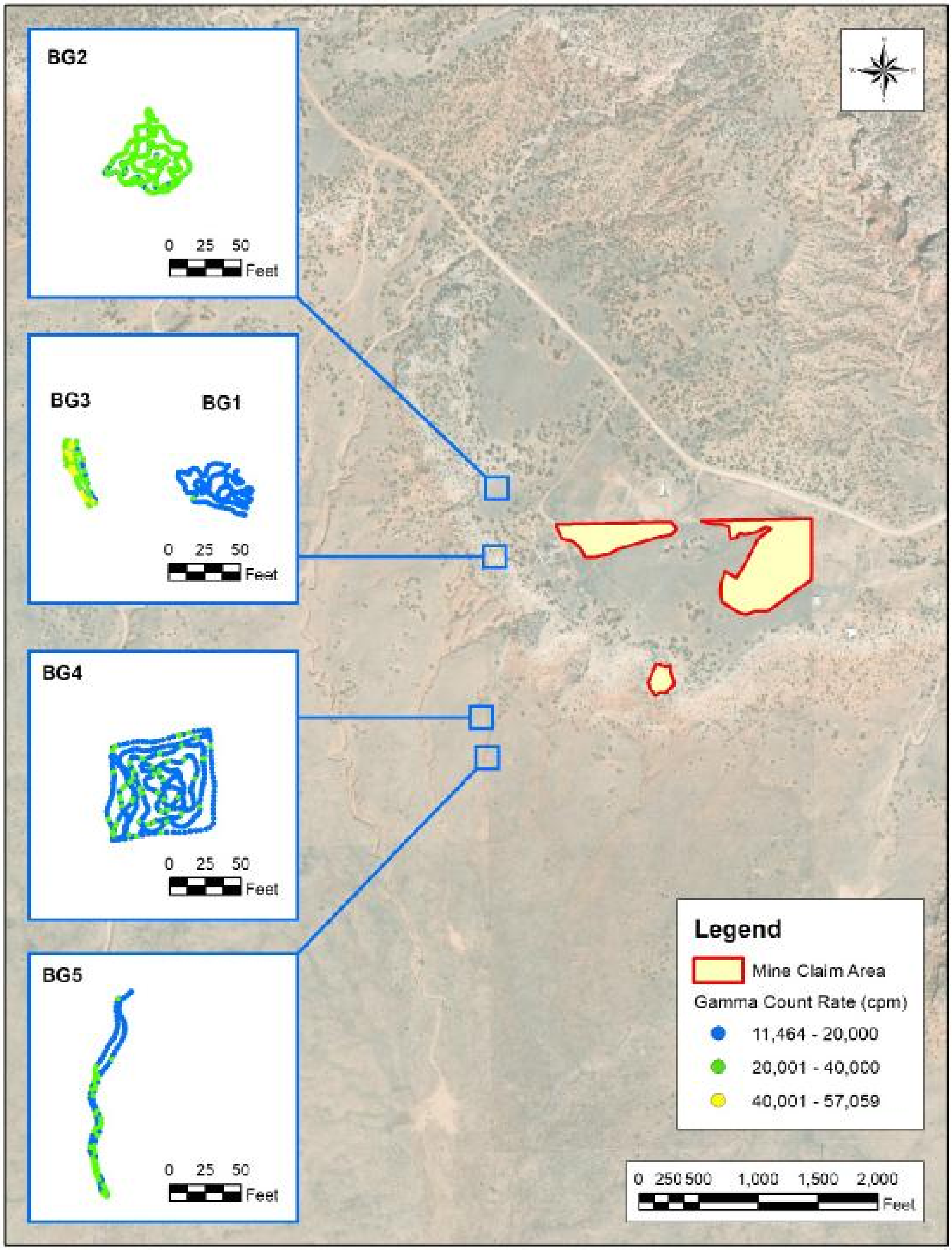
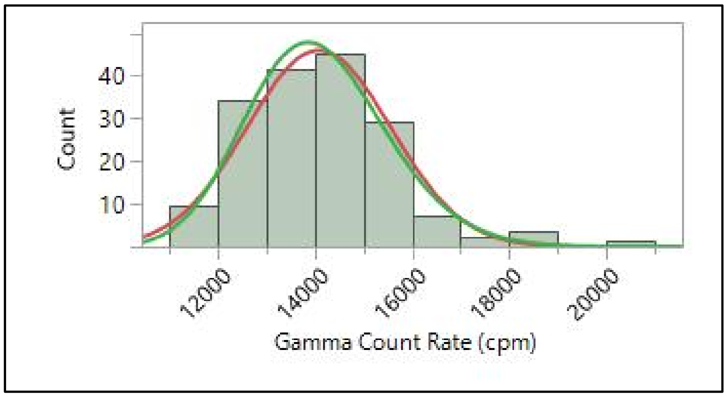
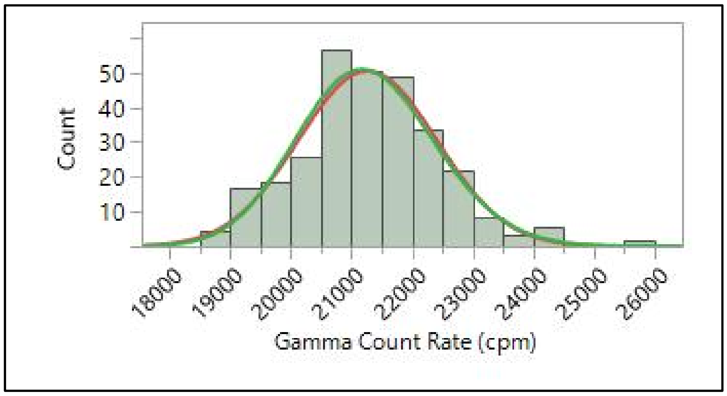


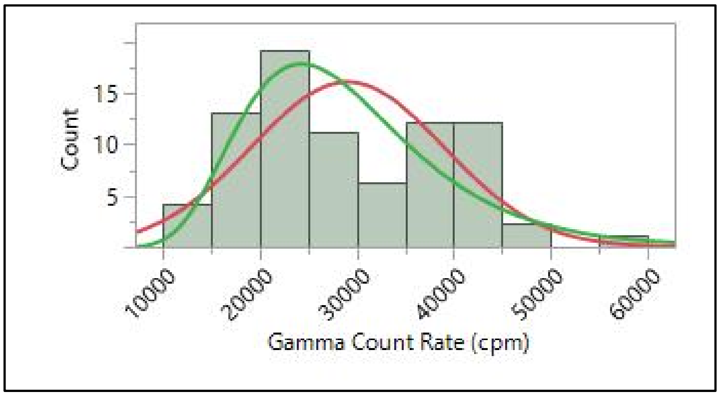
Figure 2. Gamma count rates in the potential Background Reference Areas.



a. Background Reference Area 1

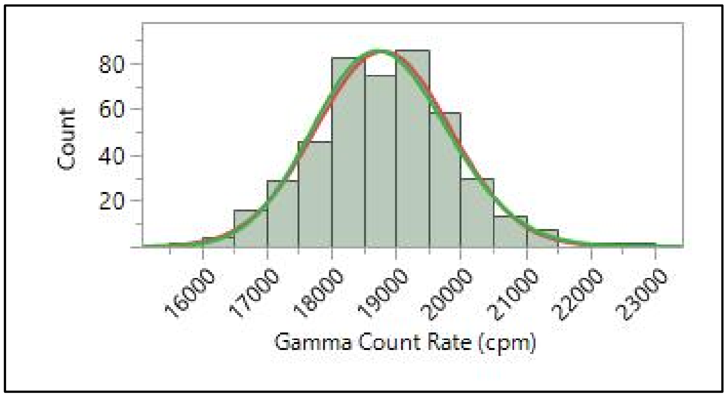


b. Background Reference Area 2

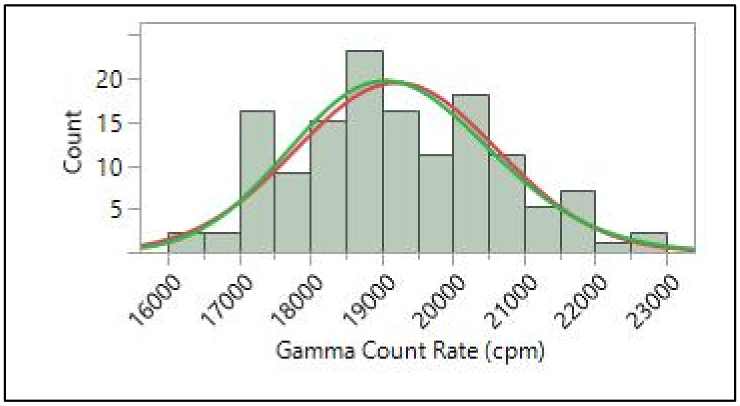


c. Background Reference Area 3

Figure 3 (1 of 2). Histograms of gamma count rates in the potential Background Reference Areas.



a. Background Reference Area 4



b. Background Reference Area 5

Figure 3 (2 of 2). Histograms of gamma count rates in the potential Background Reference Areas.

2.2 Survey Area

The gamma count rates observed in the Survey Area are depicted in Figure 4. Elevated count rates were associated with waste rock in each of the mine claims; i.e., in several small areas of the northwestern claim, the north and east edges of the northeastern claim, and the center of the southern claim. Elevated count rates also were observed outside the northeastern and southern claims along the edge of the mesa and continuing onto the valley floor below.

Figure 5 is a histogram of the gamma count rate measurements made in the Survey Area, including the area surveyed outside the 100-ft buffer. As stated in Section 2.1, the red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could

be expected if the distributions were normal or lognormal. The distribution of the right-tailed set of measurements, evaluated using U.S. Environmental Protection Agency software ProUCL (version 5.1.002), is not defined. The box plot in Figure 6 depicts cutoffs as horizontal bars, from bottom to top, for the following values or percentiles: minimum, 0.5, 2.5, 10, 25, 50, 75, 90, 97.5, 99.5, and maximum. The 25th, 50th, and 75th percentiles (the three horizontal lines of the box inside the box plot) are 21,267, 25,949, and 33,641 cpm, respectively.

Table 3 is a statistical summary of the measurements, which range from 8,652 to 749,127 cpm and have a central tendency (median) of 25,949 cpm.

Table 3. Summary statistics for gamma count rates in the Survey Area.

Parameter	Gamma Count Rate (cpm)
n	71,563
Minimum	8,652
Maximum	749,127
Mean	32,664
Median	25,949
Standard Deviation	28,212

Notes:
cpm = counts per minute

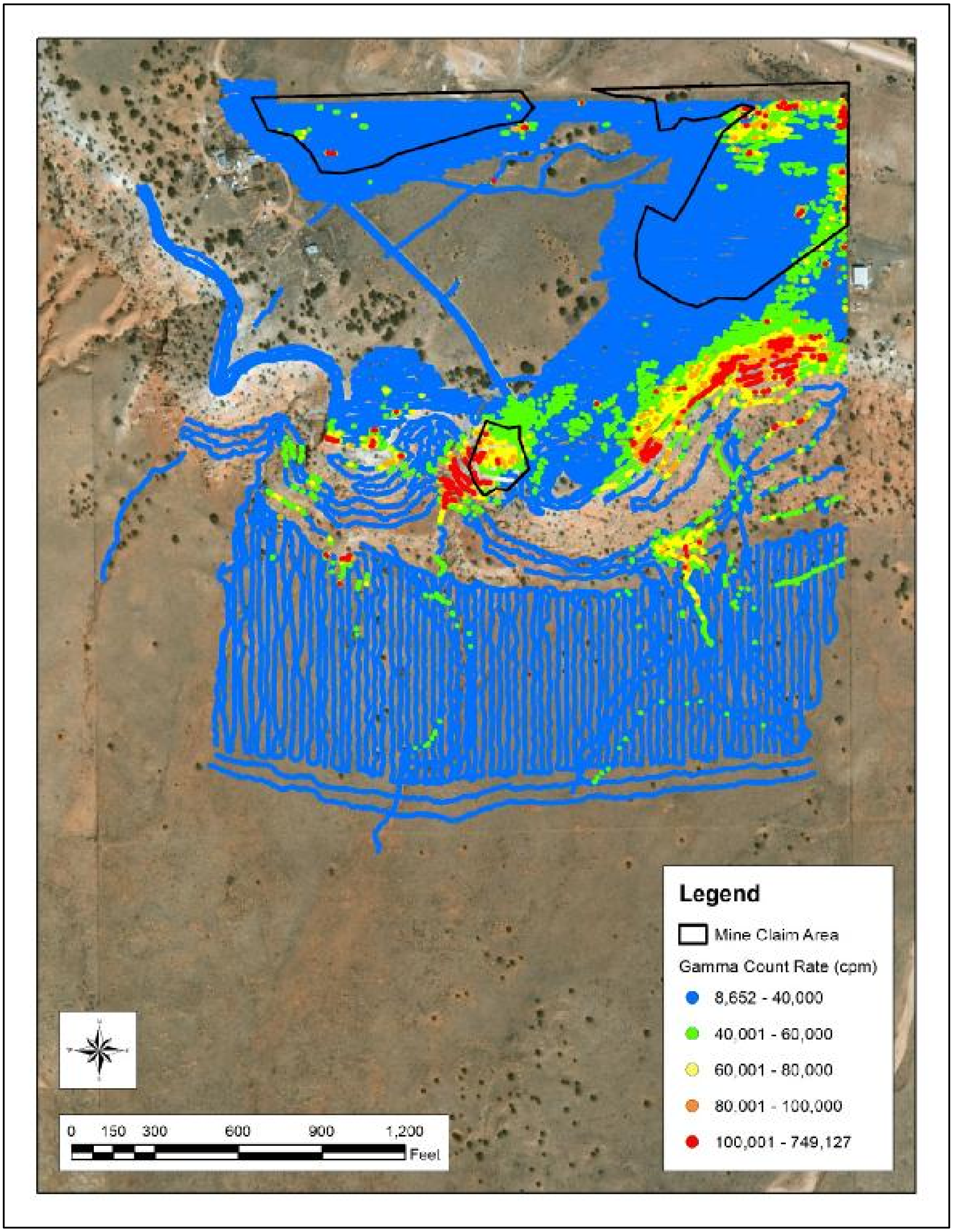


Figure 4. Gamma count rates in the Survey Area.

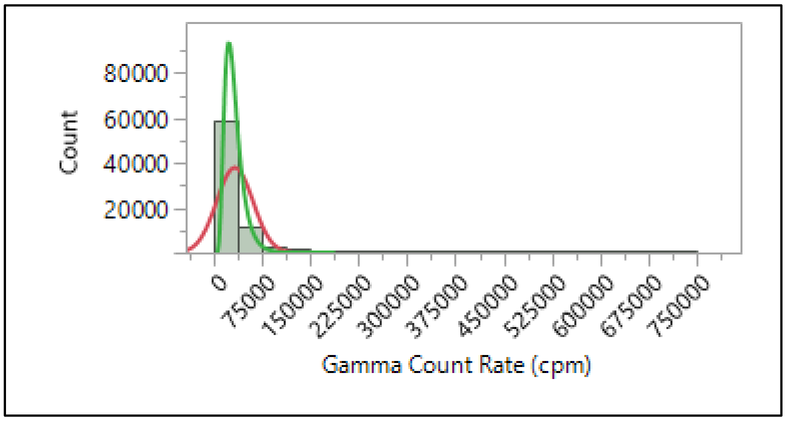


Figure 5. Histogram of gamma count rates in the Survey Area.

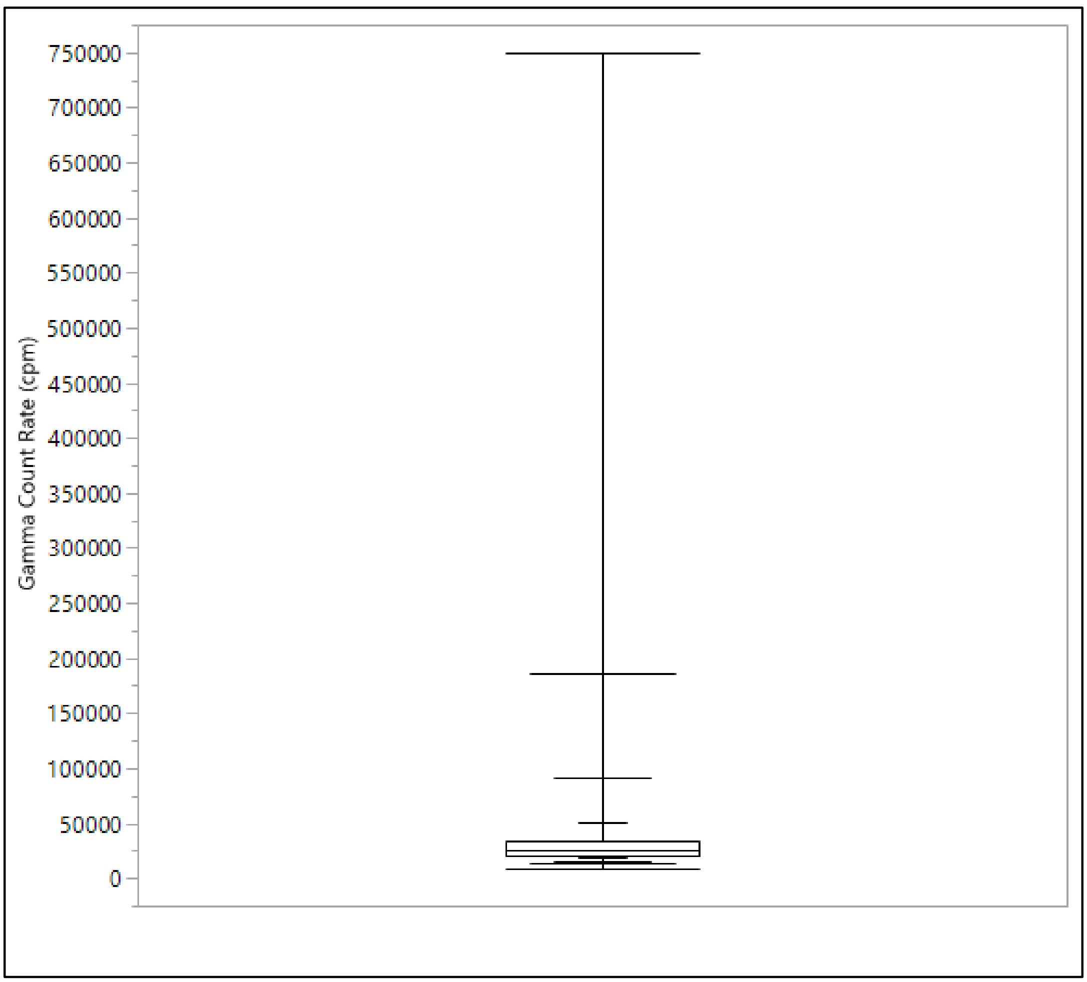


Figure 6. Box plot of gamma count rates in the Survey Area.

3.0 Correlation Studies

The following sections address the activities under two types of correlation studies outlined in the RSE Work plan: comparisons of 1) radium-226 concentrations in surface soils and gamma count rates and 2) exposure rates and gamma count rates. GPS-based gamma count rate measurements were made over small areas for the former study. The means of the measurements were used in this case. Static gamma count rate measurements, co-located with exposure rate measurements, were used in the latter study.

3.1 Radium-226 concentrations in surface soils and gamma count rates

On March 29, 2017 field personnel made GPS-based gamma count rate measurements and collected five-point composite samples of surface soils in each of the five areas at the AUM. These areas were selected using criteria established in the RSE Workplan. The activities were performed contemporaneously, by area and all 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 locations. Figure 7 shows the GPS-based gamma count rate measurements in the five areas (labeled with location identifiers).

The soil samples were analyzed by ALS Laboratories in Ft Collins, CO for radium-226 and isotopic thorium. The latter analysis was included to assess the potential effects of thorium series isotopes on the correlation and evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. Table 4 lists the results of the gamma count rate measurements and radium-226 concentrations in the soil samples. The means of the gamma count rate measurements range from 21,632 to 165,200 cpm. The concentrations of radium-226 in the soil samples range from 1.26 to 25.2 picocuries per gram (pCi/g).

Table 5 lists the concentrations of isotopes of thorium (thorium-228, -230, and -232) in the same soil samples.

Laboratory analyses are presented in Appendix F.2, Laboratory Analytical Data and Data Validation Report, in the “Section 26 Removal Site Evaluation Report” (Stantec, 2018).

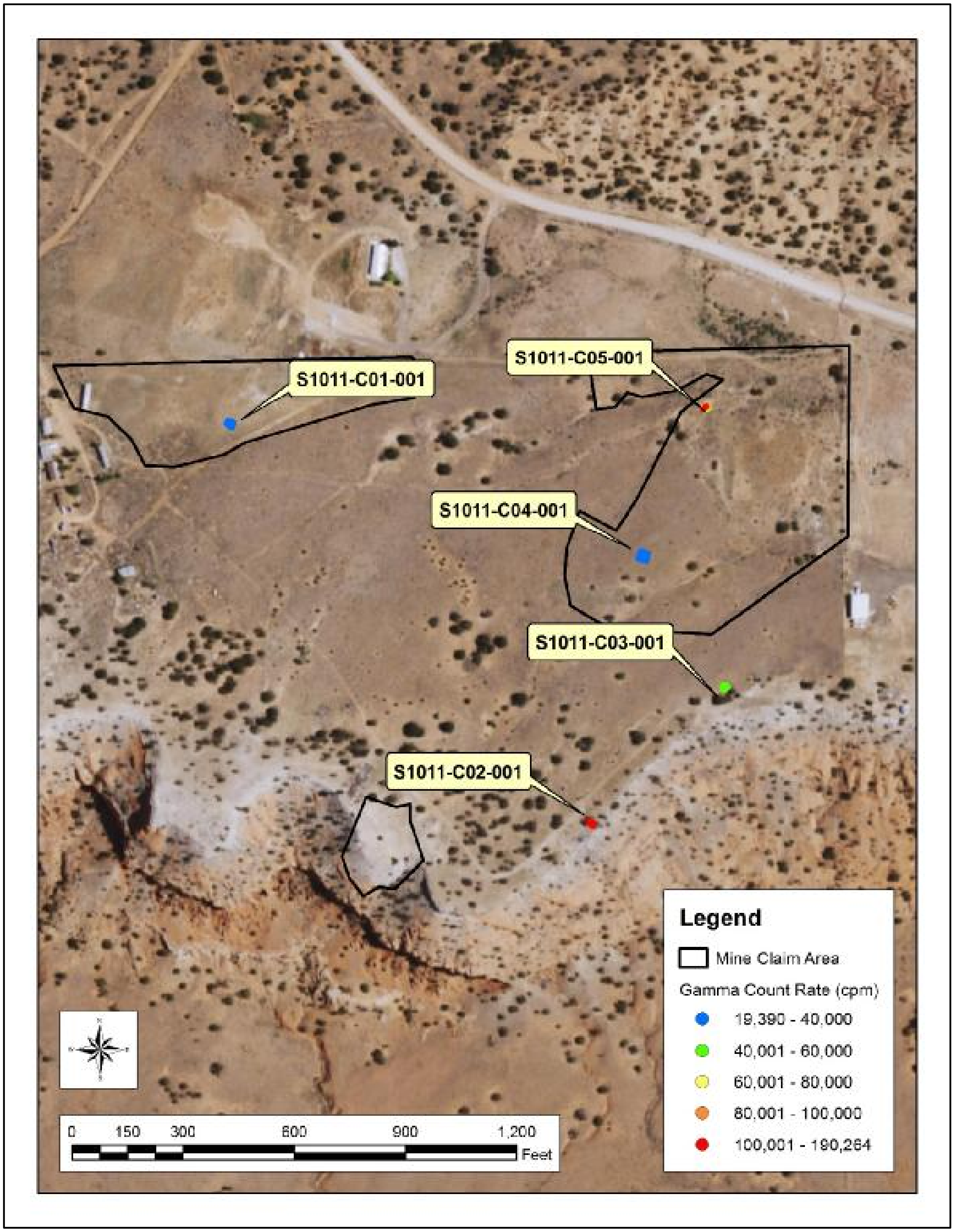


Figure 7. GPS-based gamma count rate measurements made for the correlation study.

Table 4. Gamma count rates and associated concentrations of radium-226 in samples of surface soils obtained in the correlation study.

		Gamma Count Rate (cpm)				Radium-226 (pCi/g)		
Location	Area (m^2)	Mean	Minimum	Maximum	σ	Result	Error ±2σ	MDC
S1011-C01-001	31.8	21,632	19,390	25,165	1,174	1.26	0.3	0.44
S1011-C02-001	14.3	165,200	136,070	190,264	14,389	25.2	3.1	1
S1011-C03-001	24.6	55,042	50,933	59,275	2,143	11	1.4	0.5
S1011-C04-001	65.8	28,422	25,883	30,438	975	1.83	0.33	0.08
S1011-C05-001	23.3	76,851	46,675	121,502	18,779	9	1.2	0.5

Notes:
cpm = counts per minute
m^2= square meters
MDC = minimal detectable concentration
pCi/g = picocuries per gram
σ = standard deviation

Table 5. Concentrations of isotopes of thorium in samples of surface soils obtained in the correlation study.

	Thorium-228 (pCi/g)			Thorium-230 (pCi/g)			Thorium-232 (pCi/g)		
Sample ID	Result	Error ± 2 σ	MDC	Result	Error ± 2 σ	MDC	Result	Error ± 2 σ	MDC
S1011-C01-001	0.48	0.1	0.1	0.9	0.17	0.1	0.451	0.092	0.021
S1011-C02-001	0.341	0.081	0.053	15.5	2.4	0.1	0.335	0.075	0.02
S1011-C03-001	0.359	0.084	0.056	4.95	0.79	0.08	0.368	0.08	0.025
S1011-C04-001	0.52	0.11	0.05	1.4	0.25	0.08	0.48	0.1	0.02
S1011-C05-001	0.372	0.085	0.05	4.07	0.66	0.08	0.356	0.078	0.019

Notes:
MDC = minimal detectable concentration
pCi/g = picocuries per gram
σ = standard deviation

A linear model was made of the results in Table 4, predicting the concentrations of radium-226 in surface soils from the mean gamma count rate in each area. The model, shown in Figure 8, is a strong, linear function with an adjusted Pearson's Correlation Coefficient (R^2) of 0.93, as expressed in the equation:

$$\text{Gamma Count Rate (cpm)} = 5822 * [\text{Radium-226 concentration (pCi/g)}] + 13201$$

The root mean square error and p-value for the model are $1.5X10^4$ and 0.0048, respectively; these parameters are not data quality objectives (DQOs) and are included only as information.

This equation was used to convert the gamma count rate measurements observed in the gamma surveys to predicted concentrations of radium-226. Table 6 presents summary statistics for the predicted concentrations of radium-226 in the Survey Area. The range of the predicted concentrations of radium-226 in the Survey Area is -0.8 to 126.4 pCi/g, with a mean and median of 3.3 and 2.2 pCi/g, respectively. While the gamma correlation equation can be used to convert gamma count rates to concentrations of radium-226 in soil, the resulting radium concentrations are highly uncertain estimates, as the wide prediction interval bands illustrated in Figure 8 demonstrate. Users of the regression equation should be aware of the limitations of the dataset and be cautious when estimating radium-226 concentrations.

Soil concentrations of potassium-40 (K-40) were not expected to be spatially variable within the site, and therefore this radionuclide was not separately accounted for in the RSE Workplan. If K-40 concentrations did vary, this variability would be included in the regression model and, if the magnitude of the effect were sufficiently large, would result in failure of DQOs related to the regression analysis.

A multivariate linear regression (MLR) was used to evaluate the influence of thorium-232 and thorium-228, isotopes in the thorium series, on the average gamma count rate in the correlation locations. The MLR model was first run using radium-226, thorium-232, and thorium-228 as predictors of gamma count rate. The model failed to produce results because thorium-232 and thorium-228 are colinear. The MLR model was subsequently run without thorium-228. For the second model, the p-values for radium-226 and thorium-232 were both greater than 0.05 (0.07 and 0.83 respectively) and therefore not significant predictors of gamma count rate collectively. Thorium-232 and radium-226 were then each modelled individually as a predictor of gamma count rate. The p-value for thorium-232 coefficient was 0.1 with an adjusted R^2 of 0.5. The thorium-232 coefficient is not significant and the R^2 value does not meet the project DQO. Subsequently it is concluded that thorium-232 and thorium-228 concentrations in soil are not significant predictors of gamma count rate. The p-value for radium-226 was significant as described above and the R^2 value met the project DQOs.

The depletion of radon-222 in surface soil due to environmental factors is assumed to be relatively constant across the correlation locations (i.e., the loss is a fixed fraction of the available source). Provided this is the case, any loss of radon-222 in surface soil is unimportant and accounted for within the statistical model. If the loss is not a consistent fraction at each correlation location, it is one of many potential correlation confounders that are all linked to spatial heterogeneity of the environmental conditions, and especially spatial heterogeneity of the soil matrix.

The presence of heterogeneous concentrations of gamma emitting radionuclides in sub-surface soil can affect the gamma correlation model. If subsurface soil concentrations of gamma emitting radionuclides were variable between correlation locations, this variability would be included in the regression model, and if the magnitude of the effect were sufficiently large, it would result in failure of the DQOs related to the regression analysis.

Figure 9 shows the predicted concentrations of radium-226, the spatial and numerical distribution of which mirror those depicted in Figure 4.

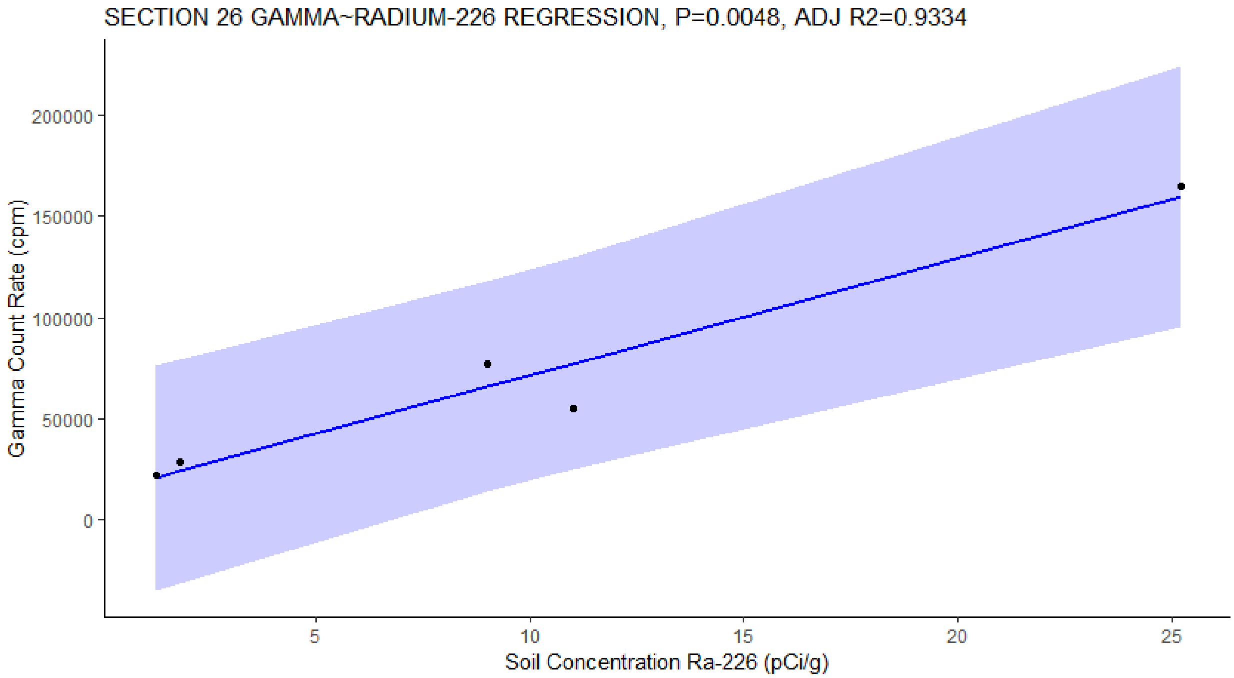


Figure 8. Correlation of gamma count rates and concentrations of radium-226 in surface soils.

Table 6. Predicted concentrations of radium-226 in the Survey Area.

Parameter	Radium-226 (pCi/g)
n	71,563
Minimum	-0.8
Maximum	126.4
Mean	3.3
Median	2.2
Standard Deviation	4.8

Notes:
pCi/g = picocuries per gram

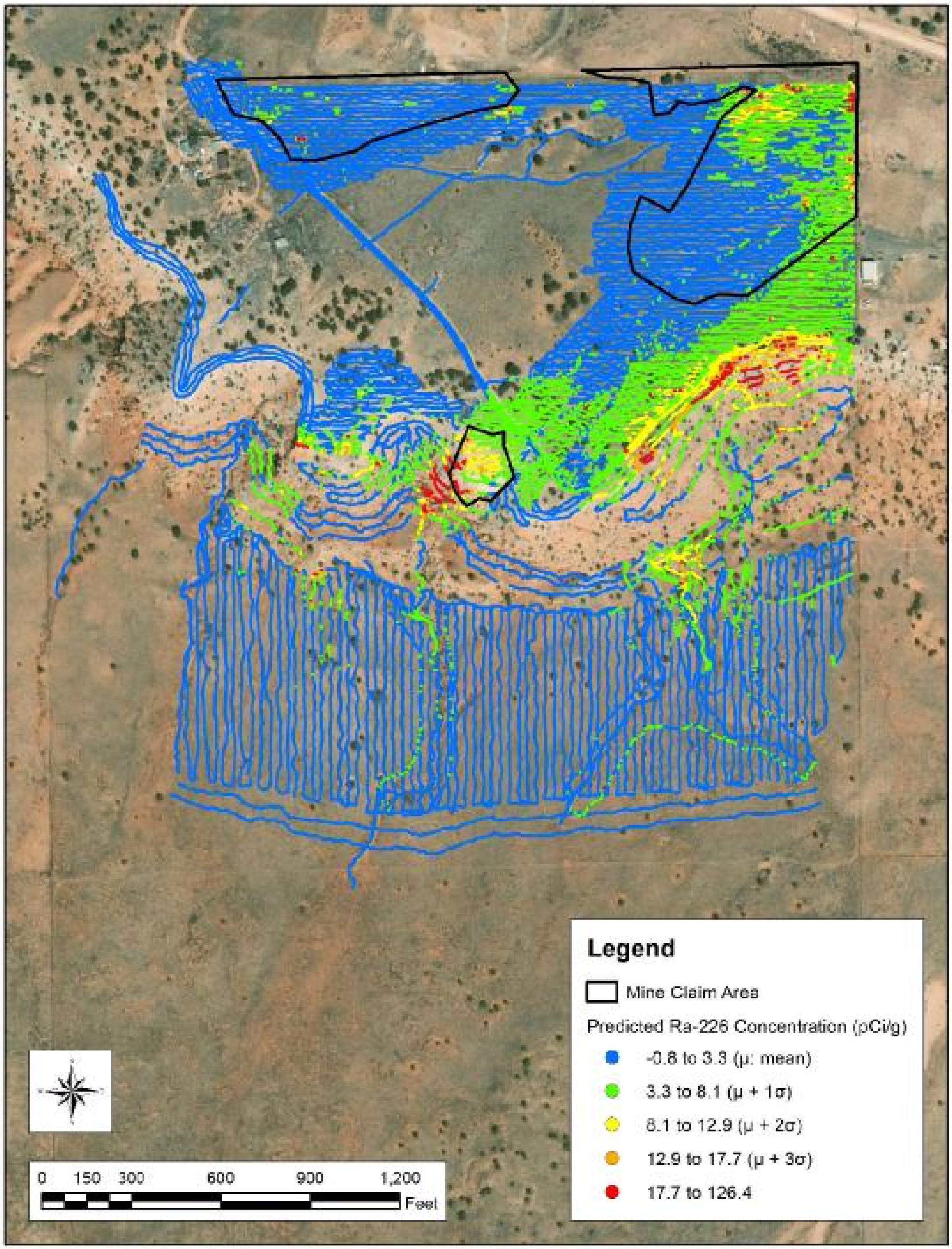


Figure 9. Predicted concentrations of radium-226 in the Survey Area.

3.2 Equilibrium in the uranium series

Secular equilibrium is a condition that occurs when the half-life of a decay-product nuclide is significantly shorter than that of its parent nuclide. After a period of ingrowth equal to approximately seven times the half-life of the decay product, the two nuclides effectively decay with the half-life of the parent. When two radionuclides are in secular equilibrium, their activities are equal.

Equilibrium, for the purpose of this report, is defined as a condition whereby a parent nuclide and its decay product are present in the environment at a fixed ratio, but this ratio – for whatever reason – is not a one-to-one relationship indicative of secular equilibrium. Most commonly, an equilibrium condition results from an environmental process which chemically selects for and transports one nuclide (parent or decay product) away from the other nuclide. Because a consistent fraction of one nuclide has been removed, the two nuclides are present at a fixed ratio other than one-to-one.

Determination of secular equilibrium for an AUM can be an important part of the risk assessment process, as the assumed fraction of radium-226 decay products present in the environment greatly influences a hypothetical receptor's radiation dose and mortality risk. However, it is also acceptable and conservative to assume secular equilibrium between radium-226 and its decay products for the purpose of risk assessment, and therefore to avoid the need to conclusively determine the secular equilibrium status of an AUM. Thus, an inconclusive result regarding secular equilibrium is not a study data gap, as the risk assessment phase may still proceed, provided that conservative assumptions are included regarding equilibrium concentrations of radium-226 decay products.

Regardless, the RSE Workplan specified that an evaluation of secular equilibrium would be made at each of the 16 Trust AUMs, and so a robust statistical examination of secular equilibrium status for radium-226 and its decay products at each AUM was conducted. The ratio of thorium-230 to radium-226 can be evaluated even though different analytic methods were used to measure activity concentrations. Radium-226 was measured by EPA method 901.1m, which is a total-activity method and thorium-230 was measured by alpha spectroscopy following digestion with hydrofluoric acid, which is also a total-activity method. Thus, it is appropriate to compare the two method results.

The evaluation of secular equilibrium for each mine site proceeded as follows:

1. Construction of a figure that depicts soil concentrations of thorium-230 plotted against soil concentrations of radium-226.
2. Simple linear regression is performed on the dataset; the p-value and the adjusted R^2 are recorded. The resulting linear model and the 95% UCL bands are plotted on the figure generated in step 1.
3. The line y=x is added to the figure generated in step 2 (this line represents a perfect 1:1 ratio between thorium-230 to radium-226, indicative of secular equilibrium).

4. An examination of the model and the figure is made sequentially:

   a. If the p-value for the regression slope is insignificant (i.e., $p > 0.05$) or the adjusted R^2 does not meet the study's data quality objective (adjusted $R^2 > 0.8$), ERG concludes that there is insufficient evidence to conclude that radium-226 and thorium-230 are in equilibrium (secular or otherwise).

   b. If the p-value for the regression slope is significant (i.e., $p < 0.05$) and the adjusted R^2 meets the DQO (Adjusted $R^2 > 0.8$) there are two possible conditions, which are evaluated via visual examination of the figure generated in step 3.

      i. If the y=x line falls fully within the bounds of the 95% UCL bands on the regression, ERG concludes that there is evidence that radium-226 and thorium-230 are in secular equilibrium at the site.

      ii. If the y=x line falls partially or completely outside the bounds of the 95% UCL bands on the regression, ERG concludes that there is evidence that radium-226 and thorium-230 are in equilibrium, but not secular equilibrium at the site.

Based on this method, ERG concludes that there is evidence that radium-226 and thorium-230 are in equilibrium, but not secular equilibrium at the site. (Figure 10).

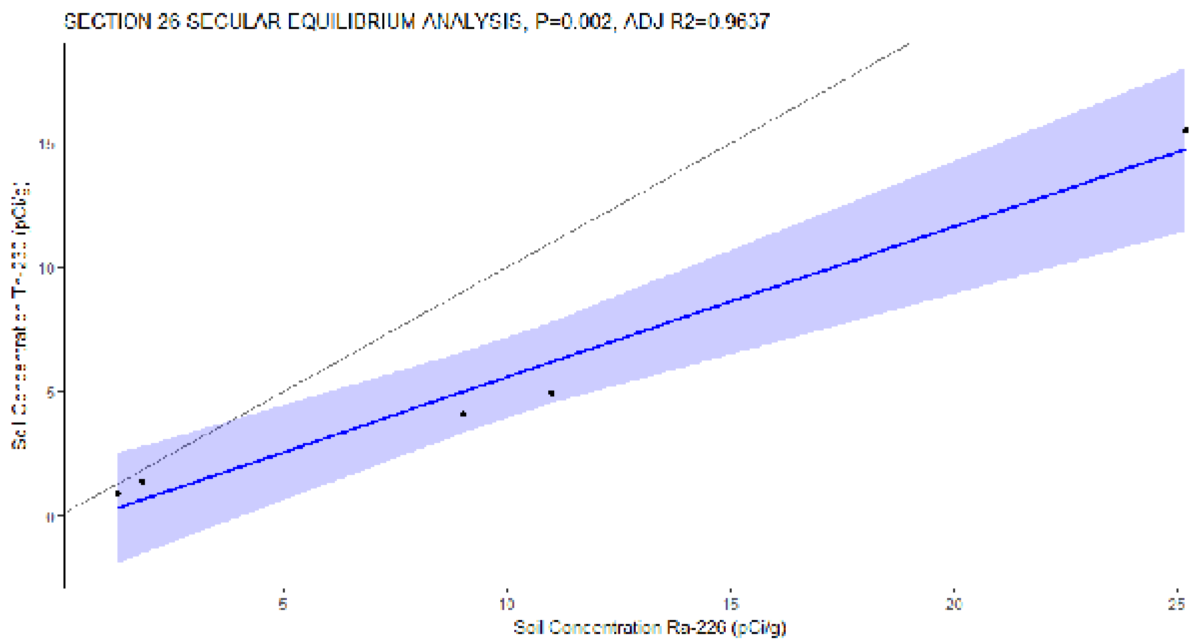


Figure 10. Evaluation of secular equilibrium in the uranium decay series.

3.3 Exposure rates and gamma count rates

On June 29, 2017 field personnel made co-located 1-minute static count rate and exposure rate measurements at five locations within the Survey Area, representing the range of gamma count rates obtained in the GPS-based gamma survey. Figure 7 shows the locations of the co-located measurements, which were made in the centers of the areas.

The gamma count rate and exposure rate measurements were made at 0.5 meters (m) and 1 m above the ground surface, respectively. The gamma count rate measurements were made using a Ludlum Model 44-20, 3-inch by 3-inch sodium iodide detector (NaI) coupled with a Ludlum Model 2221 ratemeter/scaler (Serial Numbers PR202073/190166). The exposure rate measurements were made using a Reuter Stokes Model RS-S131-200-ER000 (Serial Number 1000992) high pressure ionization chamber (HPIC) at 1-second intervals for about 10 minutes. The HPIC output the 1-second measurements as 1-minute averages. The exposure rate used in the comparison was the mean of these measurements, less those occurring in initial instrument warm-ups. The HPIC was in current calibration and function checked before and after use. Calibration forms for the HPIC are provided in Appendix A. Table 7 presents the results for the two types of measurements made at each of the five locations. Appendix B presents the 1-minute average exposure rate measurements.

The best predictive relationship between the measurements is linear with an R^2 of 0.97. The root mean square error and p-value for the model are 2.68 and 0.002, respectively; these parameters are not DQOs and are included only as information.

The following equation is the linear regression (shown in Figure 10) between the mean exposure rate and gamma count rate results in Table 7 that was generated using MS Excel:

Exposure Rate (microRoentgens per hour [µR/h]) = 2.66×10^{-4} x [Gamma Count Rate (cpm)] + 5.355

Figure 11 presents the exposure rates predicted from the gamma count rate measurements, the spatial and numerical distribution of which mirror those depicted in Figure 4.

Tables 8 and 9 present summary statistics for the predicted exposure rates in the five Background Reference Areas, respectively.

The range of predicted exposure rates at:

- BG1 is 8.4 to 10.7 µR/h, with a mean and median of 9.1 µR/h
- BG2 is 10.3 to 12.1 µR/h, with a mean and median of 11.0 µR/h
- BG3 is 8.9 to 20.5 µR/h, with a mean and median of 13.1 and 12.4 µR/h, respectively
- BG4 is 9.6 to 11.4 µR/h, with a mean and median of 10.4 µR/h
- BG5 is 9.7 to 11.4 µR/h, with a mean and median of 10.5 and 10.4 µR/h, respectively

The range of predicted exposure rates in the Survey Area is 7.7 to 204.6 µR/h, with a mean and median of 14.0 and 12.3 µR/h, respectively.

Table 7. Co-located gamma count rate and exposure rate measurements.

Location	Gamma Count Rate (cpm)	Exposure Rate (µR/h)
S1011-C01-001	19,139	11.9
S1011-C02-001	79,012	27.4
S1011-C03-001	30,008	13.8
S1011-C04-001	71,276	20.2
S1011-C05-001	147,023	45.6

Notes:
cpm = counts per minute
µR/h = microRoentgens per hour

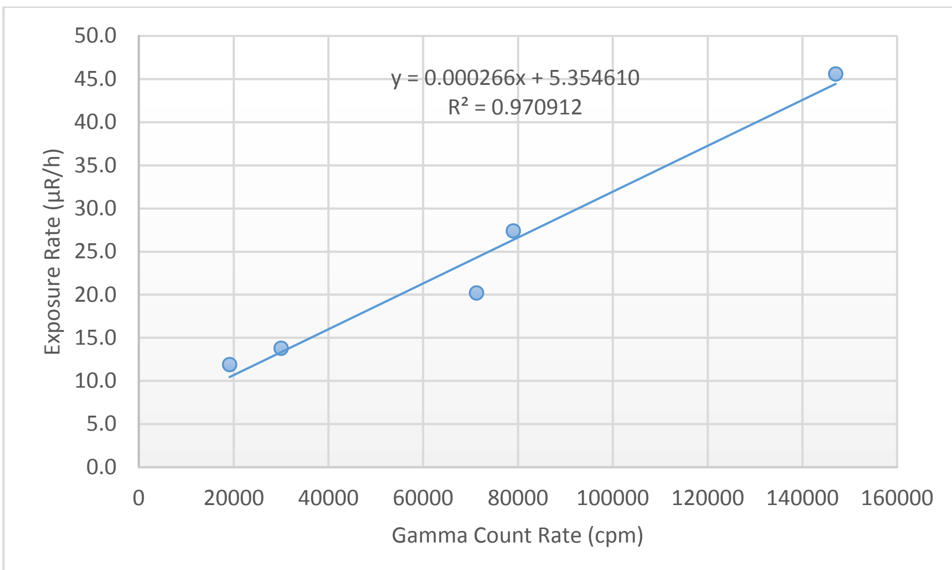


Figure 11. Correlation of gamma count rates and exposure rates.

Table 8. Predicted exposure rates in the potential Background Reference Areas.

Parameter	BG1	BG2	BG3	BG4	BG5
n	171	288	80	442	138
Minimum	8.4	10.3	8.9	9.6	9.7
Maximum	10.7	12.1	20.5	11.4	11.4
Mean	9.1	11.0	13.1	10.4	10.5
Median	9.1	11.0	12.4	10.4	10.4
Standard Deviation	0.4	0.3	2.6	0.3	0.4

Notes:
BG1 = Background Reference Area 1
BG2 = Background Reference Area 2
BG3 = Background Reference Area 3
BG4 = Background Reference Area 4
BG5 = Background Reference Area 5
µR/h = microRoentgens per hour

Table 9. Predicted exposure rates in the Survey Area.

Parameter	Exposure Rate (µR/h)
n	71,563
Minimum	7.7
Maximum	204.6
Mean	14.0
Median	12.3
Standard Deviation	7.5

Notes:
µR/h = microRoentgens per hour

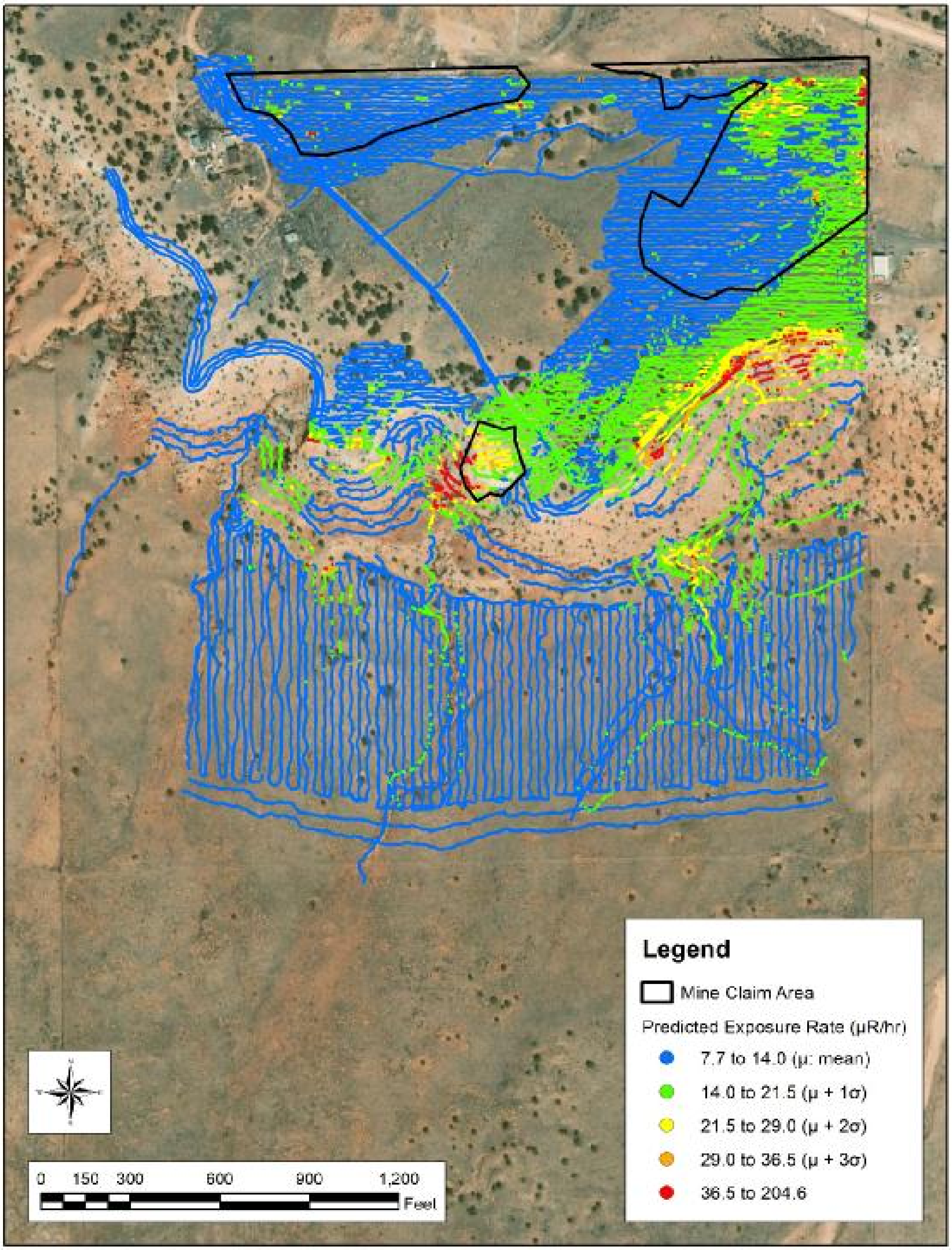


Figure 12. Predicted exposure rates in the Survey Area.

4.0 Deviations from the RSE Work Plan

The RSE Work Plan specifies that the comparison of gamma count rates and radium concentrations in surface soils was to occur in 900 square foot areas. Field personnel adjusted the areas as necessary, to minimize the variability of gamma count rates observed, particularly where the spatial distribution of waste rock was heterogeneous.

A second deviation to the RSE Work Plan was the use of 3-inch by 3-inch sodium iodide detectors in lieu of the 2-inch by 2-inch detectors that were specified in the plan. The change was made such that the gamma count rate measurements could be compared to those made previously by others using 3-inch by 3-inch sodium iodide detectors (Ecology and Environment, 2014).

5.0 Conclusions

The findings of the RSE pertaining to these activities are:

- The horizontal extent and magnitude of mining-related materials were delineated sufficiently to support additional characterization of the subsurface.
- Elevated count rates were associated with waste rock in each of the mine claims; i.e., in several small areas of the northwestern claim, the north and east edges of the northeastern claim, and the center of the southern claim. Elevated count rates also were observed outside the northeastern and southern claims along the edge of the mesa and continuing onto the valley floor below.
- Five potential Background Reference Areas were established.
- The relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface) is described by a linear regression model:

  Gamma Count Rate (cpm)=5822 * [Radium-226 concentration (pCi/g)] +13201

- The distribution of concentrations of radium-226 in surface soils predicted using this model resembles a lognormal distribution. The values in the Survey Area range from -0.8 to 126.4 pCi/g, with a central tendency (median) of 2.2 pCi/g.
- The thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226 from gamma count rates.
- There is evidence that radium-226 and thorium-230 are in equilibrium, but not secular equilibrium at the site.

- The relationship between gamma count rates and exposure rates is described by a linear regression model:

Exposure Rate (microRoentgens per hour [μR/h]) = 2.66×10^{-4} x [Gamma Count Rate (cpm)] + 5.355

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 7.7 to 204.6 μR/h, with a central tendency (median) of 12.3 μR/h.

- Further work is recommended to support a robust gamma correlation.

6.0 References

ANSI, 1997. Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments, American National Standards Institute (ANSI) Standard N232A. June 20, 2014.

Ecology and Environment, 2014. Removal Assessment Report, Tronox AUM Section 26, Baca/Haystack Chapter, Eastern Agency, Navajo Nation. February.

MWH, 2016. Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan, October 24, 2016.

Stantec, 2018. Section 26 Removal Site Evaluation Report, January 2018.

Appendix A Instrument calibration and completed function check forms

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	196086
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR262406

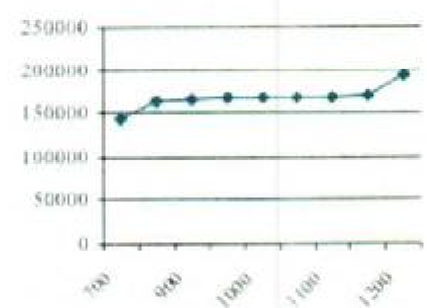
☐ Mechanical Check ☐ THR/WIN Operation HV Check (+/- 2.5%): ☐ 500 V ☐ 1000 V ☐ 1500 V
☐ F/S Response Check ☐ Reset Check Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:
☐ Geotropism ☐ Audio Check
☐ Meter Zeroed ☐ Battery Check (Min 4.4 VDC) Barometric Pressure: inches Hg
Source Distance: ☐ Contact ✔ 6 inches ☐ Other: Threshold: Temperature: °F
Source Geometry: ✔ Side ☐ Below ☐ Other: Window: Relative Humidity: %

Instrument found within tolerance: ✔ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

High Voltage	Source Counts	Background
700	144169	
800	162193	
900	166057	
950	167388	
1000	167489	21583
1050	167574	
1100	168254	
1150	170145	
1200	192327	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1000

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932
Fluke multimeter serial number: ☐ 87490128
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03
☐ Other Source:

Calibrated By: [signature] Calibration Date: 7 March 17 Calibration Due: 7 March 18

Reviewed By: [signature] Date: 3-7-17

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A-1997

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	254772
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR269980

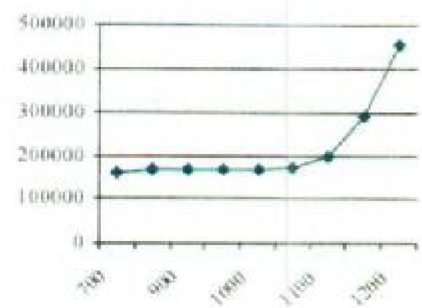
☐ Mechanical Check ☐ THR/WIN Operation HV Check (+/- 2.5%): ☐ 500 V ☐ 1000 V ☐ 1500 V
☐ F/S Response Check ☐ Reset Check Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:
☐ Geotropism ☐ Audio Check
☐ Meter Zeroed ☐ Battery Check (Min 4.4 VDC) Barometric Pressure: inches Hg
Source Distance: ☐ Contact ✔ 6 inches ☐ Other: Threshold: Temperature: °F
Source Geometry: ✔ Side ☐ Below ☐ Other: Window: Relative Humidity: %

Instrument found within tolerance: ✔ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

High Voltage	Source Counts	Background
700	162620	
800	168495	
900	170240	
950	170850	22731
1000	171277	
1050	172525	
1100	197371	
1150	291452	
1200	453265	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV =950

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Ludlum pulser serial number: ☐ 97743 ✔ 201932
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By: [signature] Calibration Date: 7 March 17 Calibration Due: 7 March 18

Reviewed By: [signature] Date: 3-7-17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	271435
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR213432

✔ Mechanical Check ✔ THR/WIN Operation
✔ F/S Response Check ✔ Reset Check
✔ Geotropism ✔ Audio Check
✔ Meter Zeroed ✔ Battery Check (Min 4.4 VDC)
Source Distance: ☐ Contact ✔ 6 inches ☐ Other:
Source Geometry: ✔ Side ☐ Below ☐ Other:

HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:

Threshold: 10 mV
Window:

Barometric Pressure: 24.72 inches Hg
Temperature: 68 °F
Relative Humidity: 20 %

Instrument found within tolerance: ✔ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399058	400
x 1000	100	100	100		100
x 100	400	400	400	39908	400
x 100	100	100	100		100
x 10	400	400	400	3989	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	117585	
800	155051	
900	164169	
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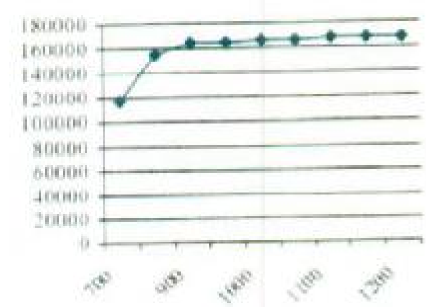
1000	166858	
1050	166722	
1100	168083	20644
1150	167659	
1200	168487	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1100

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932
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☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By:
Reviewed By:

Calibration Date: 7 March 17 Calibration Due: 7 March 18

Date: 3-7-17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	190166
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR269985

☑ Mechanical Check ☑ THR/WIN Operation
☑ F/S Response Check ☑ Reset Check
☑ Geotropism ☑ Audio Check
☑ Meter Zeroed ☑ Battery Check (Min 4.4 VDC)
Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Source Geometry: ☑ Side ☐ Below ☐ Other:

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch ☐ Other:

Threshold: 10 mV
Window:

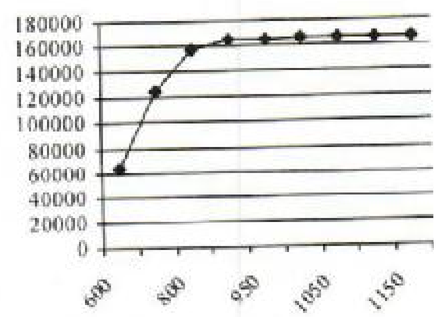
Barometric Pressure: 24.66 inches Hg
Temperature: 75 °F
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Coun
x 1000	400	400	400	399389	400
x 1000	100	100	100		100
x 100	400	400	400	39940	400
x 100	100	100	100		100
x 10	400	400	400	3999	400
x 10	100	100	100		100
x 1	400	400	400	400	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
600	64081	
700	125567	
800	157563	
900	165079	
950	164853	
1000	165840	21364
1050	166555	
1100	166593	
1150	166782	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1000

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
Fluke multimeter serial number: ☐ 87490128
☐ Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12)
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12)
☐ Other Source:

Calibrated By: [signature] Calibration Date: 5-12-17 Calibration Due: 5-12-18

Reviewed By: [signature] Date: 5/12/17

ERG Form ITC. 101.A

Certificate of Calibration

Calibration and Voltage Plateau

ERG

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	190166
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR202073

Mechanical Check
F/S Response Check
Geotropism
Meter Zeroed

THR/WIN Operation
Reset Check
Audio Check
Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): 500 V 1000 V 1500 V
Cable Length: 39-inch ✔ 72-inch Other:

Barometric Pressure: inches Hg
Temperature: °F
Relative Humidity: %

Source Distance: Contact 6 inches Other: Threshold:
Source Geometry: Side Below Other: Window:

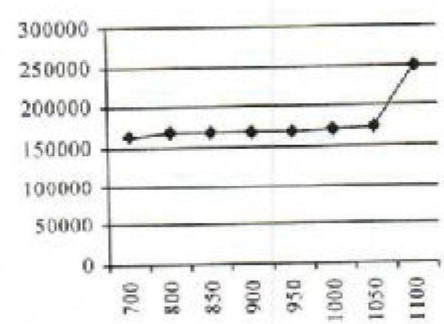
Instrument found within tolerance: ✔ Yes No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

See other (x) sheet

High Voltage	Source Counts	Background
700	164061	
800	168372	
850	169017	
900	170276	24149
950	170410	
1000	170754	
1050	175368	
1100	250364	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 900

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 201932
Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12)
Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12)

Fluke multimeter serial number: 87490128
✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
Other Source:

Calibrated By: Calibration Date: 6-14-17 Calibration Due: 6-14-18

Reviewed By: Date: 6-14-17

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	218564
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	051517S

Mechanical Check | THR/WIN Operation | HV Check (+/- 2.5%): 500 V 1000 V 1500 V

F/S Response Check | Reset Check | Cable Length: 39-inch ✔ 72-inch Other:

Geotropism | Audio Check

Meter Zeroed | Battery Check (Min 4.4 VDC) | Barometric Pressure: inches Hg

Source Distance: Contact ✔ 6 inches Other: | Threshold: 10 mV | Temperature: °F

Source Geometry: ✔ Side Below Other: | Window: | Relative Humidity: %

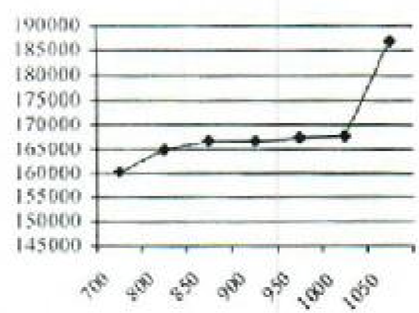
Instrument found within tolerance: ✔ Yes No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

See Ludlum Cal Sheet

High Voltage	Source Counts	Background
700	160304	
800	164819	
850	166661	
900	166927	23453
950	167592	
1000	167697	
1050	186865	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 900

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 ✔ 201932 | Fluke multimeter serial number: 87490128

Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12) | ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12) | Other Source:

Calibrated By: [signature] | Calibration Date: 9-7-17 | Calibration Due: 9-7-18

Reviewed By: T. [signature] | Date: 09/08/17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

Ludlum Measurements, Inc. — Designer and Manufacturer of Scientific and Industrial Instruments

www.ludlums.com

CERTIFICATE OF CALIBRATION

501 Oak Street
325-235-5494
Sweetwater, TX 79556, U.S.A.

ACCREDITED
CERT # 4084.01

ORDER NO. 20315056/451872

Customer ERG

Mfg. Ludlum Measurements, Inc. Model 2221 Serial No. 218564

Mfg. Model Serial No.

Cal. Date 14-Jul-17 Cal Due Date 14-Jul-18 Cal. Interval 1 Year Meterface 202-159

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 47 % Alt 709.0 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☑ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck.
☑ Calibrated in accordance with LMI SOP 14.8 ☐ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set 1000 V Input Sens. 100 mV Det. Oper. ______ V at ______ mV Threshold Dial Ratio 100 = 10 mV

☐ HV Readout (2 points) Ref./Inst. 500 / 499 V Ref./Inst. 2000 / 2000 V

COMMENTS:

Calibrated with 39" cable
Firmware: 261027

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 1000	400 Kcpm	N/A	400
X 1000	100 Kcpm		100
X 100	40 Kcpm		400
X 100	10 Kcpm		100
X 10	4 Kcpm		400
X 10	1 Kcpm		100
X 1	400 cpm		400
X 1	100 cpm		100

ALL Range(s) Calibrated Electronically

*Uncertainty within ± 10% C.F. within ± 20%

Digital Readout REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
400 Kcpm	N/A	40155 (6)
40 Kcpm		4010
4 Kcpm		401
400 cpm		40
40 cpm		4

Log Scale REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
500 Kcpm	N/A	500 Kcpm
50 Kcpm		50
5 Kcpm		5
500 cpm		500 cpm
50 cpm		50

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 ISO/IE 17025:2005(E) State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 069 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521 ☐ 5-394 ☐ 5-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☐ Y982 ☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☐ 2168CP

☐ Alpha S/N ☐ Beta S/N ☐ Other

☑ m 500 S/N 201934 ☐ Oscilloscope S/N ☑ Multimeter S/N 92780460

Calibrator Josie Ruiz Title Technician Date 14 July 17

QC'd By Title Service Dept QC Date 14 Jul 17

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

FORM C22A 12/12/2016 Page 1 of 1

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	254772
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR269985

Mechanical Check — THR/WIN Operation — HV Check (+/- 2.5%): 500 V 1000 V 1500 V

F/S Response Check — Reset Check — Cable Length: 39-inch ✔ 72-inch Other:

Geotropism — Audio Check

Meter Zeroed — Battery Check (Min 4.4 VDC) — Barometric Pressure: inches Hg

Source Distance: Contact ✔ 6 inches Other: — Threshold: — Temperature: °F

Source Geometry: ✔ Side Below Other: — Window: — Relative Humidity: %

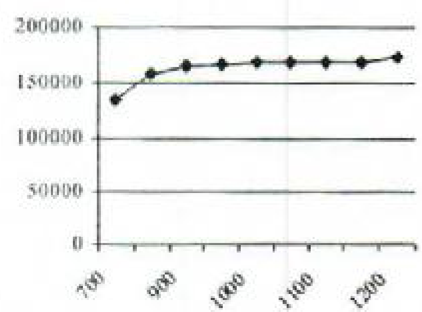
Instrument found within tolerance: Yes ✔ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

See Ludlum Cal Sheet

High Voltage	Source Counts	Background
700	133844	
800	158402	
900	164459	
950	166477	
1000	167466	
1050	167781	27111
1100	168169	
1150	168450	
1200	172562	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1050

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 201932 — Fluke multimeter serial number: 87490128

Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12) — ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12) — Other Source:

Calibrated By: [signature] — Calibration Date: 9-7-17 — Calibration Due: 9-7-18

Reviewed By: T. [signature] — Date: 09/08/17

www.ludlums.com

of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

501 Oak Street
325-235-5494
Sweetwater, TX 79556, U.S.A.

ACCREDITED
CERT # 4084.01

ORDER NO. 20316590/452897

Customer ERG

Mfg. Ludlum Measurements, Inc. Model 2221 Serial No. 254772

Mfg. ______ Model ______ Serial No. ______

Cal. Date 11-Aug-17 Cal Due Date 11-Aug-18 Cal. Interval 1 Year Meterface 202-159

Check mark ✓ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 47 % Alt 698.0 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☑ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck.

☑ Calibrated in accordance with LMI SOP 14.8 ☐ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set 500 V Input Sens. JR 10 ~~100~~ mV Det. Oper. ______ V at ______ mV Threshold Dial Ratio 100 = 10 mV

☐ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 1500 / 1501 V

COMMENTS:

Firmware: 261027
Calibrated with Window in "OUT" position.
Calibrated with 39" cable.

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 1000	400 Kcpm	N/A	400
X 1000	100 Kcpm		100
X 100	40 Kcpm		400
X 100	10 Kcpm		100
X 10	4 Kcpm		400
X 10	1 Kcpm		100
X 1	400 cpm		400
X 1	100 cpm		100

ALL Range(s) Calibrated Electronically

*Uncertainty within ± 10% C.F. within ± 20%

Digital Readout: REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	Log Scale: REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
400 Kcpm	N/A	40156 (0)	500 Kcpm	N/A	500 Kcpm
40 Kcpm		4011	50 Kcpm		50
4 Kcpm		401	5 Kcpm		5
400 cpm		40	500 cpm		500 cpm
40 cpm		4	50 cpm		50

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 ISO/IE 17025:2005(E) State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521 Neutron Am-241 Be ☐ T-304 Ra-226 ☐ Y982
☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☐ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082

☐ Alpha S/N ______ ☐ Beta S/N ______ ☐ Other ______

☑ m 500 S/N 201934 ☐ Oscilloscope S/N ______ ☑ Multimeter S/N 92780460

Calibrator Josie Ruiz [signature] Title Technician Date 11 Aug 17

QC'd By [signature] Title ______ Date 11 Aug 17

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed: ______

FORM SC22A 12/12/2016 Page 1 of 1

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	262334
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	051517P

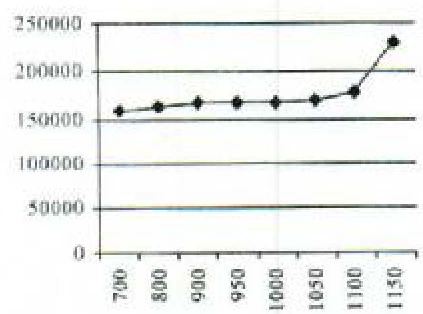
✔ Mechanical Check ✔ THR/WIN Operation HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
✔ F/S Response Check ✔ Reset Check Cable Length: 39-inch ✔ 72-inch Other:
✔ Geotropism ✔ Audio Check
✔ Meter Zeroed ✔ Battery Check (Min 4.4 VDC) Barometric Pressure: 24.69 inches Hg
Source Distance: Contact ✔ 6 inches Other: Threshold: 10 mV Temperature: 75 °F
Source Geometry: ✔ Side Below Other: Window: Relative Humidity: 20 %

Instrument found within tolerance: ✔ Yes No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	398990	400
x 1000	100	100	100		100
x 100	400	400	400	39893	400
x 100	100	100	100		100
x 10	400	400	400	3986	400
x 10	100	100	100		100
x 1	400	400	400	398	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	159361	
800	163970	
900	166805	
950	167531	26434
1000	168157	
1050	169245	
1100	177000	
1150	229347	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 950

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 ✔ 201932 Fluke multimeter serial number: 87490128

Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12) ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12) Other Source:

Calibrated By: [signature] Calibration Date: 9-7-17 Calibration Due: 9-7-18

Reviewed By: T. [signature] Date: 09/08/17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

Reuter-Stokes

Calibration Certificate

Reuter-Stokes certifies that the Environmental Radiation Monitor, identified below, has been calibrated for output using the shadow shield technique*, and calibrated with radiation sources traceable to the National Institute of Standards and Technology.

Sensor Type: 100 R/Hr

Serial Number: 1000992

Calibration Date: 03/16/2017

Sensitivity: -2.281E-8 A/R/h

Authorized Signature

*Calibration Procedure: RS-SOP 238.1

Reuter-Stokes

Calibration Data

Sensor Type:	100 R/Hr	Source (CS-137):	BB-400
Serial Number:	1000992	Date of Certification:	12/01/1994
Calibration Date:	03/16/2017	Exposure Rate at 1 meter:	4.226 mR/h

Customer Name: STOCK

Sensitivity (Ra-226): -2.281E-8 A/R/h

Distance		Exposure Rate	P+S+A	S+A	P	k(CS-137)
Feet	cm	µR/h	A	A	A	A/R/h
12	366	185.323	-5.403E-12	-1.164E-12	-4.239E-12	-2.287E-08
14	427	135.592	-4.135E-12	-1.012E-12	-3.123E-12	-2.303E-08
16	488	103.384	-3.294E-12	-9.029E-13	-2.391E-12	-2.313E-08
18	549	81.348	-2.708E-12	-8.209E-13	-1.887E-12	-2.319E-08

k(CS-137) = -2.306E-8 A/R/h

k(Ra-226) = 0.9892 k(CS-137)

k(Ra-226) = -2.281E-8 A/R/h

k = -2.306E-8 A/R/h

σ = 1.39E-10 A/R/h

$V = \frac{\sigma}{k}$ = -0.603%

By: John Lal

Date: 3-17-17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	196086
Cal. Due Date:	3-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR262406
Cal. Due Date:	3-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: N/A cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-25-17	0926	5.5	1005	100	94365	14878	79487	NW	Section 26 near trailer
3-25-17	1454	5.4	998	100	96316	13481	82835	NW	Section 26 near trailer
3-26-17	1035	5.5	1004	102	94314	14114	80200	NW	Section 26 near trailer
3-26-17	1401	5.3	999	100	93248	13531	79717	NW	Section 26 near trailer
3-28-17	0835	5.5	1005	101	96188	14430	81758	NW	Section 26 near trailer
3-28-17	1212	5.3	1003	101	103245	22269	80976	NW	Section 26 on road @ southern claim
3-29-17	0840	5.4	1005	101	95732	14653	81079	NW	Section 26 near trailer.
3-29-17	1232	5.2	1002	101	94834	15054	79780	NW	Section 26 near trailer
					[signature]				
					4-2-16				

Reviewed by: [signature] Review Date: 1/29/18

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	3-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR 269986 ~~S~~ NW
Cal. Due Date:	3-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: N/A cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-25-17	0931	5.7	752	100	96657	16184	80463	NV	Section 26, near trailer
3-25-17	1457	5.6	746	100	96139	14624	81515	NV	Section 26, near trailer
3-26-17	1031	5.7	952	100	95441	15227	80214	NV	Section 26, near trailer
3-26-17	1358	5.5	947	100	96336	14730	81606	NW	Section 26 near trailer
3-28-17	0840	5.6	952	101	96138	16340	79798	NW	Section 26, near trailer
3-28-17	1218	5.5	749	100	104022	23070	80952	NW	Section 26, road at southern claim
3-29-17	0837	5.6	952	101	96719	15960	80759	NW	Section 26, near trailer
3-29-17	1236	5.5	949	101	97836	15710	82126	NW	Section 26, near trailer
					NW 4-2-17				

Reviewed by: [signature] Review Date: 1/29/18

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ERG

Single-Channel Function Check Log

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	271435
Cal. Due Date:	3-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR213432
Cal. Due Date:	3-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: N/A cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-25-17	0937	5.5	1055	102	94755	14061	80694	NW	Section 26 near trailer
3-25-17	1451	5.4	1051	101	94302	13177	81125	NW	Section 26 near trailer
3-26-17	1039	5.5	1057	102	92236	13069	79167	NW	Section 26 near trailer
3-26-17	1355	5.3	1051	101	93583	12884	80699	NW	Section 26 near trailer
3-28-17	0836	5.5	1058	102	95338	14043	81295	NW	Section 26 near trailer
3-28-17	1210	5.3	1055	102	101737	20756	80981	NW	Section 26 road at southern claim
3-29-17	0832	5.4	1057	102	94866	13882	81984	NW	Section 26 near trailer
3-29-17	1230	DID NOT USE							

4-2-17

Reviewed by: [signature] Review Date: 11/29/18

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METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	190166
Cal. Due Date:	6-14-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR202073
Cal. Due Date:	6-14-18

Comments:
NNEAT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-29-17	0915	5.5	900	100	91966	13959	78007	NW	Section 26
6-30-17	0845	5.5	900	100	99574	21622	77952	NW	ERG office

7-5-17

Reviewed by: [signature]

Review Date: ~~1/19~~ 1/29/18

ERG Form ITC.201.A

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Single-Channel Function Check Log

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METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	218564
Cal. Due Date:	9-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	051517[illegible]
Cal. Due Date:	9-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-19-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
9-18-17	0836	6.1	950	99	120544	41247	79297	NW	Section 26 @ corral
9-18-17	1502	6.0	947	99	88788	12852	75936	NW	Milan roadside
9-19-17	0824	6.0	950	99	92200	14954	77246	NW	Section 26 @ trailer
9-19-17	1400	6.0	947	99	113273	36312	76961	NW	Section 26 @ corral

[illegible] 9-23-17

Reviewed by: [illegible] Review Date: 10/9/17

(2)

ERG

Single-Channel Function Check Log

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METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	9-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR269995
Cal. Due Date:	9-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
9-18-17	0841	6.2	1053	100	120777	42659	78118	NW	Section 26 @ corral
9-18-17	1508	6.1	1046	100	90560	13975	76585	NW	Milan roadside
					NW 9-23-17				

Reviewed by: MM Review Date: 10/9/17

(

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Single-Channel Function Check Log

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METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	262334
Cal. Due Date:	9-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	051517P
Cal. Due Date:	9-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
9-18-17	0842	5.3	953	100	122187	41250	80937	NW	Section 26 @ corral
9-18-17	1505	5.3	945	100	90087	12767	77320	NW	Milan roadside

NW 9-27-17

Reviewed by: MM Review Date: 10/9/17

ERG

Single-Channel Function Check Log

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METER	
Manufacturer:	Reuter Stokes
Model:	RS-S131-200-ER000U
Serial No.:	1000992
Cal. Due Date:	3-16-18

DETECTOR	
Manufacturer:	Reuter Stokes
Model:	RS-S131-200-ER000U
Serial No.:	1000992
Cal. Due Date:	3-16-18

Comments:
NNERT - HPIC

Source: Cs-137 Activity: 4 uCi Source Date: 4-12-96 Distance to Source: Contact housing

Serial No.: S44-46 Emission Rate: NA cpm/emissions

← μR/h →

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-26-17	0630	8.18	401.2	NA	~14.2	~8.5	~5.7	NW	Home 2 Suites room! Farmington
6-26-17	2100	7.93	401.1	NA	~14.5	~8.6	~5.9	NW	Hilton Garden Inn room! Gallup
6-29-17	0950	8.25	401.3	NA	~18	~12.5	~5.5	NW	Section 26
6-30-17	0740	8.21	401.3	NA	~19	~13.4	~5.6	NW	ERG office

NW 6-30-17

Reviewed by: MA Review Date: 10/9/17

Appendix B Exposure Rate Measurements

Date and Time	Exposure Rate (mR/h)	Location
06/29/2017 9:50	0.0093	Correlation Location 1
06/29/2017 9:51	0.0116	Correlation Location 1
06/29/2017 9:52	0.0119	Correlation Location 1
06/29/2017 9:53	0.0121	Correlation Location 1
06/29/2017 9:54	0.0120	Correlation Location 1
06/29/2017 9:55	0.0119	Correlation Location 1
06/29/2017 9:56	0.0123	Correlation Location 1
06/29/2017 9:57	0.0118	Correlation Location 1
06/29/2017 9:58	0.0118	Correlation Location 1
06/29/2017 9:59	0.0121	Correlation Location 1
06/29/2017 10:19	0.0227	Correlation Location 2
06/29/2017 10:20	0.0279	Correlation Location 2
06/29/2017 10:21	0.0276	Correlation Location 2
06/29/2017 10:22	0.0270	Correlation Location 2
06/29/2017 10:23	0.0271	Correlation Location 2
06/29/2017 10:24	0.0275	Correlation Location 2
06/29/2017 10:25	0.0277	Correlation Location 2
06/29/2017 10:26	0.0268	Correlation Location 2
06/29/2017 10:27	0.0274	Correlation Location 2
06/29/2017 10:28	0.0276	Correlation Location 2
06/29/2017 10:42	0.0095	Correlation Location 3
06/29/2017 10:43	0.0135	Correlation Location 3
06/29/2017 10:44	0.0141	Correlation Location 3
06/29/2017 10:45	0.0140	Correlation Location 3
06/29/2017 10:46	0.0138	Correlation Location 3
06/29/2017 10:47	0.0144	Correlation Location 3

Date and Time	Exposure Rate (mR/h)	Location
06/29/2017 10:48	0.0139	Correlation Location 3
06/29/2017 10:49	0.0135	Correlation Location 3
06/29/2017 10:50	0.0135	Correlation Location 3
06/29/2017 10:51	0.0134	Correlation Location 3
06/29/2017 10:52	0.0137	Correlation Location 3
06/29/2017 11:05	0.0130	Correlation Location 4
06/29/2017 11:06	0.0194	Correlation Location 4
06/29/2017 11:07	0.0207	Correlation Location 4
06/29/2017 11:08	0.0206	Correlation Location 4
06/29/2017 11:09	0.0202	Correlation Location 4
06/29/2017 11:10	0.0206	Correlation Location 4
06/29/2017 11:11	0.0194	Correlation Location 4
06/29/2017 11:12	0.0206	Correlation Location 4
06/29/2017 11:13	0.0201	Correlation Location 4
06/29/2017 11:14	0.0201	Correlation Location 4
06/29/2017 11:27	0.0191	Correlation Location 5
06/29/2017 11:28	0.0399	Correlation Location 5
06/29/2017 11:29	0.0450	Correlation Location 5
06/29/2017 11:30	0.0456	Correlation Location 5
06/29/2017 11:31	0.0456	Correlation Location 5
06/29/2017 11:32	0.0462	Correlation Location 5
06/29/2017 11:33	0.0459	Correlation Location 5
06/29/2017 11:34	0.0453	Correlation Location 5
06/29/2017 11:35	0.0462	Correlation Location 5
06/29/2017 11:36	0.0451	Correlation Location 5
06/29/2017 11:37	0.0453	Correlation Location 5

Appendix C Technical Memo from ERG to Stantec. “Statistical Analysis of the Navajo Trustee Mines Dataset: Multivariate Linear Regression for Evaluation of Gamma Correlation with Ra-226 and Evaluation of Secular Equilibrium Between Ra-226 and Th-230”.

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Memo

To: Kirsty Woods, Program Director, Stantec

From: Liz Ruedig, PhD, CHP, and Mike Schierman, CHP, Environmental Restoration Group

Date: 7/31/2018

Re: Statistical Analysis of the Navajo Trustee Mines Dataset: Multivariate Linear Regression for Evaluation of Gamma Correlation with Ra-226 and Evaluation of Secular Equilibrium Between Ra-226 and Th-230

Multivariate Linear Regression for Evaluation of Gamma Count Rate with Ra-226 Concentrations in Surface Soil

Due to a large number of reviewer comments at the sixteen Navajo Trust Abandoned Uranium Mines (AUMs) concerning the influence of gamma-emitting radionuclides not within the uranium-238 decay series on the correlation between dynamic gamma count rate and soil concentration of radium-226, Environmental Restoration Group has performed multivariate linear regression (MLR), relating gamma count rate to multiple soil radionuclides simultaneously. MLR models the influence of a set of predictor variables (in this case, soil concentrations of several gamma-emitting radionuclides, or surrogates for these radionuclides) on a single response variable (in this case, dynamic gamma count rate), accounting for the influence of each predictor variable upon the response variable independently of the other predictor variables within the set.

In a MLR, it is possible to distinguish from a large set of variables the subset that significantly predicts a response variable. This is done by evaluating potential models on a number of criteria:

1. **The multi-collinearity of predictor variables.**

   Predictor variables that are linearly related to each other (i.e., variables y and x, where y may also be mathematically expressed as some multiple of x) produce a condition known as multicollinearity, where the matrix math used to solve the multivariate linear regression becomes irreducible. A physical example of multicollinearity occurs when modelling the influence of two radionuclides in equilibrium with each other (e.g., Th-230 and Ra-226) on a single response variable (e.g., gamma count rate). In order to compute a mathematical solution to the regression model, one of the multicollinear variables must be removed from the regression matrix. The multicollinear variables are identifiable by a large variance inflation factor (VIF), typically greater than 7, but in cases of near-perfect multicollinearity, often much greater than this value (e.g., > 100).

   It is also possible to identify multicollinear predictor variables by regressing two suspect variables upon each other. A high degree of correlation (i.e., $p < 0.05$ and high adjusted R^2) between the two variables suggests that the predictor variables are multicollinear, and that one variable should be eliminated from the multivariate regression prior to analysis.

2. **The p-value of predictor variables**

   For a variable to be considered a significant predictor of the response variable, the p-value of its slope (as calculated in an ANOVA table) must be significant (i.e., $p < 0.05$). In a MLR, the adjusted R^2 value for individual predictor variables is not indicative of overall model quality.

For the Navajo Trust AUMs there are three potential gamma-contributing radionuclides (defined as radionuclides that emit gamma radiation, or whose short-lived decay products emit gamma radiation) present in soil: thorium-232, radium-226 and, thorium-228. Thorium-230, which does not emit gamma radiation, was excluded as a potentially significant gamma-contributing radionuclide.

A MLR model: gamma = radium-226 + thorium-228 + thorium-232 was run for each AUM. For 15 of the 16 mines, thorium-232 and thorium-228 were multicollinear. On this basis, thorium-228 was excluded from the MLR. No multicollinearity was detected at Barton 3. However, none of the predictor variables was a significant predictor of gamma count rate ($p > 0.05$) for the complete model. As such, analysis for all 16 AUMs proceeded by removing thorium-228 from the set of predictor variables and running a new MLR model: gamma = radium-226 + thorium-232. None of the 16 models exhibited multicollinearity with the reduced model. After accounting for the effect of radium-226, thorium-232 was not a significant predictor of gamma count rate at any of the 16 AUMs. Radium-226 was a significant predictor ($p < 0.05$) of gamma count rate (after accounting for the influence of thorium-232 and thorium-228) at some of the AUMs (six of 16 AUMs).

Since neither predictor variable (thorium-232 or radium-226) was unambiguously a predictor in the MLR, two univariate regression models were performed as a final step: gamma = radium-226 and gamma = thorium-232. Thorium-232 was a significant predictor of gamma count rate ($p < 0.05$) only at Standing Rock, which is not unexpected given the geological conditions at this AUM. At all other sites, thorium-232 (and thorium-228 by association) were not significant predictors of gamma count rate ($p > 0.05$). By way of contrast, radium-226 was a significant predictor of the gamma count rate ($p < 0.05$) at 13 of the 16 AUMs. At three AUMs (Mitten, NA-0928, and Tsosie 1) none of the measured radionuclides significantly predicted the gamma count rate. Additionally, the adjusted R^2 values for the correlation models at the three AUMs, plus Claim 28, fail to meet the specified data quality objective (DQO) of greater than 0.8.

The failure to construct statistically defensible correlation models at four AUMs has been identified as a data gap in the relevant AUM report. The unsatisfactory correlation result at these locations is likely due to the small number of correlation locations, or environmental conditions at the AUMs (e.g., spatial heterogeneity in radionuclide concentration in soil, topographic features influencing gamma count rate, etc.), or some combination thereof.

Note that while the statistical measures (i.e., conformance with the study DQO of $R^2 > 0.8$) associated with these regressions can be improved by fitting a power curve to the data, and reporting unadjusted R^2 values, with only five data points at each AUM, ERG does not believe that any statistical correlation model is sufficiently robust to make meaningful inferences concerning soil radium-226 concentration from the gamma scanning data. ERG believes that linear functions – not power curves – best mimic the conceptual model for the physical processes governing the observed data. Fitting any other function in an effort to achieve the study DQO for R^2 is not a statistically rigorous approach, and improving R^2 does not commensurately improve a statistical model's predictive ability. Figure *1* compares the result of fitting a linear versus a power function to the available correlation data for one AUM (Hoskie Tso); the other AUM results are similar.

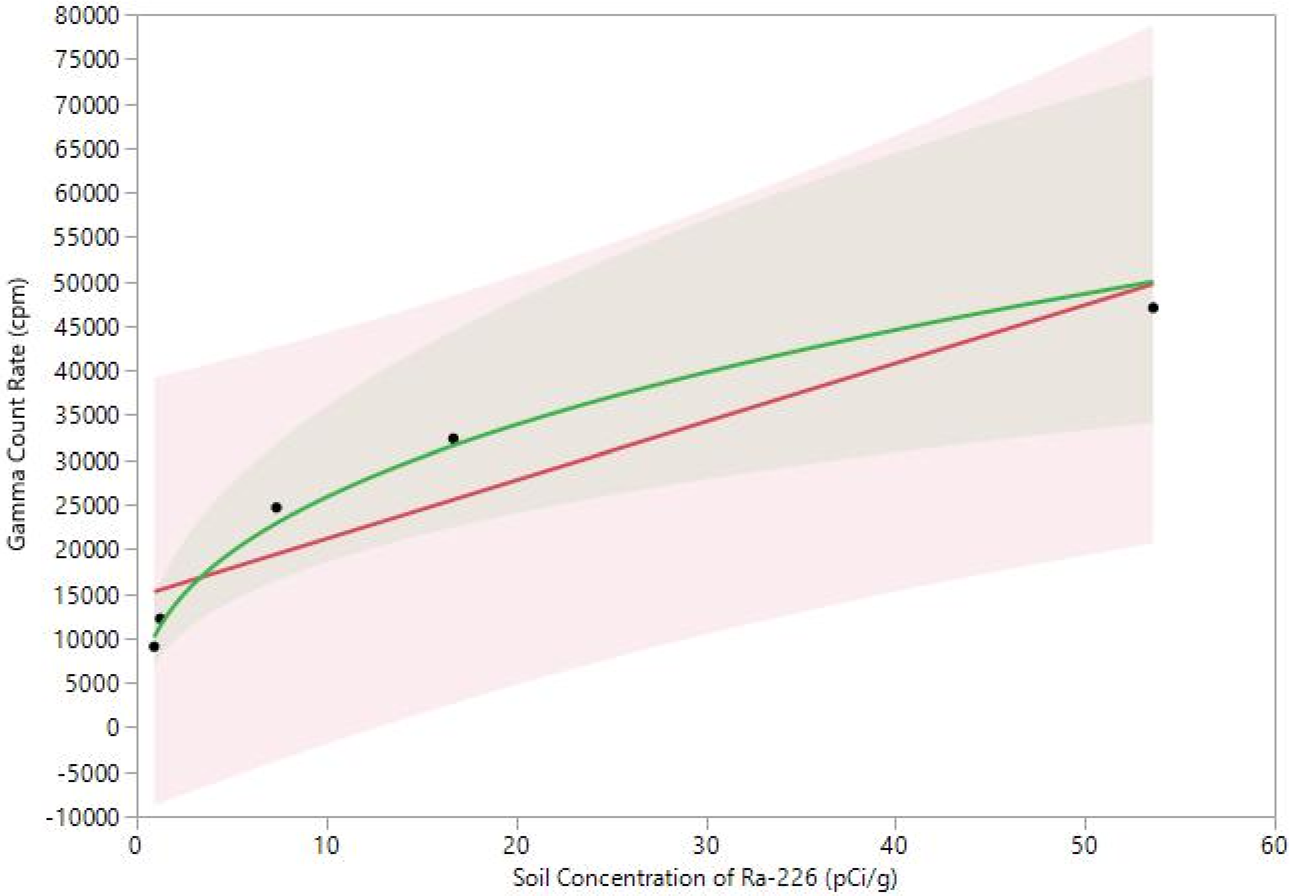


Figure 1. Regression models (linear versus power curve) for gamma count rate regressed on radium-226 showing 95% UPLs (upper prediction limits). Both models meet the study DQO for adjusted R^2 (greater than 0.8). Gamma count rate is not an especially strong predictor of soil concentration of radium-226 for either function.

ERG has updated the individual AUM reports with linear correlation functions and reported the more robust measures of statistical performance described in this memo.

Evaluation of Secular Equilibrium Between Ra-226 and Th-230

Secular equilibrium is a condition that occurs when the half-life of a decay-product nuclide is significantly shorter than that of its parent nuclide. After a period of ingrowth equal to approximately seven times the half-life of the decay product, the two nuclides effectively decay with the half-life of the parent. When two radionuclides are in secular equilibrium, their activities are equal.

Equilibrium, for the purpose of this report, is defined as a condition whereby a parent nuclide and its decay product are present in the environment at a fixed ratio, but this ratio – for whatever reason – is not a one-to-one relationship indicative of secular equilibrium. Most commonly, an equilibrium condition results from an environmental process which chemically selects for and transports one nuclide (parent or decay product) away from the other nuclide. Because a consistent fraction of one nuclide has been removed, the two nuclides are present at a fixed ratio other than one-to-one.

Determination of secular equilibrium for an AUM can be an important part of the risk assessment process, as the assumed fraction of radium-226 decay products present in the environment greatly influences a hypothetical receptor's radiation dose and mortality risk. However, it is also acceptable and conservative to assume secular equilibrium between radium-226 and its decay products for the purpose of risk assessment, and therefore to avoid the need to conclusively determine the secular equilibrium status of an AUM. Thus, an inconclusive result regarding secular equilibrium is not a study data gap, as the risk assessment phase may still proceed, provided that conservative assumptions are included regarding equilibrium concentrations of radium-226 decay products.

Regardless, the Navajo Nation AUM Environmental Response Trust RSE workplan specified that an evaluation of secular equilibrium would be made at each of the 16 Trust AUMs, and so a robust statistical examination of secular equilibrium status for radium-226 and its decay products at each AUM was conducted. One method of evaluating equilibrium between Ra-226 and Th-230 is to calculate the ratio (φ) between the two nuclides for each soil sample location, i.e.,

$$\varphi = \frac{[^{226}Ra]}{[^{230}Th]}$$

When φ is unity, the two nuclides may be said to be in secular equilibrium. Sometimes, φ is averaged over a number of locations, and if the average is unity, the population of measurement locations is said to be in secular equilibrium. Similarly, if φ is consistently some number other than one, it may be concluded that the measured population is in equilibrium. This approach does not account for the statistical uncertainty associated with making inferences across a population, nor the bias introduced into the measurement by averaging a potentially large number of ratios. It is also difficult to establish defensible cutoffs for whether Ra-226 and Th-230 are in secular equilibrium at a particular site using a ratio approach, as there is no objective basis for concluding, e.g., that φ must be between 0.8 and 1.2 (versus any other range of values for φ) for secular equilibrium to occur.

Due to a large number of reviewer comments concerning secular equilibrium within the RSE reports, Environmental Restoration Group opted to re-evaluate equilibrium at each mine site using a more robust statistical method: simple linear regression. This was done after confirming the methods to analyze Ra-226 (EPA Method 901.1) and Th-230 (alpha spectroscopy following sample digestion with hydrofluoric acid) are both total-activity methods with comparable results (L. Steere, ALS personal email communication, July 25, 2018). Evaluation of secular equilibrium for each mine site proceeded as follows:

1. Construction of a figure that depicts soil concentrations of Th-230 plotted against soil concentrations of Ra-226.

2. Simple linear regression is performed on the dataset; the p-value and the adjusted R^2 are recorded. The resulting linear model and the 95% UCL (upper confidence limit) bands are plotted on the figure generated in step 1.

3. The line y=x is added to the figure generated in step 2 (this line represents a perfect 1:1 ratio between Th-230 to Ra-226, indicative of secular equilibrium).

4. An examination of the model and the figure is made sequentially:

    a. If the p-value for the regression slope is insignificant (i.e., $p > 0.05$) or the adjusted R^2 does not meet the study's data quality objective (Adjusted $R^2 > 0.8$), ERG concludes that there is insufficient evidence to conclude that Ra-226 and Th-230 are in equilibrium (secular or otherwise) therefore, it is listed as inconclusive (no equilibrium). Figure *2* depicts the regression result for an AUM (Mitten) that failed to meet the p-value and adjusted R^2 criteria.

    b. If the p-value for the regression slope is significant (i.e., $p < 0.05$) and the adjusted R^2 meets the DQO (Adjusted $R^2 > 0.8$) there are two possible conditions, which are evaluated via visual examination of the figure generated in step 3.

        i. If the y=x line falls fully within the bounds of the 95% UCL bands on the regression, ERG concludes that there is evidence that Ra-226 and Th-230 are in secular equilibrium at the site. Figure *3* depicts the regression result for an AUM (Harvey Blackwater) where there is evidence that Ra-226 and Th-230 are in secular equilibrium.

        ii. If the y=x line falls partially or completely outside the bounds of the 95% UCL bands on the regression, ERG concludes that there is evidence that Ra-226 and Th-230 are in equilibrium, but not secular equilibrium at the site. Figure *4* depicts the regression result for an AUM (Alongo Mines) where there is evidence that Ra-226 and Th-230 are in equilibrium, but not secular equilibrium.

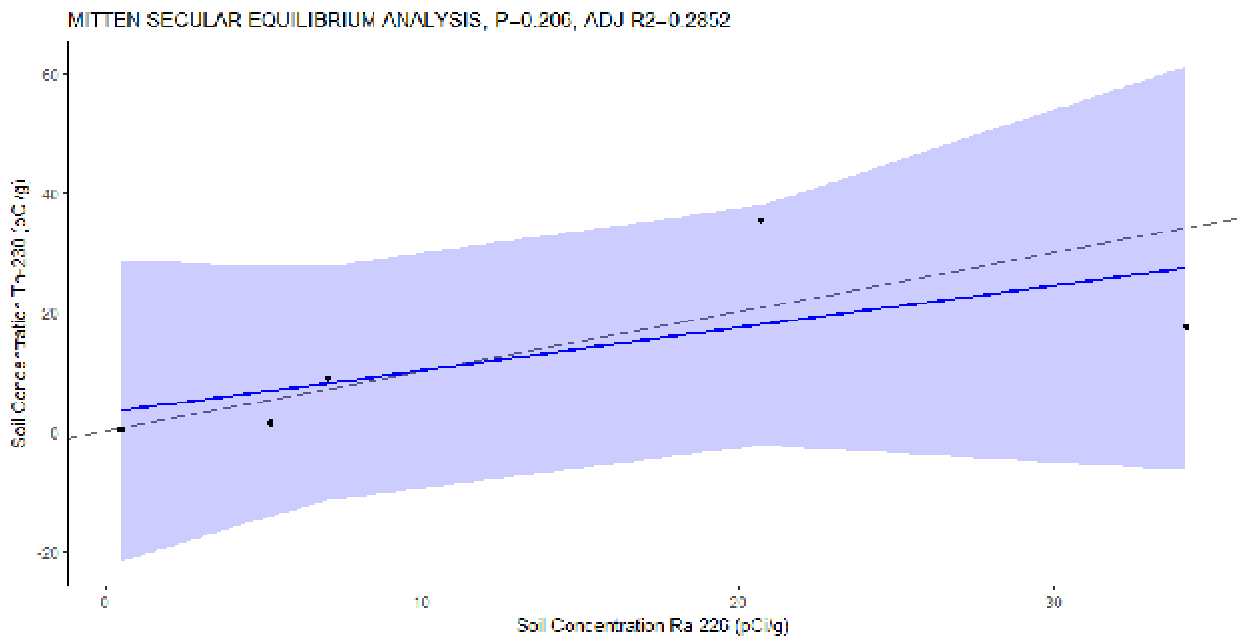


Figure 2. Result for Mitten secular equilibrium analysis, showing failure to meet p-value and adjusted R^2 criteria, i.e., the data are poorly correlated.

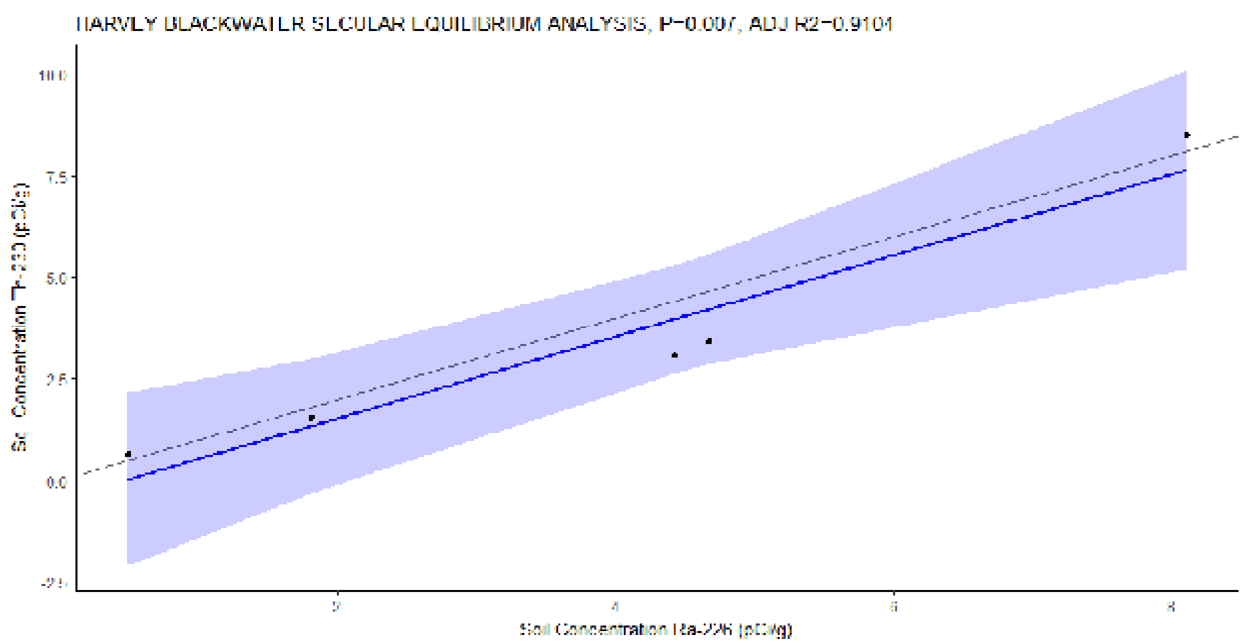


Figure 3. Result for Harvey Blackwater secular equilibrium analysis, showing excellent correlation between the data and the y=x line, i.e., Th-230 and Ra-226 are in secular equilibrium.

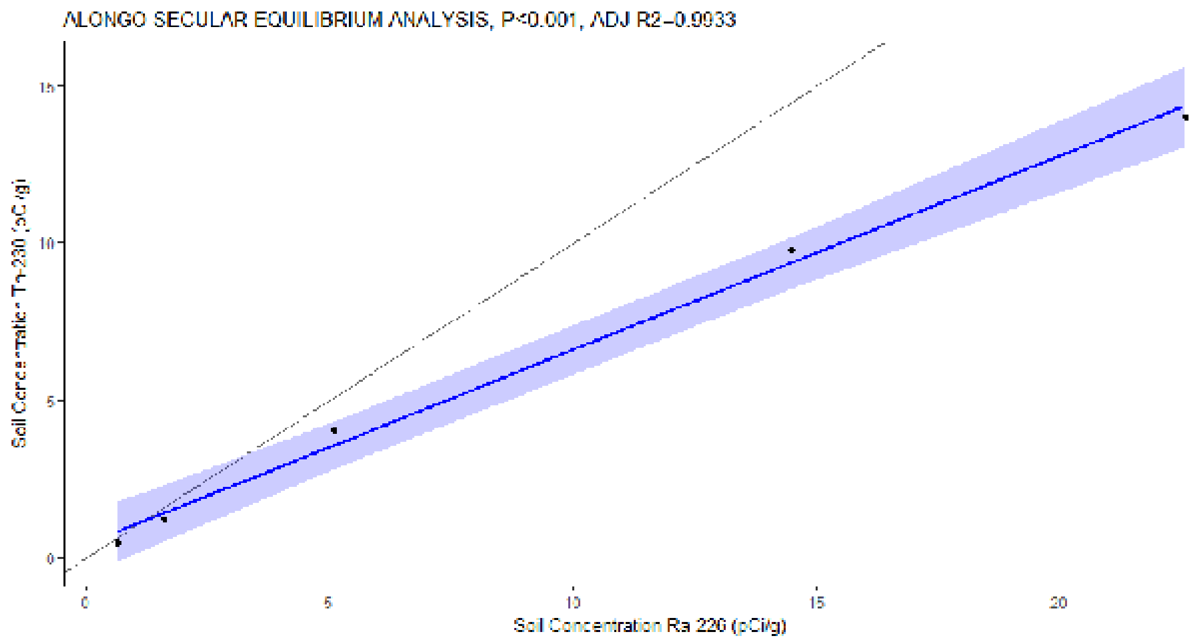


Figure 4. Result for Alongo Mines secular equilibrium analysis, showing excellent correlation between the data, but poor agreement with the y=x line, i.e., Th-230 and Ra-226 are in equilibrium, but not secular equilibrium.

ERG tested for secular equilibrium at each of the 16 Navajo AUMs using the process described above. The results are summarized in Table 1 and in the RSE report for each AUM, respectively. ERG concluded that the data provide evidence that that Ra-226 and Th-230 are in secular equilibrium in soils at two mines (Harvey Blackwater and NA-0928). At one mine (Mitten) there was insufficient evidence to draw any conclusions regarding equilibrium. At the remaining sites, there is evidence that Ra-226 and Th-230 are in equilibrium.

Table 1. Results of secular equilibrium analysis for each of the 16 Navajo Trust AUMs.

Mine	p-value	Adjusted R^2	Conclusion
Alongo Mine	<0.001	0.99	Equilibrium
Barton 3	<0.001	0.98	Equilibrium
Boyd Tisi	<0.001	0.99	Equilibrium
Charles Keith	<0.001	0.99	Equilibrium
Claim 28	<0.001	0.99	Equilibrium
Eunice Becenti	<0.001	0.99	Equilibrium
Harvey Blackwater	0.008	0.91	Secular Equilibrium
Hoskie Tso	<0.001	0.99	Equilibrium
Mitten	0.2	0.29	No Equilibrium
NA-0904	0.001	0.98	Equilibrium
NA-0928	0.002	0.97	Secular Equilibrium
Oak 124-125	<0.001	0.99	Equilibrium
Occurrence B	<0.001	0.98	Equilibrium
Section 26	0.002	0.96	Equilibrium
Standing Rock	0.008	0.91	Equilibrium
Tsosie 1	0.02	0.86	Equilibrium

Appendix D Preliminary Report "Radiological Characterization of the Section 26 (Desidero Group) Abandoned Uranium Mines "

Disclaimer: Data and analytical methods used in this Preliminary Report are superseded by the Final Report.

Radiological Characterization of the Section 26 (Desidero Group) Abandoned Uranium Mines

Preliminary

February 20, 2018

prepared for:

Stantec Consulting Services Inc.

2130 Resort Drive, Suite 350
Steamboat Springs, CO 80487

prepared by:

ERG

Environmental Restoration Group, Inc.

8809 Washington St. NE
Suite 150
Albuquerque, NM 87113

Contents

Tables

Figures

Appendices

Acronyms

ANSI	American National Standards Institute
AUM	abandoned uranium mine
BG1	Background Reference Area 1
BG2	Background Reference Area 2
BG3	Background Reference Area 3
BG4	Background Reference Area 4
BG5	Background Reference Area 5
cpm	counts per minute
DQOs	data quality objectives
ERG	Environmental Restoration Group, Inc.
ft	foot
GPS	global positioning system
m	meter
MDL	method detection limit
µR/h	microRoentgens per hour
pCi/g	picocuries per gram
R^2	Pearson's Correlation Coefficient
RSE	removal site evaluation
σ	standard deviation
Stantec	Stantec Consulting Services Inc.

Executive Summary

This report addresses the radiological characterization of the Section 26 (Desidero Group) abandoned uranium mines (AUMs) located in the Baca/Haystack Chapter of the Navajo Nation north of Milan, New Mexico. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase.

This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of the gamma count rates at these AUMs to exposure rates and concentrations of radium-226 in surface soils, and 3) an assessment of equilibrium in the uranium series. The field activities addressed in this report were conducted on March 25, 26, 28, and 29; June 29, and September 18 and 19, 2017. They included a GPS-based radiological survey of land surfaces over a Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, areas where the survey was extended; and correlation studies.

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in "Section 26 Removal Site Evaluation Report" (Stantec, 2018).

The findings of the RSE pertaining to these activities are:

- The horizontal extent and magnitude of mining-related materials were delineated sufficiently to support additional characterization of the subsurface.

- Elevated count rates were associated with waste rock in each of the mine claims; i.e., in several small areas of the northwestern claim, the north and east edges of the northeastern claim, and the center of the southern claim. Elevated count rates also were observed outside the northeastern and southern claims along the edge of the mesa and continuing onto the valley floor below.

- Five potential Background Reference Areas were established.

- The relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface) is described by a linear regression model:

$$\text{Radium-226 Concentration (picocuries per gram [pCi/g])} = 2\times10^{-4}\,\text{(Gamma Count Rate in counts per minute [cpm])} - 1.6716$$

- The distribution of concentrations of radium-226 in surface soils predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 0.1 to 148, with a central tendency (median) of 3.5 pCi/g.

- The thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226 from gamma count rates.

- The uranium series radionuclides appear not to be in secular equilibrium.

- The relationship between gamma count rates and exposure rates is described by a linear regression model:

  Exposure Rate (microRoentgens per hour [μR/h]) = Gamma Count Rate (cpm) x 2×10^{-4} + 11.736

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 13.5 to 162, with a central tendency (median) of 16.9 μR/h.

1.0 Introduction

This report addresses the radiological characterization of the Section 26 (Desidero Group) abandoned uranium mines (AUMs) located in the Baca/Haystack Chapter of the Navajo Nation north of Milan, New Mexico. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase.

This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of the gamma count rates at these AUMs to exposure rates and concentrations of radium-226 in surface soils, and 3) an assessment of equilibrium in the uranium series. The field activities addressed in this report were conducted on March 25, 26, 28, and 29; June 29, and September 18 and 19, 2017. They included a GPS-based radiological survey of land surfaces over an approximately 28-acre Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, areas where the survey was extended, five potential Background Reference Areas; and correlation studies.

A salient deviation to the RSE Work Plan was the use of 3-inch by 3-inch sodium iodide detectors in lieu of the 2-inch by 2-inch detectors that were specified in the plan. The change was made such that the gamma count rate measurements could be compared to those made previously by others using 3-inch by 3-inch sodium iodide detectors (Ecology and Environment, 2014).

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in “Section 26 Removal Site Evaluation Report” (Stantec, 2018).

Figure 1 shows the location of the AUMs. Background information that is pertinent to the characterization of these AUMs is presented in “Section 26 Removal Site Evaluation Report” (Stantec, 2018).

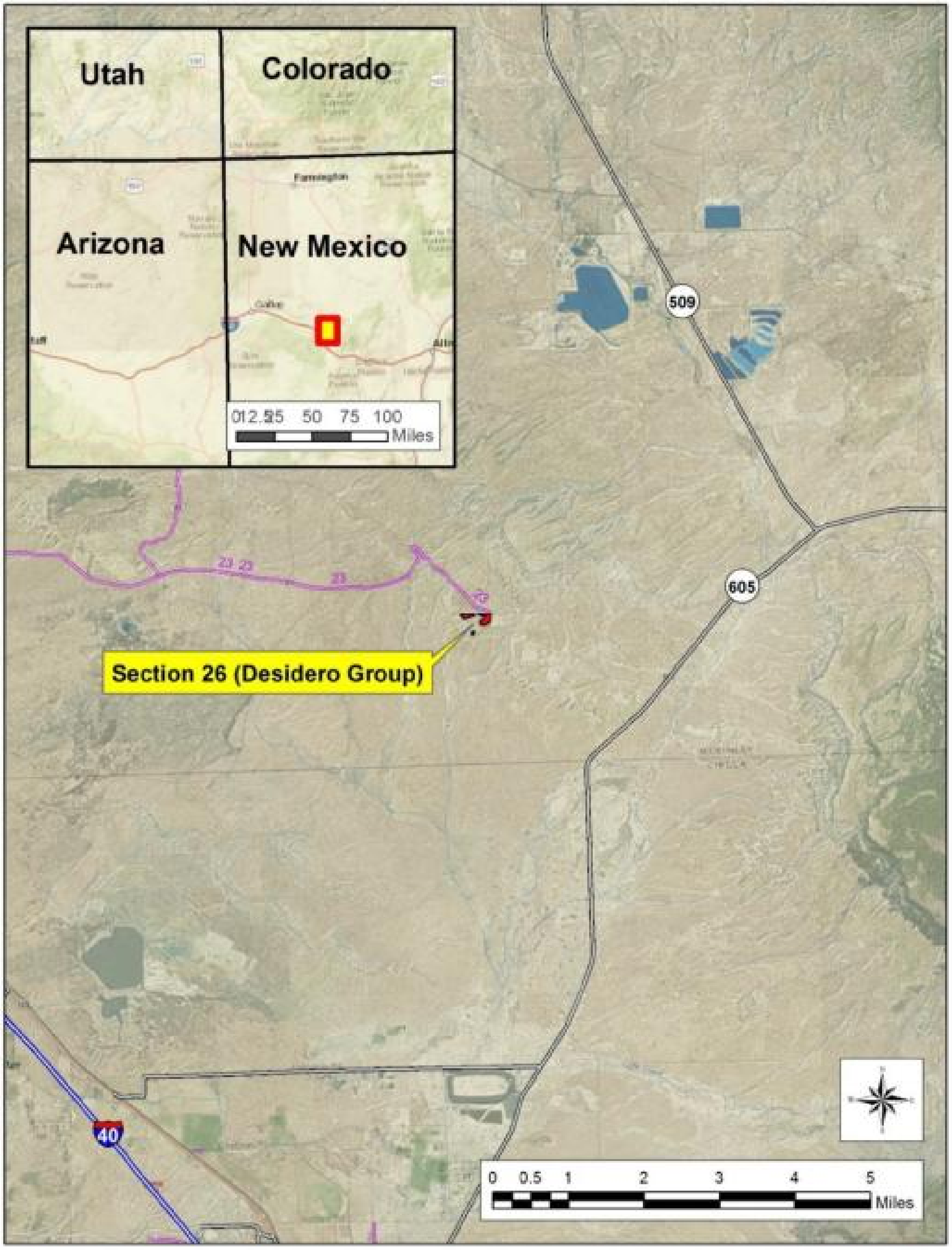


Figure 1. Location of the Section 26 (Desidero Group) Abandoned Uranium Mines

2.0 GPS-Based Gamma Survey

This section addresses the GPS-based surveys conducted in five potential Background Reference Areas and the Survey Area. The survey was extended to bound areas in which elevated count rates were observed. Table 1 lists the detection systems used in the survey, which were function-checked before and after each day of use and within calibration, in accordance with American National Standards Institute (ANSI) Standard N232A (ANSI, 1997). Appendix A presents the completed function check forms and calibration certificates for the instruments.

Table 1. Detection systems used in the GPS-Based gamma surveys.

Survey Area	Ludlum Model 44-20	Ludlum Model 2221 Ratemeter/Scaler
Potential Background Reference Areas	PR202073[a]	190166[a]
	PR213432	271435
	051517S	218564
Survey Area	051517P	262334
	PR202073[a]	190166[a]
	PR213432	271435
	PR269880	254772
	PR269985	254772
	PR262406	196086

Notes:
[a]Detection system used in the correlation studies described in Sections 3.1 and 3.3.

2.1 Potential Background Reference Areas

Five potential Background Reference Areas were surveyed, the locations and results of which are depicted on Figure 2. BG1, BG2, BG3, BG4, and BG5 in the figure are Background Reference Areas 1 through 5, respectively. Table 2 lists a summary of the gamma count rates, which in:

- BG1 ranged from 11,464 to 20,015 counts per minute (cpm), with a mean and median of 14,082 and 14,041 cpm, respectively.
- BG2 ranged from 18,508 to 25,542 cpm, with a mean and median of 21,269 and 21,227 cpm, respectively.
- BG3 ranged from 13,202 to 57,059 cpm, with a mean and median of 29,080 and 26,603 cpm, respectively.
- BG4 ranged from 15,868 to 22,772 cpm, with a mean and median of 18,804 and 18,780 cpm, respectively.

- BG5 ranged from 16,299 to 22,914 cpm, with a mean and median of 19,213 and 19,101 cpm, respectively.

Figure 3 depicts histograms of the gamma count rates in the potential Background Reference Areas. The red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could be expected if the distributions were normal or lognormal.

Table 2. Summary statistics for gamma count rates in the potential Background Reference Areas.

			Gamma Count Rate (cpm)			
Potential Background Reference Area	**n**	**Minimum**	**Maximum**	**Mean**	**Median**	**Standard Deviation**
1	171	11,464	20,015	14,082	14,041	1,483
2	288	18,508	25,542	21,269	21,227	1,139
3	80	13,202	57,059	29,080	26,603	9,927
4	442	15,868	22,772	18,804	18,780	1,035
5	138	16,299	22,914	19,213	19,101	1,412

Notes:
cpm = counts per minute

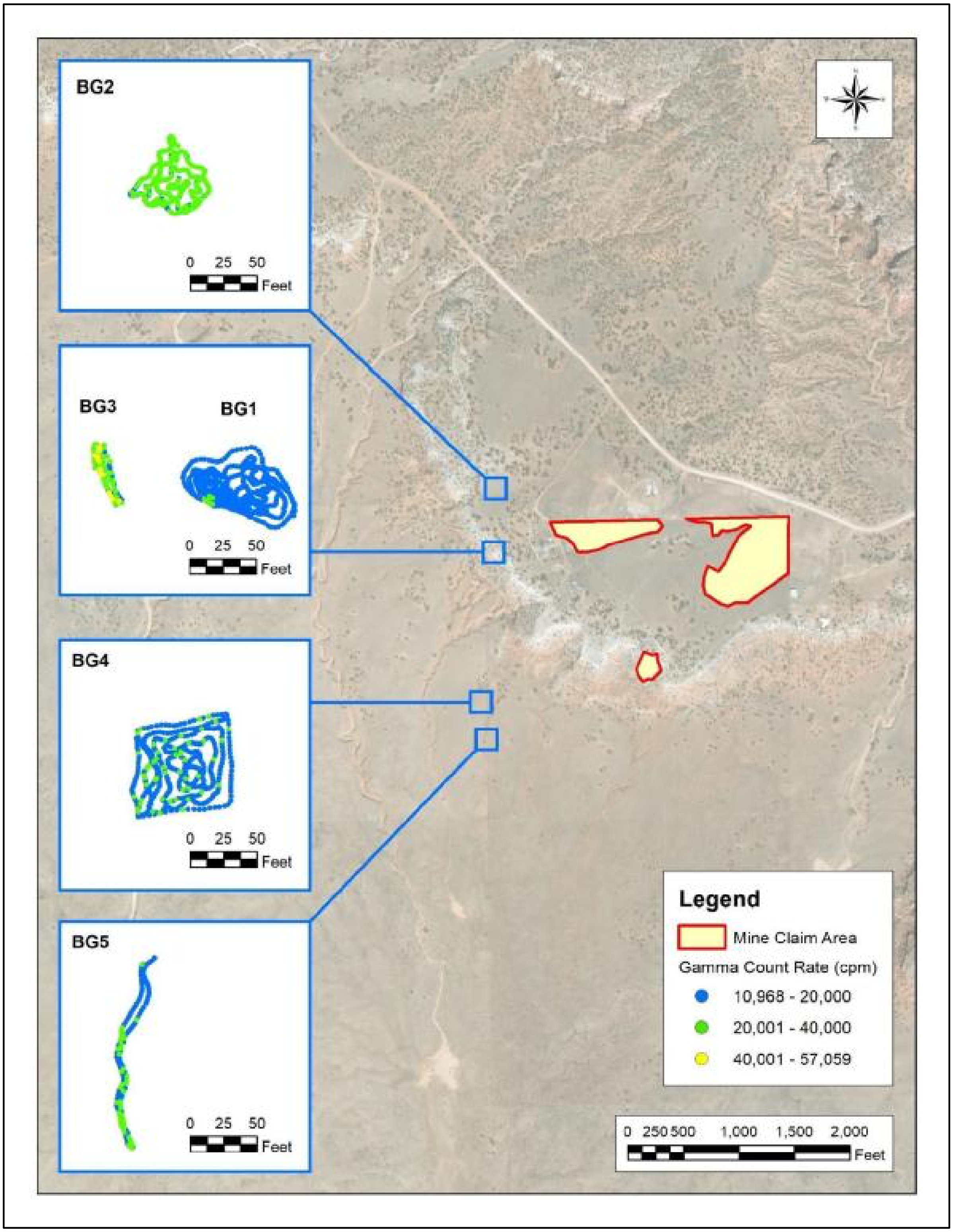
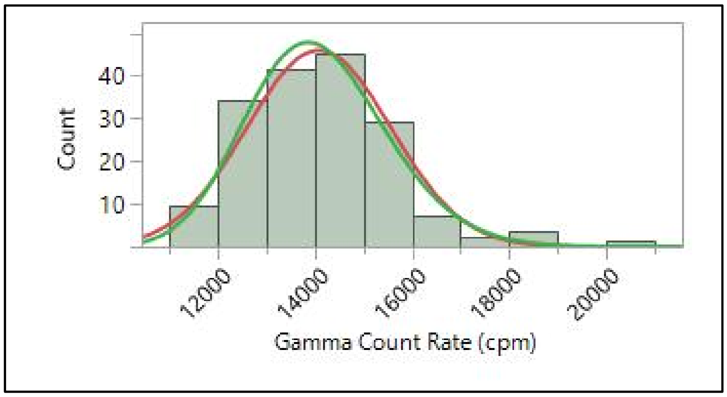
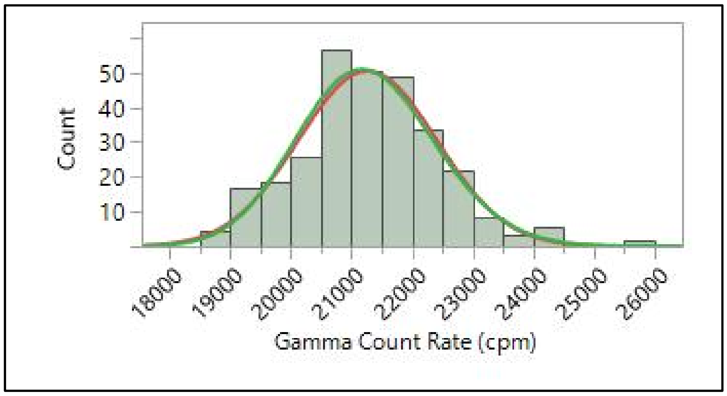


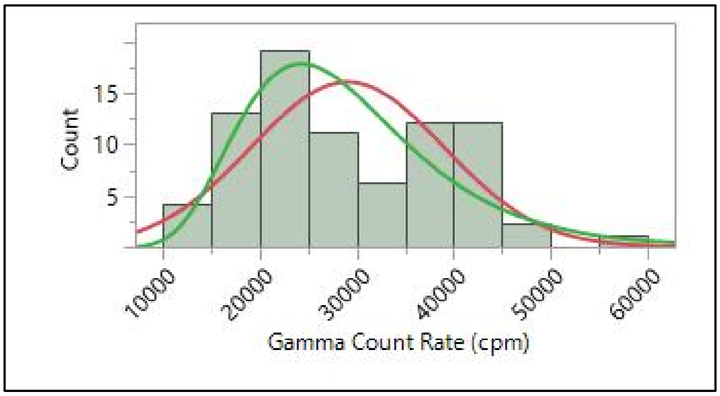
Figure 2. Gamma count rates in the potential Background Reference Areas.



a. Background Reference Area 1

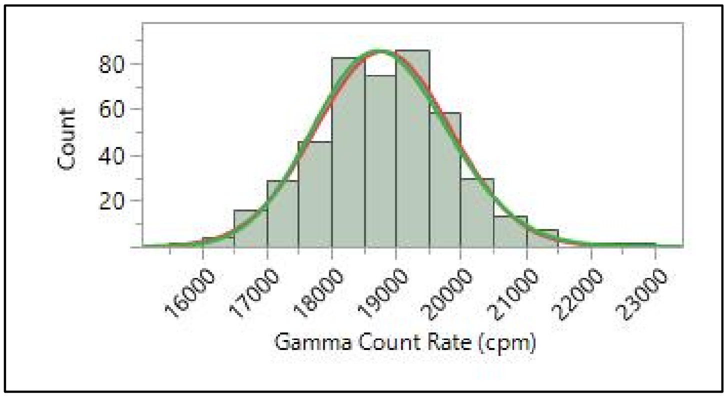


b. Background Reference Area 2

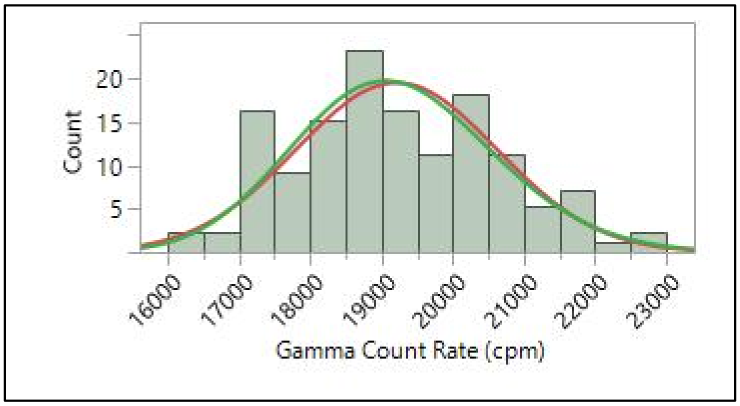


c. Background Reference Area 3

Figure 3 (1 of 2). Histograms of gamma count rates in the potential Background Reference Areas.



a. Background Reference Area 4



b. Background Reference Area 5

Figure 3 (2 of 2). Histograms of gamma count rates in the potential Background Reference Areas.

2.2 Survey Area

The gamma count rates observed in the Survey Area are depicted in Figure 4. Elevated count rates were associated with waste rock in each of the mine claims; i.e., in several small areas of the northwestern claim, the north and east edges of the northeastern claim, and the center of the southern claim. Elevated count rates also were observed outside the northeastern and southern claims along the edge of the mesa and continuing onto the valley floor below.

Figure 5 is a histogram of the gamma count rate measurements made in the Survey Area, including the area surveyed outside the 100-ft buffer. As stated in Section 2.1, the red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could

be expected if the distributions were normal or lognormal. The distribution of the right-tailed set of measurements, evaluated using U.S. Environmental Protection Agency software ProUCL (version 5.1.002), is not defined; i.e., neither normal or logarithmic. The box plot in Figure 6 depicts cutoffs as horizontal bars, from bottom to top, for the following values or percentiles: minimum, 0.5, 2.5, 10, 25, 50, 75, 90, 97.5, 99.5, and maximum. The 25th, 50th, and 75th percentiles (the three horizontal lines of the box inside the box plot) are 21,267, 25,949, and 33,641 cpm, respectively.

Table 3 is a statistical summary of the measurements, which range from 8,652 to 749,127 cpm and have a central tendency (median) of 25,949 cpm.

Table 3. Summary statistics for gamma count rates in the Survey Area.

Parameter	Gamma Count Rate (cpm)
n	71,563
Minimum	8,652
Maximum	749,127
Mean	32,664
Median	25,949
Standard Deviation	28,212

Notes:
cpm = counts per minute

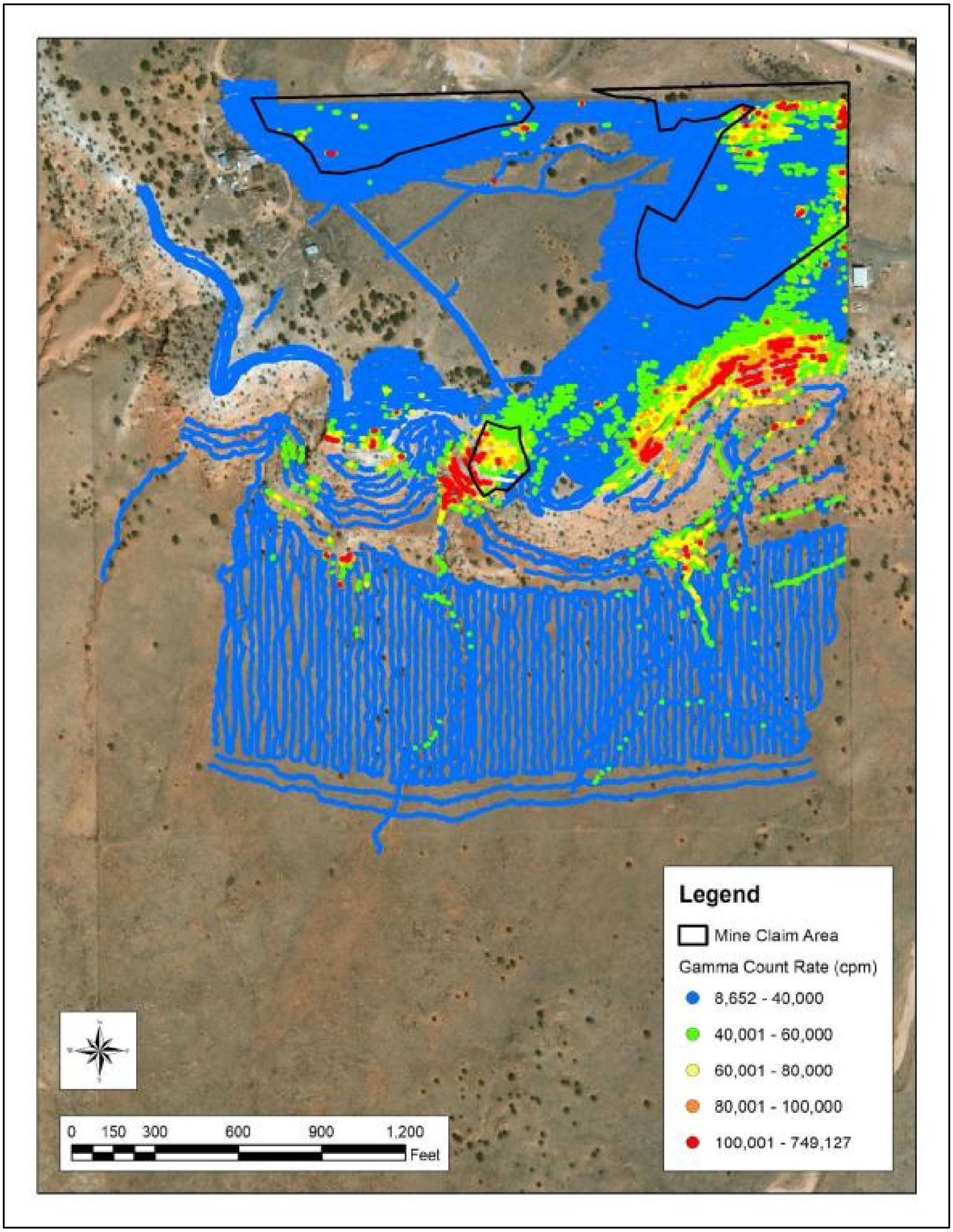


Figure 4. Gamma count rates in the Survey Area.

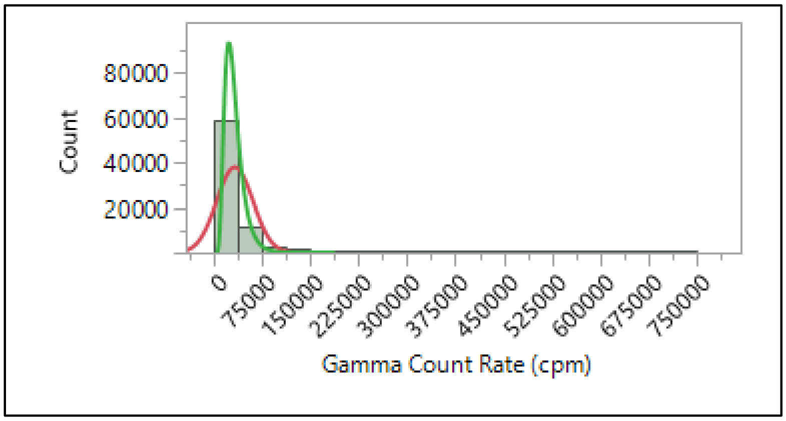


Figure 5. Histogram of gamma count rates in the Survey Area.

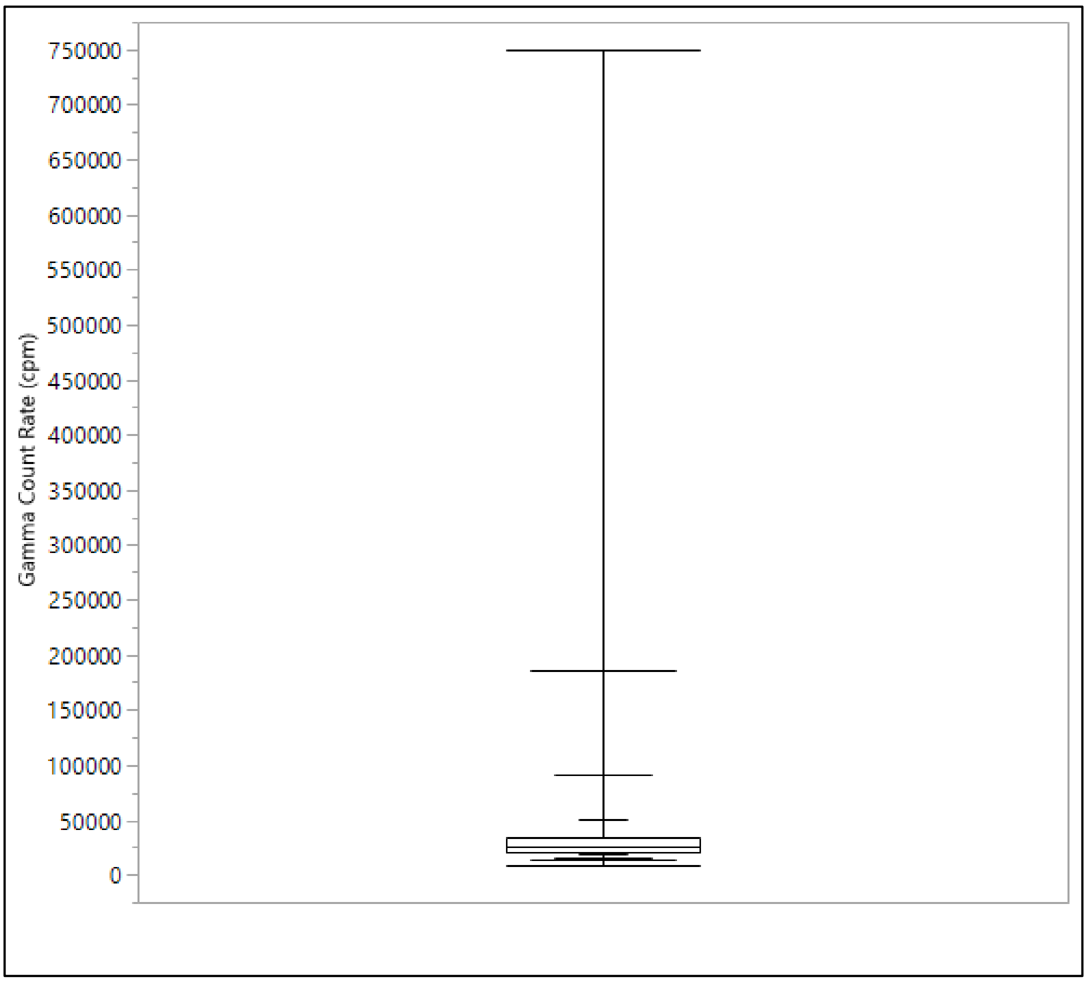


Figure 6. Box plot of gamma count rates in the Survey Area.

3.0 Correlation Studies

The following sections address the activities under two types of correlation studies outlined in the RSE Work Plan: comparisons of 1) radium-226 concentrations in surface soils and gamma count rates and 2) exposure rates and gamma count rates. GPS-based gamma count rate measurements were made over small areas for the former study. The means of the measurements were used in this case. Static gamma count rate measurements, co-located with exposure rate measurements, were used in the latter study.

3.1 Radium-226 concentrations in surface soils and gamma count rates

On March 29, 2017 field personnel made GPS-based gamma count rates measurements and collected five-point composite samples of surface soils in each of five areas at the AUMs. The activities were performed contemporaneously, by area and all 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 locations. Figure 7 shows the GPS-based gamma count rate measurements in the five areas (labeled with location identifiers).

The soil samples were analyzed by ALS Laboratories in Ft Collins, CO for radium-226 and isotopic thorium. The latter analysis was included to assess the potential effects of thorium series isotopes on the correlation and evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. Table 4 lists the results of the gamma count rate measurements and radium-226 concentrations in the soil samples. The means of the gamma count rate measurements range from 28,568 to 165,200 cpm. The concentrations of radium-226 in the soil samples range from 1.26 to 25.2 picocuries per gram (pCi/g).

Table 5 lists the concentrations of isotopes of thorium (thorium-228, -230, and -232) in the same soil samples.

Laboratory analyses are presented in Appendix D, Laboratory Analytical Data and Data Usability Report, in “Section 26 Removal Site Evaluation Report” (Stantec, 2018).

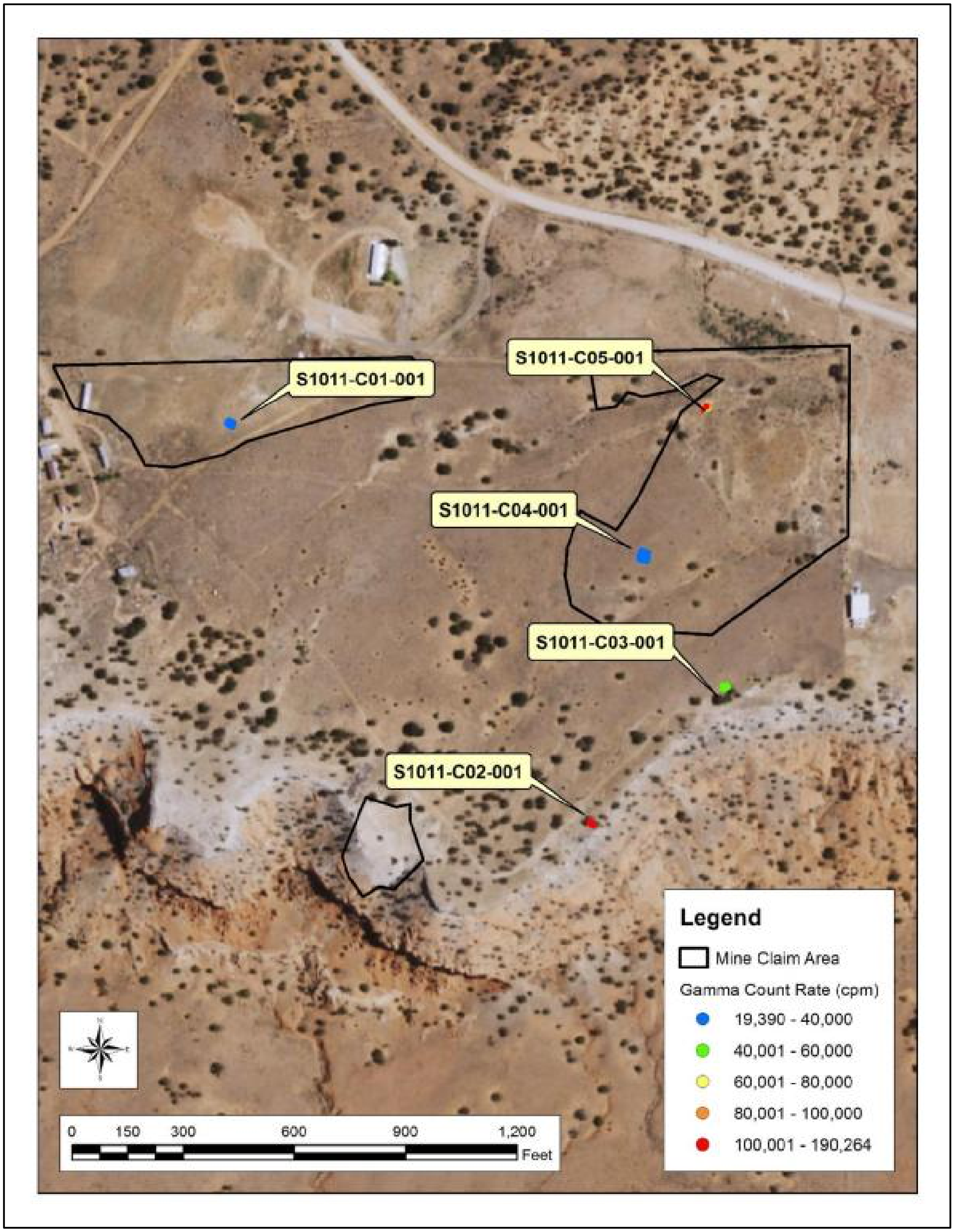


Figure 7. GPS-based gamma count rate measurements made for the correlation study.

Table 4. Gamma count rates and associated concentrations of radium-226 in samples of surface soils obtained in the correlation study.

	Gamma Count Rate (cpm)				Ra-226 (pCi/g)		
Location	Mean	Minimum	Maximum	σ	Result	Error ±1σ	MDL
S1011-C01-001	21,632	19,390	25,165	1,174	1.26	0.3	0.3
S1011-C02-001	165,200	136,070	190,264	14,389	25.2	3.1	3.1
S1011-C03-001	55,042	50,933	59,275	2,143	11	1.4	1.4
S1011-C04-001	28,422	25,883	30,438	975	1.83	0.33	0.33
S1011-C05-001	76,851	46,675	121,502	18,779	9	1.2	1.2

Notes:
cpm = counts per minute
MDL = method detection limit
pCi/g = picocuries per gram
σ = standard deviation

Table 5. Concentrations of isotopes of thorium in samples of surface soils obtained in the correlation study.

	Thorium-228 (pCi/g)			Thorium-230 (pCi/g)			Thorium-232 (pCi/g)		
Sample ID	Result	Error ± 1 σ	MDL	Result	Error ± 1 σ	MDL	Result	Error ± 1 σ	MDL
S1011-C01-001	0.51	0.11	0.05	0.87	0.16	0.07	0.49	0.096	0.011
S1011-C02-001	0.341	0.081	0.053	15.5	2.4	0.1	0.335	0.075	0.02
S1011-C03-001	0.359	0.084	0.056	4.95	0.79	0.08	0.368	0.08	0.025
S1011-C04-001	0.52	0.11	0.05	1.4	0.25	0.08	0.48	0.1	0.02
S1011-C05-001	0.372	0.085	0.05	4.07	0.66	0.08	0.356	0.078	0.019

Notes:
MDL = method detection limit
pCi/g = picocuries per gram
σ = standard deviation

A model was made of the results in Table 4, predicting the concentrations of radium-226 in surface soils from the mean gamma count rate in each area. The best predictive relationship between the measurements, shown in **Figure 8,**, is a strong, linear function with a Pearson's Correlation Coefficient (R^2) of 0.95, as expressed in the equation:

$$\text{Radium-226 concentration (pCi/g)} = 2 \times 10^{-4} \times \text{Gamma Count Rate (cpm)} - 1.6716$$

R^2 is a measure of the dependence between two variables and is expressed as a value between -1 and +1 where +1 is a positive correlation, 0 is no correlation, and -1 is a negative correlation. The root mean square error and p-value for the model are 2.500962 and 0.0048, respectively; these parameters are not data quality objectives (DQOs) and are included only as information.

The concentrations of thorium-232 and thorium-228, isotopes in the thorium series, in the correlation samples are similar and at most 0.52 pCi/g. Given these low concentrations and the high R^2 of the linear function, the thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226, using gamma count rates.

This equation was used to convert the gamma count rate measurements observed in the gamma surveys to predicted concentrations of radium-226. Table 6 presents summary statistics for the predicted concentrations of radium-226 in the Survey Area. The range of the predicted concentrations of radium-226 in the Survey Area is 0.1 to 148 pCi/g, with a mean and median of 4.9 and 3.5 pCi/g, respectively. Note that the radium-226 concentrations predicted from gamma count rate measurements exceeding approximately 165,000 cpm are extrapolated from the regression model and are uncertain.

Figure 9 shows the predicted concentrations of radium-226, the spatial and numerical distribution of which mirror those depicted in Figure 4.

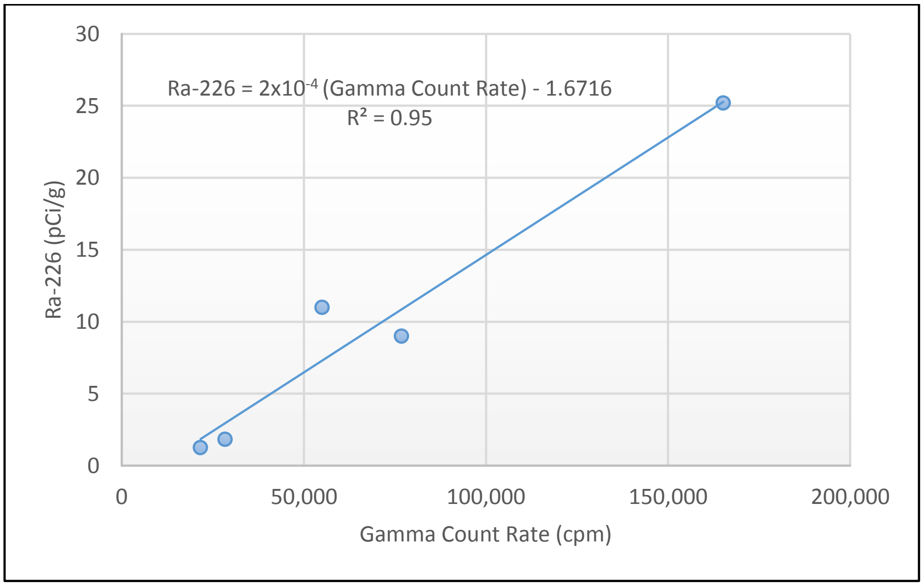


Figure 8. Correlation of gamma count rates and concentrations of radium-226 in surface soils.

Table 6. Predicted concentrations of radium-226 in the Survey Area.

Parameter	Radium-226 (pCi/g)
n	71,563
Minimum	0.1
Maximum	148
Mean	4.9
Median	3.5
Standard Deviation	5.6

Notes:
pCi/g = picocuries per gram

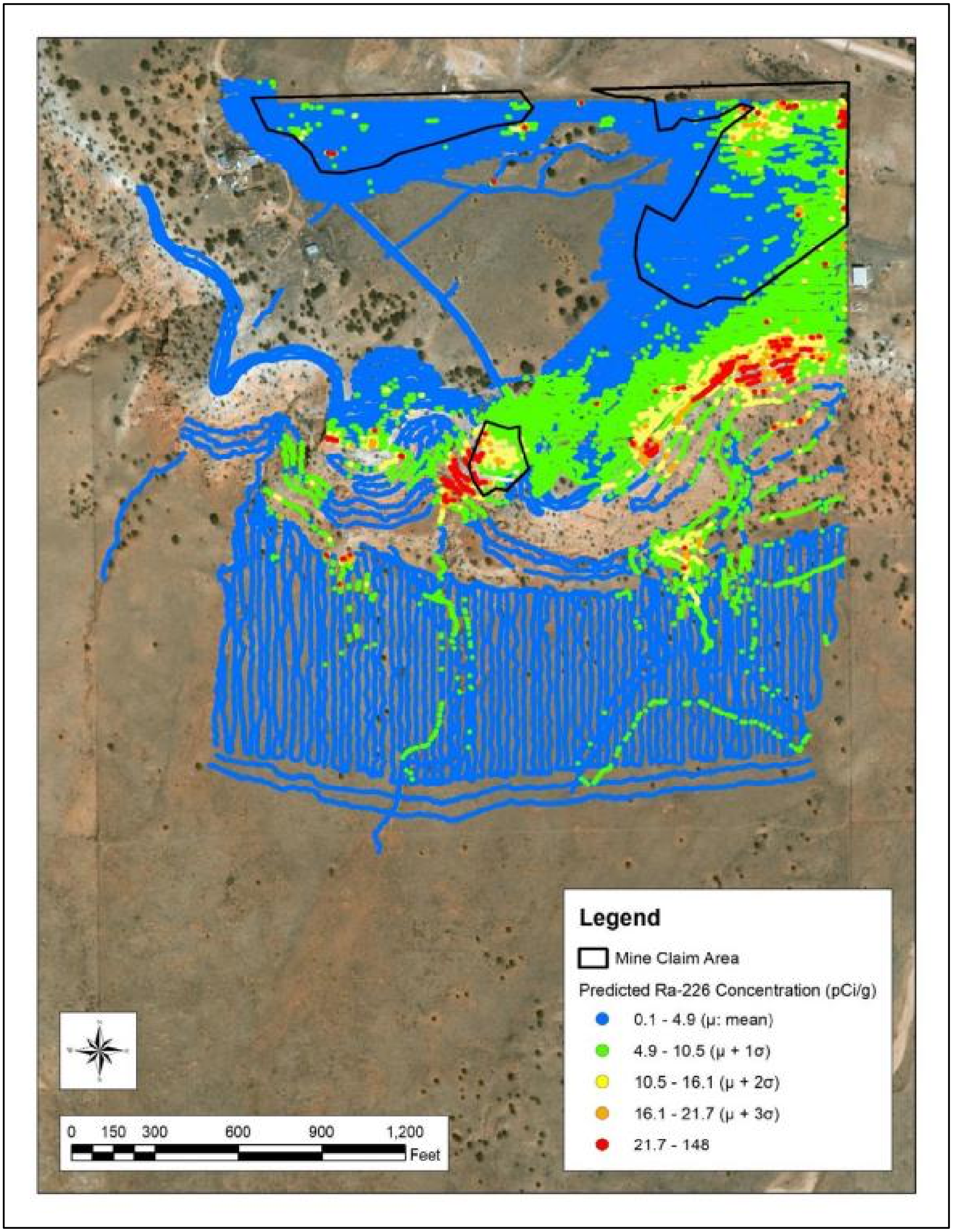

Legend
Mine Claim Area
Predicted Ra-226 Concentration (pCi/g)
0.1 - 4.9 (μ: mean)
4.9 - 10.5 (μ + 1σ)
10.5 - 16.1 (μ + 2σ)
16.1 - 21.7 (μ + 3σ)
21.7 - 148
0 150 300 600 900 1,200
Feet

Figure 9. Predicted concentrations of radium-226 in the Survey Area.

3.2 Equilibrium in the uranium series

Secular equilibrium occurs when the activities of a parent radionuclide and its decay product are equal. This can occur in a closed system, when the half-life of the parent radionuclide is much larger than that of the decay product.

The ratio of the concentrations of radium-226 to thorium-230 can be used as an indicator of the status of equilibrium in the uranium series. The half-lives of thorium-230 and radium-226 are 77,000 and 1,600 years, respectively. The ratios in the five correlation samples are 1.5 (Sample S1011-C01-001), 1.6 (Sample S1011-C02-001), 2.2 (Sample S1011-C03-001), 1.3 (Sample S1011-C04-001), and 2.2 (Sample S1011-C05-001) indicating that thorium-230 is depleted in relation to radium-226 and, by extrapolation, the uranium series itself is not in secular equilibrium.

Note this observation is based on the results of five samples, subject to differing analytical methods. Gamma spectroscopy, the method used to determine the concentration of radium-226, assesses an intact portion of the whole sample as it was collected. The concentration of thorium-230 was determined by alpha spectroscopy of an acid-leached aliquot of the sample.

This evaluation is not related to the correlation of radium-226 concentrations in surface soils and gamma count rates. It may be used for a future risk assessment.

3.3 Exposure rates and gamma count rates

On June 29, 2017 field personnel made co-located 1-minute static count rate and exposure rate measurements at five locations within the Survey Area, representing the range of gamma count rates obtained in the GPS-based gamma survey. Figure 7 shows the locations of the co-located measurements, which were made in the centers of the areas.

The gamma count rate and exposure rate measurements were made at 0.5 meters (m) and 1 m above the ground surface, respectively. The gamma count rate measurements were made using a Ludlum Model 44-20 3-inch by 3-inch sodium iodide detector coupled with a Ludlum Model 2221 ratemeter/scaler (Serial Numbers PR202073/190166). The exposure rate measurements were made using a Reuter Stokes Model RS-S131-200-ER000 (Serial Number 1000992) high pressure ionization chamber (HPIC) at 1-second intervals for about 10 minutes. The HPIC output the 1-second measurements as 1-minute averages. The exposure rate used in the comparison was the mean of these measurements, less those occurring in initial instrument warm-ups. The HPIC was in current calibration and function checked before and after use. Calibration forms for the HPIC are provided in Appendix A. **Table 7** presents the results for the two types of measurements made at each of the five locations. Appendix B presents the 1-minute average exposure rate measurements.

The best predictive relationship between the measurements is linear with a R^2 of 0.7983, indicating a positive correlation. The root mean square error and p-value for the model are 7.065987 and 0.0410, respectively; these parameters are not DQOs and are included only as information.

The correlation is weaker than those observed at the other AUMs addressed in the RSE Work Plan, given that the sources of elevated gamma count rates at Locations S1011-C01-001, S1011-C02-001, S1011-C04-001, and S1011-C05-001 were heterogenous and caused by waste rock scattered on the ground surface.

The following equation is the linear regression (shown in **Figure 10**) between the mean exposure rate and gamma count rate results in Table 7 that was generated using MS Excel:

Exposure Rate (microRoentgens per hour [µR/h]) = 2×10^{-4} x Gamma Count Rate (cpm) + 11.736

Figure 11 presents the exposure rates predicted from the gamma count rate measurements, the spatial and numerical distribution of which mirror those depicted in Figure 4.

Tables 8 and 9 present summary statistics for the predicted exposure rates in the five Background Reference Areas and AUMs, respectively.

The range of predicted exposure rates at:

- BG1 is 14.0 to 15.7 µR/h, with a mean and median of 14.6 and 14.5 µR/h, respectively
- BG2 is 15.4 to 16.8 µR/h, with a mean and median of 16.0 µR/h
- BG3 is 14.4 to 23.1 µR/h, with a mean and median of 17.5 and 17.1 µR/h, respectively
- BG4 is 14.9 to 16.3 µR/h, with a mean and median of 15.5
- BG5 is 15.0 to 16.3 µR/h, with a mean and median of 15.6

The range of predicted exposure rates in the Survey Area is 13.5 to 162 µR/h, with a mean and median of 18.3 and 16.9 µR/h, respectively.

Table 7. Co-located gamma count rate and exposure rate measurements.

Location	Gamma Count Rate (cpm)	Exposure Rate (µR/h)
S1011-C01-001	19,139	11.9
S1011-C02-001	30,713	27.4
S1011-C03-001	9,893	13.8
S1011-C04-001	71,276	20.2
S1011-C05-001	147,023	45.6

Notes:
cpm = counts per minute
µR/h = microRoentgens per hour

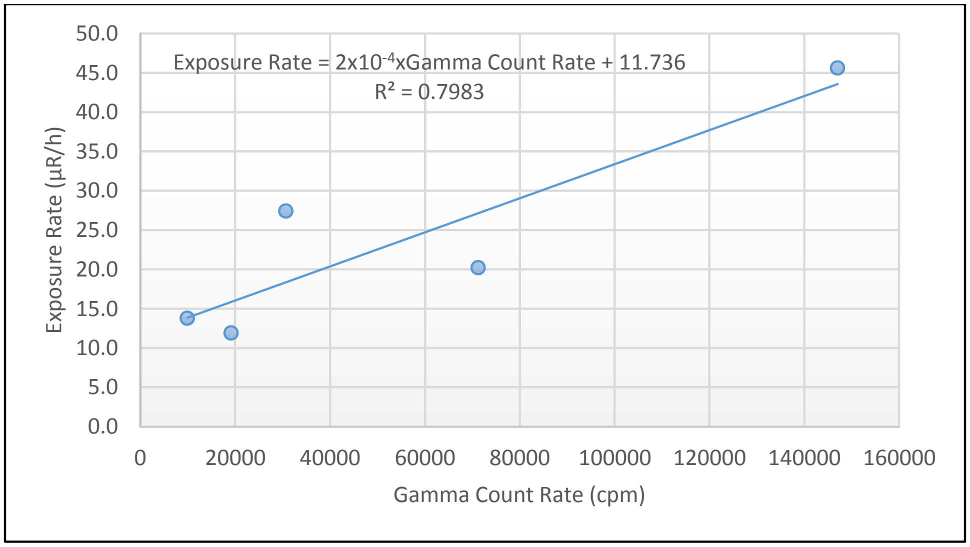


Figure 10. Correlation of gamma count rates and exposure rates.

Table 8. Predicted exposure rates in the potential Background Reference Areas.

Potential Background Reference Area	BG1	BG2	BG3	BG4	BG5
Parameter	Exposure Rate (µR/h)				
N	171	288	80	442	138
Minimum	14.0	15.4	14.4	14.9	15.0
Maximum	15.7	16.8	23.1	16.3	16.3
Mean	14.6	16.0	17.5	15.5	15.6
Median	14.5	16.0	17.1	15.5	15.6
Standard Deviation	0.3	0.2	2.0	0.2	0.3

Notes:
BG1 = Background Reference Area 1
BG2 = Background Reference Area 2
BG3 = Background Reference Area 3
BG4 = Background Reference Area 4
BG5 = Background Reference Area 5
µR/h = microRoentgens per hour

Table 9. Predicted exposure rates in the Survey Area.

Parameter	Exposure Rate (µR/h)
n	71,563
Minimum	13.5
Maximum	162
Mean	18.3
Median	16.9
Standard Deviation	5.6

Notes:
µR/h = microRoentgens per hour

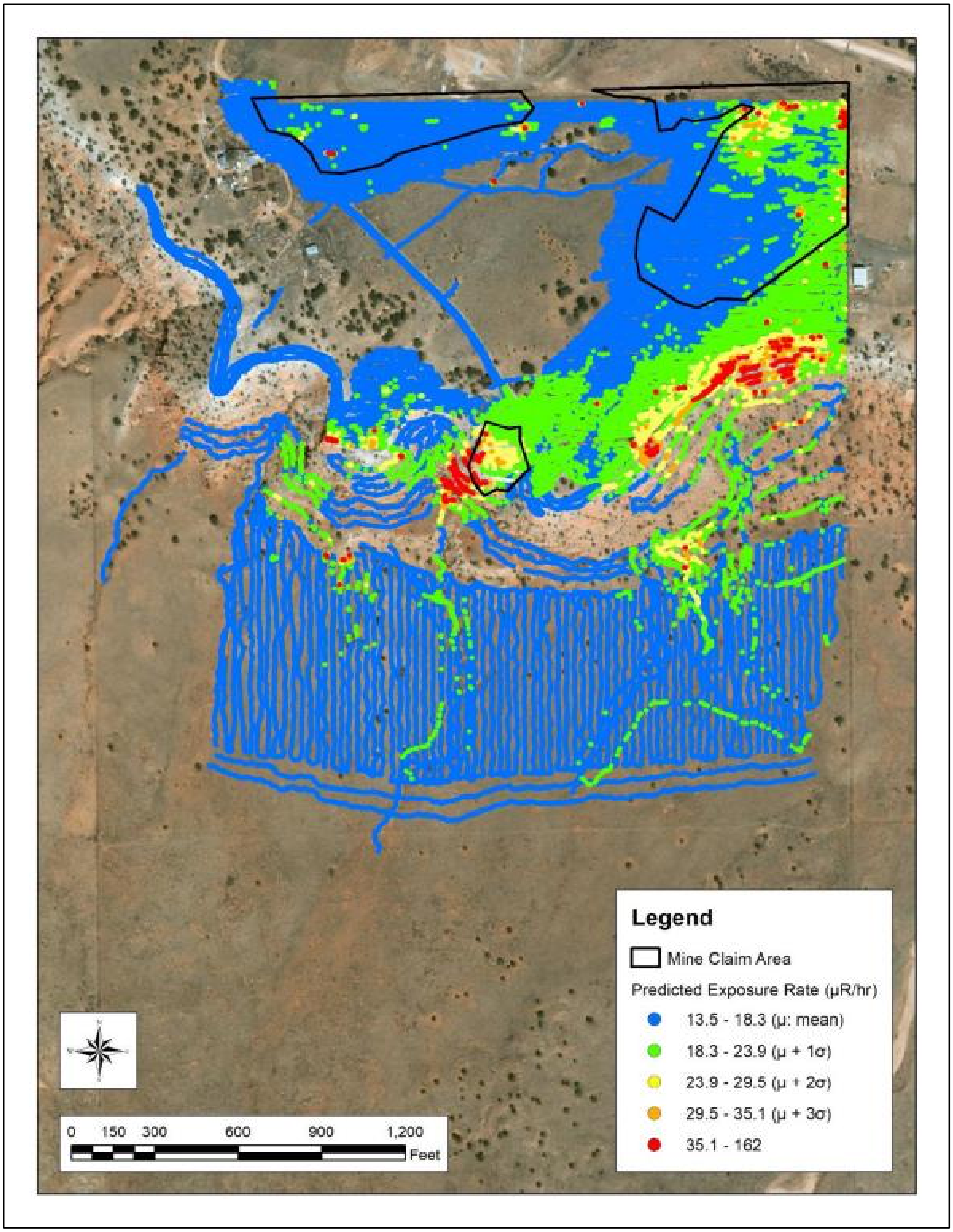


Figure 11. Predicted exposure rates in the Survey Area.

4.0 Deviations to RSE Work Plan

The RSE Work Plan specifies that the comparison of gamma count rates and radium concentrations in surface soils was to occur in 900 square foot areas. Field personnel adjusted the areas as necessary, to minimize the variability of gamma count rates observed, particularly where the spatial distribution of waste rock was heterogeneous.

A second deviation to the RSE Work Plan was the use of 3-inch by 3-inch sodium iodide detectors in lieu of the 2-inch by 2-inch detectors that were specified in the plan. The change was made such that the gamma count rate measurements could be compared to those made previously by others using 3-inch by 3-inch sodium iodide detectors (Ecology and Environment, 2014).

5.0 Conclusions

The findings of the RSE pertaining to these activities are:

- The horizontal extent and magnitude of mining-related materials were delineated sufficiently to support additional characterization of the subsurface.
- Elevated count rates were associated with waste rock in each of the mine claims; i.e., in several small areas of the northwestern claim, the north and east edges of the northeastern claim, and the center of the southern claim. Elevated count rates also were observed outside the northeastern and southern claims along the edge of the mesa and continuing onto the valley floor below.
- Five potential Background Reference Areas were established.
- The relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface) is described by a linear regression model:

  Radium-226 Concentration (pCi/g) = 2×10^{-4} (Gamma Count Rate in cpm) – 1.6716

- The distribution of concentrations of radium-226 in surface soils predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 0.1 to 148, with a central tendency (median) of 3.5 pCi/g.
- The thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226 from gamma count rates.
- The uranium series radionuclides appear not to be in secular equilibrium.
- The relationship between gamma count rates and exposure rates is described by a linear regression model:

$$\text{Exposure Rate } (\mu R/h) = \text{Gamma Count Rate (cpm)} \times 2 \times 10^{-4} + 11.736$$

The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 13.5 to 162, with a central tendency (median) of 16.9 μR/h.

6.0 References

ANSI, 1997. Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments, American National Standards Institute (ANSI) Standard N232A. June 20, 2014.

Ecology and Environment, 2014. Removal Assessment Report, Tronox AUM Section 26, Baca/Haystack Chapter, Eastern Agency, Navajo Nation. February.

MWH, 2016. Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan, October 24, 2016.

Stantec, 2018. Section 26 Removal Site Evaluation Report, January 2018.

Appendix A Instrument calibration and completed function check forms

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	196086
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR262406

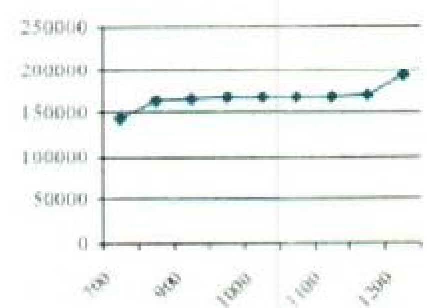
☐ Mechanical Check ☐ THR/WIN Operation HV Check (+/- 2.5%): ☐ 500 V ☐ 1000 V ☐ 1500 V
☐ F/S Response Check ☐ Reset Check Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:
☐ Geotropism ☐ Audio Check
☐ Meter Zeroed ☐ Battery Check (Min 4.4 VDC) Barometric Pressure: inches Hg
Source Distance: ☐ Contact ✔ 6 inches ☐ Other: Threshold: Temperature: °F
Source Geometry: ✔ Side ☐ Below ☐ Other: Window: Relative Humidity: %

Instrument found within tolerance: ✔ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

High Voltage	Source Counts	Background
700	144169	
800	162193	
900	166057	
950	167388	
1000	167489	21583
1050	167574	
1100	168254	
1150	170145	
1200	192327	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1000

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By: Calibration Date: 7 March 17 Calibration Due: 7 March 18

Reviewed By: Date: 3-7-17

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	254772
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR269980

☐ Mechanical Check ☐ THR/WIN Operation HV Check (+/- 2.5%): ☐ 500 V ☐ 1000 V ☐ 1500 V

☐ F/S Response Check ☐ Reset Check Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:

☐ Geotropism ☐ Audio Check

☐ Meter Zeroed ☐ Battery Check (Min 4.4 VDC) Barometric Pressure: inches Hg

Source Distance: ☐ Contact ✔ 6 inches ☐ Other: Threshold: Temperature: °F

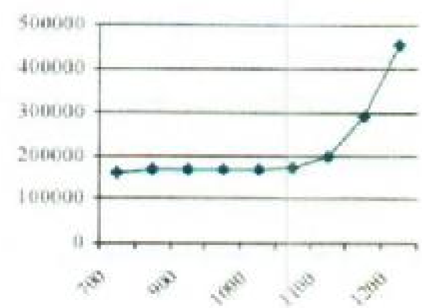
Source Geometry: ✔ Side ☐ Below ☐ Other: Window: Relative Humidity: %

Instrument found within tolerance: ✔ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

High Voltage	Source Counts	Background
700	162620	
800	168495	
900	170240	
950	170850	22731
1000	171277	
1050	172525	
1100	197371	
1150	291452	
1200	453265	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV =950

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932

Fluke multimeter serial number: ☐ 87490128

☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03

✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

☐ Other Source:

Calibrated By: [signature] Calibration Date: 7 March 17 Calibration Due: 7 March 18

Reviewed By: [signature] Date: 3-7-17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	271435
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR213432

✔ Mechanical Check ✔ THR/WIN Operation
✔ F/S Response Check ✔ Reset Check
✔ Geotropism ✔ Audio Check
✔ Meter Zeroed ✔ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:

Source Distance: ☐ Contact ✔ 6 inches ☐ Other:
Source Geometry: ✔ Side ☐ Below ☐ Other:

Threshold: 10 mV
Window:

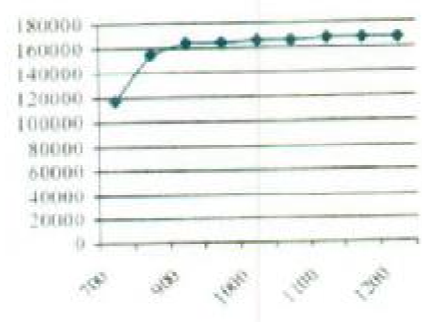
Barometric Pressure: 24.72 inches Hg
Temperature: 68 °F
Relative Humidity: 20 %

Instrument found within tolerance: ✔ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399058	400
x 1000	100	100	100		100
x 100	400	400	400	39908	400
x 100	100	100	100		100
x 10	400	400	400	3989	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	117585	
800	155051	
900	164169	
950	165480	
1000	166858	
1050	166722	
1100	168083	20644
1150	167659	
1200	168487	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1100

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
✔ Gamma Source: Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By:
Reviewed By:

Calibration Date: 7 March 17 Calibration Due: 7 March 18

Date: 3-7-17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	190166
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR269985

☑ Mechanical Check ☑ THR/WIN Operation
☑ F/S Response Check ☑ Reset Check
☑ Geotropism ☑ Audio Check
☑ Meter Zeroed ☑ Battery Check (Min 4.4 VDC)
Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Source Geometry: ☑ Side ☐ Below ☐ Other:

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch ☐ Other:

Threshold: 10 mV
Window:

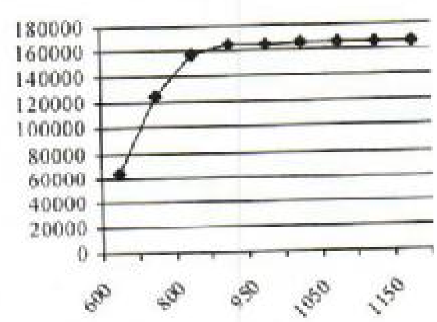
Barometric Pressure: 24.66 inches Hg
Temperature: 75 °F
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Coun
x 1000	400	400	400	399389	400
x 1000	100	100	100		100
x 100	400	400	400	39940	400
x 100	100	100	100		100
x 10	400	400	400	3999	400
x 10	100	100	100		100
x 1	400	400	400	400	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
600	64081	
700	125567	
800	157563	
900	165079	
950	164853	
1000	165840	21364
1050	166555	
1100	166593	
1150	166782	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1000

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
Fluke multimeter serial number: ☐ 87490128
☐ Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12)
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12)
☐ Other Source:

Calibrated By:
Calibration Date: 5-12-17
Calibration Due: 5-12-18

Reviewed By:
Date: 5/12/17

ERG Form ITC. 101.A

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	190166
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR202073

Mechanical Check — THR/WIN Operation — HV Check (+/- 2.5%): 500 V 1000 V 1500 V

F/S Response Check — Reset Check — Cable Length: 39-inch ✔ 72-inch Other:

Geotropism — Audio Check

Meter Zeroed — Battery Check (Min 4.4 VDC) — Barometric Pressure: inches Hg

Source Distance: Contact 6 inches Other: — Threshold: — Temperature: °F

Source Geometry: Side Below Other: — Window: — Relative Humidity: %

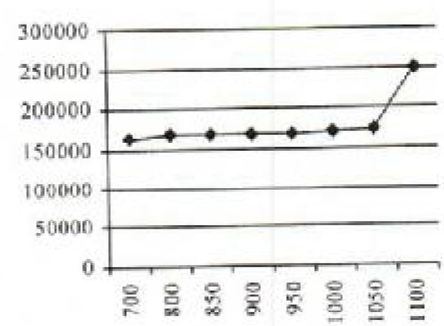
Instrument found within tolerance: ✔ Yes No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

See other (+) Sheet

High Voltage	Source Counts	Background
700	164061	
800	168372	
850	169017	
900	170276	24149
950	170410	
1000	170754	
1050	175368	
1100	250364	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 900

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 201932 — Fluke multimeter serial number: 87490128

Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12) — ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12) — Other Source:

Calibrated By: [signature] — Calibration Date: 6-14-17 — Calibration Due: 6-14-18

Reviewed By: [signature] — Date: 6-14-17

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	218564
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	051517S

Mechanical Check — THR/WIN Operation — HV Check (+/- 2.5%): 500 V 1000 V 1500 V

F/S Response Check — Reset Check — Cable Length: 39-inch ✔ 72-inch Other:

Geotropism — Audio Check

Meter Zeroed — Battery Check (Min 4.4 VDC) — Barometric Pressure: inches Hg

Source Distance: Contact ✔ 6 inches Other: — Threshold: 10 mV — Temperature: °F

Source Geometry: ✔ Side Below Other: — Window: — Relative Humidity: %

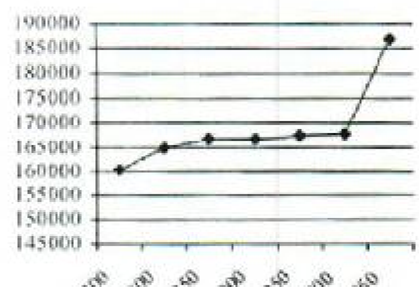
Instrument found within tolerance: ✔ Yes No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

See Ludlum Cal Sheet

High Voltage	Source Counts	Background
700	160304	
800	164819	
850	166661	
900	166927	23453
950	167592	
1000	167697	
1050	186865	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 900

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 ✔ 201932 — Fluke multimeter serial number: 87490128

Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12) — ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12) — Other Source:

Calibrated By: [signature] — Calibration Date: 9-7-17 — Calibration Due: 9-7-18

Reviewed By: T. [signature] — Date: 09/08/17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

of
Scientific and Industrial
Instruments

www.ludlums.com

CERTIFICATE OF CALIBRATION

501 Oak Street
325-235-5494
Sweetwater, TX 79556, U.S.A.

ACCREDITED
CERT # 4084.01

ORDER NO. 20315056/451872

Customer ERG

Mfg. Ludlum Measurements, Inc. Model 2221 Serial No. 218564

Mfg. Model Serial No.

Cal. Date 14-Jul-17 Cal Due Date 14-Jul-18 Cal. Interval 1 Year Meterface 202-159

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 47 % Alt 709.0 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ ~~Requiring Repair~~ ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☑ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck.
☑ Calibrated in accordance with LMI SOP 14.8 ☐ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set 1000 V Input Sens. 100 mV Det. Oper. ______ V at ______ mV Threshold Dial Ratio 100 = 10 mV

☐ HV Readout (2 points) Ref./Inst. 500 / 499 V Ref./Inst. 2000 / 2000 V

COMMENTS:

Calibrated with 39" cable
Firmware: 261027

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 1000	400 Kcpm	N/A	400
X 1000	100 Kcpm		100
X 100	40 Kcpm		400
X 100	10 Kcpm		100
X 10	4 Kcpm		400
X 10	1 Kcpm		100
X 1	400 cpm		400
X 1	100 cpm		100

ALL Range(s) Calibrated Electronically

*Uncertainty within ± 10% C.F. within ± 20%

Digital Readout REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
400 Kcpm	N/A	40155 (6)
40 Kcpm		4010
4 Kcpm		401
400 cpm		40
40 cpm		4

Log Scale REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
500 Kcpm	N/A	500 Kcpm
50 Kcpm		50
5 Kcpm		5
500 cpm		500 cpm
50 cpm		50

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. ISO/IE 17025:2005(E) State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521 ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☐ Y982 ☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☐ 2168CP

☐ Alpha S/N ☐ Beta S/N ☐ Other
☑ m 500 S/N 201934 ☐ Oscilloscope S/N ☑ Multimeter S/N 92780460

Calibrator Josie Ruiz Josie Ruiz Title Technician Date 14 July 17

QC'd By Title Service Dept QC Date 14 Jul 17

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	254772
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR269985

Mechanical Check — THR/WIN Operation — HV Check (+/- 2.5%): 500 V 1000 V 1500 V

F/S Response Check — Reset Check — Cable Length: 39-inch ✔ 72-inch Other:

Geotropism — Audio Check

Meter Zeroed — Battery Check (Min 4.4 VDC) — Barometric Pressure: inches Hg

Source Distance: Contact ✔ 6 inches Other: — Threshold: — Temperature: °F

Source Geometry: ✔ Side Below Other: — Window: — Relative Humidity: %

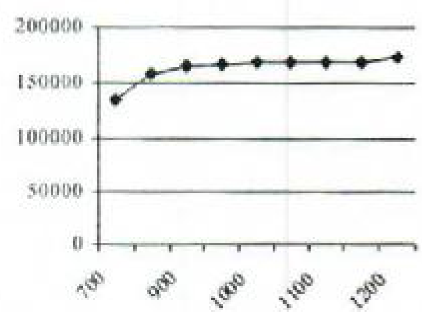
Instrument found within tolerance: Yes ✔ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

See Ludlum Cal Sheet

High Voltage	Source Counts	Background
700	133844	
800	158402	
900	164459	
950	166477	
1000	167466	
1050	167781	27111
1100	168169	
1150	168450	
1200	172562	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1050

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 201932 — Fluke multimeter serial number: 87490128

Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12) — ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12) — Other Source:

Calibrated By: [signature] — Calibration Date: 9-7-17 — Calibration Due: 9-7-18

Reviewed By: T. [signature] — Date: 09/08/17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

of Scientific and Industrial Instruments

www.ludlums.com

CERTIFICATE OF CALIBRATION

501 Oak Street
325-235-5494
Sweetwater, TX 79556, U.S.A.

ACCREDITED
CERT # 4084.01

ORDER NO. 20316590/452897

Customer ERG

Mfg. Ludlum Measurements, Inc. Model 2221 Serial No. 254772

Mfg. ______ Model ______ Serial No. ______

Cal. Date 11-Aug-17 Cal Due Date 11-Aug-18 Cal. Interval 1 Year Meterface 202-159

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 47 % Alt 698.0 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☑ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck.
☑ Calibrated in accordance with LMI SOP 14.8 ☐ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set 500 V Input Sens. ~~100~~ 10 JR mV Det. Oper. ______ V at ______ mV Threshold Dial Ratio 100 = 10 mV

☐ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 1500 / 1501 V

COMMENTS:

Firmware: 261027
Calibrated with Window in "OUT" position.
Calibrated with 39" cable.

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 1000	400 Kcpm	N/A	400
X 1000	100 Kcpm		100
X 100	40 Kcpm		400
X 100	10 Kcpm		100
X 10	4 Kcpm		400
X 10	1 Kcpm		100
X 1	400 cpm		400
X 1	100 cpm		100

ALL Range(s) Calibrated Electronically

*Uncertainty within ± 10% C.F. within ± 20%

Digital Readout

REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
400 Kcpm	N/A	40156 (0)
40 Kcpm		4011
4 Kcpm		401
400 cpm		40
40 cpm		4

Log Scale

REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
500 Kcpm	N/A	500 Kcpm
50 Kcpm		50
5 Kcpm		5
500 cpm		500 cpm
50 cpm		50

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 ISO/IEC 17025:2005(E) State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521 Neutron Am-241 Be ☐ T-304 Ra-226 ☐ Y982
☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☐ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082

☐ Alpha S/N ______ ☐ Beta S/N ______ ☐ Other ______
☑ m 500 S/N 201934 ☐ Oscilloscope S/N ______ ☑ Multimeter S/N 92780460

Calibrator Josie Ruiz Josie Ruiz Title Technician Date 11 Aug 17

QC'd By [signature] Title ______ Date 11 Aug 17

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed: ______

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	262334
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	051517P

✔ Mechanical Check ✔ THR/WIN Operation
✔ F/S Response Check ✔ Reset Check
✔ Geotropism ✔ Audio Check
✔ Meter Zeroed ✔ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
Cable Length: 39-inch ✔ 72-inch Other:

Source Distance: Contact ✔ 6 inches Other:
Source Geometry: ✔ Side Below Other:

Threshold: 10 mV
Window:

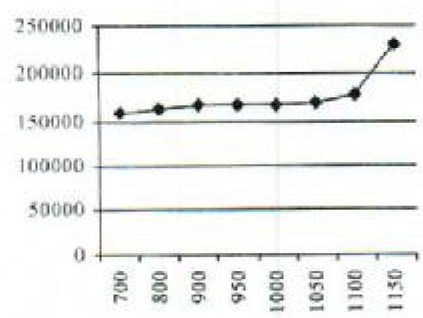
Barometric Pressure: 24.69 inches Hg
Temperature: 75 °F
Relative Humidity: 20 %

Instrument found within tolerance: ✔ Yes No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	398990	400
x 1000	100	100	100		100
x 100	400	400	400	39893	400
x 100	100	100	100		100
x 10	400	400	400	3986	400
x 10	100	100	100		100
x 1	400	400	400	398	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	159361	
800	163970	
900	166805	
950	167531	26434
1000	168157	
1050	169245	
1100	177000	
1150	229347	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 950

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 ✔ 201932
Fluke multimeter serial number: 87490128

Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12)
✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
Beta Source: ✔ Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12)
Other Source:

Calibrated By: [signature]
Calibration Date: 9-7-17
Calibration Due: 9-7-18

Reviewed By: T. [signature]
Date: 09/08/17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

Reuter-Stokes

Calibration Certificate

Reuter-Stokes certifies that the Environmental Radiation Monitor, identified below, has been calibrated for output using the shadow shield technique*, and calibrated with radiation sources traceable to the National Institute of Standards and Technology.

Sensor Type: 100 R/Hr

Serial Number: 1000992

Calibration Date: 03/16/2017

Sensitivity: -2.281E-8 A/R/h

Richard J. Betley
Authorized Signature

*Calibration Procedure: RS-SOP 238.1

Reuter-Stokes

Calibration Data

Sensor Type:	100 R/Hr	Source (CS-137):	BB-400
Serial Number:	1000992	Date of Certification:	12/01/1994
Calibration Date:	03/16/2017	Exposure Rate at 1 meter:	4.226 mR/h

Customer Name: STOCK

Sensitivity (Ra-226): -2.281E-8 A/R/h

Distance		Exposure Rate	P+S+A	S+A	P	k(CS-137)
Feet	cm	μR/h	A	A	A	A/R/h
12	366	185.323	-5.403E-12	-1.164E-12	-4.239E-12	-2.287E-08
14	427	135.592	-4.135E-12	-1.012E-12	-3.123E-12	-2.303E-08
16	488	103.384	-3.294E-12	-9.029E-13	-2.391E-12	-2.313E-08
18	549	81.348	-2.708E-12	-8.209E-13	-1.887E-12	-2.319E-08

k(CS-137) = -2.306E-8 A/R/h

k(Ra-226) = 0.9892 k(CS-137)

k(Ra-226) = -2.281E-8 A/R/h

$\bar{k}$ = -2.306E-8 A/R/h

σ = 1.39E-10 A/R/h

$V = \frac{\sigma}{\bar{k}} =$ -0.603%

By: John Lak

Date: 3-17-17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	196086
Cal. Due Date:	3-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR262406
Cal. Due Date:	3-7-18

Comments:
UNEAT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: N/A cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-25-17	0926	5.5	1005	100	94365	14878	79487	NW	Section 26 near trailer
3-25-17	1454	5.4	998	100	96316	13481	82835	NW	Section 26 near trailer
3-26-17	1035	5.5	1004	102	94314	14114	80200	NW	Section 26 near trailer
3-26-17	1401	5.3	999	100	93248	13531	79717	NW	Section 26 near trailer
3-28-17	0833	5.5	1005	101	96188	14430	81758	NW	Section 26 near trailer
3-28-17	1212	5.3	1003	101	103245	22269	80976	NW	Section 26 on road @ southern claim
3-29-17	0840	5.4	1005	101	95732	14653	81079	NW	Section 26 near trailer.
3-29-17	1232	5.2	1002	101	94834	15054	79780	NW	Section 26 near trailer
					NW				
					4-2-16				

Reviewed by: [signature] Review Date: 1/29/18

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	3-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR 269980 ~~SAS~~ NW
Cal. Due Date:	3-7-18

Comments:
NNERT

Source: Cs-137
Serial No.: 544-96
Activity: 4 uCi
Emission Rate: N/A cpm/emissions
Source Date: 4-18-96
Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-25-17	0931	5.7	952	100	96657	16184	80463	NW	Section 26, near trailer
3-25-17	1457	5.6	946	100	96139	14624	81515	NW	Section 26, near trailer
3-26-17	1031	5.7	952	100	95441	15227	80214	NW	Section 26, near trailer
3-26-17	1352	5.5	947	100	96336	14730	81606	NW	Section 26 near trailer
3-28-17	0840	5.6	952	101	96138	16340	79798	NW	Section 26, near trailer
3-28-17	1218	5.5	949	100	104022	23070	80952	NW	Section 26, road at southern claim
3-29-17	0837	5.6	952	101	96719	15960	80759	NW	Section 26, near trailer
3-29-17	1236	5.5	949	101	97836	15710	82126	NW	Section 26, near trailer
					NW				
						4-2-17			

Reviewed by: [signature]
Review Date: 1/29/18

(4)

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	271435
Cal. Due Date:	3-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR213432
Cal. Due Date:	3-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: N/A cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-25-17	0937	5.5	1055	102	94755	14061	80694	NW	Section 26 near trailer
3-25-17	1451	5.4	1051	101	94302	13177	81125	NW	Section 26 near trailer
3-26-17	1039	5.5	1057	102	92236	13069	79167	NW	Section 26 near trailer
3-26-17	1355	5.3	1051	101	93583	12884	80699	NW	Section 26 near trailer
3-28-17	0836	5.5	1058	102	95338	14043	81295	NW	Section 26 near trailer
3-28-17	1210	5.3	1055	102	101737	20756	80981	NW	Section 26 road at southern claim
3-29-17	0832	5.4	1057	102	94866	13882	81984	NW	Section 26 near trailer
3-29-17	1230	DID NOT USE							

[signature] 4-2-17

Reviewed by: [signature] Review Date: 1/29/18

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	190166
Cal. Due Date:	6-14-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR202073
Cal. Due Date:	6-14-18

Comments:
NNEAT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: N/A cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-29-17	0915	5.5	900	100	91966	13959	78007	NW	Section 26
6-30-17	0845	5.5	900	100	99374	21622	77752	NW	ERG office

7-5-17

Reviewed by: [signature] Review Date: ~~1/19~~ 1/29/18

ERG Form ITC.201.A

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	218564
Cal. Due Date:	9-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	051517?
Cal. Due Date:	9-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-19-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
9-18-17	0836	6.1	950	99	120544	41247	79297	NW	Section 26 @ corral
9-18-17	1502	6.0	947	99	88788	12852	75936	NW	Milan roadside
9-19-17	0824	6.0	950	99	92200	14959	77246	NW	Section 26 @ trailer
9-19-17	1400	6.0	947	99	113273	36312	76961	NW	Section 26 @ corral

NW 9-23-17

Reviewed by: [signature] Review Date: 10/9/17

②

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	9-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR269995
Cal. Due Date:	9-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
9-13-17	0841	6.2	1053	100	120777	42659	78118	NW	Section 26 @ corral
9-15-17	1508	6.1	1046	100	90560	13975	76585	NW	Milan roadside

NW 9-23-17

Reviewed by: MM Review Date: 10/9/17

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ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	262334
Cal. Due Date:	9-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	051517P
Cal. Due Date:	9-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
9-18-17	0842	5.3	953	100	122187	41250	80937	NW	Section 26 @ corral
9-18-17	1505	5.3	945	100	90087	12767	77320	NW	Milan roadside

NW 9-21-17

Reviewed by: MM Review Date: 10/9/17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Reuter Stokes
Model:	RS-S131-200-ER000U
Serial No.:	1000992
Cal. Due Date:	3-16-18

DETECTOR	
Manufacturer:	Reuter Stokes
Model:	RS-S131-200-ER000U
Serial No.:	1000992
Cal. Due Date:	3-16-18

Comments:
NNERT - HPIC

Source: Cs-137 Activity: 4 uCi Source Date: 4-12-96 Distance to Source: Contact housing

Serial No.: 544-96 Emission Rate: NA cpm/emissions

← μR/h →

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-26-17	0630	8.18	401.2	NA	~14.2	~8.5	~5.7	NW	Home 2 Suites room / Farmington
6-26-17	2100	7.93	401.1	NA	~14.5	~8.6	~5.9	NW	Hilton Garden Inn room / Gallup
6-29-17	0850	8.25	401.3	NA	~18	~12.5	~5.5	NW	Section 26
6-30-17	0740	8.21	401.3	NA	~19	~13.4	~5.6	NW	ERG office

NW 6-30-17

Reviewed by: MR Review Date: 10/9/17

Appendix B Exposure Rate Measurements

Date and Time	Exposure Rate (mR/h)	Location
06/29/2017 9:50	0.0093	Correlation Location 1
06/29/2017 9:51	0.0116	Correlation Location 1
06/29/2017 9:52	0.0119	Correlation Location 1
06/29/2017 9:53	0.0121	Correlation Location 1
06/29/2017 9:54	0.0120	Correlation Location 1
06/29/2017 9:55	0.0119	Correlation Location 1
06/29/2017 9:56	0.0123	Correlation Location 1
06/29/2017 9:57	0.0118	Correlation Location 1
06/29/2017 9:58	0.0118	Correlation Location 1
06/29/2017 9:59	0.0121	Correlation Location 1
06/29/2017 10:19	0.0227	Correlation Location 2
06/29/2017 10:20	0.0279	Correlation Location 2
06/29/2017 10:21	0.0276	Correlation Location 2
06/29/2017 10:22	0.0270	Correlation Location 2
06/29/2017 10:23	0.0271	Correlation Location 2
06/29/2017 10:24	0.0275	Correlation Location 2
06/29/2017 10:25	0.0277	Correlation Location 2
06/29/2017 10:26	0.0268	Correlation Location 2
06/29/2017 10:27	0.0274	Correlation Location 2
06/29/2017 10:28	0.0276	Correlation Location 2
06/29/2017 10:42	0.0095	Correlation Location 3
06/29/2017 10:43	0.0135	Correlation Location 3
06/29/2017 10:44	0.0141	Correlation Location 3
06/29/2017 10:45	0.0140	Correlation Location 3
06/29/2017 10:46	0.0138	Correlation Location 3
06/29/2017 10:47	0.0144	Correlation Location 3

Date and Time	Exposure Rate (mR/h)	Location
06/29/2017 10:48	0.0139	Correlation Location 3
06/29/2017 10:49	0.0135	Correlation Location 3
06/29/2017 10:50	0.0135	Correlation Location 3
06/29/2017 10:51	0.0134	Correlation Location 3
06/29/2017 10:52	0.0137	Correlation Location 3
06/29/2017 11:05	0.0130	Correlation Location 4
06/29/2017 11:06	0.0194	Correlation Location 4
06/29/2017 11:07	0.0207	Correlation Location 4
06/29/2017 11:08	0.0206	Correlation Location 4
06/29/2017 11:09	0.0202	Correlation Location 4
06/29/2017 11:10	0.0206	Correlation Location 4
06/29/2017 11:11	0.0194	Correlation Location 4
06/29/2017 11:12	0.0206	Correlation Location 4
06/29/2017 11:13	0.0201	Correlation Location 4
06/29/2017 11:14	0.0201	Correlation Location 4
06/29/2017 11:27	0.0191	Correlation Location 5
06/29/2017 11:28	0.0399	Correlation Location 5
06/29/2017 11:29	0.0450	Correlation Location 5
06/29/2017 11:30	0.0456	Correlation Location 5
06/29/2017 11:31	0.0456	Correlation Location 5
06/29/2017 11:32	0.0462	Correlation Location 5
06/29/2017 11:33	0.0459	Correlation Location 5
06/29/2017 11:34	0.0453	Correlation Location 5
06/29/2017 11:35	0.0462	Correlation Location 5
06/29/2017 11:36	0.0451	Correlation Location 5
06/29/2017 11:37	0.0453	Correlation Location 5

RPT-2017-033, Rev. 0

Geophysical Characterization of the Section 26 Historic Uranium Mining Site – Navajo Nation, NM

N. Crook, Ph.D.
M. McNeill

hydroGEOPHYSICS

2302 N. Forbes Blvd, Tucson, AZ 85745 USA

Date Published
July 2017

Prepared for:

Stantec

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

This report documents the results of a geophysical characterization survey conducted at the Section 26 Site, in June 2017, under contract to Stantec by hydroGEOPHYSICS, Inc. (HGI). The geophysical survey consisted of electrical resistivity and multi-channel analysis of surface wave (MASW) surveying, and was conducted along thirteen coincident survey lines to characterize this historic uranium mining area within the Navajo Nation.

1.2 LOCATION

The Section 26 Site is located approximately 13 miles north of the town of Grants, NM, in McKinley County. Figure 1 shows the location of the Section 26 Site geophysical survey area; the electrical resistivity and MASW survey lines are overlaid onto the satellite image in Figure 2.

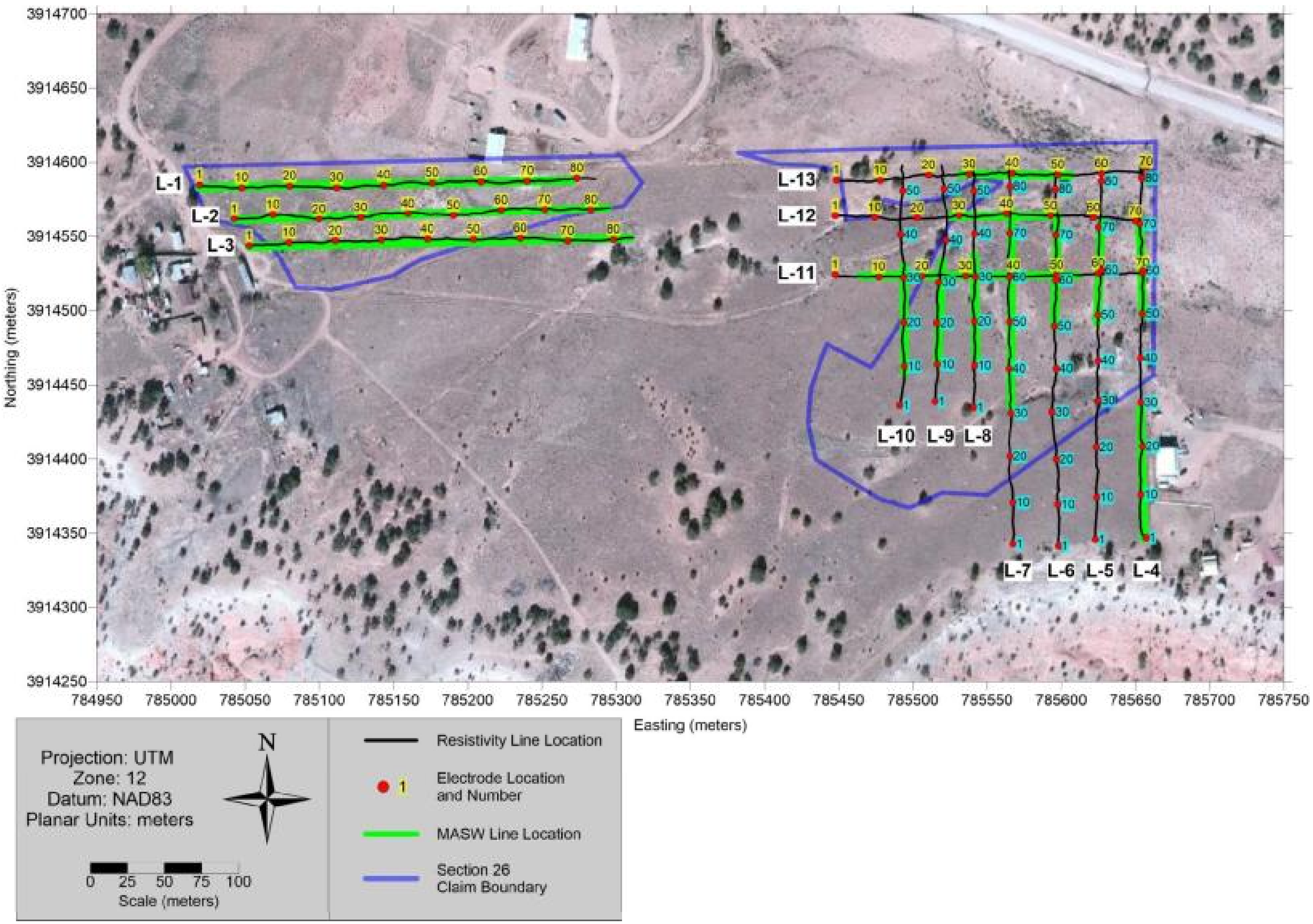
1.3 OBJECTIVE OF INVESTIGATION

The objectives of the geophysical investigation were to determine the presence of any underlying void spaces and thickness of the soil or overburden at the site.

The methods were selected to take advantage of physical property contrasts that are reflective of site conditions. For example, it was expected that the void spaces would be of significantly higher resistivity and lower acoustic velocity compared to the background bedrock or overburden. In addition, it was anticipated that the soil or overburden would present a contrast in geophysical parameters compared to the underlying bedrock strata.

Figure 1. General Location Map of the Section 26 Site - Geophysical Survey Area.

Figure 2. General Site Map with Electrical Resistivity and Multi-Channel Analysis of Surface Wave Survey Lines.



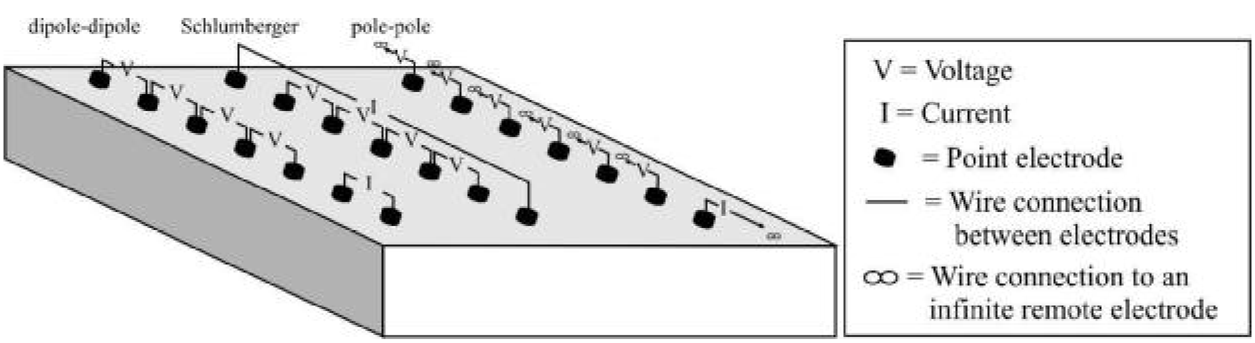
2.0 GEOPHYSICAL THEORY

2.1 ELECTRICAL RESISTIVITY

Electrical resistivity is a volumetric property that describes the resistance of electrical current flow within a medium (Rucker et al., 2011; Telford et al., 1990). Direct electrical current is propagated in rocks and minerals by electronic or electrolytic means. Electronic conduction occurs in minerals where free electrons are available, such as the electrical current flow through metal. Electrolytic conduction, on the other hand, relies on the dissociation of ionic species within a pore space and is more common in the partially saturated sandy alluvium and fractured bedrock. With electrolytic conduction, the movement of electrons varies with the mobility, concentration, and the degree of dissociation of the ions. Competent rock free of fissures and fractures will have a higher resistivity compared to less competent rock.

Mechanistically, the resistivity method uses electric current (I) that is transmitted into the earth through one pair of electrodes (transmitting dipole) that are in contact with the soil. The resultant voltage potential (V) is then measured across another pair of electrodes (receiving dipole). Numerous electrodes can be deployed along a transect (which may be anywhere from feet to miles in length), or within a grid. Figure 3 shows examples of electrode layouts for surveying. The figure shows transects with a variety of array types (dipole-dipole, Schlumberger, pole-pole). A complete set of measurements occurs when each electrode (or adjacent electrode pair) passes current, while all other adjacent electrode pairs are utilized for voltage measurements. Modern equipment automatically switches the transmitting and receiving electrode pairs through a single multi-core cable connection. Rucker et al. (2009) describe in more detail the methodology for efficiently conducting an electrical resistivity survey.

Figure 3. Possible Arrays for use in Electrical Resistivity Characterization



The modern application of the resistivity method uses numerical modeling and inversion theory to estimate the electrical resistivity distribution of the subsurface given the known quantities of electrical current, measured voltage, and electrode positions. A common resistivity inverse method incorporated in commercially available codes is the regularized least squares optimization method (Sasaki, 1989; Loke, et al., 2003). The objective function within the optimization aims to minimize the difference between measured and modeled potentials (subject to certain constraints, such as the type and degree of spatial smoothing or regularization) and the optimization is conducted iteratively due to the nonlinear nature of the model that describes the potential distribution. The relationship between the subsurface resistivity (ρ) and the measured voltage is given by the following equation (from Dey and Morrison, 1979):

$$-\nabla \cdot \left[\frac{1}{\rho(x,y,z)} \nabla V(x,y,z) \right] = \left(\frac{I}{U} \right) \delta(x-x_s)\,\delta(y-y_s)\,\delta(z-z_s) \qquad (1)$$

where I is the current applied over an elemental volume U specified at a point (x_s, y_s, z_s) by the Dirac delta function.

Equation (1) is solved many times over the volume of the earth by iteratively updating the resistivity model values using either the L_2-norm smoothness-constrained least squares method, which aims to minimize the square of the misfit between the measured and modeled data (de Groot-Hedlin & Constable, 1990; Ellis & Oldenburg, 1994):

$$\left(J_i^T J_i + \lambda_i W^T W \right) \Delta r_i = J_i^T g_i - \lambda_i W^T W r_{i-1} \qquad (2)$$

or the L_1-norm that minimizes the sum of the absolute value of the misfit:

$$\left(J_i^T R_d J_i + \lambda_i W^T R_m W \right) \Delta r_i = J_i^T R_d g_i - \lambda_i W^T R_m W r_{i-1} \qquad (3)$$

where g is the data misfit vector containing the difference between the measured and modeled data, J is the Jacobian matrix of partial derivatives, W is a roughness filter, R_d and R_m are the weighting matrices to equate model misfit and model roughness, Δr_i is the change in model parameters for the i^{th} iteration, r_i is the model parameters for the previous iteration, and λ_i = the damping factor.

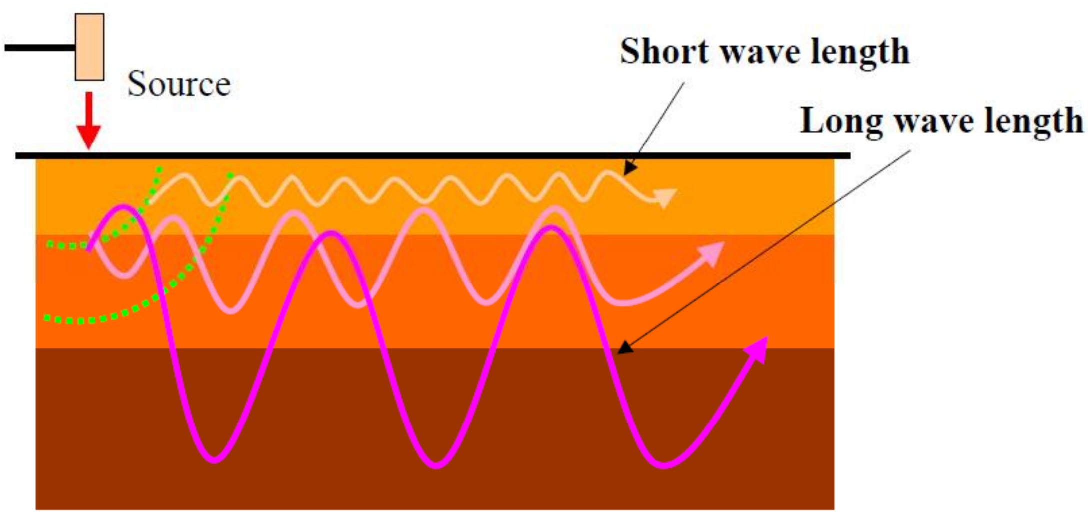
2.2 MULTI-CHANNEL ANALYSIS OF SURFACE WAVES (MASW)

Dispersion, or change in phase velocity with frequency, is the fundamental property utilized in surface-wave methods. Phase velocity of surface-wave is sensitive to the shear wave velocity (Vs); phase velocity of surface-wave is typically 90-95% that of the shear wave velocity. Surface wave dispersion can be significant in the presence of velocity layering, which is common in the near-surface environment. There are other types of surface waves, or waves that travel along a surface, but in this application we are concerned with the Rayleigh wave, which is also called "ground roll" since the Rayleigh wave is the dominant component of ground roll.

"Active source" surface-wave surveying means that seismic energy is intentionally generated at a specific location relative to the geophone spread and recording begins when the source energy is imparted into the ground. This is in contrast to "passive source" surveying, also called "microtremor" surveying, or sometimes referred to as "refraction microtremor" (or the commercial term "ReMi") surveying, where there is no time break and motion from ambient energy generated by cultural noise, wind, wave motion, etc. at various, and usually unknown, locations relative to the geophone spread is recorded.

Surface-wave energy decays exponentially with depth beneath the surface. Longer wavelength (that is, longer-period and lower-frequency) surface waves travel deeper and thus contain more information about deeper velocity structure (Figure 4). Shorter wavelength (that is, shorter-period and higher-frequency) surface waves travel shallower and thus contain more information about shallower velocity structure. In this context, by their nature and proximity to the geophone spread, it can be said that higher frequency active source surface waves resolve the shallower velocity structure and lower frequency passive source surface waves resolve the deeper velocity structure.

Figure 4. Example of Surface Wave Dispersion Produce During Multi-Channel Analysis of Surface Wave Surveying



MASW surveys are conducted using the same source and seismograph equipment as the more common P-wave seismic refraction surveys, requiring only a change to lower frequency geophones (typically 4.5Hz). They are much easier to conduct than shear wave surveys, and benefit from increasing source power efficiency (for each sledgehammer blow 67% of the energy produced is in the form of surface-waves, 26% shear waves, and 7% P-waves) and consequently improved signal to noise. The techniques works best in soft rock geology conditions with minimal or constant topography change across the spread.

Shear wave velocity is one of the elastic constants and closely related to Young's modulus. Under most circumstances, shear wave velocity is a direct indicator of the ground strength (stiffness) and therefore can be used to derive load-bearing capacity.

3.0 METHODOLOGY

3.1 SURVEY AREA AND LOGISTICS

A geophysical survey, including electrical resistivity and MASW, was completed at the Section 26 Site between the 12th and 19th of June, 2017. The geophysical survey consisted of thirteen coincident survey lines of electrical resistivity and MASW. Figure 2 shows a detailed line layout for the geophysical surveying.

3.2 EQUIPMENT

3.2.1 Equipment for Electrical Resistivity Surveying

Data were collected using a Supersting™ R8 multichannel electrical resistivity system (Advanced Geosciences, Inc. (AGI), Texas) and associated cables, electrodes, and battery power supply. The Supersting™ R8 meter is commonly used in surface geophysical projects and has proven itself to be reliable for long-term, continuous acquisition. The stainless steel electrodes were laid out along lines with a constant electrode spacing of approximately 10 feet (3 meters). Multi-electrode systems allow for automatic switching through preprogrammed combinations of four electrode measurements.

Electrode locations were determined based on the distance along the cable length, with a handheld Garmin GPS used to survey in the electrode locations along each line.

3.2.2 Equipment for MASW Surveying

Two Geode Ultra-Light Exploration 24 –Channel Seismographs (Geometrics Inc., San Jose, CA) were used for MASW surveying, providing a total of 48-channels. 4.5Hz geophone placement was every 10 feet (approximately 3 meters), shot point spacing was 20 feet (approximately 6 meters) located at the midpoint of geophone positions along the spread, with off-end shots at either 25 or 30 feet (approximately 7.5 and 9 meters) beyond the first and last geophones. The seismic source consisted of a 16-lb sledgehammer and polyethylene strike plate. The Geodes ran from a laptop in order to view each shot to ensure acceptable data quality. Additional hammer blows forming a new "stack" of data were added until the desired data quality was achieved. The shot record (seismogram) was also saved to the computer and stored for subsequent processing. A real-time noise monitor showing all geophones was carefully scrutinized during shots to ensure that noise levels were at a minimum for each shot. This included waiting for breaks in wind noise, drilling activities, and other sources of noise.

3.3 DATA PROCESSING

3.3.1 Quality Control – Onsite

Data for each survey method were given a preliminary assessment for quality control (QC) in the field to assure quality of data before progressing the survey. Following onsite QC, the data were transferred to the HGI server for storage and detailed data processing and analysis.

3.3.2 Electrical Resistivity Processing

3.3.2.1 Resistivity Data Editing

The geophysical data for the resistivity survey, including measured voltage, current, measurement (repeat) error, and electrode position, were recorded digitally with the AGI SuperSting R8 resistivity meter. Each line of acquisition was recorded with a separate file name. Following field data collection, the raw resistivity data files were transmitted to the HGI server located in Tucson, Arizona. Data quality was inspected and checked for consistency with respect to adjacent line results, then data files were saved to designated folders on the server. The server was backed up nightly and backup tapes were stored at an offsite location on a weekly and monthly basis.

The raw data were evaluated for measurement noise. Those data that appeared to be extremely noisy and fell outside the normal range of accepted conditions were removed. Examples of conditions that would cause data to be removed include: negative or very low voltages, high-calculated apparent resistivity, extremely low current, and high repeat measurement error.

3.3.2.2 2D Resistivity Inversion

RES2DINVx64 software (Geotomo, Inc.) was used for inverting individual lines in two dimensions. RES2DINVx64 is a commercial resistivity inversion software package available to the public from www.geoelectrical.com. An input file was created from the edited resistivity data and inversion parameters were chosen to maximize the likelihood of convergence. It is important to note that up to this point, no resistivity data values had been manipulated or changed, such as smoothing routines or box filters. Noisy data had only been removed from the general population.

The inversion process followed a set of stages that utilized consistent inversion parameters to maintain consistency between each model. Inversion parameter choices included the starting model, the inversion routine (robust or smooth), the constraint defining the value of smoothing and various routine halting criteria that automatically determined when an inversion was complete. Convergence of the inversion was judged whether the model achieved an RMS of less than 5% within three to five iterations.

3.3.2.3 2D Resistivity Plotting

The inverted data were output from RES2DINVx64 into an .XYZ data file and were then gridded and color contoured in Surfer (Golden Software, Inc.). Electrode locations and other relevant line features were plotted on the resistivity sections to assist in data analysis. Qualified in-house inversion experts subjected each profile to a final review.

3.3.3 MASW Processing

The data processing flow for the MASW used the SeisImager (Geometrics Inc., San Jose, CA) seismic processing software. Any geometry changes to correct for errors made during the field acquisition were conducted within the SeisImager software called Pickwin (Version 4.2.0.0). Topography variations across all the MASW profiles collected were smooth and kept to a minimum between geophones (<1 foot) for the chosen survey line locations.

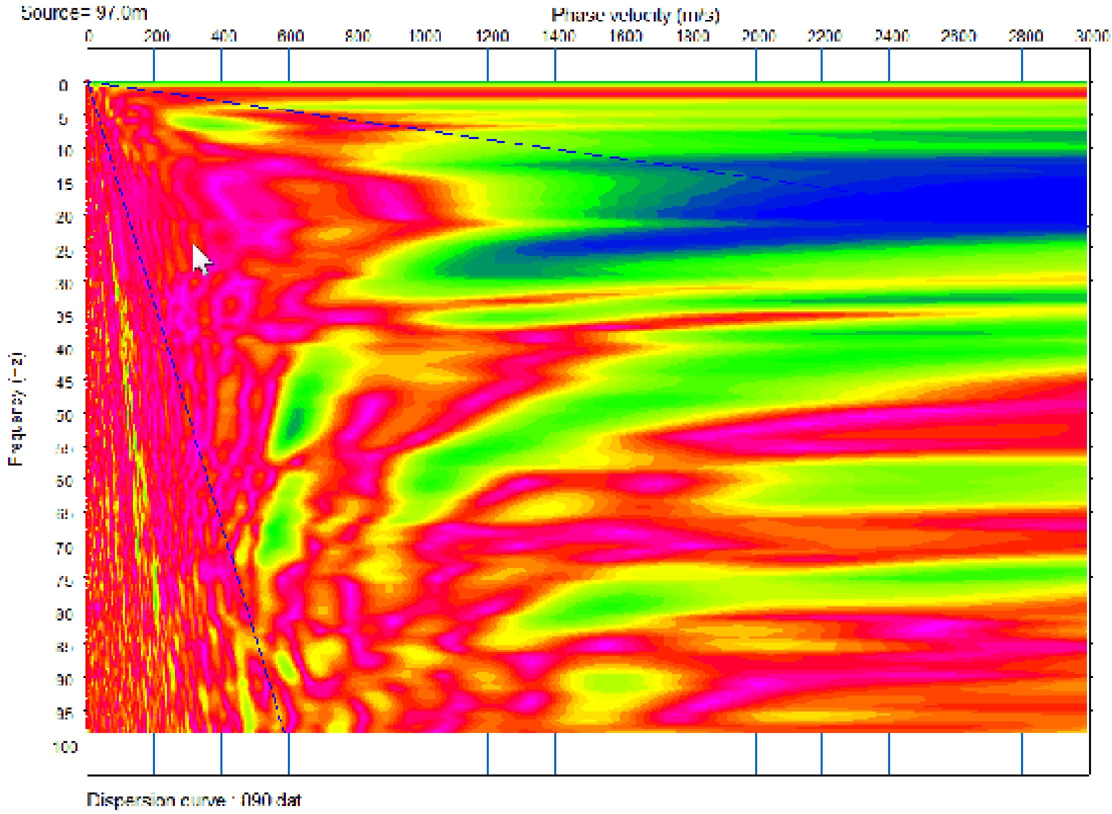
SeisImager's Pickwin was then used to calculate the Common Mid-Point (CMP) cross-correlation gathers, a bin size of 20 feet was used for the collected profiles. SeisImager's WaveEq module was used to generate the dispersion curves and run the inversion to produce the shear wave velocity profile. A multichannel field record is first decomposed via Fast Fourier Transformation (FFT) into individual frequency component, and then amplitude normalization is applied to the each component. Then, for a given testing phase velocity in a certain range, the necessary amount of phase shifts are calculated to compensate for the time delay corresponding to a specific offset, applied to individual components, and all of them are summed together. This is repeated for different frequency components. Display of all summed energy in frequency-phase velocity space will show patterns of energy accumulation that represents the dispersion curve as shown in Figure 5.

The inversion is then performed within SeisImager's WaveEq module using a non-linear least square method to iteratively seek the 2D shear wave velocity profile, with the goal of minimizing the root-mean squared (RMS) error between the observed and calculated velocity curves. Convergence of the inversion was judged whether the model achieved an RMS of less than 5% within five to seven iterations.

3.3.3.1 MASW Plotting

The inverted data were output from SeisImager's WaveEq into an .XYZ data file and were then gridded and color contoured in Surfer (Golden Software, Inc.). Qualified in-house inversion experts subjected each profile to a final review.

Figure 5. Example Dispersion Curve.



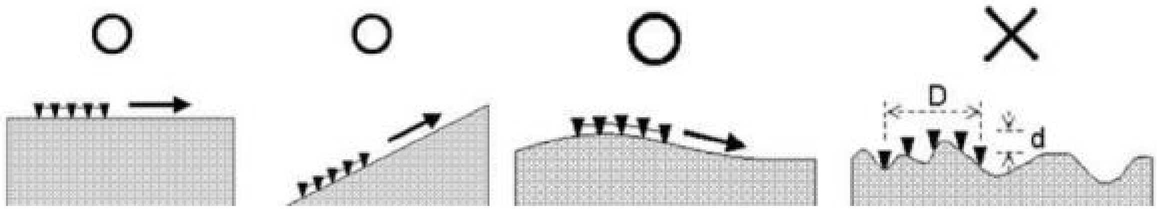
3.4 SURVEY LIMITATIONS

A number of survey limitations were encountered with respect to the MASW surveying:

- For all the MASW profiles collected at the site the frequency range in the dispersion curves generally had a high end cut off around 25 - 30 Hz. This may have been a result of the near-surface materials not being conducive to producing or significantly attenuating higher frequencies. This likely resulted in a decrease in the resolution of the near-surface velocity structure in the presented model results, since as stated earlier the higher frequency active source surface waves resolve the shallower velocity structure and lower frequency passive source surface waves resolve the deeper velocity structure.

- The MASW profiles for the eastern area of the Section 26 site (Lines 4 through 13) do not extend across the entire electrical resistivity survey line in each case. This was a result of the significant topography variations along the electrical resistivity survey lines in this area. Undulating topography, as illustrated in Figure 6, can hinder the generation of surface waves, resulting in poor quality data and unreliable model results. Therefore, after consultation with the client it was decided to limit the MASW coverage along these lines to better target section conducive to surface wave generation.

Figure 6. Typical terrain conditions favorable and unfavorable for the MASW survey.



4.0 RESULTS & INTERPRETATION

The inverse model results for the electrical resistivity and MASW lines are presented in Figures 9 through 21. Separate common color contouring scales are used for each technique for all of the lines to highlight any features that may be indicative of void features or fill material and provide the ability to compare intensity of targets from line to line. Electrically conductive (low resistivity) or low shear-wave velocity subsurface regions are represented by cool hues (pinks to blues) and electrically resistive or high shear-wave velocity regions are represented by warm hues (reds to browns). Other notes of interest about the site where present, either observed by or relayed to HGI, are also annotated on the profiles.

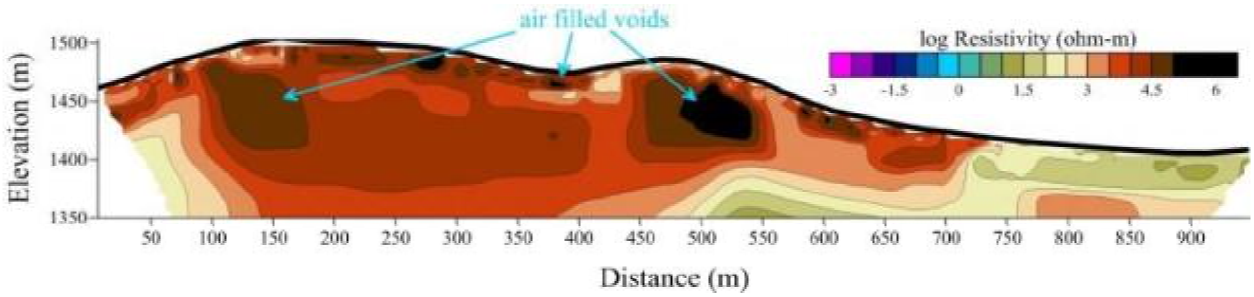
The objective of the survey was to geophysically characterize areas that indicate features representative of subsurface voids, depth to bedrock, or fill material associated with the historic mining activities. Therefore, in the case of air-filled voids, the targets for the electrical resistivity survey would be regions of high resistivity (low conductivity) based on the assumption that the void space would have increased resistivity compared to the surrounding bedrock or sediments. The case for sediment-filled or collapsed voids would differ significantly since the material in the voids would tend to be more conductive, if the surrounding material were bedrock or stiff soil for example. Therefore, the collapsed or infilled void space would likely be regions of low resistivity (high conductivity) based on the assumption that the materials in the void space would have increased conductivity compared to the surrounding strata.

The contrast in resistivity between the native material and subsurface voids will depend on a number of factors, including the depth to the voids, the fill material of the void (air, sea-water, a mixture), dimensions of the void, and the nature of the slag material (massive, granular, combination, weathered). An example of a resistivity survey HGI performed looking for subsurface voids over the Kartchner Caverns State Park in Arizona is shown in Figure 7. The known air filled voids show up as resistive features, displaying resistivity values of the order of 1,000’s to 10,000’s of ohm-m, within a background of limestone bedrock, displaying resistivity values of 100’s of ohm-m. There is a fair amount of variability in resistivity value depending on the dimensions of and depths to the subsurface voids. The background material in this example is fairly resistive, similar to the upper bedrock in this area.

We anticipate that the contrast in resistivity between the fill materials associated with the historic mining activities would be more conductive than the underlying bedrock across the site. Therefore, areas where the mining waste material or pits were backfilled would likely be regions of low resistivity (high conductivity) compared to the resistive bedrock. However, it may be difficult to differentiate the fill material from native soils across the site, based on their likely unconsolidated and heterogeneous nature, by geophysical methods alone.

The MASW technique was chosen to complement the electrical resistivity to help better constrain the interpretations. The MASW technique will work in a similar manner to the electrical resistivity, with the void spaces and fill materials creating a measurable contrast in properties, shear wave velocity in this case. Therefore, in the case of subsurface voids the targets for the MASW survey would be regions of low seismic velocity based on the assumption that the void space, whether air- or water-filled, would have decreased seismic velocity compared to the native material. The contrast in seismic velocity between the native material and subsurface voids will depend on a number of factors, including the depth to the voids, the fill material of the void (air, sediments, or a mix of both), dimensions of the void, and the nature of the surrounding materials.

Figure 7. Electrical Resistivity Profile over the Kartchner Caverns State Park, AZ. The Air Filled Voids and the Caverns and Passageways show up as Resistive Features in the more Conductive Limestone Bedrock Background.



4.1 LINE 1

Figure 9 displays the resistivity and MASW model results for Line 1, which runs in a west to east direction. The resistivity model results display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which is on average 30 feet thick, with a more conductive layer extending to the depth limits of the model beneath this. A number of boreholes were drilled and logged across the site (Figure 8); these were typically extended a short way into the bedrock which tended to be either limestone or marl based on the geological logs. The geological logs for boreholes S1011-SCX-015 through -018 indicate that the limestone bedrock in this area is very close to the ground surface, with less than a foot of gravelly soil cover in some cases. These boreholes are located towards the southern end of Lines 5 through 7, where a highly resistive layer is observed approaching the ground surface. This would indicate that the resistive layer in the resistivity model results represents the limestone bedrock unit for these lines, and therefore likely represents the shallow bedrock in the model results from across the site. Therefore, the resistive layer running across this profile is interpreted to be a response to the bedrock, with the geological logs from S1011-SCX-012 indicating marl and sandstone in this area.

The geological logs from borehole S1011-SCX-012, which is located approximately 115 feet along the line and approximately 15-20 feet to the south, indicates approximately 5 feet of fine-grained sediments overlying the marl and sandstone bedrock. Therefore, the near-surface conductive layer is likely a response to the overlying soils and unconsolidated materials. This layer is approximately 20 feet in thickness between 0 and 200 feet along the line, which corresponds to the approximate borehole location, displaying some discrepancy to the 5 feet thickness indicated by the geological logs. This could be a result of variations in the unconsolidated material thickness across the area.

Therefore, the near-surface conductive layer, representing the unconsolidated materials, either native soil or fill material, is approximately 20 feet thick between 0 and 200 feet along the line, indicated by the dashed red line in Figure 9. As mentioned earlier, it will likely be difficult to differentiate the native soils from the fill material associated with the historic mining activities based on the electrical resistivity or seismic properties. It then decreases to approximately 8 to 10 feet in thickness, and remains similar along the rest of the line. There are a number of regions, notably between 465 and 510, and 590 and 625 feet along the line, where the conductive layer appears to thicken. Increasing to approximately 20 feet thick between 465 and 510 feet along the line. The region between 590 and 625 feet along the line is associated with a conductive break in the underlying resistive layer. This could represent a more fractured region of the bedrock, which tends to reduce the resistivity of a material due to the damaged nature of the bedrock and potential higher moisture content from infiltration. This break appears to extend down to the lower conductive layer, possibly representing a more conductive underlying bedrock layer, although it is difficult to be certain what depth the break actually ends based on the similar resistivity values of this feature and the underlying layer. Beyond 675 feet along the line the resistive layer again appears to display a number of breaks, and since the resistivity values of the bedrock layer in this area is generally lower it may represent a more fractured region of the bedrock.

The MASW results display a narrow range in shear wave velocities, between approximately 2,000 and 2,600 ft/sec, falling within the dense soil or weathered bedrock category for the majority of the line. There are a number of near-surface regions, for example between 100 and 200 feet along the line, that display shear-wave velocities towards the lower end of the range which corresponds to the thicker conductive layer, suggesting thicker layer of unconsolidated materials. In addition, the conductive break in the resistive layer, between 600 and 700 feet along the line, correlates to a vertical region of lower shear-wave velocity, which would agree with the interpretation that this represent a more fractured region of the bedrock.

4.2 LINE 2

Figure 10 displays the resistivity and MASW model results for Line 2, which runs in a west to east direction. The resistivity model results again display a three-layer structure; with a thin conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which is on average 25 feet thick, with a more conductive layer extending to the depth limits of the model beneath this.

Based on the interpretations for Line 1, the resistive layer would tend to represent the upper bedrock unit across the site. The geological logs from boreholes S1011-SCX-010 and -011, which are located 30 and 140 feet along the line respectively, indicate approximately 5 feet of fine-grained sediments overlying the limestone bedrock. This correlates well to the approximate thickness of the near-surface conductive layer in these locations, suggesting again that this layer represents the unconsolidated materials, either native soils or fill materials.

The near-surface conductive layer is approximately 20 feet thick between 50 and 105 feet along the line, before decreasing significantly to approximately 5 feet thickness between 105 and 290 feet along the line, indicated by the dashed red line in Figure 10. The resistive layer appears to approach the ground surface between 290 and 330 feet along the line, with little indication of the conductive layer, likely indicating shallow bedrock. The conductive layer then increases to an average of 10 feet thickness for the remainder of the line. The thicker section of the conductive layer at the beginning of the line corresponds to a significant low shear wave velocity region in the MASW results, which extends from 0 to 165 feet along the line, and could represent the unconsolidated materials. There appears to be a similar low shear wave velocity region beneath this, at a depth of 75 feet below ground surface (bgs), which could indicate a void space or heavily fractured bedrock, unfortunately we cannot correlate this to the resistivity model results due to the lack of coverage in this area. The remainder of the MASW model result appears to display small fluctuations in the shear wave velocity, likely indicating variations in competency of the soils or bedrock materials. We do observed a number of decreases in shear wave velocity associated with conductive breaks in the resistive layer, between 400 to 430 and 675 to 700 feet along the line for example. Again, these could represent a more fractured or weathered region of the bedrock.

4.3 LINE 3

Figure 11 displays the resistivity and MASW model results for Line 3, which runs in a west to east direction. The resistivity model results again display a three-layer structure; with a thin conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which is on average 20 feet thick and appears more discontinuous along this line, with a more conductive layer extending to the depth limits of the model beneath this. The geological logs from boreholes S1011-SCX-0009, which is located 100 feet along the line, indicate approximately 2.5 feet of fine-grained sediments overlying the limestone bedrock. This correlates well to the approximate thickness of the near-surface conductive layer in these locations, suggesting again that this layer represents unconsolidated materials at the site.

The near-surface conductive layer is approximately 10 feet thick between 0 and 90 feet along the line. The layer decreases in thickness to approximately 5 feet between 90 and 175 feet along the line, before increasing gradually to approximately 10 feet thick between 175 and 245 feet along the line, where the resistive layer appears to pinch out or has potentially been excavated and backfilled with more conductive material. Between 245 and 265 feet along the line there appears to be an isolated resistive region, with only a thin veneer of the conductive layer overlying this. The resistive layer again appears to be absent between 265 and 315 feet along the line, where the near-surface conductive layer is approximately 15 feet thick, again potentially indicating a more fractured or weathered region of bedrock. The near-surface conductive layer becomes a thin veneer between 315 and 430 feet along the line, where the resistive layer, representing the limestone bedrock, approaches the ground surface. The conductive layer then increases in thickness between 430 and 525 feet, to a maximum thickness of approximately 10 feet. A conductive break in the resistive layer is observed between 500 and 555 feet along the line, again potentially indicating less competent/more fractured bedrock areas. The conductive layer then decreases in thickness, to approximately 5 feet by 585 feet along the line, remaining a similar thickness until the end of the line.

The majority of the MASW model results displays a fairly narrow range in shear wave velocity, between approximately 2,300 to 2,600 ft/sec, falling within the dense soil or weathered bedrock category for the majority of the line. There are a number of near-surface lower velocity regions, for example between 135 to 240 and 400 to 470 feet along the line, which could indicate less competent unconsolidated materials. A deeper low shear-wave velocity region is observed between 40 and 100 feet along the line, and at a depth of approximately 35 feet (bgs). The observed velocity contrast would not tend to indicate an air-filled void space, although could relate to a collapsed/infilled void space or heavily fractured bedrock, unfortunately we cannot correlate to the resistivity model results due to the lack of coverage in this area.

4.4 LINE 4

Figure 12 displays the resistivity and MASW model results for Line 4, which runs in a south to north direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which is on average 30 feet thick although appears to thicken significantly towards the middle of the line, with a more conductive layer extending to the depth limits of the model beneath this. The geological logs from boreholes S1011-SCX-021 and -023, which are located 680 and 730 feet along the line respectively, indicate approximately 18 and 20 feet of fine-grained sediments overlying the limestone bedrock. This significant increase in the overburden correlates well to the approximate thickness of the near-surface conductive layer in these locations, suggesting again that this layer represents unconsolidated materials at the site.

The near-surface conductive layer is approximately 5 to 8 feet thick between 0 and 280 feet along the line, and likely corresponds to an undisturbed soil layer overlying the limestone bedrock, which from nearby boreholes is very shallow in this area. Between 280 and 365 feet along the line, the resistive layer appears to approach the ground surface. However, there are two regions located at approximately 290 and 350 feet along the line where the conductive layer appears to thicken significantly to 20 feet. The conductive layer then remains on average approximately 10 feet thick, between 365 and 560 feet along the line. A significant conductive break is observed at 510 feet along the line, which cuts through the underlying resistive layer. This potentially indicates a region that has been excavated down into the bedrock, with more unconsolidated material now present. Alternatively, since this location is coincident with a drainage channel it could indicate an area of less competent/more fractured bedrock that appears more conductive due to weathering and increase moisture content.

Beyond 560 feet along the line the near-surface conductive layer thickens significantly, to between 20 and 25 feet, towards the end of the line. This correlates well to the borehole information in this area and potentially reflects an increase in unconsolidated material. There is a region in the near-surface between 630 and 660 feet along the line that appears more resistive than the surrounding layer, which could indicate coarser grained material or broken bedrock present in this location.

Due to the significant variations in topography across the survey lines in the eastern area of the site, the MASW coverage was limited to avoid the worst of the undulating terrain. Line 4A was collected along the first 230 feet of the resistivity line to confirm the presence of bedrock in the near-surface. The results indicate a higher range of shear wave velocities, between approximately 2,600 and 3,000 ft/sec, which would tend to indicate more competent material than previous survey lines, as would be expected with the underlying shallow limestone bedrock. In contrast, Line 4C displays a similar range of shear wave velocity as observed in the previous survey lines, indicating the presence of the overlying unconsolidated material and potentially more weathered bedrock. The line crosses the location of the conductive break in the resistive layer, however we don't observe a significant reduction in shear wave velocity likely suggesting the resistivity feature is not a response to an excavated region. We do observed a general decrease in shear-wave velocity coincident with the increase in the near-surface conductive layer thickness, potentially suggesting this is associated with unconsolidated material in this area.

4.5 LINE 5

Figure 13 displays the resistivity and MASW model results for Line 5, which runs in a south to north direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which varies between 25 and 30 feet in thickness, with a more conductive layer extending to the depth limits of the model beneath this.

A number of boreholes are located along or in close proximity to Line 5, including S1011-SCX-019, -027, -020, and -034, which are located 405, 475, 540, and 715 feet along the line. The majority of the geological logs indicate less than 8 feet of fine-grained sediments overlying the limestone bedrock. The depth to bedrock does not correlate well to the approximate thickness of the near-surface conductive layer in these locations, which tends to indicate approximately 10 feet of unconsolidated materials. In most cases the discrepancy is small and likely suggests variations associated with the offsets between resistivity line and drill locations. The geological log from S1011-SCX-034 indicates 12 feet of fine-grained sediments overlying the limestone bedrock, which correlates well to the thickness of the conductive layer, suggesting again that this layer represents unconsolidated material at the site.

The near-surface conductive layer is almost absent between 0 and 190 feet along the line, with just a thin veneer visible in places, which agrees well with the geological logs in this area that indicate typically less than 2 feet of cover over the limestone bedrock. Between 190 and 290 feet along the line, the conductive layer is approximately 6 feet thick, before appearing to pinch out as the resistive layer approaches the ground surface again. The geological logs closest to this area tend to indicate the bedrock is within 2 to 3 feet of the ground surface, correlating well to the apparent lack of the conductive layer. The conductive layer becomes apparent again at 355 feet along the line, where it gradually thickens from approximately 10 feet to a maximum of 25 feet at 630 feet along the line. A conductive break in the resistive layer is observed between 620 and 640 feet along the line, potentially indicating the thickening of the conductive layer is associated with a greater amount of unconsolidated material above the underlying bedrock. Additional smaller conductive breaks in the resistive layer are observed at 330 and 505 feet along the line, again potentially indicating regions with increased thickness of unconsolidated material or alternatively relating to less competent/more fractured bedrock areas. Beyond 630 feet along the line, the conductive layer decreases in thickness abruptly, to approximately 10 feet, before thickening once more towards the end of the line, ending at an approximate thickness of 20 feet.

The MASW results, associated with between 470 and 712 feet along the resistivity line, again display a similar narrow range of shear-wave velocity to previous lines, falling within the dense soil or weathered bedrock category along the majority of the line. The region of lower shear wave velocity, centered on approximately 550 feet along the line, tends to be associated with one of the mound features seen across this area of the site. This could be associated with unconsolidated material in this area.

4.6 LINE 6

Figure 14 displays the resistivity and MASW model results for Line 6, which runs in a south to north direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which varies between approximately 20 and 30 feet thick although appears to thicken significantly towards the middle of the line, with a more conductive layer extending to the depth limits of the model beneath this. The geological logs from borehole S1011-SCX-032, which is located 485 feet along the line, indicate approximately 9 feet of fine-grained sediments overlying the marl bedrock. The depth to bedrock does not correlates well to the approximate thickness of the near-surface conductive layer in this location, which tends to indicate approximately 20 feet of unconsolidated materials. This discrepancy could be related to the bedrock material, with the marl potentially being more conductive than the limestone based on the texture or weathering of the materials. There does appear to be a transition around 10 feet (bgs) depth in the conductive layer which may reflect this difference, with the deeper interface with the resistive layer, at 20 feet (bgs), potentially reflecting a contact with the limestone bedrock.

The near-surface conductive layer is almost absent between 0 and 170 feet along the line, with just a thin veneer visible in places, which agrees well with the geological logs in this area that indicate typically less than 2 feet of cover over the limestone bedrock. Between 170 and 310 feet along the line, the conductive layer is approximately 6 feet thick, before appearing to pinch out as the resistive layer approaches the ground surface again, potentially indicating shallow bedrock. The conductive layer becomes apparent again at 335 feet along the line, where it is approximately 10 feet thick, with an abrupt increase in thickness occurring at 370 feet along the line, to approximately 20 feet thick. This increase in thickness could be related to an excavation based on the abrupt nature of the change. It remains a constant thickness until 505 feet along the line, where the conductive layer appears to thin over a hump feature in the resistive layer, located between 505 and 610 feet along the line. This feature is associated with another significant conductive break in the underlying resistive layer, located between 530 and 560 feet along the line, again potentially relating to less competent/more fractured bedrock areas. Beyond 550 feet along the line, the conductive layer increases in thickness, to approximately 25 feet at 625 feet along the line, remaining a similar thickness until the end of the line.

The MASW results, associated with between 480 and 720 feet along the resistivity line, on average displays a lower range of shear-wave velocity to previous lines, although still within the dense soil or weathered bedrock category. Again, the lower shear-wave velocities are associated with the near-surface materials, potentially indicating unconsolidated materials in these areas. The MASW line location passes across the region associated with the conductive break in the resistivity results, located between 530 and 560 feet along the line. The MASW results appear to indicate a decrease in the shear-wave velocity at depth associated with this location, compared to the surrounding velocities at this depth, which could correlate to lithology changes or increased fracturing/weathering interpretation of this feature.

4.7 LINE 7

Figure 15 displays the resistivity and MASW model results for Line 7, which runs in a south to north direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which varies between approximately 25 and 30 feet thick although appears to thicken significantly towards the middle of the line, with a more conductive layer, evident between 150 and 500 feet along the line, extending to the depth limits of the model beneath this. In addition, Line 7 passes to the immediate west of the fenced enclosure around the vertical open mine shaft (located approximately 10 feet to the east of the line), at 640 feet along the line.

A number of boreholes are located along or in close proximity to Line 7, including S1011-SCX-028, -026, -036, and -035, which are located 410, 545, 600, and 740 feet along the line. The geological logs from S1011-SCX-028 and -035 indicate approximately 14 and 17 feet of fine-grained sediments overlying the marl and limestone bedrock respectively. This correlates well to the approximate thickness of the near-surface conductive layer in these locations, suggesting again that this layer represents unconsolidated materials at the site. The remaining two boreholes indicate a much thinner sediment cover, between 4 and 6 feet, over the bedrock. This does not correlate well to the approximate thickness of the near-surface conductive layer in these locations, which tends to indicate almost 30 feet of soil cover or fill materials. These discrepancies could be related to the scale of the features observed in resistivity results, potentially related to small-scale excavations in the bedrock, which do not have extensive lateral limits and which the drilling could miss.

The near-surface conductive layer is almost absent between 0 and 100 feet along the line with just a thin veneer visible in places, which agrees well with the geological logs in this area that indicate typically less than 2 feet of cover over the limestone bedrock. Between 100 and 325 feet along the line, the conductive layer is approximately 7 to 10 feet thick, before increasing in thickness between 325 and 395 feet, to a maximum of 25 feet. It gradually decreases back to approximately 10 feet thickness, between 395 and 500 feet along the line. At 500 feet along the line, this layer increases in a stepwise manner to approximately 55 feet thickness, extending to 535 feet along the line. This abrupt increase in thickness could be related to an excavation based on the sharp nature of the change. Beyond 535 feet along the line, the conductive layer decreases in thickness, to approximately 30 feet at 550 feet along the line, remaining a similar thickness until the end of the line. We do not observe any anomalous resistive features around 640 feet along the line that could be related to air-filled voids associated with the open shaft. However, there does appear to be a more conductive feature associated with the near-surface in this region that extends vertically downwards before branching out to the north and south at an approximate depth of 20 feet (bgs). While this could be related to a region of finer grained sediments in this layer, its shape reflects what we might expect for mining activity and could be a response to increased moisture in the subsurface related to drainage down the shaft or to backfilled/collapsed mine workings in the subsurface.

The MASW results, associated with between 305 and 745 feet along the resistivity line, in general displays a higher shear wave velocity range than the majority of previous lines, between approximately 2,600 and 3,100 ft/sec, falling within the weathered to competent bedrock category. The main feature of this line is a near-surface reduced shear-wave velocity region, located between 450 and 650 feet along the line. The velocity contrast associated with this region is likely not significant enough to indicate air-filled void spaces, but could indicate less competent or unconsolidated materials. The location correlates to the potential excavated region in the resistivity results, between 500 and 535 feet along the line, and also incorporates the resistivity feature associated with the open shaft area. While we do not observe a similar shaped feature in the MASW results, this could be related to the lowered resolution of the seismic method that suffered at this site due to the lack of higher frequencies in the dispersion curves. Therefore, the lower shear-wave velocity region may be averaged response to the backfilled or collapsed regions associated with these features in the resistivity results.

4.8 LINE 8

Figure 16 displays the resistivity and MASW model results for Line 8, which runs in a south to north direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which is on average 55 feet thick, with a more conductive layer just apparent at the base of the model results beneath this (due to the shorter length of Lines 8 to 10 the imaging depth is reduced accordingly). The geological logs from boreholes S1011-SCX-030 and -024, which are located 155 and 320 feet along the line respectively, indicate approximately 10 and 4 feet of fine-grained sediments overlying the marl bedrock. We observe a good agreement with the approximate thickness of the near-surface conductive layer associated with the S1011-SCX-030 location, suggesting again that this layer represents unconsolidated materials at the site. However, the S1011-SCX-024 location displays a significant discrepancy, with an approximate 20 feet conductive layer thickness. This could be a results of the borehole locations being approximately 30 feet to the west of the line, thus undulations in the thickness of the overlying unconsolidated materials would lead to discrepancies. Alternately, the marl bedrock may present as conductive in the resistivity results, either due to its texture or weathered nature, resulting in this thickening of the conductive layer.

The near-surface conductive layer has a fairly consistent thickness between 0 and 400 feet along the line, increasing slightly from approximately 20 to 25 feet. At 400 feet along the line, there is an abrupt step, decreasing the thickness of the conductive layer to approximately 10 feet. This change in thickness could be related to an excavation based on the abrupt nature of the change. The thickness of the conductive layer then increases gradually to the end of line, where it is approximately 15 feet thick. There is another highly conductive region within this layer, between 300 and 395 feet along the line, which correlates well to the location of a similar feature associated with the open shaft location in Line 7. This again could reflect a response to increased moisture in the tunnels or backfilled/collapsed shafts associated with historic mining activities in the subsurface.

The MASW results, associated with between 100 and 350 feet along the resistivity line, on average displays a lower range of shear-wave velocity to previous lines, although still within the dense soil or weathered bedrock category. A region of lower shear wave velocities is observed towards the beginning of this line, with a shear-wave velocity range of 1,600 to 1,800 ft/sec, located between 100 and 150 feet along the line and extending to a depth of 30 feet (bgs). This is associated with a resistive region, at a depth of approximately 30 feet (bgs) in the resistivity results, and could potentially be related to an air-filled void. However, the velocity contrast would tend to indicate this is likely related to increased weathering or fracturing of the bedrock material in this region. We only observe a very subtle decrease in the shear wave velocity of the region associated with the highly conductive feature in the resistivity results, potentially indicating this is a response to finer grained sediments in the near-surface conductive layer.

4.9 LINE 9

Figure 17 displays the resistivity and MASW model results for Line 9, which runs in a south to north direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which ranges between 30 and 50 feet thick, with a more conductive layer apparent at the base of the model results beneath this (due to the shorter length of Lines 8 to 10 the imaging depth is reduced accordingly). The closest geological logs are from boreholes S1011-SCX-030 and -024 again, which are located 140 and 320 feet along the line respectively, although are offset approximately 45 feet to the east of the line in each case. The geological logs indicate approximately 10 and 4 feet of fine-grained sediments overlying the marl bedrock respectively. We observe a good agreement with the approximate thickness of the near-surface conductive layer associated with both locations along this line, suggesting that this layer represents unconsolidated materials at the site.

The near-surface conductive layer has a consistent thickness of approximately 15 feet, between 0 and 200 feet along the line. At 200 feet along the line, the conductive layer decreases in thickness, to approximately 10 feet, with a similar thickness observed through to 260 feet along the line. The resistive layer appears to approach the ground surface between 260 and 340 feet along the line, which tends to be confirmed from the geological logs of S1011-SCX-024 located in this area. We observe what appears to be undercutting of the resistive layer along this section of the line, with conductive material apparent on the south and north sides of this shallow resistive feature, located at 275 and 345 feet along the line respectively. This potentially indicates regions within the bedrock that are less competent/more fractured. The undercutting area on the north side is associated with an increase in the conductive layer thickness, to approximately 20 feet, which extends to 370 feet along the line. The conductive layer decreases in thickness significantly between 370 and 390 feet along the line, to approximately 5 feet thick. It then gradually increases in thickness towards the end of the line at 505 feet, where it is approximately 15 feet thick.

The MASW results, associated with between 95 and 325 feet along the resistivity line, in general displays a higher shear wave velocity range than the majority of previous lines, between approximately 2,600 and 2,900 ft/sec falling within the weathered to competent bedrock category. This would tend to indicate the majority of this section of the line is representative of the limestone bedrock and correlates well to the indication that the resistive layer approaches the ground surface in this area. The main feature of this line is a near-surface lower shear-wave velocity region located between 95 and 140 feet along the line, which is likely a response to the thicker near-surface layer representing the unconsolidated materials.

4.10 LINE 10

Figure 18 displays the resistivity and MASW model results for Line 10, which runs in a south to north direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which is on average approximately 35 feet thick, with a more conductive layer apparent at the base of the model results beneath this (due to the shorter length of Lines 8 to 10 the imaging depth is reduced accordingly). There are no boreholes within proximity to Line 10.

The near-surface conductive layer has a consistent thickness between 0 and 80 feet along the line, of approximately 15 feet. Between 80 and 130 feet along the line, the conductive layer appears to increase significantly in thickness, to approximately 30 feet, before decreasing back to approximately 10 feet thickness. The conductive layer then remains a constant thickness until 400 feet along the line, where it increases gradually in thickness towards the end of the line, to approximately 15 feet thick. The exception to this trend occurs between 205 and 230 feet along the line, where the conductive layer abruptly increases in thickness to approximately 20 feet. These abrupt increases in thickness potentially indicate regions that have been excavated or alternatively relating to less competent/more fractured bedrock areas. Both of the increases in thickness described share a similar shape, and likely represent unconsolidated material in this area.

The MASW results, associated with between 80 and 315 feet along the resistivity line, in general displays two layer structure, with a higher shear-wave velocity lower layer, displaying a velocity range between approximately 2,600 and 2,900 ft/sec falling within the weathered to competent bedrock category. The upper layer display on average a lower shear-wave velocity range and tends to correlate with the conductive layer in the resistivity results, and is likely a response to the unconsolidated materials. In addition, the thinning of the near-surface conductive layer between 130 and 280 feet along the line in the resistivity results tends to correlate with an increase in the shear-wave velocity of the near-surface layer in the MASW results. This would suggest the bedrock again is approaching the ground surface as with previous lines, potentially indicating a bedrock high or ridge in this area.

4.11 LINE 11

Figure 19 displays the resistivity and MASW model results for Line 11, which runs in a west to east direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which ranges between 40 and 65 feet thick, with a more conductive layer apparent at the base of the model results beneath this (due to the shorter length of Lines 11 to 13 the imaging depth is reduced accordingly). The closest geological log is from borehole S1011-SCX-036, which is located 360 feet along the line, which indicates approximately 4 feet of fine-grained sediments overlying the marl bedrock. The depth to bedrock does not correlates well to the approximate thickness of the near-surface conductive layer in these locations, which tends to indicate approximately 20 feet of fine-grained sediments. This discrepancy could be related to the bedrock material, as with previous survey lines where the bedrock is indicated to be marl it is potentially more conductive than the limestone based on texture of the materials. Alternatively, since the borehole does not coincide directly with the survey line and the bedrock topography has been observed to vary significantly over short distances, this could lead to these discrepancies.

The near-surface conductive layer is approximately 7 to 10 feet thick between 0 and 220 feet along the line, and based on the location likely corresponds to unconsolidated materials overlying the bedrock. Between 220 and 280 feet along the line, the conductive layer increases in thickness to approximately 25 feet. This region also corresponds to a significant conductive break in the underlying resistive layer, extending between 235 and 260 feet along the line. Again, this break could indicate regions of less competent/more fractured bedrock, or represent a fault trace in the near surface. From 280 to 425 feet along the line, the conductive layer increases in thickness, to approximately 30 feet, before gradually decreasing in thickness towards the end of line, where it is approximately 15 feet thick. Line 11 crosses close to the open shaft at 400 feet along the line, approximately 15 feet to the south of the fenced enclosure. This location corresponds to a more conductive feature in the near-surface layer, at a depth of approximately 20 feet (bgs). While this is not the anticipated response for an air-filled void it could relate to enhanced moisture in the subsurface around this shaft based on run off of precipitation and drainage down the shaft, or relate to collapsed or backfilled mine workings leading off the shaft that contain finer gained material or enhanced moisture content based on porosity.

The MASW results, associated with between 70 and 480 feet along the resistivity line, in general displays a shear-wave velocity range between approximately 2,300 to 2,600 ft/sec, falling into the dense soil or weathered bedrock category. A near-surface lower velocity region is observed between 280 and 480 feet along the line, with the velocity contrast likely indicating unconsolidated materials, which correlates well to the thickening of the conductive layer observed in the resistivity results.

4.12 LINE 12

Figure 20 displays the resistivity and MASW model results for Line 12, which runs in a west to east direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which ranges between 30 and 60 feet thick, with a more conductive layer apparent at the base of the model results beneath this (due to the shorter length of Lines 11 to 13 the imaging depth is reduced accordingly). The geological logs from boreholes S1011-SCX-035, -034, and -021, which are located approximately 395, 600, and 660 feet along the line respectively, indicate approximately 17, 12, and 18 feet of fine-grained sediments overlying the marl and limestone bedrock. In general, we observe a good agreement with the approximate thickness of the near-surface conductive layer associated with the first two borehole locations along this line, suggesting that this layer represents unconsolidated materials at the site. We do not have coverage for the location of S1011-SCX-021 due to the position towards the end of the line, where the imaging depth is limited.

The near-surface conductive layer is approximately 5 to 8 feet thick between 0 and 290 feet along the line, and based on the location likely corresponds to unconsolidated materials overlying the bedrock. At 290 feet along the line, there is an abrupt increase in the thickness of the conductive layer, to approximately 30 feet. This region corresponds to a significant conductive break in the underlying resistive layer, extending between 290 and 315 feet along the line. Again, this break could indicate regions of less competent/more fractured bedrock, or based on the offset of the resistive layer could represent a fault trace in the near surface, similar to the conductive break observed in Line 11. Between 290 and 410 feet along the line, the conductive layer remains approximately 30 feet in thickness, before decreasing to approximately 20 feet in thickness between 410 and 540 feet along the line. At 540 feet along the line, the conductive layer begins to decrease in thickness, to approximately 10 feet thick at 575 feet along the line, before appearing to increase in thickness towards the end of the line. The section of the conductive layer between 415 and 550 feet along the line appears highly conductive, compared to the surrounding regions. This could be a response to an area of finer grained material, potentially clay rich sediments, or alternatively a region of increased soil moisture.

The MASW results, associated with between 270 and 505 feet along the resistivity line, in general displays a homogeneous shear-wave velocity above approximately 350 feet along the profile, with a anomalously low velocity below this. The MASW results did not converge well for this inversion model run, relating to the poor data quality of the shot points along this line, and consequently our confidence in the structure tends to be low for this survey line.

4.13 LINE 13

Figure 21 displays the resistivity and MASW model results for Line 13, which runs in a west to east direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which appears on average approximately 65 feet thick, with a more conductive layer apparent at the base of the model results beneath this (due to the shorter length of Lines 11 to 13 the imaging depth is reduced accordingly). There are no boreholes within proximity to Line 13.

The near-surface conductive layer is approximately 15 feet thick between 0 and 75 feet along the line. It gradually increases in thickness between 75 and 215 feet along the line, to a maximum thickness of 25 feet, where it remains between 20 and 25 feet thick along the remainder of the survey line. The one exception is between 285 and 325 feet along the line, where a bedrock ridge type feature decreases the conductive layer thickness to approximately 15 feet. A significant conductive break in the underlying resistive layer is observed extending between approximately 400 and 450 feet along the line. This may relate to regions of less competent/more fractured bedrock or represent a fault trace in the near surface, although we do not observe any offset in the resistive layer for this survey line. The section of the conductive layer between approximately 520 feet along the line and the end of the line appears highly conductive, compared to the surrounding regions. This could be a response to an area of finer grained material, potentially clay rich sediments, or alternatively a region of increased soil moisture.

The MASW results, associated with between 270 and 505 feet along the resistivity line, in general displays a homogeneous shear wave velocity model, with a very narrow range of between 2,400 and 2,600 ft/sec, falling into the dense soil or weathered bedrock category. There is a subtle decrease in shear wave velocity at around 410 feet along the profile, which correlates to the conductive break in the resistive layer of the resistivity model results. This would tend to confirm this features is related to a higher degree of fracturing in the bedrock or a fault location, where the competency of the bedrock is likely reduced.

Figure 8. Survey Layout for the Electrical Resistivity and MASW, with the Drilling Location Overlaid.

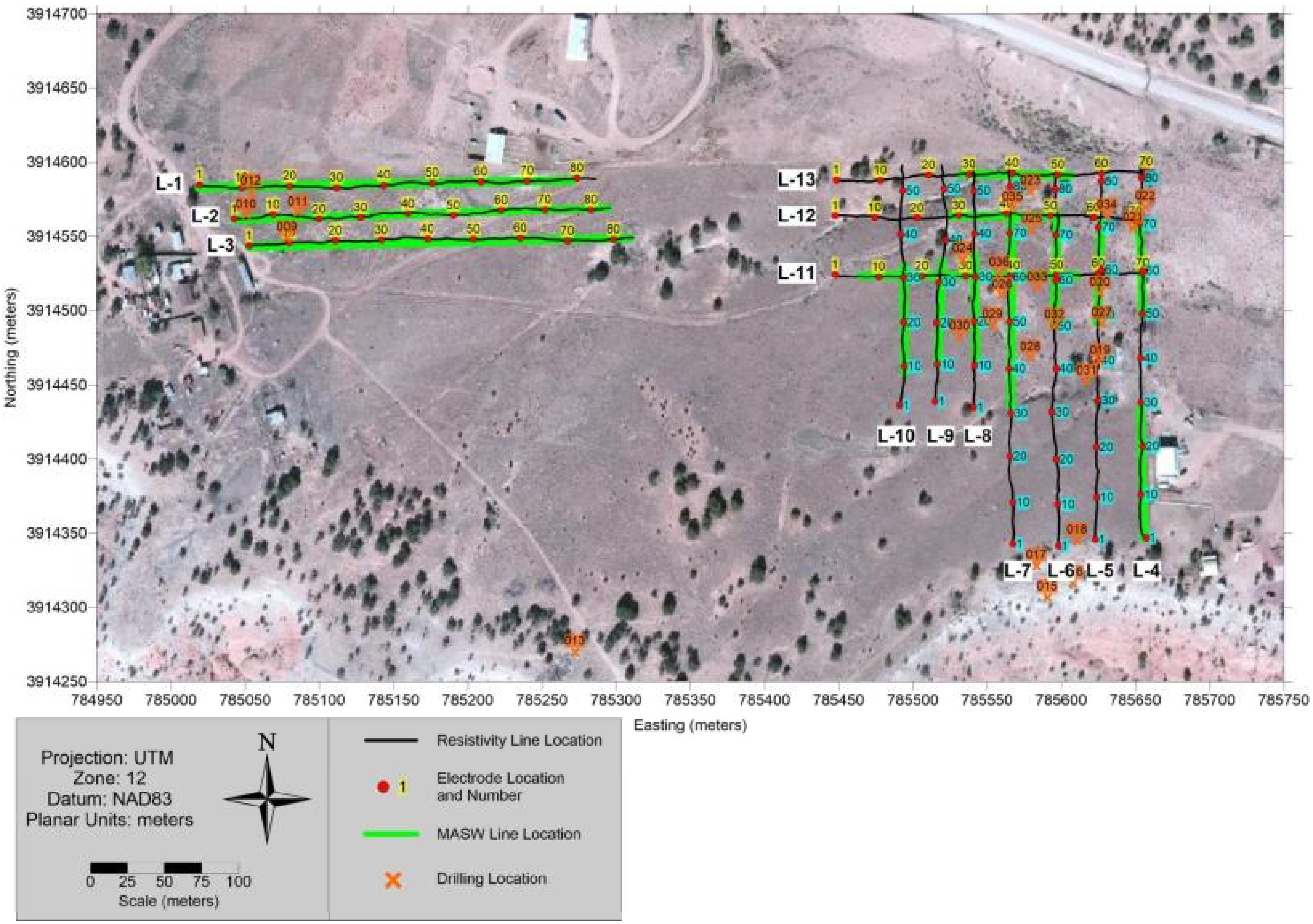


Figure 9. Line 1 Electrical Resistivity and MASW Model Results.

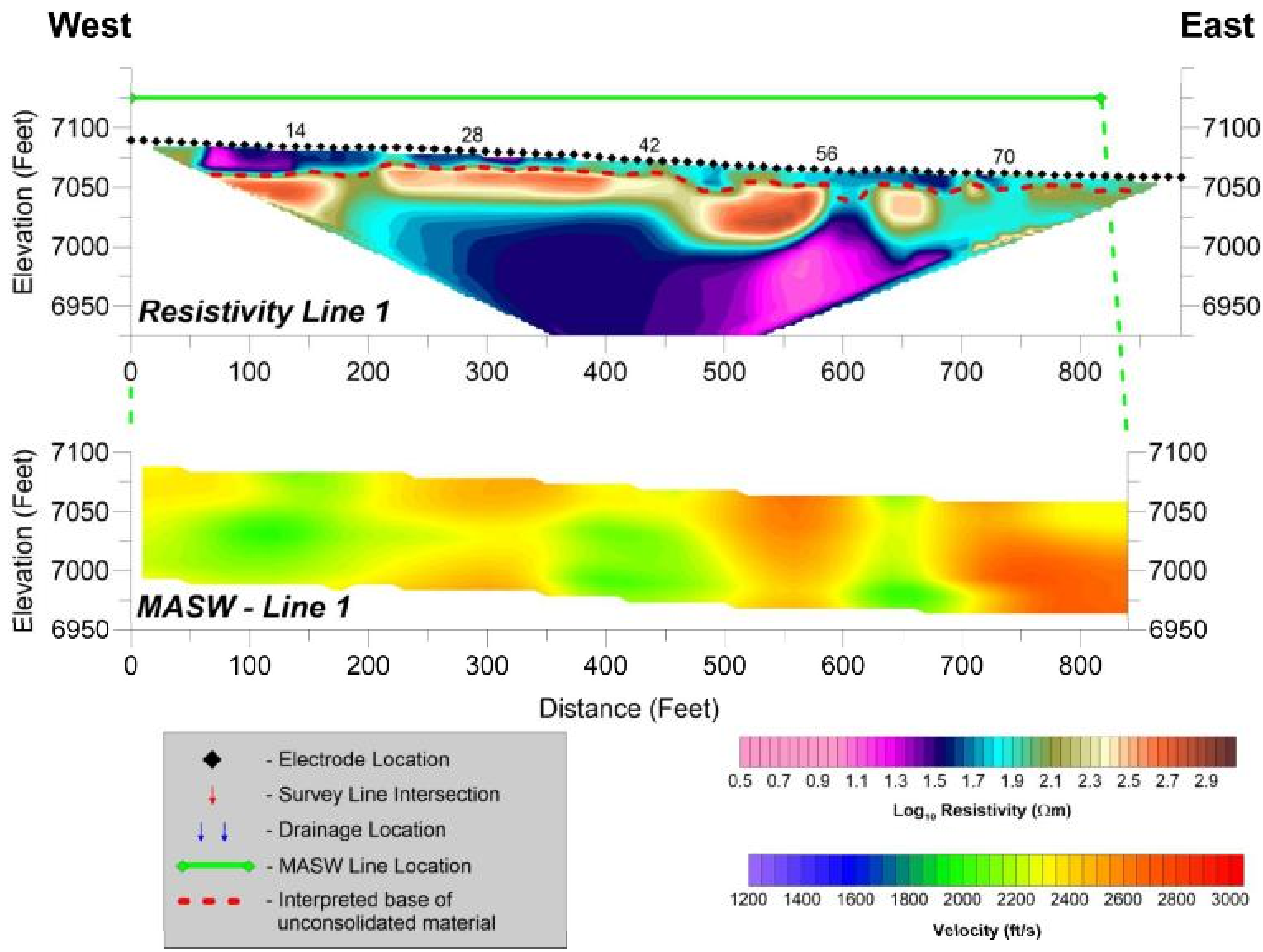


Figure 10. Line 2 Electrical Resistivity and MASW Model Results.

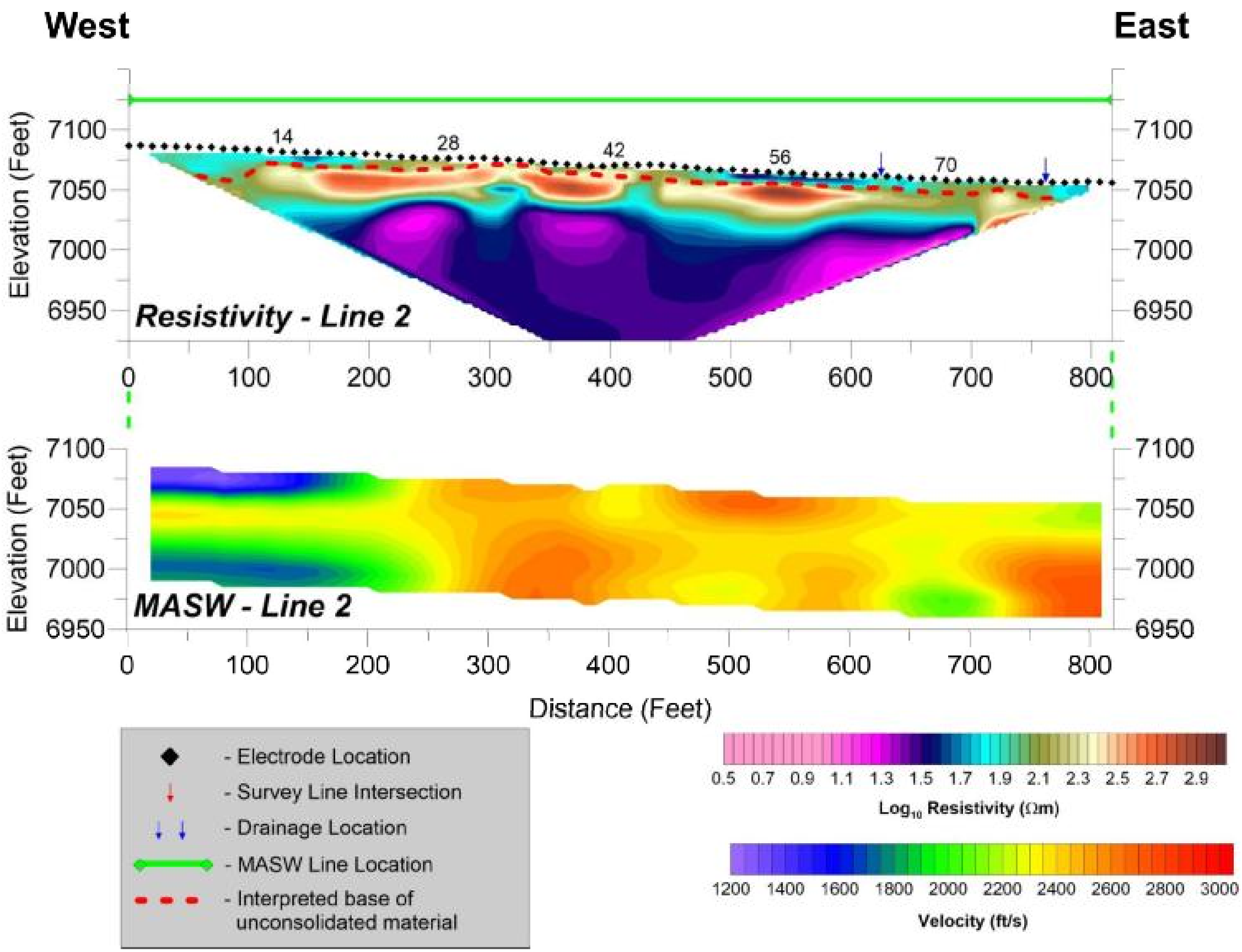


Figure 11. Line 3 Electrical Resistivity and MASW Model Results.

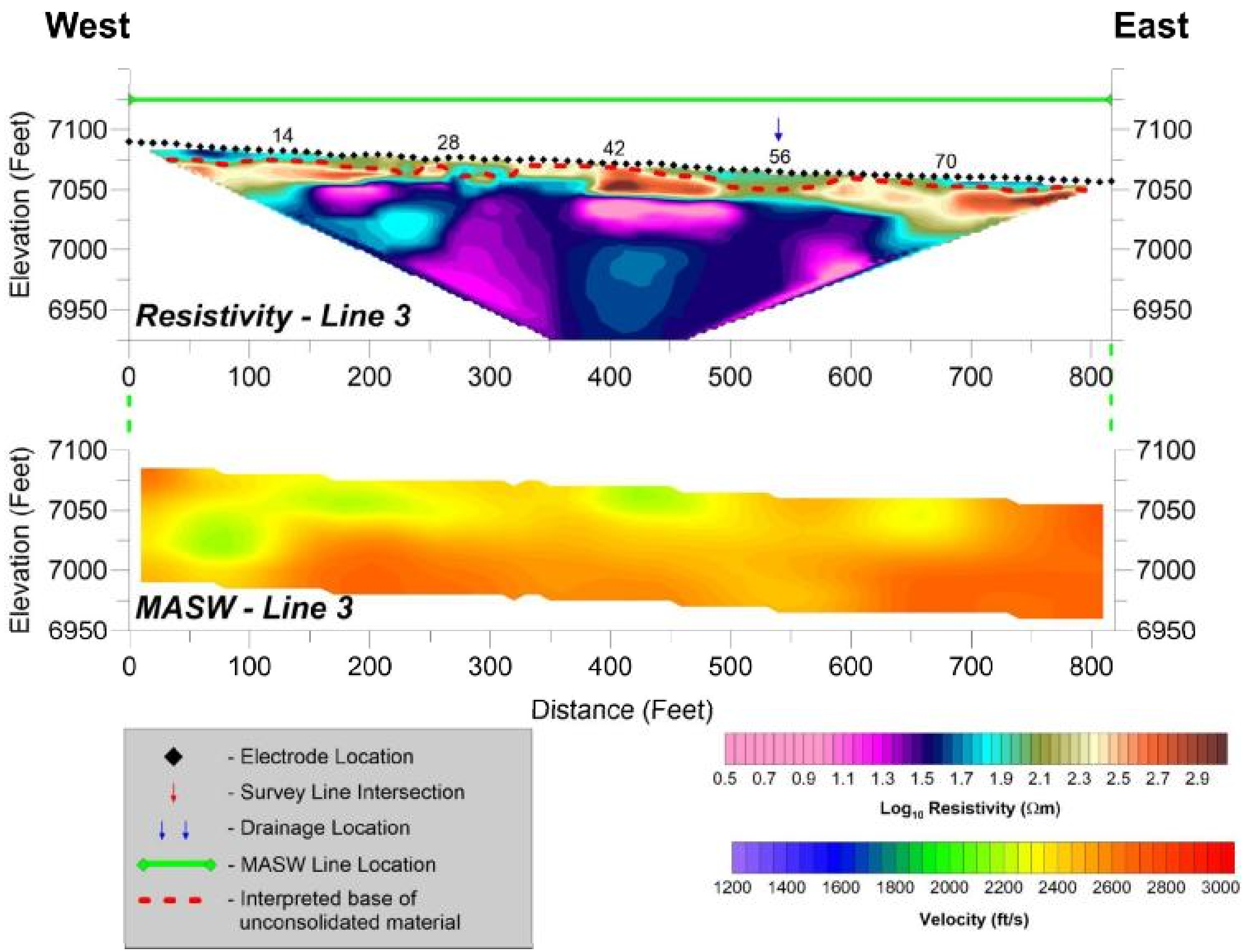


Figure 12. Line 4 Electrical Resistivity and MASW Model Results.

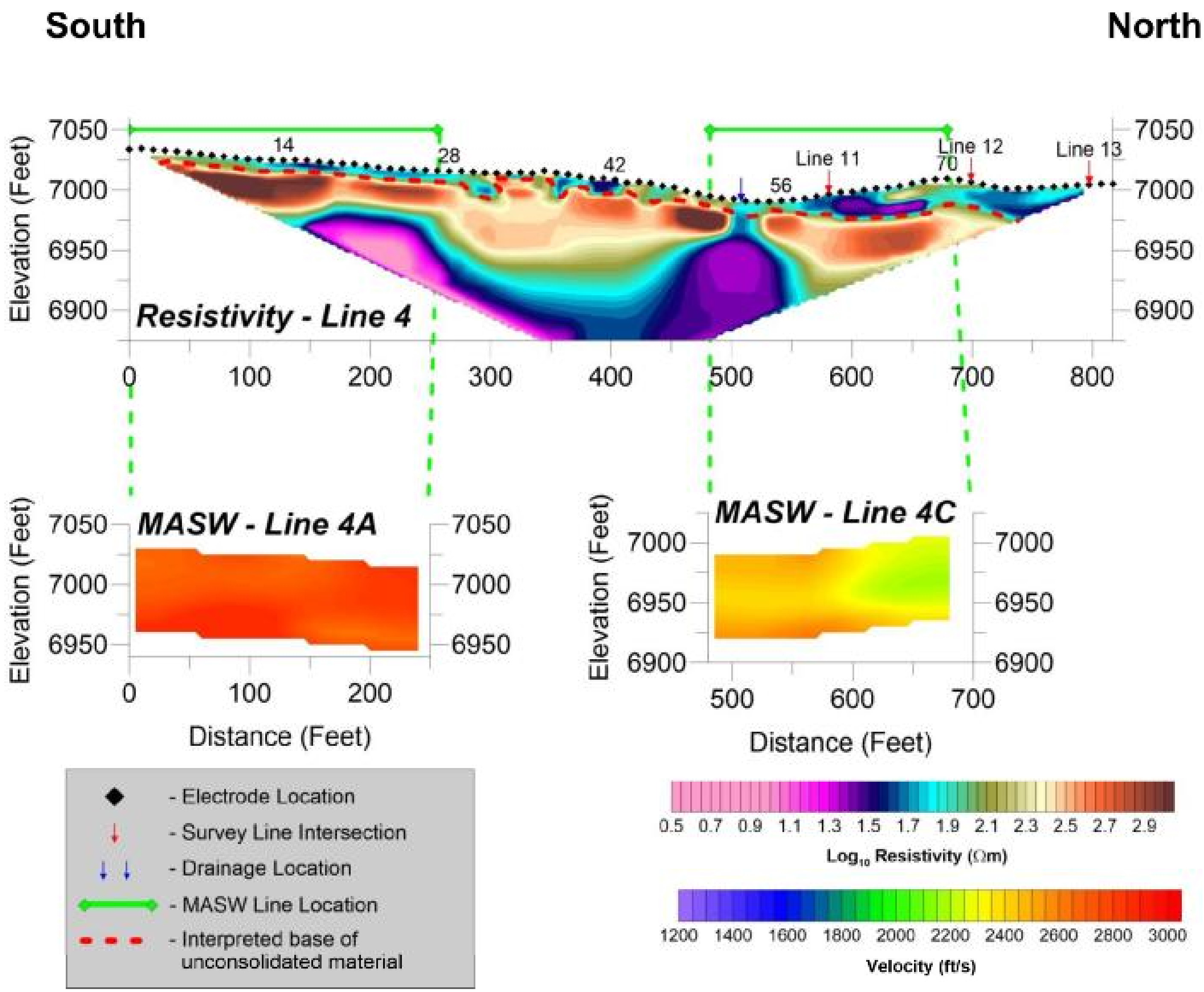


Figure 13. Line 5 Electrical Resistivity and MASW Model Results.

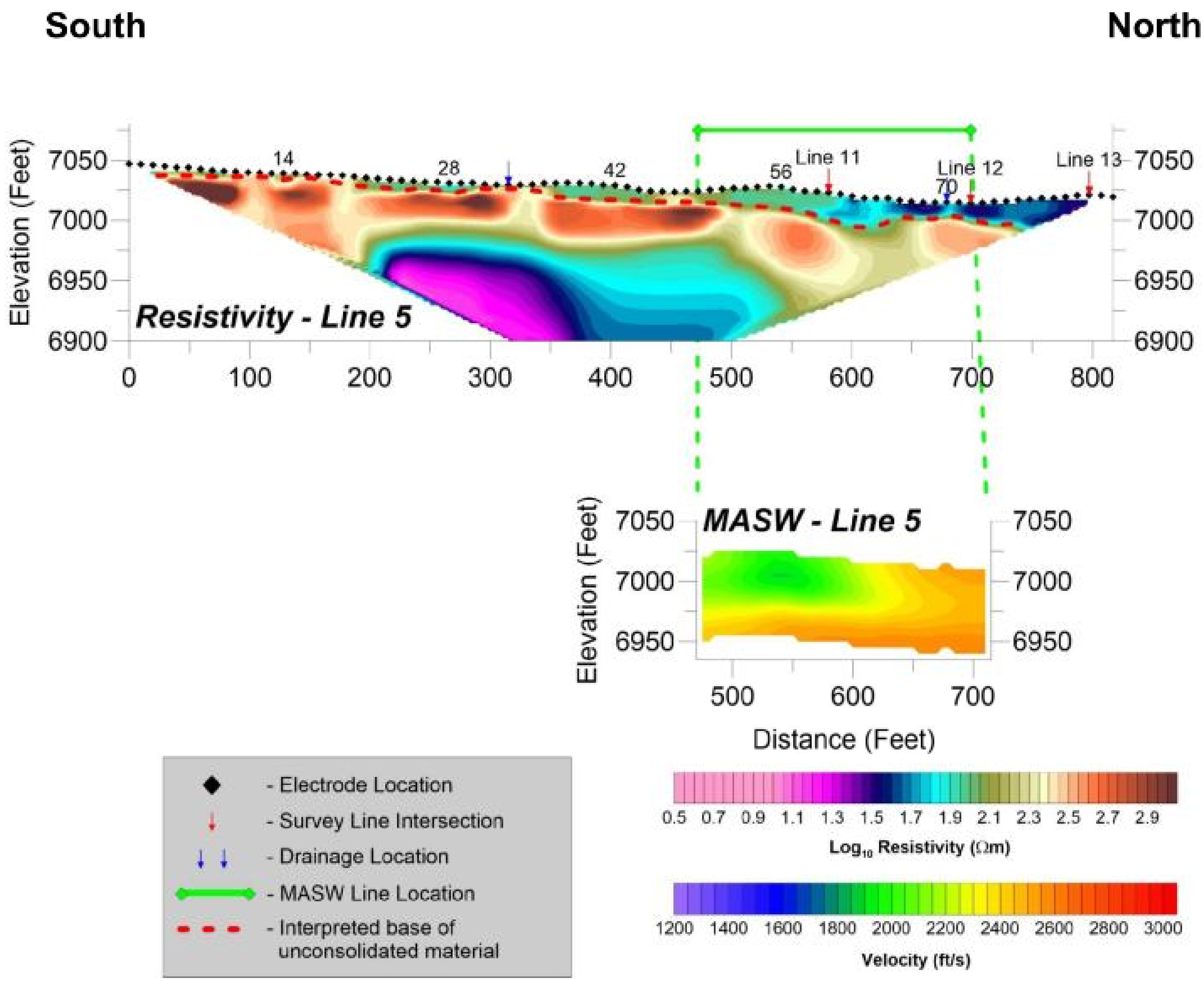


Figure 14. Line 6 Electrical Resistivity and MASW Model Results.

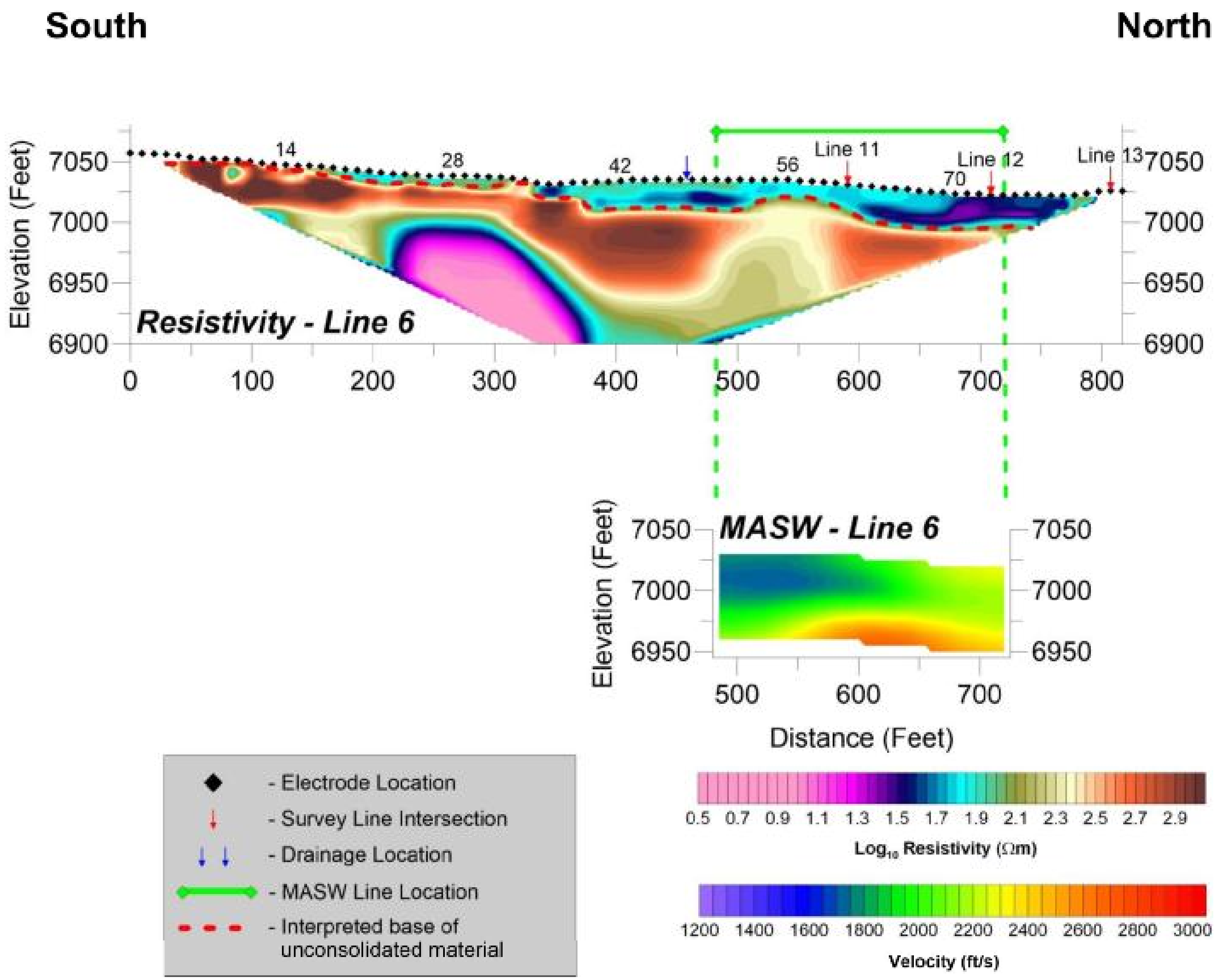


Figure 15. Line 7 Electrical Resistivity and MASW Model Results.

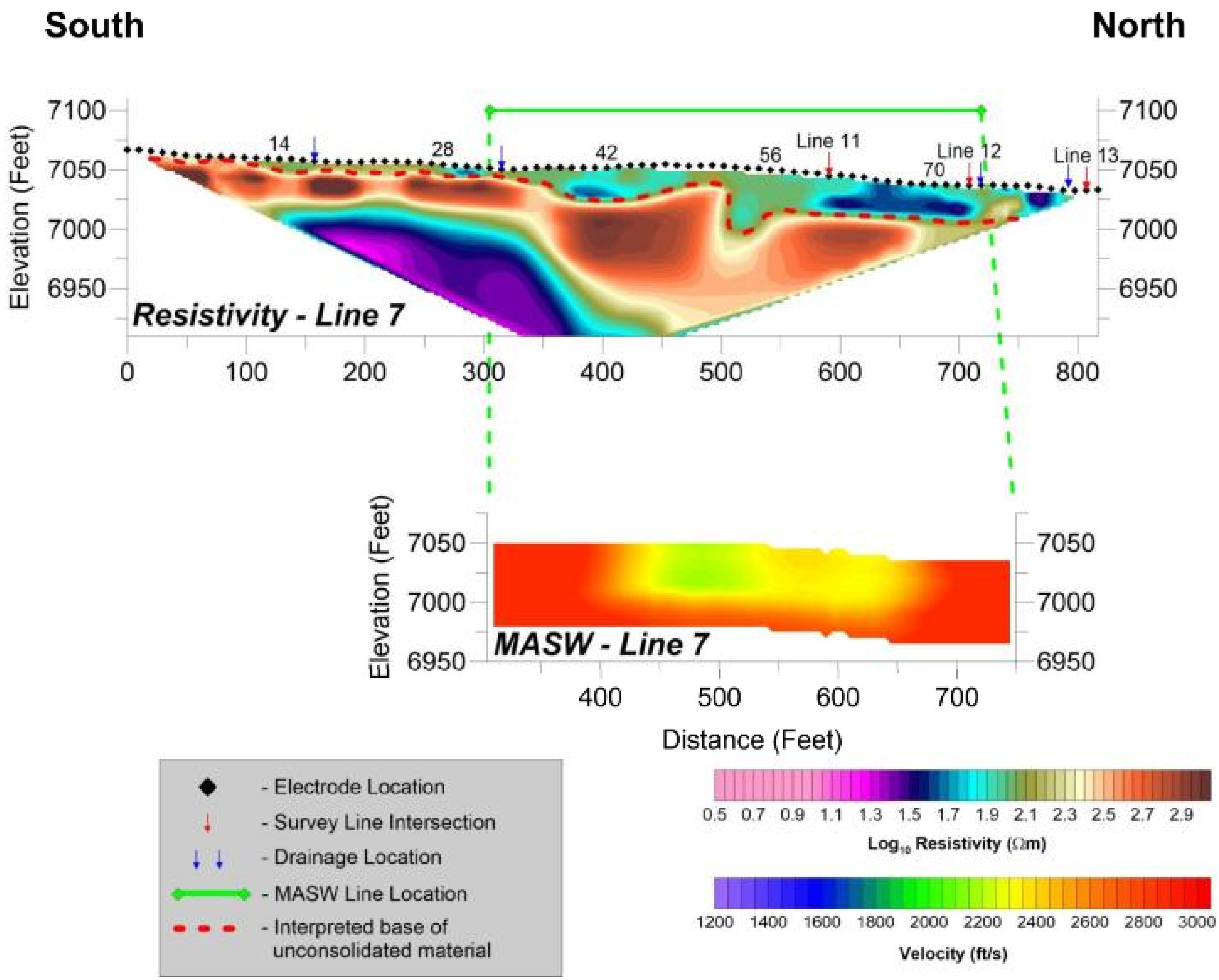


Figure 16. Line 8 Electrical Resistivity and MASW Model Results.

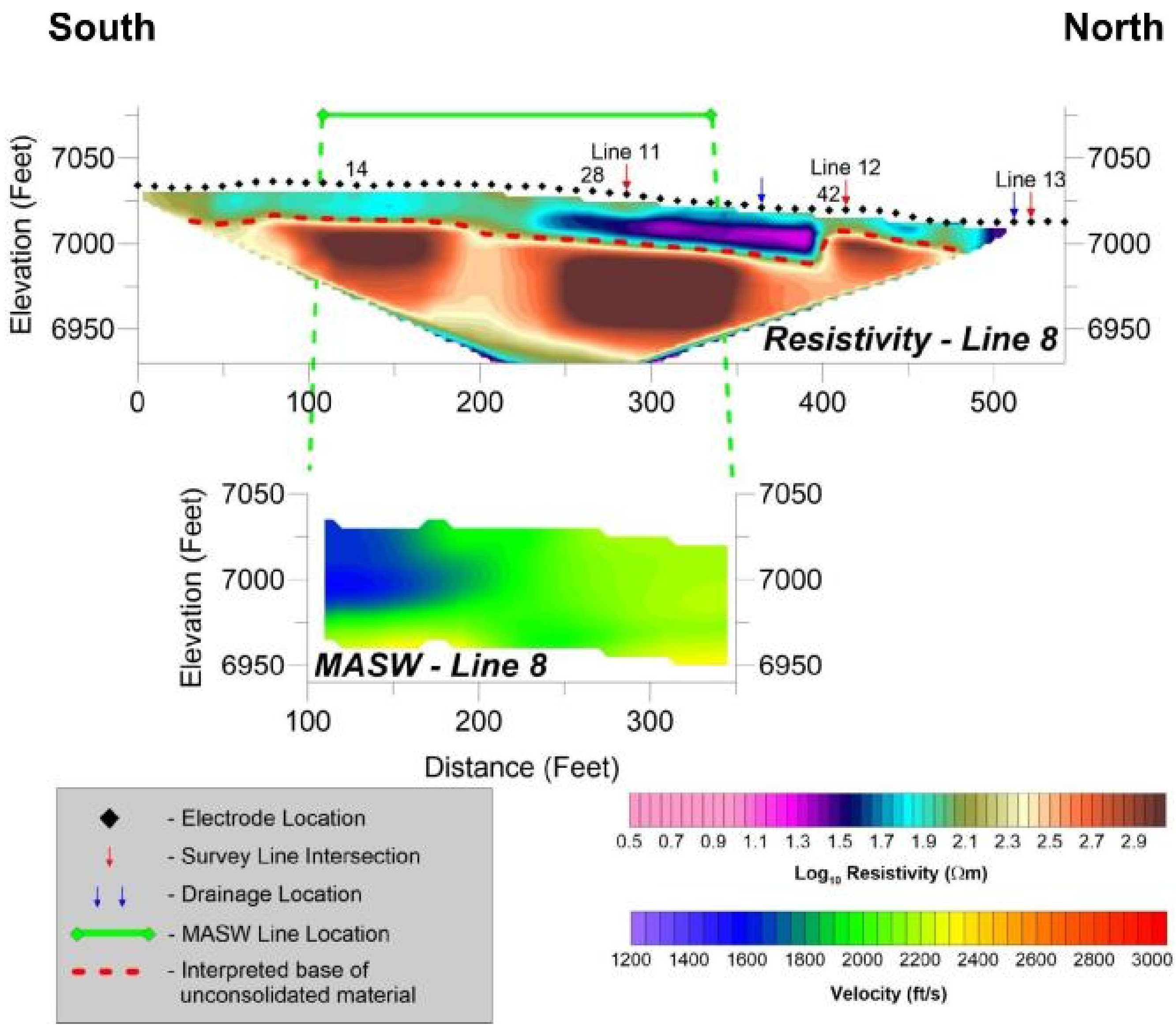


Figure 17. Line 9 Electrical Resistivity and MASW Model Results.

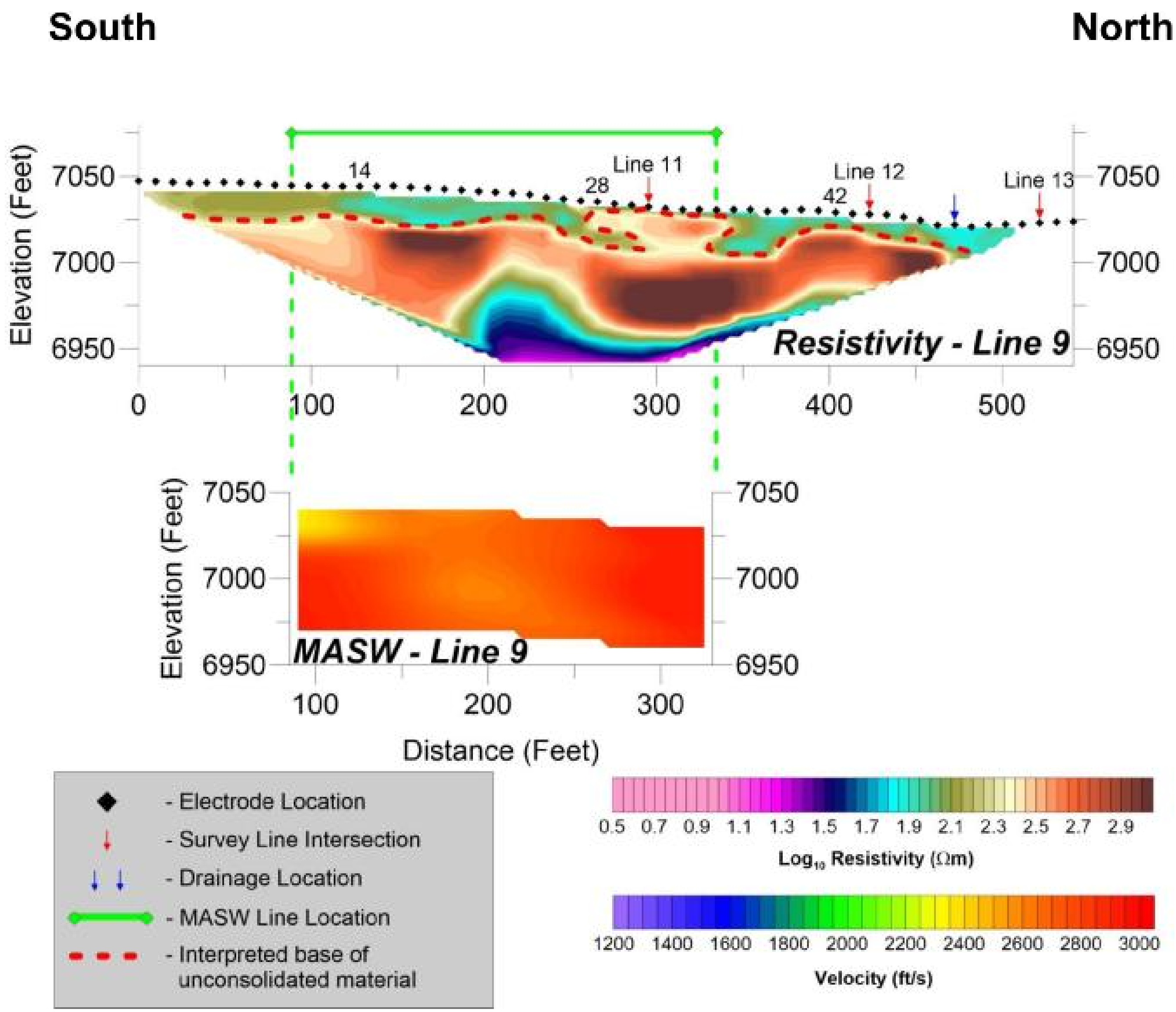


Figure 18. Line 10 Electrical Resistivity and MASW Model Results.

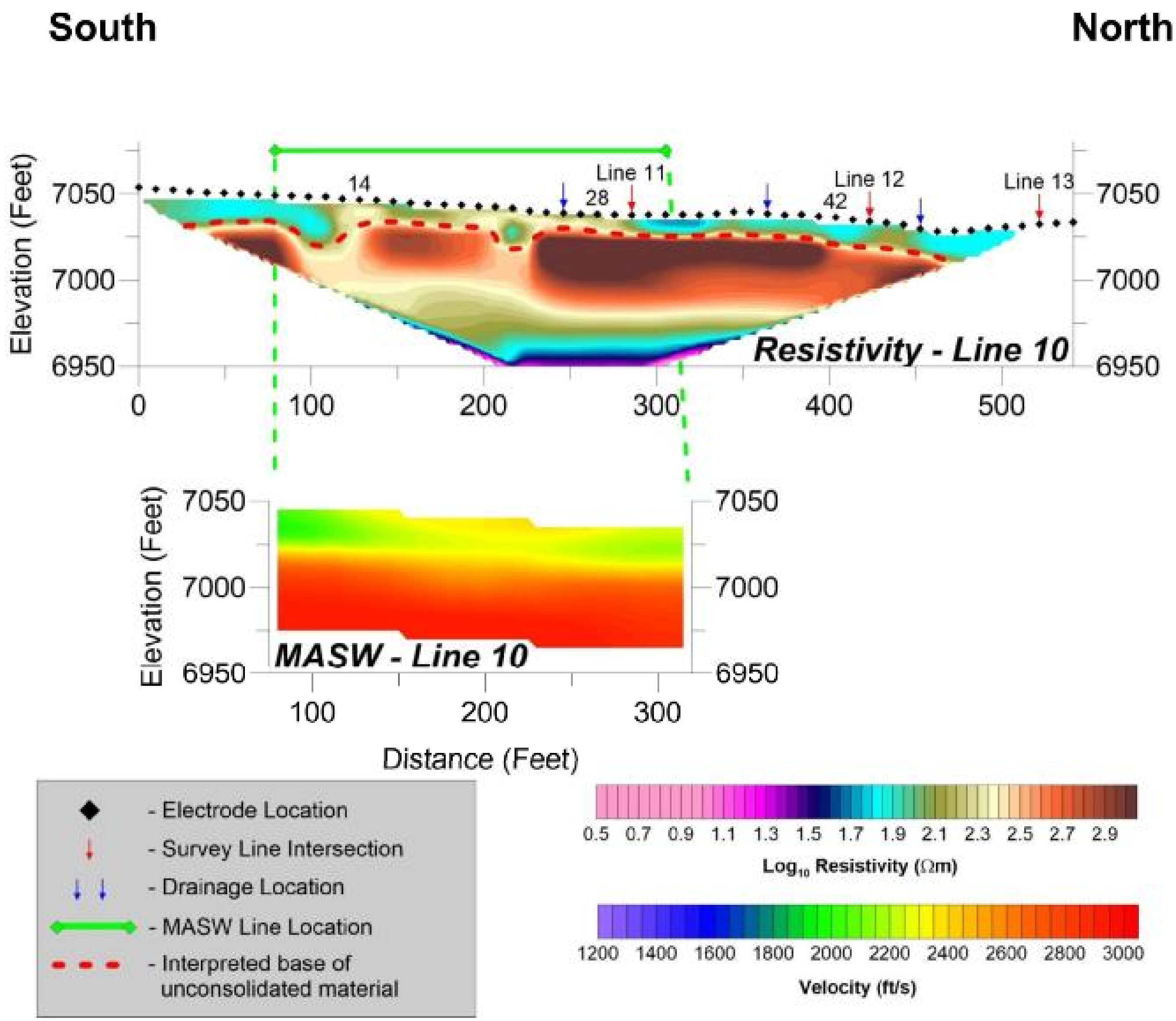


Figure 19. Line 11 Electrical Resistivity and MASW Model Results.

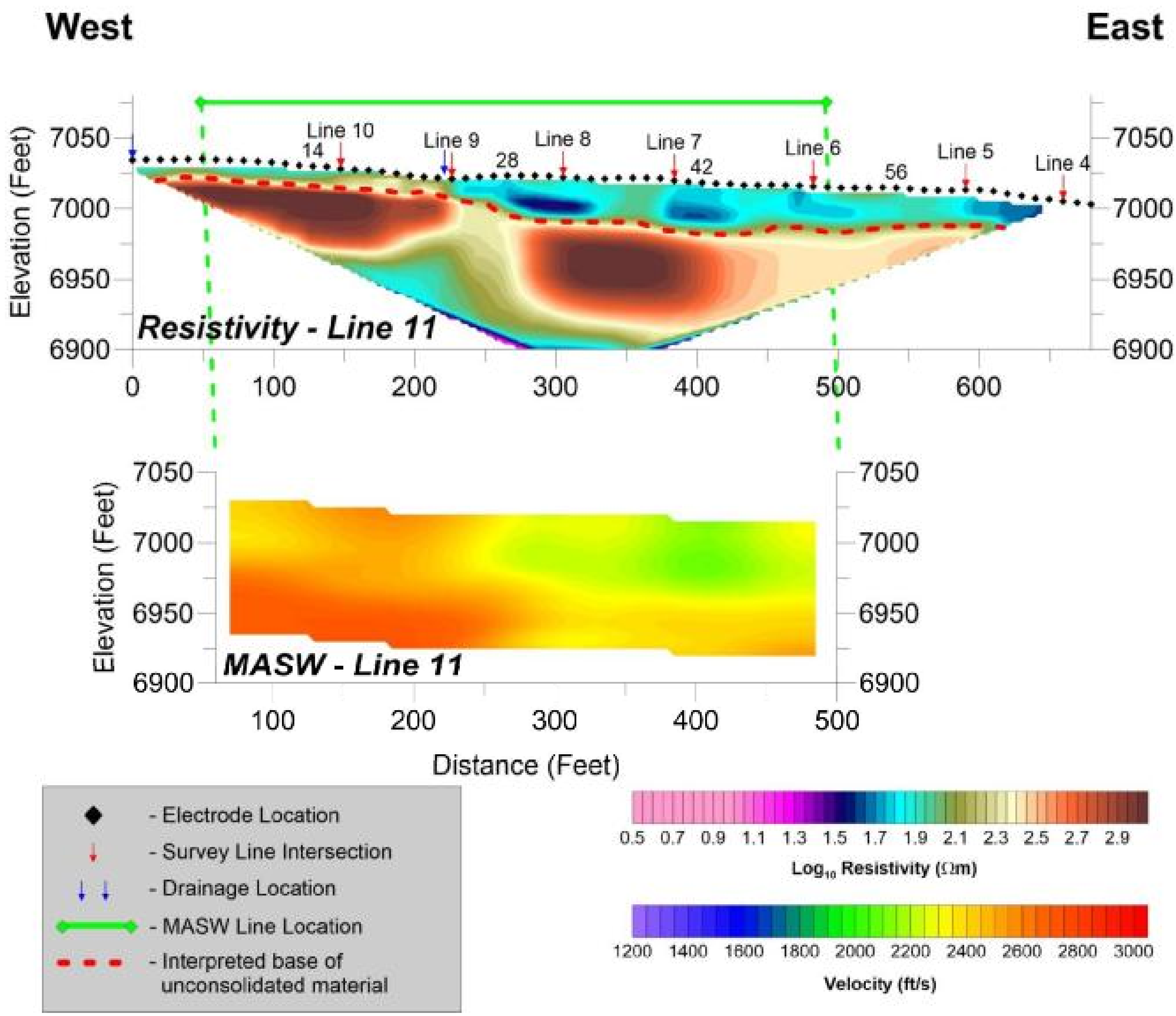


Figure 20. Line 12 Electrical Resistivity and MASW Model Results.

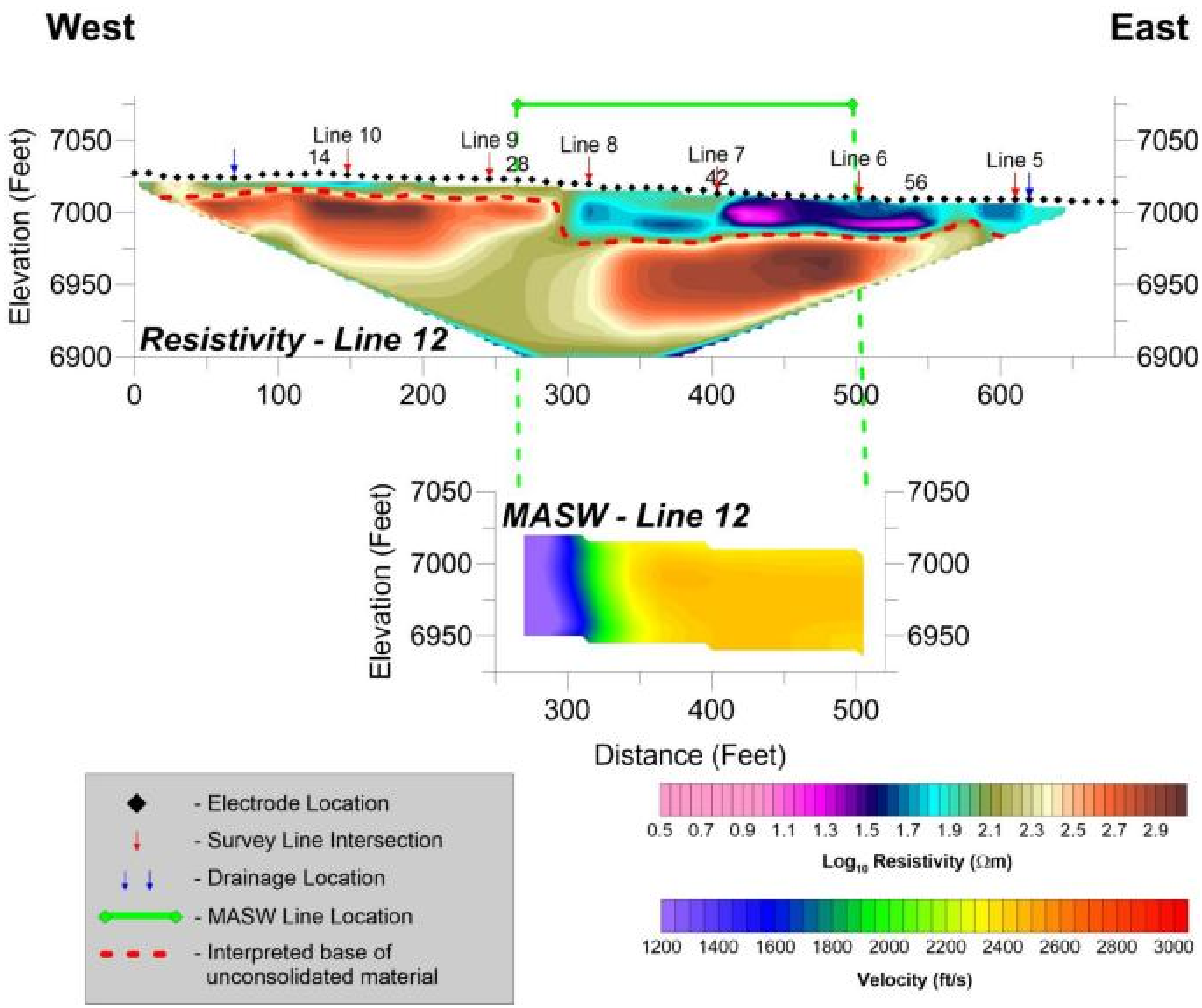
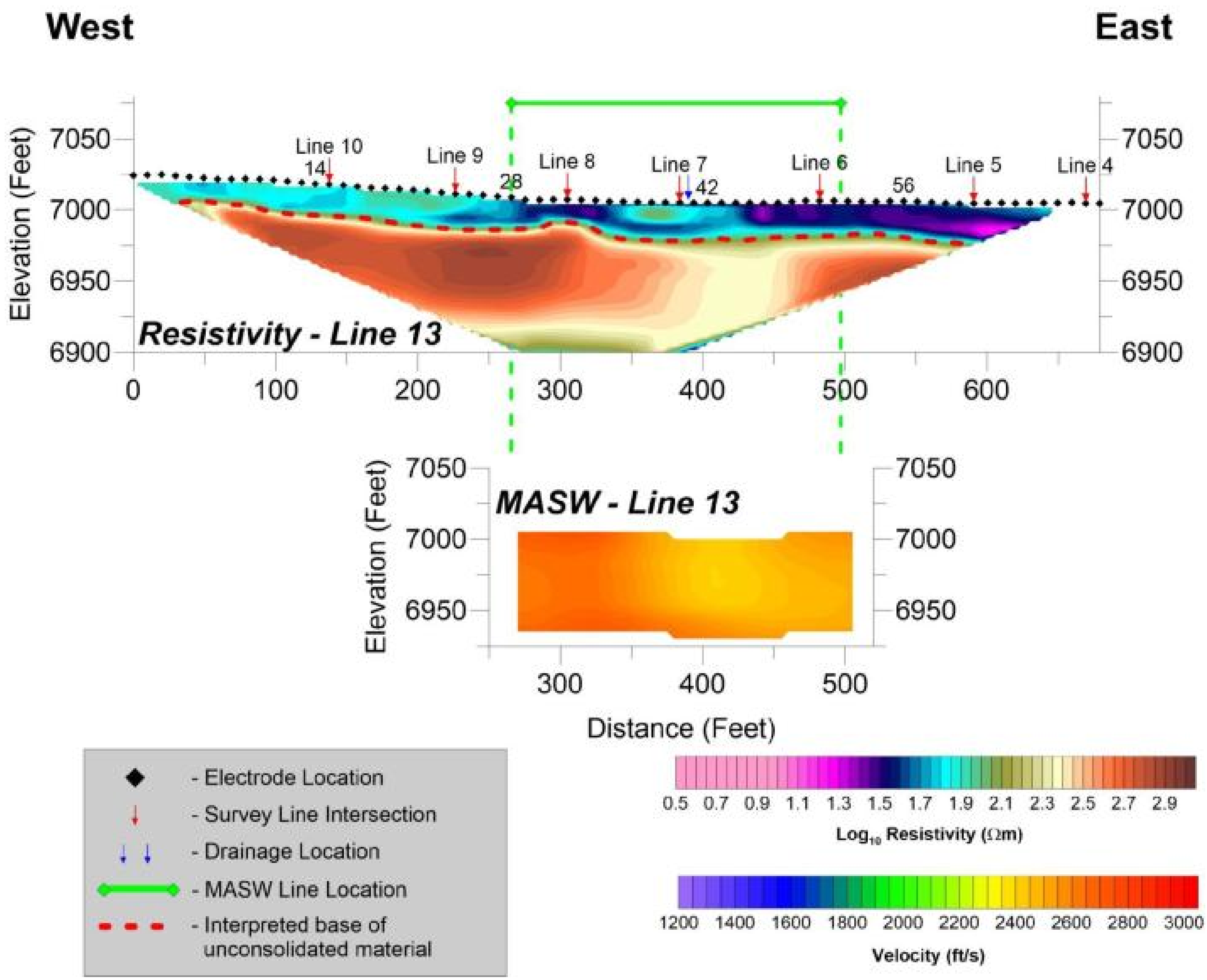


Figure 21. Line 13 Electrical Resistivity and MASW Model Results.



5.0 SUMMARY

Geophysical characterization, which included thirteen coincident lines of electrical resistivity and multi-channel analysis of surface waves (MASW), was completed at the Section 26 Site. Data were acquired between the 12th and 19th of June, 2017.

The objectives of the geophysical investigation were to determine the presence of any underlying void spaces and thickness of historic mining material overlying the bedrock at the site.

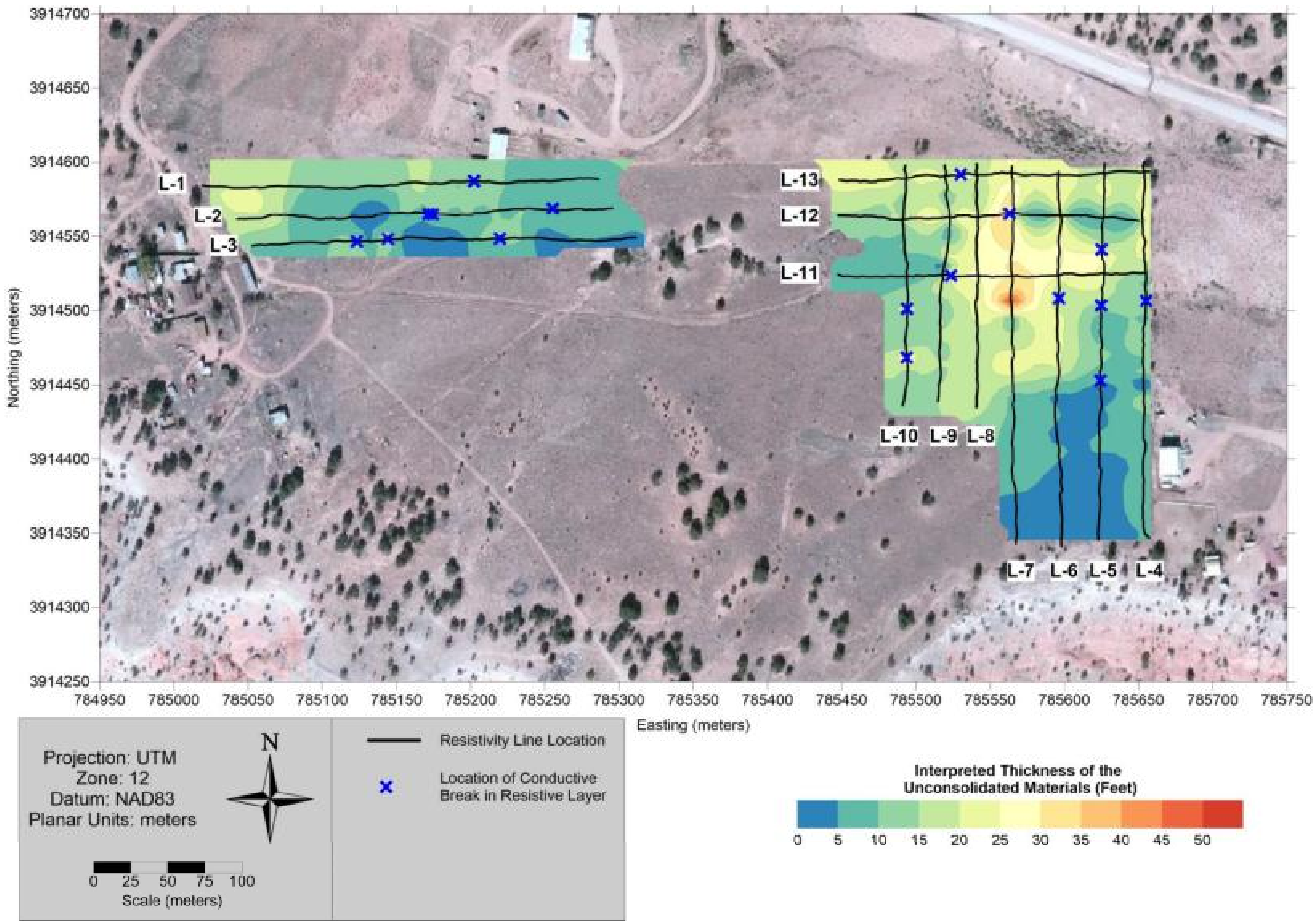
In summary;

- There were no significant features within the electrical resistivity or MASW model results that would indicate the presence of air-filled voids associated with historic mine workings or shafts across the site. We do observe a number of highly conductive features in the electrical resistivity lines that align with the fenced enclosure surrounding the open mine shaft in the eastern area of the site. These were observed in Lines 7, 8, 11, and potentially 12. While the conductive nature of these features precludes air-filled voids, they could be associated with backfilled or collapsed mine workings associated with the open shaft. Alternatively, and potentially more likely is that the open shaft is acting as a conduit for infiltration, leading to increased moisture content in the sediments surrounding this area. The increased moisture content would decrease the resistivity value of the affected sediments, compared to the surrounding materials. Only one of these conductive features, in Line 7, correlates to a decrease in shear-wave velocity, as we might expect for backfilled or collapsed workings. This would lead us to conclude the likely cause of the conductive features relates to an increase in soil moisture or finer grained material in these regions.
- The electrical resistivity model results displayed a similar structure for each survey line, with a near-surface conductive layer interpreted to represent the native soil cover or possibly fill material associated with the historic mining activities. This overlies a resistive layer, which was interpreted to represent the upper limestone or marl bedrock unit, with a more conductive layer extending to the depth limits of the model beneath this. In general, the near-surface layer displayed lower shear-wave velocities, relating to the unconsolidated soils or fill material, in the MASW model results. The thickness of the near-surface layer associated with the native soil or historic mining activity was estimated along each survey line, with the contoured results presented in Figure 22. As previously stated, it was not possible to differentiate between the native soils and the fill material associated with the mining geophysically. However, we can see that in general the areas where known mining activity took place, for example the northeastern area of site from historic aerial photographs, we observe much greater thicknesses of fill

material. In contrast, the undisturbed soils tend to have a smaller thickness (for example <10 feet). This information can be used to provide an estimate of the volume of the fill material associated with the historic uranium mining at the site.

- An additional feature of interest in the model results was related to the conductive breaks observed in the resistive layer, representing the limestone or marl bedrock layer, the locations of which are highlighted in Figure 22. It is likely these are related to increased weathering or highly fractured regions of the bedrock material, either allowing for increased moisture content in the bedrock or finer grained material based on the breakdown of the bedrock.

Figure 22. Interpreted Thickness of the Unconsolidated Materials at the Section 26 Site.



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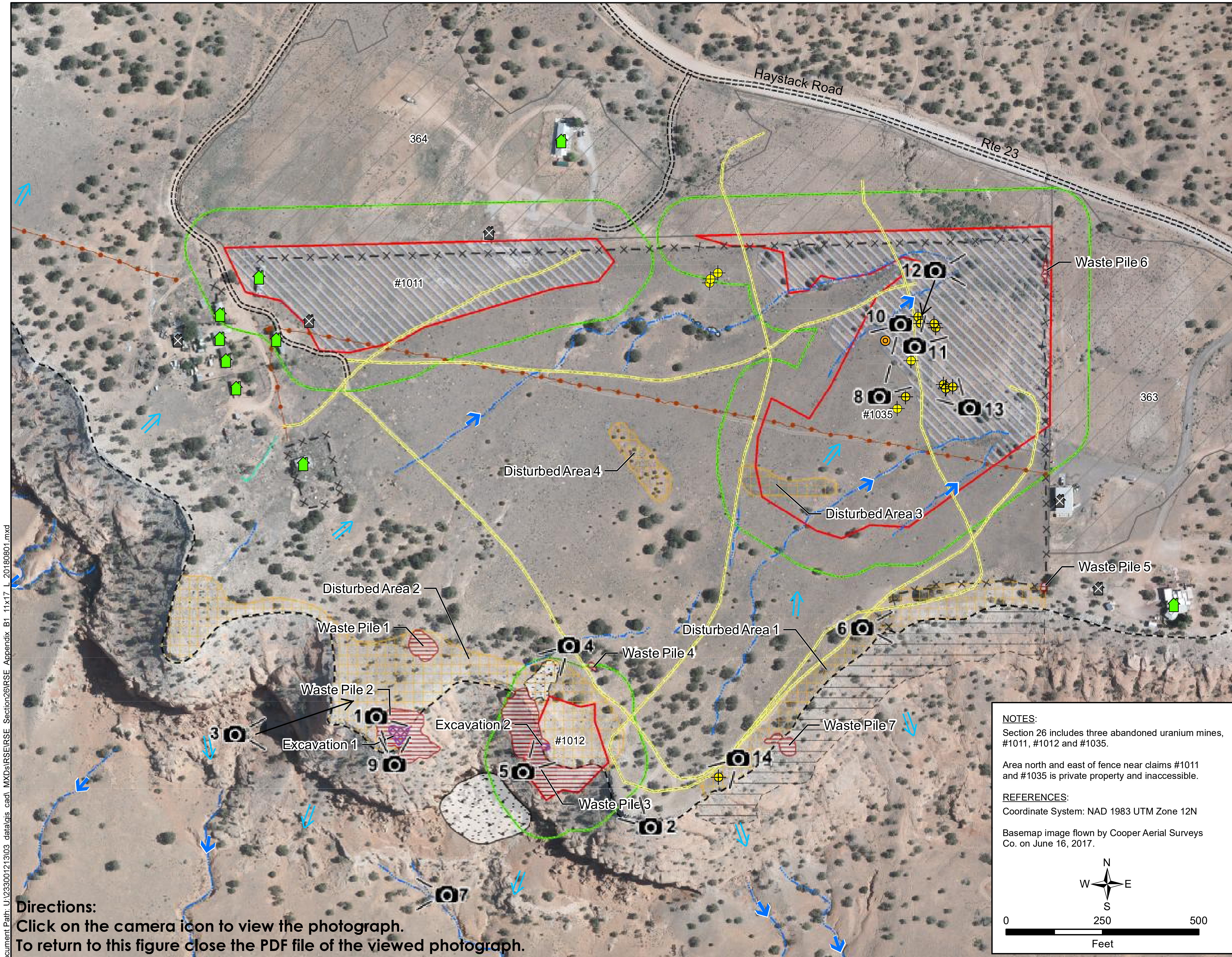
Appendix B Site Photographs

B.1 Site Photographs

B.2 Regional Photographs

NAVAJO NATION
AUM Environmental Response Trust-First Phase



NOTES:

Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

Area north and east of fence near claims #1011 and #1035 is private property and inaccessible.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

LEGEND

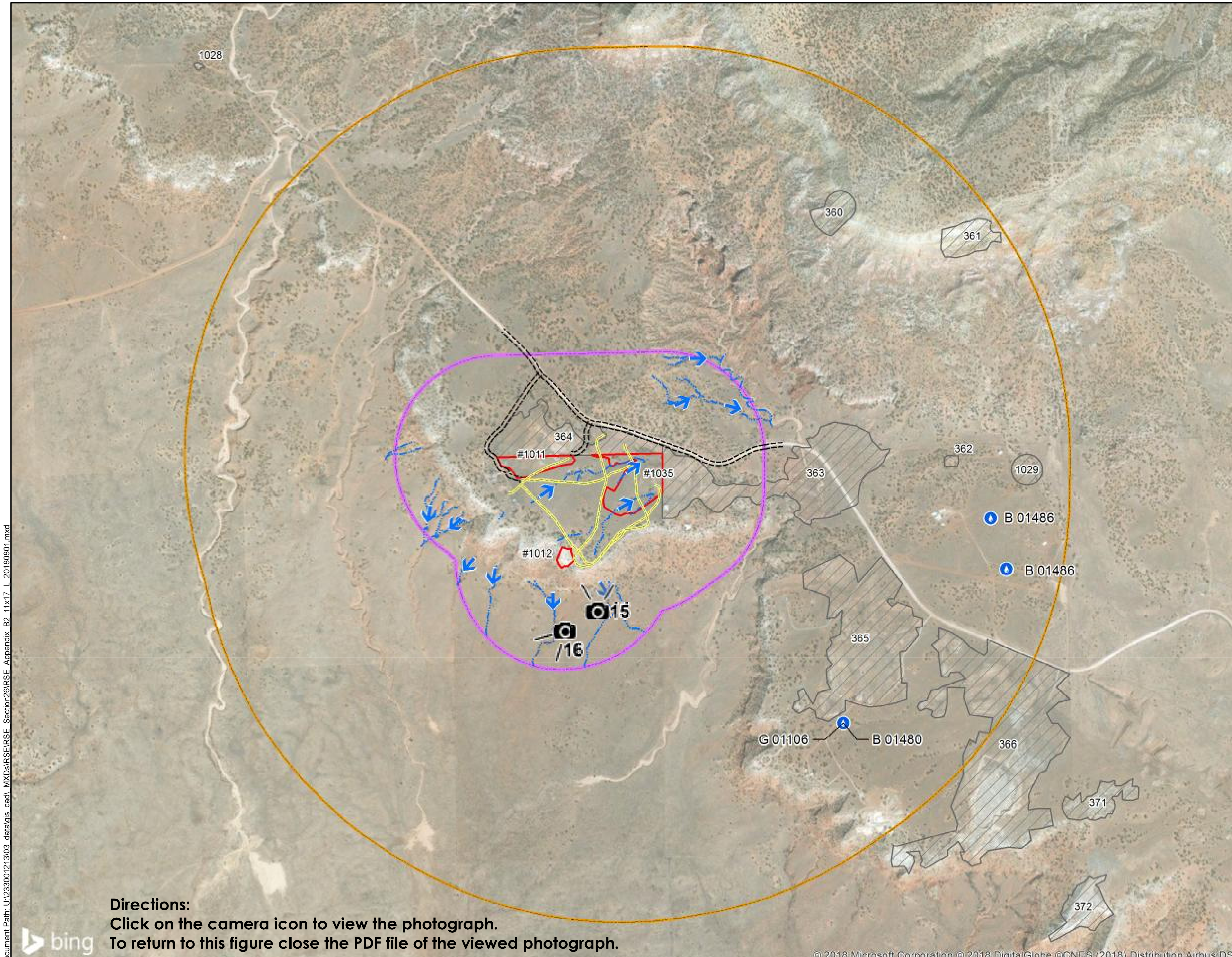
- Photograph Indicating Direction Taken
- Habitable Building
- Uninhabitable Building
- Possible Portal or Storage
- Historical Borehole
- Flow Direction
- Approximate Overland Water Flow Direction
- Drainage
- Fence
- Potential Haul Road
- Power Line
- Road
- Water Line
- Approximate Edge of Mesa
- Debris
- Excavation
- Graded / Disturbed Reclaimed Area
- Potential Mining Disturbed
- Potential Waste Rock
- Waste Pile
- Vertical Mine Shafts
- Claim Boundary
- 100-Foot Claim Buffer
- Other Claim Boundary

TITLE: Site Photographs

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 8/2/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: B-1	

Document Path: U:\123300121\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Appendix_B1_11x17_L_20180801.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Photograph Indicating Direction Taken
- Site Clearance Identified Water Feature[1]
- Flow Direction
- Drainage
- Potential Haul Road
- Road
- Claim Boundary
- 1/4-Mile Claim Boundary Buffer
- 1-Mile Claim Boundary Buffer
- Other Claim Boundary

NOTES:

1. Water features and identification names identified in 2007 AUM Atlas.

2. Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

N S W E

0 1,250 2,500
Feet

TITLE: Regional Site Photographs

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 8/2/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: B-2

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE\RSE_Section26\RSE_Appendix_B2_11x17_L_20180801.mxd

Appendix C Field Activity Forms

C.1 Soil Sample Field Forms

C.2 Drilling and Hand Auger Borehole Logs

C.1 Soil Sample Field Forms

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG1-001

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1030

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS Sunny windy, 20°

FIELD USCS DESCRIPTIONS Gray silty sand, minor clay, trace m/f sands

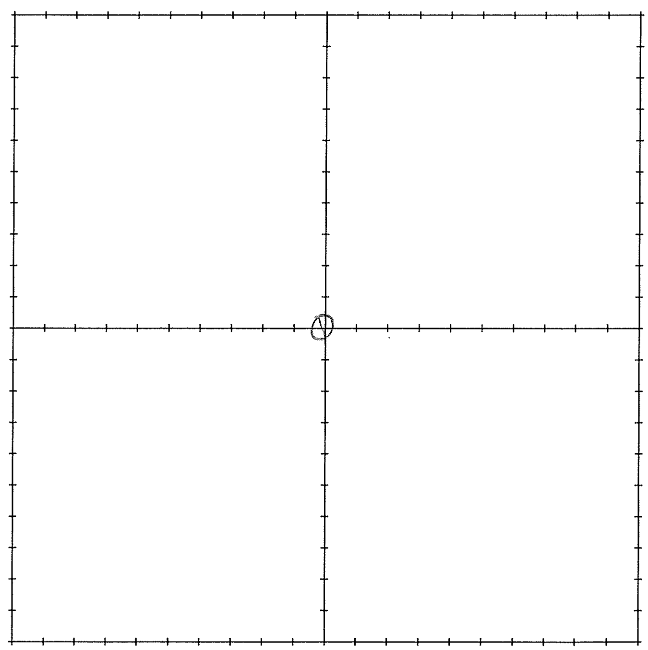
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☑ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG1-002

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1045

SAMPLE COLLECTED BY L Lee

WEATHER CONDITIONS Sunny Windy 20's

FIELD USCS DESCRIPTIONS Fine gray silty sand, minor clay

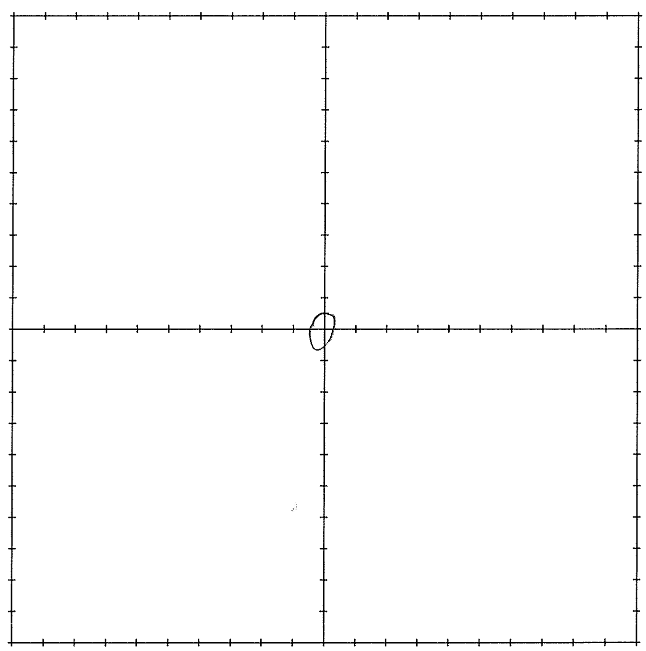
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☑ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☑ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG1-003

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1050

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine gray silty sand, minor clay

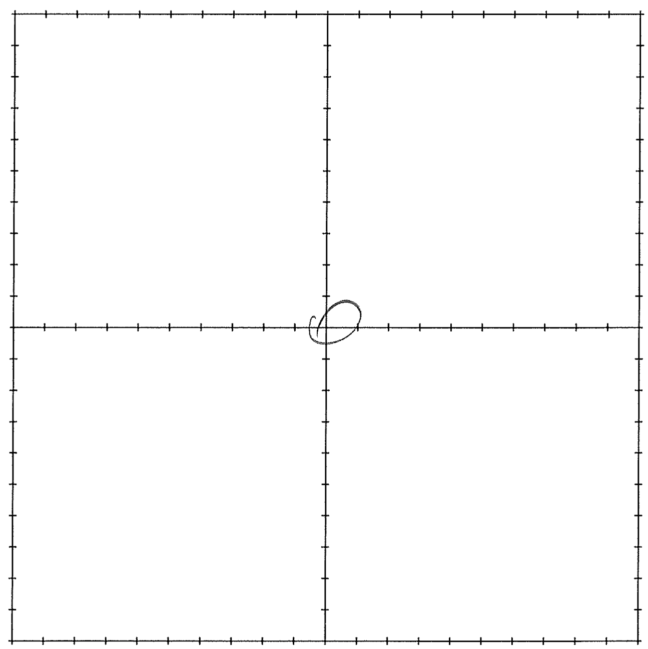
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 Ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S10φ1 (Secti 26)

SAMPLE I.D. S1011-BG1-0041

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1105

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine red silty sand, trace clay

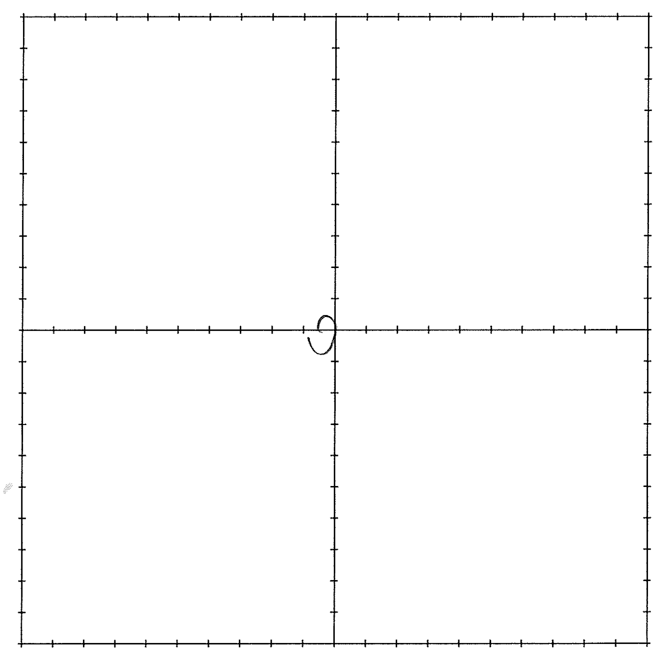
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG1-005 MS, MSD

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1115

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy, 70's

FIELD USCS DESCRIPTIONS Fine med sand, minor flaky coarse sands, trace clay

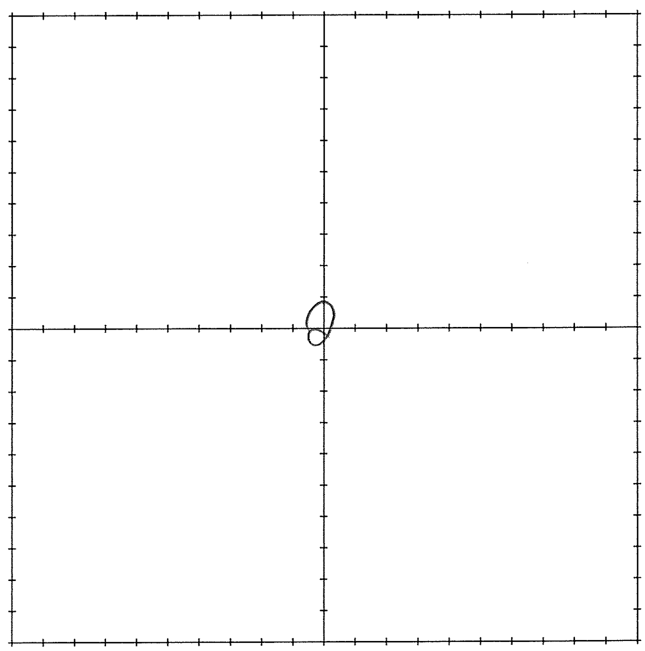
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011 - BG1 - 006

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1120

SAMPLE COLLECTED BY LR

WEATHER CONDITIONS 20-30° F, windy

FIELD USCS DESCRIPTIONS Fine gray/red sand, well-sorted

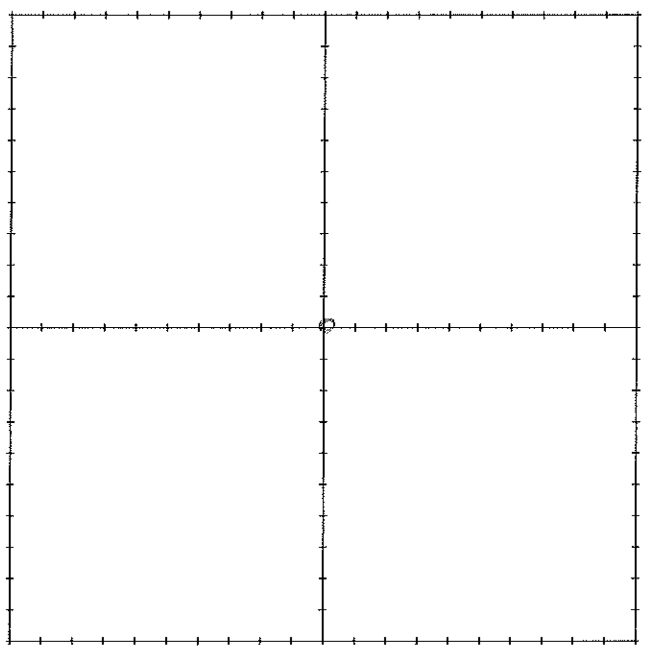
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG1-007

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1130

SAMPLE COLLECTED BY L Lee

WEATHER CONDITIONS Sunny, windy, 20's

FIELD USCS DESCRIPTIONS Fine well/gravel sand, minor small, coarse sand

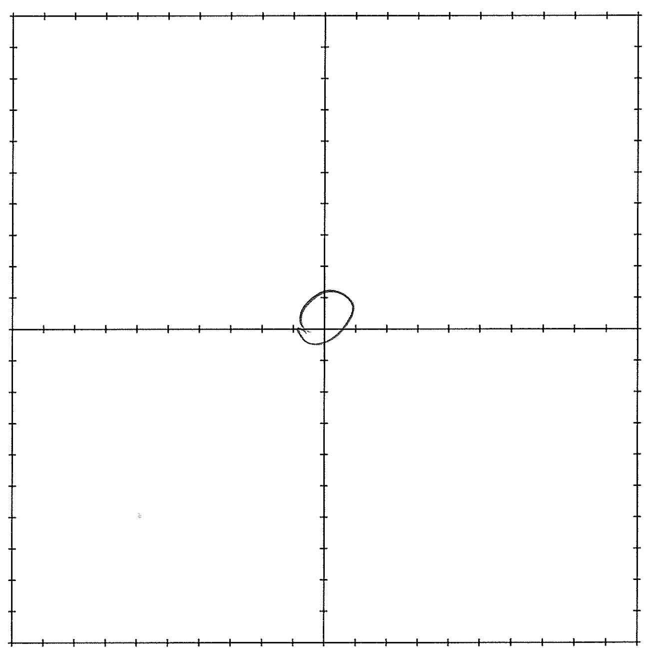
MAJOR DIVISIONS: ❑ OH ❑ CH ❑ MH ❑ OH ❑ CL ❑ ML ❑ SC
❑ SM ☒ SP ❑ SW ❑ GC ❑ GM ❑ GP ❑ GW

QUALIFIERS: ❑ TRACE ☒ MINOR ❑ SOME; SAND SIZE ❑ FINE ❑ MEDIUM ❑ COARSE

MOISTURE: ❑ DRY ☒ MOIST ❑ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG1-008

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1140

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny Windy 70's

FIELD USCS DESCRIPTIONS Brown/red fine sand, trace gray frags

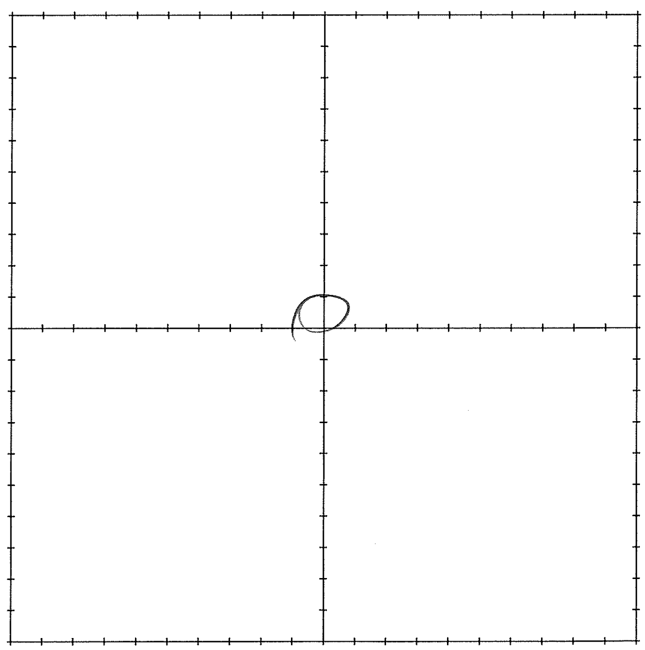
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 zip-lock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG1-009

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1145

SAMPLE COLLECTED BY L Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Brown/tan fine sand, trace gray fines

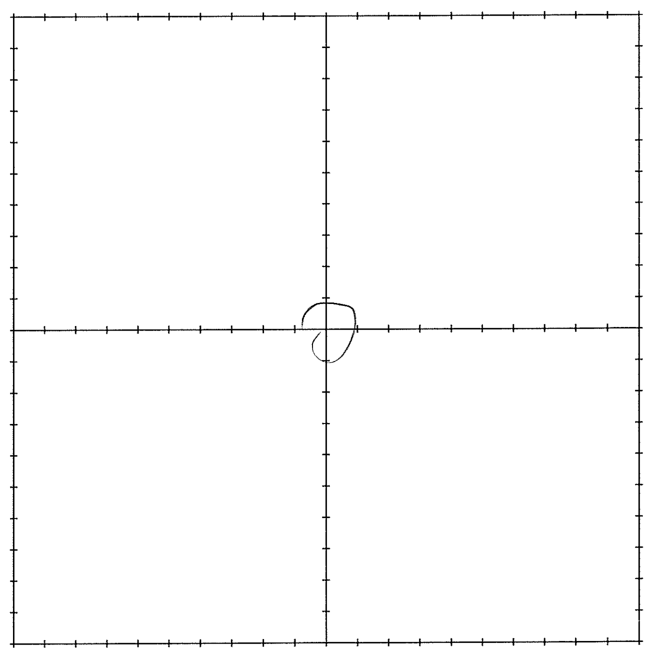
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S6011 (Section 26)

SAMPLE I.D. S1011 - B61 - 010

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1200

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny Windy 20's

FIELD USCS DESCRIPTIONS Red fine sand, trace clay

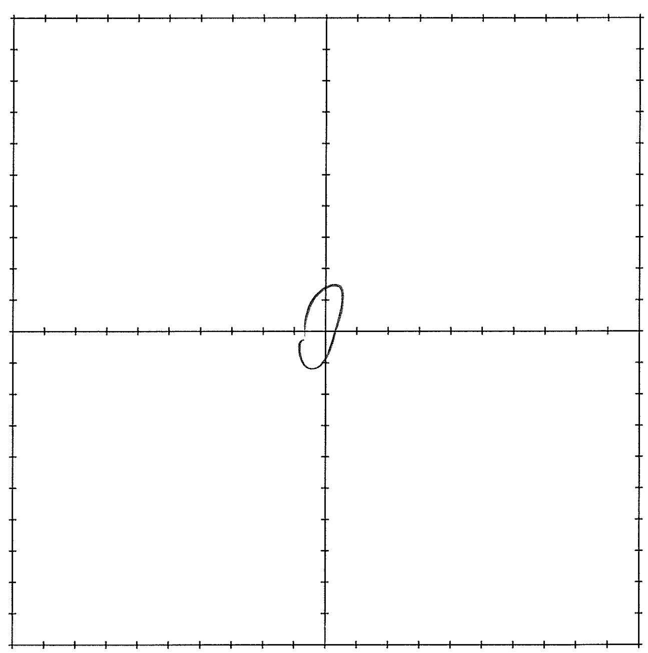
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-B602-001

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1210

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine red sand

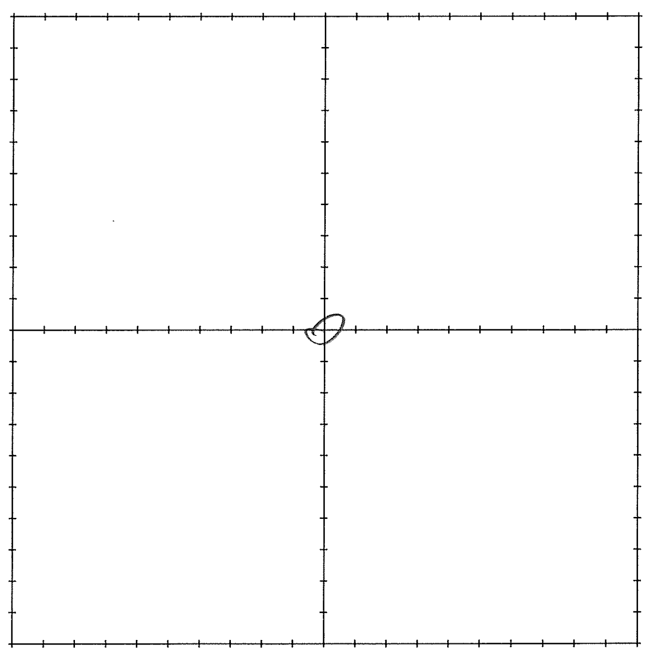
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG2-002

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1215

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine and sand, trace clay

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra-226, Metals

MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-B42-003

SAMPLE COLLECTION DATE 11/30/10

SAMPLE COLLECTION TIME 1220

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine red sand, trace clay

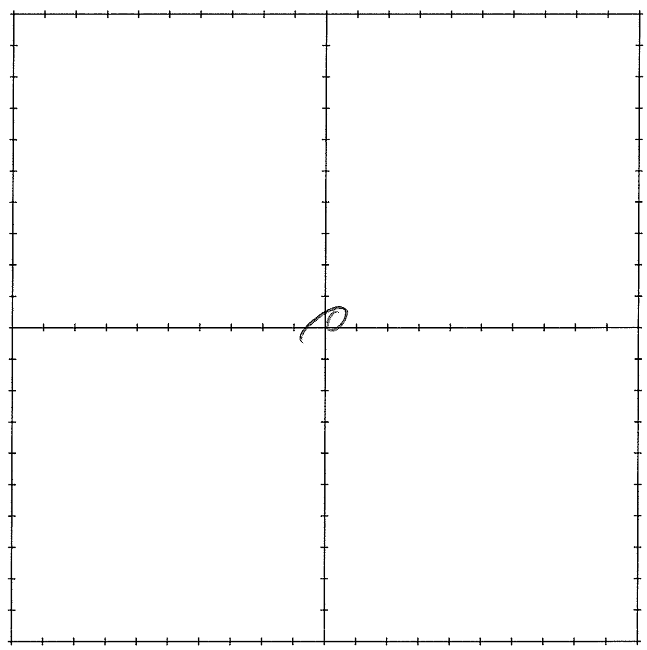
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Sector 26)

SAMPLE I.D. S1011-BG2-004

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1225

SAMPLE COLLECTED BY L Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine med sand, some clay

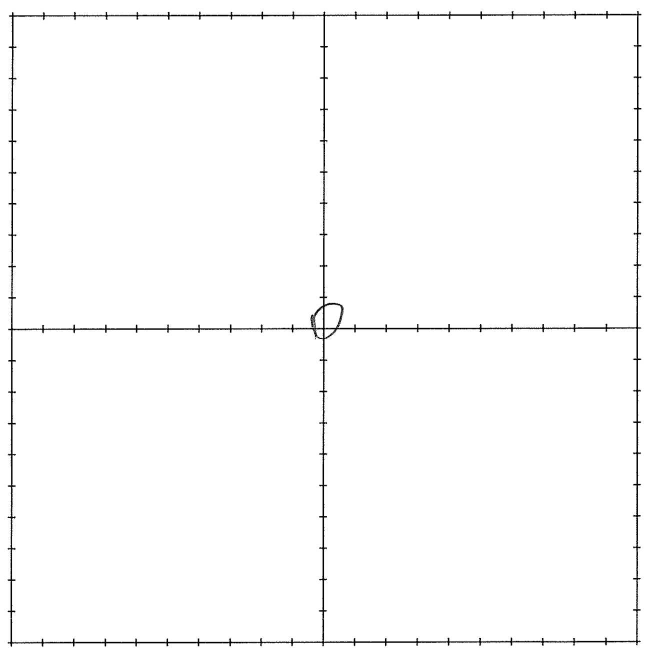
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG2-005

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1230

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine med sand, trace clay

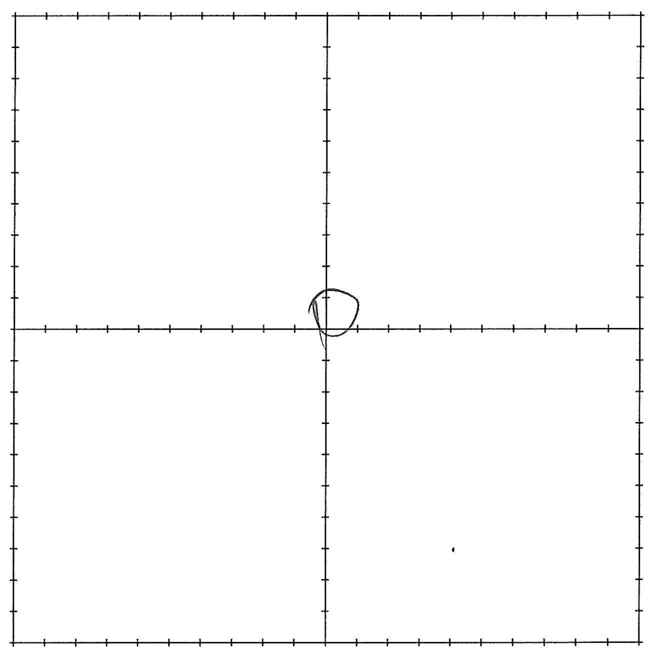
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 260)

SAMPLE I.D. S1011-B62-006, 206

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1235

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine red sand, some clay

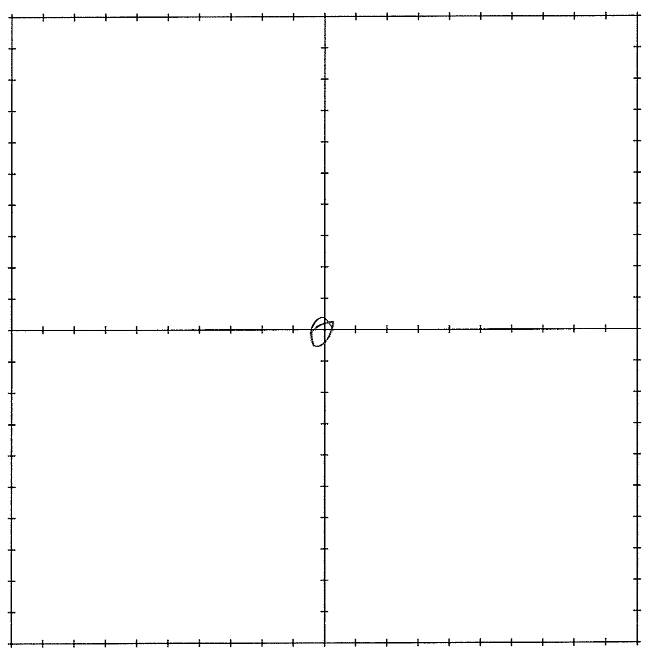
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011 - BG2 - 007

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1240

SAMPLE COLLECTED BY L. Lee

WEATHER CONDITIONS Sunny, Windy, 70°

FIELD USCS DESCRIPTIONS Fine red Sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 Ziploc

ANALYSES: Ra-226, Metals

MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Secti 26)

SAMPLE I.D. S1011-BG2-008

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1245

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine red sand, trace clays

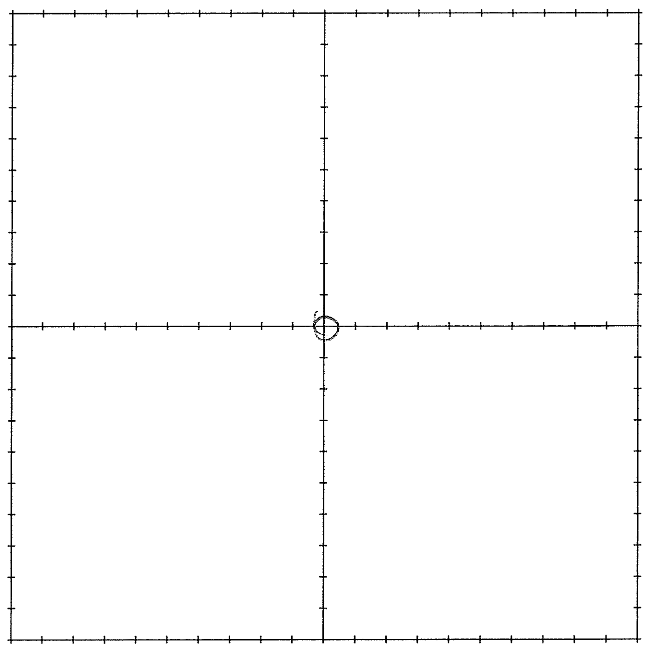
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BGR-009 MS MSD

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1250

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy 20's

FIELD USCS DESCRIPTIONS Fine red sand, trace clay

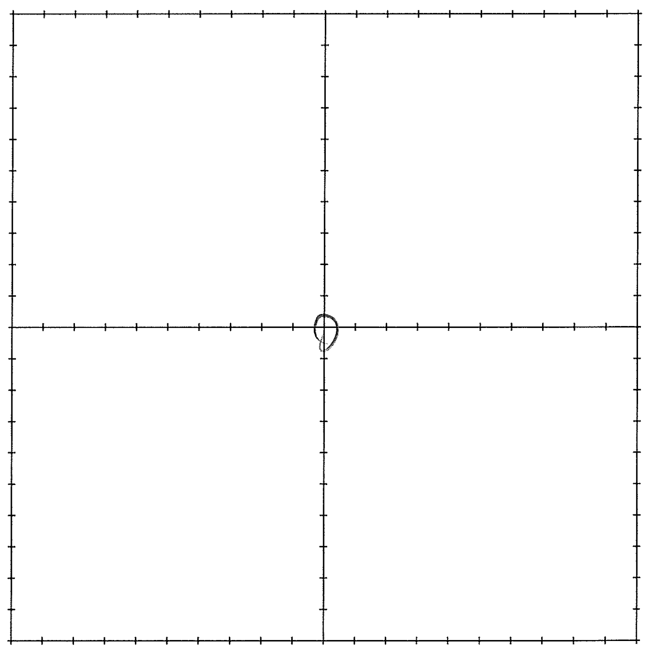
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Safi 26)

SAMPLE I.D. S1011-BG2-010

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1300

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy, 70's

FIELD USCS DESCRIPTIONS Fine red sand

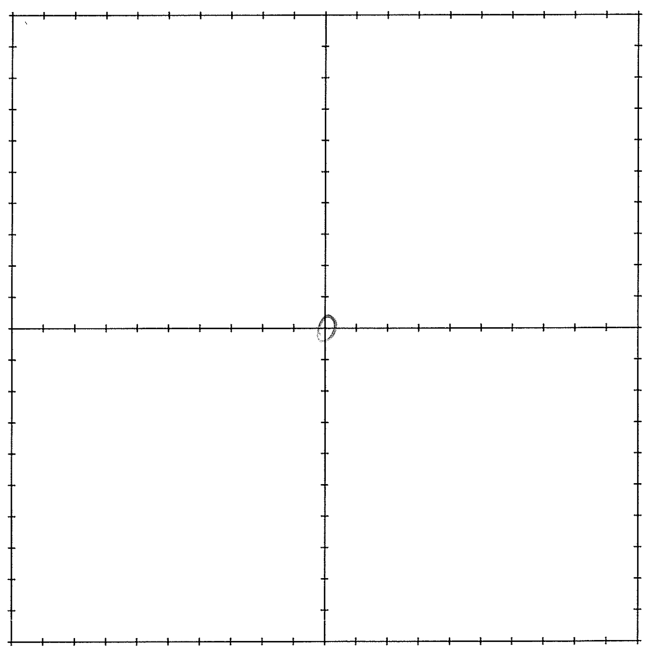
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-BG-3-001-0

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1020

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny ~~[illegible]~~ 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand with gravel (SP) Light gray (5 YR 7/1), dry, loose, medium to coarse sand

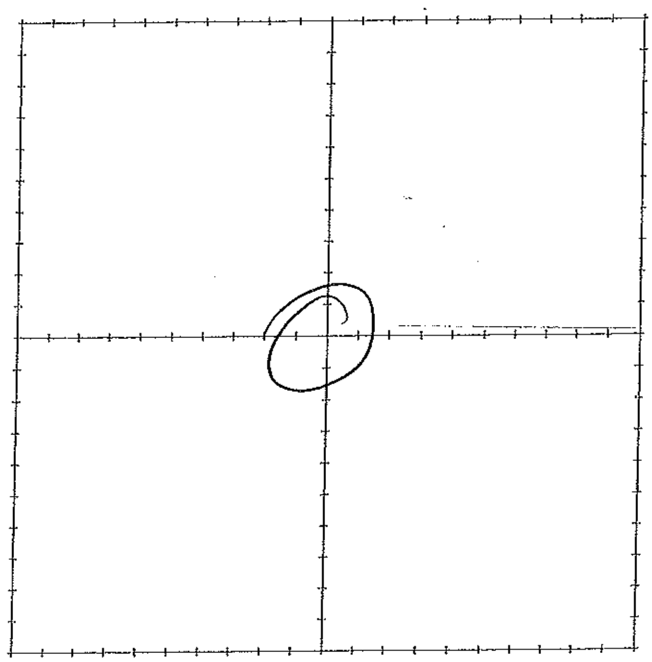
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☑ MEDIUM ☑ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME section 26

SAMPLE I.D. S1011-BG-3-002

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1034

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand with gravel (SP), Light gray (5 YR 7/1), loose, dry, medium to coarse sand

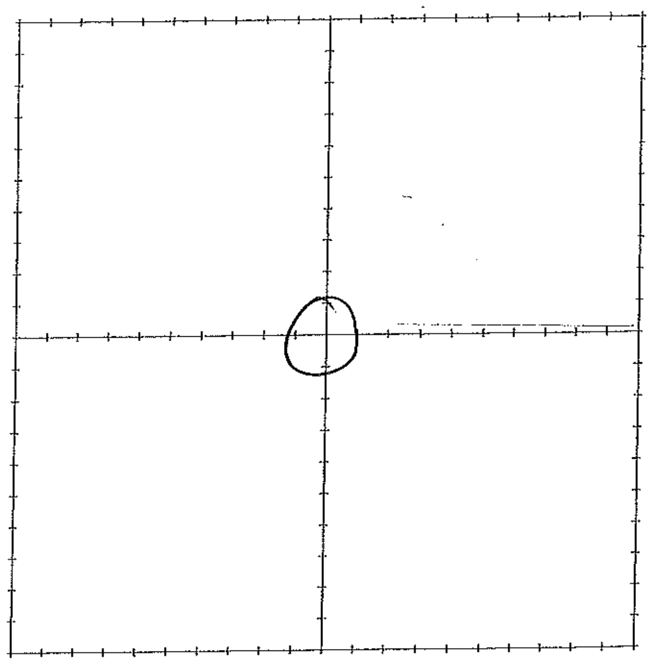
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☒ MEDIUM ☒ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 226

SAMPLE I.D. S1011-BG3-007

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1047

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand with gravel (SP), light gray (5YR 7/1), loose, dry, medium to coarse sand

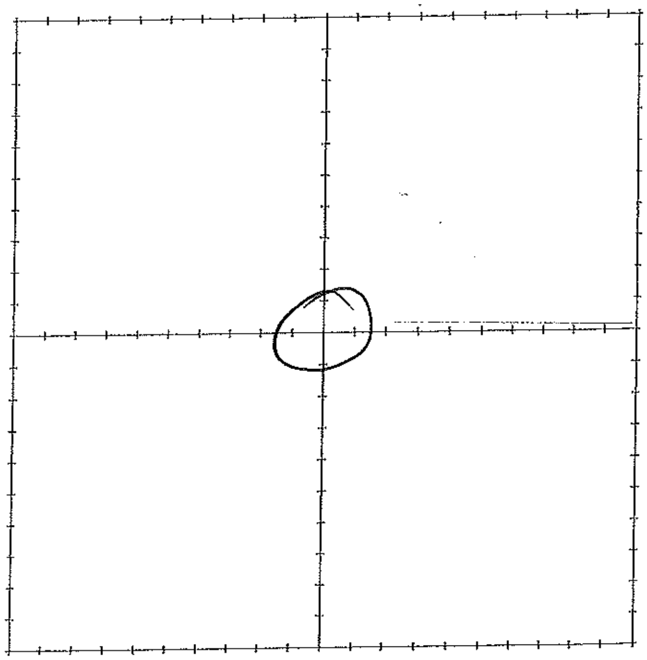
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☒ MEDIUM ☒ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags,

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S104 - ~~SEX~~ BG3 - 004

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1056

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand with gravel (SP) Light gray (5YR 7/1), Loose, dry, medium to coarse sand

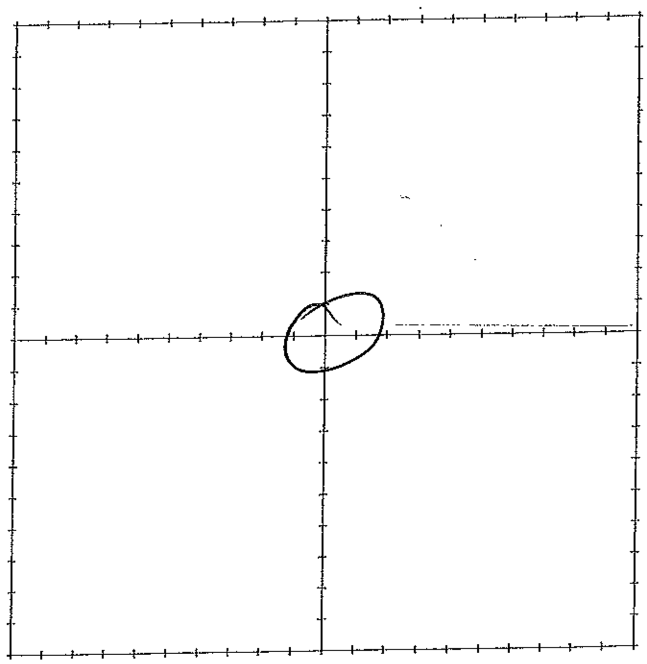
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☒ MEDIUM ☒ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 2B

SAMPLE I.D. S1011-BG3-005

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1108

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny, 75° F

FIELD USCS DESCRIPTIONS Poorly graded sand with gravel (SP), light gray (5YR 7/1), loose, dry, med-coarse sand

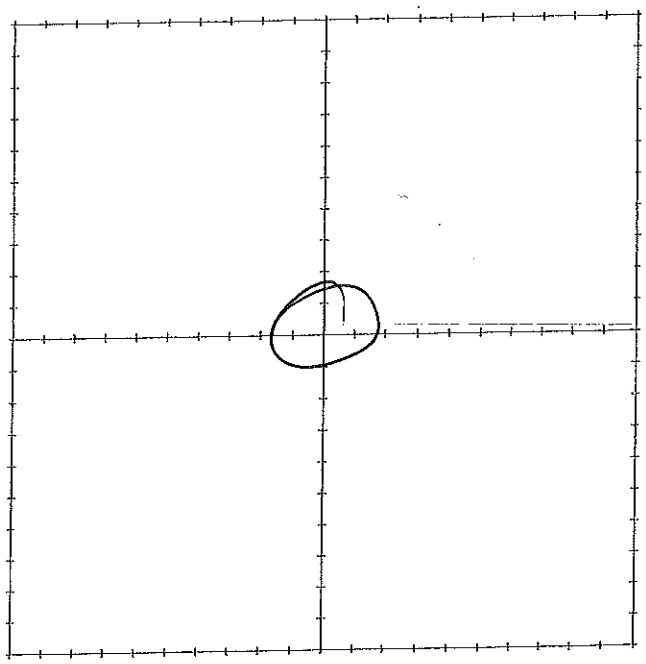
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☑ MEDIUM ☑ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-BG3-006

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1120

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand with gravel (SP), light gray (5YR 7/1), dry, loose, med-coarse sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC

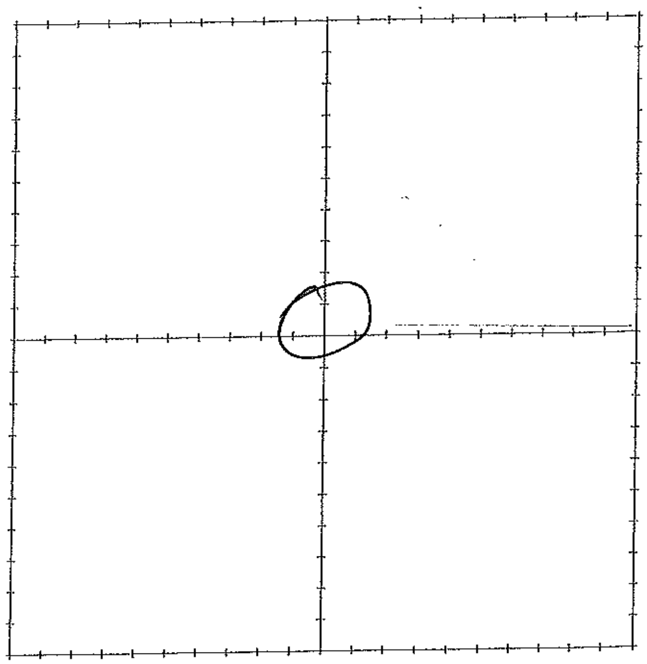
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☑ MEDIUM ☑ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-BG3-007

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1130

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand with gravel (SP), light gray (5YR 7/1), Loose, dry, med-Coarse sand

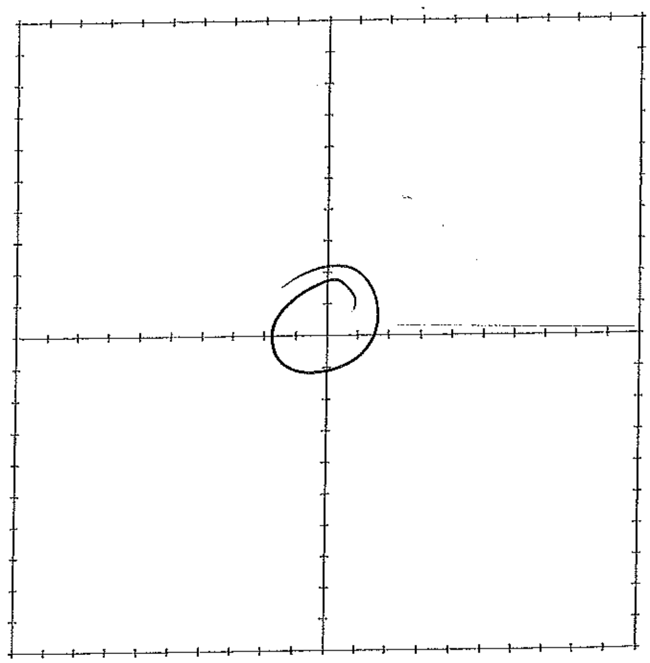
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☒ MEDIUM ☒ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-8G3-008

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1143

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 75° F

FIELD USCS DESCRIPTIONS Poorly graded Sand with gravels (SP) Light gray (5YR 7/1), loose, dry, med - coarse sand

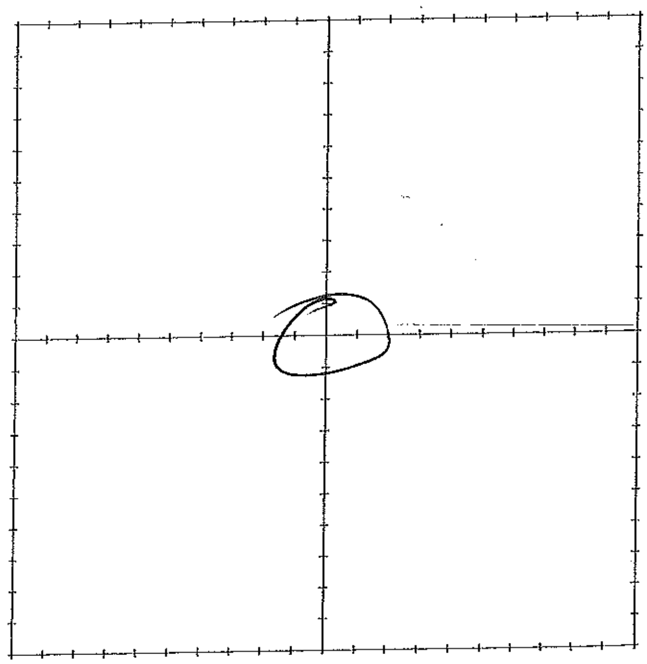
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☑ MEDIUM ☑ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-BG3-009

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1153

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS poorly graded sand with gravel (SP), light gray (5YR 7/1), loose, dry, med - coarse sand

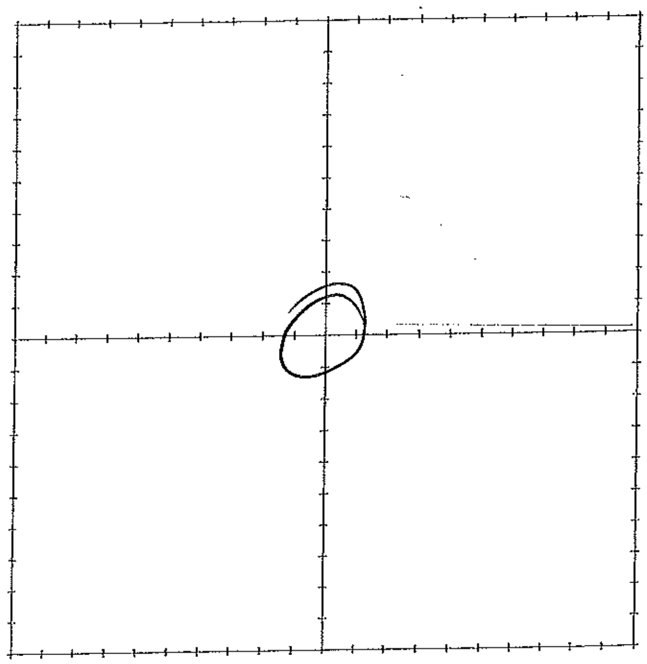
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☑ MEDIUM ☑ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - 863 - 010

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1202

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny, 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand with gravels (SP) light gray (5 YR 7/1), loose, dry, med - coarse sand,

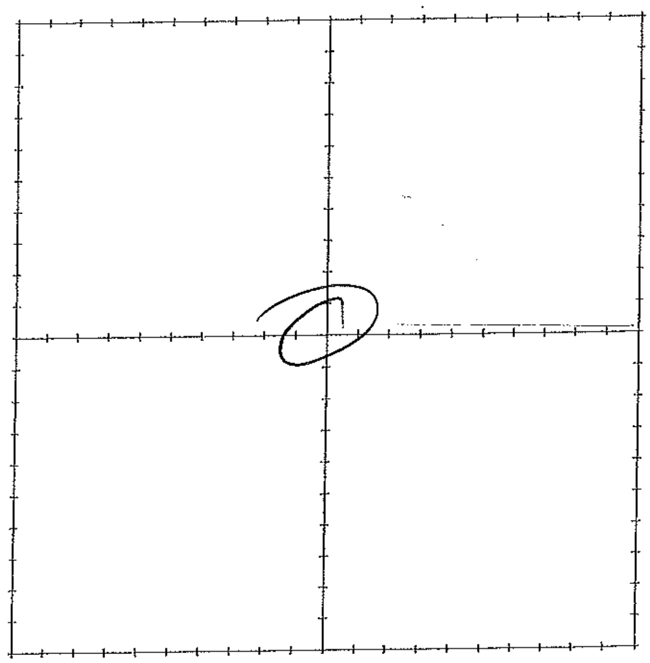
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☒ MEDIUM ☒ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: RA - 226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - 8G4 - 001

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1023

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80 °F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP) Strong brown (7.5 YR 5/8) fine to med sand, Loose, dry,

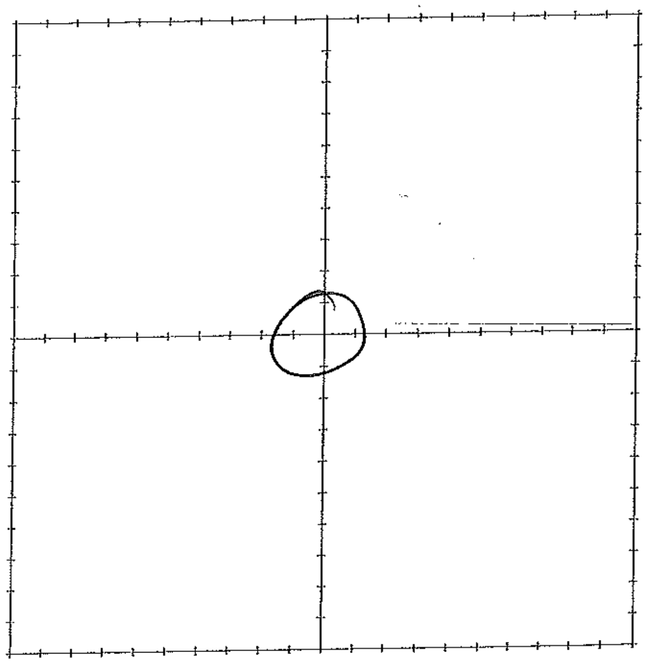
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: Section 26

SAMPLE I.D.: S1011 - BG4 - 002

SAMPLE COLLECTION DATE: 9/19/17

SAMPLE COLLECTION TIME: 1028

SAMPLE COLLECTED BY: JR

WEATHER CONDITIONS: Sunny 80°F

FIELD USCS DESCRIPTIONS: Poorly graded sand (SP), strong brown (7.5 YR 7/1), loose, dry, fine - med sand

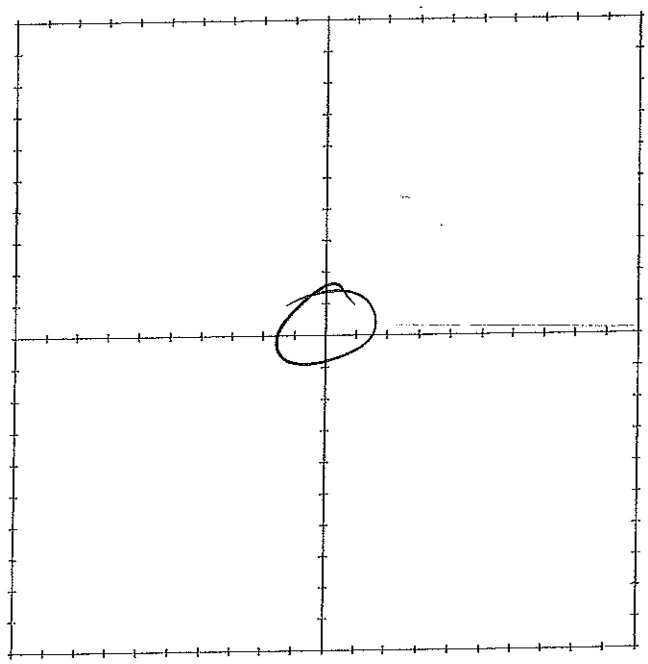
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE): 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-BG4-003

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1032

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP) strong brown (7.5 YR 5/8), loose, dry, fine - med. sand

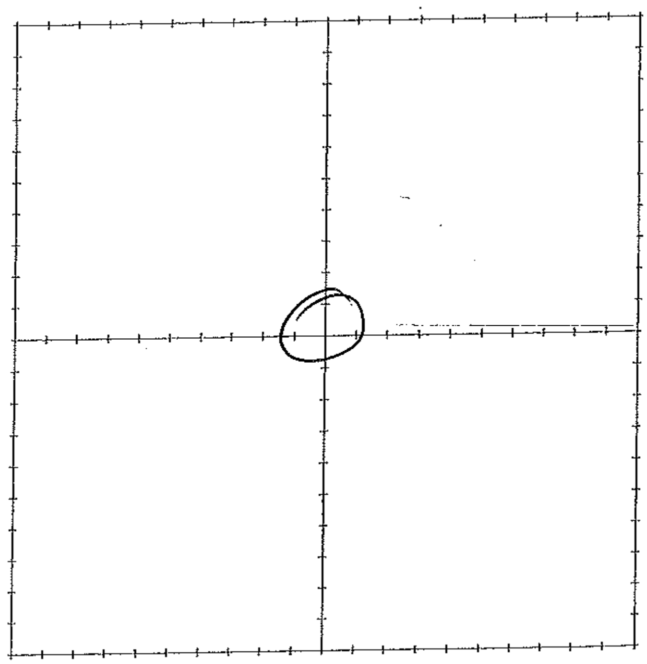
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-8G-4-004

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1034

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8), loose, dry, fine-med sand.

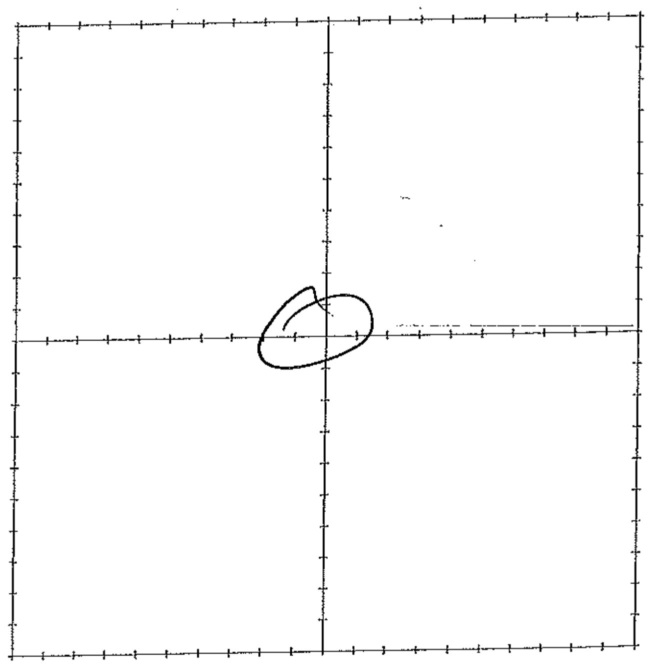
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - BG-4 - 005

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1038

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (5 YR 5/8), loose, dry, fine-med. sand,

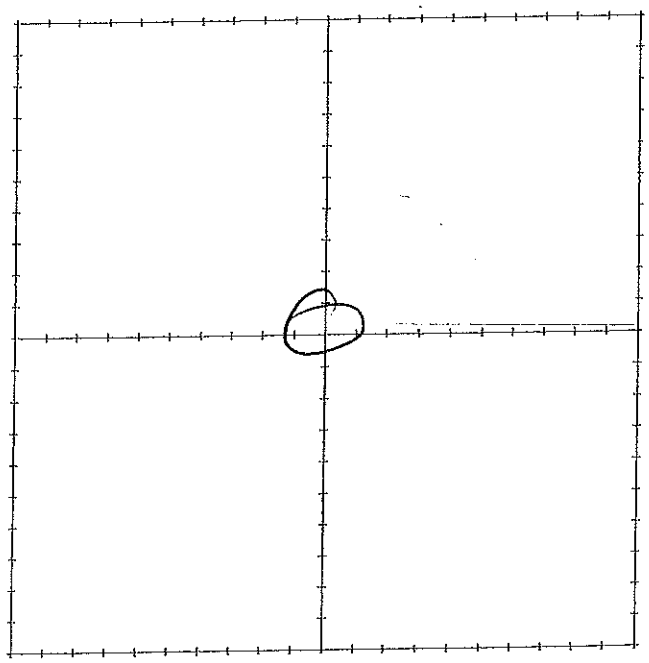
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☒ FINE ☒ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-8G4-006

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1040

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80 °F

FIELD USCS DESCRIPTIONS Poorly graded Sand (SP), strong brown (7.5YR 5/8), Loose, dry, med - fine sand

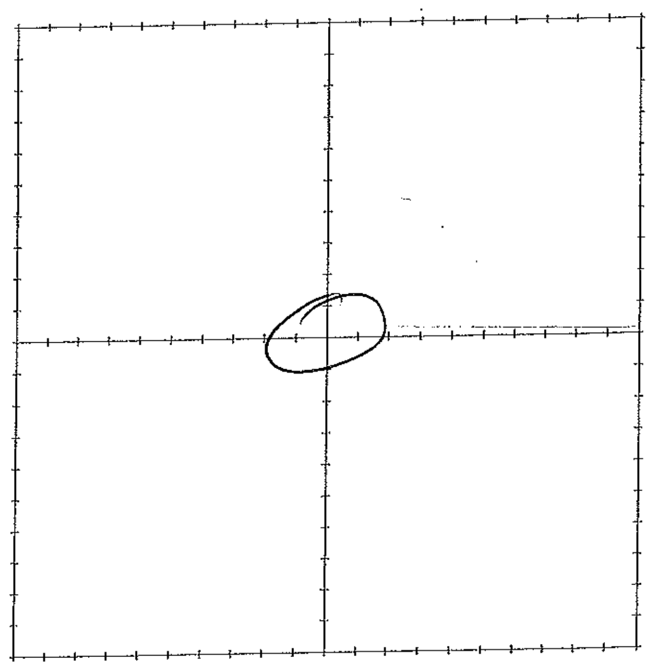
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - BG-4 - 007

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1043

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny, 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8), loose, dry, fine - med. sand

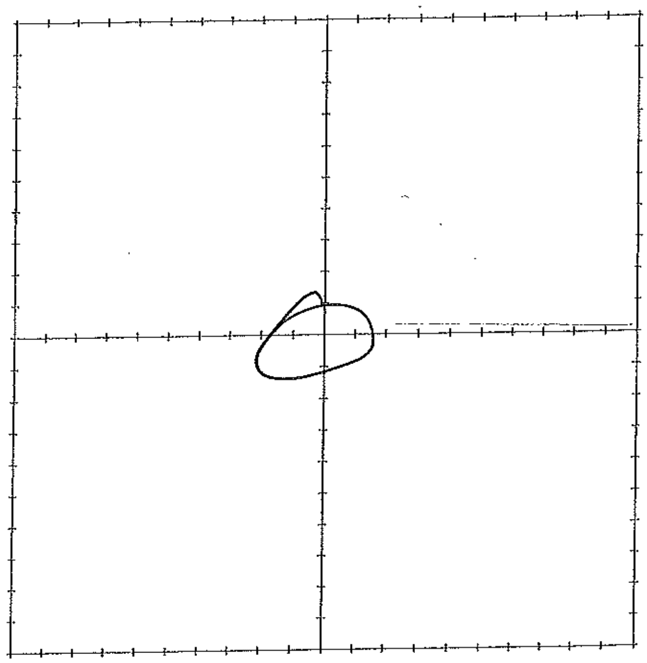
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - BG4 - 008

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1045

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8), dry, loose, med-fine sand,

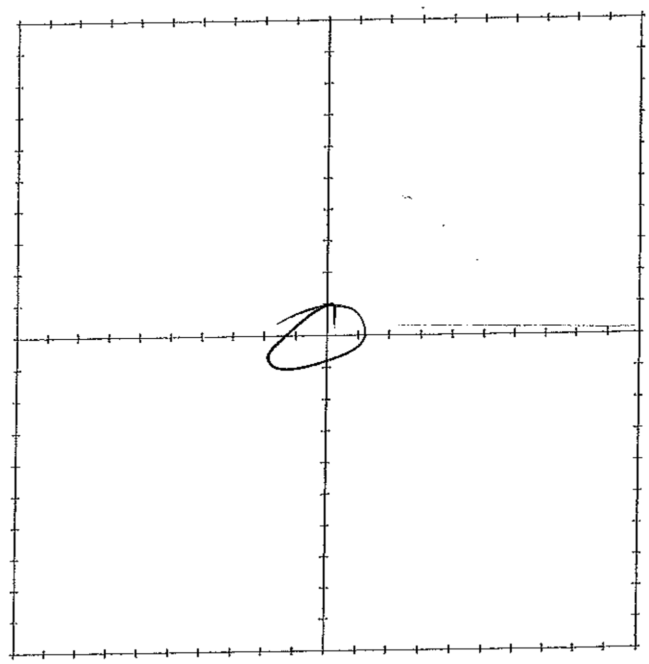
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-864-009

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1047

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80 °F

FIELD USCS DESCRIPTIONS poorly graded sand (SP), strong brown (7.5 YR 5/8), loose, dry, med-fine sand,

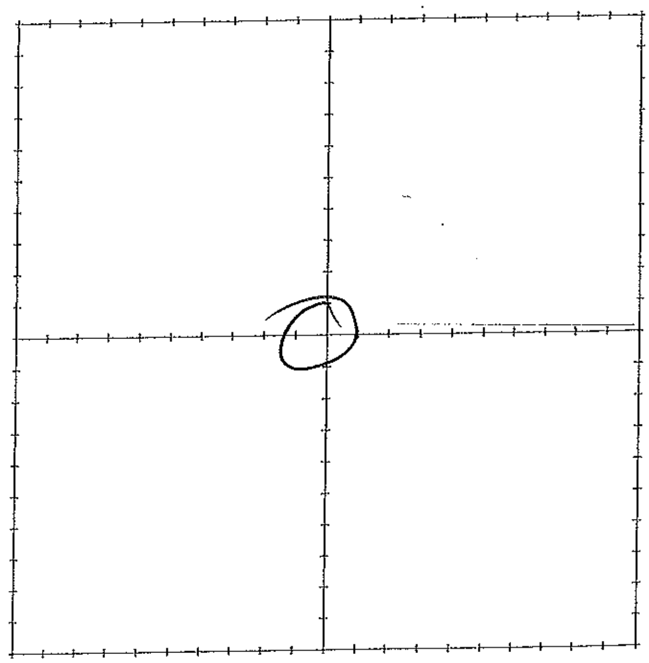
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-BG4-010

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1052

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80 °F

FIELD USCS DESCRIPTIONS Poorly graded Sand (SP), strong brown (7.5 YR 5/8), Loose, dry, med-fine Sand.

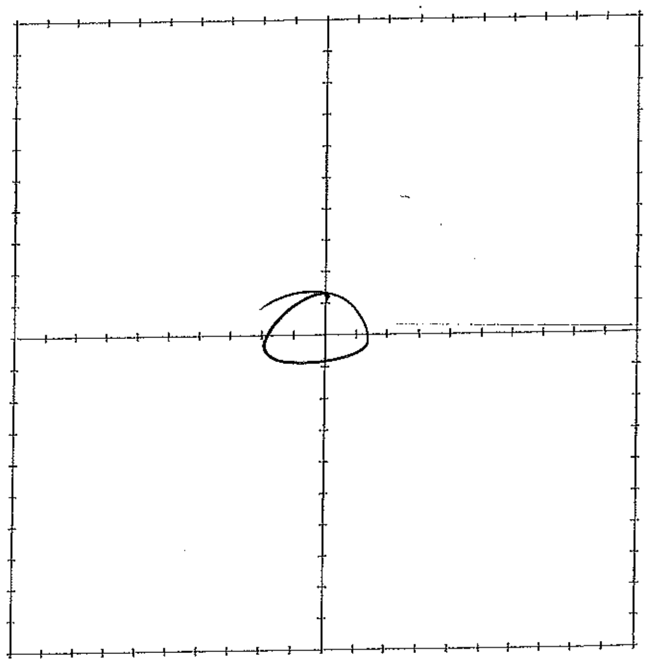
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals.



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. 51011-8G5-001

SAMPLE COLLECTION DATE 9/19/18

SAMPLE COLLECTION TIME 1118

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80F

FIELD USCS DESCRIPTIONS poorly graded sand (SP), strong brown (7.5 YR 5/8), loose, dry, fine-med.

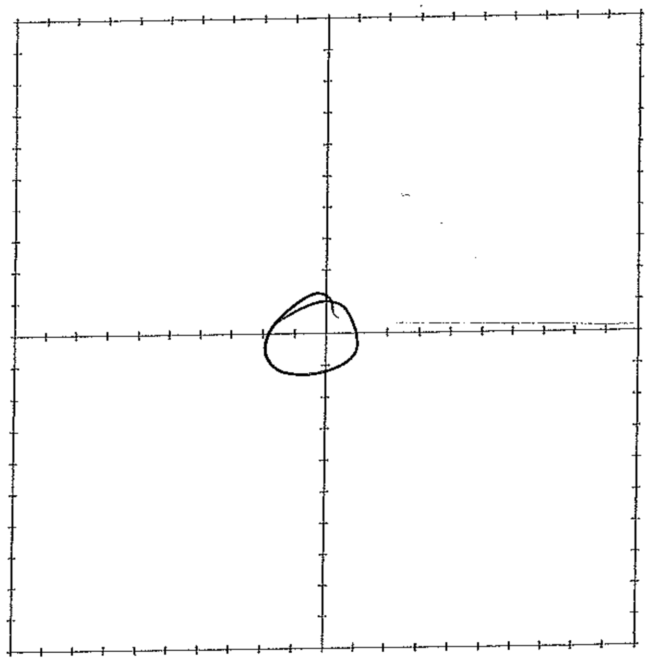
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☒ FINE ☒ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME section 26

SAMPLE I.D. S1011-BGS-002

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1122

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8), loose, dry, fine - med sand

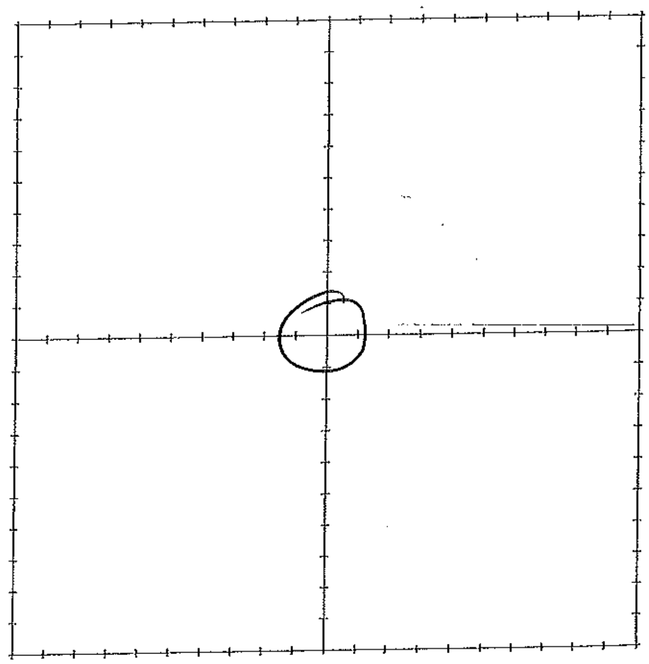
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA - 226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-BGS-003

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1125

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8) ~~loose~~, dry, fine-med. sand.

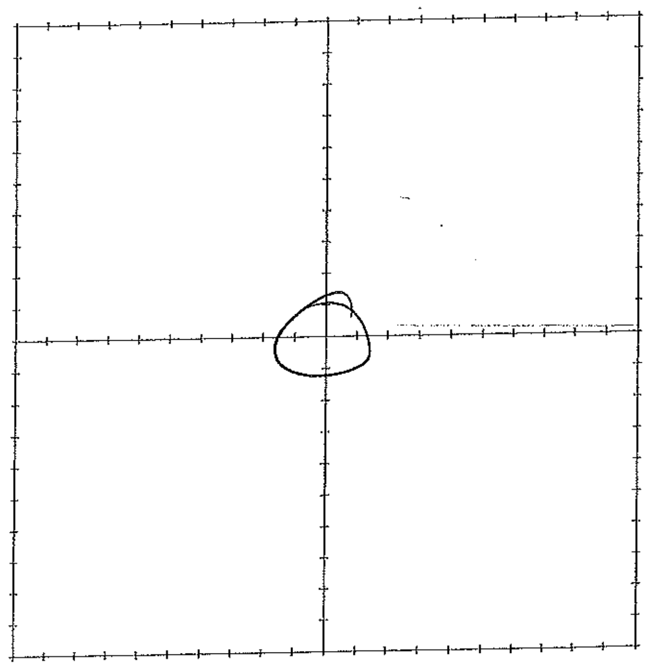
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - BGS - 004

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1131

SAMPLE COLLECTED BY SR

WEATHER CONDITIONS Sunny 80 °F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8), loose, dry, fine - med sand.

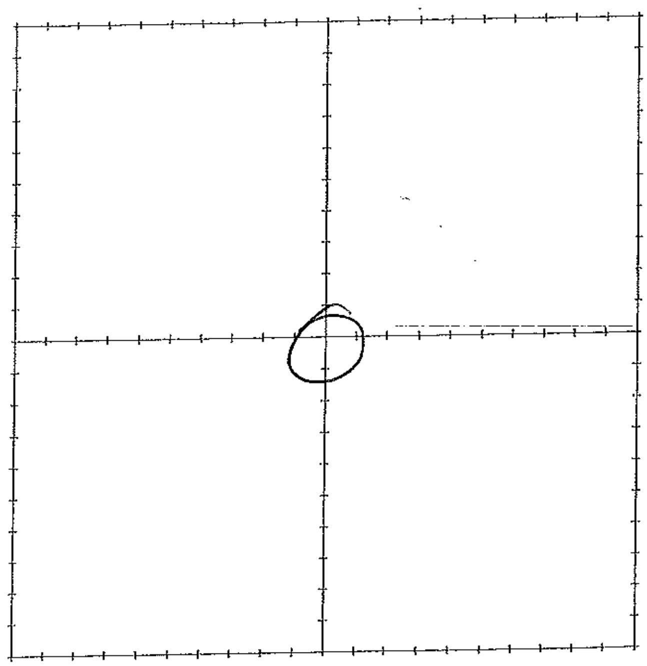
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA - 226, - Metals.



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - 8G5 - 005

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1134

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80 °F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8) Loose, dry, fine-med sand.

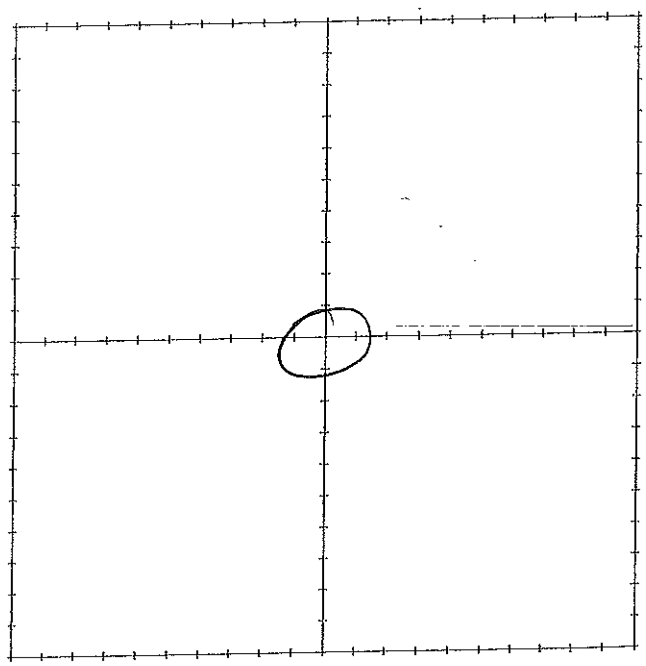
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME section 26

SAMPLE I.D. S1011-805-006

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1037

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80 °F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), Strong brown (7.5YR 5/8) Loose, dry, fine-med. sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC

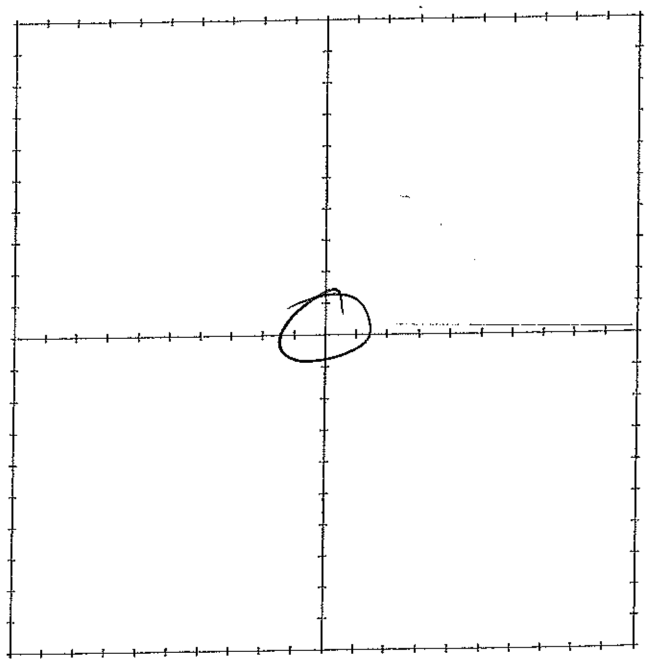
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME section 26

SAMPLE I.D. S1011-BG5-007

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1142

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80 °F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP) strong brown (7.5 YR 5/8), dry, loose, fine-med, sand

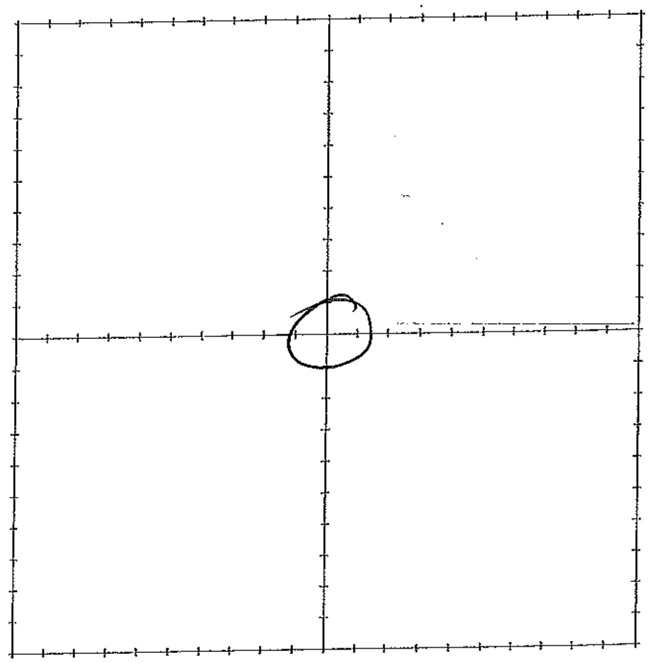
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-BGS-008

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1146

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80 °F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP) strong brown (7.5 YR 5/8), loose, dry, fine - med., sand

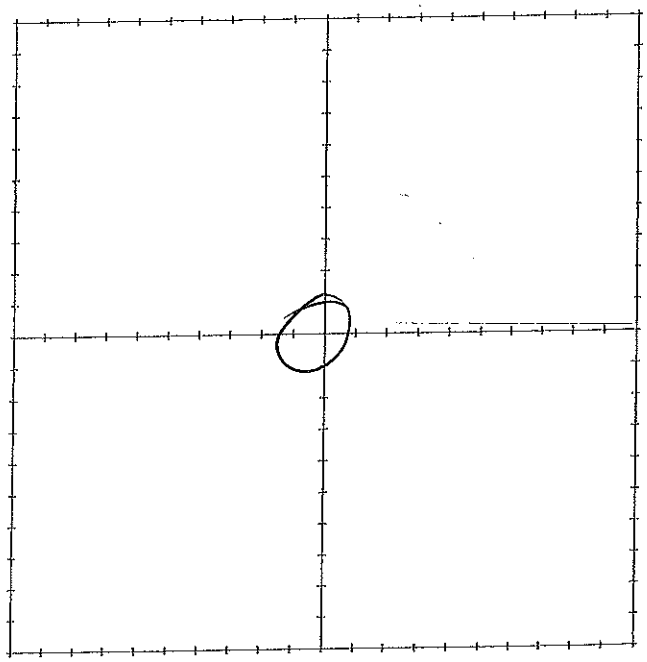
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☒ FINE ☒ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: Section 26

SAMPLE I.D.: S1011-8G5-009

SAMPLE COLLECTION DATE: 9/19/17

SAMPLE COLLECTION TIME: 1150

SAMPLE COLLECTED BY: JR

WEATHER CONDITIONS: Sunny, 80 °F

FIELD USCS DESCRIPTIONS: Poorly graded sand (SP), strong brown (7.5 YR 5/8), loose, dry, fine-med., sand

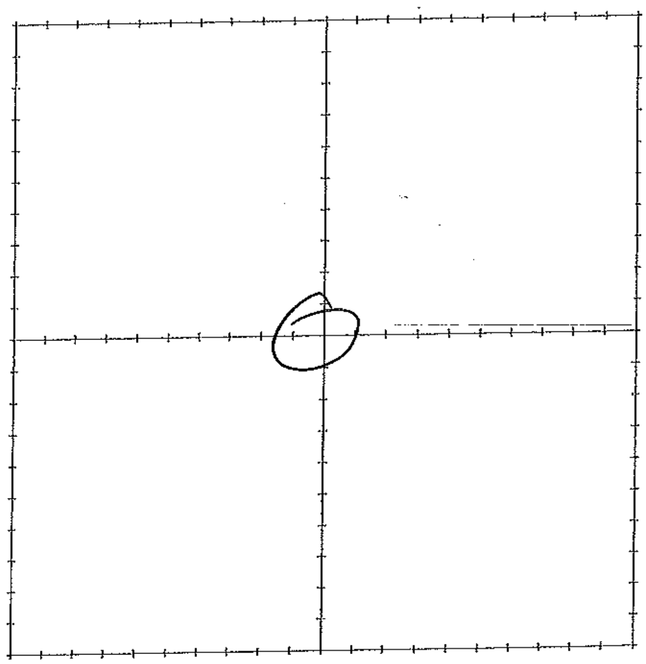
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE): 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-BGS-010

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1156

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8) Loose, dry, fine-med, Sand

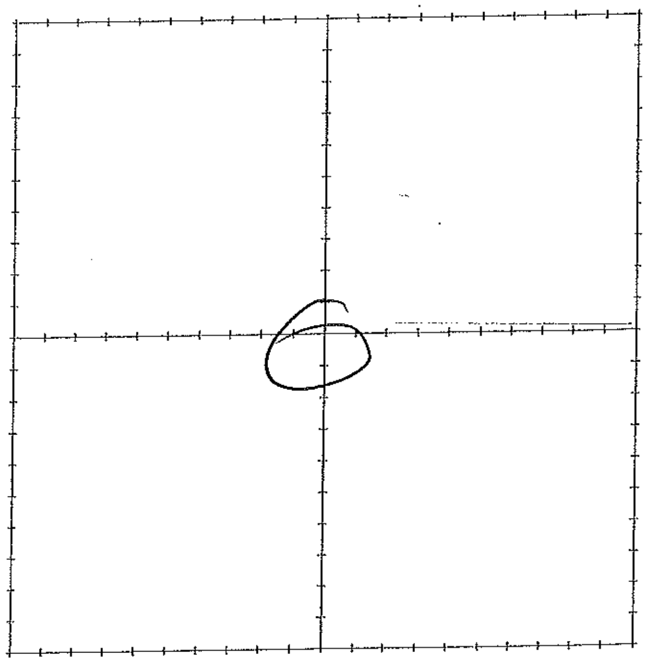
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☒ FINE ☒ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Santa 26 (S1011)

SAMPLE I.D. S1011-C01+001

SAMPLE COLLECTION DATE 3/29/17

SAMPLE COLLECTION TIME 0920

SAMPLE COLLECTED BY Chee

WEATHER CONDITIONS 35°F, Sunny

FIELD USCS DESCRIPTIONS Silty Sand, moist at surface, brown/tan, minor gravels

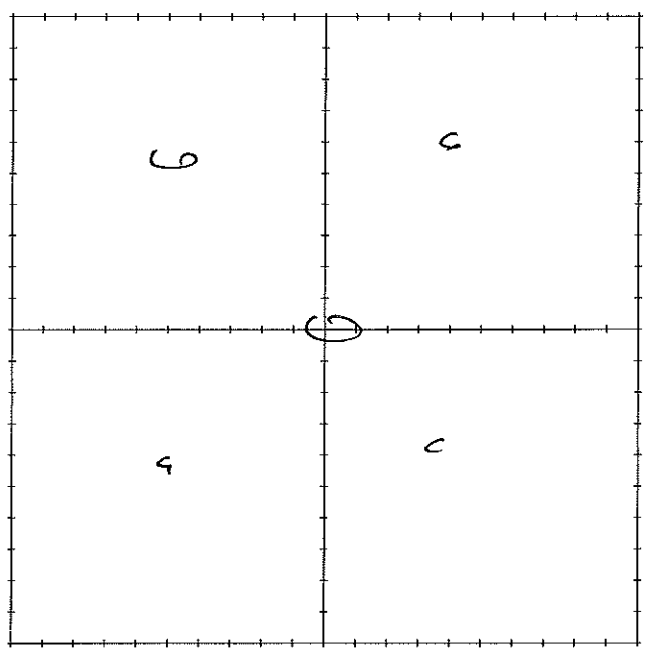
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☒ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - C02-001

SAMPLE COLLECTION DATE 3/29/17

SAMPLE COLLECTION TIME 1000

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS 35°F, Sunny

FIELD USCS DESCRIPTIONS Silty sand w/25% gravels, brownish orge

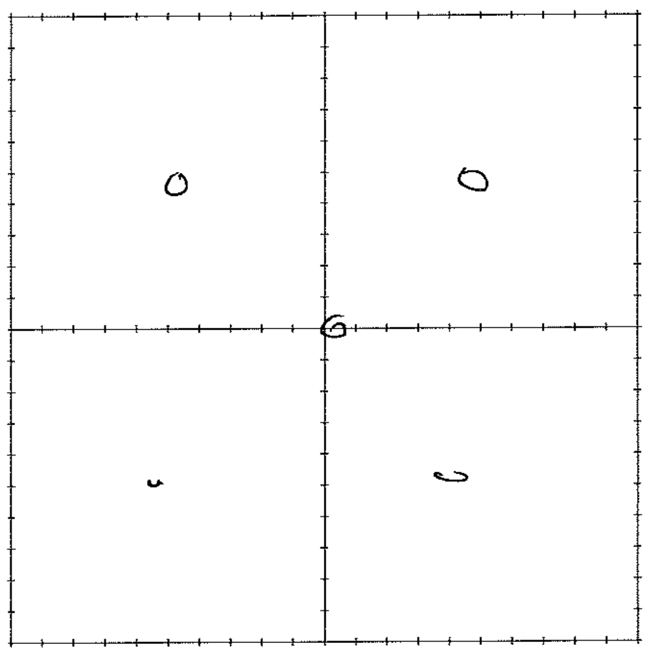
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☒ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☒ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011-C03-001

SAMPLE COLLECTION DATE 3/29/17

SAMPLE COLLECTION TIME 1030

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 35°F, Sunny

FIELD USCS DESCRIPTIONS Sandy clay w/ minor gravel, med. plast, moist

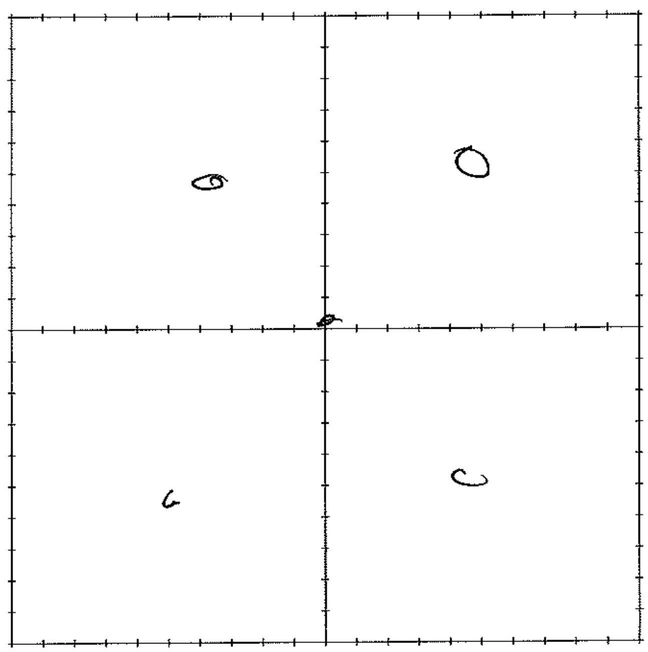
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☒ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011-C04-001

SAMPLE COLLECTION DATE 3/29/17

SAMPLE COLLECTION TIME 1055

SAMPLE COLLECTED BY L. Lee

WEATHER CONDITIONS 35°F, Sunny

FIELD USCS DESCRIPTIONS Sandy clay, w/minor gravel, med. plast., moist

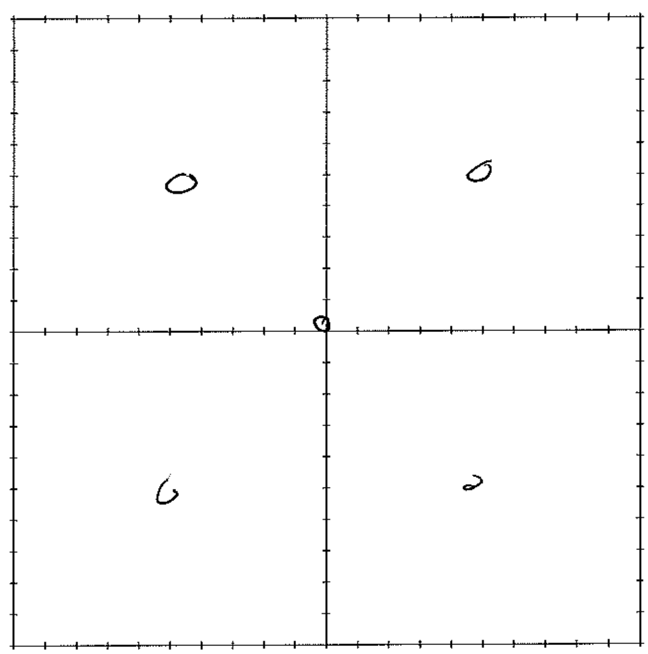
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☒ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☒ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011-C05-001

SAMPLE COLLECTION DATE 3/29/17

SAMPLE COLLECTION TIME 1118

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 35°F, Sunny

FIELD USCS DESCRIPTIONS Clayey sand, minor gravel, reddish brown, moist

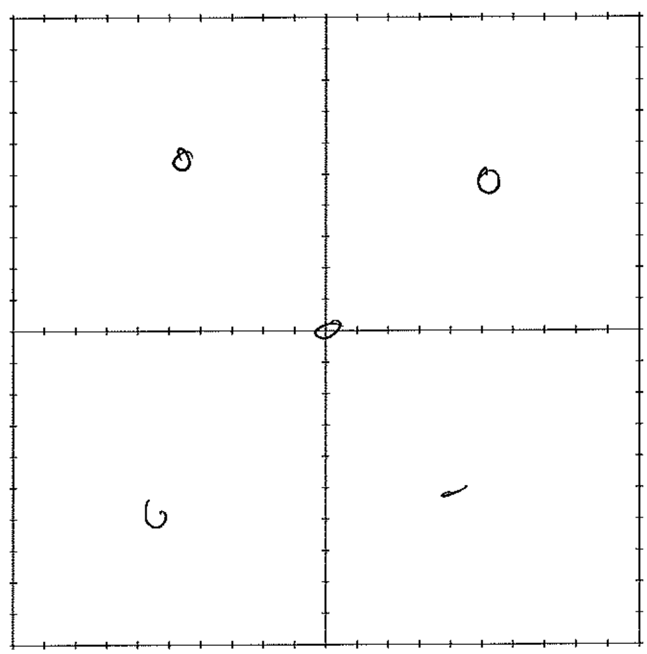
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☒ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-Gx-001

SAMPLE COLLECTION DATE 12/1/16

SAMPLE COLLECTION TIME 1010

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Cloudy, 30's

FIELD USCS DESCRIPTIONS Fine red sand, trace clay

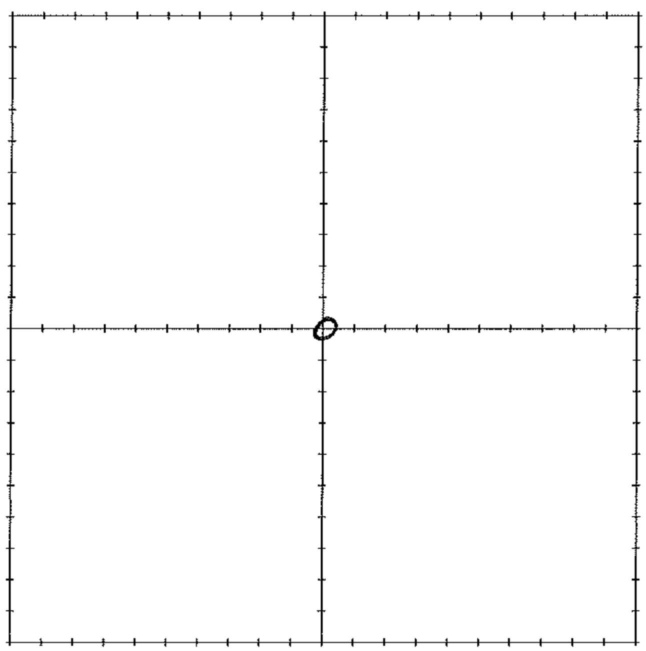
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-GX-002

SAMPLE COLLECTION DATE 12/1/16

SAMPLE COLLECTION TIME 1035

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS Cloudy, 30's

FIELD USCS DESCRIPTIONS Fine red sand

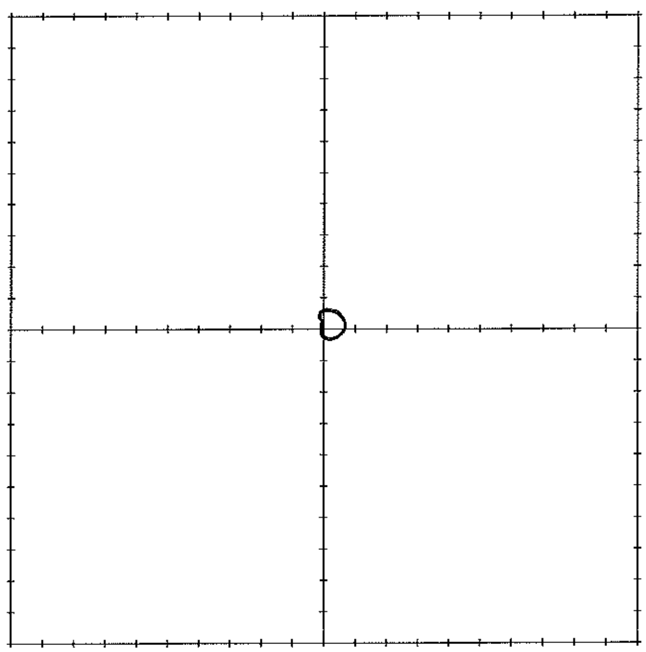
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-CX-003

SAMPLE COLLECTION DATE 12/1/16

SAMPLE COLLECTION TIME 1045

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS Cloudy, 30's

FIELD USCS DESCRIPTIONS Fine red sand, minor coarse gray sand (~10-20%)

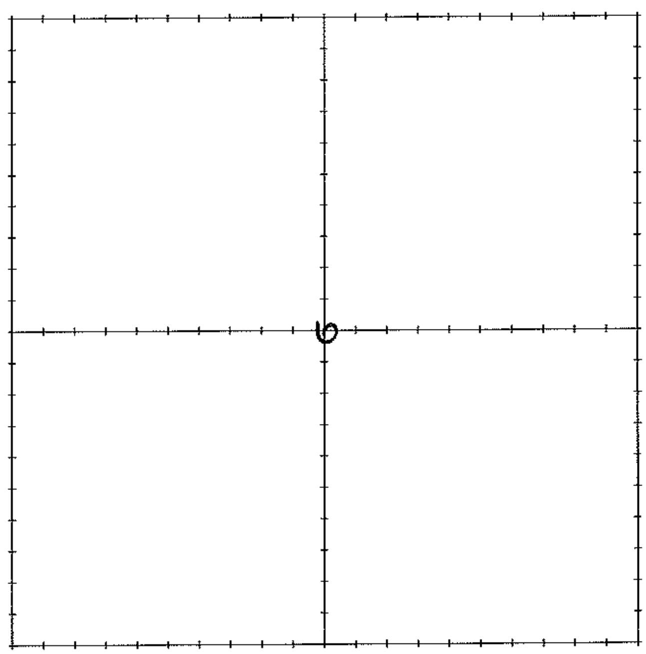
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-CX-0044, 2084

SAMPLE COLLECTION DATE ~~12~~ 12/1/16

SAMPLE COLLECTION TIME 1105

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Cloudy, 30's

FIELD USCS DESCRIPTIONS Brown/red fine sand, minor clay, trace coarse sand

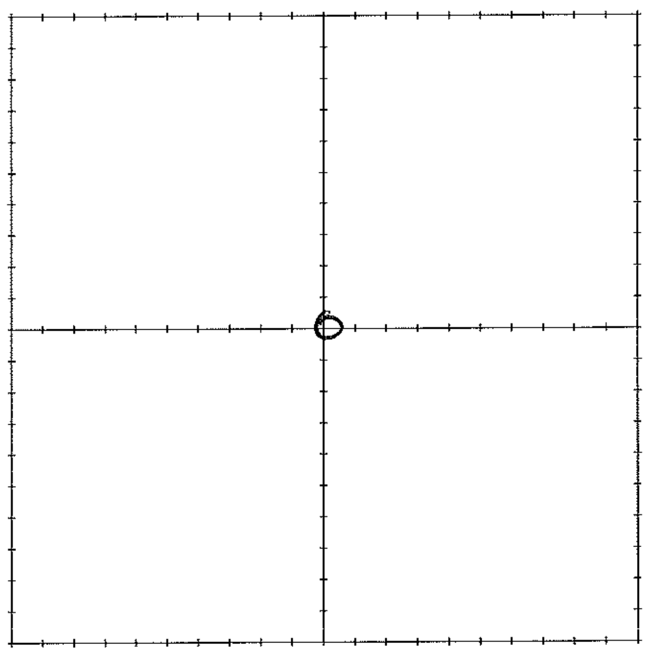
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011 - CX-005

SAMPLE COLLECTION DATE 12/1/16

SAMPLE COLLECTION TIME 1135

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS Cloudy, 30's

FIELD USCS DESCRIPTIONS Fine brown/red sand, minor clay, trace coarse sand

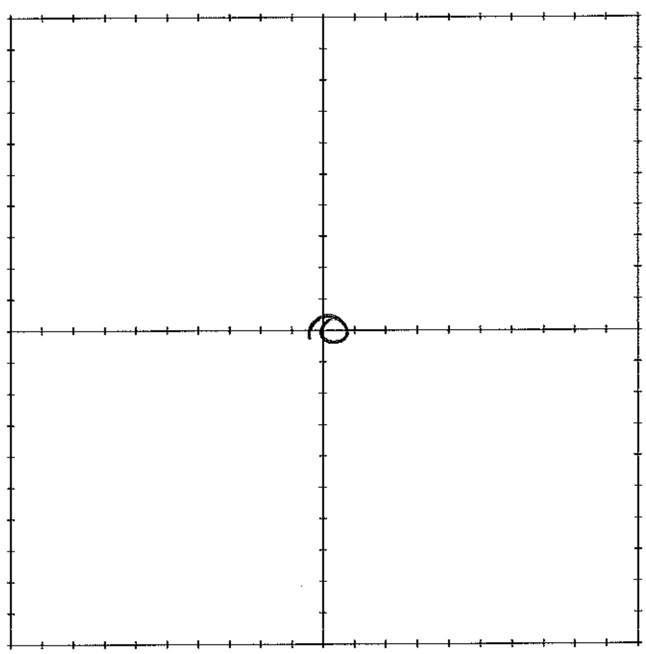
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011 - CX-006

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1124

SAMPLE COLLECTED BY MW/CC

WEATHER CONDITIONS 70's, windy

FIELD USCS DESCRIPTIONS Fine red sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

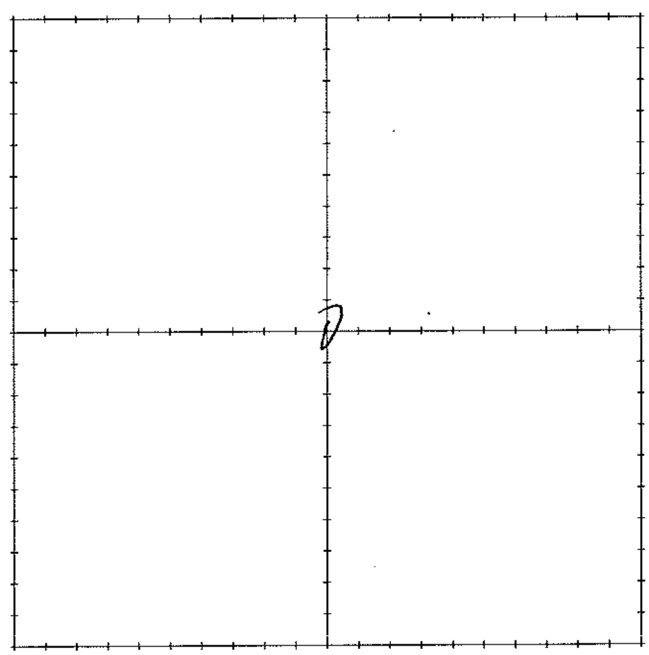
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011-CX-007

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1138

SAMPLE COLLECTED BY MW/CK

WEATHER CONDITIONS Fine gray sand

FIELD USCS DESCRIPTIONS 70's, windy

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

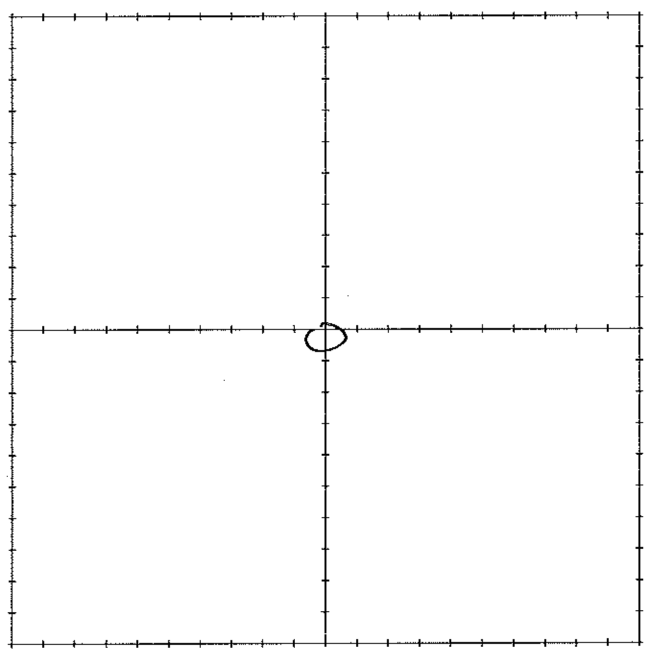
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011-CX-008

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1150

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 70s windy

FIELD USCS DESCRIPTIONS Fine red sand from drainage

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

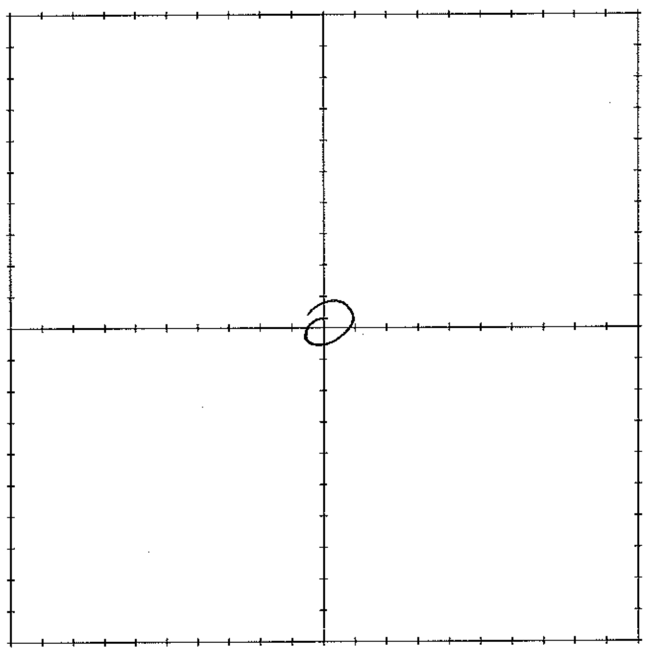
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011 - CX - 009

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1158

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 70's, windy

FIELD USCS DESCRIPTIONS Fine med sand from Drainage

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

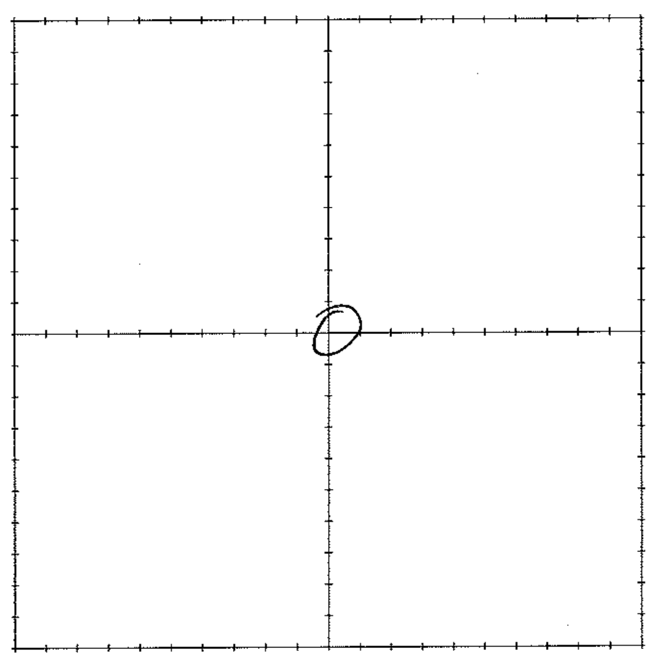
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011-CK-010

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1334

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 70's, windy

FIELD USCS DESCRIPTIONS Fine light brown sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

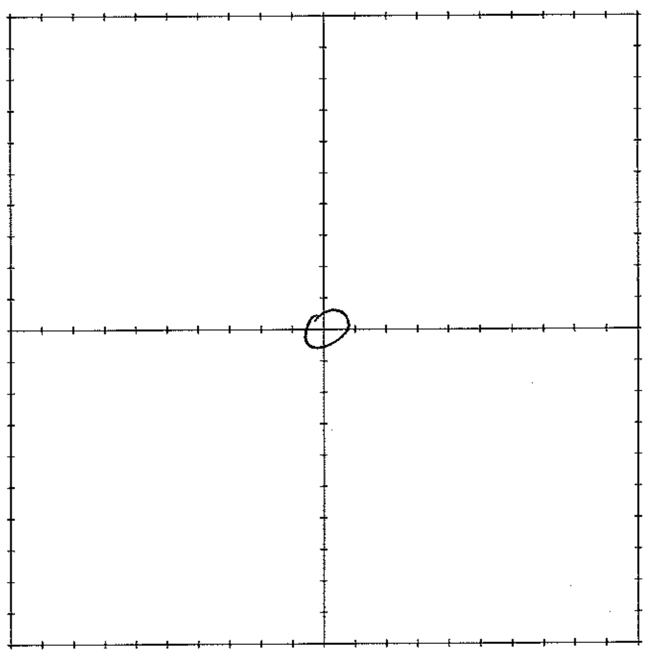
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Sector 26 (S1011)

SAMPLE I.D. S1011 - ~~CX-001~~ ~~CX-006~~ CX-011

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1020

SAMPLE COLLECTED BY MW / CL

WEATHER CONDITIONS 70's, windy

FIELD USCS DESCRIPTIONS Fine gray sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

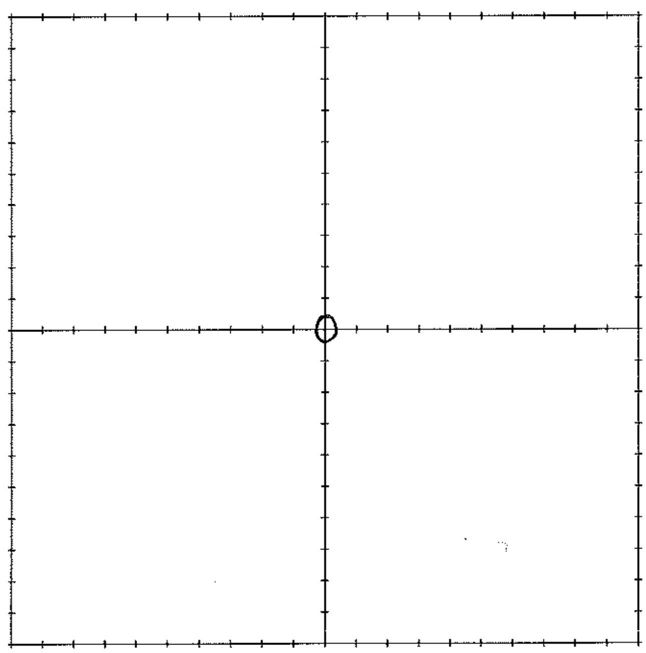
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME ~~S10H~~ Section 26 (S1011)

SAMPLE I.D. S1011 - CC - ~~002~~ ~~007~~ ~~00~~ 012

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1027

SAMPLE COLLECTED BY MW / CL

WEATHER CONDITIONS 70's, windy

FIELD USCS DESCRIPTIONS Rock flow, very fine, gray,

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC

☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

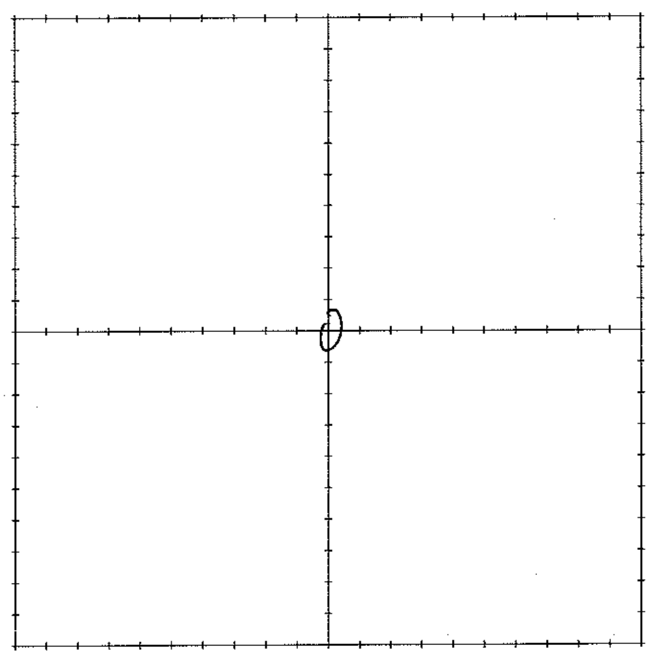
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME ~~Stanley Road~~ Section 26 (S1011)

SAMPLE I.D. S1011-CX-~~003~~, ~~203~~ 013, 213

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1052

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 70's, windy

FIELD USCS DESCRIPTIONS Fine tan/gray sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals

MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011-CK-~~004~~ 014
CL

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1059

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS Fine light brown sand, <10% fine gravels,

FIELD USCS DESCRIPTIONS CL 70's windy

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

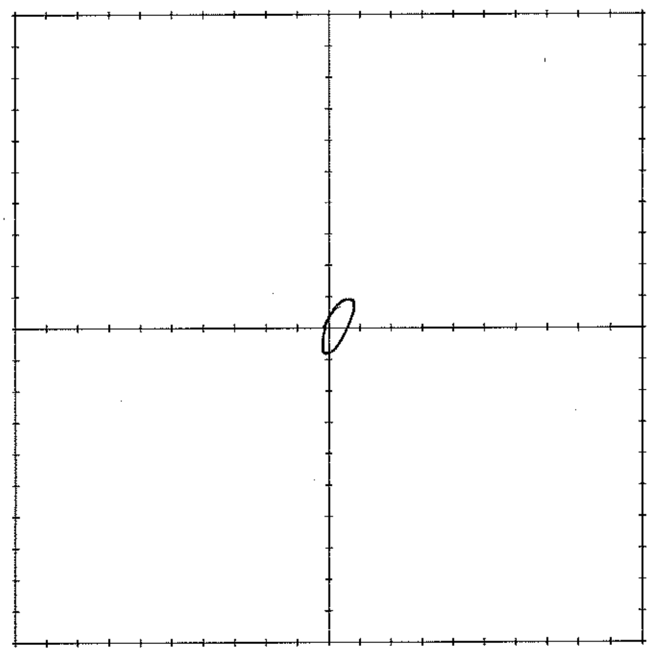
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226 Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011 - CX - ~~005~~ 015 MS/MSD

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1109

SAMPLE COLLECTED BY CL / MW

WEATHER CONDITIONS 70's windy

FIELD USCS DESCRIPTIONS Fine light brown sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC

☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

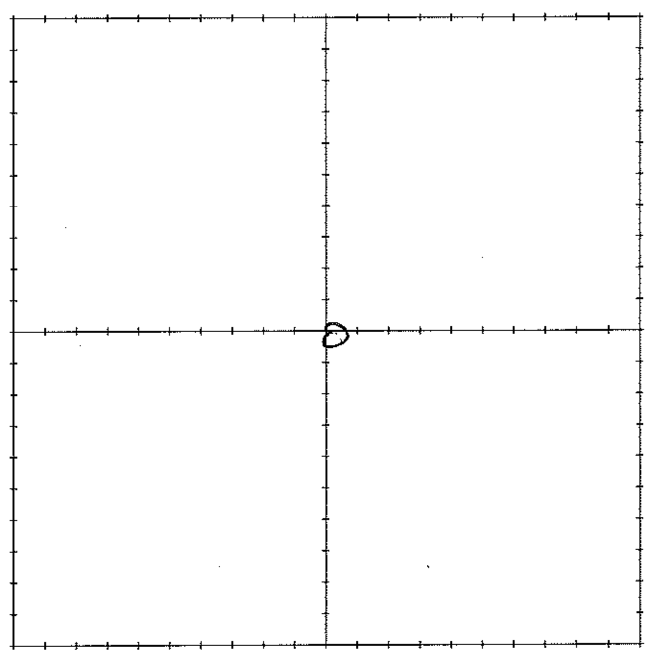
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

C.2 Drilling and Hand Auger Borehole Logs

Stantec	NAVAJO NATION AUM Environmental Response Trust-First Phase	BOREHOLE ID:	**S1011-BG1-011**
		CLIENT:	NNAUMERT
		PROJECT:	Removal Site Evaluation
		SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:		NAD 1983 UTM Zone 13N	
DRILLING METHOD:	Hand auger	EASTING:	784866.57	NORTHING:	3914510.88
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	3/25/2017	DATE STARTED:	3/25/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.9	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		SILTY SAND (SM): light brown, fine grained sand, moist.	7345	S1011-BG1-011-1	0-0.2	grab	1.62
			7963	S1011-BG1-011-2	0.5-0.7	grab	1.51
1		Terminated hand auger borehole at 0.9 ft. below ground surface. Refusal on bedrock.					
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

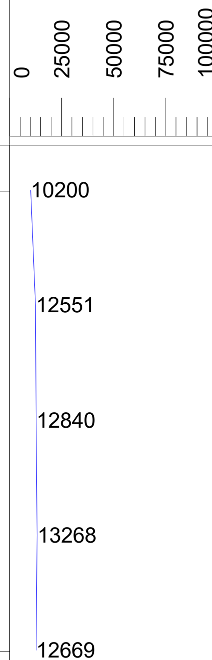
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-BG2-011**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:		NAD 1983 UTM Zone 13N	
DRILLING METHOD:	Hand auger	EASTING:	784860.27	NORTHING:	3914688.14
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	3/25/2017	DATE STARTED:	3/25/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	2	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		SILTY SAND (SM): light brown, fine grained sand, moist.	10200	S1011-BG2-011-1	0-0.2	grab	2.03
			12551				
1			12840				
			13268	S1011-BG2-011-3	1.5-2	grab	1.59
2		Terminated hand auger borehole at 2 ft. below ground surface. Borehole was terminated as the depth reached met the approved RSE Work Plan requirement.	12669				
3							
4							
5							



Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

BOREHOLE ID:	**S1011-BG3-011**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:		NAD 1983 UTM Zone 13N	
DRILLING METHOD:	Hand auger	EASTING:	784838.27	NORTHING:	3914513.01
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	9/19/2017	DATE STARTED:	9/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.25	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 – 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED GRAVEL WITH SAND (GP): reddish brown (5YR 5/3), gravels are angular to subangular, hard, dry, loose. Very limited sampling.	6390 6387	S1011-BG3-011-1	0-0.2	grab	1.16
		Terminated hand auger borehole at 0.25 ft. below ground surface. Refusal on sandstone.					
1							
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

BOREHOLE ID:	**S1011-BG4-011**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N		
DRILLING METHOD:	Hand auger	EASTING:	784820.16	NORTHING:	3914103.04
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	9/19/2017	DATE STARTED:	9/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	3	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL (SP): strong brown (7.5YR 5/6), medium grained sand, loose, dry, few gray gravels.	7788	S1011-BG4-011-1	0-0.2	grab	0.71
			9706				
1			10481				
			10271	S1011-BG4-011-2	0.2-3	comp	0.56
2			10313				
			10099				
3		Terminated hand auger borehole at 3.0 ft. below ground surface. Borehole was terminated as the depth reached met the approved RSE Work Plan requirement.	10616				
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S1011-BG5-011**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N	
DRILLING METHOD:	Hand auger	EASTING: 784820.87	NORTHING:	3913992.27
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 9/19/2017	DATE STARTED:	9/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 2	BOREHOLE ANGLE:	90 degrees
		LOGGED BY: Michael Ward		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0–2	POORLY GRADED SAND (SP): strong brown (7.5YR 5/6), fine to medium grained sand, loose, dry. Sampled in dry incised drainage.	8008	S1011-BG5-011-1	0-0.2	grab	0.63
		10302				
		11450	S1011-BG5-011-2	0.2-2	comp	0.74
		11465				
2	Terminated hand auger borehole at 2.0 ft. below ground surface. Refusal on hard surface.	11496				

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec

NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-001**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:		NAD 1983 UTM Zone 13N	
DRILLING METHOD:	Hand auger	EASTING:	785487.09	NORTHING:	3914060.74
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	5/12/2017	DATE STARTED:	5/12/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	1.5	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 – 25000 – 50000 – 75000 – 100000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL (SP): red, fine grained sand.	18116	S1011-SCX-001-1	0-0.5	grab	1.93
0.5		40% gravel.	40869				
1			42405	S1011-SCX-001-2	0.5-1.5	grab	2.48
1.5		Terminated hand auger borehole at 1.5 ft. below ground surface. Refusal on hard rock.	34807				
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-002**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec
DRILLING METHOD:	Hand auger
DRILLING EQUIPMENT:	Hand auger
SAMPLING METHOD:	Regular hand auger, 3 inch diameter

COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N		
EASTING:	785452.75	NORTHING:	3914047.76
DATE STARTED:	5/12/2017	DATE STARTED:	5/12/2017
TOTAL DEPTH (ft.):	1.5	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): red, brown, fine grained sand.	9941				
			11730	S1011-SCX-002-1	0-0.5	grab	0.95
1			12136	S1011-SCX-002-2	0.5-1.5	grab	0.54
1.5		Terminated hand auger borehole at 1.5 ft. below ground surface. Refusal on hard rock.	13372				
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-003**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:		NAD 1983 UTM Zone 13N	
DRILLING METHOD:	Hand auger	EASTING:	785501.03	NORTHING:	3913974.16
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	5/12/2017	DATE STARTED:	5/12/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	2.25	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 / 25000 / 50000 / 75000 / 100000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): brown, medium grained sand.	10529	S1011-SCX-003-1 S1011-SCX-203-1	0-0.5	grab	1.64 1.55
		less than 10% gravels.	16417				
1			21117	S1011-SCX-003-2	0.5-1.5	grab	2.23
		10% to 15% gravels.	27011				
2			30415	S1011-SCX-003-3	1.5-2.25	grab	3.41
		Terminated hand auger borehole at 2.25 ft. below ground surface. Refusal on hard rock.	34453				
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-004**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:		NAD 1983 UTM Zone 13N	
DRILLING METHOD:	Hand auger	EASTING:	785203.77	NORTHING:	3913866.67
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	5/12/2017	DATE STARTED:	5/12/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	2	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	POORLY GRADED SAND (SP): red, fine grained sand.	9633	S1011-SCX-004-1	0-0.5	grab	1.53
0.5	less than 5% gravels.	13991	S1011-SCX-004-2	0.5-1.5	grab	2.26
1		17635				
1.5	less than 10% gravels.	20059	S1011-SCX-004-3	1.5-2	grab	3.51
2	Terminated hand auger borehole at 2 ft. below ground surface. Refusal on hard surface.	29039				

Gamma scale (cpm): 0, 25000, 50000, 75000, 100000

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S1011-SCX-005**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N
DRILLING METHOD:	Hand auger	EASTING: 785220.83	NORTHING: 3914043.33
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 5/12/2017	DATE STARTED: 5/12/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 2	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Michael Ward

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm) (0–100000)
0	POORLY GRADED SAND (SP): red, brown, fine grained sand.	14559
0.5		12706
1		13934
1.5	less than 10% gravels.	17422
2	Terminated hand auger borehole at 2 ft. below ground surface. Refusal on hard rock.	22217

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-005-1	0-0.5	grab	1.59
S1011-SCX-005-2	0.5-1.5	grab	1.90
S1011-SCX-005-3	1.5-2	grab	3.10

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec	NAVAJO NATION AUM Environmental Response Trust-First Phase	BOREHOLE ID:	**S1011-SCX-006**
		CLIENT:	NNAUMERT
		PROJECT:	Removal Site Evaluation
		SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N		
DRILLING METHOD:	Hand auger	EASTING:	785219.67	NORTHING:	3914156.27
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	5/12/2017	DATE STARTED:	5/12/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	1.25	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 100000 200000 300000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): brown, fine grained sand.	154022 154588	S1011-SCX-006-1	0-0.5	grab	24.30
		with tan and gray sand.					
1			75424 47582	S1011-SCX-006-2	0.5-1.25	grab	23.80
		Terminated hand auger borehole at 1.25 ft. below ground surface. Refusal on hard rock.					
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-007**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec
DRILLING METHOD:	Hand auger
DRILLING EQUIPMENT:	Hand auger
SAMPLING METHOD:	Regular hand auger, 3 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 13N	
EASTING:	785278.25	NORTHING:	3914225.38
DATE STARTED:	5/13/2017	DATE STARTED:	5/13/2017
TOTAL DEPTH (ft.):	1.5	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL (SP): red, fine grained sand, 20% gravel, gravels are 0.25 inch to 2.0 inch diameter, subrounded.	20946	S1011-SCX-007-1	0-0.5	grab	5.34
		tan, red sands, 10% gravels.	20893	S1011-SCX-007-2	0.5-1	grab	3.74
1		tan, 10% gravels, moist.	19694	S1011-SCX-007-3	1-1.5	grab	4.69
		Terminated hand auger borehole at 1.5 ft. below ground surface. Refusal on hard surface.	16236				
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-008**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec
DRILLING METHOD:	Hand auger
DRILLING EQUIPMENT:	Hand auger
SAMPLING METHOD:	Regular hand auger, 3 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 13N	
EASTING:	785261.82	NORTHING:	3914202.15
DATE STARTED:	5/13/2017	DATE STARTED:	5/13/2017
TOTAL DEPTH (ft.):	1.5	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): tan, red, fine grained sand.	42178	S1011-SCX-008-1	0-0.5	grab	12.00
			57060	S1011-SCX-008-2	0.5-1	grab	6.61
1			72800	S1011-SCX-008-3	1-1.5	grab	8.90
		Terminated hand auger borehole at 1.5 ft. below ground surface. Refusal on rock.	103982				
2							
3							
4							
5							

Gamma (cpm) scale: 0, 50000, 100000, 150000, 200000

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-009**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785237.74	NORTHING: 3914584.48
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/9/2017	DATE STARTED: 6/9/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 7	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–2	POORLY GRADED FINE SAND WITH GRAVEL (SP): red brown (5YR 5/4), 70% sand, 30% gravel, gravels are subangular to subrounded, minor roots and organic material.
2–2.5	WELL GRADED GRAVEL AND SAND (GW): light red gray (5YR 7/4), gravel are 0.25 inch to 2.0 inch, subangular to subrounded,
2.5–7	SHALE: green to grey, with thin discontinuous lamination, some mottled zones.
7	Terminated borehole at 7 ft. below ground surface in bedrock.

Gamma (cpm) (scale 0, 25000, 50000, 75000, 100000)

Depth (feet)	Gamma (cpm)
0	8544
1	11686
2	10692
3	15044
4	17232
5	17936
6	19196

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-009-001	0-0.5	grab	0.88
S1011-SCX-009-002	0.5-2	comp	0.92

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

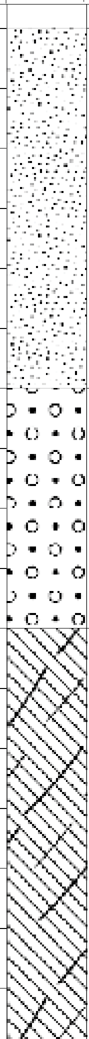
BOREHOLE ID:	**S1011-SCX-010**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling
DRILLING METHOD:	Rotary Sonic
DRILLING EQUIPMENT:	Geoprobe 8140LC
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter

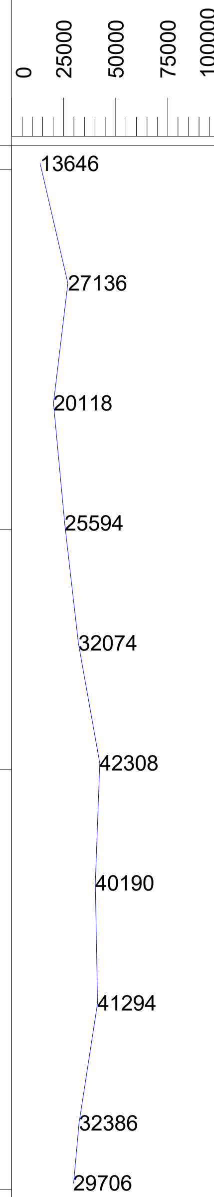
COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
EASTING:	785312.16	NORTHING:	3914564.96
DATE STARTED:	6/9/2017	DATE STARTED:	6/9/2017
TOTAL DEPTH (ft.):	8.5	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–3	POORLY GRADED SAND WITH GRAVEL (SP): red brown (5YR 5/4), loose, dry, alluvial.
3–5	WELL GRADED GRAVEL AND SAND (GW): white, with angular to subangular limestone gravels, coarse to fine sand.
5–8.5	SHALE: grey, with some limestone clasts.
8.5	Terminated borehole at 8.5 ft. below ground surface in bedrock.

LITHOLOGICAL GRAPHIC



Gamma (cpm)



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-010-001	0-0.5	grab	5.11
S1011-SCX-010-002	0.5-3	comp	2.36

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-011**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785079.02	NORTHING: 3914548.27
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/9/2017	DATE STARTED: 6/9/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 9	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

LITHOLOGICAL DESCRIPTION

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED FINE SAND (SP): red (5YR 5/6), loose, dry, with minor organics (0-1 ft.), alluvial.
3	WELL GRADED GRAVEL AND SAND (GW): light red (2.5YR 6/4), angular to subangular.
4	SHALE: green, red, thin discontinuous laminations.
5.5	with interbedded limestone concretions.
8	green and light red, thinly laminated.
9	Terminated borehole at 9 ft. below ground surface in bedrock.

Gamma (cpm)

DEPTH (feet)	Gamma (cpm)
0	8652
1	11026
2	11312
3	10428
4	9968
5	16896
6	17812
7	13242
8	12348
8.5	13386

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-011-001 S1011-SCX-011-201	0-0.5	grab	1.53 1.58
S1011-SCX-011-002	0.5-3	comp	0.78
S1011-SCX-011-003	3-4	grab	1.00

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-012**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785051.55	NORTHING: 3914563.92
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/9/2017	DATE STARTED: 6/9/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 9	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED FINE SAND (SP): red (5YR 5/4), loose, dry.	10932	S1011-SCX-012-001	0-0.5	grab	2.60
1			14594				
1.5		dense to medium dense, red (5YR5/4).					
2			13230				
3			11274	S1011-SCX-012-002	3-4	grab	1.12
3.5		WELL GRADED GRAVEL WITH SAND (GW): subangular to subrounded, gravels are 0.25 inch to 3 inch diameter.					
4		WELL GRADED SAND AND GRAVEL (SW): subangular to subrounded, 0.25 inch to 1 inch diameter.	9858				
5		CLAYSTONE: green, light red, interbedded marl and shale.	12308				
6			13940				
6.5		SANDSTONE: white, fine to medium grained.					
7			11776				
8			11426				
9		Terminated borehole at 9 ft. below ground surface in bedrock.	10814				
10							

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-013**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785086.48	NORTHING: 3914565.56
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/9/2017	DATE STARTED: 6/9/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 5	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm) (0–100000)
0	POORLY GRADED FINE SAND (SP)	8736
0.5	CLAYSTONE: green, light red, interbedded marl and shales.	
1		14258
2		16410
3		16580
4	SANDSTONE: white, fine grained.	18010
5	Terminated borehole at 5 ft. below ground surface in competent sandstone.	13298

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-013-001	0-0.5	grab	2.50

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-014**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
DRILLING METHOD:	Rotary Sonic	EASTING:	785054.8	NORTHING:	3914579.57
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED:	6/9/2017	DATE STARTED:	6/9/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.):	6.5	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm) (scale 0, 25000, 50000, 75000, 100000)
0	POORLY GRADED SAND WITH GRAVEL (SP): red (5YR 6/4), dry.	33406
1		10820
2		9438
3		9166
4	SANDSTONE: white, with sandy limestone.	10578
5		10380
5.5		18802
6.5	Terminated borehole at 6.5 ft. below ground surface in competent sandstone.	

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-014-001	0-0.5	grab	3.21
S1011-SCX-014-002	0.5-4	comp	0.81

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-015**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
DRILLING METHOD:	Rotary Sonic	EASTING:	785273.11	NORTHING:	3914269.22
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED:	6/10/2017	DATE STARTED:	6/10/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.):	2	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Tom Osborn		

SUBSURFACE SAMPLE INFORMATION

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	POORLY GRADED GRAVEL WITH SAND AND COBBLE (GP): gray (10YR 7/2). Interval contains metal refuse from existing surface waste dump next to borehole (refer to Appendix B-1, photograph number 4).	8296	S1011-SCX-015-001 S1011-SCX-015-201	0-0.5	grab	2.27 2.05
0.5–1.5	POORLY GRADED GRAVEL WITH SAND (GP): light brown (10YR 7/4).	9484	S1011-SCX-015-002	0.5-1.5	grab	3.59
1.5–2	LIMESTONE: gray.	8832				
2	Terminated borehole at 2 ft. below ground surface in competent limestone.					

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-016**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785251	NORTHING: 3914237.4
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/10/2017	DATE STARTED: 6/10/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 4	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm) (0, 25000, 50000, 75000, 100000)
0	WELL GRADED GRAVEL WITH SAND (GW): gray, 80% gravels and 20% sand, gravels are subangular limestone.	10728
1		9288
2		11334
3	LIMESTONE: light gray.	15094
4	Terminated borehole at 4 ft. below ground surface in competent limestone.	
5		

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-016-001	0-0.5	grab	2.93
S1011-SCX-016-002	2.5-3	grab	3.85

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

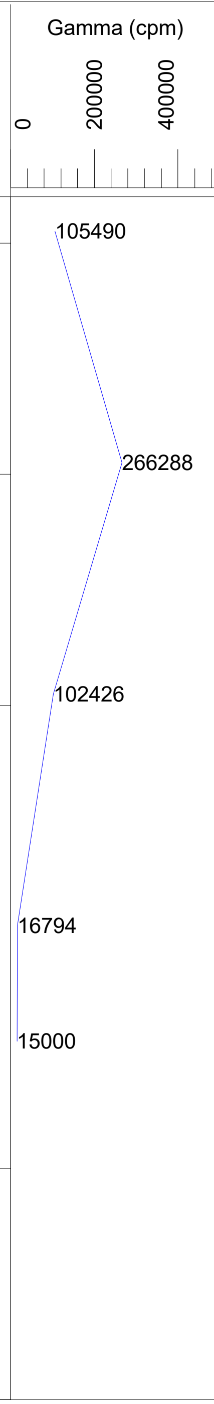
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-017**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
DRILLING METHOD:	Rotary Sonic	EASTING:	785591.45	NORTHING:	3914306.09
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED:	6/10/2017	DATE STARTED:	6/10/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.):	4	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0		105490
0–1	POORLY GRADED GRAVEL WITH SAND (GP): gray, gravels 80%, sand 20%, gravels are angular to subangular limestone with minor amounts of yellow Carnotite filling fractures.	266288
1–2	LIMESTONE: gray, with minor amounts of yellow Carnotite filling fractures.	102426
2–4	No sample recovery. Core lost from broken sample bag.	16794; 15000
4	Terminated borehole at 4 ft. below ground surface in competent limestone.	



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-017-001	0-0.5	grab	64.40
S1011-SCX-017-002	0.5-1	grab	66.40

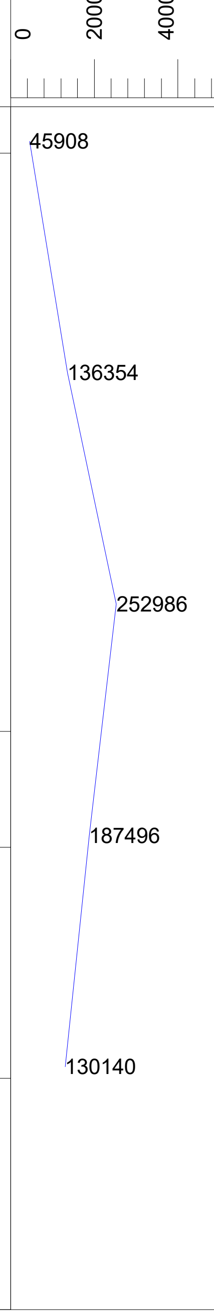
Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-018**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785608.82	NORTHING: 3914315.71
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/10/2017	DATE STARTED: 6/10/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 4	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED GRAVEL WITH SAND (GP): white and gray, gravels are angular to subangular, dry.
2.5	WELL GRADED GRAVELS AND SAND (GW): gray.
3	LIMESTONE: gray.
4	Terminated borehole at 4 ft. below ground surface in competent limestone.

Gamma (cpm)



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-018-001	0-0.5	grab	19.80
S1011-SCX-018-002	1-3.5	comp	80.20

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

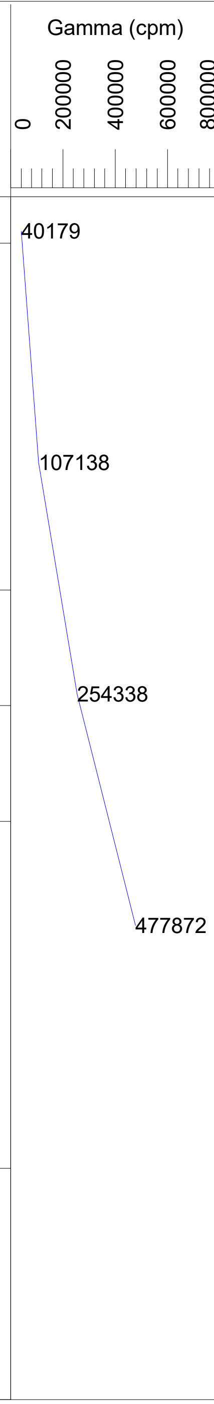
Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-019**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785584.19	NORTHING: 3914327.37
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/10/2017	DATE STARTED: 6/10/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 4	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–1.5	WELL GRADED GRAVELS AND SAND (GW): light gray, dry.
1.5–2.0	POORLY GRADED SAND WITH GRAVEL (SP): light brown.
2.0–2.5	WELL GRADED GRAVEL AND SAND (GW): light gray, dry.
2.5–4.0	LIMESTONE: gray, Carnotite mineralization on some fracture surfaces.
4	Terminated borehole at 4 ft. below ground surface in competent limestone.

Gamma (cpm)



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-019-001	0-0.5	grab	13.60
S1011-SCX-019-002	0.5-2.5	comp	37.20

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	S1011-SCX-020
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785611.49	NORTHING: 3914344.48
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/10/2017	DATE STARTED: 6/10/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 6	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED FINE SAND WITH GRAVEL (SP): red (5YR 5/6).	20449
1		25622
2		28812
3	with lenses of medium sand grains and inorganic stiff clays.	45588
4		76812
5	LIMESTONE: gray	79874
6	Terminated borehole at 6 ft. below ground surface in competent limestone.	118858

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-020-001	0-0.5	grab	6.24
S1011-SCX-020-002	0.5-4	comp	6.23

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

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BOREHOLE ID:	**S1011-SCX-021**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling
DRILLING METHOD:	Rotary Sonic
DRILLING EQUIPMENT:	Geoprobe 8140LC
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
EASTING:	785627.17	NORTHING:	3914465.38
DATE STARTED:	6/10/2017	DATE STARTED:	6/10/2017
TOTAL DEPTH (ft.):	20	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Tom Osborn		

LITHOLOGICAL DESCRIPTION

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–3	POORLY GRADED FINE SAND WITH GRAVEL (SP): red (5YR 5/6), gravels are angular to subangular, loose dry, sand 85%, gravel 15%, minor roots.
3–12	becoming moderately dense.
12–14	WELL GRADED SAND AND GRAVEL (SW): red, gray, dry.
14–15	WELL GRADED GRAVEL AND SAND (GW): red, dry.
15–17	WELL GRADED SAND AND GRAVEL (SW): dry, loose, red, gray.
17–18	WELL GRADED GRAVEL AND SAND (GW): red, dry, gravels are subangular.
18–19.5	SHALE: assorted color.
19.5–20	LIMESTONE: black, dark gray.
20	Terminated borehole at 20 ft. below ground surface in competent limestone.

Gamma (cpm)

DEPTH (feet)	Gamma (cpm)
0	11964
1	14878
2	16610
3	16712
4	17798
5	17462
6	17212
7	16554
8	14260
9	13470
10	14074
11	16628
12	25502
13	30366
14	26570
15	22026
16	15886
17	17180
18	29628
19	37786
20	29272

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-021-001	0-0.5	grab	3.02
S1011-SCX-021-005	12-13	grab	5.59
S1011-SCX-021-002 S1011-SCX-021-202	14-15	grab	3.99 4.15
S1011-SCX-021-003	17-18	grab	5.76
S1011-SCX-021-004	19-20	grab	6.75

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-022**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

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NAVAJO NATION AUM Environmental Response Trust-First Phase

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785626.97	NORTHING: 3914511.23
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/10/2017	DATE STARTED: 6/10/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 22	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	WELL GRADED SAND AND GRAVEL (SW): light red, with subrounded to subangular gravels.	11584
0.5–5	POORLY GRADED GRAVEL WITH SAND (GP): gray, limestone cobbles and boulders. Poor sample recovery.	10014 (1), 10162 (2), 10390 (3), 10572 (4)
5	POORLY GRADED SAND (SP): red, fine sand 100%.	10538
6	grey, fine sands.	10160
	red.	
7	grey, fine sands.	10124
	red, fine sand.	11216 (8), 14474 (9)
10	POORLY GRADED SAND WITH GRAVEL (SP): red (5YR 3/6), dry.	16838 (10), 19754 (11)
12	WELL GRADED GRAVEL AND SAND (GW): light red, dry.	21062
13	WELL GRADED SAND AND GRAVEL (SW): red (5YR 5/6).	22684 (13), 21010 (14), 23160 (15), 23892 (16), 23822 (17)
18	increase in cobbles, white, light brown.	26782 (18), 29084 (19)
20	LIMESTONE: gray, brown, limonite staining.	33188
22	Terminated borehole at 22 ft. below ground surface in competent limestone.	

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-022-001	0-0.5	grab	3.64
S1011-SCX-022-002	5-7	comp	0.78

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec | **NAVAJO NATION** AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-023**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling
DRILLING METHOD:	Rotary Sonic
DRILLING EQUIPMENT:	Geoprobe 8140LC
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
EASTING:	785649.39	NORTHING:	3914554.88
DATE STARTED:	6/10/2017	DATE STARTED:	6/10/2017
TOTAL DEPTH (ft.):	17.5	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–14	POORLY GRADED SAND WITH GRAVEL (SP): red (5YR 5/6), loose, dry.
14–15	WELL GRADED GRAVEL AND SAND (GW): gravels are 0.25 inch to 4 inch in diameter, angular to subangular, gravels are composed of limestone.
15–17.5	SHALE: assorted color, thin discontinuous lamination, green, pink.
17.5	Terminated borehole at 17.5 ft. below ground surface in bedrock.

Gamma (cpm) (scale 0, 25000, 50000, 75000, 100000)

DEPTH (feet)	Gamma (cpm)
0	11194
1	12954
2	13554
3	13538
4	13460
5	12650
6	11678
7	12514
8	13054
9	13532
10	13714
11	14780
12	14028
13	13874
14	18286
15	26014

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-023-001	0-0.5	grab	1.44
S1011-SCX-023-002	0.5-5	comp	0.84
S1011-SCX-023-003	13.5-14.5	grab	1.22

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

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BOREHOLE ID:	**S1011-SCX-024**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785657.63	NORTHING: 3914569.55
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/11/2017	DATE STARTED: 6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 7	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED SAND (SP): red (5YR 5/6).	32082
1		26124
2	SANDY FAT CLAY (CH): stiff, dense, increase in fines and density with depth.	16190
3		15480
4	SHALE: green, marl, mottled discontinuous laminations, effervesces with hydrochloric acid (HCL).	18898
5		22238
6		25878
7	Terminated borehole at 7 ft. below ground surface in bedrock.	27094

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-024-001 S1011-SCX-024-201	0-0.5	grab	9.00 6.67
S1011-SCX-024-002	3-4	grab	10.20

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

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NAVAJO NATION
AUM Environmental Response Trust - First Phase

BOREHOLE ID:	**S1011-SCX-025**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785580.09	NORTHING: 3914579.83
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/11/2017	DATE STARTED: 6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 8	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED SAND WITH GRAVEL (SP): red (5YR 5/6).	14636
1		23846
2		18968
2.5	SILT WITH FINE SAND (ML): green, gray (10Y 7/1), with red (5YR 5/6).	
3	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM): gravels are subangular dark gray limestone.	17256
4		17846
5		17792
6	SHALE: green, marl with discontinuous laminations.	20898
7		29730
8	Terminated borehole at 8 ft. below ground surface in bedrock.	39254
9		
10		

Gamma (cpm) scale: 0, 25000, 50000, 75000, 100000

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-025-001	0-0.5	grab	6.08
S1011-SCX-025-002	0.5-3	comp	3.32

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

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BOREHOLE ID:	**S1011-SCX-026**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785534.46	NORTHING: 3914533.87
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/11/2017	DATE STARTED: 6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 9	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm) (0–100000)
0	POORLY GRADED SAND (SP): red (5YR 5/6), dry, loose, trace gravel.	11826
1		16592
2		18044
3		16534
4		16388
5		15326
6	LIMESTONE: gray, planar bedding.	15000
7		12426
8		12886
8.5		13314
9	Terminated borehole at 9 ft. below ground surface in bedrock.	
10		

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-026-001	0-0.5	grab	1.26
S1011-SCX-026-002	0.5-5	comp	1.48
S1011-SCX-026-003	5-6	grab	1.12

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

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BOREHOLE ID:	**S1011-SCX-027**		
CLIENT:	NNAUMERT		
PROJECT:	Removal Site Evaluation		
SITE LOCATION:	Section 26		
DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785581.12	NORTHING: 3914553.94
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/11/2017	DATE STARTED: 6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 9	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED SAND (SP): red, loose, with trace gravels.	14552
1		13266
2	SILTY SAND (SM): red, brown, dense, trace gravels.	13404
3		10856
4		9462
5	WELL GRADED GRAVEL WITH SAND (GW): red, gray, subangular to subrounded.	8428
6		8884
7	SILTY SAND (SM): brown, red, dense to very dense sands, trace gravels.	9148
8	LIMESTONE: gray.	8580
9	Terminated borehole at 9 ft. below ground surface in bedrock.	8958
10		

Gamma (cpm) scale: 0, 25000, 50000, 75000, 100000

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-027-001	0-0.5	grab	1.74
S1011-SCX-027-002	0.5-3	comp	1.15
S1011-SCX-027-003	6-8.5	comp	1.20

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

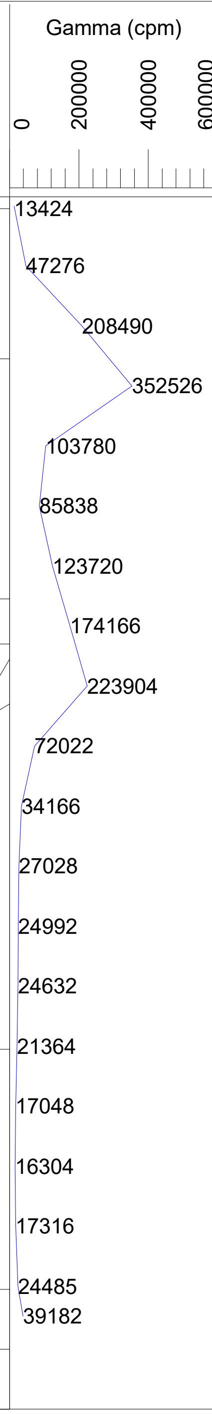
Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-028**		
CLIENT:	NNAUMERT		
PROJECT:	Removal Site Evaluation		
SITE LOCATION:	Section 26		
DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785561.15	NORTHING: 3914509.67
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/11/2017	DATE STARTED: 6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 19	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Tom Osborn

LITHOLOGICAL DESCRIPTION

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED SAND (SP): with trace gravels, angular, gravels are limestone.
2.5	increase in angular gravels.
6.5	LIMESTONE: cobble or small boulder.
7.25	POORLY GRADED SAND (SP): with trace gravels, angular, gravels are limestone.
7.75	LIMESTONE: grey, cobble or small boulder.
8.25	POORLY GRADED SAND (SP): red (5yr 5/6), dry, loose, with trace gravels, angular, gravels are limestone.
14	SHALE: green and pink, mottled, marl with discontinuous laminations.
18	SANDSTONE: fine grained, calcium carbonate cement.
19	Terminated borehole at 19 ft. below ground surface in bedrock.

Gamma (cpm)



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-028-001	0-0.5	grab	1.91
S1011-SCX-028-002 S1011-SCX-028-202	0.5-5	comp	47.10 45.80
S1011-SCX-028-003	5-8	comp	10.60
S1011-SCX-028-004	8-10	comp	13.80
S1011-SCX-028-005	10-12	comp	0.63
S1011-SCX-028-006	12-14	comp	1.36

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

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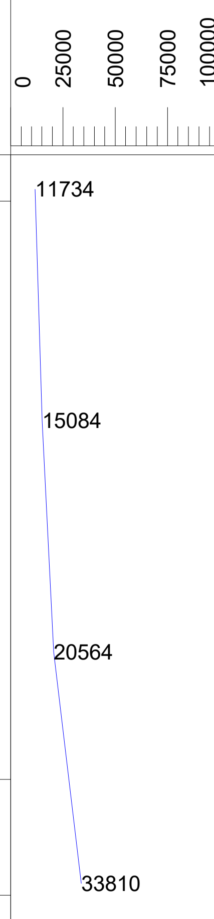
BOREHOLE ID:	**S1011-SCX-029**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785628.21	NORTHING: 3914490.56
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/11/2017	DATE STARTED: 6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 3.5	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–2.5	POORLY GRADED SAND WITH GRAVEL (SP): red (5YR 5/6), sand 75%, gravel 25%, angular, gravels are limestone.
2.5–3	POORLY GRADED GRAVEL WITH SAND (GP): light red, dense, gravel 60%, sand 40%.
3–3.5	LIMESTONE: gray.
3.5	Terminated borehole at 3.5 ft. below ground surface in bedrock.

Gamma (cpm)



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-029-001	0-0.5	grab	1.73
S1011-SCX-029-002	0.5-3	comp	2.87

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-030**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

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DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785580.14	NORTHING: 3914467.81
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/11/2017	DATE STARTED: 6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 14	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED SAND (SP): red (5YR 5/6), trace gravel, rounded, gravel are 0.25 inch diameter.	10412
1		11078
2		10834
3		11048
4		11634
5		12246
6	with few subrounded limestone gravel, 0.5 inch to 2.0 inch diameter.	13378
7		14020
8		14542
9		16164
10	MUDSTONE: green, light red, assorted colors, with discontinuous laminations.	14666
11		14218
12		16740
13		17184
		18014
14	Terminated borehole at 14 ft. below ground surface in bedrock.	
15		

Gamma (cpm) scale: 0, 25000, 50000, 75000, 100000

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-030-001	0-0.5	grab	1.16
S1011-SCX-030-002	0.5-5	comp	0.79

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-031**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785554.61	NORTHING: 3914489.46
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/11/2017	DATE STARTED: 6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 19	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–6	POORLY GRADED SAND (SP): red (5YR 5/6), trace gravel, gravels are rounded to subrounded.
6–6.5	Refuse including cans, paper, bottle caps.
6.5–16	POORLY GRADED SAND (SP): red (5YR 5/6), dry, loose, trace gravel.
16–18	POORLY GRADED GRAVEL WITH SAND (GP): subrounded, gravel are limestone.
18–19	LIMESTONE: with sand, grey.
19	Terminated borehole at 19 ft. below ground surface in bedrock.

DEPTH (feet)	Gamma (cpm)
0	10658
1	11560
2	12288
3	12194
4	13318
5	14170
6	23174
7	112936
8	46570
9	14706
10	12666
11	12820
12	13212
13	13678
14	14856
15	16104
16	16732
17	17160

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-031-001	0-0.5	grab	0.98
S1011-SCX-031-002	0.5-5	comp	0.92
S1011-SCX-031-003	5-7	comp	0.69
S1011-SCX-031-004	7-10	comp	0.67
S1011-SCX-031-005 S1011-SCX-031-205	10-12	comp	0.57 0.61

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-032**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785532.4	NORTHING: 3914481.94
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/11/2017	DATE STARTED: 6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 12	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–1	POORLY GRADED SAND (SP): red (5YR 5/6), dry, loose, trace gravel.
1–2	WELL GRADED SAND WITH GRAVEL (SW): red (5YR 5/6), dry, loose, sand is fine to medium grained, gravels are rounded.
2–9	POORLY GRADED SAND WITH GRAVEL (SP): red (5YR 5/6), gravels are rounded to subrounded.
9–12	MUDSTONE: green, pink, with interfingering sandstone.
12	Terminated borehole at 12 ft. below ground surface in bedrock.

Gamma (cpm) (scale 0, 25000, 50000, 75000, 100000)

DEPTH (feet)	Gamma (cpm)
0	10570
1	14382
2	16332
3	14894
4	13608
5	13554
6	14296
7	14250
8	14892
9	17310
10	21916
11	23336

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-032-001	0-0.5	grab	1.44
S1011-SCX-032-002	0.5-5	comp	0.81
S1011-SCX-032-003	5-9	comp	1.01

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

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NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S1011-SCX-033**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Section 26

DRILLING CONTRACTOR: Cascade Drilling
DRILLING METHOD: Rotary Sonic
DRILLING EQUIPMENT: Geoprobe 8140LC
SAMPLING METHOD: Sonic Core Barrel, 4 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 785618.17 NORTHING: 3914451.68
DATE STARTED: 6/11/2017 DATE STARTED: 6/11/2017
TOTAL DEPTH (ft.): 11 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED SAND (SP): red (5YR 5/6), dry, loose, with a few gravel.	12994
1		18482
2		18922
3		18392
4		20686
5	LIMESTONE: cobble or small boulder.	23166
5.5	WELL GRADED SAND WITH GRAVEL (SP): fine sand, angular gravel 0.25 inch to 0.5 inch.	
6		24122
7	becoming dense, fines increase with depth, minor coarse sands and trace gravel.	22206
8		22044
9	LIMESTONE: with wavy laminations, red mineralization.	23926
10		31118
11	Terminated borehole at 11 ft. below ground surface in bedrock.	

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-033-001 S1011-SCX-033-201	0-0.5	grab	1.75 1.54
S1011-SCX-033-002	0.5-5	comp	1.59
S1011-SCX-033-003	5-9	comp	3.31

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-034**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling
DRILLING METHOD:	Rotary Sonic
DRILLING EQUIPMENT:	Geoprobe 8140LC
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
EASTING:	785596.46	NORTHING:	3914489.25
DATE STARTED:	6/11/2017	DATE STARTED:	6/11/2017
TOTAL DEPTH (ft.):	15	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Tom Osborn		

LITHOLOGICAL DESCRIPTION

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED SAND WITH GRAVEL (SP): thin shale gravel, cuttings less than 0.5 inches, 90% sand, 10% gravel. Minor organics including roots and grass.
2	POORLY GRADED SAND (SP): red (5YR 5/6),100% sand.
8	fine gray sand.
	red (5YR 5/6),100% sand.
9	POORLY GRADED SAND WITH GRAVEL (SP): light brown (10R 6/3), gravels are rounded.
10	CLAYEY SAND (SC): with some silt and gravel, dense, weathered bedrock gravels.
12	CLAYSTONE: green, marl, weathered.
13	MUDSTONE: green, with minor sandstone.
15	Terminated borehole at 15 ft. below ground surface in bedrock.

Gamma (cpm)

Scale: 0, 25000, 50000, 75000, 100000

DEPTH (feet)	Gamma (cpm)
0	10216
1	12334
2	10874
3	10392
4	10602
5	11044
6	11470
7	11290
8	12642
9	13500
10	13430
11	14888
13	18172
14	19656
14.5	21210

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-034-001	0-0.5	grab	1.26
S1011-SCX-034-002	0.5-5	comp	0.66
S1011-SCX-034-003	5-10	comp	0.65

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-035**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785584.73	NORTHING: 3914514.82
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/12/2017	DATE STARTED: 6/12/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 20	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	SILTY SAND (SM): with roots.	11674
1	with calcium carbonate in thin discontinuous lenses.	14782
2	increase in density.	16220
3	POORLY GRADED SAND (SP): red (5YR 5/6), dry, loose, trace subrounded gravel.	16496
4		14548
5		13084
6		13386
7		13298
8		13728
9		13652
10	POORLY GRADED SAND WITH GRAVEL (SP): red (5YR 5/6).	14074
11		13990
12		15622
13		15690
14		15844
15		17532
16		18100
17	LIMESTONE: gray and tan, sandy limestone.	17820
18		17452
19		29954
20	Terminated borehole at 20 ft. below ground surface in bedrock.	31690
21		

Gamma (cpm) scale: 0, 25000, 50000, 75000, 100000

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-035-001	0-0.5	grab	1.51
S1011-SCX-035-002	0.5-5	comp	0.94
S1011-SCX-035-003	5-8	comp	1.33

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-036**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785631.74	NORTHING: 3914563.54
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/12/2017	DATE STARTED: 6/12/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 7.5	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED SAND (SP): red (5YR 5/6), sands are fine.
1	dense, with few angular gravel, dry.
3	SILTY SAND (SM): with few angular gravel.
4	MUDSTONE: marl, green, purple, light pink, with calcium carbonate.
7.5	Terminated borehole at 7.5 ft. below ground surface in bedrock.

Gamma (cpm) (scale 0, 25000, 50000, 75000, 100000)

DEPTH (feet)	Gamma (cpm)
0	13564
1	15048
2	14742
3	12738
4	11068
5	13984
6	21554
7	25802
7.5	22384

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-036-001 S1011-SCX-036-201	0-0.5	grab	3.79 3.74
S1011-SCX-036-002	0.5-3	comp	2.11

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

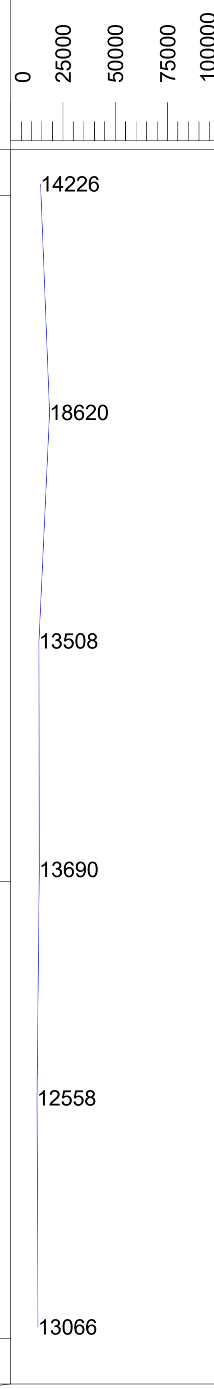
BOREHOLE ID:	**S1011-SCX-037**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling
DRILLING METHOD:	Rotary Sonic
DRILLING EQUIPMENT:	Geoprobe 8140LC
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
EASTING:	785568.09	NORTHING:	3914568.95
DATE STARTED:	6/12/2017	DATE STARTED:	6/12/2017
TOTAL DEPTH (ft.):	5	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–3	POORLY GRADED SAND WITH GRAVEL (SP): red (5YR 5/6), dry, subangular, gravel are 0.5 inch diameter.
3–5	MUDSTONE: green, pink, mottled, calcium carbonate.
5	Terminated borehole at 5 ft. below ground surface in bedrock.

Gamma (cpm)



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-037-001	0-0.5	grab	7.80
S1011-SCX-037-002	0.5-3	comp	1.28

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S1011-SCX-038**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Section 26

DRILLING CONTRACTOR: Cascade Drilling
DRILLING METHOD: Rotary Sonic
DRILLING EQUIPMENT: Geoprobe 8140LC
SAMPLING METHOD: Sonic Core Barrel, 4 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 785559.08 NORTHING: 3914524.77
DATE STARTED: 6/12/2017 DATE STARTED: 6/12/2017
TOTAL DEPTH (ft.): 19.5 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED SAND (SP): red (5YR 5/6), loose, minor roots and grass.
2	POORLY GRADED SAND WITH GRAVEL (SP): brown, red (7.5YR 4/4), dense, dry.
3	POORLY GRADED SAND (SP): red (5YR 5/6), loose, fine sand.
8	trace gravel, subangular, dry, limestone gravel.
16	LIMESTONE: gray, sandy.
19.5	Terminated borehole at 19.5 ft. below ground surface in bedrock.

Gamma (cpm) (scale 0, 25000, 50000, 75000, 100000)

DEPTH (feet)	Gamma (cpm)
0	24372
1	17094
2	12736
3	16092
4	13244
5	11722
6	12444
7	13204
8	14028
9	14446
10	15148
11	14630
12	15030
13	15232
14	14684
15	13868
16	13826
17	14336
18	13668
19	12206
19.5	14560

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-038-001	0-0.5	grab	8.20
S1011-SCX-038-002	0.5-3	comp	0.73
S1011-SCX-038-003	3-10	comp	0.68

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-039**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N		
DRILLING METHOD:	Hand auger	EASTING:	785065.71	NORTHING:	3914559.84
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	9/19/2017	DATE STARTED:	9/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.2	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 50000 100000 150000 200000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL (SP): reddish gray (10YR 6/1), loose, dry, angular gravels, small to large.	25341 72575	S1011-SCX-039-1	0-0.2	grab	6.90
		Terminated hand auger borehole at 0.2 ft. below ground surface. Refusal on rock.					
1							
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-040**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N
DRILLING METHOD:	Hand auger	EASTING: 785071.9	NORTHING: 3914571.15
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 9/19/2017	DATE STARTED: 9/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 0.2	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Michael Ward

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL (SP): yellowish red (5YR 5/6), loose, dry, fine to medium grained sand.	16404 24374	S1011-SCX-040-1	0-0.2	grab	2.91
		Terminated hand auger borehole at 0.2 ft. below ground surface. Refusal on rock.					
1							
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-041**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N
DRILLING METHOD:	Hand auger	EASTING: 785167.65	NORTHING: 3914012.35
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 9/19/2017	DATE STARTED: 9/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 2.5	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Michael Ward

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	POORLY GRADED SAND WITH GRAVEL (SP): strong brown (7.5YR 5/8), fine to medium grained sand, loose, dry.	8725	S1011-SCX-041-1	0-0.2	grab	0.72
0.5		11463				
1		14067	S1011-SCX-041-2	0.2-2.5	comp	1.66
1.5		14704				
2		16358				
2.5	Terminated hand auger borehole at 2.5 ft. below ground surface in undisturbed native material.	17072				
3						
4						
5						

Gamma (cpm) scale: 0, 25000, 50000, 75000, 100000

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-042**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N
DRILLING METHOD:	Hand auger	EASTING: 785341.87	NORTHING: 3914013.37
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 9/19/2017	DATE STARTED: 9/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 2	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Michael Ward

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm) (0 – 25000 – 50000 – 75000 – 100000)
0	POORLY GRADED SAND WITH GRAVEL (SP): strong brown (7.5YR 5/8), fine to medium grained sand, loose, dry.	8158
0.5		9653
1		10000
1.5		9725
2	Terminated hand auger borehole at 2.0 ft. below ground surface in undisturbed native material.	9365
3		
4		
5		

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-042-1	0-0.2	grab	1.11
S1011-SCX-042-2	0.2-2	comp	0.56

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-043**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N		
DRILLING METHOD:	Hand auger	EASTING:	785626.96	NORTHING:	3914061.41
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	9/19/2017	DATE STARTED:	9/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.2	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL (SP): strong brown (7.5YR 5/8), fine to medium grained sand, dense to medium dense. Sampled in compacted unsealed road.	10128 12081	S1011-SCX-043-1 S1011-SCX-243-1	0-0.2	grab	1.77 1.99
		Terminated hand auger borehole at 0.2 ft. below ground surface. Refusal on rock.					
1							
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-044**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N		
DRILLING METHOD:	Hand auger	EASTING:	785065.4598	NORTHING:	3914556.9391
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	9/19/2017	DATE STARTED:	9/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.7	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL (SP): light reddish brown (5YR 6/3), fine to coarse grained sand, mostly medium grained sand, gravels are subangular to angular, gravels are gray, loose, dry.	18638	S1011-SCX-044-1	0-0.2	grab	7.80
			32807	S1011-SCX-044-2	0.2-0.7	grab	7.01
			37173				
		Terminated hand auger borehole at 0.7 ft. below ground surface. Refusal on rock.					
1							
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Appendix D Evaluation of RSE Data

D.1 Background Reference Area Selection

D.2 Statistical Evaluation

BACKGROUND REFERENCE AREA SELECTION

1.0 INTRODUCTION

This appendix presents the rationale for selection of the background reference areas for the Section 26 Site (Site). To select the background reference areas for the Site, personnel considered geology, predominant wind direction, hydrologic influence, similarities of vegetation and ground cover, distance from the Site, and visual evidence of impacts due to mining (or other anthropogenic sources) in accordance with the *Multi-Agency Radiation Survey and Site Investigation Manual – Appendix A* ([MARSSIM] USEPA, 2000).

2.0 POTENTIAL BACKGROUND REFERENCE AREAS

The potential background reference area study was initiated during the Site Clearance desktop study and field investigations. In November 2016, two potential background reference areas were identified to represent the geologic formations at the Site where mining-impacted material was assumed to be present: BG-1 represents areas of the Site within the Luciano Mesa Member of the Todilto Formation (Todilto Limestone) and BG-2 represents areas of the Site within the Quaternary deposits. BG-1 and BG-2 were initially gamma surveyed using a Ludlum Model 44-20 2-inch by 2-inch sodium iodide (NaI) high-energy gamma detector in May 2016. Soil samples were collected at BG-1 and BG-2 in November 2016. Following discussions with the Agencies, it was identified that the Site would be characterized using a 3-inch by 3-inch NaI detector; BG-1 and BG-2 were surveyed using a 3-inch by 3-inch NaI detector in March 2017. The initial (3-inch by 3-inch NaI detector) gamma survey at BG-1 did not cover the areal extent of the surface soil samples collected in BG-1, so BG-1 was surveyed again in September 2017 and those survey data were used for the Removal Site Evaluation (RSE).

BG-1 and BG-2 are shown in Figure D.1-1. It should be considered that BG-1 is located along the inferred geologic contact between the Todilto Limestone and the Quaternary deposits. The geologic contact was adapted from a regional geologic map (shown in Figure 2-5 of the RSE Report) based on aerial imagery. While there are Quaternary soils present in BG-1, they are assumed to limited in depth across the potential background reference area.

Following review of the data collected during Baseline Studies and Site Characterization, Stantec observed that mining-related impacts extended down the mesa sidewall and into the plains area south of the Site. Additional potential background reference areas were required to represent the additional geological conditions. Potential mining-related impacts were observed in the following geologic units (refer to Figure D.1-1):

- Todilto Limestone (BG-1)
- Quaternary deposits (BG-2, BG-4, BG-7 and BG-8))
- Entrada Sandstone (BG-3)
- Wingate Sandstone (BG-6)

Section 3.3.1.2 in the RSE report discusses the extent of the surface gamma survey at the Site, the geologic conditions present within the Survey Area, and how the Survey Area is broken up into individual Survey Areas (Survey Area A, Survey Area B, etc.) based on MARSSIM criteria, including geologic conditions. Figure 3-4 in the RSE Report shows the separate Survey Areas. Six additional potential background reference areas were identified to represent the geologic conditions, as described below, where potential mining-related impacts were observed. Gamma surveys were conducted in June 2017 (BG-3 and BG-6) and in September 2017 (BG-4, BG-5, BG-7, and BG-8). Following review of Site Characterization data, it was determined that BG-6, BG-7, and BG-8 would not be used to represent the Site, as described in Section 3.0 below. Soil/sediment samples were collected from BG-3, BG-4, and BG-5 in September 2017. It was later determined that BG-6 should have been sampled to provide a background reference area to represent the Wingate Sandstone. The need to collect soil samples in BG-6 is identified as a data gap in the RSE Report.

The locations of the eight potential background reference areas (BG-1 through BG-8), geology, and predominant wind direction are shown in Figure D.1-2. The potential background reference areas are described below:

- BG-1 encompasses an area of 1,708 ft^2 (approximately 0.04 acres), is located 521 ft west of claim #1011, and is upwind and hydrologically cross-gradient from the Site. The thin soils and bedrock outcrops represent the portions of the survey areas within the Todilto Limestone on the mesa top. The vegetation and ground cover at BG-1 are similar to the portions of the Site on the mesa edge.
- BG-2 encompasses an area of 2,362 ft^2 (approximately 0.05 acres), is located 557 ft northwest of claim #1011, and is upwind and hydrologically cross-gradient from the Site. The thicker soils represent the portions of the survey areas that consist of undifferentiated Quaternary deposits on the mesa top including residual soils, alluvium, and eolian deposits. The vegetation and ground cover at BG-2 are similar to the portions of the Site on the mesa top.
- BG-3 encompasses an area of 683 ft^2 (approximately 0.02 acres), is located 618 ft west of claim #1011, and is upwind and hydrologically cross-gradient from the Site. The thin soils, colluvium-covered slopes, and bedrock outcrops represent the portions of the survey areas within the Entrada Sandstone on the mesa sidewall. The vegetation and ground cover at BG-3 are similar to the portions of the Site on the mesa sidewall.
- BG-4 encompasses an area of 5,623 ft^2 (approximately 0.13 acres), is located 1,387 ft west of claim #1012, and is upwind and hydrologically cross-gradient from the Site. The soils

represent the portions of the survey areas that consist of undifferentiated Quaternary deposits on the plains below the claim boundaries. The vegetation and ground cover at BG-4 are similar to the areas of the Site on the plains.

- BG-5 encompasses an area of 1,151 ft^2 (approximately 0.03 acres), is located 1,447 ft southwest of claim #1012, and is upwind and hydrologically cross-gradient from the Site. The sediments represent the portions of the survey areas that consist of Quaternary alluvium in the drainages. The vegetation and ground cover at BG-5 are similar to the alluvial drainages on the plains.

- BG-6 encompasses an area of 2,957 ft^2 (approximately 0.07 acres), is located 1,017 ft west of claim #1012, is upwind and hydrologically cross-gradient from the Site, and across multiple drainage divides. The thin soils, colluvium-covered slopes, and bedrock outcrops represent the portions of the survey areas within the Wingate Sandstone on the plains. The vegetation and ground cover at BG-6 are similar to the portions of the Site where mesa sidewall transitions to the plains.

- BG-7 encompasses an area of 5,273 ft^2 (approximately 0.12 acres), is located 1,173 ft west of claim #1012, is upwind and hydrologically cross-gradient from the Site, and is across multiple drainage divides. The soils represent the portions of the survey areas that consist of Quaternary deposits on the plains. The vegetation and ground cover at BG-7 are similar to the areas of the Site that are on the plains.

- BG-8 encompasses an area of 2,338 ft^2 (approximately 0.05 acres), is located 1,873 ft southwest of claim #1012 on the plains, is upwind and cross-gradient from the Site, and across multiple drainage divides. The sediments represent the portions of the survey areas that consist of Quaternary alluvium in the drainages. The vegetation and ground cover at BG-8 are similar to the alluvial drainages on the plains.

The potential background reference area evaluation included surface gamma surveys, surface and subsurface static gamma measurements, and collection of surface and subsurface soil/sediment samples as described below:

- BG-1– 11 surface soil grab samples were collected from 11 locations; one subsurface soil grab sample, and surface and subsurface static gamma measurements, were collected from borehole location S1011-BG1-011

- BG-2 –11 surface soil grab samples were collected from 11 locations; one subsurface soil grab sample, and surface and subsurface static gamma measurements, were collected from borehole location S1011-BG2-011

- BG-3 –11 surface soil grab samples were collected from 11 locations; a borehole could not be advanced beyond 0.25 feet below ground surface (ft bgs) at S1011-BG3-011, so no subsurface samples were collected at BG-3; surface and subsurface static gamma measurements were collected at S1011-BG3-011

- BG-4 –11 surface soil grab samples were collected from 11 locations; one subsurface soil composite sample, and surface and subsurface static gamma measurements, were collected from borehole location S1011-BG4-011

- BG-5 –11 surface sediment grab samples were collected from 11 locations; one subsurface sediment composite sample, and surface and subsurface static gamma measurements, were collected from borehole location S1011-BG5-011
- BG-6 – surface gamma survey only
- BG-7 – surface gamma survey only
- BG-8 – surface gamma survey only

The sample locations and surface gamma survey data for BG-1, BG-2, BG-3 and BG-4 are shown in Figure D.1-2. The sample locations for BG-5, and the surface gamma survey data for BG-6, BG-7, and BG-8, are shown in Figure D.1-3. Samples were categorized as surface soil/sediment samples where sample depths were up to 0.5 ft bgs, and as subsurface samples where sample depths were greater than 0.5 ft bgs. Static gamma measurements were categorized as surface where static gamma was measured at the ground surface, and as subsurface where static gamma was measured at or greater than 0.1 ft bgs. Tables D.1-1 and D.1-2 provide descriptive statistics for the metals/Ra-226 concentrations and the surface gamma measurements, respectively. Field forms, including borehole logs, are provided in Appendix C of the RSE Report.

The equipment used for the surface gamma survey (with the exception that a 2-inch by 2-inch NaI detector was used due to borehole diameter) were also used for static one-minute gamma measurements at the ground surface, and for subsurface gamma measurements at the borehole locations. Soil/sediment samples and gamma measurements were collected according to the methods described in the *Removal Site Evaluation Work Plan* (MWH, 2016).

3.0 SELECTION OF BACKGROUND REFERENCE AREA

Background reference areas were selected to represent the areas of the Site where mining-related disturbances may have occurred or otherwise come to be located including downgradient drainages. BG-1, BG-2, BG-3, BG-4 and BG-5 were selected to represent their respective geologic formations described above. BG-4 and BG-5 were selected to represent the Quaternary deposits (e.g., Quaternary alluvium, respectively, on the plains area of the Site because the gamma measurements in the plains area were generally lower than those within the Quaternary deposits on the mesa top.

The need to collect soil samples from BG-6 to represent the Wingate Sandstone is identified as a data gap in the RSE report. Gamma measurements from BG-6 were considered for the estimation of the location and volume of mining-impacted material for the RSE.

BG-7 was not selected as a background reference area, because it was redundant with BG-4. BG-4 was selected over BG-7 because it was located across a drainage from the area of the plains downgradient from the Site.

BG-8 was not selected as a background reference area, because it was redundant with BG-5. BG-8 also appeared to extend outside of the center of the drainage and the Quaternary alluvium.

Surface gamma survey measurements, soil and sediment sample results, and subsurface static gamma measurements collected from BG-1, BG-2, BG-3, BG-4, BG-5 and the gamma survey measurements collected from BG-6 were used for the remainder of the RSE of the Site.

4.0 REFERENCES

MWH, 2016. *Navajo Nation AUM Environmental Response Trust – First Phase Removal Site Evaluation Work Plan*. October.

USEPA, 2000. *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM), EPA 402-R-97-016, Rev. 1.

Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Reference Area Study - Background Area 1 - Todilto Limestone						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	18%	100%	--	--	--
Minimum[1]	2	--	--	1.60	5.50	1.05
Minimum Detect[2]	--	0.320	--	--	--	--
Mean[1]	4.32	--	--	2.17	11.5	1.47
Mean Detects[2]	--	0.567	--	--	--	--
Median[1]	3.40	--	--	2.10	11.0	1.43
Median Detects[2]	--	0.490	--	--	--	--
Maximum[1]	11	--	--	2.80	26.0	1.86
Maximum Detect[2]	--	1.40	--	--	--	--
Distribution	Normal	Gamma	Not Calculated	Normal	Normal	Normal
Coefficient of Variation[1]	0.621	--	--	0.172	0.488	0.160
CV Detects[2]	--	0.587	--	--	--	--
UCL Type	95% Student's-t UCL	95% KM Adjusted Gamma UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	5.78	0.824	Not Calculated	2.38	14.6	1.60
UTL Type	UTL Normal	UTL KM Gamma WH	Not Calculated	UTL Normal	UTL Normal	UTL Normal
UTL Result	11.9	2.26	Not Calculated	3.23	27.3	2.13
Background Reference Area Study - Background Area 2 - Quaternary Deposits (Mesa Top)						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	82%	100%	--	--	--
Minimum[1]	1.30	--	--	1.30	6.70	1.73
Minimum Detect[2]	--	0.220	--	--	--	--
Mean[1]	1.69	--	--	1.69	8.52	2.07
Mean Detects[2]	--	0.275	--	--	--	--
Median[1]	1.70	--	--	1.50	8.60	2.02
Median Detects[2]	--	0.275	--	--	--	--
Maximum[1]	2.00	--	--	3.40	10.0	2.70
Maximum Detect[2]	--	0.330	--	--	--	--
Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
Coefficient of Variation[1]	0.136	--	--	0.347	0.114	0.152
CV Detects[2]	--	0.283	--	--	--	--
UCL Type	95% Student's-t UCL	95% KM (t) UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	1.82	0.156	Not Calculated	2.01	9.05	2.25
UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
UTL Result	2.34	0.346	Not Calculated	3.34	11.2	2.96

Table D.1-1
Soil and Sediment Sampling Summary
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Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Study Reference Area 3 - Entrada Sandstone						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	64%	100%	--	--	--
Minimum[1]	1	--	--	0.600	9.20	0.710
Minimum Detect[2]	--	0.200	--	--	--	--
Mean[1]	1.57	--	--	1.05	11.3	0.985
Mean Detects[2]	--	0.260	--	--	--	--
Median[1]	1.20	--	--	1.00	10.0	0.990
Median Detects[2]	--	0.235	--	--	--	--
Maximum[1]	5.20	--	--	1.60	15.0	1.23
Maximum Detect[2]	--	0.370	--	--	--	--
Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
Coefficient of Variation[1]	0.772	--	--	0.293	0.191	0.181
CV Detects[2]	--	0.300	--	--	--	--
UCL Type	95% Student's-t UCL	95% KM (t) UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	2.24	0.245	Not Calculated	1.21	12.5	1.08
UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
UTL Result	4.99	0.367	Not Calculated	1.91	17.4	1.49
Background Study Reference Area 4 - Quaternary Deposits (Plains)						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	82%	100%	--	--	--
Minimum[1]	1.20	--	--	0.360	7.7	0.710
Minimum Detect[2]	--	0.200	--	--	--	--
Mean[1]	1.43	--	--	0.444	9.01	0.985
Mean Detects[2]	--	0.205	--	--	--	--
Median[1]	1.50	--	--	0.460	9.20	1.04
Median Detects[2]	--	0.205	--	--	--	--
Maximum[1]	1.60	--	--	0.490	9.80	1.27
Maximum Detect[2]	--	0.210	--	--	--	--
Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
Coefficient of Variation[1]	0.083	--	--	0.088	0.077	0.18
CV Detects[2]	--	0.035	--	--	--	--
UCL Type	95% Student's-t UCL	95% KM (t) UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	1.49	0.197	Not Calculated	0.465	9.39	1.08
UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
UTL Result	1.76	0.210	Not Calculated	0.554	11.0	1.49

Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Study Reference Area 5 - Quaternary Alluvium (Plains)						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	100%	100%	--	--	--
Minimum[1]	1.10	--	--	0.290	5.10	0.500
Minimum Detect[2]	--	--	--	--	--	--
Mean[1]	1.27	--	--	0.415	7.32	0.610
Mean Detects[2]	--	--	--	--	--	--
Median[1]	1.30	--	--	0.410	7.50	0.630
Maximum[1]	1.60	--	--	0.680	9.40	0.790
Maximum Detect[2]	--	--	--	--	--	--
Distribution	Normal	Not Calculated	Not Calculated	Normal	Normal	Normal
Coefficient of Variation[1]	0.127	--	--	0.237	0.165	0.134
UCL Type	95% Student's-t UCL	Not Calculated	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	1.36	Not Calculated	Not Calculated	0.468	7.98	0.655
UTL Type	UTL Normal	Not Calculated	Not Calculated	UTL Normal	UTL Normal	UTL Normal
UTL Result	1.73	Not Calculated	Not Calculated	0.691	10.7	0.839

Notes
[1] This statistic is reported by ProUCL when the dataset contains 100 percent detections.
[2] This statistic is reported by ProUCL when non-detect values exist in the dataset. The value reported is calculated using detections only.

CV	Coefficient of variation
KM	Kaplan Meier
mg/kg	Milligrams per kilogram
--	Not applicable
pCi/g	Picocuries per gram
WH	Wilson Hilferty

Table D.1-2
Surface Gamma Survey Summary
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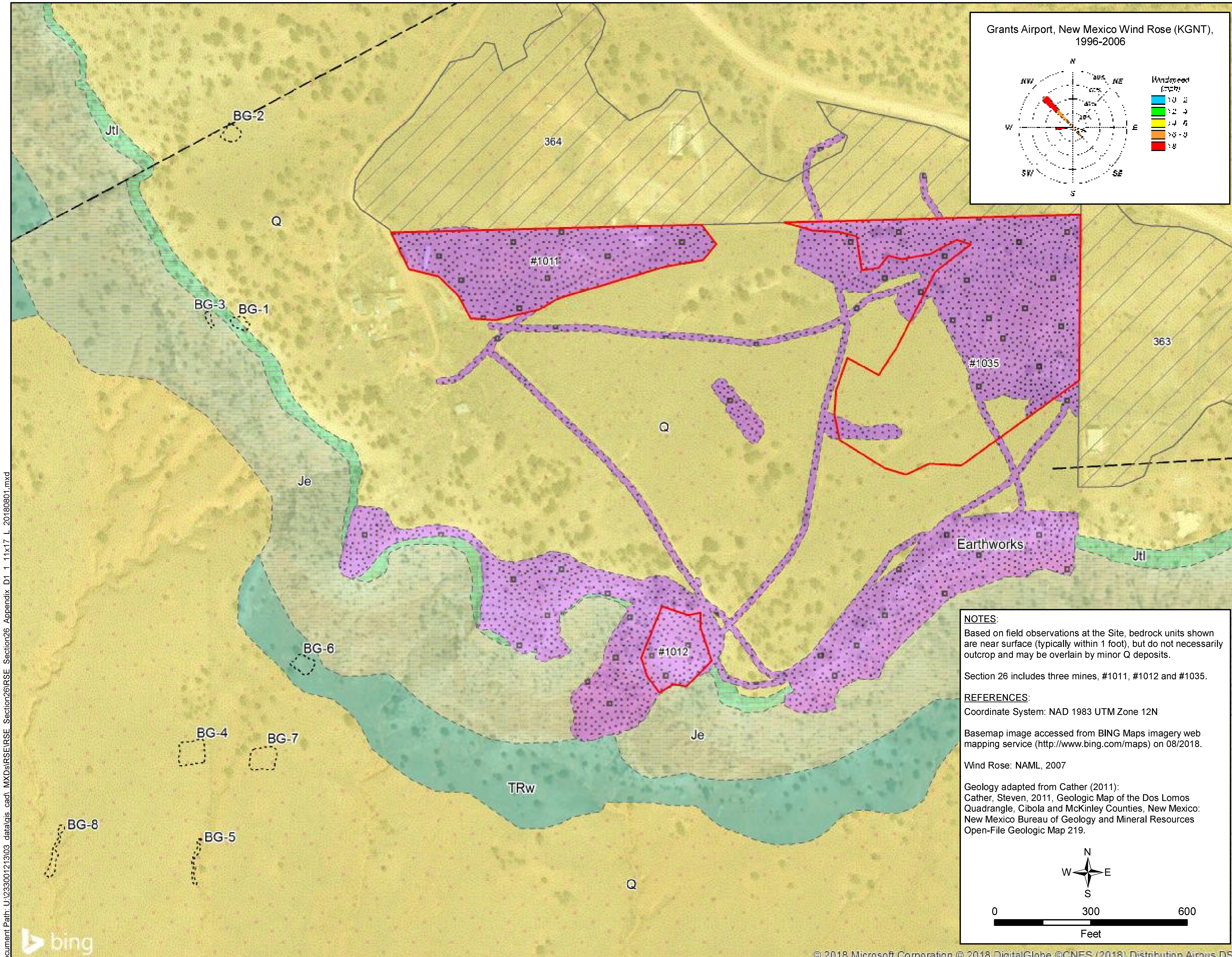
Navajo Nation AUM Environmental Response Trust - First Phase

	Background Reference Area 1 (BG-1)	Background Reference Area 2 (BG-2)	Background Reference Area 3 (BG-3)	Background Reference Area 4 (BG-4)	Background Reference Area 5 (BG-5)	Background Reference Area 6 (BG-6)	Background Reference Area 7 (BG-7)	Background Reference Area 8 (BG-8)
Geologic Formation	Todilto Limestone	Quaternary Deposits (Mesa Top)	Entrada Sandstone	Quaternary Deposits (Plains)	Quaternary Alluvium (Plains)	Wingate Sandstone	Quaternary Deposits (Plains)	Quaternary Alluvium (Plains)
Statistic								
Total Number of Observations	171	288	80	442	138	127	370	205
Minimum	11,464	18,508	13,202	15,868	16,299	14,221	15,313	16,424
Mean	14,082	21,269	29,080	18,804	19,213	23,377	18,694	18,824
Median	14,041	21,227	26,603	18,780	19,101	21,966	18,696	18,808
Maximum	20,015	25,542	57,059	22,772	22,914	37,524	21,537	21,532
Distribution	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Coefficient of Variation	0.105	0.0540	0.341	0.0550	0.0740	0.250	0.0577	0.0594
UCL Type	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	14,269	21,379	30,927	18,886	19,412	24,238	18,786	18,953
UTL Type	UTL Normal	UTL Normal	UTL Normal	UTL Normal	UTL Normal	UTL Normal	UTL Normal	UTL Normal
UTL Result	16,829	23,320	48,542	20,637	21,864	34,429	20,615	20,875

Notes
cpm Counts per minute
UCL Upper confidence limit
UTL Upper tolerance limit
WH Wilson Hilferty



NOTES:
Based on field observations at the Site, bedrock units shown are near surface (typically within 1 foot), but do not necessarily outcrop and may be overlain by minor Q deposits.

Section 26 includes three mines, #1011, #1012 and #1035.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

Wind Rose: NAML, 2007

Geology adapted from Cather (2011):
Cather, Steven, 2011, Geologic Map of the Dos Lomos Quadrangle, Cibola and McKinley Counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-File Geologic Map 219.

N
W E
S

0 300 600
Feet

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Potential Background Reference Area (BG-1)

Claim Boundary

Other Claim Boundary

Geology Contact (Inferred)

Fault

Site Geology

HOLOCENE

Earthworks: Human-caused disturbance of the land surface potentially related to mining or reclamation.

Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly colluvial and alluvial deposits, and eolian sand deposits.

JURASSIC

Jtl: Luciano Mesa Member of the Todilto Formation (Upper Jurassic) – Olive-gray to pale-yellow, thin- to thick-bedded limestone deposited in a lacustrine or saline environment.

Je: Entrada Sandstone – (Upper and Middle Jurassic) – Reddish-orange to reddish-brown fine- to medium-grained eolian crossbedded sandstone and dark-reddish-brown clayey siltstone and very fine grained silty sandstone.

TRIASSIC

TRw: Wingate Sandstone (Upper Triassic) – Reddish-brown, fine- to medium-grained, cross-bedded eolian sandstone.

TITLE:
Geologic Map and Potential Background Reference Areas

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 8/1/2018

DOCUMENT NAME: Removal Site Evaluation Report

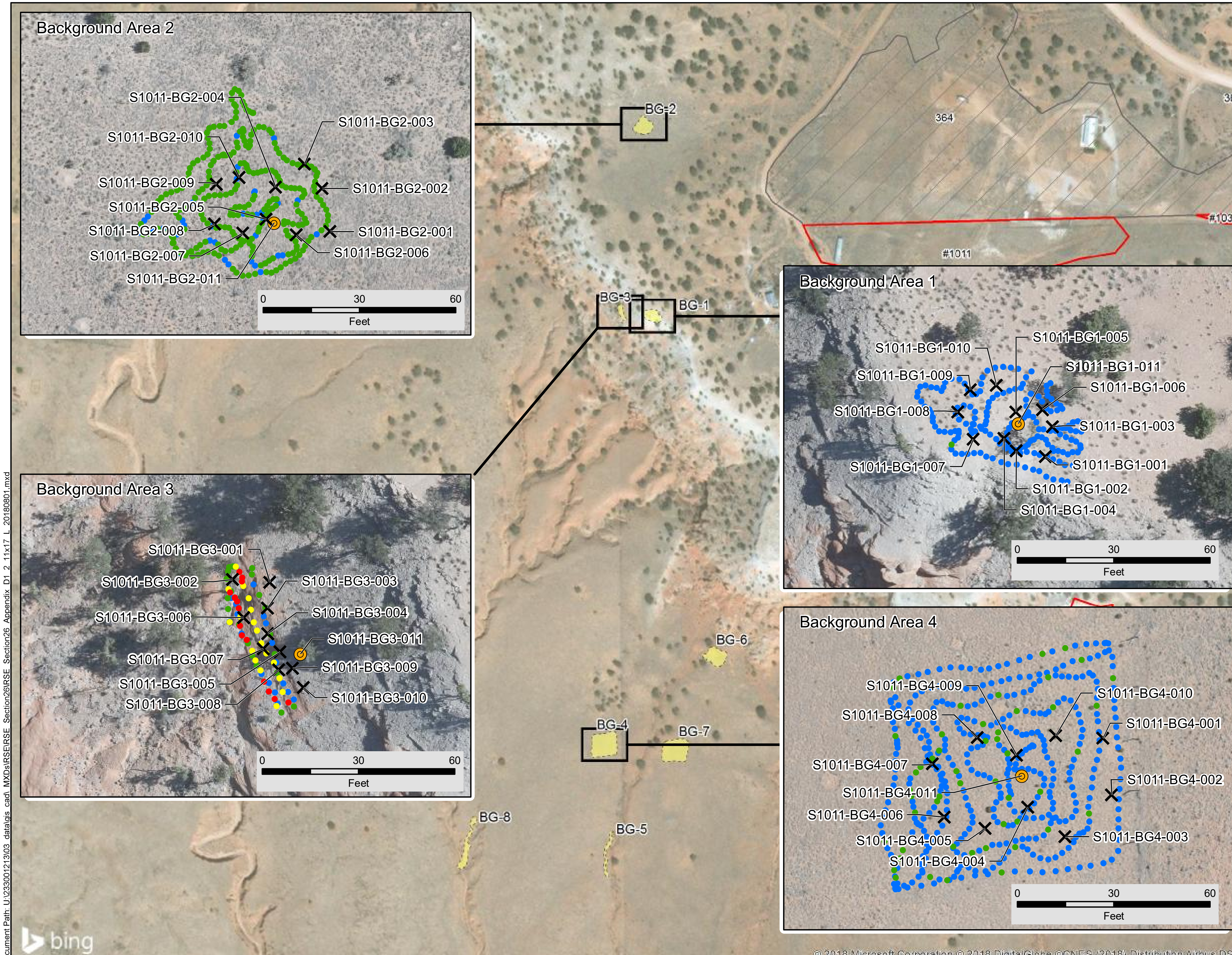
Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: D.1-1

Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_Section26\RSE_Section26_Appendix_D1_1_11x17_L_20180801.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Subsurface Borehole Location for Background Reference
- Potential Background Reference Area
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 11,464 - 20,000
- 20,001 - 30,000
- 30,001 - 40,000
- 40,001 - 57,059

NOTES:
Surface gamma measurements were collected using a 3 x 3 inch detector.

Section 26 includes three mines, #1011, #1012 and #1035.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Main display basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

Inset basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 300 600
Feet

TITLE:
Gamma Radiation Survey Results and Soil Sample Locations for Potential Background Reference Areas 1 through 4

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

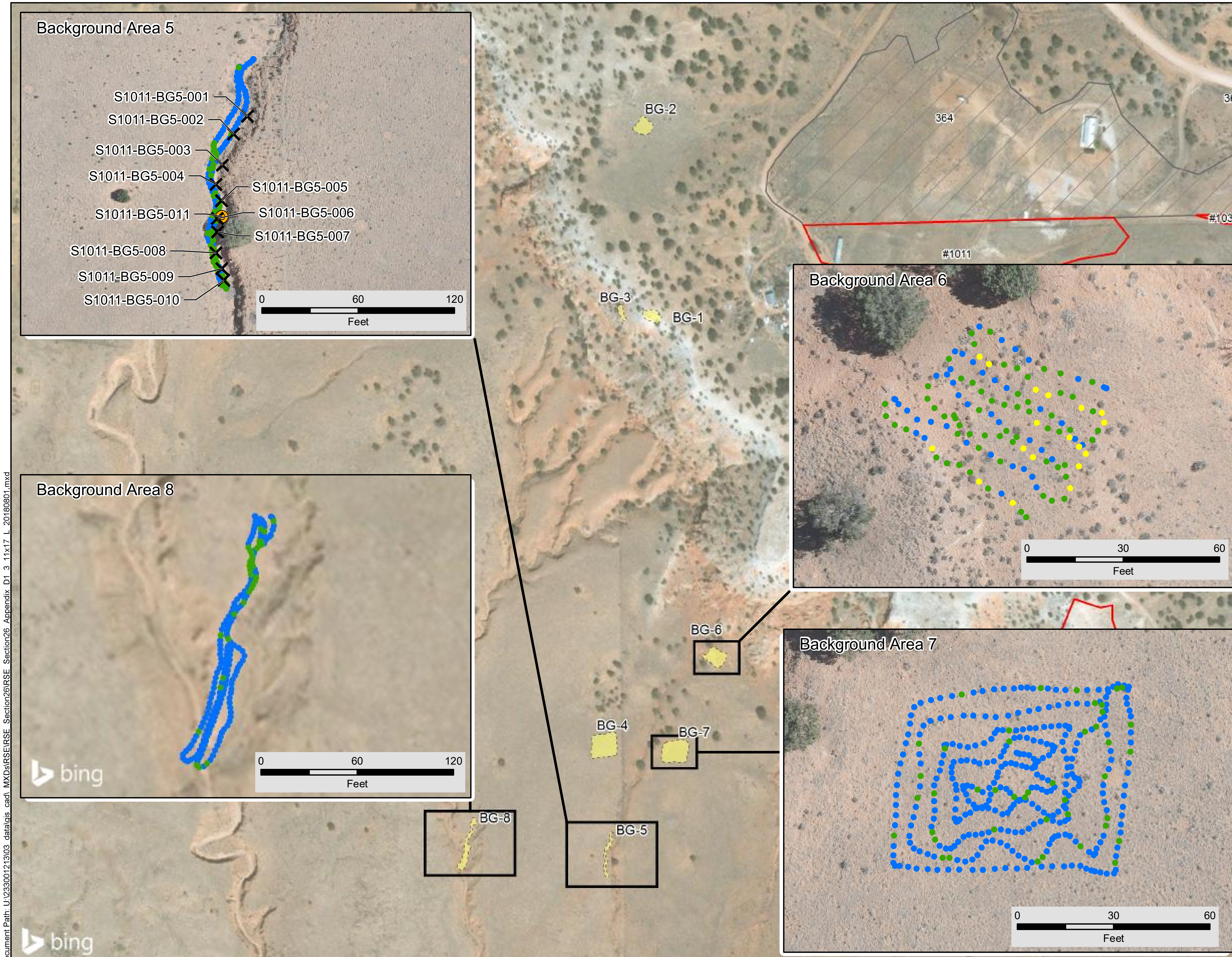
DATE: 9/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ
REVIEWER: CBB

FIGURE: D.1-2



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- Subsurface Borehole Location for Background Reference
- Potential Background Reference Area
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 14,221 - 20,000
- 20,001 - 30,000
- 30,001 - 37,524

NOTES:

Surface gamma measurements were collected using a 3 x 3 inch detector.

Section 26 includes three mines, #1011, #1012 and #1035.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Main display and Background Area 8 basemap image inset accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

Inset basemap image for Background Areas 5 - 7, flown by Cooper Aerial Surveys Co. on June 16, 2017.

N
W E
S

0 300 600
Feet

TITLE:	Gamma Radiation Survey Results and Soil Sample Locations for Potential Background Reference Areas 5 through 8
PROJECT:	Removal Site Evaluation Section 26 Mine Site
DATE: 9/19/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: EDZ / REVIEWER: CBB
	FIGURE: D.1-3

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Appendix_D1_3_11x17_L_20180801.mxd

STATISTICAL EVALUATION

1.0 INTRODUCTION

This statistical evaluation presents the methods used in, and results of, statistical analyses performed on gamma radiation survey results and soil sample analytical results collected from the Section 26 Site (Site). The evaluation includes comparing background reference area and Survey Area data distributions, and documents the decision process followed to select site-specific investigation levels (ILs). The ILs are used to confirm contaminants of potential concern (COPCs) listed in the *RSE Work Plan*, and to support identification of technologically enhanced naturally occurring radioactive materials (TENORM) at the Site.

2.0 EVALUATIONS

The evaluation process included compiling the results for gamma radiation surveys and soil sample analytical results from five background reference areas and five Survey Areas. These areas are designated Background Reference Area 1 (BG-1) through Background Reference Area 5 (BG-5), Survey Area A, Survey Area B, Survey Area C, Survey Area D, and Survey Area E. The Background Reference Areas BG-1 through BG-5 were selected to represent the Site's natural conditions as described in Appendix D.1. The gamma radiation survey data and soil sample analytical results for the background reference areas and Survey Areas were evaluated to determine the appropriate ILs for the Site as follows:

1. Identify and examine potential outlier values. Potential outlier values were identified statistically and, if justified upon further examination, removed from a dataset prior to further evaluation and calculations. No data were removed from the dataset for the calculations presented in this appendix.

2. Compare data populations between BG-1 and Survey Area A, BG-2 and Survey Area B, BG-3 and Survey Area C, BG-4 and Survey Area D, and BG-5 and Survey Area E (box plots, probability plots, hypothesis testing with Wilcoxon Mann-Whitney test). Soil sample and gamma radiation survey results were compared between background reference areas and Survey Areas qualitatively and quantitatively to evaluate similarity or difference in data distributions between the areas, and as a component of evaluating background area adequacy and representativeness.

3. Develop descriptive statistics. Descriptive statistics for gamma survey results and soil sample analytical results (e.g., number of observations, mean, maximum, median, etc.) were generated to facilitate qualitative comparisons of soil sample and gamma radiation survey results from one area to another.

4. Select ILs for the Site based on the results of the statistical evaluations.

3.0 RESULTS

The following sections present the evaluation of potential outlier values in the dataset, calculated descriptive statistics, and comparison of data populations between groups in support of determining ILs for use at the Site.

3.1 POTENTIAL OUTLIER VALUES

A potential outlier is a data point within a random sample of a population that is different enough from the majority of other values in the sample as to be considered potentially unrepresentative of the population, and therefore requires further inspection and evaluation. Unrepresentative values in a dataset have potential to yield distorted estimates of population parameters of interest (e.g., means, upper confidence limits, upper percentiles). Therefore, potential outliers in the Site data were evaluated further prior to performing data comparisons (Section 3.2) and developing the descriptive statistics (Section 3.3). In the context of this statistical evaluation, extreme values and statistical outliers are referred to as potential outliers.

A potential outlier value in a sample may be a true representative value in the test population (not a “discrepant” value), simply representing a degree of inherent variation present in the population. Furthermore, a statistical determination of one or more potential outliers does not indicate that the measurements are actually discrepant from the rest of the data set. Therefore, general statistical guidance does not recommend that extreme values (potential outliers) be removed from an analysis solely on a statistical basis. Statistical outlier tests can provide supportive information, but a reasonable scientific rationale needs to be identified for the removal of any potential outlier values (e.g., sampling error, records error, or the potential outlier is determined to violate underlying assumptions of the sampling design, such as the targeted geology).

In the background reference areas, soil samples were collected randomly. Potential outliers in the background reference area datasets were examined using box plots, probability plots and statistical testing. Descriptive statistics were then calculated with and without the potential outliers, as applicable. Finally, the potential outlier values were evaluated to determine if a reason could be found to remove the data points before calculating final statistics. The results of these evaluations are described in the following sections.

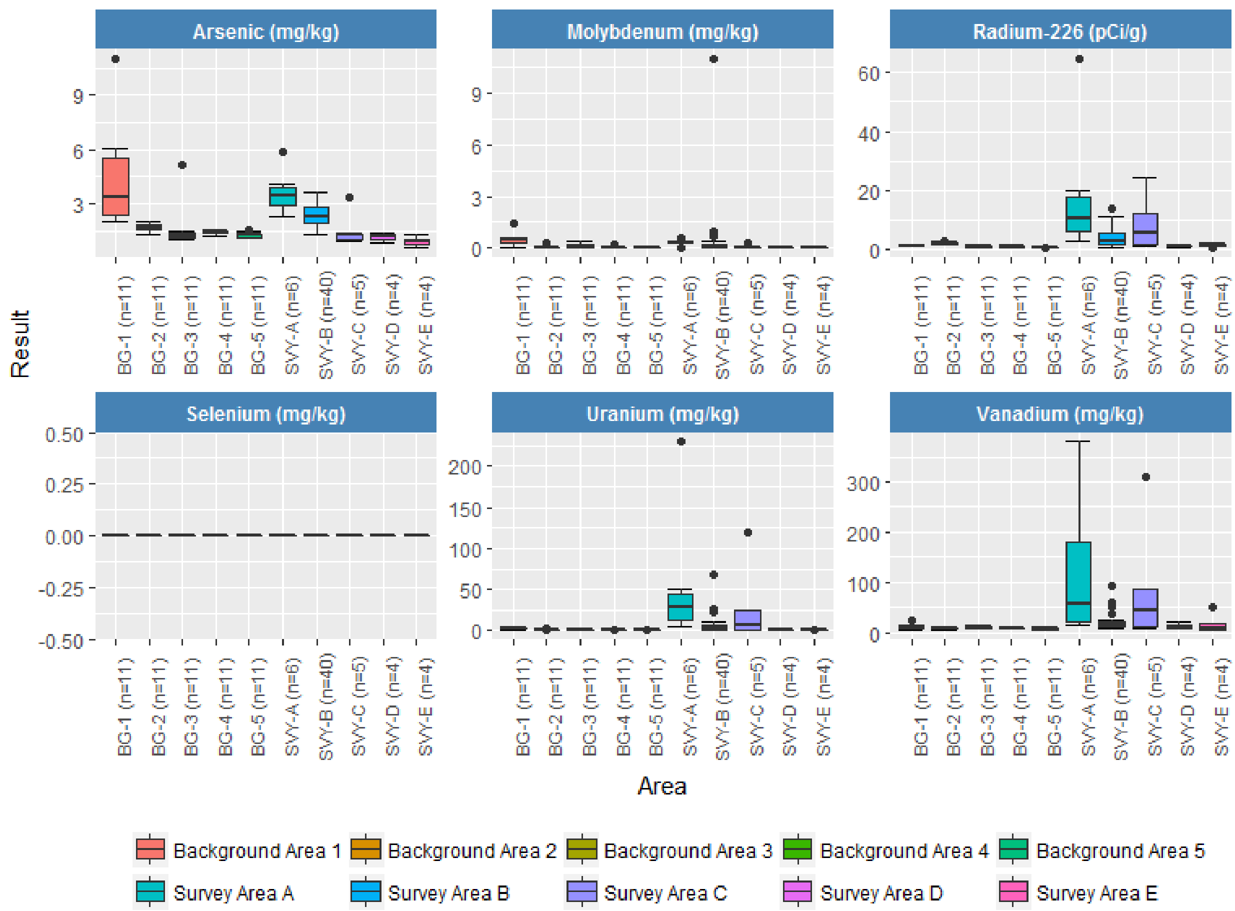
In the Survey Areas at Section 26, soil samples were collected using a judgmental sampling approach. Specifically, some sample locations were selected to characterize areas of higher gamma radiation and, as a result, potential outlier values are not unexpected in the Survey Area sample statistics. Potential outliers in this context mean values that are well-separated from the majority of the data set coming from the far/extreme tails of the data distribution (USEPA, 2016a). Descriptive statistics for the survey areas and some comparisons to background reference areas are still presented for qualitative assessment. However, potential outlier values in the Survey Areas are not evaluated further nor removed from the dataset.

3.1.1 Box Plots

Box plots depict descriptive statistics from a group of data (Figure 1A). The interquartile range is represented by the bounds of the box, the minimum and maximum values, not including potential outlier values (extreme values), are depicted by the whiskers (vertical lines), and any potential outliers are identified as singular dots. Potential outliers in this context are defined as values outside 1.5 times the interquartile range above or below the box.

3.1.1.1 Soil Sample Results Box Plots

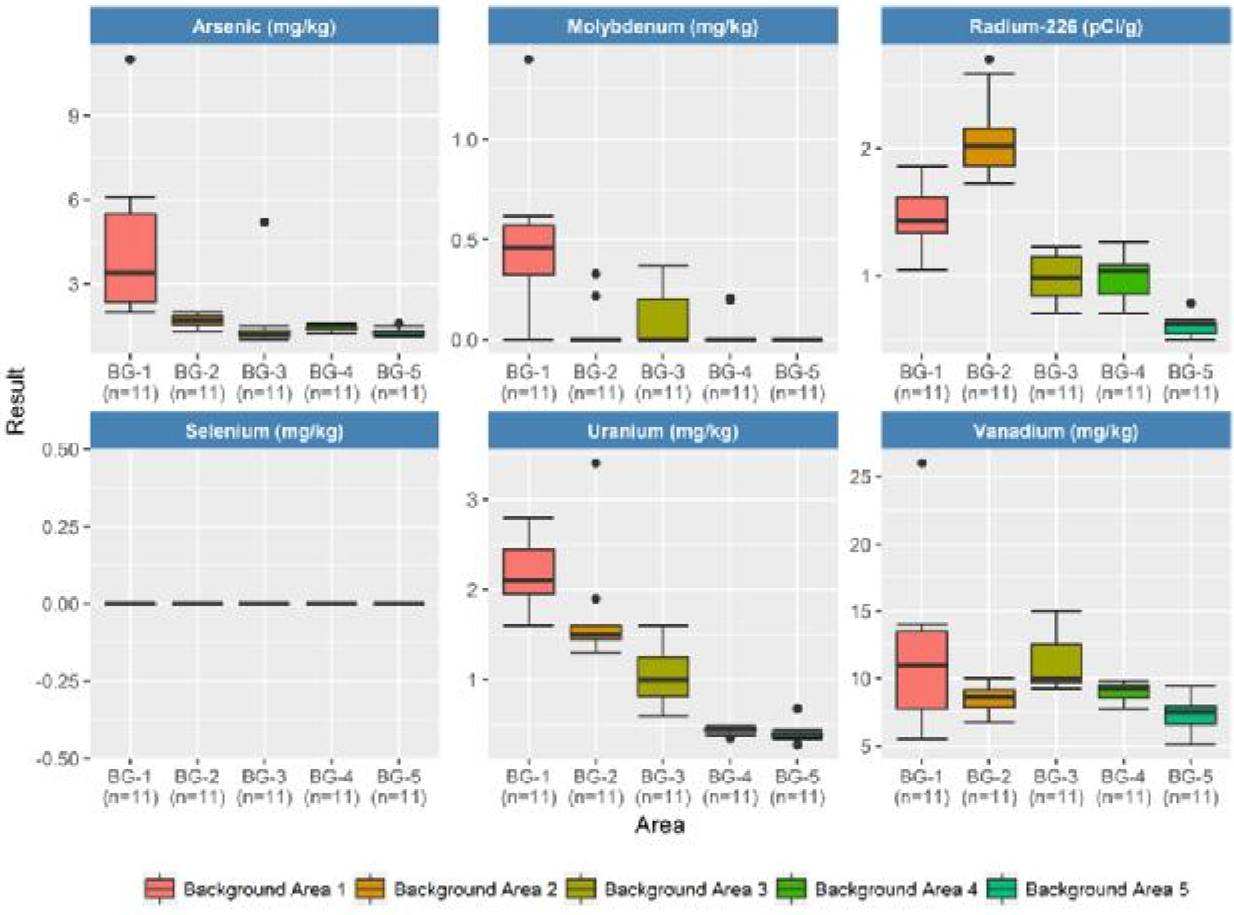
Figure 1A. Survey Areas A, B, C, D and E and Background Reference Areas 1 (BG-1), 2 (BG-2), 3 (BG-3), 4 (BG-4) and 5 (BG-5) Soil Sample Box Plots



The soil sample box plots shown on Figure 1A depict differences in the data distributions for analytical constituent concentrations between background reference areas and Survey Areas. One or more potential outlier values are present in the datasets for each background reference area and all Survey Areas except Survey Area D.

Potential outlier values are of greatest concern in the background reference area datasets as these data are to be used to determine the ILs. Background reference area data are presented alone in Figure 1B.

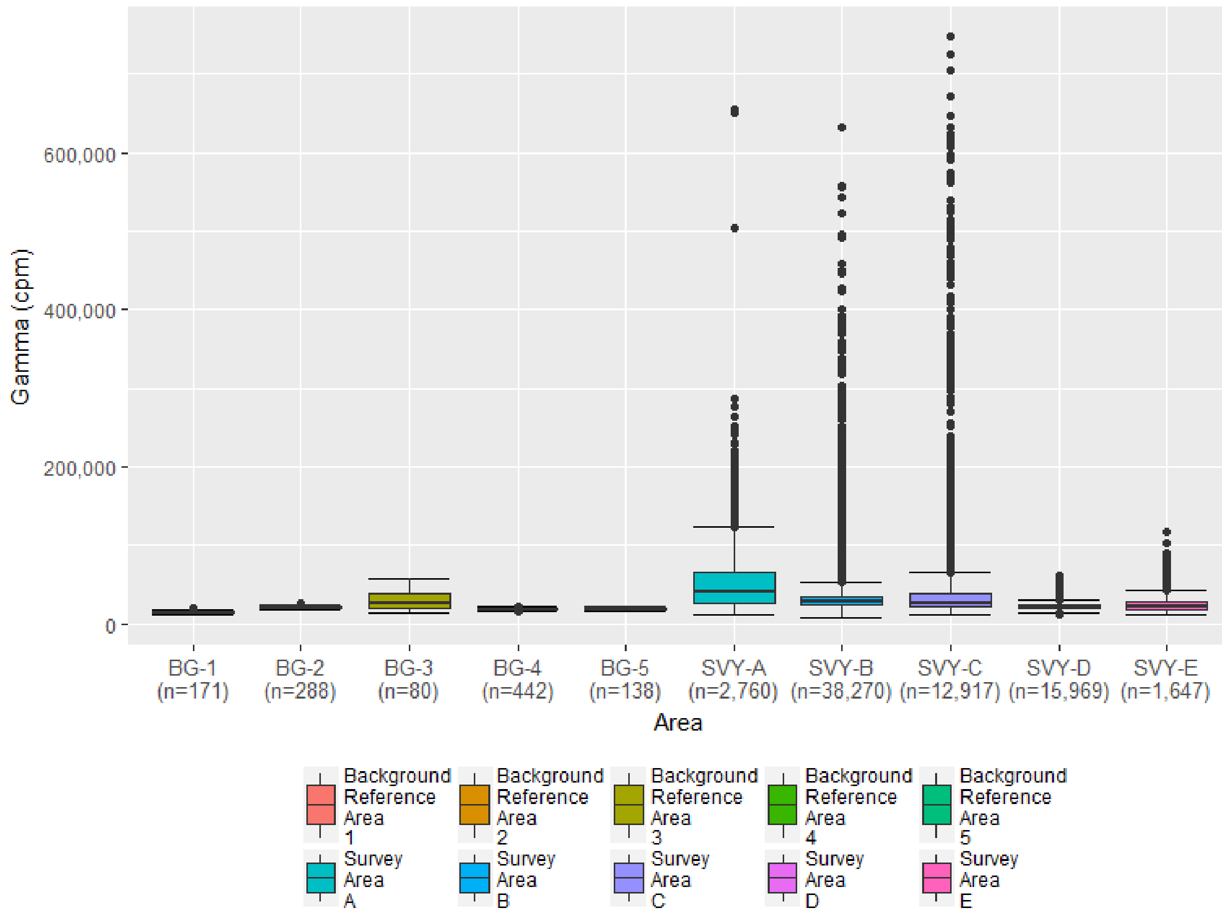
Figure 1B. Background Reference Areas 1 (BG-1), 2 (BG-2), 3 (BG-3), 4 (BG-4) and 5 (BG-5) Soil Sample Box Plots



As shown in Figure 1B, in the boxplots for BG-1, one high value each for arsenic (As), molybdenum (Mo), and vanadium (V) are identified as potential outliers (i.e., above 1.5 times the interquartile range); in the boxplots for BG-2, three high values each for molybdenum, uranium (U), and radium-226 (Ra-226) are identified as potential outliers; in the boxplots for BG-3, one high value for arsenic is identified as a potential outlier; in the boxplots for BG-4, two high values for molybdenum and one low value for uranium are identified as potential outliers; and in the boxplots for BG-5, one high value each for arsenic and Ra-226 and one high and one low value for uranium are identified as potential outliers. These potential outlier values are further evaluated with the use of probability plots in Section 3.1.2 and statistical outlier testing in Section 3.1.3.

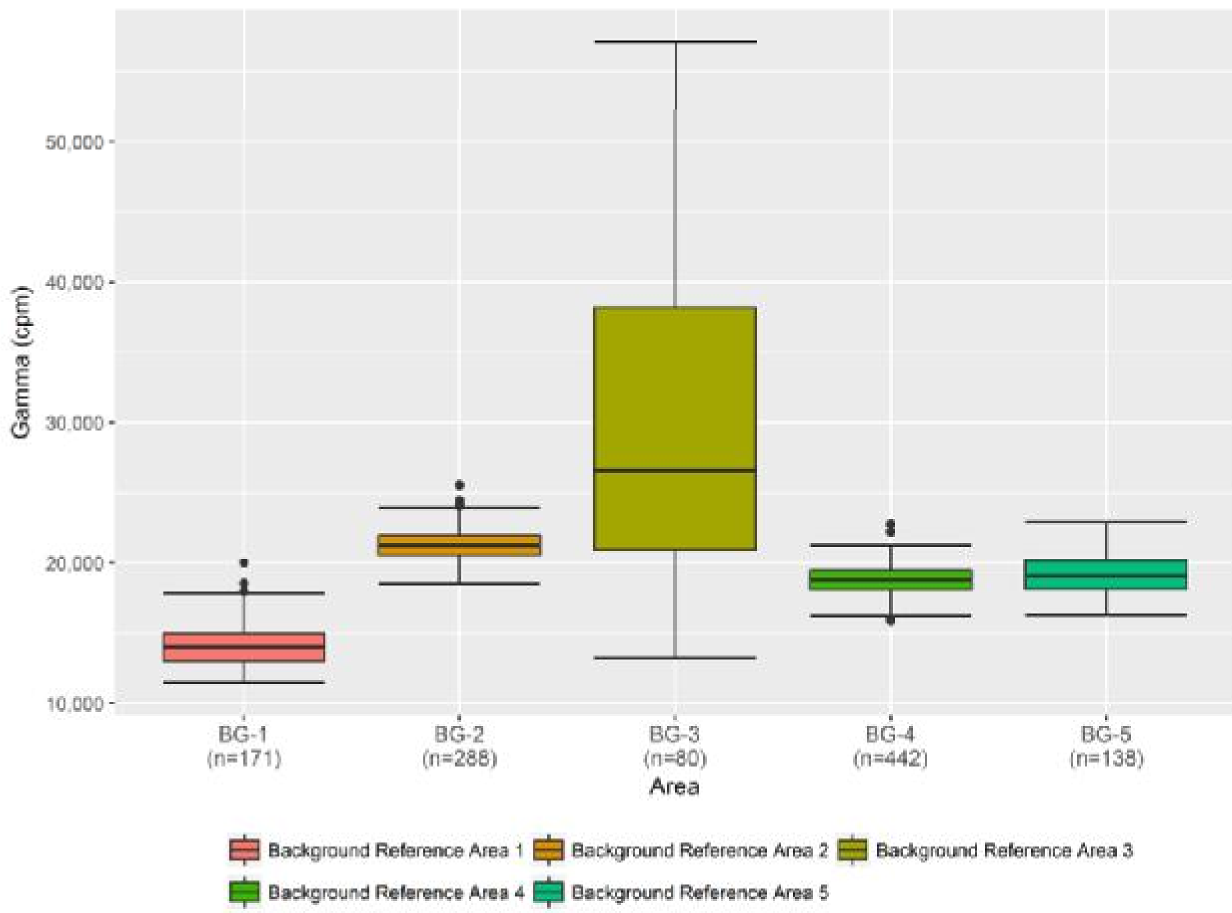
3.1.1.2 Gamma Radiation Results Box Plots

Figure 2A. Survey Areas and Background Reference Area Gamma Radiation Box Plots



The gamma radiation survey results box plots shown on Figure 2A depict differences in the data distribution for gamma measurements between background reference areas and Survey Areas. The large number of potential outlier values in the Survey Area box plots indicate high skewness or possibly non-normally distributed data, instead of outlier values. Based on Site geology, the potential gamma radiation outlier values observed for the Survey Area data on Figure 2A represent localized areas of higher gamma radiation with respect to other parts of each of the Survey Areas, as would be expected in areas with varying levels of mineralization, naturally occurring radioactive material (NORM) and potential TENORM.

Figure 2B. Background Reference Areas Gamma Radiation Box Plots



As shown in Figure 2B, there are five, six, and four high potential outlier values shown for gamma data in the BG-1, BG-2, and BG-4 datasets, respectively. These potential outlier values do not represent skewed data as do the Survey Area results, and the gamma data are shown to be more normally distributed in the background reference areas than in the Survey Areas. The potential outlier values shown in the background reference areas are most likely representative of natural variation of gamma in these areas. These observations are further evaluated with the use of probability plots in Section 3.1.2 and statistical outlier testing in Section 3.1.4.

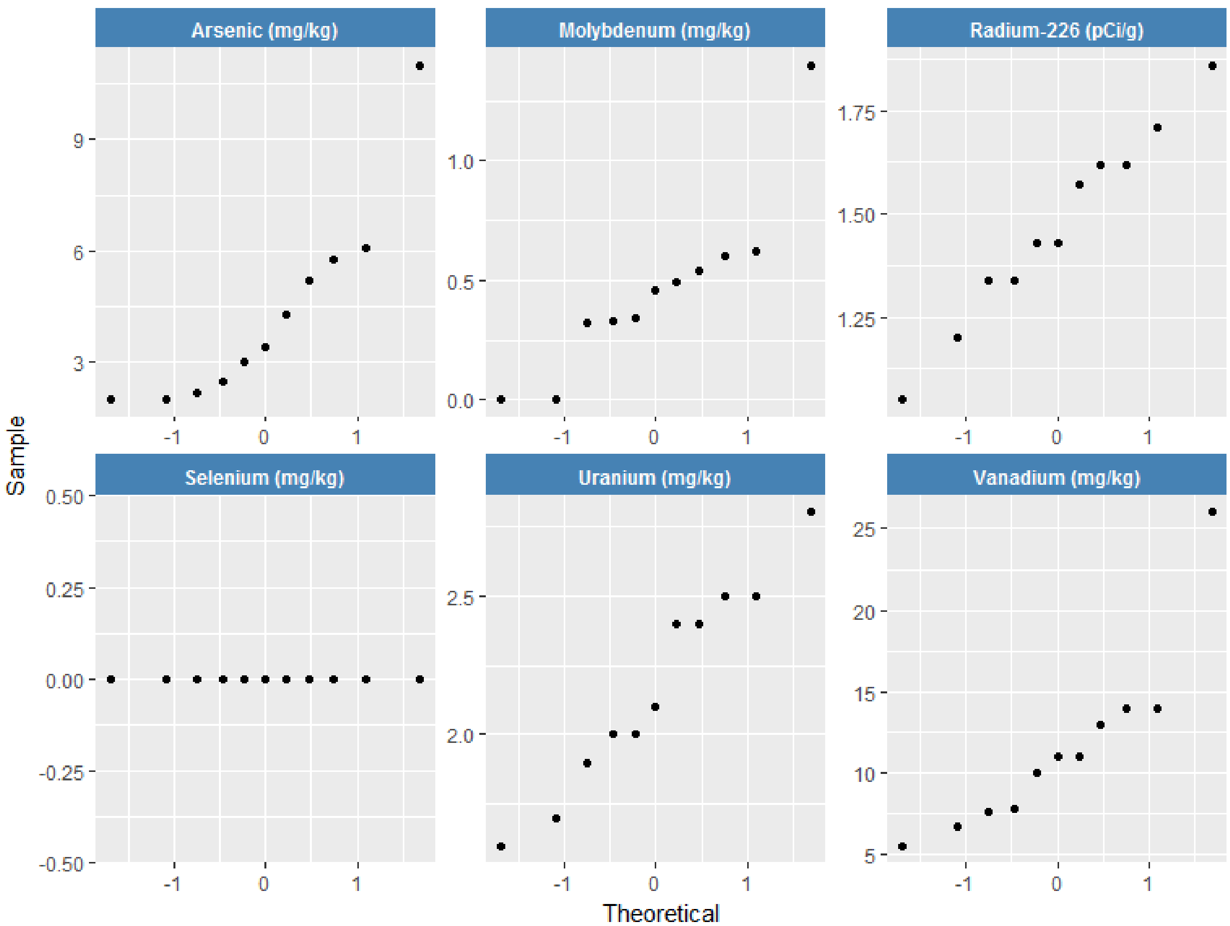
3.1.2 Probability Plots

The normal probability plot is a graphical technique for assessing whether or not a data set is approximately normally distributed and where there may be potential outlier values. The data are plotted against a theoretical normal distribution in such a way that the points, if normally distributed, should form an approximate straight line. Curved lines may indicate non-normally or log-normally distributed data, and "S"-shaped lines may indicate two distinct groups within the dataset.

3.1.2.1 Soil Sample Results Probability Plots

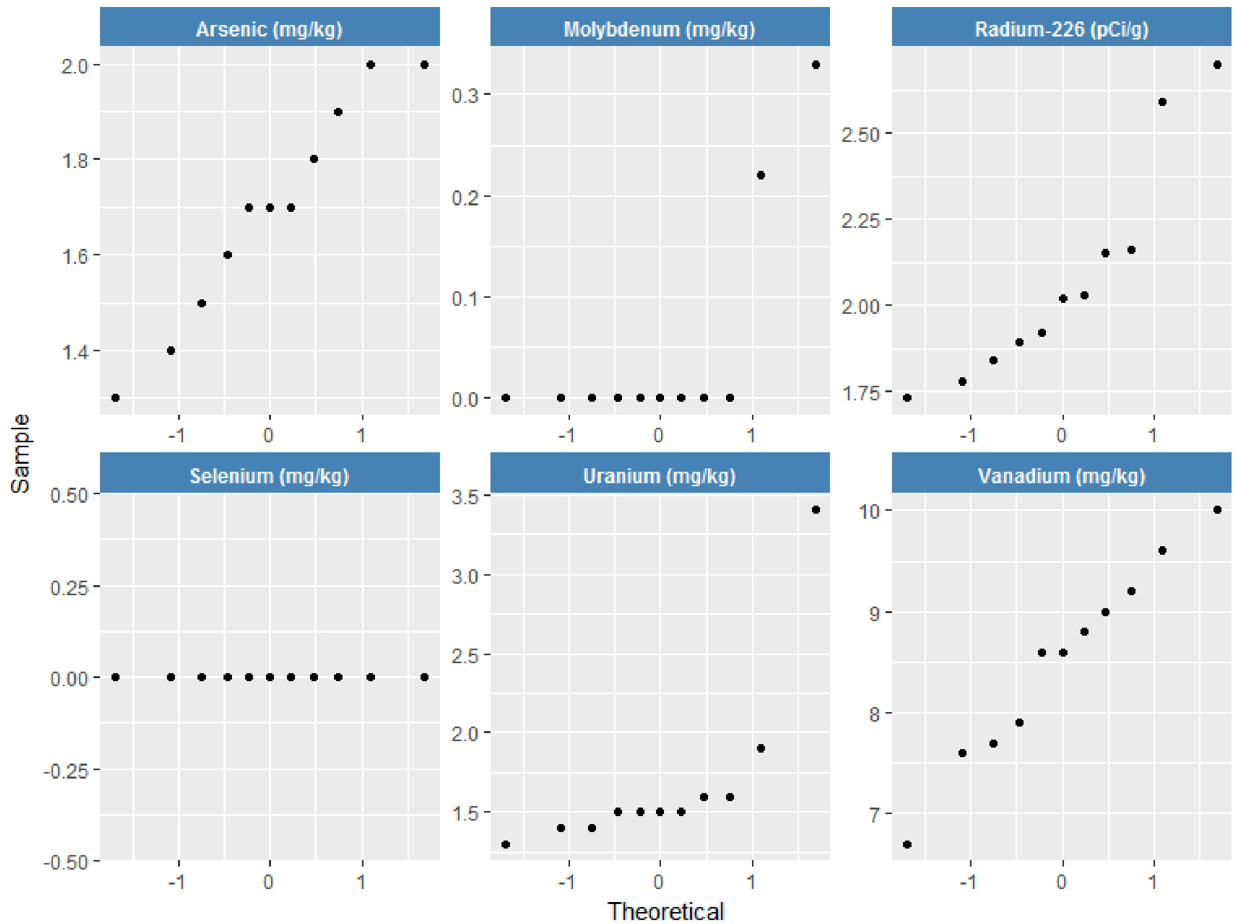
Figure 3 through 7 depict the probability plots for metals and Ra-226 results at background reference areas.

Figure 3. Background Reference Area 1 (BG-1) Soil Sample Probability Plots



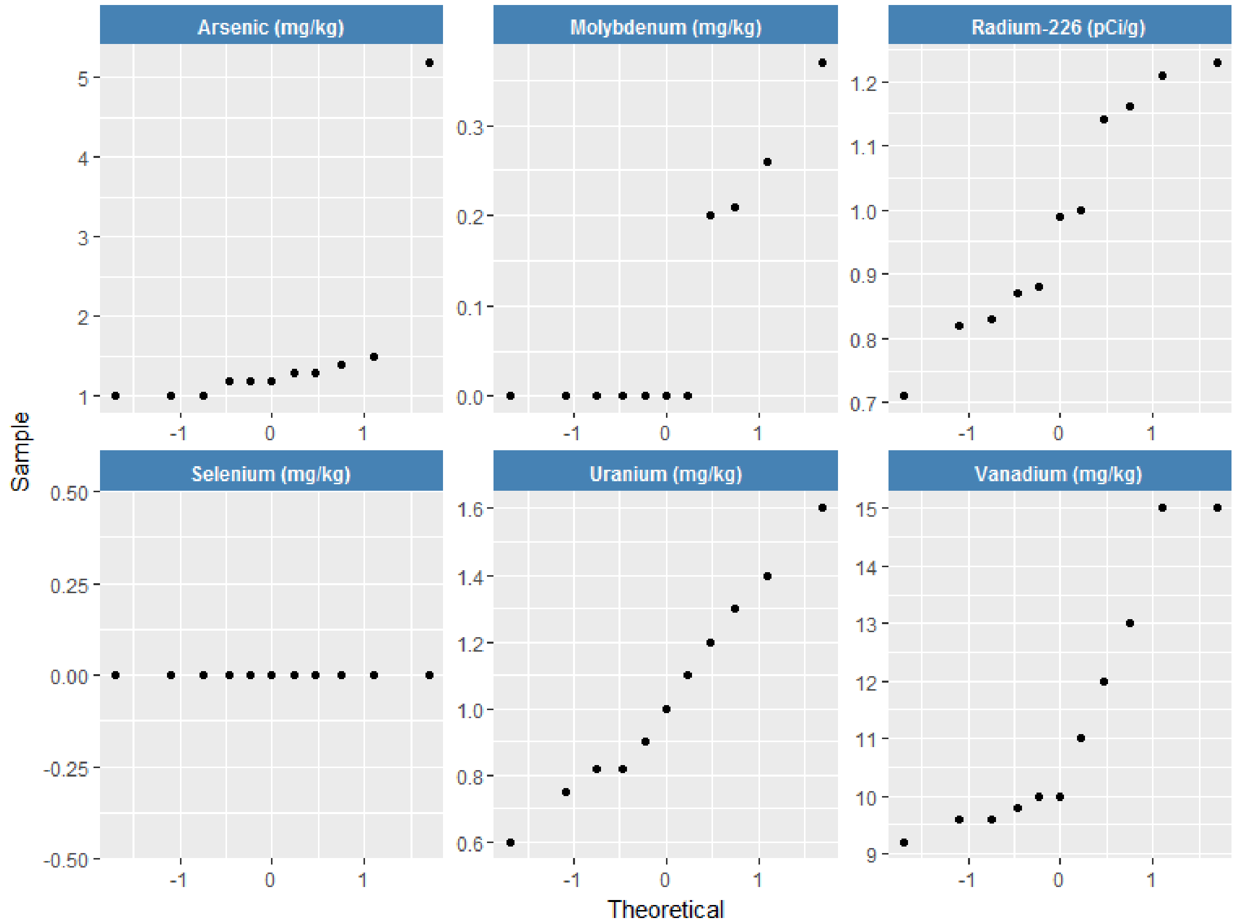
One high value each for arsenic, molybdenum and vanadium were identified as potential outliers (i.e., above 1.5 times the interquartile range) in the BG-1 box plots in Figure 1B. When viewed in the probability plots in Figure 3, these values do appear to be substantially higher than the rest of their respective datasets. The values for Ra-226 and uranium are approximately linear in Figure 3, indicating a normally distributed dataset. These three values are tested further for statistical significance as potential outliers in Section 3.1.3.

Figure 4. Background Reference Area 2 (BG-2) Soil Sample Probability Plots



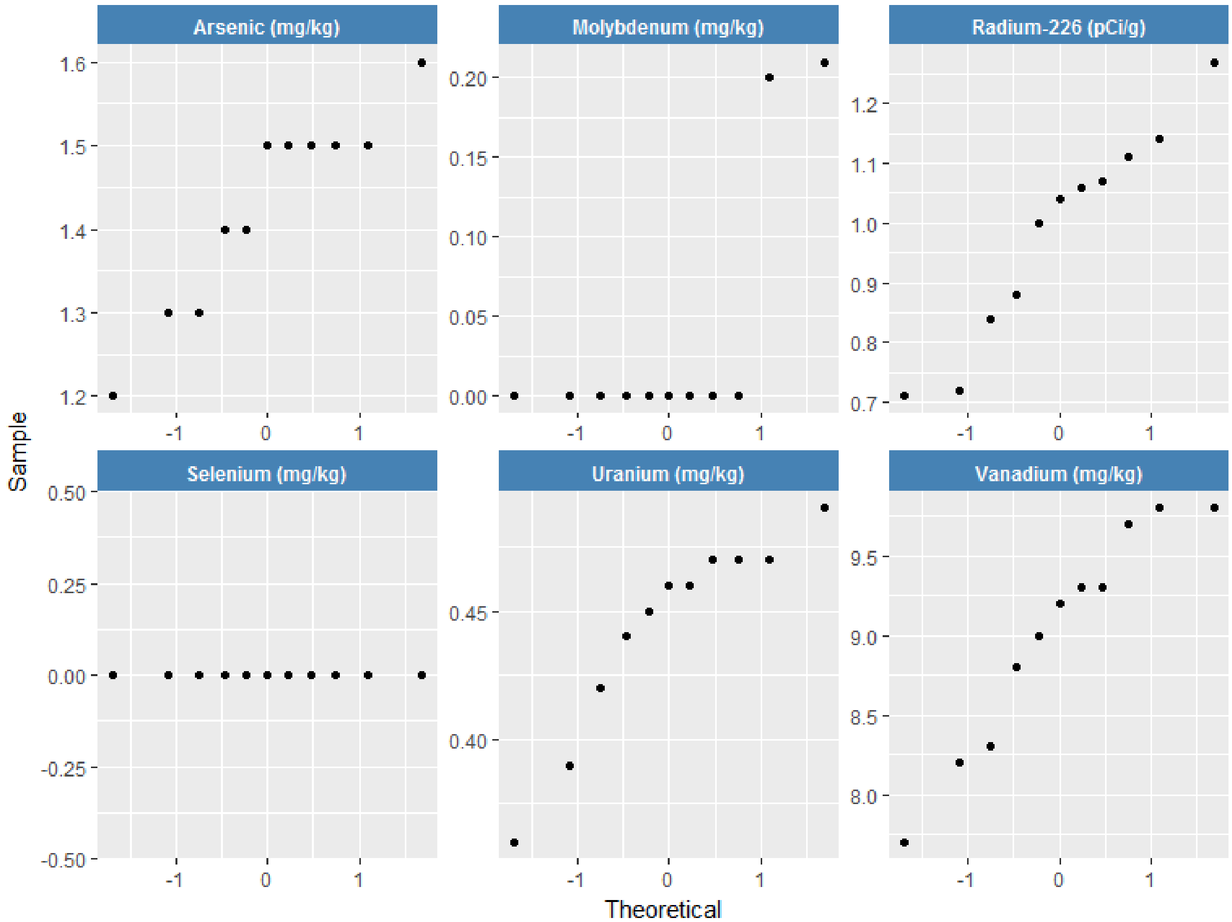
Two high values for molybdenum and uranium and one high value for Ra-226 were identified as potential outliers (i.e., above 1.5 times the interquartile range) in the BG-2 box plots in Figure 1B. When viewed in the probability plots in Figure 4, the highest value for uranium does appear to be substantially higher than the rest of the dataset, while the second potential outlier is only slightly out of line with the rest of the data. The high values for molybdenum are the only detected values in the BG-2 dataset. The one high value for Ra-226 does appear to be substantially higher than the rest of the dataset; although there appears to be a second potential outlier in the Ra-226 dataset, this high value is equal to, but not greater than, 1.5 times the interquartile range. The values for arsenic, Ra-226 and vanadium are approximately linear in Figure 4, indicating a normally distributed dataset. These five potential outlier values are tested further for statistical significance in Section 3.1.3.

Figure 5. Background Reference Area 3 (BG-3) Soil Sample Probability Plots



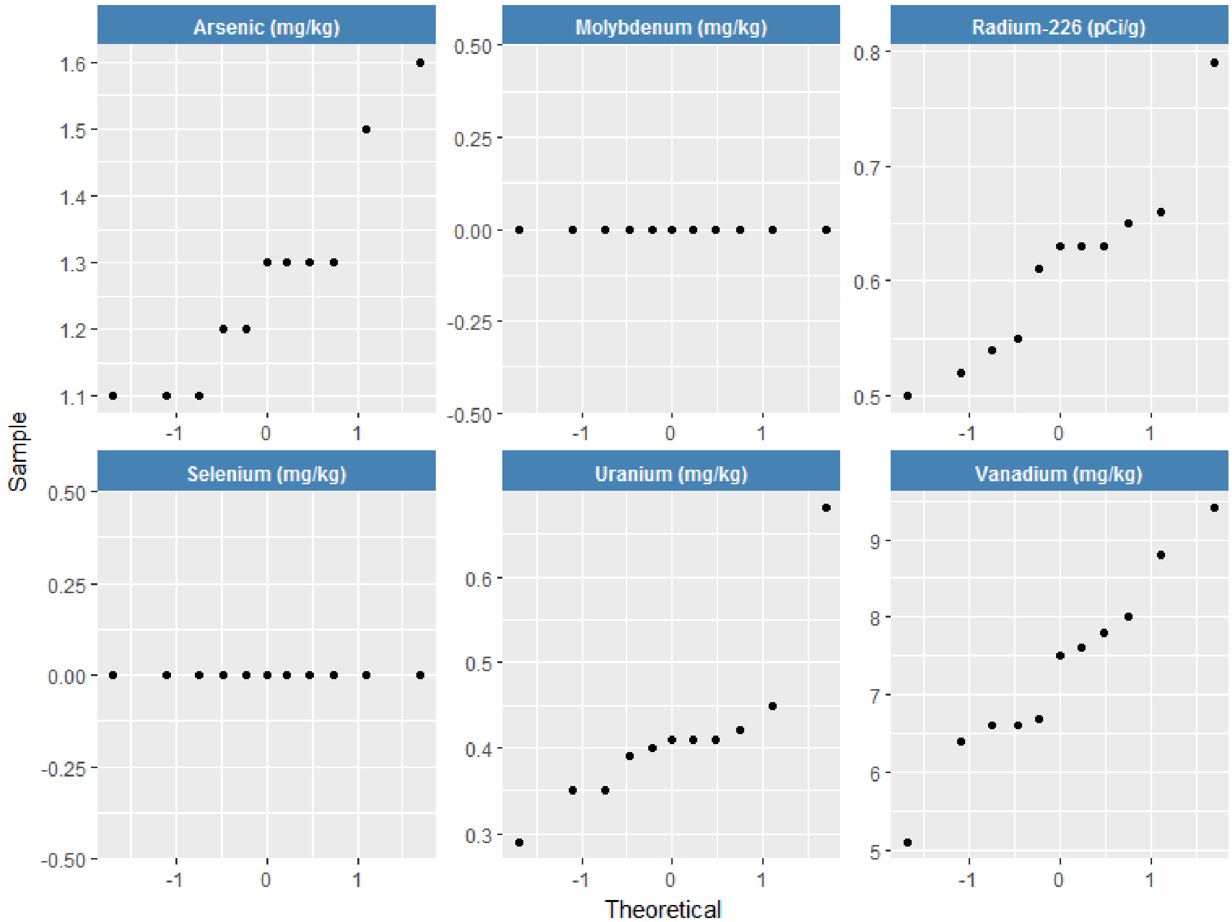
One high value for arsenic was identified as a potential outlier (i.e., above 1.5 times the interquartile range) in the BG-3 box plots in Figure 1B. When viewed in the probability plot in Figure 1B, the value does appear to be substantially higher than the rest of the dataset. The values for Ra-226, uranium and vanadium, and the detected values for molybdenum are approximately linear in Figure 5, indicating a normally distributed dataset. The one potential arsenic outlier value is tested further for statistical significance in Section 3.1.3.

Figure 6. Background Reference Area 4 (BG-4) Soil Sample Probability Plots



Two high values for molybdenum and one low value for uranium were identified as potential outliers (i.e., 1.5 times the interquartile range) in the BG-4 box plots in Figure 1B. When viewed in the probability plot in Figure 6, it is apparent that the high values for molybdenum are the only detected values in the BG-4 dataset. The low uranium value appears to be only slightly lower than the rest of the dataset. The values for arsenic, Ra-226, and vanadium are approximately linear in Figure 6, indicating a normally distributed dataset. These three potential outlier values are tested further for statistical significance as potential outliers in Section 3.1.3.

Figure 7. Background Reference Area 5 (BG-5) Soil Sample Probability Plots

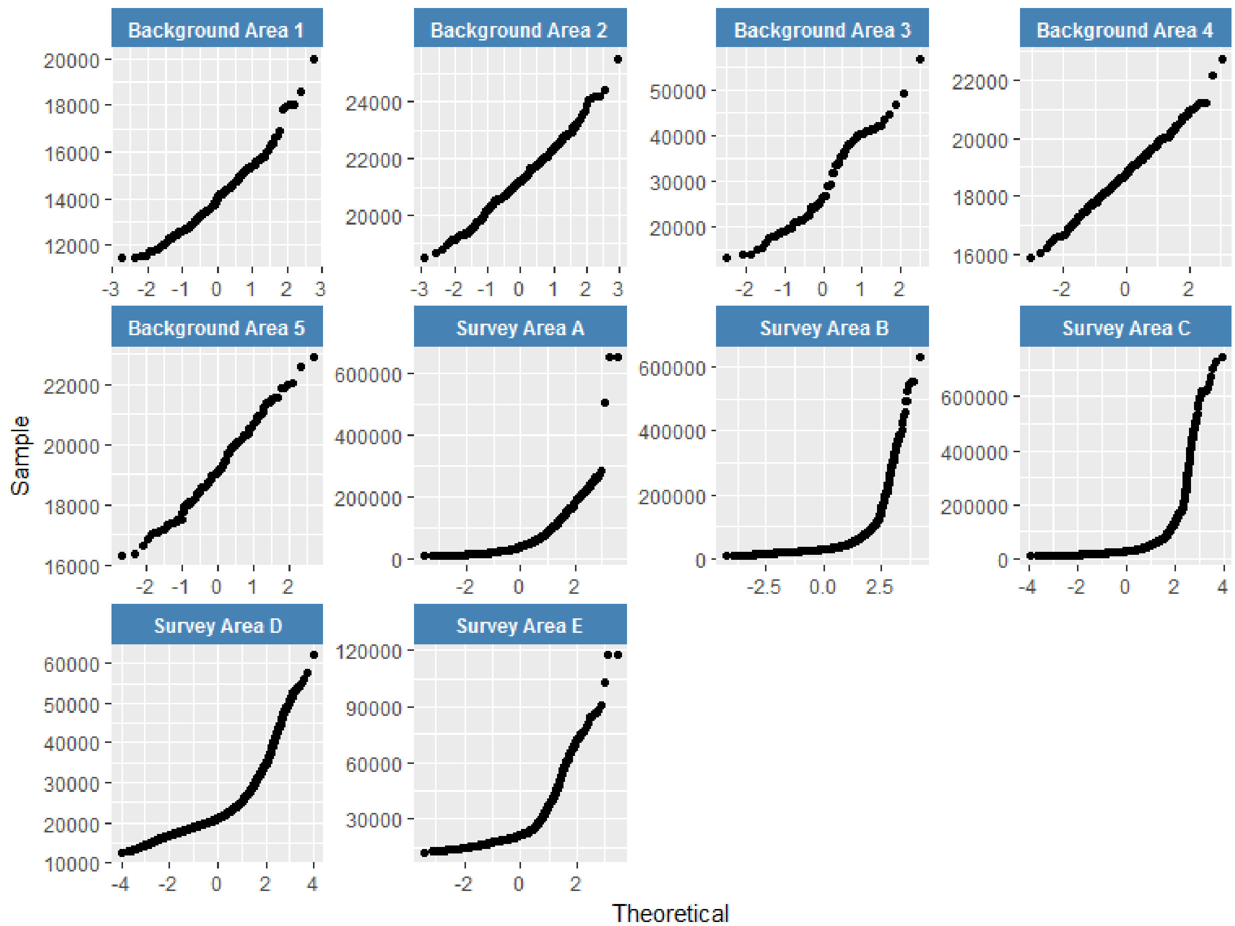


One high value each for arsenic and Ra-226, and one high value and one low value for uranium, were identified as potential outliers (i.e., 1.5 times the interquartile range) in the BG-5 box plots in Figure 1B. When viewed in the probability plots in Figure 7, the high values for Ra-226 and uranium, and the low value for uranium, do appear to be substantially higher or lower than the rest of their respective datasets. The high value for arsenic does not appear to be out of line with the rest of the dataset, suggesting that it represents natural variability within the dataset rather than an aberrant measurement. The values for arsenic and vanadium are approximately linear in Figure 7, indicating a normally distributed dataset. Although the highest arsenic value does not appear substantially different than the rest of the arsenic dataset, all four potential outlier values are tested further for statistical significance as potential outliers in Section 3.1.3.

3.1.2.2 Gamma Survey Results Probability Plots

Figure 8 depicts the probability plots for gamma radiation results at background reference areas and the Survey Areas.

Figure 8. Survey Area and Background Reference Area Gamma Probability Plots



The gamma probability plots for background reference areas in Figure 8 are approximately linear; these plots indicate that gamma data at background reference areas are approximately normally distributed. The five highest values in BG-1, identified as potential outliers in the box plot in Figure 2B, appear to be higher than, and out of line with, the distribution of the rest of the dataset indicating that they are potential outliers. High values at BG-2 and BG-4 also appear to be significantly elevated compared with the rest of the gamma datasets for these background reference areas. The 15 potential outliers in BG-1, BG-2 and BG-4 are further evaluated for statistical significance in Section 3.1.4. The highest values in the BG-3 and BG-5 datasets also appear slightly elevated relative to the rest of the data, however, these values are not outside 1.5 times the interquartile range for their respective datasets, and were not identified as potential outliers.

The gamma probability plots in Figure 8 for Survey Areas A, B, C, D and E are non-linear or S-shaped, indicating that gamma data from these Survey Areas are not normally distributed. The shape of the Survey Area A, B, C, D and E gamma probability plots indicates that the data may represent two or three distinct sub-groups of gamma radiation values within these Survey Areas. The smoothness of the probability plots for the survey areas at Section 26 suggests that high values shown in Figure 2B are not potential outliers, but rather are representative of the spatial variability of gamma radiation in these areas.

3.1.3 Potential Soil Sample Data Outliers

Fourteen high results and two low results were identified as potential outlier values in the box plots in Figure 1B and probability plots in Figures 3 through 7. These values are:

Background Reference Area 1 (BG-1)

- Arsenic: 11.0 mg/kg
- Molybdenum: 1.40 mg/kg
- Vanadium: 26.0 mg/kg

Background Reference Area 2 (BG-2)

- Molybdenum: 0.220 mg/kg, 0.330 mg/kg
- Radium-226: 2.70 mg/kg
- Uranium: 1.90 mg/kg, 3.40 mg/kg

Background Reference Area 3 (BG-3)

- Arsenic: 5.20 mg/kg

Background Reference Area 4 (BG-4)

- Molybdenum: 0.200 mg/kg, 0.210 mg/kg
- Uranium: 0.360 mg/kg (low)

Background Reference Area 5 (BG-5)

- Arsenic: 1.60 mg/kg
- Ra-226: 0.790 pCi/g
- Uranium: 0.290 mg/kg (low), 0.680 mg/kg

Dixon’s Test (Dixon, 1953) is designed to be used for datasets containing a small number potential outlier values. Therefore, Dixon's Test was performed to the 95% confidence level on each of the potential outlier values identified in the BG-1, BG-2, BG-3, BG-4, and BG-5 datasets. The results of Dixon’s Test are summarized in Table 1.

Table 1. Summary of Dixon's Test on Maximum Values

Area	Constituent	Location ID	Method	Hypothesis	p_Value	Conclusion
Background Reference Area 1 (BG-1)	As	S1011-BG1-005	Dixon test for potential outliers	High value 11.0 is a potential outlier	> 0.05	Hypothesis rejected
	Mo	S1011-BG1-005	Dixon test for potential outliers	High value 1.40 is a potential outlier	> 0.05	Hypothesis rejected
	V	S1011-BG1-005	Dixon test for potential outliers	High value 26.0 is a potential outlier	> 0.05	Hypothesis rejected
Background Reference Area 2 (BG-2)	Mo	S1011-BG2-009	Dixon test for potential outliers	High value 0.220 is a potential outlier	< 0.05	Hypothesis accepted
	Mo	S1011-BG2-010	Dixon test for potential outliers	High value 0.330 is a potential outlier	< 0.05	Hypothesis accepted
	Ra-226	S1011-BG2-002	Dixon test for potential outliers	High value 2.70 is a potential outlier	> 0.05	Hypothesis rejected
	U	S1011-BG2-003	Dixon test for potential outliers	High value 1.90 is a potential outlier	< 0.05	Hypothesis accepted
	U	S1011-BG2-010	Dixon test for potential outliers	High value 3.40 is a potential outlier	< 0.05	Hypothesis accepted
Background Reference Area 3 (BG-3)	As	S1011-BG3-010	Dixon test for potential outliers	High value 5.20 is a potential outlier	< 0.05	Hypothesis accepted
Background Reference Area 4 (BG-4)	Mo	S1011-BG4-004	Dixon test for potential outliers	High value 0.210 is a potential outlier	< 0.05	Hypothesis accepted
	Mo	S1011-BG4-009	Dixon test for potential outliers	High value 0.200 is a potential outlier	< 0.05	Hypothesis accepted
	U	S1011-BG4-001	Dixon test for potential outliers	Low value 0.360 is a potential outlier	> 0.05	Hypothesis rejected
Background Reference Area 5 (BG-5)	As	S1011-BG5-011	Dixon test for potential outliers	High value 1.60 is a potential outlier	> 0.05	Hypothesis rejected
	Ra-226	S1011-BG5-008	Dixon test for potential outliers	High value 0.790 is a potential outlier	> 0.05	Hypothesis rejected
	U	S1011-BG5-004	Dixon test for potential outliers	Low value 0.290 is a potential outlier	> 0.05	Hypothesis rejected
	U	S1011-BG5-007	Dixon test for potential outliers	High value 0.680 is a potential outlier	< 0.05	Hypothesis accepted

As = Arsenic Mo = Molybdenum U = Uranium V = Vanadium Ra-226 = Radium 226

The test confirms that eight of the 16 potential outliers tested are statistically significant (p value <0.05). These potential outlier values were further investigated by reviewing sample forms, notes and laboratory reports. Field staff and field notes indicated nothing abnormal about the locations where these samples were collected, and the laboratory datasets show no data quality flags were applied that would call the accuracy of the results in to question. Therefore, while these values: 1) are outside the interquartile range of their respective datasets (Figure 1B), 2) do not conform with their dataset distributions in the probability plots (Figures 3 through 7), and 3) are deemed potential outliers by Dixon's Test, they were not removed from the background reference area datasets because no scientific reason was found to justify removing them, and they are considered representative of the natural variation of the background reference areas. However, Section 3.3 presents statistics calculated both with and without these potential outlier values.

3.1.4 Potential Gamma Data Outliers

A total of 15 potential outliers were identified from the background reference area gamma survey datasets. These values were initially identified in the box plots in Figure 2B.

High gamma values were identified for the BG-1, BG-2, and BG-4 gamma datasets shown in the boxplots in Figure 2B. When viewed in the probability plots in Figure 8, gamma probability plots for all the background reference areas are largely linear, indicating normal distribution. Because the number of values in the background reference areas gamma datasets are each >30, Dixon's Test was not appropriate for testing potential outliers. Instead, because the values appear to be generally normally distributed, it was appropriate to identify potential outliers using Z, t and chi squared scoring methods at the 95% confidence level. These tests were performed in the 'Outliers' package in R (Lukasz Komsta, 2011), and the results are summarized in Table 2. The R programming language complements ProUCL in its ability to provide more meaningful and useful graphics and summarizes the results equivalent to ProUCL. Because ProUCL and R packages follow similar statistical procedures, the results are comparable. The interquartile range evaluation (values outside 1.5 times the interquartile range) results are also provided in Table 2.

The results presented in Table 2 are deemed potential outliers and represent 15 of 901 data points (1.7 percent) in BG-1, BG-2 and BG-4. One possible reason for the small number/percentage of potential outliers in the gamma radiation dataset, may be the presence of a localized source of radiation within a background reference area. Nothing in the field notes or the gamma data records indicates a scientific reason for these values to be excluded (e.g., data handling error, equipment malfunction), and there is no record of anomalous soil or other material in the background reference areas. Therefore, the values are considered representative of the natural variation present, and there is no basis to remove them from the gamma dataset. However, descriptive statistics were calculated with and without these values for comparison (Section 3.3.2).

Table 2. Potential Gamma Outlier Interquartile Range, Z Score, t Score and Chi Squared Score Results

Area	Value (cpm)	Interquartile Range Result	Z Score Result	t Score Result	Chi Sq Score Result
Background Reference Area 1 (BG-1)	20,015	High	Potential Outlier	Potential Outlier	Potential Outlier
	18,564	High	Potential Outlier	Potential Outlier	Potential Outlier
	18,022	High	Potential Outlier	Potential Outlier	Potential Outlier
	18,021	High	Potential Outlier	Potential Outlier	Potential Outlier
	17,971	High	Potential Outlier	Potential Outlier	Potential Outlier
Background Reference Area 2 (BG-2)	25,542	High	Potential Outlier	Potential Outlier	Potential Outlier
	24,440	High	Potential Outlier	Potential Outlier	Potential Outlier
	24,202	High	Potential Outlier	Potential Outlier	Potential Outlier
	24,192	High	Potential Outlier	Potential Outlier	Potential Outlier
	24,160	High	Potential Outlier	Potential Outlier	Potential Outlier
	24,080	High	Potential Outlier	Potential Outlier	Potential Outlier
Background Reference Area 4 (BG-4)	22,772	High	Potential Outlier	Potential Outlier	Potential Outlier
	22,206	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,008	Low	Potential Outlier	Potential Outlier	Potential Outlier
	15,868	Low	Potential Outlier	Potential Outlier	Potential Outlier

cpm Counts per minute

Potential outlier values in the gamma dataset for the Survey Areas appear in the Figure 2A boxplots. Because of the non-linear shape and continuous distribution of gamma results shown in the probability plot in Figure 8, the values are thought to be representative of the heterogeneous nature of radioactive materials within the Survey Areas and are not outlier values. Figure 4-1 of the RSE Report shows that while gamma results for the majority of each of the Survey Areas are within the range of background, localized areas of elevated gamma results associated with mineralized areas are also present.

3.2 COMPARE DATA POPULATIONS

Group comparison analyses provide insight into the relative concentrations of constituents between background reference areas and the Survey Areas. Observations made during these analyses may indicate the need for further evaluation or discussion regarding the influence of potential outlier values, and the use of background data. For instance, if two or more background areas were determined to be statistically similar to each other, these data could be combined to calculate more robust statistics (not a factor in this evaluation, as one background area each was selected to represent the five Survey Areas). Alternatively, testing of this kind may reveal background concentrations statistically higher than corresponding Survey Area concentrations, requiring additional interpretation or modifications in the use of background area datasets. Finally, results of these evaluations are a component of determining background area representativeness, though statistical comparisons are not the only factors to be considered in judging representativeness. Factors such as geologic materials, topographic gradient, distance from the site being represented, wind direction and non-impacted condition are all important to the selection of background reference areas.

Group comparisons, therefore, are considered instructive as a component of the overall evaluation of soil sample and gamma radiation survey results collected from the background reference areas and the Survey Areas. Relative data distributions were investigated by evaluating the box plots and probability plots in Figures 1A through 8, and by hypothesis testing with the non-parametric Mann-Whitney test, as applicable.

3.2.1 Evaluation of Box Plots

3.2.1.1 Soil Sample Box Plots

When interpreting the soil sample boxplots in Figures 1A and 1B, it is important to note that samples at background reference areas were collected randomly, while samples in the Survey Areas were collected judgmentally from areas of suspected contamination. Analytic constituent results from background reference areas tend to be lower than, or similar to, analytical results from their respective Survey Areas. Analytical constituent-specific observations from the boxplots in Figures 1A and 1B indicate:

- Arsenic. Arsenic results appear highest at BG-1 and its corresponding Survey Area A. Arsenic results at Survey Area B appear higher than in BG-2. Arsenic results from the BG-3, BG-4 and BG-5 are similar to those measured in their corresponding Survey Areas.
- Molybdenum. Molybdenum results appear highest at BG-1 and at Survey Area B. Molybdenum results from BG-3 are similar to Survey Area C. Molybdenum results from BG-1 appear higher than in Survey Area A. Molybdenum was not detected in BG-5, Survey Area D and Survey Area E.
- Ra-226. Ra-226 results appear highest in Survey Areas A and C. Ra-226 results appear higher in all Survey Areas when compared to their respective background reference areas.
- Selenium. Selenium was not detected in any background reference area or Survey Area.
- Uranium. Uranium results appear highest in Survey Area A. Uranium results appear similar between BG-2, BG-3, BG-4, BG-5, Survey Area D and Survey Area E, and slightly elevated at BG-1. Uranium results in Survey Areas A, B and C are higher than in the background reference areas.
- Vanadium. Vanadium results appear highest in Survey Area A. Vanadium results appear similar between BG-1, BG-2, BG-3, BG-4, BG-5 and Survey Area D, and elevated at Survey Areas A, B, C, and E.

3.2.1.2 Gamma Radiation Box Plots and Probability Plots

The box plot comparison in Figures 2A and 2B suggests that mean, median and interquartile range gamma values are similar between BG-1, BG-2, BG-4 and BG-5, while those in BG-3 are higher. Gamma values in the Survey Areas appear higher, and more skewed, than the background reference areas, with this being most pronounced in the Survey Area A, Survey Area B and Survey Area C datasets. These observations of relative similarities and differences between the gamma datasets are further evaluated in Section 3.2.2 using the non-parametric Mann-Whitney test.

3.2.2 Mann-Whitney Testing

The Mann-Whitney test (Bain and Engelhardt, 1992) is a nonparametric test used to determine whether a difference exists between two or more population distributions. This test is also known as the Wilcoxon Rank Sum (WRS) test. This test evaluates whether measurements from one population consistently tend to be larger (or smaller) than those from another population. This test was selected over other comparative tests such as the Student's t test and analysis of variance (ANOVA) because it remains robust in the absence of required assumptions that these two tests require, such as normally distributed data and equality of variances.

Soil samples at background reference areas were collected randomly, while soil samples in the Survey Areas were collected judgmentally (see Section 3.1). Mann-Whitney testing is not appropriate for comparative analysis if one or both groups contain data collected using a judgmental approach. Therefore, the Mann-Whitney test was not performed for soil sample data between background reference areas and Survey Areas. Gamma radiation data, however, do represent non-judgmental sampling, and so the Mann-Whitney test was appropriate for comparison between background reference areas and Survey Areas (Table 3). Therefore, the test was performed 2-sided on the background reference area and Survey Area gamma radiation data. The two-sided test accounts for results from one group being lower or higher than any other group (i.e., the hypothesis tested whether the two groups differ, independent of which group is higher). A test result p-value of 0.05 or smaller indicates that a significant difference exists between any two groups that are compared. Results of Mann-Whitney testing are presented in Table 3.

Table 3. Summary of Gamma Survey Mann-Whitney Test Results

Comparison	p_Value	Description
Background Reference Area 1 (BG-1) vs Survey Area A	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 1 (BG-1) Potential Outliers Excluded	0.643	No Significant Difference
Background Reference Area 1 (BG-1) Potential Outliers Excluded vs Survey Area A	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Survey Area B	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Background Reference Area 2 (BG-2) Potential Outliers Excluded	0.667	No Significant Difference
Background Reference Area 2 (BG-2) Potential Outliers Excluded vs Survey Area B	<0.05	Significant Difference
Background Reference Area 3 (BG-3) vs Survey Area C	0.303	No Significant Difference
Background Reference Area 4 (BG-4) vs Survey Area D	<0.05	Significant Difference
Background Reference Area 4 (BG-4) vs Background Reference Area 4 (BG-4) Potential Outliers Excluded	1.00	No Significant Difference
Background Reference Area 4 (BG-4) Potential Outliers Excluded vs Survey Area D	<0.05	Significant Difference
Background Reference Area 5 (BG-5) vs Survey Area E	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 2 (BG-2)	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 3 (BG-3)	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 4 (BG-4)	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 5 (BG-5)	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Background Reference Area 3 (BG-3)	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Background Reference Area 4 (BG-4)	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Background Reference Area 5 (BG-5)	<0.05	Significant Difference
Background Reference Area 3 (BG-3) vs Background Reference Area 4 (BG-4)	<0.05	Significant Difference
Background Reference Area 3 (BG-3) vs Background Reference Area 5 (BG-5)	<0.05	Significant Difference
Background Reference Area 4 (BG-4) vs Background Reference Area 5 (BG-5)	<0.05	Significant Difference
Survey Area A vs Survey Area B	<0.05	Significant Difference
Survey Area A vs Survey Area C	<0.05	Significant Difference
Survey Area A vs Survey Area D	<0.05	Significant Difference
Survey Area A vs Survey Area E	<0.05	Significant Difference
Survey Area B vs Survey Area C	<0.05	Significant Difference
Survey Area B vs Survey Area D	<0.05	Significant Difference
Survey Area B vs Survey Area E	<0.05	Significant Difference
Survey Area C vs Survey Area D	<0.05	Significant Difference
Survey Area C vs Survey Area E	<0.05	Significant Difference
Survey Area D vs Survey Area E	<0.05	Significant Difference

The results of the Mann-Whitney testing on gamma radiation survey results in Table 3 indicate the following:

- Gamma results are statistically elevated in Survey Area A with respect to BG-1.
- Gamma results are statistically elevated in Survey Area B with respect to BG-2. The inclusion or removal of potential outlier values from BG-2 has no effect on this result.
- Gamma results are not statistically different between BG-3 and Survey Area C. While there are much higher values in the Survey Area C dataset compared to BG-3, the Mann-Whitney test compares group means and concludes that mean gamma results are not statistically different between BG-3 and Survey Area C.
- Gamma results are statistically elevated in Survey Area D with respect to BG-4. The inclusion or removal of potential outlier values from BG-4 has no effect on this result.
- Gamma results are statistically elevated in Survey Area E with respect to BG-5.
- Gamma datasets from all five background reference areas differ significantly from each other.
- Gamma datasets from all five Survey Areas differ significantly from each other.
- The observation that gamma results at four Survey Areas are elevated relative to their respective background reference areas is likely attributable to the fact that background reference areas may not fully represent the degree of natural mineralization present at Survey Areas (see RSE Report Section 3.2.2.2). This latter point does not prohibit use of the gamma ILs calculated from these background reference areas, but this observation should be considered, as Site conditions are further evaluated for remediation.

3.3 DESCRIPTIVE STATISTICS

Descriptive statistics, including the upper confidence limit (UCL) of the mean and the 95-95 upper tolerance limit (UTL), were calculated from gamma survey data and soil sample results. Descriptive statistics are important for any data evaluation to present the basic statistics of a data set with regards to its limits (maximum and minimum), central tendencies (mean and median) as well as data dispersion (coefficient of variance). The ILs for the Site also are taken from the descriptive statistics, namely the 95-95 UTL. The parameters and constituents evaluated include gamma radiation, arsenic, molybdenum, selenium, uranium, vanadium, and Ra-226. Selenium results for all background reference areas and molybdenum results for BG-5 were 100 percent non-detect; therefore, no statistics were calculated for selenium and molybdenum at these respective background reference areas.

Statistics were calculated using Environmental Protection Agency (EPA) ProUCL version 5.1 software. Statistical methodology employed by the software is documented in the *ProUCL Version 5.1 Technical Guide Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations* (EPA, 2015). In the case of non-detect results, ProUCL does not recommend detection limit substitution methods (e.g., 1/2 the detection limit), considering these methods to be imprecise and out of date (EPA, 2015). The software instead calculates descriptive statistics for the detected results only, and follows various methods accordingly to calculate UCL and UTL values based on the percentage of non-detect results present in the dataset and on the distribution of the data (i.e., normal, lognormal, gamma, or unknown distribution).

Descriptive statistics for soil samples and gamma radiation survey results have been calculated with and without the potential outlier values previously identified, as applicable. Select descriptive statistics for these constituents are presented in Tables 4 and 5.

3.3.1 Soil Sample Analytical Results Summary

Table 4 presents the descriptive statistics output from the ProUCL software for the soil sample results.

The relative levels of arsenic, molybdenum, selenium, uranium, vanadium, and Ra-226 results measured between the background reference areas and Survey Areas are shown in the box plots in Figures 1A and 1B and are described in Section 3.2.1.1. An important consideration when comparing concentrations of metals and Ra-226 between background reference areas and the Survey Areas is that the background reference areas were selected to be representative of the geology present in the region around the Site, whereas the Site was selected as a mine claim because it is in an area of mineralized bedrock likely to have localized, naturally elevated uranium concentrations (see RSE Report Section 3.2.2.2). In addition, soil sampling for metals and Ra-226 in the background reference areas was conducted in a random manner, whereas soil sampling for metals and Ra-226 in the Survey Areas was judgmental. As a result, it's not surprising that metals and Ra-226 concentrations in the Survey Areas appear to be elevated relative to the background reference areas. It should be noted, however, that concentrations of several of the metals measured in the Survey Areas are within the range of metals concentrations typically observed in Western U.S. soils (United States Geological Survey [USGS], 1984):

- Arsenic (mean = 5.5 mg/kg; range <0.10 – 97 mg/kg)
- Molybdenum (mean = 0.85 mg/kg; range <3 – 7 mg/kg)
- Selenium (mean = 0.23 mg/kg; range <0.1 – 4.3 mg/kg)
- Uranium (mean = 2.5 mg/kg; range 0.68 – 7.9 mg/kg)
- Vanadium (mean = 70 mg/kg; range 7 – 500 mg/kg)

As shown in Table 4, maximum detected concentrations of arsenic and vanadium in the Survey Areas are within typical ranges reported for Western U.S soils, and may not be related to the uranium mineralization. Exceptions to the above are molybdenum, uranium, and Ra-226; elevated concentrations of these constituents in the Survey Area are present in soils associated with mining-related disturbances at the Site.

Table 4. Summary of Soil Sampling Results

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Reference Area 1 (BG-1) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	18%	100%	--	--	--
	Minimum[1]	2.00	--	--	1.60	5.50	1.05
	Minimum Detect[2]	--	0.320	--	--	--	--
	Mean[1]	4.32	--	--	2.17	11.5	1.47
	Mean Detects[2]	--	0.567	--	--	--	--
	Median[1]	3.40	--	--	2.10	11.0	1.43
	Median Detects[2]	--	0.490	--	--	--	--
	Maximum[1]	11.0	--	--	2.80	26.0	1.86
	Maximum Detect[2]	--	1.40	--	--	--	--
	Distribution	Normal	Gamma	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation[1]	0.621	--	--	0.172	0.488	0.160
	CV Detects[2]	--	0.587	--	--	--	--
	UCL Type	95% Student's-t UCL	95% KM Adjusted Gamma UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	5.78	0.824	Not Calculated	2.38	14.6	1.60
	UTL Type	UTL Normal	UTL KM Gamma WH	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	11.9	2.26	Not Calculated	3.23	27.3	2.13
Background Reference Area 2 (BG-2) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	82%	100%	--	--	--
	Minimum[1]	1.30	--	--	1.30	6.70	1.73
	Minimum Detect[2]	--	0.220	--	--	--	--
	Mean[1]	1.69	--	--	1.69	8.52	2.07
	Mean Detects[2]	--	0.275	--	--	--	--
	Median[1]	1.70	--	--	1.50	8.60	2.02
	Median Detects[2]	--	0.275	--	--	--	--
	Maximum[1]	2.00	--	--	3.40	10.0	2.70
	Maximum Detect[2]	--	0.330	--	--	--	--
	Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation[1]	0.136	--	--	0.347	0.114	0.152
	CV Detects[2]	--	0.283	--	--	--	--
	UCL Type	95% Student's-t UCL	95% KM (t) UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	1.82	0.156	Not Calculated	2.01	9.05	2.25
	UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	2.34	0.346	Not Calculated	3.34	11.2	2.96
Background Reference Area 2 (BG-2) Excluding Potential Outliers [3]	Total Number of Observations	--	9	--	9	--	--
	Percent Non-Detects	--	100%	--	--	--	--
	Minimum[1]	--	--	--	1.30	--	--
	Minimum Detect[2]	--	--	--	--	--	--
	Mean[1]	--	--	--	1.48	--	--
	Mean Detects[2]	--	--	--	--	--	--
	Median[1]	--	--	--	1.50	--	--
	Maximum[1]	--	--	--	1.60	--	--
	Maximum Detect[2]	--	--	--	--	--	--
	Distribution	--	Not Calculated	--	Normal	--	--
	Coefficient of Variation[1]	--	--	--	0.066	--	--
	UCL Type	--	Not Calculated	--	95% Student's-t UCL	--	--
	UCL Result	--	Not Calculated	--	1.54	--	--
	UTL Type	--	Not Calculated	--	UTL Normal	--	--
	UTL Result	--	Not Calculated	--	1.77	--	--

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Reference Area 3 (BG-3) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	64%	100%	--	--	--
	Minimum¹	1.00	--	--	0.600	9.20	0.710
	Minimum Detect²	--	0.200	--	--	--	--
	Mean¹	1.57	--	--	1.05	11.3	0.985
	Mean Detects²	--	0.260	--	--	--	--
	Median¹	1.20	--	--	1.00	10.0	0.990
	Median Detects²	--	0.235	--	--	--	--
	Maximum¹	5.20	--	--	1.60	15.0	1.23
	Maximum Detect²	--	0.370	--	--	--	--
	Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation¹	0.772	--	--	0.293	0.191	0.181
	CV Detects²	--	0.300	--	--	--	--
	UCL Type	95% Student's-t UCL	95% KM (t) UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	2.24	0.245	Not Calculated	1.21	12.5	1.08
	UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	4.99	0.367	Not Calculated	1.91	17.4	1.49
Background Reference Area 3 (BG-3) Excluding Potential Outliers ³	Total Number of Observations	10	--	--	--	--	--
	Minimum¹	1.00	--	--	--	--	--
	Mean¹	1.21	--	--	--	--	--
	Median¹	1.20	--	--	--	--	--
	Maximum¹	1.50	--	--	--	--	--
	Distribution	Normal	--	--	--	--	--
	Coefficient of Variation¹	0.143	--	--	--	--	--
	UCL Type	95% Student's-t UCL	--	--	--	--	--
	UCL Result	1.31	--	--	--	--	--
	UTL Type	UTL Normal	--	--	--	--	--
	UTL Result	1.71	--	--	--	--	--
Background Reference Area 4 (BG-4) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	82%	100%	--	--	--
	Minimum¹	1.20	--	--	0.360	7.70	0.710
	Minimum Detect²	--	0.200	--	--	--	--
	Mean¹	1.43	--	--	0.444	9.01	0.985
	Mean Detects²	--	0.205	--	--	--	--
	Median¹	1.50	--	--	0.460	9.20	1.04
	Median Detects²	--	0.205	--	--	--	--
	Maximum¹	1.60	--	--	0.490	9.80	1.27
	Maximum Detect²	--	0.210	--	--	--	--
	Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation¹	0.083	--	--	0.088	0.077	0.180
	CV Detects²	--	0.035	--	--	--	--
	UCL Type	95% Student's-t UCL	95% KM (t) UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	1.49	0.197	Not Calculated	0.465	9.39	1.08
	UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	1.76	0.210	Not Calculated	0.554	11.0	1.49
Background Reference Area 4 (BG-4) Excluding Potential Outliers	Total Number of Observations	--	9	--	--	--	--
	Percent Non-Detects	--	100%	--	--	--	--
	Distribution	--	Not Calculated	--	--	--	--
	UCL Type	--	Not Calculated	--	--	--	--
	UCL Result	--	Not Calculated	--	--	--	--
	UTL Type	--	Not Calculated	--	--	--	--
	UTL Result	--	Not Calculated	--	--	--	--

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Reference Area 5 (BG-5) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	100%	100%	--	--	--
	Minimum¹	1.10	--	--	0.290	5.10	0.500
	Minimum Detect²	--	--	--	--	--	--
	Mean¹	1.27	--	--	0.415	7.32	0.610
	Mean Detects²	--	--	--	--	--	--
	Median¹	1.30	--	--	0.410	7.50	0.630
	Maximum¹	1.60	--	--	0.680	9.40	0.790
	Maximum Detect²	--	--	--	--	--	--
	Distribution	Normal	Not Calculated	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation¹	0.127	--	--	0.237	0.165	0.134
	UCL Type	95% Student's-t UCL	Not Calculated	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	1.36	Not Calculated	Not Calculated	0.468	7.98	0.655
	UTL Type	UTL Normal	Not Calculated	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	1.73	Not Calculated	Not Calculated	0.691	10.7	0.839
Background Reference Area 5 (BG-5) Excluding Potential Outliers	Total Number of Observations	--	--	--	10	--	--
	Minimum¹	--	--	--	0.290	--	--
	Mean¹	--	--	--	0.388	--	--
	Median¹	--	--	--	0.405	--	--
	Maximum¹	--	--	--	0.450	--	--
	Distribution	--	--	--	Normal	--	--
	Coefficient of Variation¹	--	--	--	0.118	--	--
	UCL Type	--	--	--	95% Student's-t UCL	--	--
	UCL Result	--	--	--	0.415	--	--
	UTL Type	--	--	--	UTL Normal	--	--
	UTL Result	--	--	--	0.522	--	--
Survey Area A	Total Number of Observations	6	6	6	6	6	6
	Percent Non-Detects	--	17%	100%	--	--	--
	Minimum¹	2.30	--	--	5.30	16.0	2.93
	Minimum Detect²	--	0.270	--	--	--	--
	Mean¹	3.67	--	--	58.2	123	18.9
	Mean Detects²	--	0.384	--	--	--	--
	Median¹	3.45	--	--	28.5	57.0	10.3
	Median Detects²	--	0.350	--	--	--	--
	Maximum¹	5.90	--	--	230	380	64.4
	Maximum Detect²	--	0.580	--	--	--	--
	Distribution	Normal	Normal	Not Calculated	Gamma	Normal	Normal
	Coefficient of Variation¹	0.343	--	--	1.47	1.18	1.22
	CV Detects²	--	0.311	--	--	--	--
	UCL Type	95% Student's-t UCL	95% KM (t) UCL	Not Calculated	95% Adjusted Gamma UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	4.70	0.463	Not Calculated	376	243	37.8
	UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Gamma WH	UTL Normal	UTL Normal
	UTL Result	8.33	0.801	Not Calculated	766	664	104

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Survey Area B	Total Number of Observations	40	40	40	40	40	40
	Percent Non-Detects	--	55%	100%	--	--	--
	Minimum¹	1.30	--	--	0.560	7.20	0.880
	Minimum Detect²	--	0.200	--	--	--	--
	Mean¹	2.34	--	--	6.55	21.4	4.06
	Mean Detects²	--	0.927	--	--	--	--
	Median¹	2.25	--	--	2.45	14.5	2.76
	Median Detects²	--	0.240	--	--	--	--
	Maximum¹	3.60	--	--	68.0	92.0	13.6
	Maximum Detect²	--	11.0	--	--	--	--
	Distribution	Normal	Unknown	Not Calculated	Lognormal	Unknown	Gamma
	Coefficient of Variation¹	0.238	--	--	1.79	0.805	0.785
	CV Detects²	--	2.72	--	--	--	--
	UCL Type	95% Student's-t UCL	95% KM (Chebyshev) UCL	Not Calculated	95% H-UCL	95% Chebyshev (Mean, Sd) UCL	95% Adjusted Gamma UCL
	UCL Result	2.48	1.65	Not Calculated	9.49	33.2	5.01
	UTL Type	UTL Normal	Non-Parametric -Max	Not Calculated	UTL Lognormal	UTL Non-Parametric	UTL Gamma WH
	UTL Result	3.51	11.0	Not Calculated	34.6	92.0	12.4
Survey Area C	Total Number of Observations	5	5	5	5	5	5
	Percent Non-Detects	--	80%	100%	--	--	--
	Minimum¹	0.940	--	--	0.480	8.30	0.950
	Minimum Detect²	--	0.270	--	--	--	--
	Mean¹	1.59	--	--	30.5	91.7	8.98
	Mean Detects²	--	0.270	--	--	--	--
	Median¹	1.30	--	--	7.10	43.0	5.64
	Maximum¹	3.40	--	--	120	310	24.3
	Maximum Detect²	--	0.270	--	--	--	--
	Distribution	Lognormal	Not Calculated	Not Calculated	Gamma	Normal	Normal
	Coefficient of Variation¹	0.646	--	--	1.67	1.37	1.07
	UCL Type	95% H-UCL	Not Calculated	Not Calculated	95% Adjusted Gamma UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	3.48	Not Calculated	Not Calculated	656	212	18.2
	UTL Type	UTL Lognormal	Not Calculated	Not Calculated	UTL Gamma WH	UTL Normal	UTL Normal
	UTL Result	12.3	Not Calculated	Not Calculated	826	621	49.4
Survey Area D	Total Number of Observations	4	4	4	4	4	4
	Percent Non-Detects	--	100%	100%	--	--	--
	Minimum¹	0.840	--	--	0.570	8.40	0.720
	Minimum Detect²	--	--	--	--	--	--
	Mean¹	1.16	--	--	1.11	13.3	1.20
	Mean Detects²	--	--	--	--	--	--
	Median¹	1.20	--	--	0.940	12.5	1.15
	Maximum¹	1.40	--	--	2.00	20.0	1.77
	Maximum Detect²	--	--	--	--	--	--
	Distribution	Normal	Not Calculated	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation¹	0.213	--	--	0.614	0.396	0.363
	UCL Type	95% Student's-t UCL	Not Calculated	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	1.45	Not Calculated	Not Calculated	1.92	19.5	1.71
	UTL Type	UTL Normal	Not Calculated	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	2.43	Not Calculated	Not Calculated	4.63	40.4	3.43

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Survey Area E	Total Number of Observations	4	4	4	4	4	4
	Percent Non-Detects	--	100%	100%	--	--	--
	Minimum¹	0.560	--	--	0.680	4.10	0.720
	Minimum Detect²	--	--	--	--	--	--
	Mean¹	0.913	--	--	1.03	17.9	1.37
	Mean Detects²	--	--	--	--	--	--
	Median¹	0.895	--	--	0.765	7.75	1.56
	Maximum¹	1.30	--	--	1.90	52.0	1.64
	Maximum Detect²	--	--	--	--	--	--
	Distribution	Normal	Not Calculated	Not Calculated	Normal	Gamma	Normal
	Coefficient of Variation¹	0.340	--	--	0.569	1.27	0.318
	UCL Type	95% Student's-t UCL	Not Calculated	Not Calculated	95% Student's-t UCL	95% Adjusted Gamma UCL	95% Student's-t UCL
	UCL Result	1.28	Not Calculated	Not Calculated	1.72	--	1.88
	UTL Type	UTL Normal	Not Calculated	Not Calculated	UTL Normal	UTL Gamma WH	UTL Normal
	UTL Result	2.51	Not Calculated	Not Calculated	4.03	382	3.61

1	This statistic is reported by ProUCL when the dataset contains 100 percent detections.
2	This statistic is reported by ProUCL when non-detect values exist in the dataset. The value reported is calculated using detections only.
3	Statistics shown are for the constituents where statistical potential outliers were identified, calculated with the potential outliers removed.
CV	Coefficient of variation
KM	Kaplan Meier
mg/kg	Milligrams per kilogram
--	Not applicable
pCi/g	Picocuries per gram
WH	Wilson Hilferty
Note	The UTL result that is shown on the table is based on the output from ProUCL. ProUCL evaluates the data and provides all possible UCLs from its UCL module for three possible data distributions, then identifies a recommended UCL value. ProUCL does not identify a recommended UTL value. The UTLs are therefore based on the distribution of the recommended UCL. Please refer to *ProUCL Version 5.1 Technical Guide Statistical Software for Environmental Applications for Data Sets with and without Non-detect Observations* (EPA, 2015) for further information

3.3.2 Gamma Radiation Results Summary

As noted for metals and Ra-226 in Section 3.3.1, gamma results measured within the Survey Areas are elevated relative to gamma results measured in background reference areas because background reference areas were selected to represent the geology present in the region around the Site, whereas the Site was selected as a mine claim because it is in an area of mineralized bedrock likely to have localized naturally elevated uranium concentrations. Therefore, it’s not surprising that gamma results within the Survey Areas are somewhat higher than gamma results at the background reference areas. Elevated gamma results in portions of the Survey Areas are likely attributable to historic waste piles, as well as a higher degree of natural mineralization within the Survey Areas relative to the background reference areas.

Table 5 presents the descriptive statistics output from the ProUCL software for the gamma radiation survey results.

Table 5. Summary of Walk-over Gamma Results

Area	Statistic	Gamma (cpm)
Background Reference Area 1 (BG-1) All Data	Total Number of Observations	171
	Minimum	11,464
	Mean	14,082
	Median	14,041
	Maximum	20,015
	Distribution	Normal
	Coefficient of Variation	0.105
	UCL Type	95% Student's-t UCL
	UCL Result	14,269
	UTL Type	UTL Normal
	UTL Result	16,829
Background Reference Area 1 (BG-1) Excluding Potential Outliers	Total Number of Observations	166
	Minimum	11,464
	Mean	13,948
	Median	13,944
	Maximum	17,840
	Distribution	Normal
	Coefficient of Variation	0.092
	UCL Type	95% Student's-t UCL
	UCL Result	14,112
	UTL Type	UTL Normal
	UTL Result	16,319
Background Reference Area 2 (BG-2) All Data	Total Number of Observations	288
	Minimum	18,508
	Mean	21,269
	Median	21,227
	Maximum	25,542
	Distribution	Normal
	Coefficient of Variation	0.054
	UCL Type	95% Student's-t UCL
	UCL Result	21,379
	UTL Type	UTL Normal
	UTL Result	23,320
Background Reference Area 2 (BG-2) Excluding Potential Outliers	Total Number of Observations	282
	Minimum	18,508
	Mean	21,201
	Median	21,207
	Maximum	23,932
	Distribution	Normal
	Coefficient of Variation	0.050
	UCL Type	95% Student's-t UCL
	UCL Result	21,304
	UTL Type	UTL Normal
	UTL Result	23,093
Background Reference Area 3 (BG-3) All Data	Total Number of Observations	80
	Minimum	13,202
	Mean	29,080
	Median	26,603
	Maximum	57,059
	Distribution	Normal
	Coefficient of Variation	0.341
	UCL Type	95% Student's-t UCL
	UCL Result	30,927
	UTL Type	UTL Normal
	UTL Result	48,542
Background Reference Area 4 (BG-4) All Data	Total Number of Observations	442
	Minimum	15,868
	Mean	18,804
	Median	18,780
	Maximum	22,772
	Distribution	Normal
	Coefficient of Variation	0.055
	UCL Type	95% Student's-t UCL
	UCL Result	18,886
	UTL Type	UTL Normal
	UTL Result	20,637
Background Reference Area 4 (BG-4) Excluding Potential Outliers	Total Number of Observations	438
	Minimum	16,230
	Mean	18,801
	Median	18,780
	Maximum	21,239
	Distribution	Normal
	Coefficient of Variation	0.053
	UCL Type	95% Student's-t UCL
	UCL Result	18,879
	UTL Type	UTL Normal
	UTL Result	20,555
Background Reference Area 5 (BG-5) All Data	Total Number of Observations	138
	Minimum	16,299
	Mean	19,213
	Median	19,101
	Maximum	22,914
	Distribution	Normal
	Coefficient of Variation	0.074
	UCL Type	95% Student's-t UCL
	UCL Result	19,412
	UTL Type	UTL Normal
	UTL Result	21,864

Area	Statistic	Gamma (cpm)
Survey Area A	Total Number of Observations	2,760
	Minimum	11,058
	Mean	54,008
	Median	40,409
	Maximum	654,837
	Distribution	Unknown
	Coefficient of Variation	0.842
	UCL Type	95% Chebyshev (Mean, Sd) UCL
	UCL Result	57,781
	UTL Type	UTL Non-Parametric
	UTL Result	154,167
Survey Area B	Total Number of Observations	38,270
	Minimum	8,652
	Mean	33,786
	Median	28,107
	Maximum	633,057
	Distribution	Normal
	Coefficient of Variation	0.694
	UCL Type	95% Student's-t UCL
	UCL Result	33,983
	UTL Type	UTL Normal
	UTL Result	72,663
Survey Area C	Total Number of Observations	12,917
	Minimum	11,527
	Mean	28,427
	Median	27,310
	Maximum	749,127
	Distribution	Unknown
	Coefficient of Variation	1.17
	UCL Type	95% Chebyshev (Mean, Sd) UCL
	UCL Result	40,149
	UTL Type	UTL Non-Parametric
	UTL Result	91,235
Survey Area D	Total Number of Observations	15,969
	Minimum	12,476
	Mean	22,219
	Median	21,069
	Maximum	62,220
	Distribution	Normal
	Coefficient of Variation	0.203
	UCL Type	95% Student's-t UCL
	UCL Result	22,277
	UTL Type	UTL Normal
	UTL Result	29,722
Survey Area E	Total Number of Observations	1,647
	Minimum	12,054
	Mean	26,892
	Median	21,675
	Maximum	117,875
	Distribution	Normal
	Coefficient of Variation	0.528
	UCL Type	95% Student's-t UCL
	UCL Result	27,468
	UTL Type	UTL Normal
	UTL Result	51,153

cpm Counts per minute

4.0 INVESTIGATION LEVELS

The calculated 95-95 UTL values described in Section 3.3 are used as the ILs for gamma measurement results and soil sampling results because they reflect the natural variability in the background data, and provide an upper limit from background data to be used for single-point comparisons to Survey Area data. The ILs for analytical results of soil samples and gamma radiation results in Survey Areas A, B, C, D and E are based on Background Reference Areas BG-1, BG-2, BG-3, BG-3, BG-4 and BG-5, respectively.

4.1 SURVEY AREA A INVESTIGATION LEVELS

- Arsenic (mg/kg): 11.9
- Molybdenum (mg/kg): 2.26
- Selenium (mg/kg): None (All results non-detect)
- Uranium (mg/kg): 3.23
- Vanadium (mg/kg): 27.3
- Ra-226 (pCi/g): 2.13
- Gamma radiation measurements (cpm): 16,829

4.2 SURVEY AREA B INVESTIGATION LEVELS

- Arsenic (mg/kg): 2.34
- Molybdenum (mg/kg): 0.346
- Selenium (mg/kg): None (All results non-detect)
- Uranium (mg/kg): 3.34
- Vanadium (mg/kg): 11.2
- Ra-226 (pCi/g): 2.96
- Gamma radiation measurements (cpm): 23,320

4.3 SURVEY AREA C INVESTIGATION LEVELS

- Arsenic (mg/kg): 4.99
- Molybdenum (mg/kg): 0.367
- Selenium (mg/kg): None (All results non-detect)
- Uranium (mg/kg): 1.91
- Vanadium (mg/kg): 17.4
- Ra-226 (pCi/g): 1.49
- Gamma radiation measurements (cpm): 48,542

4.4 SURVEY AREA D INVESTIGATION LEVELS

- Arsenic (mg/kg): 1.76
- Molybdenum (mg/kg): 0.210
- Selenium (mg/kg): None (All results non-detect)
- Uranium (mg/kg): 0.554
- Vanadium (mg/kg): 11.0
- Ra-226 (pCi/g): 1.49
- Gamma radiation measurements (cpm): 20,637

4.5 SURVEY AREA E INVESTIGATION LEVELS

- Arsenic (mg/kg): 1.73
- Molybdenum (mg/kg): None (All results non-detect)
- Selenium (mg/kg): None (All results non-detect)
- Uranium (mg/kg): 0.691
- Vanadium (mg/kg): 10.7
- Ra-226 (pCi/g): 0.839
- Gamma radiation measurements (cpm): 21,864

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Appendix E Cultural and Biological Resource Clearance Documents

BIOLOGICAL EVALUATION

For the Proposed:

Section 26 (Desidero Group)
Abandon Uranium Mine - Environmental Response Trust Project

Sponsored by:

MWH Global / Stantec

MWH now part of Stantec

Prepared by:

Adkins Consulting, Inc.
180 East 12th Street, Unit 5
Durango, Colorado 81301

Revised August 2016
June 2016

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1. INTRODUCTION AND PROJECT BACKGROUND

The federal Endangered Species Act (ESA) of 1973, 16 U.S.C. §1531 et seq., requires all federal departments and agencies to conserve threatened, endangered, and critical and sensitive species and the habitats on which they depend, and to consult with the U.S. Fish and Wildlife Service (USFWS) on all actions authorized, funded, or carried out by each agency to ensure that the action will not likely jeopardize the continued existence of any threatened and endangered species or adversely modify critical habitat [USFWS 1998]. This report describes the potential for federal ESA-listed species and Navajo Nation Endangered Species List (NESL) endangered, threatened, candidate, or otherwise designated sensitive flora and fauna to occur in the proposed action area. The action area with regard to the ESA is defined as any area that may be directly or indirectly impacted by the proposed action [50 CFR §402.02]. This report is intended to provide the responsible official with information to make determinations of effect on species with special conservation status.

As the result of settlement by the United States, the Navajo Nation AUM Environmental Response Trust—First Phase was established to evaluate certain abandoned uranium mines located across the Navajo Nation. The project requires investigation of these sites prior to potential remediation activities in the future. MWH Global, a division of Stantec (MWH), will conduct exploratory activities at the Section 26 (Desidero Group) abandoned uranium mine (AUM) such as pedestrian gamma surveys, mapping, well sampling, and surface soil sampling within the mine claim boundaries and surrounding buffer zone. Subsequent earthwork and long term monitoring may be involved after final approval by the Navajo Nation Environmental Protection Agency (NNEPA) in conjunction with the U. S. Environmental Protection Agency (USEPA).

In support of this project, MWH contracted Adkins Consulting, Inc. (ACI) to conduct surveys for ESA-listed fauna and Navajo Nation Endangered Species List (NESL) endangered, threatened, candidate, or otherwise designated sensitive fauna. MWH contracted Redente Ecological Consultants (Redente) to conduct surveys for NESL and ESA-listed plant species. The results of the 2016 Redente biological investigations will be incorporated in Sections 4.2 and 4.3 of this report and can be found in entirety attached as Appendix C.

The objectives of the biological surveys were as follows:

- To compile a list of ESA-listed or NESL species potentially occurring in the proposed action area.
- To provide a physical and biological description of the proposed action area.
- To determine the presence of ESA-listed or NESL species in the proposed action area.
- To assess potential impacts the proposed action may have on any ESA-listed or NESL species present in the area.
- To assess potential impacts to species protected under the Migratory Bird Treaty Act (MBTA).

2. PROJECT DESCRIPTION

2.1. Location

Section 26 (Desidero Group) is comprised of three separate areas within close proximity to one another within Township 13 North, Range 10 West, New Mexico Principal Meridian (NMPM). Two of the areas are located on the northern end of Section 26 and the northern extent of their site buffers extend into the southern end of Section 23 while the easternmost buffer extends into Section 25. The third area is located to the south in the middle of Section 26. The Section 26 (Desidero Group) is located in McKinley County, New Mexico approximately 12.8 miles north of Grants, New Mexico at an elevation of approximately 7,117 feet. Global Positioning System coordinates are 35° 20' N by 107° 51.57' W NAD 83. Project area maps are provided in Appendix A.

2.2. Estimated Disturbance

MWH proposes a phased approach to scientific investigations at the Section 26 (Desidero Group) AUM. The study area is comprised of three separate areas within close proximity to one another. The three areas together including the buffer zones surrounding the perimeter of the boundaries encompass approximately 32.8 acres. Please refer to Appendix A for maps delineating the mine claim boundaries and buffer zones.

The project will also include a walkover survey for gamma radiation across a small area known as the "background area". Please refer to Appendix A for a map of the background sample areas. A few soil samples approximately 3 inches in diameter and up to 6 inches deep will be collected by hand in these areas.

- Phase I: Spring of 2016, activity would entail pedestrian biological surveys and land surveying. Fall of 2016 work would entail pedestrian activity including gamma surveys, mapping, well sampling, and surface soil sampling. In 2016 there will be a maximum of 5 people onsite for no more than 5 to 7 days. Surface disturbance would be minimal and noise would be light.

- Phase II: Beginning in 2017, equipment including an excavator or small mobile drilling unit may be used to collect one or more soil samples. Up to 8 people may be onsite all day for a period of one week. Equipment travel would be confined to a temporary travel corridor approximately 20 feet in width. Within the travel corridor, vegetation and surface soil would sustain some disturbance but would not be bladed or bulldozed. During Phase II, noise may be moderate for a short duration, and surface disturbance will be light to moderate but confined to a minimal footprint within the study area. No permanent structures will be left on site.

3. AFFECTED ENVIRONMENT

3.1. Proposed Project Area (PPA)

The proposed project area (PPA) includes the mine boundaries with 100-foot buffers surrounding the perimeter of the boundaries. The affected environment or action area includes any area that may be directly or indirectly impacted by the proposed activities. Project area maps are provided in Appendix A.

3.1.1. Environmental Setting

Project activities would occur in northwestern New Mexico located within the USEPA designated Arizona/New Mexico Plateau Level III Ecoregion. The Arizona/New Mexico Plateau occurs primarily in Arizona, Colorado, and New Mexico, with a small portion in Nevada. This ecoregion is approximately 45,870,500 acres, and the elevation ranges from 2,165 to 11,949 feet. The ecoregion's landscapes include low mountains, hills, mesas, foothills, irregular plains, alkaline basins, some sand dunes, and wetlands. This ecoregion is a large transitional region between the semiarid grasslands to the east, the drier shrublands and woodlands to the north, and the lower, hotter, less vegetated areas to the west and south.

Section 26 (Desidero Group) is comprised of three separate areas within close proximity to one another. The areas are situated on a low cuesta rim with crumbling sandstone cliffs off the south side of the area and previous disturbance from residences and driveways throughout.

Flora

Vegetation communities found within the Arizona/New Mexico Plateau ecoregion include shrublands with big sagebrush, rabbitbrush, winterfat, shadscale saltbush, and greasewood; and grasslands of blue grama, Western wheatgrass, green needlegrass, and needle-and-thread grass. Higher elevations may support piñon pine and juniper woodlands. The Section 26 (Desidero Group) is sparsely vegetated grassland with sporadic shrubs and scattered piñon/juniper on the eastern and southernmost boundaries. Vegetative cover is estimated to be approximately 25 percent in areas undisturbed by residences or unmaintained road.

Fauna

Wildlife or evidence of wildlife observed within the PPA included common raven (*Corvus corax*), common nighthawk (*Chordeiles minor*), cottontail rabbit (*Sylvilagus* sp.), and mule deer (*Odocoileus hemionus*). No signs of consistent raptor use such as whitewash or nests were observed. No prairie dog (*Cynomys* sp.) burrows were recorded within the PPA or immediate vicinity. Further analysis of sensitive species can be found in Section 4 of this document.

Hydrology/Wetlands

Under Executive Orders 11988 and 11990, Federal agencies are required to minimize the destruction, loss, or degradation of wetlands and floodplains, and preserve and enhance their natural and beneficial values. These habitats should be conserved through avoidance, or mitigated to ensure that there would be no net loss of wetlands function and value.

Run-off from precipitation in the project area generally drains southeast across the top of the cuesta and then connects with a larger ephemeral / intermittent, north-south trending ravine to the east. The larger ravine eventually ends at a fresh water pond approximately 1.2 miles south of the project area. The Rio San Jose is the nearest perennial water source, approximately 7 miles south of the PPA. There are no wetlands, seeps, springs, or riparian areas within the proposed project area. The proposed project activities would contribute to a negligible increase in sedimentation down gradient of the project area. This increase is not anticipated to be a factor due to the distance from perennial waters. ESA-listed fish species are not known to occur in Rio San Jose, nor is it considered critical habitat of any ESA-listed species.

Cumulative impacts to surface waters would be negligible. Surface-disturbing activities other than the proposed action that may cause accelerated erosion include, but are not limited to, construction of roads, other facilities, and installation of trenches for utilities; road maintenance such as grading or ditch-cleaning; public recreational activities; vegetation manipulation and management activities; natural and prescribed fires; and livestock grazing. Because the proposed action would have a negligible impact to downstream surface water quality, the cumulative impact also would be negligible when added to other past, present, and reasonably foreseeable activities.

4. THREATENED, ENDANGERED, AND SENSITIVE SPECIES EVALUATION

The Endangered Species Act (ESA) of 1973 requires all federal departments and agencies to conserve threatened, endangered, and critical and sensitive species and the habitats on which they depend, and to consult with the U.S. Fish and Wildlife Service (USFWS) on all actions authorized, funded, or carried out by the agency to ensure that the action will not likely jeopardize the continued existence of any threatened and endangered species or adversely modify critical habitat.

4.1. Methods

4.1.1. Off-site Methods

Prior to conducting fieldwork, ACI compiled data on animal species listed under the ESA. Informal consultation was initiated by requesting an Official Species List from the USFWS Information, Planning, and Conservation System (IPaC) website (http://ecos.fws.gov/ipac/). ACI received the Official Species

List (02ENNM00-2016-SLI-0447) on April 8, 2016. See Table 1 for USFWS-listed threatened, endangered, or candidate species with potential to occur in the PPA.

The Navajo Nation Department of Fish and Wildlife (NNDFW), Navajo Natural Heritage Program (File # 15mwh101) sent MWH a NESL information letter dated 29 December, 2015. The letter suggests biologists determine habitat suitability within the project area for the provided list of species of concern with potential to occur on the 7.5-minute quadrangles containing the project boundaries. The Navajo species of concern listed in the NESL information letter are included in Table 2.a below.

In addition to the above listed species, ACI reviewed species protected under the MBTA with potential to occur in the proposed project and action area (Table 3).

4.1.2. On-site Survey Methods

An on-site pedestrian survey was conducted in April 2016 by ACI personnel under a permit issued by NNDFW. The purpose of the survey was to assess habitat potential for ESA-listed or NESL animal species. Field biologists with considerable experience identifying local wildlife species lead survey crews. The survey consisted of walking transects ten feet apart throughout the PPA including a survey buffer of approximately 50 feet beyond the PPA edge of disturbance. The surrounding areas were visually inspected with binoculars for nests, raptors, or past signs of raptor use. Weather conditions were clear with a slight breeze. All plant and wildlife species observed in the action area were recorded, and digital photos were taken (Appendix B).

Redente conducted surveys for plant species of concern. The results of the 2016 Redente biological investigations will be incorporated in Sections 4.2 and 4.3 of this report and can be found in entirety attached as Appendix C.

4.2. ESA-Listed Species Analysis and Results

4.2.1. Species from the USFWS IPaC Official Species List

Table 1 includes ESA-listed plant and animal species that have the potential to occur in the project area based on the USFWS IPaC Official Species List. Biologists evaluated habitat suitability within and surrounding the PPA for the species in Table 1.

Table 1: USFWS Species List for the Section 26 Project

Species	Status	Occurrence Within Region	Habitat	Potential to Occur within Action Area
BIRDS				
Southwestern Willow Flycatcher (*Empidonax traillii extimus*)	Endangered with Designated Critical Habitat	Summer/breeding range.[2]	Breeds in dense riparian habitat.[2]	No potential. Action area does not provide suitable habitat for species to occur.
Mexican spotted owl (*Strix occidentalis lucida*)	Threatened with Designated Critical Habitat	Year-round range.[1]	Mixed conifer forests. Typically where unlogged, uneven-aged, closed-canopy forests occur in steep canyons.[1]	No potential. Action area does not provide suitable habitat for species to occur.
Western Yellow-Billed Cuckoo (*Coccyzus americanus*)	Threatened	Possible rare summer/breeding occurrences.[2]	In the southwestern U.S., associated with riparian woodlands dominated by cottonwood or willow trees. In New Mexico, native or exotic species may be used.[2]	No potential. Action area does not provide suitable habitat for species to occur.

Table 1: USFWS Species List for the Section 26 Project

Species	Status	Occurrence Within Region	Habitat	Potential to Occur within Action Area
FISHES				
Zuni Bluehead Sucker (*Catostomus discobolus yarrowi*)	Endangered	Native to headwater streams of the Little Colorado River in east-central AZ and west-central NM; current range in NM is limited to the upper Río Nutria drainage.[2]	Low-velocity pools and pool-runs with seasonally dense perilithic and periphytic algae, particularly shady, cobble/boulder/bedrock substrates in streams with frequent runs and pools.[2]	No potential. Action area does not provide suitable habitat for species to occur.
PLANTS				
Zuni fleabane (*Erigeron rhizomatus*)	Threatened	Zuni and Chuska Mountains, and Datil and Sawtooth ranges in New Mexico.[3]	Found on fine textured clay hillsides of mid to high elevation between 7000 and 8300ft. It is known from clays derived from the Chinle Formation in the Zuni and Chuska Mountains, and to similar clays of the Baca Formation in the Datil and Sawtooth ranges in New Mexico.[3]	No potential. Action area does not provide suitable habitat for species to occur. No individuals found during Redente site surveys.[5]

[1]USFWS; [2]NatureServe Explorer; [3]Navajo Endangered Species List, Species Accounts 2008, [4] IUCN Red List, [5]Redente 2016

4.2.2. ESA-Listed Species Eliminated From Further Consideration

Table 1 includes five (5) ESA-listed species that have the potential to occur in the project area based on the USFWS IPaC Official Species List. All of the species in Table 1 have been eliminated from further discussion in this report. There would be no direct, indirect or cumulative impacts to the species in Table 1.

4.3. NESL Species Analysis and Results

4.3.1. Navajo Endangered Species List (NESL) and Species of Concern

Table 2.a lists species of concern with potential to occur on the 7.5-minute quadrangle(s) containing the project boundaries. According to the NESL information letter received from the NFWD found in Appendix D, there is no record of species of concern occurring on or near the project site. Biologists evaluated the potential for species of concern listed in the table below to occur within the project area.

Additionally, the NESL information letter requested that the potential for black-footed ferret (*Mustela nigripes*) be evaluated if prairie dog towns of sufficient size (per NFWD guidelines) occur in the project area, and that potential for Parish's alkali grass (*Puccinellia parishii*) be evaluated if wetland conditions exist that contain white alkaline crusts. Species listed by the USFWS in Table 1 are not reiterated here.

Table 2.a: Navajo Endangered Species List (NESL) and Species of Concern

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area
ANIMALS			
Black-Footed ferret (*Mustela nigripes*)	Endangered	Open habitat, including grasslands, steppe, and shrub steppe. Closely associated with prairie dog colonies. At least 40 hectares of prairie dog colony required to support one ferret.[2]	No potential. Action area does not provide suitable habitat for species to occur. Action area does not provide prairie dog colonies of sufficient size
Mountain plover *(Charadrius montanus)*	NESL G4	Typically nests in flat (<2% slope) to slightly rolling expanses of grassland, semi-desert, or badland, in an area with short, sparse vegetation, large bare areas (often >1/3 of total area), and that is typically disturbed (e.g. grazed); may also nest in plowed or fallow cultivation fields. Nest is a scrape in dirt often next to a grass clump or old cow manure pile. Migration habitat is similar to breeding habitat.[2,3]	No potential. Action area does not provide suitable habitat for species to occur.
Western burrowing owl (*Athene cunicularia hypugaea*)	NESL G4	Open grasslands and sometimes other open areas (such as vacant lots). Nests in abandoned burrows, such as those dug by prairie dogs.[2,3]	No potential. Action area does not provide suitable habitat for species to occur.
Golden eagle (*Aquila chrysaetos*)	NESL G3	In the west, mostly open habitats in mountainous, canyon terrain. Nests primarily on cliffs.[1,3]	Action area provides potential foraging habitat for species to occur.
American peregrine falcon (*Falco peregrinus*)	NESL G4 NM-T	Nests on steep cliffs >30 m tall (typically >45 m) in a scrape on sheltered ledges or potholes. Foraging habitat quality is an important factor; often, but not always, extensive wetland and/or forest habitat is within the falcon's hunting range of <=12 km. Nest in ledges or potholes on cliffs in wooded/forested habitats; Forage over riparian woodlands, coniferous & deciduous forests, shrublands, prairies.[3]	Action area provides potential foraging habitat for species to occur.
PLANTS			
Parish's alkali grass (*Puccinellia parishii*)	NESL G4 NM-E	Alkaline springs, seeps, and seasonally wet areas that occur at the heads of drainages or on gentle slopes. Elevation: 2600-7200 feet.[2,3]	No potential. Action area does not provide suitable habitat for species to occur.

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area

Species are listed by the NESL as; Group 2: Endangered (survival or recruitment in jeopardy); Group 3: Endangered (survival or recruitment in jeopardy in foreseeable future); and Group 4: Species of Consideration. NESL Species with New Mexico State Endangered or Threatened status are labeled as NM-T or NM-E.

Sources: [1]New Mexico Natural Heritage Program 2010, [2]NatureServe Explorer; [3]Navajo Endangered Species List, Species Accounts 2008, [4] IUCN Red List, [5]Redente 2016, [6] Hammerson et al 2004.

4.3.2. NESL Species Eliminated From Further Consideration

Table 2.a includes six (6) NESL and Navajo Species of Concern that have the potential to occur in the project area based on general geographical association. The following species have been eliminated from further discussion in this report because the action area does not provide suitable habitat for them to occur: Mountain plover *(Charadrius montanus),* Western burrowing owl (*Athene cunicularia hypugaea*), Black-footed ferret (*Mustela nigripes*), and Parish's alkali grass (*Puccinellia parishii*). None of these species were observed during surveys of the proposed project area or immediate surroundings. Critical habitats of these species do not exist within or adjacent to the proposed project area. There would be no direct, indirect or cumulative impacts to these species.

4.3.3. NESL Species Warranting Further Analysis

Table 2.b lists NESL and Navajo Species of Concern with potential to occur within the proposed project area based on habitat suitability or actual record of observation.

Table 2.b: NESL and Navajo Species of Concern Warranting Further Analysis

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area
ANIMALS			
Golden eagle (*Aquila chrysaetos*)	NESL G3	In the west, mostly open habitats in mountainous, canyon terrain. Nests primarily on cliffs.[1,4]	Action area provides potential foraging habitat for species to occur.
American peregrine falcon (*Falco peregrinus*)	NESL G4 NM-T	Nest in ledges or potholes on cliffs in wooded/forested habitats; Forage over riparian woodlands, coniferous & deciduous forests, shrublands, prairies.	Action area provides potential foraging habitat for species to occur.

Species are listed by the NESL as; Group 2: Endangered (survival or recruitment in jeopardy); Group 3: Endangered (survival or recruitment in jeopardy in foreseeable future); and Group 4: Species of Consideration. NESL Species with New Mexico State Endangered or Threatened status are labeled as NM-T or NM-E.

Sources: [1]New Mexico Natural Heritage Program 2010, [2]NatureServe Explorer; [3]Navajo Endangered Species List, Species Accounts 2008, [4] IUCN Red List, [5]Redente 2016, [6] Hammerson et al 2004.

4.4. Migratory Bird Species

The Migratory Bird Treaty Act (MBTA) implements various treaties and conventions between the U.S. and Canada, Japan, Mexico and the former Soviet Union for the protection of migratory birds. Under the Act, taking, killing or possessing migratory birds is unlawful.

The bald eagle (*Haliaeetus leucocephalus*) was delisted under the ESA on August 9, 2007. Both the bald eagle and golden eagle (*Aquila chrysaetos*) are still protected under the MBTA and Bald and Golden Eagle Protection Act (BGEPA). The BGEPA affords both eagles protection in addition to that provided by the MBTA, in particular, by making it unlawful to "disturb" eagles.

In preparation for conducting the migratory bird survey, information from the New Mexico Partners In Flight website (http://www.hawksaloft.org/pif.shtml), the New Mexico PIF highest priority list of species of concern by vegetation type, the USFWS's Division of Migratory Bird Management website (http://www.fws.gov/migratorybirds/), and the 2002 Birds of Conservation Concern Report for the Southern Rockies/Colorado Plateau Bird Conservation Region (BCR) No. 16, were used to develop a list of high priority migratory bird species with potential to occur in the area of the proposed action. Species addressed previously will not be reiterated here.

Table 3: Priority Birds of Conservation Concern with Potential to Occur in the Project Area

Species Name	Habitat Associations	Potential to Occur in the Project Area
Black-throated sparrow (*Amphispiza bilineata*)	Xeric habitats dominated by open shrubs with areas of bare ground.	Suitable habitat is present within the action area for species to occur.
Brewer's sparrow (*Spizella breweri*)	Closely associated with sagebrush, preferring dense stands broken up with grassy areas.	No suitable habitat is present within the action area for species to occur.
Gray vireo (*Vireo vicinior*)	Open stands of piñon pine and Utah juniper (5,800 – 7,200 ft) with a shrub component and mostly bare ground; antelope bitterbrush, mountain mahogany, Utah serviceberry and big sagebrush often present. Broad, flat or gently sloped canyons, in areas with rock outcroppings, or near ridge-tops.	No suitable habitat is present within the action area for species to occur.
Loggerhead shrike (*Lanius ludovicianus*)	Open country interspersed with improved pastures, grasslands, and hayfields. Nests in sagebrush areas, desert scrub, and woodland edges.	Suitable habitat is present within the action area for species to occur.
Mountain bluebird (*Sialia currucoides*)	Open piñon-juniper woodlands, mountain meadows, and sagebrush shrublands; requires larger trees and snags for cavity nesting.	No suitable habitat is present within the action area for species to occur.
Mourning dove (*Zenaida macroura*)	Open country, scattered trees, and woodland edges. Feeds on ground in grasslands and agricultural fields. Roost in woodlands in the winter. Nests in trees or on ground.	Suitable habitat is present within the action area for species to occur.
Sage sparrow (*Amphispiza belli*)	Large and contiguous areas of tall and dense sagebrush. Negatively associated with seral mosaics and patchy shrublands and abundance of greasewood.	No suitable habitat is present within the action area for species to occur.
Sage thrasher (*Oreoscoptes montanus*)	Shrub-steppe dominated by big sagebrush.	Marginal habitat is present within the action area for species to occur. Lack of significant sagebrush shrubland likely a limiting factor.
Scaled quail (*Callipepla squamata*)	Brushy arroyos, cactus flats, sagebrush or mesquite plains, desert grasslands, Plains grasslands, and agricultural areas. Good breeding habitat has a diverse grass composition, with varied forbs and scattered shrubs.	No suitable habitat present within the action area for species to occur. Lack of diverse grass composition with varied forbs likely a limiting factor.
Swainson's hawk (*Buteo swainsoni*)	A mixture of grassland, cropland, and shrub vegetation; nests on utility poles and in isolated trees in rangeland. Nest densities higher in agricultural areas.	No suitable habitat is present within the action area for species to occur.

Vesper sparrow (*Pooecetes gramineus*)	Dry montane meadows, grasslands, prairie, and sagebrush steppe with grass component; nests on ground at base of grass clumps.	No suitable habitat present within the action area for species to occur. Lack of significant grassland/prairie component a limiting factor.
Bald eagle (*Haliaeetus leucocephalus*)	Near lakes, rivers and cottonwood galleries. Nests near surface water in large trees. May forage terrestrially in winter	No suitable habitat present within the action area for species to occur.
Bendire's thrasher (*Toxostoma bendirei*)	Typically inhabits sparse desert shrubland & open woodland with scattered shrubs; breeds in scattered locations in central & western portions of NM; most common in southwest NM.	Suitable habitat is present within the action area for species to occur. However likely out of species typical range.
Piñon jay (*Gymnorhinus cyanocephalus*)	Foothills throughout CO and NM wherever large blocks of piñon-juniper woodland habitat occurs.	No suitable habitat present within the action area for species to occur.
Prairie falcon (*Falco mexicanus*)	Arid, open country, grasslands or desert scrub, rangeland; nests on cliff ledges, trees, power structures.	Action area provides potential foraging habitat for species to occur.
Ferruginous hawk (*Buteo regalis*)	Breed in open country, usually prairies, plains and badlands; semi- desert grass-shrub, sagebrush-grass & piñon-juniper plant associations.	No suitable habitat present within the action area for species to occur.

5. EFFECTS ANALYSIS

Effects or impacts can be either long term (permanent or residual) or short term (incidental or temporary). Short-term impacts affect the environment for only a limited period and then the environment reverts rapidly back to pre-action conditions. Long-term impacts are substantial and permanent alterations to the pre-existing environmental condition. Direct effects are those effects that are caused by the action and occur in the same time and place as the action. Indirect effects are those effects that are caused by or will result from the proposed action and are later in time but still reasonably certain to occur (USFWS 1998).

5.1. Direct and Indirect Effects

The PPA includes the claim boundary and a 100-foot perimeter buffer for a total of approximately 32.8 acres. The project will also include a walkover survey for gamma radiation across a small area known as the "background area" (see Appendix A for map). A few soil samples approximately 3 inches in diameter and up to 6 inches deep will be collected by hand in these areas. The proposed action would result in a short term increase in human activity within the PPA at varying degrees depending on the project phase:

- Phase I: Spring of 2016 activity would entail pedestrian biological surveys and land surveying. During 2016, work would entail pedestrian activity including gamma surveys, mapping, well sampling, and surface soil sampling. For this phase, there will be a maximum of 5 people onsite for no more than 5 to 7 days. Surface disturbance would be minimal and noise would be light.

- Phase II: Beginning in 2017, equipment including an excavator or small mobile drilling unit may be used to collect soil samples. Up to 8 people may be onsite all day for a period of one week. Equipment travel would be confined to a temporary travel corridor approximately 20 feet in width. Within the travel corridor, vegetation and surface soil would sustain some disturbance but would not be bladed or bulldozed. One or more soil samples may be taken using an excavator or small mobile drilling unit. During Phase II, noise may be moderate for a short duration, and surface disturbance will be light to moderate but confined to a minimal footprint within the study area. No permanent structures will be left on site.

Best Management Practices (BMPs) incorporated into project design will reduce potential impacts including: confining equipment travel to PPA boundary, minimizing travel corridors as much as practicable, limiting truck and equipment travel within the PPA when surfaces are wet and soil may become deeply rutted, and using previously disturbed areas for travel when possible.

5.1.1. Golden eagle, American peregrine falcon

Due to the mobility of adult raptors and the lack of appropriate nesting sites in the vicinity of the proposed project area, it is unlikely that the proposed project would result in 1) injury to a raptor, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior. Short term audial and visual disturbances associated with the Phase II activity could cause minor indirect habitat loss by temporarily deterring raptors from using available habitat adjacent to the proposed project area.

5.1.2. Migratory Birds

The PPA encompasses approximately 32.8 acres of potential migratory bird habitat in the form of Great Basin Desert scrub. Approximately 50-60 trees are within the PPA boundary.

Phase I:
Noise and surface disturbance will be low during pedestrian survey activity. Adult migratory birds would not be directly impacted by Phase I because of their mobility and ability to avoid areas of human activity. Minor human presence during project activities within the breeding season may indirectly disturb or displace adults from nests and foraging habitats for a short period of time. Direct and indirect effects are expected to be short term and negligible.

Phase II:
Adult migratory birds would not be directly harmed by the activities because of their mobility and ability to avoid areas of human activity. During Phase II, noise may be moderate but for a short duration, and surface disturbance will be light to moderate but confined to a minimal footprint within the study area. Equipment travel may require the removal of no more than five trees. No permanent structures will be left on site. Direct impacts are more likely if surface disturbing activities occur during the breeding season (April 1 through August 15); however, surface disturbance will be confined to a minimal footprint (likely less than one acre) within the study area. The increased human presence during project activities within the breeding season may indirectly disturb or displace adults from nests and foraging habitats for a short period of time.

5.2. Cumulative Effects

Cumulative impacts of an action include the total effects on a resource or ecosystem. Cumulative effects in the context of the Endangered Species Act pertain to non-Federal actions, and are reasonably certain to occur in the action area (USFWS 1998).

5.2.1. Golden eagle, American peregrine falcon

Additional existing surface disturbances within the action area include unimproved access roads to the residences nearby, all-terrain vehicle use and active wildlife and livestock grazing. Local plant and animal pest control are also activities that may occur in the vicinity. These foreseeable actions would cumulatively impact raptors through habitat loss or contamination. Human activity may also increase available prey base if the activity leads to an increase in rodent population numbers. The intensity of indirect effects would be dependent upon the species, its life history, time of year and/or day and the type and level of human and vehicular activity is occurring.

5.2.2. *Migratory Birds*

With the implementation of BMPs discussed in Section 5.1, the cumulative impact of the proposed action on migratory birds would be low based on the minimal surface disturbance involved and the availability of adjacent similar habitats.

6. CONCLUSIONS

U.S. Fish and Wildlife Service Listed Species (USFWS)

ACI conducted informal consultation with the USFWS and received an Official Species List for the proposed project area. Qualified ACI biologists evaluated habitat suitability within and surrounding the PPA for these species and concluded the potential does not exist for USFWS-listed species to occur within the proposed project area. No further consultation with the USFWS is required.

Migratory Birds

The proposed action phases would result in short term activity within approximately 32.8 acres of potential migratory bird habitat in the form of Great Basin Desert scrub/grassland and approximately 50-60 piñon-juniper trees. During Phase I, noise and surface disturbance will be low during pedestrian survey activity. Direct and indirect effects are expected to be short term and negligible. For Phase II, the total surface disturbance is unknown at this point; however equipment movement would be confined to only a few temporary travel corridors. Within the travel corridors, vegetation and surface soil would sustain some disturbance but would not be bladed or bulldozed. Equipment travel may require the removal of no more than five trees. Possible direct impacts would be short term and are more likely if surface disturbing activities occur during the breeding season (April 1 through August 15). Effects to potential habitat for migratory birds is anticipated to be minor and short term due to the limited degree of vegetation and soil disruption and the abundance of adjacent habitat for these species.

Wetlands

Under Executive Orders 11988 and 11990, Federal agencies are required to minimize the destruction, loss, or degradation of wetlands and floodplains, and preserve and enhance their natural and beneficial values. These habitats should be conserved through avoidance, or mitigated to ensure that there would be no net loss of wetlands function and value. No impacts to wetlands are anticipated. The proposed project activities would contribute to a negligible increase in sedimentation down gradient of the project area. This increase is not anticipated to be a factor due to the distance from perennial waters. There is no suitable habitat for ESA-listed fish in Chaco Wash, nor is it considered critical habitat of any ESA-listed species.

Navajo Endangered Species List (NESL) and Species of Concern

Two (2) NESL and Navajo species of concern have potential to occur within the PPA based on habitat suitability or actual record of observation. Based on site surveys, ACI determined the PPA contains potential foraging habitat for the following: golden eagle and American peregrine falcon. Due to the mobility of adult raptors and the lack of appropriate nesting sites in the vicinity of the proposed project area, it is unlikely that the proposed project would result in detriment to the raptors.

7. RECOMMENDATIONS FOR AVOIDANCE

ACI recommends that the proponent implement standard Best Management Practices (BMPs) designed to protect sensitive wildlife species during project activity including: confining equipment travel to PPA boundary, minimizing travel corridors as much as practicable, limiting truck and equipment travel within the PPA when surfaces are wet and soil may become deeply rutted, and using previously disturbed areas for travel when possible.

8. SUPPORTING INFORMATION

8.1. Consultation and Coordination

John Nystedt, Fish and Wildlife Biologist/AESO Tribal Coordinator
USFWS AZ Ecological Services Office - Flagstaff Suboffice
Southwest Forest Science Complex, 2500 S Pine Knoll Dr, Rm 232
Flagstaff, AZ 86001

Pam Kyselka, Project Reviewer and
Chad Smith, Zoologist
Navajo Nation Department of Fish and Wildlife
Natural Heritage Program
PO Box 1480
Window Rock, AZ 86515

8.2. Report Preparers and Certification

Adkins Consulting, Inc.
180 E. 12th Street, Unit 5
Durango, Colorado 81301
Lori Gregory, Biologist; Sarah McCloskey, Field Biologist; Arnold Clifford, Lead Field Biologist

It is believed by Adkins Consulting that the proposed action would not violate any of the provisions of the Endangered Species Act of 1973, as amended. Conclusions are based on actual field examination and are correct to the best of my knowledge.

1 August 2016

Lori Gregory
Wildlife Biologist
Adkins Consulting
505.787.4088

Date

8.3. References

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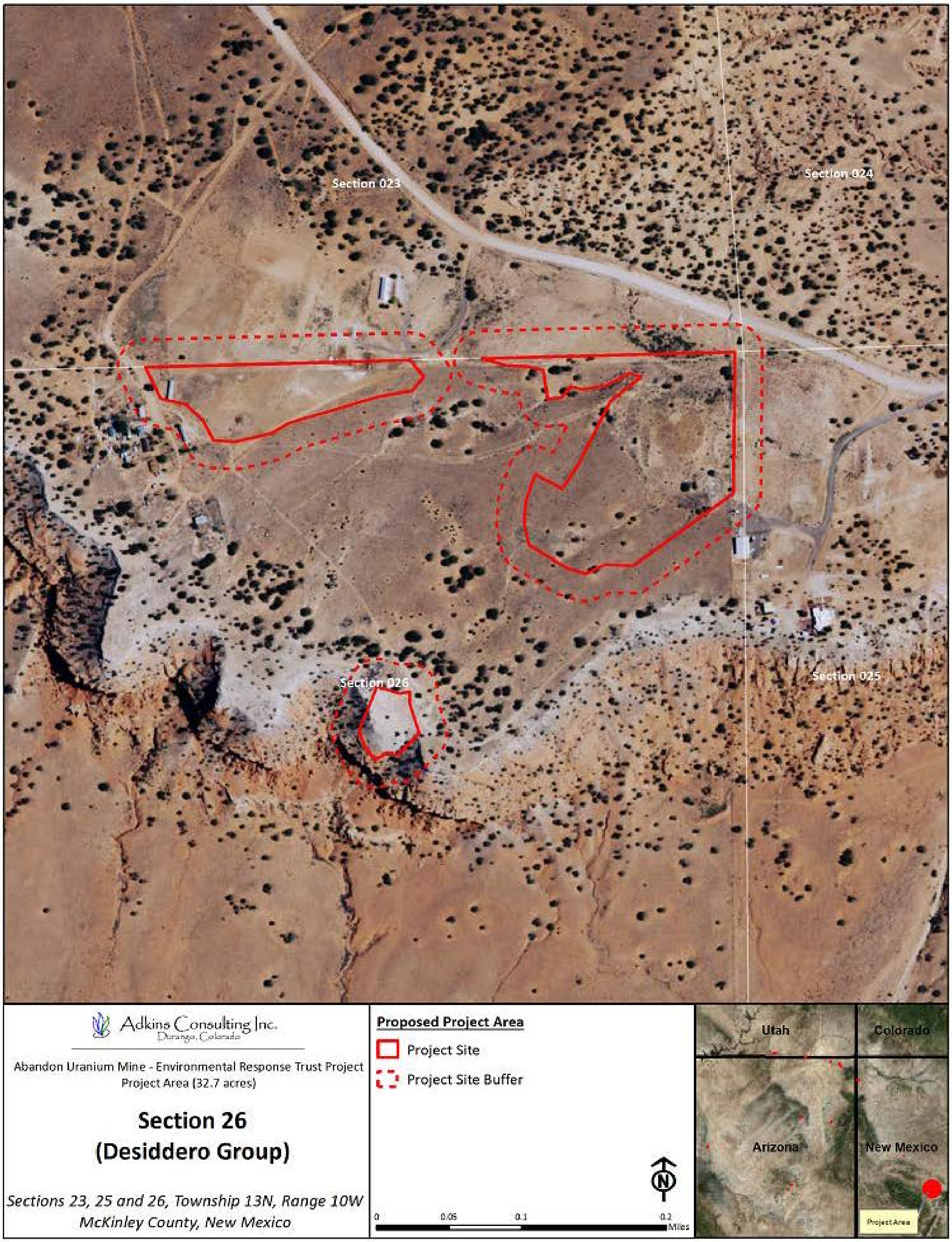
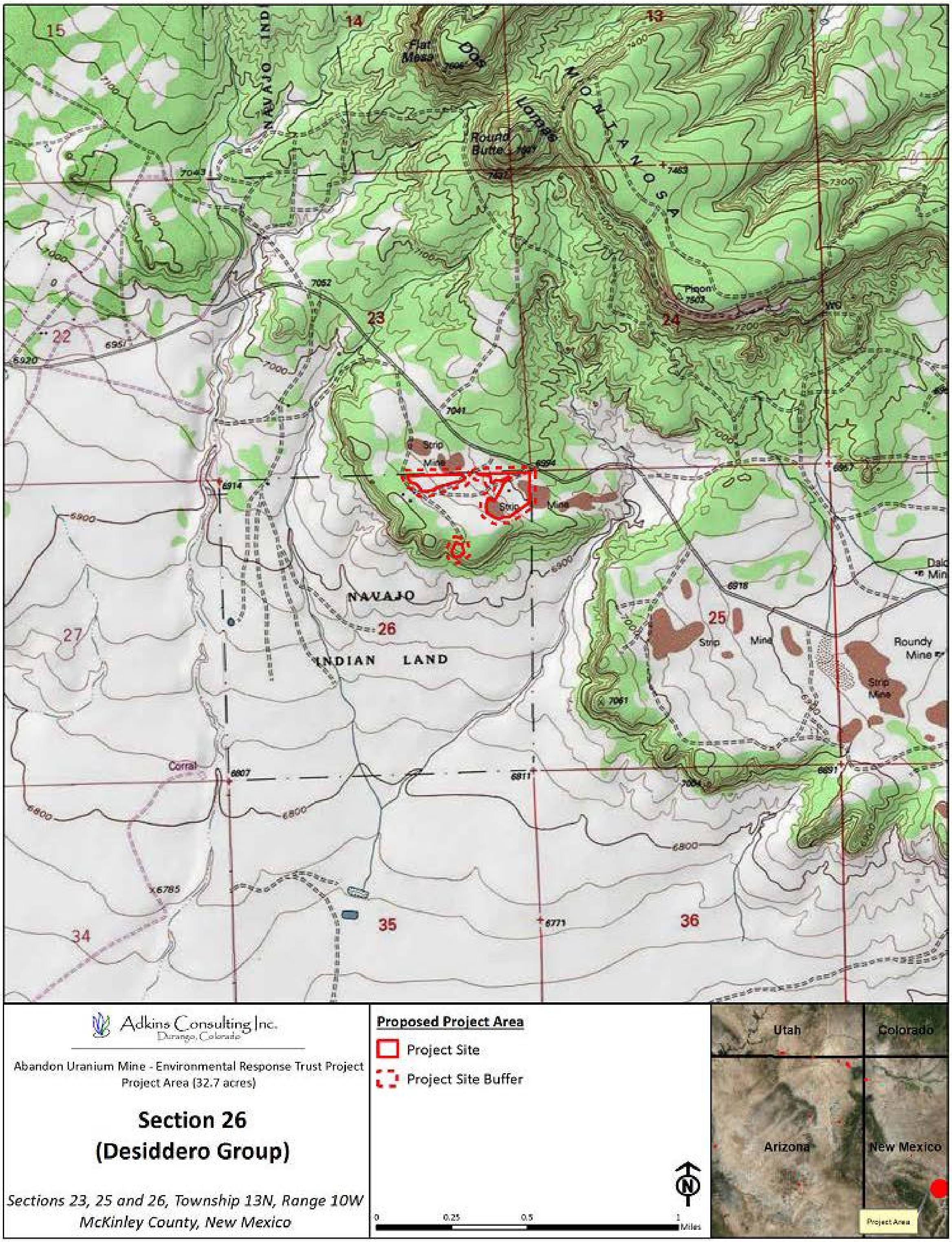
APPENDIX A. MAPS





Adkins Consulting Inc.
Durango, Colorado

Abandon Uranium Mine - Environmental Response Trust Project
Project Area (32.7 acres)

Section 26
(Desiddero Group)

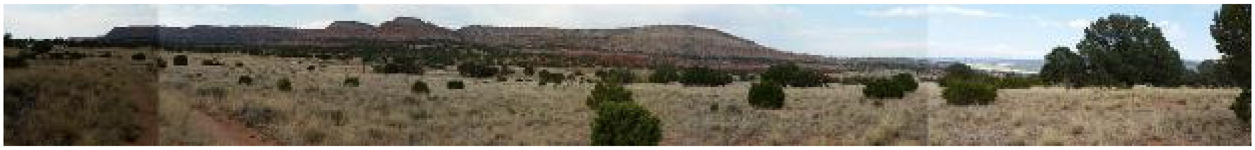
Sections 23, 25 and 26, Township 13N, Range 10W
McKinley County, New Mexico

Proposed Project Area

Project Site

Project Site Buffer

APPENDIX B. PHOTOGRAPHS



Site overview looking north from southern end of site boundary

View north from southern end of northern area boundary

View south from northern end of southern area boundary

APPENDIX C. REDENTE PLANT SURVEY REPORT

Navajo Nation AUM Environmental Response Trust

Plant Survey Report for Species of Concern At Section 26 (Desidero Group) Project Site McKinley County, New Mexico August 2016

Prepared by:
Redente Ecological Consultants
1322 Alene Circle
Fort Collins, CO 80525

TABLE OF CONTENTS

INTRODUCTION

Purpose of Report

A biological survey was conducted at the Section 26 (Desidero Group) site as part of the Navajo Nation AUM Environmental Response Trust. The purpose of the survey is to determine if plant species of concern are present within the claim boundary and extending 100 feet around the site. Biological clearance is required at each site prior to any site investigation to determine if the project may affect potential species-of-concern or potential federal threatened and endangered (T&Es) species and/or critical habitat.

Site Location

Section 26 (Desidero Group) is located in McKinley County New Mexico, approximately 35 km (22 miles) east of Thoreau, New Mexico at an elevation of approximately 2,134 m (7,000 ft). Global Positioning System coordinates are 35° 19’ 59” N by 107° 51’ 38” W (North American Datum of 1983). The site is located on an allotment.

Environmental Setting

Climate

The climate of the Section 26 (Desidero Group) site is classified as semi-arid. The average annual precipitation at the closest official weather station in Thoreau, New Mexico is 287 mm (11.3 in), with the greatest precipitation months occurring in July and August. Average annual temperature is 10.7° C (51.3° F).

Soils

The U.S. Department of Agriculture (USDA) Soil Survey for McKinley County was published in 1993 and covers the area just to the south of Section 26 (Desidero Group) . The soil mapping unit for this site is the Penistaja-San Mateo Series and consists of fan terraces, flood plains and alluvial fans with slopes ranging from 1 to 10%. The soil are primarily fine sandy loams that are deep and well drained.

Plant Community Type

The vegetation on the Section 26 site is classified as an open canopy Pinyon-Juniper woodland. The most common species on the site include pinyon pine (*Pinus edulis*), oneseeded juniper (*Juniperus monosperma*), blue grama (*Bouteloua gracilis*), sand dropseed (*Sporobolus cryptandrus*), Indian ricegrass (*Achnatherum hymenoides*), fourwing saltbush (*Atriplex canescens*), rubber rabbitbrush (*Ericameria nauseosa*), broom snakeweed (*Gutierrizia sarathrae*) and winterfat (*Krascheninnikovia lanata*).

Land Use

The land type on the Section 26 site is rangeland and the principal land use is domestic grazing.

REGULATORY SETTING

The survey for vegetation species-of-concern was conducted according to the Navajo Natural Heritage Program (NNHP) guidelines and the Endangered Species Act (ESA), including the procedures set forth in the *Biological Resource Land Use Clearance Policies and Procedures* (RCP), RCS-44-08 (NNDFW 2008), the Species Accounts document (NNHP 2008), and the USFWS survey protocols and recommendations. Data requests for species of concern were submitted to the NNHP and for federal T&E species to the USFWS. NNHP responded to the request for species of concern with a letter to MWH dated 19 November 2015. The letter provided a list of species of concern known to occur within the proximity of the project area. The list of species included their status as either NESL (Navajo Endangered Species List), Federally Endangered, Federally Threatened, or Federal Candidate. Species were further classified as G2, G3 or G4. G2 includes endangered species or subspecies whose prospects of survival or recruitment are in jeopardy. G3 includes endangered species or subspecies whose prospects of survival or recruitment are likely to be in jeopardy in the foreseeable future. G4 are “candidates” and includes those species or subspecies which may be endangered but for which we lack sufficient information to support being listed.

The Navajo Natural Heritage Program and the USFWS listed one endangered plant species that may occur in the project area—Zuni fleabane (*Erigeron rhizomatus*).

METHODS

Study Area

The area evaluated for plant species of concern was defined by the claim boundary, with an additional 100 foot buffer around all sides.

Database Queries and Literature Review

Prior to initiating field surveys, a target list of all potentially occurring species of concern identified by NNHP and the USFWS was compiled. Ecologic and taxonomic information was reviewed for each species prior to initiating field work to better understand ecological characteristics of the species, habitat requirements and key taxonomic indicators for proper identification (ANPS 2000).

Rare Plant Survey Protocols

The plant survey followed currently accepted resource agency protocols and guidelines, for conducting and reporting botanical inventories for special status plant species (USFWS 1996). According to these protocols, rare plant surveys were conducted by botanists with considerable experience with the local flora. All species observed during the surveys were identified to the degree necessary to correctly identify the species and determine if the plant had special status. The survey was conducted in the summer (July) of 2016 during the appropriate season to observe the phenological characteristics of the special status plant species that were necessary for identification.

The botanical survey team was assisted during the survey by GIS trained staff from MWH with training specifically in the use of the Garmin Montana 600. The GPS operator was also instructed in sight identification of species of concern to help delineate points or polygons and other data collection and data management tasks. GPS units were preloaded for the plant team with background and data files that showed the aerial photographic base map, the site boundaries, and the study area, so team members could clearly identify their exact location in the field at all times.

2016 Field Survey

The project site was surveyed by a field botanist. The botanist walked "transect" lines through each area and looked for suitable habitat for *Erigeron rhizomatus*, specifically fine-textured clay hillsides. The most emphasis was placed in areas with suitable habitat for the species of concern. If a species of concern was identified, the location would be recorded using the point or polygon feature in the GPS units. Further, the population size was planned to be obtained either by direct counts, estimations, or by sampling the population.

Field botanists documented every field visit on field forms, by area, and took photographs of field conditions and species of concern, if found on site. The botanist also recorded all plant communities and plant species observed during each field visit. Plant community types were also photographed to document site conditions (Photos #1 and #2).

RESULTS

One plant species of concern, *Erigeron rhizomatus,* was identified as potentially occurring within the proximity of the project area. *Erigeron rhizomatus* is native perennial forb found in McKinley, San Juan and Catron Counties. It is found growing on fine textured clay hillsides primarily in Pinyon-Juniper type. It occurs at elevation ranges between 2,135 and 2,530 m (7,005 and 8,301 ft).

The survey at Section 26 (Desidero Group) on July 19, 2016 did not identify *Erigeron rhizomatus* on the Section 26 site. The habitat at Section 26 may not be appropriate for the occurrence of this species because fine-textured clay hillsides were not present on site.

Photo #1—Overview of general landscape and plant community at Section 26 (Desidero Group).

Photo #2—Overview of general landscape and plant community at Section 26 (Desidero Group).

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LIST OF PREPARERS

Redente, Edward F. Plant Ecologist. B.A., M.S. and Ph.D. Over 40 years of experience in plant ecology and plant survey studies throughout the semi-arid and arid western U.S. Author or Co-author of over 200 publications.

APPENDIX D. NESL LETTER

NNHP
Navajo Natural Heritage Program

PO Box 1480
Window Rock, AZ
86515

P 928.871.6472
F 928.871.7603

http://nnhp.nndfw.org

15mwh101

19-November-2015

Eileen Dornfest - Project Manager
MWH Americas
3665 John F Kennedy Parkway
Bldg 1, Suite 206
Ft. Collins, CO 80525

SUBJECT: Navajo Nation AUM Environmental Response Trust (ERT) Project - 16 Abandoned Uranium Mine (AUM) Sites

Eileen Dornfest,

NNHP has performed an analysis of your project in comparison to known biological resources of the Navajo Nation and has included the findings in this letter. The letter is composed of seven parts. The sections as they appear in the letter are:

1. **Known Species** – a list of all species within relative proximity to the project
2. **Potential Species** – a list of potential species based on project proximity to respective suitable habitat
3. **Quadrangles** – an exhaustive list of quads containing the project
4. **Project Summary** – a categorized list of biological resources within relative proximity to the project grouped by individual project site(s) or quads
5. **Conditional Criteria Notes** – additional details concerning various species, habitat, etc.
6. **Personnel Contacts** – a list of employee contacts
7. **Resources** – identifies sources for further information

Known Species lists "species of concern" known to occur within proximity to the project area. Planning for avoidance of these species is expected. If no species are displayed then based upon the records of the Navajo Nation Department of Fish and Wildlife (NNDFW) there are no "species of concern" within proximity to the project. Refer to the Navajo Endangered Species List (NESL) Species Accounts for recommended avoidance measures, biology, and distribution of NESL species on the Navajo Nation (http://nnhp.nndfw.org/sp_account.htm).

Potential Species lists species that are potentially within proximity to the project area and need to be evaluated for presence/absence. If no species are found within the Known or Potential Species lists, the project is not expected to affect any federally listed species, nor significantly impact any tribally listed species or other species of concern. Potential for species has been determined primarily on habitat characteristics and species range information. A thorough habitat analysis, and if necessary, species specific surveys, are required to determine the potential for each species.

Species of concern include protected, candidate, and other rare or otherwise sensitive species, including certain native species and species of economic or cultural significance. For legally protected species, the following tribal and federal statuses are indicated: NESL, federal Endangered Species Act (ESA), Migratory

Bird Treaty Act (MBTA), and Eagle Protection Act (EPA). No legal protection is afforded species with only ESA candidate, NESL group 4 status, and species listed on the Sensitive Species List. Please be aware of these species during surveys and inform the NNDFW of observations. Reported observations of these species and documenting them in project planning and management is important for conservation and may contribute to ensuring they will not be up listed in the future.

In any and all correspondence with NNDFW or NNHP concerning this project please cite the Data Request Code associated with this document. It can be found in this report on the top right corner of the every page. Additionally please cite this code in any biological evaluation documents returned to our office.

1. Known Species *(NESL=Navajo Endangered Species List, FE=Federally Endangered, FT=Federally Threatened, FC=Federal Candidate)*

Species

AMPE = Amsonia peeblesii / Peebles' Blue-star NESL G4
AQCH = Aquila chrysaetos / Golden Eagle NESL G3
CASP = Carex specuicola / Navajo Sedge NESL G3 FT
LIPI = Lithobates pipiens / Northern Leopard Frog NESL G2
PEAMCI = Perognathus amplus cineris / Wupatki Pocket Mouse NESL G4
PUPA = Puccinellia parishii / Parish's Alkali Grass NESL G4
**All or parts of this project currently are within areas protected by the Golden and Bald Eagle Nest Protection Regulations; consult with NNDFW zoologist or EA Reviewer for more information and recommendations.

2. Potential Species

Species

ALGO = Allium gooddingii / Gooding's Onion NESL G3
AMPE = Amsonia peeblesii / Peebles' Blue-star NESL G4
AQCH = Aquila chrysaetos / Golden Eagle NESL G3
ASBE = Astragalus beathii / Beath Milk-vetch NESL G4
ASNA = Astragalus naturitensis / Naturita Milk-vetch NESL G3
ASWE = Asclepias welshii / Welsh's Milkweed NESL G3 FT
ATCU = Athene cunicularia / Burrowing Owl NESL G4
BURE = Buteo regalis / Ferruginous Hawk NESL G3
CASP = Carex specuicola / Navajo Sedge NESL G3 FT
CHMO = Charadrius montanus / Mountain Plover NESL G4
CIME = Cinclus mexicanus / American Dipper NESL G3
CIRY = Cirsium rydbergii / Rydberg's Thistle NESL G4
CYUT = Cystopteris utahensis / Utah Bladder-fern NESL G4
EMTREX = Empidonax traillii extimus / Southwestern Willow Flycatcher NESL G2 FE
ERAC = Erigeron acomanus / Acoma Fleabane NESL G3
ERRH = Erigeron rhizomatus / Rhizome Fleabane/zuni Fleabane NESL G2 FT
ERRO = Errazurizia rotundata / Round Dunebroom NESL G3
ERSI = Erigeron sivinskii / Sivinski's Fleabane NESL G4
FAPE = Falco peregrinus / Peregrine Falcon NESL G4
GIRO = Gila robusta / Roundtail Chub NESL G2
LENA = Lesquerella navajoensis / Navajo Bladderpod NESL G3
LIPI = Lithobates pipiens / Northern Leopard Frog NESL G2
MUNI = Mustela nigripes / Black-footed Ferret NESL G2 FE

PEAMCI = Perognathus amplus cineris / Wupatki Pocket Mouse NESL G4
PLZO = Platanthera zothecina / Alcove Bog-orchid NESL G3
PRSP = Primula specuicola / Cave Primrose NESL G4
PTLU = Ptchocheilus lucius / Colorado Pikeminnow NESL G2
PUPA = Puccinellia parishii / Parish's Alkali Grass NESL G4
SAPAER = Salvia pachyphylla ssp eremopictus / Arizona Rose Sage NESL G4
STOCLU = Strix occidentalis lucida / Mexican Spotted Owl NESL G3 FT
VUMA = Vulpes macrotis / Kit Fox NESL G4
ZIVA = Zigadenus vaginatus / Alcove Death Camass NESL G3

3. Quadrangles (7.5 Minute)

Quadrangles

Cameron SE (35111-G3) / AZ
Dalton Pass (35108-F3) / NM
Del Muerto (36109-B4) / AZ
Dos Lomas (35107-C7) / NM
Gallup East (35108-E6) / NM
Garnet Ridge (36109-H7) / AZ, UT
Horse Mesa (36109-F1) / AZ, NM
Indian Wells (35110-D1) / AZ
Mexican Hat SE (37109-A7) / UT, AZ
Oljeto (37110-A3) / UT, AZ
Toh Atin Mesa East (36109-H3) / AZ, UT
Toh Atin Mesa West (36109-H4) / AZ, UT

4. Project Summary *(EO1 Mile/EO 3 Miles=elements occuring within 1 & 3 miles., MSO=mexican spotted owl PACs, POTS=potential species, RCP=Biological Areas)*

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
Alongo Mines	None	AQCH	Horse Mesa (36109-F1) / AZ, NM	None	LIPI, FAPE, EMTREX, CHMO, BURE, ATCU, AQCH, ZIVA, PUPA, PLZO, CIRY, CASP	Area 3
Barton 3	None	None	Toh Atin Mesa West (36109-H4) / AZ, UT	None	PTLU, GIRO, EMTREX, CHMO, BURE, ATCU, AQCH, ZIVA, PLZO, CIRY, CASP	Area 3
Boyd Tisi No. 2 Western	None	AMPE, PEAMCI, LIPI	Cameron SE (35111-G3) / AZ	None	LIPI, PEAMCI, FAPE, EMTREX, BURE, AQCH, ERRO, ASBE, AMPE	Area 3
Charles Keith	None	None	Oljeto (37110-A3) / UT, AZ	None	LIPI, FAPE, EMTREX, CHMO, BURE, AQCH	Area 1, Area 3

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
Eunice Becenti	None	None	Gallup East (35108-E6) / NM	None	FAPE, EMTREX, ATCU, AQCH, LENA, ERSI, ERRH, ERAC	Area 3
Harvey Blackwater No. 3	AQCH	AQCH, PUPA	Garnet Ridge (36109-H7) / AZ, UT	None	VUMA, LIPI, FAPE, EMTREX, CIME, BURE, ATCU, AQCH, ZIVA, PUPA, PRSP, PLZO, CIRY, CASP, ASWE	Area 3
Harvey Blackwater No. 3	AQCH	AQCH, PUPA	Mexican Hat SE (37109-A7) / UT, AZ	None	VUMA, FAPE, EMTREX, ATCU, AQCH, ZIVA, PLZO, CIRY, CASP, ASWE	Area 1
Hoskie Tso No. 1	AQCH	AQCH	Indian Wells (35110-D1) / AZ	None	FAPE, CHMO, BURE, ATCU, AQCH, SAPAER	Area 3
Mitten No. 3	None	AQCH	Oljeto (37110-A3) / UT, AZ	None	LIPI, FAPE, EMTREX, CHMO, BURE, AQCH	Area 3
NA-0904	None	AQCH	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, ATCU, AQCH, PUPA	Area 3
NA-0926	None	None	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, ATCU, AQCH, PUPA	Area 3
Oak124, Oak125	AQCH	AQCH	Horse Mesa (36109-F1) / AZ, NM	None	LIPI, FAPE, EMTREX, CHMO, BURE, AQCH, ZIVA, PUPA, PLZO, CIRY, CASP	Area 3
Occurrence B	None	AQCH, CASP	Del Muerto (36109-B4) / AZ	None	LIPI, FAPE, EMTREX, CIME, AQCH, ZIVA, PLZO, CYUT, CIRY, CASP, ALGO	Area 3
Section 26 (Desiddero Group)	None	None	Dos Lomas (35107-C7) / NM	None	FAPE, CHMO, ATCU, AQCH	Area 3
Standing Rock	None	None	Dalton Pass (35108-F3) / NM	None	VUMA, MUNI, FAPE, CHMO, BURE, ATCU, AQCH, ERSI, ASNA	Area 3

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
Tsosie 1	AQCH	AQCH	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, AQCH, PUPA	Area 1, Area 3

5. Conditional Criteria Notes *(Recent revisions made please read thoroughly. For certain species, and/or circumstances, please read and comply)*

A. **Biological Resource Land Use Clearance Policies and Procedures (RCP)** - The purpose of the RCP is to assist the Navajo Nation government and chapters ensure compliance with federal and Navajo laws which protect, wildlife resources, including plants, and their habitat resulting in an expedited land use clearance process. After years of research and study, the NNDFW has identified and mapped wildlife habitat and sensitive areas that cover the entire Navajo Nation.
The following is a brief summary of six (6) wildlife areas:
1.***Highly Sensitive Area*** – recommended no development with few exceptions.
2.***Moderately Sensitive Area*** – moderate restrictions on development to avoid sensitive species/habitats.
3.***Less Sensitive Area*** – fewest restrictions on development.
4.***Community Development Area*** – areas in and around towns with few or no restrictions on development.
5.***Biological Preserve*** – no development unless compatible with the purpose of this area.
6.***Recreation Area*** – no development unless compatible with the purpose of this area.
None - outside the boundaries of the Navajo Nation
This is not intended to be a full description of the RCP please refer to the our website for additional information at http://www.nndfw.org/clup.htm.

B. **Raptors** – If raptors are known to occur within 1 mile of project location: Contact Chad Smith at 871-7070 regarding your evaluation of potential impacts and mitigation.
   - **Golden and Bald Eagles**- If Golden or Bald Eagle are known to occur within 1 mile of the project, decision makers need to ensure that they are not in violation of the Golden and Bald Eagle Nest Protection Regulations found at http://nnhp.nndfw.org/docs_reps/gben.pdf.
   - **Ferruginous Hawks** – Refer to "Navajo Nation Department of Fish and Wildlife's Ferruginous Hawk Management Guidelines for Nest Protection" http://nnhp.nndfw.org/docs_reps.htm for relevant information on avoiding impacts to Ferruginous Hawks within 1 mile of project location.
   - **Mexican Spotted Owl** - Please refer to the Navajo Nation Mexican Spotted Owl Management Plan http://nnhp.nndfw.org/docs_reps.htm for relevant information on proper project planning near/within spotted owl protected activity centers and habitat.

C. **Surveys** – Biological surveys need to be conducted during the appropriate season to ensure they are complete and accurate please refer to NN Species Accounts http://nnhp.nndfw.org/sp_account.htm. Surveyors on the Navajo Nation must be permitted by the Director, NNDFW. Contact Jeff Cole at (928) 871-7068 for permitting procedures. Questions pertaining to surveys should be directed to the NNDFW Zoologist (Chad Smith) for animals at 871-7070, and Botanist (Andrea Hazelton) for plants at (928)523-3221. Questions regarding biological evaluation should be directed to Jeff Cole at 871-7068.

D. **Oil/Gas Lease Sales** – Any settling or evaporation pits that could hold contaminants should be lined and covered. Covering pits, with a net or other material, will deter waterfowl and other migratory bird use. Lining pits will protect ground water quality.

E. **Power line Projects** – These projects need to ensure that they do not violate the regulations set forth in the Navajo Nation Raptor Electrocution Prevention Regulations found at http://nnhp.nndfw.org/docs_reps/repr.pdf.

F. **Guy Wires** – Does the project design include guy wires for structural support? If so, and if bird species may occur in relatively high concentrations in the project area, then guy wires should be equipped with highly visual markers to reduce the potential mortality due to bird-guy wire collisions. Examples of visual markers include aviation balls and bird flight diverters. Birds can be expected to occur in relatively high concentrations along migration routes (e.g., rivers, ridges or other distinctive linear topographic features) or where important habitat for breeding, feeding, roosting, etc. occurs. The U.S. Fish and Wildlife Service recommends marking guy wires with at least one marker per 100 meters of wire.

G. **San Juan River** – On 21 March 1994 (Federal Register, Vol. 59, No. 54), the U.S. Fish and Wildlife Service designated portions of the San Juan River (SJR) as critical habitat for Ptychocheilus lucius (Colorado pikeminnow) and Xyrauchen texanus (Razorback sucker). Colorado pikeminnow critical habitat includes the SJR and its 100-year floodplain from the State Route 371 Bridge in T29N, R13W, sec. 17 (New Mexico Meridian) to Neskahai Canyon in the San Juan arm of Lake Powell in T41S, R11E, sec. 26 (Salt Lake Meridian) up to the full pool elevation. Razorback sucker critical habitat includes the SJR and its 100-year floodplain from the Hogback Diversion in T29N, R16W, sec. 9 (New Mexico Meridian) to the full pool elevation at the mouth of Neskahai Canyon on the San Juan arm of Lake Powell in T41S, R11E, sec. 26 (Salt Lake Meridian). All actions carried out, funded or authorized by a federal agency which may alter the constituent elements of critical habitat must undergo section 7 consultation under the Endangered Species Act of 1973, as amended. Constituent elements are those physical and biological attributes essential to a species conservation and include, but are not limited to, water, physical habitat, and biological environment as required for each particular life stage of a species.

H. **Little Colorado River** - On 21 March 1994 (Federal Register, Vol. 59, No. 54) the U.S. Fish and Wildlife Service designated Critical Habitat along portions of the Colorado and Little Colorado Rivers (LCR) for Gila cypha (humpback chub). Within or adjacent to the Navajo Nation this critical habitat includes the LCR and its 100-year floodplain from river mile 8 in T32N R6E, sec. 12 (Salt and Gila River Meridian) to its confluence with the Colorado River in T32N R5E sec. 1 (S&GRM) and the Colorado River and 100-year floodplain from Nautuloid Canyon (River Mile 34) T36N R5E sec. 35 (S&GRM) to its confluence with the LCR. All actions carried out, funded or authorized by a federal agency which may alter the constituent elements of Critical Habitat must undergo section 7 consultation under the Endangered Species Act of 1973, as amended. Constituent elements are those physical and biological attributes essential to a species conservation and include, but are not limited to, water, physical habitat, and biological environment as required for each particular life stage of a species.

I. **Wetlands** – In Arizona and New Mexico, potential impacts to wetlands should also be evaluated. The U.S. Fish & Wildlife Service's National Wetlands Inventory (NWI) maps should be examined to determine whether areas classified as wetlands are located close enough to the project site(s) to be impacted. In cases where the maps are inconclusive (e.g., due to their small scale), field surveys must be completed. For field surveys, wetlands identification and delineation methodology contained in the "Corps of Engineers Wetlands Delineation Manual" (Technical Report Y-87-1) should be used. When wetlands are present, potential impacts must be addressed in an environmental assessment and the Army Corps of Engineers, Phoenix office, must be contacted. NWI maps are available for examination at the Navajo Natural Heritage Program (NNHP) office, or may be purchased through the U.S. Geological Survey (order forms are available through the NNHP). The NNHP has complete coverage of the Navajo Nation, excluding Utah, at 1:100,000 scale; and coverage at 1:24,000 scale in the southwestern portion of the Navajo Nation. In Utah, the U.S. Fish & Wildlife Service's National Wetlands Inventory maps are not yet available for the Utah portion of the Navajo Nation, therefore, field surveys should be completed to determine whether wetlands are located close enough to the project site(s) to be impacted. For field surveys, wetlands identification and delineation methodology contained in the "Corps of Engineers Wetlands Delineation Manual" (Technical Report Y-87-1) should be used. When wetlands are present, potential impacts must be addressed in an environmental assessment and the Army Corps of Engineers, Phoenix office, must be contacted. For more information contact the Navajo Environmental Protection Agency's Water Quality Program.

J. **Life Length of Data Request** – The information in this report was identified by the NNHP and NNDFW's biologists and computerized database, and is based on data available at the time of this response. If project planning takes more than two (02) years from the date of this response, verification of the information provided herein is necessary. It should not be regarded as the final statement on the occurrence of any species, nor should it substitute for on-site surveys. Also, because the NNDFW information is continually updated, any given information response is only wholly appropriate for its respective request.

K. **Ground Water Pumping** - Projects involving the ground water pumping for mining operations, agricultural projects or commercial wells (including municipal wells) will have to provide an analysis on the effects to surface water and address potential impacts on all aquatic and/or wetlands species listed below. NESL Species potentially impacted by ground water pumping: Carex specuicola (Navajo Sedge), Cirsium rydbergii (Rydberg's Thistle), Primula specuicola (Cave Primrose), Platanthera zothecina (Alcove Bog Orchid), Puccinellia parishii (Parish Alkali Grass), Zigadenus vaginatus (Alcove Death Camas), Perityle specuicola (Alcove Rock Daisy), Symphyotrichum welshii (Welsh's American-aster), Coccyzus americanus (Yellow-billed Cuckoo), Empidonax traillii extimus (Southwestern Willow Flycatcher), Rana pipiens (Northern Leopard Frog), Gila cypha (Humpback Chub), Gila robusta (Roundtail Chub), Ptychocheilus lucius (Colorado Pikeminnow), Xyrauchen texanus (Razorback Sucker), Cinclus mexicanus (American Dipper), Speyeria nokomis (Western Seep Fritillary), Aechmophorus clarkia (Clark's Grebe), Ceryle alcyon (Belted Kingfisher), Dendroica petechia (Yellow Warbler), Porzana carolina (Sora), Catostomus discobolus (Bluehead Sucker), Cottus bairdi (Mottled Sculpin), Oxyloma kanabense (Kanab Ambersnail)

6. Personnel Contacts

Wildlife Manager
Sam Diswood
928.871.7062
sdiswood@nndfw.org

Zoologist
Chad Smith
928.871.7070
csmith@nndfw.org

Botanist
Vacant

Biological Reviewer
Pamela Kyselka
928.871.7065
pkyselka@nndfw.org

GIS Supervisor
Dexter D Prall
928.645.2898
prall@nndfw.org

Wildlife Tech
Sonja Detsoi
928.871.6472
sdetsoi@nndfw.org

7. Resources

National Environmental Policy Act

Navajo Endangered Species List:
http://nnhp.nndfw.org/endangered.htm

Species Accounts:
http://nnhp.nndfw.org/sp_account.htm

Biological Investigation Permit Application
http://nnhp.nndfw.org/study_permit.htm

Navajo Nation Sensitive Species List
http://nnhp.nndfw.org/study_permit.htm

Various Species Management and/or Document and Reports
http://nnhp.nndfw.org/docs_reps.htm

Consultant List
(Coming Soon)

Dexter D Prall

Digitally signed by Dexter D Prall
DN: cn=Dexter D Prall, o=Navajo Nation Department of Fish and Wildlife, ou=Navajo Natural Heritage Program, email=prall@nndfw.org, c=US
Date: 2015.11.19 15:56:30 -07'00'

Dexter D Prall, GIS Supervisor - Natural Heritage Program
Navajo Nation Department of Fish and Wildlife

MWH

BUILDING A BETTER WORLD

November 18, 2015

TO: Navajo Natural Heritage Program
Navajo Nation Dept. of Fish and Wildlife
ATTN: Sonja Detsoi and Dexter Prall
P.O. Box 1480
Window Rock, AZ 86515

FROM: MWH Americas
ATTN: Eileen Dornfest, Project Manager
3665 John F Kennedy Parkway
Bldg 1, Suite 206
Ft. Collins, CO 80525
Phone: (970) 377-9410
Fax: (970) 377-9406
E-mail: Eileen.Dornfest@mwhglobal.com

SUBJECT: Request for T and E Information for 16 Abandoned Uranium Mine (AUM) Sites

PROJECT NAME:
Navajo Nation AUM Environmental Response Trust (ERT) Project

LOCATION:
16 AUM Sites (attached in GIS shape files and USGS topographic maps)

SUMMARY DESCRIPTION OF PROJECT:
The work is to be conducted at 16 Abandoned Uranium Mines (AUMs) and includes Removal Site Evaluations (RSEs) according to CERCLA at each of the Sites. The RSEs are site investigations that include the following activities:

- conducting background soil studies
- conducting gamma radiation scans of surface soils
- sampling surface and subsurface soils and sediments related to historic mining operations
- assessing radiation exposure inside mine operations buildings, homes, or other nearby structures (if present at the Sites)
- sampling existing and accessible groundwater wells
- mitigating physical hazards and other interim response actions
- preparing a final written report documenting the work performed and information obtained for each of the Sites

TOPOGRAPHIC MAPS ATTACHED:

- Blue Gap Quadrangle, Arizona-Apache Co.
- Cameron SE Quadrangle, Arizona-Coconino Co.
- Cameron South Quadrangle, Arizona-Coconino Co.
- Del Muerto Quadrangel, Arizona-Apache Co.
- Five Buttes Quadrangle, Arizona-Navajo Co.
- Garnet Ridge Quadrangle, Arizona-Utah
- Horse Mesa Quadrangle, Arizona-New Mexico
- Indian Wells Quadrangle, Arizona-Navajo Co.
- Tah Chee Wash Quadrangle, Arizona-Apache Co.
- Toh Atin Mesa East Quadrangle, Arizona-Utah
- Toh Atin Mesa West Quadrangle, Arizona-Utah
- Bluewater Quadrangle, New Mexico
- Bread Springs Quadrangle, New Mexico-McKinley Co.
- Dalton Pass Quadrangle, New Mexico-McKinley Co.
- Dos Lomas Quadrangle, New Mexico
- Gallup East Quadrangle, New Mexico-McKinley Co.
- Sand Spring Quadrangle, New Mexico-San Juan Co.
- Standing Rock Quadrangle, New Mexico-McKinley Co.
- Mexican Hat SE Quadrangle, Utah-San Juan Co.
- Oljato Quadrangle, Utah-San Juan Co.

THE NAVAJO NATION
HISTORIC PRESERVATION DEPARTMENT
PO Box 4950, Window Rock, Arizona 86515
TEL: (928) 871-7198 FAX: (928) 871-7886

CULTURAL RESOURCES COMPLIANCE FORM

ROUTE COPIES TO:	NNHPD NO.: HPD-16-565 - *REVISED*
☑ DCRM	OTHER PROJECT NO.: DCRM 2016-09

PROJECT TITLE: A Cultural Resource Inventory of Three Abandoned Uranium Mines for MWH Global, Inc.: (Eunice Becenti, Standing Rock, and Section 26 Desidero Group) in Church Rock, Nahodishgish, and Baca/Prewitt Chapters, Navajo Nation

LEAD AGENCY: BIA/NR

SPONSOR: Sadie Hoskie, Trustee, Navajo Nation AUM, Environmental Response Trust, PO Box 3330, Window Rock, Arizona 86515

PROJECT DESCRIPTION: The proposed undertaking will involve the removal site evaluations to define the horizontal extent of contamination in surface soil and sediments a three former uranium mine areas. The area of potential effect is 51.8-acres. Ground disturbing activities will be intensive and extensive with the use of heavy equipment.

LAND STATUS:	Navajo Tribal Trust												
CHAPTER:	Church Rock, Nahodishgish, Baca/Prewitt												
LOCATION:	T.	15	N.,	R.	17	W	Sec.	28;	Gallup East	Quadrangle,	McKinley	County	New Mexico	NMPM
	T.	18	N.,	R.	14	W-	Sec.	34/35;	Dalton Pass	Quadrangle,	McKinley	County	New Mexico	NMPM
	T.	13	N.,	R.	10	W-	Sec.	26;	Don Lomas	Quadrangle,	McKinley	County	New Mexico	NMPM

PROJECT ARCHAEOLOGIST:	Clifford Werito, Tristin Moone, Rena Martin, Arlo Werito with Klara Kelley and Harris Francis
NAVAJO ANTIQUITIES PERMIT NO.:	B16161
DATE INSPECTED:	5/2/2016 - 5/16/2016
DATE OF REPORT:	7/5/2016
TOTAL ACREAGE INSPECTED:	87.6 – ac
METHOD OF INVESTIGATION:	Class III pedestrian inventory with transects spaced 15 m apart.
LIST OF CULTURAL RESOURCES FOUND:	**(1) Site (NM-R-47-01); (4) Isolated Occurrences (IO), (2) In-Use Sites (IUS); (1) Traditional Cultural Property (TCP)**
LIST OF ELIGIBLE PROPERTIES:	**(1) TCP**
LIST OF NON-ELIGIBLE PROPERTIES:	**(1) Site (NM-R-47-01); (4) IO; (2) IUS**
LIST OF ARCHAEOLOGICAL RESOURCES:	**None**

EFFECT/CONDITIONS OF COMPLIANCE: No adverse effect with the following conditions:

Site NM-R-47-01:
No further work is warranted.

TCP:

1. TCP boundary will be marked/flagged by qualified archaeologist prior to remediation activities.
2. TCP will be avoided by all mining activities & a qualified archaeologist will monitor all activities within 100-at of the TCP.

If TCP cannot be avoided:

Mitigation measures will be initiated by the sponsor in consultation with NNHPD and with the Chee Bob Thompson family.

In the event of a discovery [*"discovery"* means any previously unidentified or incorrectly identified cultural resources including but not limited to archaeological deposits, human remains, or locations reportedly associated with Native American religious/traditional beliefs or practices], all operations in the immediate vicinity of the discovery must cease, and the Navajo Nation Historic Preservation Department must be notified at (928) 871-7198.

FORM PREPARED BY: **Tamara Billie**
FINALIZED: September 9, 2016

Notification to Proceed ☑ Yes ☐ No
Recommended
Conditions: ☑ Yes ☐ No

Tamara Billie · 9/9/16
The Navajo Nation Historic Preservation Office — Date

Navajo Region Approval ☒ Yes ☐ No

SEP 28 2016
BIA – Navajo Regional Office — Date
Acting

7/11/16

BIOLOGICAL RESOURCES COMPLIANCE FORM
NAVAJO NATION DEPARTMENT OF FISH AND WILDLIFE
P.O. BOX 1480, WINDOW ROCK, ARIZONA 86515-1480

It is the Department's opinion the project described below, with applicable conditions, is in compliance with Tribal and Federal laws protecting biological resources including the Navajo Endangered Species and Environmental Policy Codes, U.S. Endangered Species, Migratory Bird Treaty, Eagle Protection and National Environmental Policy Acts. This form does not preclude or replace consultation with the U.S. Fish and Wildlife Service if a Federally-listed species is affected.

PROJECT NAME & NO.: Section 26 (Desidero Group) - Abandoned Uranium Mine Project

DESCRIPTION: Proposed Phase I & II scientific investigations at an abandoned mine site. Phase I would entail biological and land surveying with a maximum of 5 people onsite for no more than 5-7 days. Disturbance would be light. Phase II would require the use of an excavator or a small mobile drilling unit to collect one or more soil samples with up to 8 people onsite for a period of one week. A temporary travel corridor 20 ft. in width would be necessary to move equipment to the site. Disturbance would be light to moderate. No permanent structures would be left onsite. The proposed project area (mine boundary and buffer) would be approximately 32.8 acres.

LOCATION: 35°20'N 107°51.57'W, Baca/Prewitt Chapter, McKinley County, New Mexico

REPRESENTATIVE: Lori Gregory, Adkins Consulting, Inc. for MWH Global/Stantec

ACTION AGENCY: U.S. Environmental Protection Agency and Navajo Nation

B.R. REPORT TITLE / DATE / PREPARER: BE-Section 26 (Desidero Group) Abandoned Uranium Mine Project/AUG 2016/Lori Gregory, Plant Survey Report for Species of Concern At Section 26 (Desidero Group) Project Site/AUG 2016/Redente Ecological Consultants

SIGNIFICANT BIOLOGICAL RESOURCES FOUND: Area 3. Suitable nesting habitat is present in the project area for Migratory Birds not listed under the NESL or ESA. Migratory Birds and their habitats are protected under the Migratory Bird Treaty Act (16 USC §703-712) and Executive Order 13186. Under the EO, all federal agencies are required to consider management impacts to protect migratory non-game birds.

POTENTIAL IMPACTS

NESL SPECIES POTENTIALLY IMPACTED: NA

FEDERALLY-LISTED SPECIES AFFECTED: NA

OTHER SIGNIFICANT IMPACTS TO BIOLOGICAL RESOURCES: NA

AVOIDANCE / MITIGATION MEASURES: Mitigation measures will be implemented to ensure that there are no impacts to migratory birds that could potentially nest in the project area.

CONDITIONS OF COMPLIANCE*: NA

FORM PREPARED BY / DATE: Pamela A. Kyselka/10 NOV 2016

COPIES TO: (add categories as necessary)

☐ ______________________ ☐ ______________________

2 NTC § 164 Recommendation:	Signature	Date
☒Approval ☐Conditional Approval (with memo) ☐Disapproval (with memo) ☐Categorical Exclusion (with request letter) ☐None (with memo)	Gloria M. Tom, Director, Navajo Nation Department of Fish and Wildlife	11/16/16

*I understand and accept the conditions of compliance, and acknowledge that lack of signature may be grounds for the Department not recommending the above described project for approval to the Tribal Decision-maker.

Representative's signature Date

From:	Nystedt, John
To:	Justin Peterson
Cc:	Lori Gregory; Pam Kyselka; tbillie@navajo-nsn.gov; Harrilene Yazzie; Melissa Mata
Subject:	Navajo Nation AUM Environmental Response Trust - -First Phase
Date:	Monday, November 07, 2016 4:08:30 PM
Attachments:	image001.png

Justin,

Thank you for your November 6, 2016, email. This email documents our response regarding the subject project, in compliance with section 7 of the Endangered Species Act of 1973 (ESA) as amended (16 U.S.C. 1531 et seq.). Based on the information you provided, we believe no endangered or threatened species or critical habitat will be affected by this project; nor is this project likely to jeopardize the continued existence of any proposed species or adversely modify any proposed critical habitat. No further review is required for this project at this time. Should project plans change or if new information on the distribution of listed or proposed species becomes available, this determination may need to be reconsidered. In all future communication on this project, please refer to consultation numbers given below.

In keeping with our trust responsibilities to American Indian Tribes, by copy of this email, we will notify the Navajo Nation, which may be affected by the proposed action and encourage you to invite the Bureau of Indian Affairs to participate in the review of your proposed action.

Should you require further assistance or if you have any questions, please contact me as indicated below, or my supervisor, Brenda Smith, at 556-2157. Thank you for your continued efforts to conserve endangered species.

Claim 28	02EAAZ00-2016-SLI-0358
Section 26 (Desiddero Group)	02ENNM00-2016-SLI-0447
Mitten #3	06E23000-2016-SLI-0210
NA-0904	02EAAZ00-2016-SLI-0363
Occurrence B	02EAAZ00-2016-SLI-0361
Standing Rock	02ENNM00-2016-SLI-0448
Alongo Mines	02ENNM00-2016-SLI-0465
Tsosie 1*	02EAAZ00-2016-SLI-0364
Boyd Tisi No. 2 Western	02EAAZ00-2016-SLI-0355
Harvey Blackwater #3	02EAAZ00-2016-SLI-0356 / 06E23000-2016-SLI-0207
Oak 124/125	02ENNM00-2016-SLI-0466
NA-0928	02EAAZ00-2016-SLI-0360
Hoskie Tso #1	02EAAZ00-2016-SLI-0362
Charles Keith	06E23000-2016-SLI-0208
Barton 3	02EAAZ00-2016-SLI-0354
Eunice Becenti	02ENNM00-2016-SLI-0444

* It is our understanding that the Tsosie No. 1 site has been put on hold indefinitely due to access issues. However, provided the results of the survey were negative (i.e., no potential for

any ESA-listed species) then we would come to the same conclusion, above, as for the other 15 projects.

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Fish and Wildlife Biologist/AESO Tribal Coordinator
USFWS AZ Ecological Services Office - Flagstaff Suboffice
Southwest Forest Science Complex, 2500 S Pine Knoll Dr, Rm 232
Flagstaff, AZ 86001-6381 (928) 556-2160 Fax-2121 Cell:(602) 478-3797
http://www.fws.gov/southwest/es/arizona/

Appendix F Data Usability Report, Laboratory Analytical Data, and Data Validation Reports

F.1 Data Usability Report

F.2 Laboratory Analytical Data and Data Validation Reports

(provided in a separate electronic file due to its file size and length)

F.1 Data Usability Report

DATA USABILITY REPORT

1.0 INTRODUCTION

This data usability report presents a summary of the validation results for the sample data collected from the Section 26 Site (the Site) as part of the Removal Site Evaluation (RSE) performed for the Navajo Nation AUM Environmental Response Trust—First Phase. The purpose of the validation was to ascertain the data usability measured against the data quality objectives (DQOs) and confirm that results obtained are scientifically defensible.

Samples were collected between November 30, 2016 and September 19, 2017 and were analyzed by ALS Environmental of Ft. Collins, Colorado, for all methods. Samples were analyzed for one or more of the following:

- Radium-226 in soil by United States Environmental Protection Agency (USEPA) Method 901.1
- Metals in soil by USEPA Method SW6020
- Isotopic thorium in soil by USDOEAS-06/EMSL/LV

Samples were collected and analyzed according to the procedures and specific criteria presented in the *Quality Assurance Project Plan, Navajo Nation AUM Environmental Response Trust (QAPP)* (MWH, 2016).

Project data were validated as follows:

- Laboratory Data Consultants, Inc. (LDC) of Carlsbad, California, performed validation of all radiological soil data, plus ten percent of the non-radiological data (Level IV only)
- All non-radiological soil data were validated by the Stantec Consulting Services Inc. (Stantec; formerly MWH) Project Chemist (Level III only)
- All samples received Level III data validation
- Ten percent of the sample results for all methods received a more detailed Level IV validation

The analytical data were validated based on the results of the following data evaluation parameters or quality control (QC) samples:

- Compliance with the QAPP
- Sample preservation
- Sample extraction and analytical holding times

- Initial calibration (ICAL), initial calibration verification (ICV), and continuing calibration verification (CCV) results
- Method and initial/continuing calibration blank (ICB/CCB) sample results
- Matrix spike/matrix spike duplicate (MS/MSD) sample results
- Laboratory duplicate results
- Serial dilution (metals analysis only)
- Interference check samples (ICS) (metals analysis only)
- Laboratory control sample (LCS) and laboratory control sample duplicate (LCSD) results
- Field duplicate sample results
- Minimum detectable concentration (radiological analyses only)
- Reporting limits
- Sample result verification
- Completeness evaluation
- Comparability evaluation

Sample results that were qualified due to quality control parameters outside of acceptance criteria are listed on Table F.1-1.

2.0 DATA VALIDATION RESULTS

Stantec reviewed the data validation reports and assessed the qualified data against the DQOs for the project. The following summarizes the data validation findings for each of the data evaluation parameters.

2.1 QUALITY ASSURANCE PROJECT PLAN COMPLIANCE EVALUATION

Based on the data validation, all samples were analyzed following the quality control criteria specified in the QAPP, with the following exception: ALS routinely dilutes all metals samples by a factor of 10 times in order to protect their ICP-MS instrument from the adverse effects of running samples with high total dissolved solids. This also includes running a long series of samples (as is common in a production laboratory) with intermediate dissolved solids. The vulnerable parts of the instrument are the nebulizer, which produces an aerosol, and the cones, which disperse the aerosol. These areas form scaly deposits from the samples in the sample solution, despite the nitric acid and other acids present in the digestate. These parts of the instrument periodically need to be taken apart and cleaned, but in a production setting the laboratory wants to avoid any downtime as much as possible. As an ameliorating factor, the laboratory also takes account of this dilution factor up front in the project planning stages. The laboratory will not quote a reporting limit for this instrument that cannot be achieved after the 10 times dilution required for the instrument. Not all of the requested reporting limits can be met using the laboratory's routine protocol. The dilution is narrated by the laboratory merely as a matter of transparency, as well as for the validator's information. The dilution should have no impact on the project's sensitivity goals.

Sample Preservation Evaluation. All samples were preserved as specified in the QAPP.

Holding Time Evaluation. All analytical holding times were met.

Initial Calibration, Initial Calibration Verification, and Continuing Calibration Verification Evaluation. All ICAL, ICV, and CCV results were within acceptance criteria.

Method Blank Evaluation. No sample data were qualified due to method blank results.

Initial and Continuing Calibration Blank Evaluation. No sample data were qualified due to ICB/CCB data.

Matrix Spike/Matrix Spike Duplicate Samples Evaluation. All MS/MSD recoveries were within acceptance criteria with the exception of several metals. Table F.1-1 lists the analytes where an MS and/or MSD percent recovery was outside the acceptance criteria. Sample results were qualified with a "J+" flag for results that are estimated and potentially biased high; sample results were qualified with a "J-"flag for results that are estimated and potentially biased low. All MS/MSD RPDs were within acceptance criteria with the exception of one RPD for the analysis of uranium. The sample result was already qualified with a "J+" flag.

Laboratory Duplicate Sample Evaluation. For some analyses, the laboratory prepared and analyzed a duplicate sample. RPD results were evaluated between the parent and laboratory duplicate samples. Several RPDs were outside the acceptance criteria for the analysis of metals. Sample results were qualified with a "J" flag if not otherwise qualified.

Serial Dilution Evaluation. All serial dilution percent differences were within acceptance criteria, except for two samples analyzed for arsenic. The sample results were qualified as estimated with a "J" flag.

Interference Check Sample Evaluation. All interference check samples were within acceptance criteria.

Laboratory Control Sample/Laboratory Control Sample Duplicate Evaluation. All LCS and LCSD recoveries were within acceptance criteria. All LCS/LCSD RPDs were within acceptance criteria.

Field Duplicate Evaluation. The RPDs were less than the guidance RPD of 30 percent established in the QAPP for all field duplicate pairs, with the exception of results for nine metals and one radium-226. The primary cause for RPDs exceeding 30 percent for some duplicate pairs is assumed to be the heterogeneity/variability of soil samples. The sample IDs, sample results, and RPDs for those results that did not meet the guidance RPD are listed in Table F.1-2. Sample results were not qualified due to RPDs exceeding the guidance criteria, as described in the QAPP.

Minimum Detectable Concentration Evaluation. All minimum detectable concentrations met reporting limits with the exception of one sample for the analysis of radium-226. However, the reported activity for this sample was greater than the achieved minimum detectable concentration and no qualification was needed.

Reporting Limit Evaluation. All sample data were reported to the reporting limit established in the QAPP, with the exception of the metals, as discussed at the beginning of this section related to dilution.

Sample Result Verification. All sample result verifications were acceptable with the exception of sixteen samples analyzed for radium-226. Cases that exceed the limit of +/- 15% of the density of the calibration standard were qualified with a "J+" flag for those results that may be biased high and a "J-" flag for those results that may be biased low (see Table F.1-1).

Completeness Evaluation. All samples and QC samples were collected as scheduled, resulting in 100 percent sampling completeness for this project. Based on the results of the data validation described in the previous sections, all data are considered valid as qualified. No data were rejected; consequently, analytical completeness was 100 percent, which met the 95 percent analytical completeness goal established in the QAPP.

Comparability Evaluation. Comparability is a qualitative parameter that expresses the confidence that one data set may be compared to another. For this project, sample collection and analysis followed standard methods and the data were reported using standard units of measure as specified in the QAPP. In addition, QC data for this project indicate the data are comparable. As a result, the data from this project should be comparable to other data collected at this Site using similar sample collection and analytical methodology.

3.0 DATA VALIDATION SUMMARY

Precision. Based on the MS/MSD sample, LCS/LCSD sample, laboratory duplicate sample, and field duplicate results, the data are precise as qualified.

Accuracy. Based on the ICAL, ICV, CCV, MS/MSD, and LCS, the data are accurate as qualified.

Representativeness. Based on the results of the sample preservation and holding time evaluation; the method and ICB/CCB blank sample results; the field duplicate sample evaluation; and the RL evaluation the data are considered representative of the Site as reported.

Completeness. All media and QC sample results were valid and collected as scheduled; therefore, completeness for this RSE is 100 percent.

Comparability. Standard methods of sample collection and standard units of measure were used during this project. The analysis performed by the laboratory was in accordance with current USEPA methodology and the QAPP.

Based on the results of the data validation, all data are considered valid as qualified.

Table F.1-1
Summary of Qualified Data
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Field Sample Identification	Sample Date	Analysis Code	Analyte	Sample Result	Units	QC Type	QC Result	QC Limit	Added Flag	Comment
S1011-BG1-005	11/30/16	SW6020	Arsenic	11	mg/kg	MS MSD LR	32% 34% 65%	75% - 125% 75% - 125% 20%	J-	Result is estimated, potentially biased low. MS and MSD recoveries below acceptance criteria. LR RPD outside acceptance criteria.
S1011-BG1-005	11/30/16	SW6020	Molybdenum	1.4	mg/kg	LR	97%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S1011-BG1-005	11/30/16	SW6020	Vanadium	26	mg/kg	MS MSD LR	-20% -20% 58%	75% - 125% 75% - 125% 20%	J-	Result is estimated, potentially biased low. MS and MSD recoveries below acceptance criteria. LR RPD outside acceptance criteria.
S1011-BG2-009	11/30/16	SW6020	Uranium	1.5	mg/kg	MS MSD MS/MSD RPD	135% 197% 21%	75% - 125% 75% - 125% 20%	J+	Result is estimated, potentially biased high. MS and MSD recoveries above acceptance criteria. MS/MSD RPD outside acceptance criteria.
S1011-CX-005	12/1/16	E901.1	Radium-226	11.3	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-CX-204	12/1/16	E901.1	Radium-226	4.81	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-CX-004	12/1/16	E901.1	Radium-226	4.24	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-BG1-011-1	3/25/17	E901.1	Radium-226	1.62	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S1011-SCX-007-1	5/13/17	SW6020	Uranium	24	mg/kg	LR	34%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S1011-SCX-007-1	5/13/17	SW6020	Vanadium	26	mg/kg	MS	64%	75% - 125%	J-	Result is estimated, potentially biased low. Ms recovery below acceptance criteria.

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
LCS laboratory control sample
LR laboratory replicate (duplicate)
MS matrix spike
MSD matrix spike duplicate
RPD relative percent difference

Field Sample Identification	Sample Date	Analysis Code	Analyte	Sample Result	Units	QC Type	QC Result	QC Limit	Added Flag	Comment
S1011-CX-002	5/13/17	E901.1	Radium-226	12.1	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S1011-CX-004	5/13/17	E901.1	Radium-226	5.54	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S1011-CX-005	5/13/17	SW6020	Uranium	1.6	mg/kg	LR	37%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S1011-SCX-009-001	6/9/17	SW6020	Arsenic	2.3	mg/kg	Serial Dilution	21%	10%	J	Result is estimated, bias unknown. Serial dilution %D greater than control limit.
S1011-SCX-009-002	6/9/17	E901.1	Radium-226	0.92	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-SCX-011-002	6/9/17	E901.1	Radium-226	0.78	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-SCX-017-001	6/10/17	E901.1	Radium-226	64.4	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S1011-SCX-019-001	6/10/17	SW6020	Arsenic	3	mg/kg	LR	121%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S1011-SCX-019-001	6/10/17	SW6020	Vanadium	92	mg/kg	LR	33%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S1011-SCX-018-001	6/10/17	E901.1	Radium-226	19.8	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S1011-SCX-020-002	6/10/17	E901.1	Radium-226	6.23	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
LCS laboratory control sample
LR laboratory replicate (duplicate)
MS matrix spike
MSD matrix spike duplicate
RPD relative percent difference

Field Sample Identification	Sample Date	Analysis Code	Analyte	Sample Result	Units	QC Type	QC Result	QC Limit	Added Flag	Comment
S1011-SCX-023-001	6/10/17	SW6020	Vanadium	21	mg/kg	MS MSD LR	25% 68% 30%	75% - 125% 75% - 125% 20%	J-	Result is estimated, potentially biased low. MS and MSD recoveries below acceptance criteria. LR RPD outside acceptance criteria.
S1011-SCX-028-001	6/11/17	SW6020	Arsenic	2.9	mg/kg	Serial Dilution	11%	10%	J	Result is estimated, bias unknown. Serial dilution %D greater than control limit.
S1011-SCX-028-001	6/11/17	SW6020	Uranium	2.1	mg/kg	MS MSD LR	21% 26% 41%	75% - 125% 75% - 125% 20%	J-	Result is estimated, potentially biased low. MS and MSD recoveries below acceptance criteria. LR RPD outside acceptance criteria.
S1011-SCX-027-002	6/11/17	E901.1	Radium-226	1.15	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-SCX-029-002	6/11/17	E901.1	Radium-226	2.87	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-SCX-024-001	6/11/17	E901.1	Radium-226	9	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-SCX-024-201	6/11/17	E901.1	Radium-226	6.67	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-SCX-035-001	6/12/17	SW6020	Uranium	0.99	mg/kg	LR	48%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S1011-SCX-042-02	9/19/17	SW6020	Vanadium	11	mg/kg	MSD	306%	75% - 125%	J+	Result is estimated, potentially biased high. MSD recovery above acceptance criteria.
S1011-BG3-002	9/18/17	SW6020	Vanadium	10	mg/kg	MS MSD	146% 181%	75% - 125% 75% - 125%	J+	Result is estimated, potentially biased high. MS and MSD recoveries above acceptance criteria.
S1011-BG3-003	9/18/17	E901.1	Radium-226	0.82	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S1011-BG5-001	9/19/17	SW6020	Uranium	0.42	mg/kg	LR	24%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
LCS laboratory control sample
LR laboratory replicate (duplicate)
MS matrix spike
MSD matrix spike duplicate
RPD relative percent difference

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Table F.1-2
Results that did not Meet the Relative Percent Difference Guidance
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Primary Sample / Duplicate Indentification	Sample Date	Parameter	Primary Result	Duplicate Result	Units	RPD (%)
S1011-BG1-006/S1011-BG1-206	11/30/2016	Arsenic	3.4	12	mg/kg	112%
S1011-BG1-006/S1011-BG1-206	11/30/2016	Molybdenum	0.62	1.7	mg/kg	93%
S1011-BG1-006/S1011-BG1-206	11/30/2016	Vanadium	10	18	mg/kg	57%
S1011-SCX-003-1/S1011-SCX-203-1	5/12/2017	Uranium	0.72	1.5	mg/kg	70%
S1011-SCX-003-1/S1011-SCX-203-1	5/12/2017	Vanadium	8.7	28	mg/kg	105%
S1011-SCX-015-001/S1011-SCX-015-201	6/10/2017	Molybdenum	0.73	0.39	mg/kg	61%
S1011-SCX-028-002/S1011-SCX-028-202	6/11/2017	Uranium	28	11	mg/kg	87%
S1011-SCX-043-01/S1011-SCX-243-01	9/19/2017	Uranium	2	0.71	mg/kg	95%
S1011-SCX-043-01/S1011-SCX-243-01	9/19/2017	Vanadium	20	13	mg/kg	42%
S1011-BG4-003/S1011-BG4-203	9/19/2017	Radium-226	0.72	1.24	pCi/g	53%

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
RPD relative percent difference

Section 26 (#1011, 1012, 1035)

Removal Site Evaluation Report

Final | September 21, 2018

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

Section 26 (#1011, 1012, 1035) Removal Site Evaluation Report - Final

September 21, 2018

Prepared for:

Navajo Nation AUM Environmental Response Trust – First Phase

Prepared by:

Stantec Consulting Services Inc.

Title and Approval Sheet

Title: Section 26 Removal Site Evaluation Report - Final

Approvals

This Removal Site Evaluation Report is approved for implementation without conditions.

Dr. Donald Benn Navajo Nation Environmental Protection Agency Executive Director	10/9/18 **Date**
Linda Reeves US Environmental Protection Agency, Region 9 Remedial Project Manager	10/9/18 **Date**
Sadie Hoskie Navajo Nation AUM Environmental Response Trust – First Phase Trustee	10/10/18 **Date**
Toby Leeson, P.G. Stantec Consulting Services, Inc. Project Technical Lead	10/10/18 **Date**

Revision Log

Revision No.	Date	Description
0	May 15, 2018	Submission of Draft RSE report to Agencies for review
1	September 21, 2018	Submission of Final RSE report to Agencies

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NAVAJO NATION AUM Environmental Response Trust-First Phase

Sign-off Sheet

This document entitled *Section 26 Removal Site Evaluation Report* was prepared by MWH, now part of Stantec Consulting Services Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase (the "Client") for submittal to the Navajo Nation Environmental Protection Agency (NNEPA) and United States Environmental Protection Agency (USEPA) (collectively, the "Agencies"). The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Per the *Navajo Nation AUM Environmental Response Trust Agreement – First Phase*, *Section 5.4.1,* (United States [US], 2015) the following certification must be signed by a person who supervised or directed the preparation of the Removal Site Evaluation report: "Under penalty of law, I certify that to the best of my knowledge, after appropriate inquiries of all relevant persons involved in the preparation of this report, the information submitted herein is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Prepared by Emily Yeager

(signature)

Emily Yeager, P.G.

Reviewed by Kelly Johnson

(signature)

Kelly Johnson, PhD, P.G.

Approved by Toby Leeson

(signature)

Toby Leeson, P.G.

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LIST OF ATTACHMENTS – PROVIDED ELECTRONICALLY TO THE AGENCIES

- Site-specific geodatabase
- Tabular database files
- 2017 Cooper aerial survey orthophotographs and data files
- Historical documents referenced in this RSE Report (refer to Section 7 for complete citation)
    - Anderson, 1980 – Abandoned or Inactive Uranium Mines in New Mexico. New Mexico Bureau of Mines and Mineral Resources
    - Chenoweth, 1985 – Historical Review of Uranium Production from the Todilto Limestone Cibola and McKinley Counties, New Mexico

- Ecology and Environment, INC, 2014 – Removal Assessment Report Tronox AUM Section 26 Baca/Haystack Chapter, Eastern Agency, Navajo Nation, Prewitt, McKinley County, New Mexico

- Green, 1982 – Origin of Intraformational Folds in the Jurassic Todilto Limestone, Ambrosia Lake Uranium Mining District, McKinley and Valencia Counties, New Mexico

- Hilpert, 1969 - Uranium Resources of Northwestern New Mexico

- McLemore and Chenoweth, 1991 – Uranium Mines and Deposits in the Grants District, Cibola and McKinley Counties, New Mexico. New Mexico Bureau of Mines and Mineral Resources Open-file Report 353

- McLemore, 1983 – Uranium and Thorium Occurrences in New Mexico, Distribution, Geology, Production, and Resources, with Selected Bibliography

- NSO, 1990 – Uranium and Thorium Occurrences in New Mexico, Distribution, Geology, Production, and Resources, with Selected Bibliography

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- USEPA, n.d., - Bluewater Abandoned Uranium Mine Site Removal Action. A USEPA Superfund Success Story

- Rasor and Toren, 1952 – Certification of Hanosh Mines, Inc., Section 26, T. 13 N., R. 10 W. Grants Mining District, McKinley County, New Mexico

- USEPA, 2007a – Abandoned Uranium Mines and the Navajo Nation. Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data

- USEPA, 2011 – Aerial Radiological Surveys Ambrosia Lake Uranium Mines. Ambrosia, NM

- Weston Solutions, 2009 - Desidero Group Uranium Mines Navajo Abandoned Uranium Mine Site Screen Report

Executive Summary

Introduction

The Section 26 Desidero Group site (the Site) is located within the Navajo Nation, Eastern Navajo Bureau of Indian Affairs (BIA) Agency, Baca/Prewitt Chapter in northwestern New Mexico. The Site is also identified as an abandoned uranium mine (AUM) claim that consists of three mine sites with identifications of #1011, #1012, and #1035. The Site is one of 46 "priority" AUMs within the Navajo Nation selected by the United States Environmental Protection Agency (USEPA) in collaboration with the Navajo Nation Environmental Protection Agency (NNEPA) for further evaluation based on radiation levels and potential for water contamination (USEPA, 2013). Mining for uranium occurred prior to, during, and after World War II, when the United States (US) sought a domestic source of uranium located on Navajo lands (USEPA, 2007a).

On April 30, 2015, the *Navajo Nation AUM Environmental Response Trust Agreement – First Phase* (the *Trust Agreement*) became effective. The *Trust Agreement* was made by and among the US, as Settlor, and as Beneficiary on behalf of the USEPA, and the Navajo Nation, as Beneficiary, and the Trustee (Sadie Hoskie). The *Trust Agreement* was developed in accordance with a settlement on April 8, 2015 between the US and Navajo Nation for the investigation of 16 specified priority AUMs. The priority sites were selected by the US and Navajo Nation, as described in the *Trust Agreement*:

> "based on two primary criteria, specifically, demonstrated levels of Radium-226[1]: (a) at or in excess of 10 times the background levels and the existence of a potentially inhabited structure located within 0.25 miles of AUM features; or (b) at or in excess of two times background levels and the existence of a potentially inhabited structure located within 200 feet (ft)."

The purpose of this report is to summarize the objectives, field investigation activities, findings, and conclusions of Site Clearance and Removal Site Evaluation (RSE) activities conducted between August 2015 and September 2017 at the Site. The primary objectives of the RSE are to provide data (e.g., review relevant information and collect data related to historical mining activities) required to evaluate relevant Site conditions and to support future Removal or Remedial Action evaluations at the Site. It is not intended to establish cleanup levels or determine cleanup options or potential remedies. The purpose of the RSE data are to determine the volume of technologically enhanced naturally occurring radioactive material (TENORM) at the Site in excess of Investigation Levels (ILs) as a result of historical mining activities. ILs are based on the background gamma measurements (in counts per minute [cpm]), and Radium-226 (Ra-226) and metals concentrations, determined through statistical analyses, that are used to

[1] The Agencies selected the priority mines based on gamma radiation but the *Trust Agreement* erroneously states "levels of Radium -226".

evaluate potential mining-related impacts. The area inclusive of the Site has naturally occurring radioactive materials (NORM), which was the reason the area was prospected and mined.

Site History and Physical Characteristics

The Site is located within the Colorado Plateau physiographic province, which is an area of approximately 240,000 square miles in the Four Corners region of Utah, Colorado, Arizona, and New Mexico. Regionally the Site is located within the Ambrosia Lake Mining Sub-district and the ore host bedrock on-site was the Jurassic Todilto Limestone. From 1950 to 1978, mines located on 43 different properties in the Ambrosia Lake Mining Sub-district produced approximately 30,000 tons of U_3O_8 (uranium oxide) from Todilto orebodies (Green, 1982). The Site is also located within the Rio Grande-Elephant Butte watershed, an area of approximately 27,000 square miles spanning New Mexico. Topographically the Site is located on a mesa top and along a mesa sidewall at an elevation of approximately 7,100 ft above mean sea level. On-site overland surface water flow, when present, is controlled by a decrease in elevation either to the north or south from the edge of the mesa. Numerous parallel patterned ephemeral drainages are present on-site that drain either to the northeast (on the mesa top) or to the south (in the plains), where they then terminate.

The Site was in operation between 1952 to 1957. Historical mine workings on-site consisted of a 155-ft incline and several open pits. The United States Atomic Energy Commission (USAEC) reported total ore production attributable to the Site was 11,110 tons (approximately 22,220,000 pounds) of ore that contained 83,752 pounds of 0.38 percent U_3O_8 and 17,518 pounds of 0.12 percent V_2O_5 (vanadium oxide).

In 1991 the USEPA conducted an Emergency Removal Action (ERA) at the three AUMs (#1011, #1012, and #1035) associated with the Site. Remediation activities included filling existing pits and covering open adits, regrading reclaimed areas until they were consistent with the surrounding terrain, and grading areas to have proper water runoff. In 2009 Weston Solutions (Weston) performed site screening on behalf of the USEPA. In 2014 Ecology and Environment Inc. (E&E) performed a Removal Site Assessment (RSA) at the Site on behalf of the USEPA.

Summary of Removal Site Evaluation Activities

The Trust conducted Site Clearance activities prior to commencing the RSE tasks to obtain information necessary to develop the *Removal Site Evaluation Work Plan* ([*RSE Work Plan*] MWH, 2016b). Following Site Clearance activities, the Trust conducted RSE activities consisting of two separate tasks: Baseline Studies activities and Site Characterization Activities and Assessment. Details of the Site Clearance activities, Baseline Studies activities, and Site Characterization and Assessment activities are as follows:

- **Site Clearance activities** consisted of a desktop study of historical information, site mapping, potential background reference area evaluation, biological (vegetation and wildlife) surveys, and cultural resource survey. Results of the Site Clearance activities provided historical information, site access information, potential background reference area data, and vegetation, wildlife, and cultural clearance of the Site for the Baseline Studies activities and Site Characterization and Assessment activities to commence.

- **Baseline Studies activities** included a background reference area study, site gamma radiation surveys, and a Gamma Correlation Study. Results of the Baseline Studies were used to plan and prepare the Site Characterization Activities and Assessment. Data collected in the background reference area study (soil sampling, laboratory analyses, surface gamma surveying, and subsurface static gamma measurements) were used to establish ILs for the Site. Data collected from the site gamma radiation survey were the primary method to evaluate potential mining-related impacts or areas containing elevated radionuclides. The Gamma Correlation Study objectives were to determine the correlations between: (1) gamma measurements and concentrations of Ra-226 in surface soils; and (2) gamma measurements and exposure rates; to be used as screening tools for site assessments.
- **Site Characterization Activities and Assessment** included surface soil and sediment sampling, subsurface soil sampling, and a geophysical survey. The results of the surface and subsurface soil and sediment sampling analyses were used to evaluate mining impacts and define the lateral and vertical extent of TENORM at the Site. The results of the geophysical survey were used to inform the TENORM volume estimate.

Findings and Discussion

Surface and subsurface soil and sediment sampling results. Five background reference areas were selected to develop surface gamma, subsurface static gamma, Ra-226, and metals ILs for the Site. Arsenic, molybdenum, selenium, uranium, vanadium, and Ra-226 concentrations and gamma radiation measurements in soil/sediment exceeded their respective ILs and are confirmed constituents of potential concern (COPCs) for the Site. Based on the data analyses performed for this report along with the multiple lines of evidence, approximately 72.2 acres, out of the 101.3 acres of the Survey Area (i.e., the full areal of the Site surface gamma survey), were estimated to contain TENORM. Of the 72.2 acres that contain TENORM, 45.2 acres contain TENORM exceeding ILs. The volume of TENORM in excess of ILs was estimated to be 170,191 cubic yards (yd^3) (130,120 cubic meters) and the volume of potential TENORM exceeding ILs was estimated to be 14,055 yds^3 (10,745 cubic meters).

Gamma Correlation Study results. The Gamma Correlation Study indicated that surface gamma survey results correlate with Ra-226 concentrations in soil. Therefore, gamma surveys could be used during site assessments as a field screening tool to estimate Ra-226 concentrations in soil. Additional correlation studies may be needed to identify the relationship between gamma and Ra-226.

Based on the Site Clearance and RSE data collection and analyses for the Site, potential data gaps were identified and are presented in Section 4.9 of this RSE report. These potential data gaps can be taken into consideration for subsequent evaluations in support of future Removal or Remedial Action evaluations at the Site.

Acronyms/Abbreviations

cm^3	cubic centimeter
°F	degrees Fahrenheit
yd^3	cubic yard
e.g.	exempli gratia
et seq.	and what follows
etc.	et cetera
ft	feet
ft^2	square feet
i.e.	id est
mg/kg	milligram per kilogram
μR/hr	microRoentgens per hour
pCi/g	picocuries per gram
Adkins	Adkins Consulting Inc.
ags	above ground surface
amsl	above mean sea level
ATSDR	Agency for Toxic Substance and Disease Control Registry
AUM	abandoned uranium mine
bgs	below ground surface
BIA	Bureau of Indian Affairs
CCV	continuing calibration verification
Cooper	Cooper Aerial Surveys Company
CFR	Code of Federal Regulations
COPC	constituent of potential concern
cpm	counts per minute
cps	counts per second
Dinétahdóó	Dinétahdóó Cultural Resource Management
DMP	Data Management Plan
DQO	data quality objective
E&E	Ecology and Environment Inc.
ERG	Environmental Restoration Group, Inc.
ERA	Emergency Removal Action
ESA	Endangered Species Act
FSP	Field Sampling Plan
GIS	geographic information system
GPS	global positioning system
HASP	Health and Safety Plan
HGI	Hydrogeophysics Inc.

ICAL	initial calibration
ICB/CCB	initial/continuing calibration blank
ICV	initial calibration verification
IL	Investigation Level
LCS/LCSD	laboratory control sample/laboratory control sample duplicate
MARSSIM	Multi-agency Radiation Survey and Site Investigation Manual
MASW	multi-channel analysis of surface wave
MBTA	Migratory Bird Treaty Act
MS/MSD	matrix spike/matrix spike duplicate
MWH	MWH, now part of Stantec Consulting Services Inc. (formerly MWH Americas, Inc.)
NaI	sodium iodide
NAML	Navajo Abandoned Mine Lands Reclamation Program
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NNDFW	Navajo Nation Department of Fish and Wildlife
NNDOJ	Navajo Nation Department of Justice
NNDNR	Navajo Nation Division of Natural Resources
NNDWR	Navajo Nation Department of Water Resources
NNEPA	Navajo Nation Environmental Protection Agency
NNESL	Navajo Nation Endangered Species List
NNHP	Navajo Natural Heritage Program
NNHPD	Navajo Nation Historic Preservation Department
NORM	Naturally Occurring Radioactive Material
NSO	Navajo Superfund Office
PA	Preliminary Assessment
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
R^2	Pearson's Correlation Coefficient
RSA	Removal Site Assessment
Ra-226	Radium 226
RSE	Removal Site Evaluation
SOP	standard operating procedure
Stantec	Stantec Consulting Services Inc.
T&E	threatened and endangered
TENORM	Technologically Enhanced Naturally Occurring Radioactive Materials
Th-230	thorium-230
Th-232	thorium-232
U-235	uranium-235
U-238	uranium-238

U_3O_8	uranium oxide
UCL	upper confidence limit
US	United States
USAEC	US Atomic Energy Commission
USC	United States Code
USDA	US Department of Agriculture
USEPA	US Environmental Protection Agency
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
UTL	upper tolerance limit
V_2O_5	vanadium oxide
Weston	Weston Solutions

Glossary

Adit – a horizontal passage leading into a mine for the purposes of access (English Oxford Dictionary, 2018).

Alluvium – material deposited by flowing water.

Arroyo – a steep sided gully cut by running water in an arid or semiarid region.

Bin Range – as presented in the RSE report, a range of values to present surface gamma measurement data in relation to: (1) the surface gamma Investigation Level (IL); (2) multiples of the surface gamma IL; or (3) the mean and standard deviation of the predicted Radium-226 (Ra-226) concentrations for the Site based on the correlation equation.

Colluvium – unconsolidated, unsorted, earth material transported under the influence of gravity and deposited on lower slopes (Schaetzl and Thompson, 2015).

Composite sample – "Volumes of material from several of the selected sampling units are physically combined and mixed in an effort to form a single homogeneous sample, which is then analyzed" (USEPA, 2002a).

Constituent of potential concern (COPC) – analytes identified in the *RSE Work Plan* where their levels were confirmed based on the results of the RSE.

Data Validation – "an analyte- and sample-specific process that extends the evaluation of data beyond, method, procedural, or contractual compliance (i.e., data verification) to determine the analytical quality of a specific data set" (USEPA, 2002b).

Data Verification – "the process of evaluating the completeness, correctness and conformance/compliance of a specific data set against the method, procedural, or contractual requirements" (USEPA, 2002b).

Earthworks - human-caused disturbance of the land surface.

Electrical Resistivity – geophysical investigation method that measures a material's resistance to electrical current.

Eolian – a deposit that forms as a result of the accumulation of wind-driven products from the weathering of solid bedrock or unconsolidated deposits.

Ephemeral – ephemeral streams flow only in direct response to surface runoff precipitation or melting snow, and their channels are at all times above the water table (USGS, 2003). This concept also applies to ephemeral ponds that contain water in response to surface runoff precipitation or melting snow and are at all times above the water table.

Ethnographic – relating to the scientific description of peoples and cultures with their customs, habits, and mutual differences.

Gamma – a type of radiation that occurs as the result of the natural decay of uranium.

Geochemical – the chemistry of the composition and alterations of the solid matter of the earth (American Heritage Dictionary, 2016).

Geomorphology – the physical features of the surface of the earth and their relation to its geologic structures (English Oxford Dictionary, 2018).

Grab sample – a sample collected from a specific location (and depth) at a certain point in time.

Hogback – a long, narrow ridge or series of hills with a narrow crest and steep slopes of nearly equal inclination on both flanks. Typically, this term is restricted to a ridge created by the differential erosion of outcropping, steeply dipping (greater than 30 to 40 degrees), homoclinal, typically sedimentary strata. One side, the backslope, of a hogback consists of the surface (bedding plane) of steeply dipping rock stratum, which is called a "dip slope." The other side, the escarpment or "frontslope" or "scarp slope", is an erosion face that cuts through the dipping strata that comprises the hogback (Hugget, 2011).

Hummocky – a general geological term referring to a small knoll or mound above ground.

Incline – an entry to a mine that is not vertical (shaft) or horizontal (adit). Often incline is reserved for those entries that are too steep for a belt conveyor, in which case a hoist and guide rails are employed (Glossary of Mining Terms, 2018).

Investigation Level (IL) – based on the background gamma measurements (in counts per minute [cpm]) and, Radium-226 (Ra-226) and metals concentrations, determined through statistical analyses, that are used to evaluate potential mining-related impacts.

Isolated Occurrences – in relation to the Site Cultural Resource Survey: Any non-structural remains of a single event: alternately, any non-structural assemblage of approximately 10 or fewer artifacts within an area of approximately 10 square meters or less, especially if it is of questionable human origin or if it appears to be the result of fortuitous causes. The number and/or composition of observed artifact classes are a useful rule of thumb for distinguishing between a site and an isolate (NNHPD, 2016).

Leachate – a solution resulting from leaching, as of soluble constituents from soil, etc., by downward percolating groundwater.

Mineralized – economically important metals in the formation of ore bodies that have been geologically deposited. For example, the process of mineralization may introduce metals, such as uranium, into a rock. That rock may then be referred to as possessing uranium mineralization (World Heritage Encyclopedia, 2017).

Multi-channel analysis of surface wave (MASW) – geophysical investigation method that measures the elastic condition of the subsurface to produce an image based on differences in transmission time of the seismic wave.

Naturally occurring radioactive material (NORM) – "materials which may contain any of the primordial radionuclides or radioactive elements as they occur in nature, such as radium, uranium, thorium, potassium, and their radioactive decay products, that are undisturbed as a result of human activities" (USEPA, 2017).

Orthophotograph – an aerial photograph or image geometrically corrected such that the scale is uniform: the photograph has the same lack of distortion as a map. Unlike an uncorrected aerial photograph, an orthophotograph can be used to measure distances, because it is an accurate representation of the earth's surface, having been adjusted for topographic relief, lens distortion, and camera tilt.

Pan Evaporation – evaporative water losses from a standardized pan.

Portal – The surface entrance to a drift, tunnel, adit, or entry (US Bureau of Mines, 2017).

Radium-226 (Ra-226) – a radioactive isotope of radium that is produced by the natural decay of uranium.

Remedial Action (or remedy) – "those actions consistent with permanent remedy taken instead of, or in addition to, removal action in the event of a release or threatened release of a hazardous substance into the environment, to prevent or minimize the release of hazardous substances so that they do not migrate to cause substantial danger to present or future public health or welfare or the environment…For the purpose of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the term also includes enforcement activities related thereto" (USEPA, 1992a).

Remove or removal – "the cleanup or removal of released hazardous substances from the environment; such actions as may be necessary taken in the event of the threat of release of hazardous substances into the environment; such actions as may be necessary to monitor, assess, and evaluate the release or threat of release of hazardous substances; the disposal of removed material; or the taking of such other actions as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare of the United States or to the environment, which may otherwise result from a release or threat of release…" (USEPA, 1992a).

Respond or response – "remove, removal, remedy, or remedial action, including enforcement activities related thereto" (USEPA, 1992a).

Secular equilibrium – a type of radioactive equilibrium in which the half-life of the precursor (parent) radioisotope is so much longer than that of the product (daughter) that the radioactivity of the daughter becomes equal to that of the parent with time; therefore, the quantity of a radioactive isotope remains constant because its production rate is equal to its decay rate. In secular equilibrium the activity remains constant.

Static gamma measurement – stationary gamma measurement collected for a specific period of time (e.g., 60 seconds).

Technologically enhanced naturally occurring radioactive material (TENORM) – "naturally occurring radioactive materials that have been concentrated or exposed to the accessible environment as a result of human activities such as manufacturing, mineral extraction, or water processing", which includes disturbance from mining activities. Where "technologically enhanced means that the radiological, physical, and chemical properties of the radioactive material have been concentrated or further altered by having been processed, or beneficiated, or disturbed in a way that increases the potential for human and/or environmental exposures" (USEPA, 2017).

Thorium (Th) – "a naturally occurring radioactive metal found at trace levels in soil, rocks, water, plants and animals. Thorium (Th) is solid under normal conditions. There are natural and man-made forms of thorium, all of which are radioactive" (USEPA, 2017).

Th-230 – a radioactive isotope of thorium that is produced by the natural decay of thorium.

Th-232 – a radioactive isotope of thorium that is produced by the natural decay of thorium.

Upper Confidence Limit (UCL) – the upper boundary (or limit) of a confidence interval of a parameter of interest such as the population mean (USEPA, 2015).

Upper Tolerance Limit (UTL) – a confidence limit on a percentile of the population rather than a confidence limit on the mean. For example, a 95 percent one-sided UTL for 95 percent coverage represents the value below which 95 percent of the population values are expected to fall with 95 percent confidence. In other words, a 95 percent UTL with coverage coefficient 95 percent represents a 95 percent UCL for the 95th percentile (USEPA, 2015).

Uranium (U) – a naturally occurring radioactive element that may be present in relatively high concentrations in the geologic materials in the southwest United States.

U-235 – a radioactive isotope of uranium that is produced by the natural decay of uranium.

U-238 – a radioactive isotope of uranium that is produced by the natural decay of uranium.

Walkover gamma radiation survey – referred to as a scanning survey in the Multi-agency Radiation Survey and Site Investigation Manual (*MARSSIM*; USEPA, 2000). A walkover gamma radiation survey is the process by which the operator uses a portable radiation detection instrument to detect the presence of radionuclides on a specific surface (i.e., ground, wall) while continuously moving across the surface at a certain speed and in a certain pattern (USEPA, 2000). Referred to in the RSE report as surface gamma survey after the first mention in the report.

Wind rose – a circular graph depicting average wind speed and direction.

1.0 INTRODUCTION

1.1 BACKGROUND

This report summarizes the purpose and objectives, field investigation activities, findings, and conclusions of Site Clearance and Removal Site Evaluation (RSE) activities conducted between August 2015 and September 2017 at the Section 26 Desidero Group site (the Site) located in northwestern New Mexico, as shown in Figure 1-1. The Site is also identified by the United States Environmental Protection Agency (USEPA) as an abandoned uranium mine (AUM) claim that consists of three mine sites with identifications of #1011, #1012, and #1035 in the *Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data* (the *2007 AUM Atlas*; USEPA, 2007a). The *2007 AUM Atlas* was prepared for the USEPA in cooperation with the Navajo Nation Environmental Protection Agency (NNEPA) and the Navajo Abandoned Mine Lands Reclamation Program (NAML). The mine site boundary polygons (refer to claim boundaries shown on Figure 2-1) used for the RSE encompassed an area of approximately 15.2 acres (662,112 square feet [ft^2]) and were provided as part of the *2007 AUM Atlas*. Per the *2007 AUM Atlas* these polygons and other factors represent the locations and surface extents of the AUMs.

Stantec Consulting Services Inc. (Stantec; formerly MWH), performed Site Clearance activities in accordance with the *Site Clearance Work Plan* (MWH, 2016a), and performed RSE activities in accordance with the *Removal Site Evaluation Work Plan* ([*RSE Work Plan*] MWH, 2016b). The *Site Clearance Work Plan* and the *RSE Work Plan* were approved in April and October 2016, respectively, by the NNEPA and the USEPA (collectively, the Agencies). Stantec conducted this investigation on behalf of Sadie Hoskie, Trustee pursuant to Section 1.1.21 of the *Navajo Nation AUM Environmental Response Trust Agreement – First Phase* (the *Trust Agreement*), effective April 30, 2015 (United States [US], 2015). The *Trust Agreement* is made by and among the US, as Settlor, and as Beneficiary on behalf of the USEPA, the Navajo Nation, as Beneficiary, and the Trustee. The *Trust Agreement* was developed in accordance with a settlement on April 8, 2015 between the US and Navajo Nation for the investigation of 16 specified "priority" AUMs.

A "Site" is defined in the *Trust Agreement* as:

> "each of the 16 AUMs listed on Appendix A to the Settlement Agreement, including the proximate areas where waste material associated with each such AUM has been deposited, stored, disposed of, placed, or otherwise come to be located." *Trust Agreement*, § 1.1.25.

The Site is one of 46 priority AUMs within the Navajo Nation selected by the USEPA in collaboration with the NNEPA for further evaluation based on radiation levels and potential for water contamination (USEPA, 2013). The 16 priority AUMs included in the *Trust Agreement* are located on Navajo Lands throughout southeastern Utah, northeastern Arizona, and western New

Mexico, as shown in Figure 1-1. The 16 priority AUMs were selected by the US and Navajo Nation, as described in the *Trust Agreement*:

> "based on two primary criteria, specifically, demonstrated levels of Radium-226[2]: (a) at or in excess of 10 times the background levels and the existence of a potentially inhabited structure located within 0.25 miles of AUM features; or (b) at or in excess of two times background levels and the existence of a potentially inhabited structure located within 200 feet (ft)." *Trust Agreement*, Recitals.

In addition, the 16 priority AUMs are, for the purposes of this investigation, a subset of priority mines for which a viable private potentially responsible party has not been identified. Mining for uranium occurred prior to, during, and after World War II, when the US sought a domestic source of uranium located on Navajo lands (USEPA, 2007a). *Trust Agreement*, Recitals.

1.2 OBJECTIVES AND PURPOSE OF THE REMOVAL SITE EVALUATION

The primary objectives of the RSE are to provide data (e.g., review relevant information and collect data related to historical mining activities) required to evaluate relevant Site conditions and to support future Removal or Remedial Action evaluations at the Site. It is not intended to establish cleanup levels or determine cleanup options or potential remedies. The purpose of the RSE data are to determine the volume of technologically enhanced naturally occurring radioactive material (TENORM) at the Site in excess of Investigation Levels (ILs) as a result of historical mining activities. ILs are based on the background gamma measurements (in counts per minute [cpm]), and Radium-226 (Ra-226) and metals concentrations, determined through statistical analyses, that are used to evaluate potential mining-related impacts. The USEPA (2017) defines TENORM as:

> "naturally occurring radioactive materials that have been concentrated or exposed to the accessible environment as a result of human activities such as manufacturing, mineral extraction, or water processing" (mine waste or other mining-related disturbance).
>
> "Technologically enhanced means that the radiological, physical, and chemical properties of the radioactive material have been concentrated or further altered by having been processed, or beneficiated, or disturbed in a way that increases the potential for human and/or environmental exposures."

An understanding of the extent and volume of TENORM that exceeds the ILs at the Site is key information for future Removal or Remedial Action evaluations, including whether, and to what extent, a Response Action is warranted under federal and Navajo law. Definitions presented in the glossary for "Removal", "Remedial Action", and "Response" are defined in 40 Code of

[2] The Agencies selected the priority mines based on gamma radiation but the *Trust Agreement* erroneously states "levels of Radium -226".

Federal Regulations (CFR) Section 300.5 of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP; USEPA, 1992a).

The Trust conducted Site Clearance activities prior to commencing the RSE tasks to obtain information necessary to develop the *RSE Work Plan*. Site Clearance activities consisted of two separate tasks: a "desktop" study (e.g., literature and historical documentation review) and field activities.

Desktop study – included review of readily available and reasonably ascertainable information including:

- Historical and current aerial photographs to identify any potential historical mining features, and to identify if buildings, homes and/or other structures, and potential haul roads were present within 0.25 miles of the Site
- Topographic and geologic maps
- Available data concerning perennial surface water features and water wells
- Previous studies and reclamation activities
- Meteorological data (e.g., predominant wind direction in the region of the Site)

Site Clearance field activities – included the following:

- Site reconnaissance to evaluate in the field: access routes to the Site, location of site boundaries, and observations presented in the Weston Solutions (Weston)(2009) report
- Mapping of site features and boundaries
- Evaluation of potential background reference areas
- Biological surveys (wildlife and vegetation)
- Cultural resource surveys

Following Site Clearance activities, RSE activities consisted of two separate tasks: Baseline Studies and Site Characterization and Assessment. Baseline Studies activities were completed to establish the basis for the Site Characterization and Assessment activities.

Baseline Studies activities – included the following:

- Background Reference Area Study – walkover gamma radiation survey (referred to hereafter as surface gamma survey), subsurface static gamma radiation measurements (referred to hereafter as subsurface static gamma measurements), surface and subsurface soil/sediment sampling, and laboratory analyses
- Site gamma survey – surface gamma survey

- Gamma Correlation Study – co-located surface static gamma measurements and exposure-rate measurements at fixed points, high-density surface gamma surveys (intended to cover 100 percent of the survey area), surface soil sampling, and laboratory analyses

Site Characterization Activities and Assessment – included the following:

- Characterization of surface soils and sediment – surface soil and sediment sampling and laboratory analyses.
- Characterization of subsurface soils – static gamma measurements (at surface and subsurface hand auger and drilling borehole locations), and subsurface sampling and laboratory analyses. Hand auger and drilling borehole locations are referred to hereafter as boreholes.

Details regarding the Site Clearance activities are provided in the *Section 26 (Desidero Group) Site Clearance Data Report* (*Site Clearance Data Report*; MWH, 2016c) and summarized in Section 3.2 of this report. Details regarding the Baseline Study activities are provided in the *Draft Section 26 (Desidero Group) Site Baseline Studies Field Report* (Stantec, 2017) and summarized in Section 3.3 of this report. Details regarding the Site Characterization Activities and Assessment are provided in Section 3.3 of this report. Findings are presented in Section 4.0 of this report.

1.3 REPORT ORGANIZATION

This report presents a comprehensive discussion of all RSE activities, including applicable aspects of the outline suggested in the *Multi-Agency Radiation Survey and Site Investigation Manual – Appendix A* ([*MARSSIM*] USEPA, 2000), and consists of the following sections:

Executive Summary – Presents a concise description of the principal elements of the RSE report.

Section 1.0 **Introduction** – Describes the purpose and objectives of the RSE process, and organization of this RSE report.

Section 2.0 **Site History and Physical Characteristics** – Presents the history, land use, and physical characteristics of the Site.

Section 3.0 **Summary of Site Investigation Activities** – Summarizes the Site Clearance and RSE activities.

Section 4.0 **Findings and Discussion** – Presents the results of the Site Clearance and RSE activities, areas that exceed ILs, areas of Naturally Occurring Radioactive Material (NORM) and TENORM, and the volume of TENORM that exceeds the ILs. Potential data gaps are also presented, as applicable.

Section 5.0 **Summary and Conclusions** – Summarizes data and presents conclusions based on results of the investigations completed to date.

Section 6.0 Estimate of Removal Site Evaluation Costs – A statement of actual or estimated costs incurred in complying with the *Trust Agreement*, as required by the *Trust Agreement*.

Section 7.0 References – Lists the reference documents cited in this RSE report.

Tables Included at the end of this RSE report.

Figures Included at the end of this RSE report.

Appendices – Appendices A through F.1 are included at the end of this RSE report and Appendix F.2 is provided as a separate electronic file due to its file size and length.

- **Appendix A** – Includes the radiological characterization report and the geophysical survey report for the Site
- **Appendix B** – Includes photographs of the Site
- **Appendix C** – Includes copies of RSE field activity forms
- **Appendix D** – Provides the potential background reference areas selection and the methods and results of the statistical data evaluation for the Site
- **Appendix E** – Includes the biological evaluation report and the biological and cultural resources compliance forms
- **Appendix F** – Includes the Data Usability Report, laboratory analytical data, and data validation reports for the RSE analyses

Attachments – Site-specific geodatabase, tabular database files, and available historical documents referenced in this RSE report.

2.0 SITE HISTORY AND PHYSICAL CHARACTERISTICS

2.1 SITE HISTORY AND LAND USE

2.1.1 Mining Practices and Background

A note to the reader: The Historical documentation for the Site is confusing and inconsistent. The Trust's AUM Section 26 Site (i.e., the Section 26 Desidero Group Site) is associated with two other AUMs, which have their own historical identification names: Hanosh Mines Inc. (also known as Indian Allotment [Rasor and Toren, 1952]) and Desidero (also known as Desidero Allotment [McLemore and Chenoweth, 1991]). However, the two other AUMs are not clearly distinguished in the historical documentation, and the terms are used interchangeably and inconsistently. For example, in1991 McLemore and Chenoweth reported the "Hanosh and Desidero Allotment" sites were combined together and referred to them collectively as Section 26. ***This reference to Section 26 is in conflict with the nomenclature for the Trust's AUM Section 26 Site***. The historical information presented in this RSE report may include just one of the AUM alternative names, or "aliases" or a combination of the AUM aliases, based on how the information was reported in the referenced historical documents. In addition, names in historical documents may not match current descriptions of the Site or surrounding mine areas. In the historical Sections 2.1.1 and 2.1.4 of this RSE report, to distinguish the Trust's AUM Site (called the Section 26 Desidero Group Site) from alternative names or aliases historically used, the Trust site will be referenced as the Trust Section 26 AUM where applicable.

The Trust Section 26 AUM is located on the Navajo Nation, in northwestern New Mexico, approximately 12.5 miles north of Grants, New Mexico, as shown in Figure 1-1 inset. The site is located within the Baca/Prewitt Chapter of the Navajo Nation. The Trust Section 26 AUM is also located in the Grants Uranium Mining District, Ambrosia Lake Sub-district. A summary of historical mining for the Trust Section 26 AUM is presented below.

In 1947 the US Atomic Energy Commission (USAEC) began a procurement program for uranium concentrate. In 1950 mineable uranium was first discovered in the Ambrosia Lake Sub-district by Navajo sheepherder Paddy Martinez (Chenoweth, 1985). Mr. Martinez collected samples of the Jurassic Luciano Mesa Member of the Todilto Limestone Formation (the Todilto Limestone) that contained yellow uranium minerals, from the foot of Haystack Butte. Though uranium was known to exist within the Gallup-Grants, New Mexico area for several years, this discovery indicated that there were vast mineable uranium resources. The news of this uranium discovery led to numerous prospectors arriving in the Gallup-Grants area. The additional prospecting led to the discovery of other deposits in the Todilto Limestone, as well as deposits in exposures of the Morrison and Dakota Formations. These discoveries triggered the uranium boom in west-central New Mexico. In 1951, leases for Hanosh Mines Inc. were granted to two Navajos who were also given allotments to the land associated with the mineral leases (Rasor and Toren, 1952). The leases (numbers I-149-Ind-8907 and I-149-Ind-8909) lasted for 15 years and authorized prospecting and mining uranium and other related materials. In 1952 mining began at the

Hanosh Mines from a small open pit, located on the mesa edge and corresponding with mine site #1012, refer to Figure 2-1 (Rasor and Toren, 1952). Mining continued until 1957, with additional mine workings consisting of a 155 ft incline and several open pits (Anderson, 1980 and McLemore, 1983). McLemore and Chenoweth (1991) reported that between 1952 and 1957 Hanosh Mines was listed as the producer and shipper of ore from "Section 26 (Hanosh) (Desidero Allotment)". The ore was shipped for processing to the Anaconda Minerals Company, located approximately six miles southwest of the Site (NSO, 1990). The USAEC reported total ore production from the "Section 26 (Hanosh) (Desidero Allotment)" between 1952 and 1957 was 11,110 tons (approximately 22,220,000 pounds) of ore that contained 83,752 pounds of 0.38 percent U_3O_8 (uranium oxide) and 17,518 pounds of 0.08 percent V_2O_5 (vanadium oxide) (McLemore and Chenoweth, 1991).

2.1.2 Ownership and Surrounding Land Use

The Site is located within the Navajo Nation, Eastern Navajo Bureau of Indian Affairs (BIA) Agency in Section 26 of Township 13 North, Range 10 West, New Mexico Principal Meridian. Land ownership where the Site is located falls under Allotted Trust lands. The Site is located within the Baca/Prewitt Chapter of the Navajo Nation, as shown in Figure 1-1, and is in Grazing Unit 16, as designated by the Navajo Nation Division of Natural Resources (NNDNR, 2006). Several home-sites are located within 0.25 miles of the Site to the west, north, and east, as shown in Figure 2-1.

2.1.3 Site Access

In 2015, the Navajo Nation Department of Justice (NNDOJ) provided the Trustee with legal access to all Navajo Trust lands to implement work in accordance with the *Trust Agreement*. The Trustee notified allotment owners via mail and also obtained individual written access agreements from residents living at or near the Site, or with an interest in lands at or near the Site, such as allotted land, home-site leases, and grazing rights, as applicable. In addition, the Trustee consulted with the Baca/Prewitt Chapter officials and nearby residents and notified them of the work.

2.1.4 Previous Work at the Site

2.1.4.1 1980 Abandoned or Inactive Mines Assessment

Between 1979 and 1980, the New Mexico Bureau of Mines and Mineral Resources assessed approximately 200 abandoned or inactive uranium mines in New Mexico (Anderson, 1980). The assessment included verifying the location, type and size of the mines, condition of the mines, ore host geologic formation, dimensions of remaining mine features, proximity to residences or towns, water quality data, and radiation levels (Anderson, 1980). The New Mexico Bureau of Mines and Mineral Resources assessed the AUMs associated with the Trust Section 26 AUM on January 15, 1980 and the following information was reported:

- The assessment included two AUMs with aliases associated with the Trust Section 26 AUM: the "Hanosh Mines" and "Section 26". The "Hanosh Mine" was located at N½ NE¼ Section 26 and "Section 26" was located at S¼ Section 23 and NE¼ Section 26. Based on these coordinate designations, and supporting photographs provided in Anderson (1980), it is believed that the "Hanosh Mine" was located in the vicinity of mine site #1035 and "Section 26" was located in the vicinity of mine site #1011 (refer to Figure 2-1). The "Section 26" designation in the 1980 assessment should not be confused with the 1991 Section 26 designation reported by McLemore and Chenoweth (1991), which was the combination of the "Hanosh and Desidero Allotment" aliases (refer to Section 2.1.1).

- The ore host geologic formation was the Todilto limestone.
- The Hanosh Mine was located within 0.5 miles of a home-site. Mine workings consisted of an incline and several open pits that extended north-westwards toward the Section 26 mine. The portal of the incline measured approximately 8 ft by 8 ft and was located at the bottom of a 75-ft-long by 20-ft-deep box cut. The 20-ft-deep box cut was entirely in unconsolidated overburden. Radiation levels were collected using a gamma ray scintillometer. Radiation readings inside the incline ranged up to 2,400 counts per second (cps) and mineralized bedrock readings inside the incline were up to 6,000 cps. The size of detector (i.e., 2-inch by 2-inch or 3-inch by 3-inch) used was not specified.
- Section 26 was located within 0.25 miles of a home-site. Mine workings consisted of an open pit complex used to mine an ore body or cluster of ore bodies in the middle and lower parts of the Todilto limestone. The pits were constructed as trenches up to 40 ft deep and 450 ft long. Radiation readings up to 5,000 cps were recorded in mineralized zones of bedrock. A small prospect pit with 8 ft high waste piles at each end was described as being present in an area of "undisturbed ground".

2.1.4.2 1990 Preliminary Assessment

In a memo dated January 1990, the Baca Chapter (the local community government that oversaw the community needs and resources) reported to the Navajo Superfund Office (NSO) that the "Desiderio Group Uranium Mines" were potentially contaminated with hazardous waste (NSO, 1990). In response to the memo, the NSO conducted a Preliminary Assessment (PA) to investigate the potentially contaminated Desiderio Group Uranium Mines. The PA was conducted at "The Desiderio Group Uranium Mines, also known as the Hanosh Mines Section 26", an area that occupied approximately 130 acres and extended into adjacent Section 23 and Section 25 (NSO, 1990). Of note, the 130 acres will be referred to as the PA site for the remainder of this RSE report section.

The PA findings identified the following known/potential problems for the PA site:

- The presence of 91,962 cubic yards (yd^3) of low grade, radioactive uranium ore and tooled mine waste piles that were exposed, uncontained, and unlined. The piles "were capable of producing leachate subject to migration into the atmosphere, groundwater and surface water systems."
- The presence of an unsecured155 ft inclined adit and unfenced open pits. The exposed surface of the adit and surface pits were also capable of "producing leachate similar in composition to that released from the mine waste piles".

- The possibility of exposure to local residents through: (1) radon gas emissions and ionizing radiation; and/or (2) direct contact of exposure through ingestion of windblown particulates contaminated with radioactive and heavy metal species. At the time of the PA, local residents were living less than 200 ft from the nearest mine waste pile.

The PA included a graphic representation of the PA site showing the locations of the residential area, mine waste piles, open pits, and adit. This graphic is presented in Figure 2-2 along with the approximate boundaries of Section 23, Section 25, and Section 26.

The PA concluded there was a potential for groundwater and surface water radioactive contamination at the PA site as a result of past uranium mining activities. The PA also concluded the soil surrounding the mines was contaminated by low grade uranium ore, abandoned after the mining ceased, and the persistent nature of radioactive and heavy metal species suggested that PA site exposure to residents was "potentially very high". The NSO submitted findings of the PA to the USEPA in a PA Package dated July 30, 1990 (NSO, 1990).

2.1.4.3 1991 Emergency Removal Action

Between August 11, 1991 and September 19, 1991, the USEPA Region 9 Emergency Response Section conducted an Emergency Removal Action (ERA) at the "Desidero mines" (USEPA, n.d.). It is unknown if the "Desidero mines" in the ERA were inclusive of the same areas, or were different areas, from the areas included as the Desidero aliases presented in Section 2.1.1. It is known, however, that the area of the Desidero mines in the ERA was inclusive of 130 acres, while the Trust Section 26 AUM claim boundaries for this RSE are inclusive of 15.2 acres (USEPA, 2007a). The ERA was in response to a health advisory (the Advisory) issued on November 21, 1990, by the US Agency for Toxic Substance and Disease Control Registry (ATSDR) (USEPA, n.d.), part of the US Center for Disease Control. The Advisory was the result of a request made by NSO to ATSDR for assistance in determining the health risk for residents living near the abandoned Desidero mines. The Advisory cited the following for the Desidero mines:

- Physical hazards which included open pits, open mine adits and ventilation shafts, all accessible by children
- Excessive gamma radiation exposure from mine tailing and low grade ore piles
- Potential leaching of heavy metals into the groundwater

Prior to ERAs occurring, well water samples from homes located near the Desidero mines were collected and analyzed. The analyses showed that heavy metals left by mining activities had not leached to the groundwater.

Based on the Advisory, USEPA Removal Action activities included the following:

- Filling existing pits and covering an open adit (it is unknown if the adit filled as part of the ERA was the 155 ft incline reported by Anderson (1980) and McLemore (1983); refer to Section 2.1.1).

- Re-grading reclaimed areas to match the surrounding terrain and ensure positive drainage.

According to the USEPA report, the ERA was completed using existing material on-site consisting of: ore piles, mine waste, and overburden that had been left behind at the mines (USEPA, n.d.). No clean topsoil or fill was brought to, nor was any contaminated material taken from the Desidero mine AUM site.

Once ERAs were completed, soil samples and radiation measurements were collected (USEPA, n.d.). Three soil samples and one background soil sample were also collected for the Desidero mines. The soil sample results for total uranium were less than 30 picocuries per gram (pCi/g) and Ra-226 concentrations were less than 5 pCi/g, for the first 15 centimeters. USEPA considered these levels acceptable for uranium mill tailing remediation under 40 CFR §192[3]. The radiation measurements were collected using a Ludlum 19 survey meter. Any area that had readings over 50 microRoentgens per hour (μR/hr), which was equal to the highest natural background reading, was reworked until the gamma reading was 50 μR/hr or less.

On September 20, 1991, USEPA prepared a post ERA summary report (USEPA, 1991). In the report USEPA stated the average gamma reading within the reclaimed area was 15 μR/hr. USEPA also stated the gamma emissions present at the Desidero mines were "within reclamation guideline levels and pose no significant health risks for long term exposures"… and "it does not appear that any mining enhanced increased indoor radon concentrations should be expected or have been measured at the homes on the Desiderio sites".

2.1.4.4 1992 Aerial Photographic Analysis

In July 1992, the USEPA Environmental Monitoring Systems Laboratory Office of Research and Development issued a report presenting a supplemental aerial photographic analysis of the Desidero mines (USEPA, 1992b). The Desidero mines appear to have included portions of mine sites #1011 #1035, as well as portions of adjacent mine sites within Sections 23 and 25, identified on Figure 2-1 as mine sites #364 and #363, respectively. The report presented volumetric data regarding piles that were removed[4], capped, or still remaining on the Desidero mines following the USEPA's ERA in 1991. The volumes were calculated by using a Carto AP190 Analytical Steroplotter to compare aerial images acquired on December 7, 1990 (prior to the ERA) to aerial images acquired on November 13, 1991 (while the ERA was underway). Results of the analysis for the Desidero mines were:

- Total volume of 24 piles removed or capped during the removal action was 53,200 yd^3
- Total volume of 15 piles that still remained after the removal action was 57,805 yd^3

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[3] https://www.epa.gov/radiation/health-and-environmental-protection-standards-uranium-and-thorium-mill-tailings-40-cfr

[4] The USEPA, 1992b document stated that clean up activity had been done at the Desidero mines and some waste piles were removed and while others were not. This is in contradiction to the 1991 ERA report that no material was taken from the Desidero mine AUM site. It is unknown if in USEPA, 1992b the use of "removal" is referring to the 1991 ERA where the waste piles were used to fill in the existing pits and audit.

The report presented the volumetric data on a map showing the volumes and locations of "uranium piles, soil overburden, debris piles, and thin veneer" located within the aerial photographic analysis area (USEPA, 1992b). The report also presented photographs of the Desidero mines before, during, and after the ERA (refer to Section 2.1.4.2).

2.1.4.5 2009 Weston Solutions Site Screening

In 2009 Weston performed site screening on behalf of the USEPA (Weston, 2009). The site screening included: (1) recording site observations (i.e., number of homes and water sources around the Site); (2) recording the type, number, and reclamation status of mine features; and (3) performing a surface gamma survey. Weston reported the following: several home-sites were within 0.25 miles of the Site, no water features were within a one-mile radius of the Site, and the Site had 74,201.80 square meters (798,701 ft^2) of historical underground workings. Weston did not provide a reference for the underground workings information it reported. Based on the surface gamma survey, Weston determined that the highest gamma measurements were greater than three times the lowest site-specific background level it used for the gamma screening.

2.1.4.6 2011 Aerial Radiological Survey

In August 2011, the USEPA Aerial Spectrophotometric Environmental Collection Technology program conducted aerial radiological surveys of approximately 22,000 acres of land near Ambrosia Lake, New Mexico (USEPA, 2011). The area of the Site was included in the 22,000 acres aerial radiological survey area. The purpose of the radiological surveys was to identify areas of elevated surface uranium contamination. In addition, approximately 375 aerial and oblique photographs were taken as part of the surveys.

The surveys collected approximately 11,000 one-second radiological spectra data points. The data points were analyzed for total count rate, exposure rate, and uranium concentration. Radiological analyses results for the surveys indicated the following:

- Approximately 20 distinct areas within the aerial radiological survey area had exposure rates that exceeded 20 μR/hr
- Approximately 1,700 acres of land within the aerial radiological survey area exceeded 5 pCi/g of equivalent uranium (as measured by the gamma emission from Bismuth-214)
- Maximum exposure rates were measured at 435 μR/hr and maximum equivalent uranium concentrations at 350 pCi/g during the survey

The survey report (USEPA, 2011) included a figure showing exposure rates for the entire 22,000 acre survey area. On the Figure the Site was located just east of the area labeled Sec.25 SEQ 18 ac. As shown on the figure, the area inclusive of the Site had exposure rates that exceeded 20 μR/hr.

2.1.4.7 2014 Ecology and Environment Inc. Removal Assessment

In 2014 Ecology and Environment Inc. (E&E) performed a Removal Site Assessment (RSA) at the Site on behalf of the USEPA (E&E, 2014). The RSA included a surface gamma survey and collection of surface and subsurface soil samples at the RSA site and at a selected background reference area. The 2014 E&E RSA site area was different from the area of the Trust Section 26 AUM included in this RSE. It included the AUM mine site boundaries for #1011, #1035 and the northern portion of mine site #1012, plus additional areas to the southwest and southeast of #1011 and #1035 (refer to Figure 1 of the 2014 RA). E&E's objectives of the 2014RSA were:

1. Determine whether, and in what areas, the 2014RSA site concentrations of Ra-226 in surface soil require removal, further assessment, or no further action, including:
   - Determine whether gamma radiation measurements can be used to characterize the 2014RSA site or if further sampling to characterize the 2014RSA site is necessary
   - Determine a suitable background location for collecting data to calculate a 2014RSA site-specific action level or identify an alternate means of setting an action level
2. Determine whether 2014RSA site concentrations of Ra-226 in subsurface soil at locations where the surface levels of Ra-226 are elevated require removal, further assessment, or no further action

For the 2014RSA the Ra-226 action level and gamma radiation investigation level, as determined by E&E, was 2.29 pCi/g and twice the daily background gamma radiation level, respectively. Before E&E began gamma surveying using a 3-inch by 3-inch gamma detector, a one-minute surface gamma radiation measurement was collected daily from three locations in the background reference area. E&E then used these measurements to calculate the daily average background gamma radiation level. The daily average background level ranged from 20,425 to 22,005 cpm, and the gamma radiation investigation level used in the field by E&E was based on twice the daily average background level.

For the 2014 RA, E&E collected surface and subsurface soil samples based on the results of the gamma radiation surveys. Surface soil samples were collected at locations where gamma measurements were below, at, and above the E&E determined gamma radiation investigation level. Subsurface soil samples were collected from locations of the highest gamma measurements based on the gamma radiation surveys. To collect subsurface soil samples potholes were excavated, using a backhoe, at 1 ft depth bgs intervals. Subsurface soil samples were collected at each interval until gamma measurements were below the E&E gamma radiation investigation level, or a maximum depth of 4 ft bgs or refusal was reached. E&E collected static 1-minute gamma measurements and soil samples from the surface of excavated soil in the backhoe bucket.

Results of the 2014RSA as reported by E&E were:

- Rocks were observed in areas with elevated gamma measurements up to concentrations exceeding 999,000 cpm. It is unknown if E&E meant bedrock or rocks that are part of the unconsolidated deposit matrix.

- Ra-226 concentrations in soil were detected above the action level of 2.29 pCi/g in surface and subsurface soils. Sampling locations with elevated levels of Ra-226 in surface soil also contained subsurface Ra-226 at concentrations exceeding the action level. Ra-226 concentrations detected at the 2014RSA site generally decreased with depth except when subsurface rocks with elevated gamma measurements were present. Again, it is unknown if E&E meant bedrock or rocks that are part of the unconsolidated deposit matrix.

E&E used the results of the gamma radiation surveys and Ra-226 analyses to determine the relationship between gamma measurements and Ra-226 concentrations. Based on this, E&E proposed removal areas. E&Es results indicate there was a correlation and linear relationship between surface soil Ra- 226 sample results and co-located 1-minute gamma measurements. However, E&E determined the reported relationship to be weak and that the relationship may have been different at lower gamma measurements and lower Ra-226 concentrations. In addition, E&E determined that a prediction interval that can effectively predict Ra-226 concentrations in soil below the action level based on a measured co-located 1-minute gamma measurements needed to be established.

E&E used the results of the 2014RSA to define areas of the 2014RSA site for further action, such as source removal or institutional controls to protect human health. E&E determined the proposed lateral extent of areas for removal based on the surface gamma measurements levels and surface soil sample results exceeding the action level. E&E used the subsurface soil sample results exceeding the E&E action level to determine the vertical extent of soil for removal.

Based on the results, E&E reported that it "appears further action was necessary at AUM Section 26 to mitigate exposure threat posed by the [2014 RA] site". E&E proposed excavation of soil totaling approximately 9,737 yd^3 for the following 2014RSA site removal areas:

1. Mine claim ID 1011[5]

    - Excavation of soil to 1 ft bgs near the closest home-site to the east (AUM26-RA-01, -02, and -03). The proposed excavation included 29,488 ft^2 (0.63 acres) for a total of 1,091 yd^3.

2. Mine claim 1035

    - Excavation of soil to 4 ft bgs around areas AUM26-SS-04, -05, and -06 (AUM26-RA-05) which were located in the vicinity of the shaft. It is unknown if the shaft is the adit filled as part of the ERA (USEPA, n.d.) and/or the 155 ft incline reported by Anderson

[5] This is the claim identification nomenclature used by E&E in the 2014RSA (e.g. Mine claim ID 1011 instead of mine site #1011).

(1980) and McLemore (1993). The proposed excavation included 7,284 ft^2 (0.17 acres) for a total of 1,079 yd^3.

- Excavation of soil to 1 ft bgs in remaining areas with elevated gamma measurements (AUM26-RA-06). The proposed excavation included 178,618 ft^2 (4.1 acres) for a total of 6,615 yd^3.

3. Area Bounded by Mine claim 1011

- Excavation of soil to 2 ft bgs around AUM26-SS-07 (AUM26-RA-04). The proposed excavation included 12,847 ft^2 (0.29 acres) for a total of 952 yd^3.

E&E recommended removal of loose rocks with elevated gamma measurements throughout the 2014RSA site, but did not provide a volume estimate for this material.

E&E reported that the area south of mine claim 1035 had gamma measurements up to 80,000 cpm, and that Ra-226 concentrations were not available for this area. The nearest location (AUM26-SS-10) with similar gamma measurements contained Ra-226 below the action level. E&E recommended additional assessment for this area, but did not include an area or volume estimate.

E&E reported that areas on the mesa had some surface soil that exceeded the Ra-226 E&E action level, but the primary source of elevated gamma measurements in these areas appeared to be bedrock. The Ra-226 concentrations in this area, except for AUM26-SS-01, were less than twice the E&E action level. E&E did not provide area or volume estimates for these locations, but recommended institutional controls, such as fencing to prevent access of these areas.

Refer to the 2014RSA figures, tables, and appendices for E&E sample locations, E&E proposed removal areas, and E&E estimated potential soil excavation volumes by removal area.

2.2 PHYSICAL CHARACTERISTICS

2.2.1 Regional and Site Physiography

The Site is located within the Colorado Plateau physiographic province, which is an area of approximately 240,000 square miles in the Four Corners region of Utah, Colorado, Arizona, and New Mexico. Figure 2-3 presents a current regional aerial photograph (BING® Maps, 2018) of the Site within a portion of the Colorado Plateau. The Colorado Plateau is typically high desert with scattered forests and varying topography having incised drainages, canyons, cliffs, buttes, arroyos, and other features consistent with a regionally uplifted, high-elevation, semi-arid plateau (Encyclopedia Britannica, 2017). The physiographic province landscape includes mountains, hills, mesas, foothills, irregular plains, alkaline basins, some sand dunes, and wetlands. This physiographic province is a large transitional area between the semi-arid grasslands to the east, the drier shrub-lands and woodlands to the north, and the lower, hotter, less-vegetated areas to the west and south.

The Colorado Plateau includes the area drained by the Colorado River and its tributaries: the Green, San Juan, and Little Colorado Rivers (Kiver and Harris, 1999). The physiographic province is composed of six sections: Uinta Basin, High Plateaus, Grand Canyon, Canyon Lands, Navajo, and Datil-Mogollon. The Site is located within the Navajo section.

Figure 2-4 presents the regional US Geological Survey (USGS) topographic map of a portion of the Colorado Plateau in the vicinity of the Site. Figure 2-5 presents the Site topography (Cooper Aerial Surveys Company [Cooper; refer to Section 3.2.2.1]) within a portion of the Colorado Plateau. The mine sites are located on a mesa top with mine site #1012 also located along a mesa sidewall. The elevation on-site is approximately 7,100 ft above mean sea level (amsl) (refer to Figure 2-5).

2.2.2 Geologic Conditions

2.2.2.1 Regional Geology

Regionally the Site is located within the Ambrosia Lake Mining Sub-district, in the southeastern portion of the Colorado Plateau and on the northeast flank of the Zuni uplift. The Ambrosia Lake Mining Sub-district consists of limestone and evaporates that were deposited in a near marine-environment that received both fresh and saline water (Green, 1982). The Colorado Plateau is a massive outcrop of generally flat-lying sedimentary rocks ranging in age from the Paleozoic Era to the Cenozoic Era (USGS, 2017). The plateau has very little regional structural deformation, compared with the mountainous basin-and-range region to the west, and the sedimentary beds range widely in thickness from less than 1 inch to hundreds of feet. Changes in paleoclimate and elevation produced alternating occurrences of deserts, streams, lakes, and shallow inland seas; and these changes contributed to the type of rock deposited in the region. The rock units of the plateau consist of shallow submarine or sub-aerially deposited rocks including sandstone, shale, limestone, mudstone, siltstone, and various other sedimentary rock subtypes. The Zuni uplift is a northwesterly trending uplift that is oval-shaped with a length of approximately 75 miles and a width of approximately 30 miles (Kelly, 1967). Precambrian rocks are exposed in several large areas along the crest of the uplift. Surrounding the Precambrian outcrops is a wide band of Permian strata that surfaces as the main portion of the uplift. Outside the Permian outcrops Mesozoic rocks form valleys, hogbacks, and mesas that mark the outer boundaries of the uplift.

The ore host bedrock on-site was the Jurassic Todilto Limestone (Hilpert, 1969). Regionally, within the Ambrosia Lake Mining Sub-district, the Todilto Limestone consists of two facies; a lower locally carbonaceous limestone facies that ranges in thickness from 0 to 40 ft and an overlying gypsum-anhydrite facies that ranges in thickness from 0 to 170 ft. Within the Ambrosia Lake Mining Sub-district, the Todilto Limestone was the host formation for numerous small- to medium-sized uranium deposits that occurred in joints, shear zones, and fractures within small to large scale intraformational folds (Green, 1982). A regional geology map is shown in Figure 2-3. With the exception of a few shallow underground mines, the majority of the Todilto ore deposits were mined from open pits on the Todilto outcrop bench. From 1950 to 1978, mines located on

43 different properties in the Ambrosia Lake Mining Sub-district produced approximately 30,000 tons of U_3O_8 from Todilto orebodies (Green, 1982).

2.2.2.2 Site Geology

Bedrock outcrops on the Site consist of the Jurassic Luciano Mesa Member of the Todilto Formation, the Jurassic Entrada Sandstone, and the Triassic Wingate Sandstone, as shown if Figure 2-7a. On-site uranium was located in Todilto Limestone (Chenoweth, 1985). The Todilto Formation consists of olive-gray to pale-yellow, thin-to thick-bedded limestone deposited in a lacustrine or saline environment. The Entrada Sandstone consists of reddish-orange to reddish-brown fine-to medium-grained eolian cross-bedded sandstone, and dark-reddish-brown clayey siltstone and very fine grained silty sandstone. The Wingate Sandstone consisted of reddish-brown, fine-to medium-grained, cross-bedded eolian sandstone. A geologic profile across the plains, mesa sidewall, and mesa top of the Site is shown in Figure 2-7a. A photograph of the primary bedrock outcrops at the Site is shown in Appendix B-1 photograph number 6. Exposed bedrock on-site is shown in Figure 2-7b.

Unconsolidated deposits on-site (i.e., Quaternary deposits) are eolian deposits, and alluvium and colluvium consisting of poorly and well graded sand and/or gravel, with varying amounts of silt, clay and cobbles, as shown on the borehole logs in Appendix C.2. Alluvium in the drainage channels consists of poorly graded sand with gravel and/or silt, and silt with fine sand. Drainage channels are shown in Figure 2-8. During the Site Characterization field activities, boreholes were advanced through the unconsolidated deposits using a hand auger or Geoprobe™ 8140LC rotary sonic drilling rig (refer to Section 3.3.2.2 and the borehole logs in Appendix C.2). The unconsolidated deposits ranged in depth from 0.2 to 20.0 ft below ground surface (bgs) at borehole locations.

Two cross-sections for the Site were produced using the subsurface borehole information, as shown in Figures 2-9a and 2-9b. The cross-sections show the extent and orientation of the consolidated and unconsolidated deposits in relation to the reclamation work that occurred on-site (refer to Section 2.1.4). The boreholes located closest to the cross-section lines were used to generate the cross-section figures and all boreholes were used to determine the average unconsolidated material depth to assist with projecting depth to bedrock in relation to the cross-sections.

According to the US Department of Agriculture (USDA) Soil Survey for McKinley County, New Mexico, soils on-site that have not been disturbed, are classified as Penistaja-San Mateo Series consisting of fine sandy loams that are deep and well drained (USDA, 1993).

2.2.3 Regional Climate

The Colorado Plateau is located in a zone of arid temperate climates characterized by periods of drought and irregular precipitation, relatively warm to hot growing seasons, and winters with sustained periods of freezing temperatures (National Park Service, 2017). The average monthly high temperature at weather station 298834, Thoreau 12 SE, New Mexico (Western Regional

Climate Center, 2017) located approximately 21 miles west of the Site, ranges between 41.8 degrees Fahrenheit (°F) in January to 83.2°F in July. Daily temperature extremes reach as high as 101°F in summer and as low as -24°F in winter. Thoreau 12 SE receives an average annual precipitation of 10.5 inches, with August being the wettest month, averaging 1.95 inches, and June being the driest month, averaging 0.47 inches.

Potential evaporation in the area is greater than the area's average annual precipitation. The potential evaporation noted at the Gallup Ranger Station weather station, located approximately 28 miles west of the Site, averages 62 inches of pan evaporation annually (Western Regional Climate Center, 2017). Average wind speeds in the area are generally moderate, although relatively strong winds often accompany occasional frontal activity, especially during late winter and spring months. Blowing dust, soil erosion, and local sand-dune migration/formation are common during dry months. The Grants, New Mexico airport, located approximately 12 miles to the south of the Site, had the most complete record of wind conditions. A wind rose for Grants airport is presented on Figure 1-1. The wind rose was produced using data contained in the *2007 AUM Atlas* for the years 1996 to 2006. Predominant winds were from the northwest (refer to the wind rose on Figure 1-1).

2.2.4 Surface Water Hydrology

The Site is located within the Rio Grande-Elephant Butte watershed, an area of approximately 27,000 square miles spanning New Mexico, as shown in Figure 1-1. On-site overland surface water flow, when present, is controlled by a decrease in elevation either to the north or south from the edge of the mesa (refer to Figures 2-5 and 2-8). Numerous parallel patterned ephemeral drainages are present on-site that drain either to the northeast (on the mesa top) or to the south (in the plains), where they then terminate, as shown in Figure 2-1.

Adkins Consulting Inc. (Adkins), under contract to Stantec, performed a wildlife evaluation as part of the Site Clearance field investigations and did not identify any wetlands, seeps, springs, or riparian areas within the Site (refer to Appendix E).

2.2.5 Vegetation and Wildlife

In the spring and summer of 2016, biological surveys were conducted as part of Site Clearance activities. In May 2016, Adkins conducted a wildlife survey. In July 2016, Redente Ecological Consultants (Redente), under contract to Stantec, conducted a summer vegetation survey. Information about each survey is provided in Appendix E, which includes the Site biological evaluation reports and the *Navajo Nation Department of Fish and Wildlife* (NNDFW) *Biological Resources Compliance Form*. A summary of the survey activities and findings are provided in Section 3.2.2.3.

Vegetation communities found within the physiographic transitional area described in Section 2.2.1 include shrublands with big sagebrush, rabbitbrush, winterfat, shadscale saltbush, and greasewood; and grasslands of blue grama, western wheatgrass, green needlegrass, and needle-and-thread grass. Higher elevations may support pinyon pine and juniper woodlands.

Vegetation communities on-site were sparsely vegetated grassland with sporadic shrubs and scattered pinyon/juniper in the eastern and southernmost areas (refer to Appendix E). During the surveys, Stantec and/or its subcontractors observed on-site wildlife including common raven, common nighthawk, cottontail rabbit, and mule deer (refer to Appendix E).

2.2.6 Cultural Resources

In May 2016, as part of Site Clearance activities, Dinétahdóó Cultural Resource Management (Dinétahdóó), under contract to Stantec, conducted a cultural resource survey, as well as ethnographic and historical data reviews, and interviewed local residents living near the Site (Dinétahdóó, 2016). The local residents recalled that mining occurred on-site through the 1950s and 1960s. The residents spoke about the Site as the southern area, the northwest area, and the northeast area. The residents recalled that in the southern area mining occurred from an open pit that was active from 1952 to 1953. The residents further recalled that in the northwest area mining occurred from an open pit with an incline, and in the northeast area, mining occurred from an open pit which extended east. The residents stated surface mining occurred from pits where a bull dozer driver stripped off the overburden and then miners would drill and set explosive charges. After the blasts were set off, a loader would put the ore into ore dump trucks. For underground mining the residents recalled mining occurred inside of inclines where miners would use a small mucking machine to load the ore into ore cars. A small engine would then pull the ore cars out of the mine and to the stockpile. Heavy equipment was used to move the ore out of the cars and onto the stockpile. The residents also recalled that around 1980, the open pit associated with the southern area was filled in by a company that was working at a mine located on Section 25. No historical documentation was found regarding a pit being filled in in 1980 (refer to Section 2.1.4).

During the 2016 cultural resource survey Dinétahdóó identified one archaeological site, two isolated occurrences, and one in-use site. Appendix E includes a copy of the *Cultural Resource Compliance Form,* and findings of the cultural resource survey are summarized in Section 3.2.2.4.

2.2.7 Observations of Potential Mining and Reclamation

During RSE activities, Stantec field personnel (field personnel) observed the following features indicative of potential mining or reclamation activities at the Site: a possible portal or storage area, potential haul roads, debris, excavation areas, potential mining disturbed areas, potential waste rock, waste piles, vertical mine shafts, graded/disturbed reclaimed areas, and historical boreholes. Details regarding these observations are presented in Section 3.2.2.1. These observations were used, along with additional lines of evidence (refer to Section 3.3.3), to identify areas at the Site where TENORM was present (refer to Section 4.6).

3.0 SUMMARY OF SITE INVESTIGATION ACTIVITIES

3.1 INTRODUCTION

This section summarizes Site Clearance and RSE activities conducted between August 2015 and September 2017. The purpose of the RSE activities was to review relevant information and collect data related to historical mining activities to support future Removal or Remedial Action evaluations for the Site. Site Clearance activities were conducted before RSE activities to obtain information necessary to develop the *RSE Work Plan*. Site Clearance activities were performed in accordance with the approved *Site Clearance Work Plan.* RSE activities were performed in accordance with the approved *RSE Work Plan.* The RSE is not intended to establish cleanup levels or determine cleanup options or potential remedies.

The *RSE Work Plan* is comprised of a Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPP), Health and Safety Plan (HASP), and a Data Management Plan (DMP). The FSP guided the fieldwork by defining sampling and data-gathering methods. The QAPP presented quality assurance/quality control (QA/QC) requirements designed to meet Data Quality Objectives (DQOs) for the environmental sampling activities. The HASP listed site hazards, safety procedures and emergency protocols. The DMP described the plan for the generation, management, and distribution of project data deliverables. The FSP, QAPP, HASP, and DMP provided the approved requirements and protocols to be followed for the RSE data collection, data management, and data analyses performed to develop this RSE report. Any deviations or modifications from the *RSE Work Plan* are described in the appropriate RSE report sections.

The RSE process followed applicable aspects of the USEPA DQO Process and *MARSSIM*, to verify that data collected during the RSE activities would be adequate to support reliable decision-making (USEPA, 2006). The USEPA DQO Process is a series of planning steps based on the scientific method for establishing criteria for data quality and developing survey designs. *MARSSIM* provides technical guidance on conducting radiation surveys and site investigations.

The USEPA DQO Process is a seven-step process[6] that was performed as part of the *RSE Work Plan* to identify RSE data objectives. The goal of the USEPA DQO Process is to minimize expenditures related to data collection by eliminating unnecessary, duplicate, or overly precise data and verifies that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application. It provides a systematic procedure for defining the criteria that the survey design should satisfy. This approach provides a more effective survey design combined with a basis for judging the usability of the data collected (USEPA, 2006).

[6] (1) State the problem; (2) Identify the goals of the study; (3) Identify the information inputs; (4) Define the boundaries of the study; (5) Develop the analytical approach; (6) Specify the tolerance on decision errors; and (7) Optimize sampling design (USEPA, 2006).

The USEPA DQO Process performed for the RSE is presented in the *RSE Work Plan*, Section 3, and identifies the purpose of the data collected as follows:

1. Background reference area soil/sediment sampling, laboratory analyses, surface gamma surveying, and subsurface static gamma measurements to establish background analyte concentrations and gamma measurements, which will be used as the ILs, for the Site.
2. Site sampling (soil and sediment), laboratory analyses, surface gamma surveying, and subsurface static gamma measurements for comparison with ILs, to define the lateral and vertical extent of contamination at the Site to characterize the Site to support future Removal or Remedial Action evaluations.

The USEPA DQO Process was used in conjunction with *MARSSIM* guidance for RSE planning and data collection. Per *MARSSIM* guidance, "planning radiation surveys, using the USEPA DQO Process, can improve radiation survey effectiveness and efficiency, and thereby the defensibility of decisions" (USEPA, 2000).

The applicable aspects of *MARSSIM* incorporated into the RSE process include:

- Historical site assessment
- Determining RSE DQOs
- Selecting background reference areas
- Selecting radiation survey techniques
- Site preparation
- Quality control
- Health and safety
- Survey planning and design
- Baseline surface gamma surveys and subsurface static gamma measurements
- Field measurement methods and instrumentation
- Media sampling and preparation for laboratory analyses

The RSE process also used applicable aspects of *MARSSIM* for interpretation of the RSE results, including:

- Data quality assessment through statistical analyses
- Evaluation of the analytical results
- Quality assurance and quality control

Sections 3.2 and 3.3 summarize the field investigation methods and procedures for data collection during the Site Clearance activities and the RSE activities, which are described in detail in the *RSE Work Plan,* Section 4. Appendix A.1 includes the radiological characterization report prepared by Environmental Restoration Group, Inc. (ERG), under contract to Stantec. Appendix B includes photographs of features at the Site and the surrounding area, Appendix C.1 includes field forms and Appendix C.2 includes borehole logs.

3.2 SUMMARY OF SITE CLEARANCE ACTIVITIES

The Site Clearance activities consisted of two tasks: a desktop study and field investigations. The desktop study was completed prior to field investigations, and the findings of the desktop study were used to guide field investigations. The Site Clearance activities are detailed in the *Site Clearance Data Report* and are described below.

3.2.1 Desktop Study

The desktop study included:

- Review of historical aerial photographs (USGS, 2016). Photographs were selected based on sufficient scale, quality, resolution, and whether the photograph met one or more of the following criteria:
    - Showed evidence of active mining or grading of the Site, or provided information on how the Site was developed or operated (e.g., haul roads and open pits).
    - Showed evidence of reclamation (e.g., soil covers).
    - Showed significant changes in ground cover compared to current photographs.
- Review of current aerial photographs for identification of buildings, homes and other structures, and potential haul roads within 0.25 miles of the Site.
- Review of topographic and geologic maps.
- Review of information related to surface water features and water wells on the Navajo Nation within a one-mile radius of the Site, provided by: (1) the Navajo Nation Department of Water Resources (NNDWR); and (2) ESRI Shapefiles data contained in the *2007 AUM Atlas*.
- Review of previous studies, information related to potential past mining, and reclamation activities.
- Identification of the predominant wind direction in the region of the Site.

Based on the list above, the following findings were identified during the desktop study:

- Historical photographs (USGS, 2016) for the Site were selected from 1952, 1956, 1991, 1997, and 2005 for comparison against a current 2017 image (Cooper, 2017). The selected historical photographs are shown in Figure 3-1a. Figure 3-1b compares the aerial photograph from 1956 and the current 2017 image. Figure 3-1c compares the aerial photograph from 1991 and the current 2017 image. Signs of mining activity, including piles of material and removal of overburden material, are present in the 1956 photograph in mine sites #1011 and #1035 (refer to Figure 3-1b). Signs of reclamation, including filling in of historical mining areas and regrading, are present in the 1991 photograph in mine sites #1011 and #1035 (refer to Figure 3-1c). From the 1991 photograph to the current 2017 photograph, the reclaimed areas appear re-vegetated, as shown in Figure 3-1c.

- The current aerial photograph review confirmed that several home-sites were located within 0.25 miles of the Site to the west, north, and east, as shown in Figure 2-1. Numerous dirt roads were identified within 0.25 miles of the Site, refer to Figure 2-1. The road type (i.e., potential haul road or road unrelated to historical mining) was identified by the current aerial photograph review, historical document review, and visual identification during the Site Clearance field investigations (refer to Section 3.2.2.1).
- Four water features were identified within a one-mile radius of the Site based on the review of information provided by the NNDWR and the *2007 AUM Atlas,* refer to Table 3-1and Figure 2-1.
- The predominant regional winds were from the northwest (refer to Section 2.2.3 and Figure 1-1).

As part of the desktop study a request was made by Stantec to NAML and New Mexico Mining and Mineral Division for any information regarding reclamation activities occurring on-site. The two departments contacted did not have any reclamation records for the Site. Previous studies and information related to past mining/exploration are discussed in Sections 2.1.1 and 2.1.4.

3.2.2 Field Investigations

3.2.2.1 Site Mapping

The *Site Clearance Work Plan* specified that the following features at and near the Site, if present, should be mapped, marked, and/or their presence confirmed:

- Claim boundaries and the 100-ft buffers of the claim boundaries
- Roads, fences/gates, utilities: haul roads to a distance of 0.25 miles or to the intersection with the next major road, whichever is closer
- Structures, homes, buildings, livestock pens, etc.
- Surface water and water well locations: surface water channels that drain the Site to a distance of 0.25 miles away from the Site or to the confluence with a major drainage, whichever is closer; surface water features and water wells identified within a one-mile radius of the Site
- Topographic features
- Potential background reference areas

- Type of ground cover, including rock, soil, waste rock, etc.
- Physical hazards

Based on the list above, the following site features were mapped during field investigations:

- Claim boundaries – 100-ft buffers of the claim boundaries, as shown in Figure 2-8, were marked in the field with stakes and/or flagging and mapped with a global positioning system (GPS).
- Topographic features – The mapped area can be divided into three primary topographic areas: the (1) mesa top; (2) mesa sidewall; and (3) plains. With the exception of the eastern portion of mine site #1035, the mesa top is a sub-horizontal surface that slopes gently to the northeast. The northeastern portion of mine site #1035 has a hummocky and irregular topography characterized by an undulating surface expression. The rim of the mesa is sinuous and dissected by gullies with several topographic prominences along the edge. The mesa sidewall is characterized by steep bedrock slopes near the top that have been undercut in areas near the base. The undercutting has created talus slopes at the transition between the mesa sidewall and the plains. The plains slope gently to the south. The topographic areas are shown in Figure 2-5 and in Appendix B-1 photograph numbers 6 and 15.
- Drainages – Numerous sub-parallel ephemeral drainages are present on-site that drained either to the northeast (on the mesa top) or to the south (in the plains), where they then terminated, as shown in Figures 2-1 and 2-8. Two of the drainages are shown in Appendix B-1 photograph number 7 and Appendix B-2 photograph number 16.
- Potential haul road – Potential haul roads were mapped, as shown in Figures 2-1 and 2-8. The potential haul roads provided access to mine sites #1011, #1012, and #1035. The potential haul roads are also shown as earthworks in Figure 2-7a and 2-7b.
- Road –Roads were mapped, as shown in Figure 2-8. The roads were dirt and provided access to home-sites or to the potential haul roads.
- Possible portal or storage area – One possible portal or storage area was mapped, as shown in Figure 2-8. The area was historically backfilled and covered with wood debris, as shown in Appendix B-1 photograph number 10. It was unknown if the possible portal or storage area was related to the historical 155 ft incline used to mine ore on-site (refer to Section 2.1.1)
- Historical boreholes – Nine historical boreholes were mapped, as shown in Figure 2-8. At least six historical boreholes were identified on mine site #1035 and were not plugged (i.e., open). The open boreholes ranged in diameter from 6 to 8 inches, and ranged in depth from 5 ft to 34 ft, based on measurements collected by field personnel with a weighted tape measure lowered into the borehole from ground surface. Some of the historical boreholes are shown in Appendix B-1 photograph numbers 13 and14. Because the boreholes were not plugged, the Agencies and Trustee decided this posed a safety risk. To mitigate the safety hazard the Trust conducted an interim closure, pursuant to the Trust provisions for interim actions. Prior to the interim closure the Trust contacted explosives experts suggested by the Agencies to investigate a potential storage area located on-site where the Agencies thought there might be unexploded munitions. On February 15, 2018, Stantec escorted three

representatives from the New Mexico State Police Bomb Squad on-site. The explosives experts assessed the potential storage area and the surrounding area and did not identify evidence of explosives or materials associated with explosives storage. After the munitions clearance, in May and July 2018, the Trust conducted the interim closure and backfilled the nine boreholes with soil. Because this work was completed separately from the RSE, it is not reported herein, and instead was reported to the Agencies in an interim action summary letter (Stantec, 2018).

- Utilities – A buried water line and a power line were mapped, as shown in Figure 2-8. The water line was not well marked and was difficult to identify. The power line connected to several home-sites and also ran across mine sites #1011 and #1035.
- Debris – Three debris piles were mapped, as shown in Figure 2-8. Contents of the center debris pile included cans, bottles, car parts/car frames, metal scraps, wood scraps pallets, wire, general construction debris, and miscellaneous trash. The center debris pile (shown in Appendix B-1 photograph number 4) filled a shallow, elongated excavation that appeared to be approximately 2 to 4 ft deep. It was not known if this excavation was related to historical mining. The northern pile contained approximately 30 to 40 tires and the southern debris pile contained more than 100 tires.
- Waste pile – Seven waste piles were mapped (Waste Pile 1 through Waste Pile 7), as shown in Figure 2-8 and Appendix B-1 photograph numbers 2, 3, 8 and Appendix B-2 photograph number 15. The waste piles consisted of gray limestone of the Todilto Formation.
- Excavation – Two excavation areas were mapped, as shown in Figure 2-8. The excavation areas were along the mesa edge, less than 10 ft deep, and were associated with Waste Pile 2 and Waste Pile 3. The excavation areas are shown as earthworks in Figures 2-7a and 2-7b. The excavation area associated with Waste Pile 2 is shown in Appendix B-1 photograph numbers 1 and 9.
- Graded/disturbed reclaimed area – Graded/disturbed reclaimed areas were mapped on mine sites #1011 and #1035, as shown in Figure 2-8. It is assumed that the areas were graded and reclaimed as part of the USEPA's 1991 ERA (refer to Section 2.1.4.2). The graded/disturbed reclaimed areas are shown as earthworks in Figures 2-7a and 2-7b.
- Potential mining disturbed areas – Four potential mining disturbed areas were mapped at, as shown in Figure 2-8. These areas are shown as earthworks in Figures 2-7a and 2-7b. Two of the disturbed areas were mapped by field personnel and were located along the mesa rim. The other two disturbed areas were identified using high resolution aerial images, and are located on the mesa top, in the central portion of the Site. Disturbed Area 3 is assumed to be the small prospect pit described in Section 2.1.4.1.
- Potential waste rock – Potential waste rock area was mapped near the mesa edge, as shown in Figure 2-8. The potential waste rock area is shown as earthworks in Figures 2-7a and 2-7b.
- Vertical mine shafts – Two unsecured vertical mine shafts were mapped, as shown in Figure 2-8. The two shafts were identified by field personnel as the primary shaft and secondary shaft. Field personnel collected measurements of the shafts using a weighted tape measure lowered into the shafts from ground surface. The primary shaft was square shaped at the

surface and measured approximately 5 ft long by 5 ft wide by approximately 28 ft deep. The secondary shaft was square shaped at the surface and measured approximately 2.5 ft long by 2.5 ft wide by 8 ft deep. Field personnel did not detect water and/or air moving inside the shafts and neither shaft appeared to be connected to underground workings. Because the shafts were unsecured, the Agencies and Trustee decided this posed a safety risk to people and animals. To immediately and temporarily mitigate the safety risk, the two shafts were surrounded by a chain link fence that measured approximately 19 ft wide by 20 ft long by 8 ft tall, had a locked gate, and barbed wire at the top. To further mitigate the safety hazard the Trust conducted an interim closure, pursuant to the Trust provisions for interim actions. In May and July 2018, the Trust conducted the interim closure and backfilled the two shafts with soil. Once the shafts were backfilled the temporary fencing was removed. Because this work was completed separately from the RSE, it is not reported herein, and instead was reported to the Agencies in an interim action summary letter (Stantec, 2018). The vertical mine shafts are shown in Appendix B-1 photograph numbers 11 and 12. It is unknown if the shafts were related to the historical 155 ft incline used to mine ore on-site (refer to Section 2.1.1). It is also unknown if the shafts were excluded from reclamation during the 1991 ERA, or if the reclamation-related backfilling of the shafts had collapsed.

- Structures – Several home-sites were located within 0.25 miles of the Site to the west, north, and east, as shown in Figure 2-1.
- Water Features – Field personnel attempted to assess the four water features identified during the desk top study but were unable to access any of the four locations because they were located on private land and behind locked gates, as summarized in Table 3-1.
- Ground cover – Ground cover and vegetation observed on-site are discussed in Sections 2.2.2.2 and 2.2.5, respectively.

Field personnel did not observe evidence of the historical underground workings reported by Weston (2009) or the historical pits discussed in Section 2.1.1. The pits were not observed because they were reclaimed during the 1991 ERA. In addition, the *2007 AUM Atlas* identified a vertical mining feature and one pit located on each of the three mine sites. The vertical mining feature located in the *2007 AUM Atlas* was in the same area as the vertical mine shafts observed by field personnel. The pits identified in the *2007 AUM Atlas* were not observed by field personnel because the *2007 AUM Atlas* located the pits in either the graded/disturbed reclaimed area (for mine sites #1011 and #1035) or the potential mining disturbed area (for mine site #1012).

In June 2018, the USEPA provided the Trust with a copy of a NNDWR database that was generated in 2018. The USEPA stated that there were discrepancies between the NNDWR water feature locations in the 2018 database and those provided in the 2016 NNDWR database used by the Trust. The USEPA provided comment that the 2018 NNDWR database indicates well 16-2-6 is within one mile of mine site #1011 and that it may need to be addressed. The 2016 NNDWR database identified well 16-2-6 outside the one-mile buffer for the Site (refer to Figure 2-1) and it was not assessed during Site Characterization. This information about the 2018 database was provided after Site Characterization activities had occurred and was therefore not included in the RSE for the Site. Comparison of the 2018 NNDWR database against the 2016 NNDWR database and the *2007 AUM Atlas* will require additional field work and it is recommended that this be addressed in future studies for the Site.

On June 28, 2018, the USEPA provided a historical "Desidero waste piles map" that showed the locations and estimated area and volumes of uranium piles, soil overburden, and debris piles across the Site (refer to Section 2.1.4.4). The USEPA confirmed this map was part of previously received report presenting a supplemental aerial photographic analysis of the Desidero mines (USEPA, 1992b), but the map was not included in the previous copy of the report. Due to the late receipt of this document, it was not evaluated for this RSE report. A copy of the map is included with the historical documents attachment. Additional analysis of this map is warranted as part of future investigations at the Site.

In addition to the Site mapping activity, the Trust took high-resolution aerial photographs and collected topographic data at the Site. The objective of the high-resolution aerial photography survey was to develop orthophotographs and topographic data of the Site to:

- Assist with identifying ground cover (e.g., soil versus bedrock)
- Assist with delineating historical mine features (e.g., haul roads, portals, and waste piles)
- Allow additional evaluation of areas that were inaccessible due to steep or unsafe terrain
- Provide site base maps (high resolution imagery and elevation data) that could be used to support future Removal or Remedial Action evaluations at the Site

Stantec proposed to perform aerial photography in order to provide an overview of the Site and identify features that could not otherwise be accomplished safely on foot. USEPA is not authorized to allow drones on sites it oversees: therefore, drone use was not an option. Although aerial photography was not included in the approved *Scope of Work* (MWH, 2016d), the Trustee notified the Agencies and obtained approval prior to commencement of the work. The Trust also consulted with Baca/Prewitt Chapter officials and nearby residents and notified them of the aerial photography survey. On June 16, 2017 Cooper flew over the Site in a piloted fixed-wing aircraft and collected 3.5-centimeter digital color stereo photographs of the Site. Cooper provided the following data:

- Digital, high-resolution color orthophotograph imagery
- AutoCAD files (2-dimensional and 3-dimensional) that included elevation contours (refer to Figure 2-4) and plan features
- Elevation point files
- Triangular Irregular Network surface files

The site orthophotographs and supporting data files were used for data analyses, including estimating volumes of potentially mining-impacted material at the Site. They also were used as the base image for selected figures included in this RSE report, to the extent applicable.

3.2.2.2 Potential Background Reference Area Evaluation

The desktop study findings and field investigation observations were used to identify eight potential background reference areas (BG-1 through BG-8) for the Site, as shown in Figure 3-2 and described in Appendix D.1. BG-1 through BG-5 were selected as suitable surface background reference areas for the Site for the following reasons:

- BG-1 encompassed an area of 1,708 ft^2 (approximately 0.04 acres), was located 521 ft west of mine site #1011, and was upwind and hydrologically cross-gradient from the Site. The thin soils and bedrock outcrops represented the portions of the Site within the Todilto Limestone. The vegetation and ground cover at BG-1 were similar to the portions of the Site on the mesa edge.

- BG-2 encompassed an area of 2,328 ft^2 (approximately 0.05 acres), was located 557 ft northwest of mine site #1011, and was upwind and hydrologically cross-gradient from the Site. The thicker soils represented the portions of the Site that consisted of undifferentiated Quaternary deposits including residual soils, alluvium, and eolian deposits. The vegetation and ground cover at BG-2 were similar to the portions of the Site on the mesa top.

- BG-3 encompassed an area of 683 ft^2 (approximately 0.02 acres), was located 618 ft west of mine site #1011, and was upwind and hydrologically cross-gradient from the Site. The thin soils, colluvium-covered slopes, and bedrock outcrops represented the portions of the Site within the Entrada Sandstone. The vegetation and ground cover at BG-3 were similar to the portions of the Site on the mesa sidewall.

- BG-4 encompassed an area of 5,623 ft^2 (approximately 0.13 acres), was located 1,387 ft west of mine site #1012, and was upwind and hydrologically cross-gradient from the Site. The soils represented the portions of the Site that consisted of undifferentiated Quaternary deposits on the plains below the mine site boundaries. The vegetation and ground cover at BG-4 were similar to the areas of the Site on the plains.

- BG-5 encompasses an area of 1,151 ft^2 (approximately 0.03 acres), was located 1,447 ft southwest of mine site #1012, and was upwind and cross-gradient from the Site. The sediments represented the portions of the Site that consisted of Quaternary alluvium in the drainages. The vegetation and ground cover at BG-5 were similar to the alluvial drainages on the plains.

- BG-6 encompasses an area of 2,957 ft^2 (approximately 0.07 acres), was located 1,017 ft west of claim #1012, was upwind and hydrologically cross-gradient from the Site, and across multiple drainage divides. The thin soils, colluvium-covered slopes, and bedrock outcrops represented the portions of the survey areas within the Wingate Sandstone on the plains. The vegetation and ground cover at BG-6 were similar to the portions of the Site where the mesa sidewall transitions to the plains.

BG-7 and BG-8 were not selected as background reference areas for the Site for the reasons described in Appendix D.1. Separate background reference areas were identified for the Quaternary deposits (BG-4) in the plains area and the Quaternary alluvium in the drainages

(BG-5) within the plains area. The Agencies have suggested that additional study may be required to develop a background reference area for the plains area (NNEPA, 2018).

The potential background reference areas were selected based on *MARSSIM* guidance (i.e., similar geology and ground conditions, distance from the Site, etc.) to:

1. Represent undisturbed conditions at the Site (e.g., pre-mining conditions)

2. Provide a basis for establishing the ILs

The approved *RSE Work Plan* did not specify any minimum or maximum size criteria for these areas. Stantec does not view the size of the selected background reference areas as affecting the validity of the background concentrations. The sizes were based on professional judgment that the identified areas were generally representative of the Site.

The background reference areas were selected in areas outside of the Site that were considered to be representative of the general conditions observed at the Site. However, an important consideration is that the background gamma radiation and metals concentrations within soil and bedrock can be variable and often contain a wider range of concentrations than what was measured at the selected background reference areas. The ILs derived from the background reference areas provide a useful reference for comparison to the Site. However, it will be important to consider the variations in concentrations when conducting site assessment work and/or to support future Removal or Remedial Action evaluations at the Site.

3.2.2.3 Biological Surveys

The objective of the biological surveys was to determine if identified species of concern or potential federal or Navajo Nation Threatened and Endangered (T&E) species and/or critical habitat are present on or near the Site. Biological (vegetation and wildlife) clearance was required at the Site before RSE activities could begin to determine if the RSE activities could affect potential species of concern or federal or Navajo Nation listed T&E species and/or critical habitat. The Site biological evaluation reports, the *NNDFW Biological Resources Compliance Form*, and the US Fish and Wildlife Service (USFWS) consultation email are provided in Appendix E.

The Federal Endangered Species Act (ESA) of 1973, 16 United States Code (USC) §1531 et seq., requires that each Federal agency confer with the USFWS on any agency action that is likely to jeopardize the continued existence of any proposed T&E species or result in the destruction or adverse modification of critical habitat proposed to be designated for such species (15 USC §1531(a)(2); USFWS, 1998). An "action area", as defined in the regulations implementing the ESA, includes "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" (50 CFR §402.2; USFWS, 1998).

The vegetation and wildlife surveys were conducted according to guidelines of the ESA and the NNDFW-Navajo Natural Heritage Program (NNHP), including the procedures set forth in the Biological Resource Land Use Clearance Policies and Procedures, RCS-44-08 (NNDFW, 2008), the

Species Accounts document (NNHP, 2008), and the USFWS survey protocols and recommendations (USFWS, 1996).

Based on the results of the vegetation and wildlife surveys, the NNDFW's opinion was that the RSE Baseline Studies and Site Characterization Activities,

> "with applicable conditions, [were] in compliance with Tribal and Federal laws protecting biological resources including the Navajo Endangered Species and Environmental Policy Codes, US Endangered Species, Migratory Bird Treaty, Eagle Protection and National Environmental Policy Acts".

A copy of the *NNDFW Biological Resources Compliance Form* is included in Appendix E. In addition, after the Trust submitted the results of the biological survey, USEPA consulted with John Nystedt of the USFWS on August 26, 2016, and received an email response on August 29, 2016 stating:

> "Based on the information you [Stantec] provided [i.e., there is no habitat for any Federally listed species in the action area], we [the USFWS] believe no endangered or threatened species or critical habitat will be affected by the project; nor is this project likely to jeopardize the continued existence of any proposed species or adversely modify any proposed critical habitat" (Nystedt, 2016).

A copy of the Nystedt email is included in Appendix E. In light of the results of the biological surveys described below, the USFWS recommended no further action from the USFWS for the project unless the project or regulations change, or a new species is listed.

Vegetation Survey - In July 2016, Redente performed a summer vegetation survey as part of the Site Clearance field investigations. Complete details of the vegetation survey, including the *NNDFW Biological Resources Compliance Form*, are included in Appendix E and summarized below.

In preparation for the vegetation survey, Redente submitted data requests for species of concern to the NNDFW and NNHP, and for Federal T&E species, to the USFWS. The NNDFW-NNHP responded to MWH by letter dated November 19, 2015. The letter provided a list of species of concern known to occur within the proximity of the Site and included their status as either Navajo Nation Endangered Species List (NNESL), and/or Federally Endangered, Federally Threatened, or Federal Candidate. The NNESL species were further classified as G2, G3, or G4[7]. A copy of this letter is included in Appendix E. A spring vegetation survey was not required for the Site because the species of concern data provided by NNDFW-NNHP did not include listed potential plant species that require a spring survey.

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[7] G2 classification includes endangered species or subspecies whose prospect of survival or recruitment are in jeopardy, G3 classification includes endangered species or subspecies whose prospect of survival or recruitment are likely to be in jeopardy in the foreseeable future, and G4 classification are "candidates" and includes those species or subspecies which may be endangered but for which sufficient information is lacking to support being listed (refer to Appendix E).

The NNDFW listed one T&E plant species that may occur on-site; Parish's alkali grass (G4). The USFWS also listed one T&E plant species that may occur on-site: Zuni fleabane (threatened). Parish's alkali grass is a native annual grass that grows in a series of widely discontinuous populations ranging from southern California to eastern Arizona and western New Mexico in alkaline seeps, springs and seasonally wet areas and washes at elevations from 5,000 ft to 7,200 ft amsl. Zuni fleabane is found on fine textured clay hillsides from clays derived from the Chinle Formation in the Zuni and Chuska Mountains, and in similar clays of the Baca Formation in the Datil and Sawtooth ranges in New Mexico, at mid to high elevations from 7,000 ft to 8,300 ft amsl.

Before beginning the Site vegetation surveys, Redente reviewed the ecologic and taxonomic information for the T&E species to understand ecological characteristics of the species, habitat requirements, and key taxonomic indicators for proper identification (Arizona Native Plant Society, 2000). Redente also reviewed currently accepted resource agency protocols and guidelines for conducting and reporting botanical inventories for special status plant species (USFWS, 1996). An experienced Redente botanist with local flora knowledge conducted the rare plant survey. The botanist walked transect lines on the Site with emphasis on areas with suitable habitat for Navajo sedge, specifically alkaline seeps and fine-textured clay hillsides.

The Redente botanist did not identify either of the two T&E species at the Site, based on observations they made during the on-site survey. The botanist concluded they did not identify any of the T&E species at the Site because the Site was not a likely habitat for the T&E species. Observed vegetation communities on-site are predominantly sparsely vegetated grassland with sporadic shrubs and scattered pinyon/juniper in the eastern and southernmost areas.

Wildlife Survey - In May 2016, Adkins performed a wildlife evaluation survey as part of the Site Clearance field investigations. The completed wildlife survey, including the *NNDFW Biological Resources Compliance Form*, are included in Appendix E and are summarized below.

Adkins performed the survey under a permit issued by NNDFW for the purpose of assessing habitat potential for ESA-listed or NNESL animal species. Adkins biologists with experience identifying local wildlife species led the field survey, which consisted of walking transects 10 ft apart throughout the Site, including a 100-ft buffer beyond the claim boundaries. The surrounding areas were visually inspected with binoculars for nests, raptors, or signs of raptor use.

The wildlife evaluation was performed for species listed as NNESL, Federally Endangered, Federally Threatened, or Federal Candidate, and species protected under the Migratory Bird Treaty Act (MBTA) that have the potential to occur on-site. Prior to the start of the wildlife survey, Adkins submitted data requests to USFWS and NNDFW for animal species listed under the ESA. The NNESL species were further classified as G2, G3, or G4. The USFWS included four ESA-species with the potential to occur in the area of the Site; three birds (southwestern willow flycatcher, Mexican spotted owl, and western yellow-billed cuckoo), and one fish (Zuni bluehead sucker). The NNDFW included: four birds (mountain plover [G4], western burrowing owl [G4], golden eagle [G3], and American peregrine falcon [G4]), and one mammal (black-footed ferret [endangered]). All species on the USFWS list and all species from the NNDFW list, with the exceptions of the golden eagle and American peregrine falcon, were eliminated from further evaluation because there was no potential for those species to occur on the Site due to lack of suitable habitat. Based on the preparation data, two birds remained as species of concern warranting further analysis during the survey: golden eagle and American peregrine falcon.

In addition, Adkins reviewed species protected under the MBTA that have the potential to occur in the area of the Site. The MBTA review resulted in the potential for identification of 16 bird species in addition to those listed above, known as priority birds of conservation concern with the potential to occur in the areas of the Site: black-throated sparrow, Brewer's sparrow, gray vireo, loggerhead shrike, mountain bluebird, mourning dove, sage sparrow, sage thrasher, scaled quail, Swainson's hawk, vesper sparrow, bald eagle, Bendire's thrasher, pinyon jay, prairie falcon, and ferruginous hawk. These 16 MBTA bird species were added for further analysis during the survey for effects to potential habitat.

The wildlife survey revealed two NNESL species of concern that had the potential to occur within or near the Site based on habitat suitability or actual recorded observation: golden eagle and American peregrine falcon. Based on these findings Adkins recommended the use of best management practices to protect potential habitat during RSE activities, specifically: (1) confining equipment travel to within the boundaries of the Site; (2) minimizing travel corridors as much as possible; (3) limiting truck and equipment travel within the Site when surfaces are wet and soil may become deeply rutted; and (4) using previously disturbed areas for travel when possible. The recommended best management practices were followed to protect potential habitat during RSE activities.

3.2.2.4 Cultural Resource Survey

In May 2016, Dinétahdóó conducted a cultural resource survey as part of the Site Clearance field investigations. Navajo Nation Historic Preservation Department (NNHPD) issued a Class B permit to Dinétahdóó to conduct the cultural resource survey. Following the cultural resource survey, the NNHPD issued a Cultural Resources Compliance Form that included a "Notification to Proceed" with RSE field work. A copy of the Cultural Resources Compliance Form is included in Appendix E. According to NNHPD, this form is the equivalent of a "permit" to conduct the work (NNHPD, 2018).

The survey included the areas of the claim boundaries and the 100-ft claim boundary buffer, as shown in Figure 2-8. Dinétahdóó did not survey areas on steep terrain due to safety concerns. The survey identified one archaeological site, two isolated occurrences, and one in-use site. For confidentiality reasons, details regarding the cultural resource survey findings are not provided herein NNHPD can be contacted for additional information. NNHPD contact information is located on the *Cultural Resource Compliance Form* included in Appendix E.

Based on the survey findings Dinétahdóó recommended archaeological clearance for the area surveyed, with the stipulation that testing and drilling would be halted if any cultural resources were encountered. Stantec complied with Dinétahdóó's recommendations while conducting RSE activities on–site and drilling did not need to be halted.

Dinétahdóó also escorted field personnel during: (1) the collection of subsurface soil/sediment samples at the background reference areas (refer to Section 3.3.1.1); and (2) during Site Characterization borehole subsurface soil/sediment sample collection in locations outside the 100-ft buffer (refer to Section 3.3.2.2). The Trust and NNHPD agreed that Dinétahdóó's archeologist would be present because the subsurface sample locations were outside of the area originally surveyed during the Site Clearance cultural resource survey.

3.3 SUMMARY OF REMOVAL SITE EVALUATION ACTIVITIES

The RSE activities consisted of two separate tasks: Baseline Studies and Site Characterization activities. The Baseline Studies included a Background Reference Area Study, Site gamma survey, and Gamma Correlation Study. The results of the Baseline Studies were used to plan and prepare the Site Characterization field investigations, which included surface and subsurface soil and sediment sampling. Results of the RSE activities are presented in Section 4.0 and Baseline Studies and Site Characterization activities are summarized in Sections 3.3.1 and 3.3.2, respectively.

3.3.1 Baseline Studies Activities

3.3.1.1 Background Reference Area Study

The Background Reference Area Study activities were completed at the background reference areas selected for the Site. Refer to Section 3.2.2.2 for an explanation of the selection of the background reference areas for the Site. The Background Reference Area Study included a surface gamma survey, static surface and subsurface gamma measurements, surface soil/sediment sampling, and subsurface soil/sediment sampling. The soil/sediment sample locations in the background reference areas were initially selected using a triangular grid, set on a random origin. Where possible, samples were collected at the center points of the triangles. However, in some instances, the actual sample locations had to be moved in the field if sampling was not possible (e.g., the location consisted of exposed bedrock or there was a large bush blocking access). In these cases, the closest accessible location was selected instead.

The background reference areas were selected based on a variety of factors, including *MARSSIM* criteria, which indicated whether the areas were representative of unmined locations, regardless of the sizes of the areas. These factors are described in this RSE report and accompanying appendices. The objectives of the background reference area study were to measure gamma radiation levels emitted by naturally occurring, undisturbed uranium-series radionuclides, and concentrations of other naturally occurring constituents. The results were used to establish background gamma levels and concentrations of Ra-226 and specific metals (uranium, arsenic, molybdenum, selenium, and vanadium). The soil/sediment sampling locations at the background reference areas are presented in Figures 3-3a and 3-3b. Field personnel performed the Background Reference Area Study in accordance with the *RSE Work Plan,* Sections 4.2, 4.4, and 4.5.

Initial surface gamma surveys at BG-1 and BG-2 were completed in May 2016 using a Ludlum Model 44-20 2-inch by 2-inch sodium iodide (NaI) high-energy gamma detector. Following discussions with the Agencies, it was identified that 3-inch by 3-inch NaI detectors (the detectors) would be used at the Site so the results could be more directly compared to the E&E Removal Assessment (refer to Section 2.1.4.7). Of note, 3-inch by 3-inch NaI detectors produce higher gamma count rates than 2-inch by 2-inch NaI detectors (when measuring an identical source) due to the higher volume of a 3-inch by 3-inch NaI detector (344.8 cubic centimeters [cm^3]) resulting in more gamma interactions when compared to the 2-inch by 2-inch NaI detector (104.2 cm^3). Gamma measurements from a 3-inch by 3-inch NaI detector are not directly comparable to measurements collected by a 2-inch by 2-inch NaI detector. BG-1 and BG-2 were re-surveyed using 3-inch by 3-inch detectors as described below. Each detector was coupled to a Ludlum Model 2221 ratemeter/scaler that in turn was coupled to a Trimble ProXRT GPS unit with a NOMAD 900 series datalogger. The detector tagged individual gamma measurements with associated geopositions recorded using the Universal Transverse Mercator Zone 12 North coordinate system. ERG matched and calibrated the detector to a National Institute of Standards and Technology-traceable cesium-137 check source, and function-checked the equipment prior-to and after each workday. ERG performed the surveys by walking the background reference areas with the detector carried by hand, along transects that varied depending on encountered topography. The gamma measurements were collected with the height of the detector varying from 1ft to 2 ft above ground surface (ags) with an average height of 1.5 ft ags to accommodate vegetation, rocks, or other surface features. If field personnel encountered an immovable obstruction (e.g., a tree) during the surface gamma surveys they went around the obstruction. Subsequent to each workday, ERG downloaded the gamma measurements to a computer and secure server. The surface gamma surveys at the background reference areas were completed using 3-inch by 3-inch NaI detectors in March, June, and September 2017 (refer to Appendix D.1).

ERG used Ludlum Model 44-10 2-inch by 2-inch NaI gamma detectors to collect static one-minute gamma measurements at the ground surface and down-hole (subsurface) at borehole locations S1011-BG1-011 (BG-1), S1011-BG2-011 (BG-2), S1011-BG2-011 (BG-3), S1011-BG4-011 (BG-4), and S1011-BG5-011 (BG-5). Refer to Appendix C.2 for borehole logs. These were different detectors than what was used for the surface gamma surveys. Static gamma measurements were categorized as surface measurements where they were collected at ground surface (0.0 ft) and as subsurface measurements where depths were below ground surface due to the influence of downhole geometric effects on subsurface static gamma measurements (refer to Section 4.1). Gamma measurements were collected according to the methods described in the *RSE Work Plan,* Section 4.2 and Appendix E.

Soil/sediment samples collected as part of the background study are detailed in Table 3-2 and sample locations are shown in Figures 3-3a and 3-3b. Soil/sediment samples were categorized as surface samples where sample depths ranged from 0.0 to 0.5 ft bgs and as subsurface samples where sample depths were greater than 0.5 ft bgs. Samples collected in drainages were classified as sediment samples. Field personnel collected the following samples from the background reference areas:

- BG-1 – In November 2016 and March 2017, 11 surface soil grab samples were collected from 11 locations and one subsurface soil grab sample was collected from borehole S1011-BG1-011.
- BG-2 – In November 2016 and March 2017, 11 surface soil grab samples were collected from 11 locations and one subsurface soil grab sample was collected from borehole S1011-BG2-011.
- BG-3 – In September 2017, 11 surface soil grab samples were collected from 11 locations. A borehole could not be advanced beyond 0.25 ft bgs at S1011-BG3-011, so no subsurface samples were collected at BG-3.
- BG-4 – In September 2017, 11 surface soil grab samples were collected from 11 locations and one subsurface soil composite sample was collected from borehole S1011-BG4-011.
- BG-5 – In September 2017, 11 surface sediment grab samples were collected from 11 locations and one subsurface sediment composite sample was collected from borehole S1011-BG5-011.

The lack of subsurface soil samples from BG-3 will not affect the derivation of Ra-226 or metal ILs because the Ra-226 and metals ILs (i.e., surface and subsurface) were based on surface soil samples (refer to Section 4.1).

A gamma survey was completed in BG-6 in June 2017; however, soil samples were not collected. Based on review of the RSE results it was determined that mining-related impacts extend onto the Wingate Sandstone along the base of the mesa sidewall. Because of these findings, the lack of soil samples from BG-6 in the Wingate Sandstone was identified as a data gap and is included in Section 4.9.

Samples were shipped to a USEPA approved laboratory, ALS Environmental Laboratories in Fort Collins, Colorado for analyses. Samples were collected according to the methods described in the *RSE Work Plan,* Section 3.8.1.1. The results of the surface gamma survey, static surface and subsurface gamma measurements, and surface and subsurface soil/sediment sample analytical results provided background reference data to guide the Site Characterization surface and subsurface soil/sediment sampling (refer to Section 3.3.2). The Background Reference Area Study results are presented in Section 4.1. The ERG survey report in Appendix A.1 provides further details on the gamma surveys. Field forms, including borehole logs, are provided in Appendix C.1 and C.2.

3.3.1.2 Site Gamma Radiation Surveys

Baseline Studies activities included a surface gamma survey of the Site in accordance with the *RSE Work Plan,* Section 4.2 and Appendix E. Approximately 10.1 acres of the Site were not surveyed during the surface gamma survey because field personnel were unable to safely access these areas, as shown on Figure 3-4. Field personnel also did not survey the area located in-between the northern most boundary of mine sites #1011 and #1035 and the northern most fence line because the landowner north of these mine sites did not allow access. These are identified as data gaps in Section 4.9. In addition, along the stretch of the northern potential haul road that extends between mine sites #1011 and #1035 (approximately 850 ft), only the approximate centerline of the road was surveyed, but the shoulders were not due to miscommunication with the field personnel. This is identified as a potential data gap in Section 4. 9.

Appendix E of the *RSE Work Plan* stated that gamma measurements would not be collected in the same areas where E&E had previously collected gamma measurements. However, Stantec decided to collect limited gamma measurements in the areas scanned by E&E to assess the potential variability between gamma measurements collected by E&E versus gamma measurements collected for this RSE. Based on the comparison, Stantec decided there was enough variability in the two gamma measurement sets that instead of using the gamma measurement data collected by E&E, Stantec would perform a gamma scan of the Site and also scan those areas previously scanned by E&E.

The surface gamma survey was used as the primary method to evaluate the extent of potential mining-related impacts or areas containing elevated radionuclides associated with uranium mineralization. In addition, surface and subsurface soil and sediment samples were also collected and used to evaluate mining-related impacts (refer to Section 3.3.2).

In March and September 2017, the surface gamma survey was performed using the methods and 3-inch by 3-inch detector equipment described in Section 3.3.1.1, with the exception that the detector was carried in a backpack when topographical features did not allow field personnel to carry the detector by hand for safety reasons. The surface gamma survey included the mine site areas (with the exception of areas on adjacent mine sites #364 and#363 located next to mine sites #1011 and #1035, respectively), and roads and drainages out to approximately 0.25 miles from the Site. The *RSE Work Plan* specified that the surface gamma survey would be an iterative process where the surface gamma survey would be extended laterally until gamma measurements appeared to be within background levels. Subsequent to each workday, the gamma measurements were evaluated by ERG and Stantec, and compared to the background reference areas to determine if additional surface gamma surveying was needed. The surface gamma survey was extended to include the areas between mine sites #1012 and #1035, additional areas along the mesa edge, the mesa sidewall, and the plains south of the Site.

The full extent of the surface gamma survey is referred to as the Survey Area, as shown in Figure 3-4. The Survey Area was 101.3 acres and was subdivided into five separate survey areas, as shown in Figure 3-4, based on *MARSSIM* criteria, including different geologic conditions on-site. Survey Area A is within the Todilto Limestone (based on BG-1), Survey Area B is within the Quaternary deposits on the mesa top (based on BG-2), Survey Area C is within the Entrada Sandstone (and Wingate Sandstone) on the mesa sidewall (based on BG-3), Survey Area D is within the Quaternary deposits on the plains (based on BG-4), and Survey Area E is within the Quaternary alluvium in the drainages (based on BG-5). Of note, the Wingate Sandstone is included in Survey Area C, but it is identified as a data gap that samples were not collected from the Wingate Sandstone and the background for the Wingate Sandstone needs to be further evaluated.

It was necessary to subdivide the Survey Area based on geologic conditions and present the findings in Section 4.0 based on the subdivision, because geologic formations can have different geochemical compositions (i.e., gamma levels and concentrations of Ra-226, uranium, arsenic, molybdenum, selenium, and vanadium). The surface gamma survey results are presented in Section 4.2. A photograph, showing elevated gamma measurements collected from the Todilto Formation, is provided in Appendix B-1 photograph number 5. The ERG survey report in Appendix A.1 provides further detailed information on the surface gamma survey.

3.3.1.3 Gamma Correlation Study

Baseline Studies activities included a Gamma Correlation Study in accordance with the *RSE Work Plan,* Section 4.3. The objectives of the Gamma Correlation Study were to determine correlations between the following constituents to be used as screening tools for site assessments:

- Gamma measurements (in cpm) and concentrations of Ra-226 in surface soils (in pCi/g)
- Gamma measurements (in cpm) and exposure rates (in μR/hr)

Two regression analyses were conducted for these correlations. The first regression analysis was performed using co-located high-density surface gamma measurements and laboratory concentrations of Ra-226 in surface soil to develop a correlation equation (refer to Section 4.2.2). The correlation equation allows for Ra-226 concentrations in soil and sediment to be estimated (predicted) based on gamma measurements in the field.

This correlation equation was not used in the field to estimate Ra-226 concentrations or to evaluate the extent of Ra-226 concentrations. The correlation was used to develop a site-specific prediction for Ra-226 concentrations from the actual gamma survey data, and was compared to actual concentrations from the soil/sediment samples to evaluate the usability of the correlation for future Removal or Remedial Action evaluations, as presented in Section 4.2.2. The correlation can be used as a site-specific field screening tool during site assessments, using the same gamma survey methods as in this RSE (e.g., walkover gamma survey) and based on site-specific conditions. The data related to the correlations are provided in Appendices A.1 and C.

The second regression analysis was performed using co-located static one-minute gamma measurements and exposure rates to develop an exposure-rate correlation equation. Exposure rates can be predicted, based on gamma measurements, using the developed exposure-rate correlation equation. The exposure rate correlation also provides a standard by which future gamma measurements can be compared to previous gamma measurements, if those previous gamma measurements were also correlated with exposure. In addition, exposure rates can be used to provide an estimate of gamma radiation levels when an exposure meter is used as a health and safety tool for field personnel working on-site. The exposure rate correlation was not used for Site Characterization. Because the exposure rates are used as a health and safety tool, and are not part of the data analyses for the RSE report, a summary of the exposure rate correlation is not presented in this report. Appendix A.1 provides a discussion of the correlations and the regression equations for both correlations.

In March 2017, field personnel identified five areas for the Gamma Correlation Study, as shown in Figure 3-5, by considering the results of the Site surface gamma survey (described in Section 3.3.1.2), field conditions (e.g., suitable terrain), and feasibility of sampling. To minimize variability when determining a correlation between gamma measurements (in cpm) and concentrations of Ra-226 in soil, the study area soils must: (1) represent a specific gamma measurement within the range of gamma measurements collected at the Survey Area; and (2) be as homogenous as possible with respect to soil type, and gamma measurement within the correlation area. At each area, field personnel completed a high-density surface gamma survey (intended to cover 100 percent of the survey area) and collected one five-point composite surface soil sample per area (refer to Table 3-2). Field personnel made a field modification from the *RSE Work Plan* by adjusting the size of the 900 ft^2 area smaller at four of the Gamma Correlation Study locations, to minimize the variability of gamma measurements observed. The area used for the Gamma Correlation Study is shown in Figure 3-5, where the box shown at the five study locations represents a 900 ft^2 area in comparison to the actual area covered for the study, as shown by the extent of the gamma measurements within each area.

Field personnel collected, logged, classified, packaged, and shipped the samples in accordance with the *RSE Work Plan,* Sections 4.4, 4.9, 4.11, and Appendix E. Soil samples were collected for analyses of Ra-226 and isotopic thorium, as described in the *RSE Work Plan,* Section 3.4.1.

The objectives of the thorium analyses were for site characterization and evaluation of potential effects of thorium on the correlation. The data can be used to assess the potential effects of thorium-232 (Th-232) series radioisotopes on the correlation of gamma measurements to concentrations of Ra-226 in surface soils (i.e., if gamma-emitting radioisotopes in the Th-232 series, such as actinium-228, lead-212, and thallium-208, are impacting gamma measurements at the Site), as discussed in Section 4.2.2. Uranium, radium, and thorium occur in three natural decay series (uranium-238 [U-238], Th-232, and U-235), each of which include significant gamma emitters (USEPA, 2007b). Therefore, in order to develop a correlation between gamma radiation and Ra-226 concentrations, the gamma radiation from each significant decay series present at the Site, may need to be taken into account. Typically, only U-238, and sometimes Th-232, are present in significant quantities. The contribution from the U-235 decay series can be excluded because U-235 is only approximately 0.72 percent of the total uranium concentration. If the Th-232 decay series is present in significant quantities, it should be accounted for in the correlation to accurately predict Ra-226 concentrations based on all significant sources of gamma radiation.

3.3.1.4 Secular Equilibrium

The Gamma Correlation Study soil samples (refer to Section 3.3.1.3) were also analyzed for thorium-230 (Th-230), in accordance with the *RSE Work Plan,* Section 3.4.1. The activities of Th-230 and Ra-226 can be compared to evaluate the status of secular equilibrium within the U-238 decay series (USEPA, 2007b). The U-238 decay series is in secular equilibrium when the radioactivity of a parent radionuclide (e.g., U-238) is equal to its decay products (refer to Appendix A.1). If the U-238 decay series is out of secular equilibrium, the quantities of the daughter products become depleted. This could be considered for potential site assessments (e.g., when evaluating the contribution of the daughter products to the total risk related to U-238 during a human health and/or ecological risk assessment). As part of the RSE, the secular equilibrium evaluation was a general indicator (e.g., screening level assessment) of the status of equilibrium at the sites. It was not used to characterize the extent of constituents of potential concern (COPCs) at the Site. The secular equilibrium evaluation is discussed here only because Th-230 was included in the isotopic thorium analysis.

3.3.2 Site Characterization Activities and Assessment

3.3.2.1 Surface Soil and Sediment Sampling

Site Characterization activities included surface soil and sediment sampling and associated laboratory analyses. The soil/sediment surface sampling locations within the Survey Area were selected based on professional judgment (i.e., non-randomly) to evaluate concentrations of Ra-226 and metals in relation to the surface gamma survey measurements and site features (e.g., historical mining features and geologic features). Based on the surface gamma survey results and site features, a limited number of samples were collected and analyzed where the gamma survey measurements were within background levels, mining and or exploration-related features were not present, and no ground disturbance was observed. The results were compared to the site-specific ILs and published regional concentrations to support the overall evaluation of potential mining impacts (refer to Section 4.3). Soil/sediment samples were categorized as surface samples where sample depths ranged from 0.0 to 0.5 ft bgs and as subsurface samples where sample depths were greater than 0.5 ft bgs. Samples collected in drainages were classified as sediment samples.

In December 2016 and May, June, and September 2017, samples were collected from the locations shown in Figure 3-6a and are summarized in Table 3-2. Sample locations and the locations of mining-related features are shown in Figure 3-6b. The number of surface samples collected within specific mine features are listed in Table 3-3. Fifty-nine surface soil/sediment grab samples were collected from 59 locations in the Survey Area (five from Survey Area A, 42 from Survey Area B, two from Survey Area C, three from Survey Area D, and seven from Survey Area E).

Field personnel collected, logged, classified, packaged, and shipped the samples in accordance with the *RSE Work Plan,* Sections 4.4, 4.9, 4.11, and Appendix E. Samples were shipped to ALS Environmental Laboratories in Fort Collins, Colorado for analyses of: Ra-226, uranium, arsenic, molybdenum, selenium, and vanadium, as described in the *RSE Work Plan,* Section 4.13.1. The surface soil/sediment analytical results are presented in Section 4.3. Field forms are provided in Appendix C.1 and the laboratory analytical data, data validation reports, and Data Usability Report for the analyses are provided in Appendix F.

3.3.2.2 Subsurface Soil and Sediment Sampling

Site Characterization activities included subsurface soil/sediment sampling and associated laboratory analyses. Similar to the surface soil/sediment sampling discussed in Section 3.3.2.1, subsurface sampling locations were selected based on professional judgment (i.e., non-randomly) to evaluate concentrations of Ra-226 and metals in relation to the surface gamma survey measurements and site features (e.g., historical mining features and geologic features). Grab samples were collected with the intent to characterize specific intervals of interest (e.g., material within zones with elevated static gamma measurements). Composite samples were collected to provide a screening level assessment across an interval (e.g., where historical mining features were located). The usefulness of a composite sample may be limited when the sample is collected over an interval with varying soil or rock types or is excessively long (e.g., greater than 5 ft), which tends to dilute the constituent concentrations or sample heterogeneity. Additionally, surface and subsurface static gamma measurements were collected in the boreholes using the 2-inch by 2-inch detector as described in Section 3.3.1.1. Static gamma measurements were collected by holding the detector in the borehole for a one-minute integrated count and are not comparable to the surface gamma survey measurements, which were collected as a walkover survey.

Subsurface samples were collected by advancing subsurface boreholes to a desired sample depth using either a 3-inch diameter hand auger or a Geoprobe™ 8140LC rotary sonic drilling rig. Field personnel advanced the hand auger to the desired sample depth manually, or the sonic drilling rig advanced the boreholes to the desired sample depth. The sonic drilling rig was equipped with a 4-inch diameter sonic core barrel that used cutting rotation and vibration to advance the boreholes. The sonic drilling method is ideal for use in rocky soils to obtain continuous samples in materials that are difficult to sample using other drilling methods (ASTM, 2016) and it recovers a continuous and relatively undisturbed core sample for review and analysis that is representative of the lithological column at that borehole location (refer to Appendix C.2).

Forty-four boreholes were advanced in the Survey Area (two in Survey Area A, 33 in Survey Area B, one in Survey Area C, three in Survey Area D, and five in Survey Area E). Boreholes were advanced until: (1) refusal at bedrock/hard surface; or (2) termination within bedrock; or (3) termination within undisturbed native material. Borehole depths ranged from 0.2 ft bgs to 22 ft bgs, and the depth of unconsolidated deposits to bedrock in boreholes ranged from 0.2 ft bgs to 20 ft bgs. The boreholes were advanced through poorly and well graded sand and/or gravel, with varying amounts of silt, clay and cobbles, mudstone, claystone, sandstone, shale, and limestone (refer to Appendix C.2 for borehole logs). Subsurface sampling was limited on the mesa sidewall due to unsafe terrain.

In December 2016 and May, June, and September 2017, samples were collected from the locations shown in Figure 3-6a and are summarized in Table 3-2. Sample locations and the locations of mining-related features are shown in Figure 3-6b. The number of subsurface samples collected within specific mine features are listed in Table 3-3. Sixty-four subsurface samples (61 soil/sediment and three soil/bedrock) were collected from 40 borehole locations in the Survey Area. Multiple samples were collected from many of the boreholes. Three subsurface samples were collected from Survey Area A, 50 from Survey Area B, one from Survey Area C, two from Survey Area D, and eight from Survey Area E.

Two cross-sections for the Site were produced using the subsurface borehole information, as shown in Figures 2-9a and 2-9b (refer to Section 2.2.2.2). Cross-section A-A' (refer to Figure 2-9a) is oriented roughly north-south. Lithological descriptions from seven boreholes (refer to Appendix C.2), in conjunction with surface geology observations made by field personnel, were used to model the north-south extent of unconsolidated earthworks and subsurface geology in the central area of mine site #1035. Cross-section B-B' (refer to Figure 2-9b) is also oriented roughly north-south. Lithological descriptions from six boreholes (refer to Appendix C.2) in conjunction with surface geology observations made by field personnel, were used to model the north-south extent of unconsolidated earthworks and subsurface geology in the eastern area of mine site #1035. The depth to bedrock along cross-section A-A' ranged from 3 ft bgs to 18 ft bgs and the average depth to bedrock increased from north to south. The depth to bedrock along cross-section B-B' ranged from 3 ft bgs to 20 ft bgs and the average depth to bedrock increased in the central portion of B-B'.

Field personnel logged, classified, packaged, and shipped the samples in accordance with the *RSE Work Plan,* Sections 4.5, 4.9, 4.11, and Appendix E. Samples were shipped to ALS Environmental Laboratories in Fort Collins, Colorado for analyses of Ra-226, uranium, arsenic, molybdenum, selenium, and vanadium, as described in the *RSE Work Plan,* Section 4.13.1. The subsurface analytical results are presented in Section 4.3. Field forms, including borehole logs showing static gamma measurements and Ra-226 analytical results, are provided in Appendix C.2. The laboratory analytical data, data validation reports, and Data Usability Report for the analyses are provided in Appendix F.

3.3.2.3 Water Sampling

According to the *RSE Work Plan*, Site Characterization activities were to include surface water and/or well water sampling, and associated laboratory analyses, of water features identified during the Site Clearance desktop study (refer to Section 3.2.1). The results of the analyses may be used to evaluate whether there are mining-related impacts to identified water feature(s). From the desktop study, four well water features were identified, as shown in Table 3-1 and Figure 2-1. Field personnel observed that the four identified water features were located behind locked gates and on private property (i.e. non-Navajo Nation lands). In addition, based on information provided by the USEPA Region 6, two of the water wells were never drilled (refer to Table 3-1). The other two identified water wells were not sampled because they were located behind locked gates on private property.

3.3.2.4 Geophysical Survey

Site Characterization activities included conducting the following geophysical surveys: (1) an electrical resistivity; and (2) a multi-channel analysis of surface waves (MASW). The geophysical surveys were performed in response to field personnel discovering open vertical shafts and boreholes at the Site (refer to Section 3.2.2.1). The geophysical surveys were conducted to assist with identifying any potential mine-related subsurface voids or tunnels, because open voids, tunnels, etc. could pose a safety risk at the Site. In addition, the results of the geophysical surveys can be used to support the identification of: (1) material type of unconsolidated deposits; and (2) depth of unconsolidated deposits to bedrock. A summary of the interpretation of the geophysical survey results is presented in Section 4.8.

Although geophysical surveys were not included in the *Scope of Work* (MWH, 2016d), the Trustee notified the Agencies and obtained approval prior to work commencing the survey. The Baca/Prewitt Chapter officials and nearby residents were consulted and notified of the additional field work. Between June 12 and June 19, 2017, Hydrogeophysics Inc. (HGI), under contract to Stantec, performed the geophysical surveys at mine sites #1011 and #1035. HGI's geophysical characterization report, included in Appendix A.2. The report provides a complete description of the geophysical survey objectives, theory, methods, and results and interpretation. The geophysical surveys conducted on-site are summarized as follows:

Electrical resistivity geophysical survey Electrical resistivity surveys are used to identify material types by measuring a material's resistance to electrical current. Materials with low electrical resistivity (high conductivity) will include materials with higher clay or moisture content, or conductive bedrock. Materials with high electrical resistivity (low conductivity) include air-filled voids or loose unconsolidated fill material, based on the assumption that the void space had increased resistivity compared to the surrounding bedrock or sediments. These assumptions also depended on other factors including sediment grain size, moisture content, chemical composition of the soil or bedrock, and the degree of compaction.

The electrical resistivity survey conducted on-site consisted of 13 electrical resistivity survey lines, as shown in Figure 3-7. Three parallel survey lines were laid out in an east-west orientation on mine site #1011, and ten survey lines on a grid pattern (three in an east-west orientation and seven in a north-south orientation) were laid out on mine site #1035. Resistivity data were collected using a multichannel electrical resistivity system consisting of cables, stainless steel electrodes, and a battery power supply, with an electrode spacing of approximately 10 ft. Electric current was transmitted into the earth through one pair of electrodes (transmitting dipole) that was in contact with the soil. The resultant voltage potential was then measured across another pair of electrodes (receiving dipole). Numerous electrodes were deployed along the survey lines. A complete set of measurements occurred when each electrode (or adjacent electrode pair) passed current, while all other adjacent electrode pairs were utilized for voltage measurements. Electrode locations were surveyed using a handheld GPS.

MASW geophysical survey The MASW geophysical surveys are used to identify material types by measuring contrasts in seismic velocity (i.e., the speed at which seismic energy travels through soil and rock). Seismic velocity typically correlates well with rock hardness and density, which in turn tends to correlate with changes in lithology, degree of fracturing, water content, and weathering. The MASW geophysical surveys measure the elastic condition of the subsurface, which produces an image based on differences in transmission time of induced seismic waves. Dense materials like competent bedrock and very dense soils tend to have increased seismic velocities, whereas voids or spaces filled with air or water display a decreased seismic velocity, compared to the native material. The contrast in seismic velocity between the native material and subsurface voids depends on a number of factors, including the depth of the feature, the fill material of a void (i.e., water, air, sediments, or a mixture of all three), void shape and dimensions, and the properties of and contrast to the native materials. Void spaces and fill materials generally display a measurable contrast in properties (lower shear wave velocities) to the surrounding materials.

The MASW survey conducted on-site also consisted of 13 survey lines, as shown in Figure 3-7. Geophones (ground motion transducers) were spaced approximately 10 ft apart along the survey lines, and their locations were surveyed using a handheld GPS. The induced seismic source was a 16 pound sledge hammer that was struck against a polyethylene strike plate. Each strike of the polyethylene strike plate is known as a shot. The locations where the seismic source was shot were spaced approximately 20 ft apart and in-between the midpoints of the geophone positions, along the survey line. Once the shot occurred, two Geode Ultra-Light Exploration 24 –Channel Seismographs were used to collect the data from the geophones, providing a total of 48 channels. The two Geodes were run from a laptop in order to view each shot to confirm acceptable data quality. Additional sledge hammer blows, forming a new "stack" of data, were added until the desired data quality was achieved. The shot record (seismogram) was saved to the computer and stored for subsequent processing. A real-time noise monitor showed all geophones were used during shots to verify that noise levels were at a minimum for each shot. This included waiting for breaks in wind noise, drilling activities, and other sources of noise.

3.3.3 Identification of TENORM Areas

Areas at the Site where TENORM is present were identified using multiple lines of evidence including:

1. Historical Data Review
    a. Aerial photographs
    b. USAEC records
    c. Reclamation records
    d. Other documents relevant to the Site, including those in the *2007 AUM Atlas*
    e. Interviews with residents living closest to the Site (for those sites where residents were available for interview)

   f. Consultation and site visits with NAML staff to identify reclamation features (for those sites reclaimed by NAML)

2. Geology/Geomorphology

   a. Hydrology/transport pathways with drainage delineation

   b. Site-specific geologic mapping including areas of mineralization

   c. Topography

3. Disturbance Mapping

   a. Exploration

   b. Mining

   c. Reclamation

4. Site Characterization

   a. Surface gamma surveys and subsurface static gamma measurements

   b. Soil/sediment sampling and analyses

Any areas where TENORM was not observed are considered to contain NORM, because soil and/or rock at the Site contain some amount of natural uranium and its daughter products. This area was mined because of the high levels of naturally occurring uranium ore. The areas containing NORM and/or TENORM are presented in Section 4.6. The volume of TENORM is presented in Section 4.7. The areas containing NORM and/or TENORM, along with additional findings of the RSE report, are identified to support future Removal or Remedial Action evaluations at the Site.

3.4 DATA MANAGEMENT AND DATA QUALITY ASSESSMENT

This section summarizes the data management and data quality assessment activities performed for the RSE.

3.4.1 Data Management

The DMP included in the *RSE Work Plan* describes the plan for the generation, validation, and distribution of project data deliverables. Successful data management comes from coordinating data collection, quality control, storage, access, reduction, evaluation, and reporting. A summary of the data management activities performed as part of the RSE process included:

- **Database** – Field-collected and laboratory analytical RSE data were stored in an Oracle SQL relational database, which increased data handling efficiency by using previously developed data entry, validation, and reporting tools. The Oracle SQL database was also used to export project data to a tabular format that can be used in a spreadsheet (e.g., Excel) and to the USEPA Scribe database format.

- **Scribe** – The Stantec Data Manager/Data Administrator was responsible for meeting the project data transfer requirements from the Oracle SQL database to Scribe, which is a software tool developed by the USEPA's Environmental Response Team to assist in the process of managing environmental data. Stantec maintained an Oracle SQL database and exported data from the Oracle SQL database to a Scribe compatible format following completion of each field investigation phase. Custom data queries and "crosswalk" export routines were built in Oracle SQL, to facilitate data export to the Scribe database format with the required frequency.

- **Geographic Information System (GIS)** – Spatial data collected during the RSE (e.g., sample locations and gamma measurements) were stored in a dedicated File Geodatabase for use in the project GIS. The geodatabase format enforces data integrity, version control, file size compression, and ease of sharing to preserve GIS output quality. Periodic geodatabase backups were performed to identify accidentally deleted or otherwise corrupt information that were then repaired or recovered, if applicable.

3.4.2 Data Quality Assessment

The QAPP, included in the *RSE Work Plan*, Appendix B, was followed for RSE data quality assessment, where the QAPP presents QA/QC requirements designed to meet the RSE DQOs. Data quality refers to the level of reliability associated with a particular data set or data point. The Data Usability Report included in Appendix F.1 provides a summary of the data quality assessment activities and qualified data for the RSE. A summary of findings, from the data quality assessment, are included below.

- **Data Verification** – The data were verified to confirm that standard operating procedures (SOPs) specified in the *RSE Work Plan* and *FSP* were followed and that the measurement systems were performed in accordance with the criteria specified in the QAPP. Any deviations or modifications from the *RSE Work Plan* are described in the appropriate RSE report sections. The USEPA definition (USEPA, 2002a) for data verification is provided in the glossary.

- **Data Validation** – The data were validated to confirm that the results of data collection activities support the objectives of the RSE as documented in the QAPP. The data quality assessment process was then applied using the validated data and determined that the quality of the data satisfies the intended use. The USEPA definition (USEPA, 2002a) for data validation is provided in the glossary. A copy of the Data Usability Report is included in Appendix F.1 and a summary of the validation results is presented below:

    - **<u>Precision</u>** Based on the matrix spike/matrix spike duplicate (MS/MSD) sample, laboratory control sample/laboratory control sample duplicate (LCS/LCSD) sample, laboratory duplicate sample, and field duplicate results, the data are precise as qualified.

    - **<u>Accuracy</u>** Based on the initial calibration (ICAL), initial calibration verification (ICV), continuing calibration verification (CCV), MS/MSD, and LCS, the data are accurate as qualified.

- **Representativeness** Based on the results of the sample preservation and holding time evaluation, the method and initial/continuing calibration blank (ICB/CCB) sample results, the field duplicate sample evaluation, and the reporting limit evaluation, the data are considered representative of the Site as reported.

- **Completeness** All media and QC sample results were valid and collected as scheduled (i.e., as planned in the *RSE Work Plan*); therefore, completeness for these is 100 percent.

- **Comparability** Standard methods of sample collection and standard units of measure were used during this project. The analyses performed by the laboratory were in accordance with current USEPA methodology and the QAPP.

Based on the results of the data validation, all data are considered valid as qualified.

4.0 FINDINGS AND DISCUSSION

4.1 BACKGROUND REFERENCE AREA STUDY RESULTS AND CALCULATION OF INVESTIGATION LEVELS

The results of the background reference area surface gamma survey are shown in Figures 4-1a through 4-1f. Sample locations in the background reference areas are shown for BG-1, BG-2, BG-3, BG-4, and BG-5 on Figures 4-1b, 4-1c, 4-1d, 4-1e and 4-1f, respectively. The surface gamma surveys in BG-2, BG-3, and BG-5 did not cover the areal extent of the sample locations; however, gamma survey measurements were within approximately 3 ft of sample locations that were outside of the survey area. Analytical results of the samples collected from the five background reference areas are summarized in Table 4-1. The gamma measurements and surface soil sample analytical results collected from BG-1, BG-2, BG-3, BG-4 and BG-5 were evaluated statistically to calculate ILs (refer to Appendix D.2) for each corresponding Survey Area (i.e., Survey Area A, Survey Area B, Survey Area C, Survey Area D and Survey Area E, respectively). As discussed in Section 3.3.1.2, the Survey Area was subdivided into five separate Survey Areas based on geologic conditions on-site where potential mining-related impacts were observed. After review of the RSE results it was determined that mining-related impacts extend onto the Wingate Sandstone along the base of the mesa sidewall. Based on these findings, the lack of soil samples from BG-6 in the Wingate Sandstone was identified as a data gap and is included in Section 4.9.

Statistical evaluation of the gamma measurements and soil sample analytical results included identifying potential outlier values, interpreting boxplots and probability plots, comparing group means between the background reference areas and the respective Survey Area data, and calculating descriptive statistics for each of the background reference areas. The descriptive statistics included the 95 percent upper confidence limit (UCL) on the mean gamma measurements and Ra-226/metals concentrations, and the 95-95 upper tolerance limits (UTLs). The data were analyzed using R statistical programming packages and ProUCL 5.1 software (USEPA, 2016).

The DQOs presented in the RSE Work Plan indicate that the ILs would be developed using the 95 percent UCL on the mean of the background sample results. However, the 95-95 UTL was used as the basis for the ILs instead because it better reflects the natural variability in the background data and lends itself to single-point comparisons to the Survey Area data; this was a change from the *RSE Work Plan*, as agreed upon with the Agencies. The UTL represents a 95 percent UCL for the 95th percentile of a background dataset whereby Survey Area results above this value are not considered representative of background conditions. The UTL is a statistical parameter for the entire population of the variable, whereas the actual results are from a sample of the population. UTLs were calculated in accordance with USEPA's *ProUCL 5.1 Technical Guidance,* Sections 3.4 and 5.3.3 (USEPA, 2015). Appendix D.2 presents a comprehensive discussion on the derivation of the ILs for the Site, which are presented below.

The *RSE Work Plan* also stated that gamma radiation measurements from the background surface and subsurface soil would be combined to develop the IL for surface gamma radiation at the Site. However, the surface gamma radiation ILs were instead developed from the surface gamma survey data only. The Agencies have commented that this should be noted as a deviation from the *RSE Work Plan*. The subsurface static gamma measurements were excluded for two reasons: (1) they were collected using a different method (static one-minute measurements versus a walkover gamma survey); and (2) because of the downhole geometric effects that influence subsurface static gamma measurements (refer to the discussion of geometric effects below).

The ILs for Survey Area A (i.e., Todilto Formation; refer to Figures 2-7a, 2-7b, and 3-4) were established using statistical analysis of background data collected from BG-1(refer to Figures 3-2 and 3-3a) and are as follows:

- Arsenic – 11.9 milligrams per kilogram (mg/kg)
- Molybdenum – 2.26 mg/kg
- Selenium – an IL for selenium was not identified because selenium sample results in BG-1 were all non-detect
- Uranium – 3.23 mg/kg
- Vanadium – 27.3 mg/kg
- Ra-226 – 2.13 pCi/g
- Surface gamma measurements – 16,829 cpm

The ILs for Survey Area B (i.e., the Quaternary deposits on the mesa top; refer to Figures 2-7a, 2-7b, and 3-4) were established using statistical analysis of background data collected from BG-2 (refer to Figures 3-2 and 3-3a) and are as follows:

- Arsenic – 2.34 mg/kg
- Molybdenum – 0.346 mg/kg
- Selenium – an IL for selenium was not identified because selenium sample results in BG-2 were all non-detect
- Uranium – 3.34 mg/kg
- Vanadium – 11.2 mg/kg
- Ra-226 – 2.96 pCi/g
- Surface gamma measurements – 23,320 cpm

The ILs for Survey Area C (i.e., the Entrada Sandstone and Wingate Sandstone; refer to refer to Figures 2-7a, 2-7b, and 3-4) were established using statistical analysis of background data collected from BG-3 (refer to Figures 3-2 and 3-3a) and are as follows:

- Arsenic – 4.99 mg/kg
- Molybdenum – 0.367 mg/kg
- Selenium – an IL for selenium was not identified because selenium sample results in BG-3 were all non-detect
- Uranium –1.91 mg/kg
- Vanadium – 17.4 mg/kg
- Ra-226 – 1.49 pCi/g
- Surface gamma measurements – 48,542 cpm

The ILs for Survey Area D (i.e., the Quaternary deposits on the plains; refer to Figures 2-7a, 2-7b, and 3-4) were established using statistical analysis of background data collected from BG-4 (refer to Figures 3-2 and 3-3a) and are as follows:

- Arsenic – 1.76 mg/kg
- Molybdenum – 0.210 mg/kg
- Selenium – an IL for selenium was not identified because selenium sample results in BG-4 were all non-detect
- Uranium – 0.554 mg/kg
- Vanadium – 11.0 mg/kg
- Ra-226 – 1.49 pCi/g
- Surface gamma measurements – 20,637 cpm

The ILs for Survey Area E (i.e., Quaternary alluvium in drainages on the plains; refer to Figures 2-7a, 2-7b, and 3-4) were established using statistical analysis of background data collected from BG-5 (refer to Figures 3-2 and 3-3b) and are as follows:

- Arsenic – 1.73 mg/kg
- Molybdenum – an IL for molybdenum was not identified because molybdenum sample results in BG-5 were all non-detect
- Selenium – an IL for selenium was not identified because selenium sample results in BG-5 were all non-detect

- Uranium –0.691 mg/kg
- Vanadium – 10.7 mg/kg
- Ra-226 – 0.839 pCi/g
- Surface gamma measurements – 21,864 cpm

Of note, the gamma survey in BG-3 was limited due to steep terrain, the sample size was low (80 measurements) and there is a notable difference between the UTL (48,542 cpm) and UCL (30,927) values (refer to Appendix D.1 Table D.1-2). Further evaluation of background for the Entrada Sandstone may be required in the future.

It is important to note that comparisons to the IL (i.e., 1.5 times the IL) are provided for context and evaluations of areas of the Site, samples, or TENORM that exceed the IL based on the statistically derived IL values.

In addition to the surface gamma survey performed in background reference areas, subsurface static gamma measurements were collected in the boreholes completed in the background reference areas. Where possible, these measurements were used to establish subsurface static gamma screening levels for Survey Areas A, B, C, D, and E. Where possible, the selected subsurface static gamma screening level measurement met the following criteria: (1) it was the lowest value measured at or below one ft bgs; and (2) it was not measured directly on bedrock.

These subsurface static gamma screening levels provide a comparison and assessment tool for Survey Areas A, B, C, D, and E, and are included as ILs for the Site. However, it is important to consider that the subsurface static gamma ILs are based on single measurements, and they are not statistically derived. For this reason, subsurface static gamma IL exceedances should be considered in conjunction with additional lines of evidence including: (1) down-hole trends of static gamma measurements; (2) changes in lithology within the borehole; and (3) a qualitative comparison of subsurface static gamma measurements to Ra-226 and/or metals concentrations in subsurface samples.

Subsurface static gamma measurements from the background reference areas are summarized in Table 4-2 and in Appendix C.2, and are described below.

- BG-1 – One subsurface static gamma measurement (7,963 cpm) was collected from borehole S1011-BG1-011 at a depth of 0.7 ft bgs. Therefore, 7,963 cpm was used as the subsurface static gamma IL for Survey Area A. This borehole was terminated at a depth of 0.9 ft bgs due to refusal on bedrock.

- BG-2 – Four subsurface static gamma measurements (12,551, 12,840, 13,268, and 12,669 cpm) were collected at down-hole depths of 0.5, 1.0, 1.5 and 2.0 ft bgs from borehole S1011-BG2-011, respectively. The lowest measured value, at or below 1 ft bgs and not directly measured on bedrock was12,669 cpm. This value was used as the subsurface static gamma IL for Survey Area B.

- BG-3 – One subsurface static gamma measurement (6,387 cpm) was collected from borehole S1001-BG3-011 at a down-hole depth of 0.25 ft bgs, therefore 6,387 cpm was used as the subsurface static gamma IL for Survey Area C. The total depth of the borehole was 0.25 ft bgs with refusal on sandstone.

- BG-4 – Six subsurface static gamma measurements (9,706, 10,481, 10,271, 10,313, 10,099, and 10,616 cpm) were collected from borehole S1011-BG4-011 at down-hole depths of 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 ft bgs, respectively. The lowest measured value, at or below 1 ft bgs and not directly measured on bedrock was 10,099 cpm. This value was used as the subsurface static gamma IL for Survey Area D.

- BG-5 – Four subsurface static gamma measurements (10,302, 11,450, 11,465, and 11,496 cpm) were collected from borehole S1011-BG5-011 at down-hole depths of 0.5, 1.0, 1.5 and 2.0 ft bgs, respectively. The lowest measured value of 10,302 cpm was measured at a depth of 0.5 ft bgs and did not meet the preferred depth criteria. The second lowest detection of 11,450 cpm was measured at 1.0 ft bgs and was used as the subsurface static gamma IL for Survey Area E.

It is important to consider that the subsurface static gamma IL measurements may be elevated relative to the surface gamma IL because increases in static gamma measurements with depth can result from the detector being in closer proximity to bedrock that has naturally elevated concentrations of radionuclides, and/or geometric effects.

Geometric effects are the result of the detector measuring gamma radiation from all directions, regardless of whether it is in a borehole or suspended in air. Gamma radiation measured with the detector held at the ground surface is primarily from the ground beneath the detector. As the detector is advanced down the borehole it measures gamma radiation from the surrounding material emanating from an increasing number of angles. Therefore, as the detector is lowered in the borehole it will generally measure increasingly higher values to a certain depth given a constant source. At approximately 1ft to 2 ft bgs, the detector is essentially surrounded by solid ground and further increases related to borehole geometry are not expected. Because downhole geometric effects influence static gamma measurements just below ground surface, static gamma measurements collected at or greater than 0.1 ft bgs are considered subsurface.

Due to the differing geometric effects, surface static gamma measurements at borehole locations may only be qualitatively compared to subsurface static gamma measurements, and the subsurface static gamma IL does not apply to the surface static gamma measurements. Instances where the surface static gamma measurement is greater than subsurface static gamma measurements suggest higher levels of radionuclides at the surface and may be indicative of the presence of TENORM at the surface. However, additional lines of evidence are generally needed to support that conclusion.

The Site gamma measurements, and soil and sediment sample analytical results were compared to their respective ILs to confirm the COPCs (refer to Section 4.4) and to identify areas of the Site where ILs are exceeded (refer to Section 4.5). The calculated ILs provide a line of evidence to evaluate potential mining-related impacts, and are provided to support considerations, as needed, for future Removal or Remedial Action evaluations at the Site.

4.2 SITE GAMMA RADIATION SURVEY RESULTS AND PREDICTED RADIUM-226 CONCENTRATIONS

4.2.1 Site Gamma Radiation Results

4.2.1.1 Surface Gamma Survey

Results of the Site surface gamma survey are shown in Figure 4-1a where the calculated ILs for each background reference area are used to set bin ranges with color coding to illustrate the spatial extent and patterns of surface gamma measurements within the entire Survey Area. The bin ranges were based on the Survey Area minimum site gamma measurements, the background reference area ILs, and the maximum site gamma measurement. The maximum gamma measurement for the Site was 749,127 cpm, which was more than 15 times the maximum IL (i.e., BG-3 IL of 48,542 cpm), and occurred in Survey Area C downgradient from Waste Pile 3 (compare Figure 2-7 with Figure 4-1a or 4-1d). Surface gamma measurements were generally highest in an area of the mesa sidewall downgradient of Waste Pile 3, on the mesa top coincident with Waste Pile 6, and in portions of Disturbed Area 1 (compare Figure 2-7 with Figure 4-1a). Descriptions and photographs of these areas are provided in Section 3.2.2.1 and Appendix B-1 photograph numbers 7, 9, 10, 11, 12, and 13.

The spatial distribution of surface gamma measurements and IL exceedances are shown in Figures 4-1b, 4-1c, 4-1d, 4-1e, and 4-1f for Survey Areas A, B, C, D, and E, respectively, and are described below:

- Survey Area A (refer to Figure 4-1b) – Surface gamma IL exceedances (greater than 16,829 cpm) occurred throughout Survey Area A except along the western-most portion of the mesa rim. The maximum measurement (654,837 cpm) occurred along the mesa rim within a central portion of Disturbed Area 1. Measurements greater than ten times the IL were observed in five locations along the mesa rim, including three locations within Disturbed Area 1, one location within Waste Pile 2, and one location west of Waste Pile 3.

- Survey Area B (refer Figure 4-1c) – Surface gamma IL exceedances (greater than 23,320 cpm) occurred throughout Survey Area B except for some southern portions of mine site #1011 and its 100-ft buffer, areas along the rim of the mesa west of Waste Pile 3, and in portions of the potential haul roads. The maximum measurement (633,057 cpm) occurred along the mesa rim within a central portion of Disturbed Area 1. Measurements greater than ten times the IL also occurred in Waste Pile 6 and in one location in the southwestern portion of mine site #1011.

- Survey Area C (refer to Figure 4-1d) – Surface gamma IL exceedances (greater than 48,542 cpm) occurred primarily in areas along the top of the mesa sidewall, and in areas downgradient from Waste Piles 2, 3, and 7. The maximum measurement (749,127 cpm) for Survey Area C (and the Site) occurred on the mesa sidewall downgradient of Waste Pile 3.

Measurements greater than ten times the IL occurred on the mesa sidewall downgradient of Waste Pile 3.

- Survey Area D (refer to Figure 4-1e) – Surface gamma IL exceedances (greater than 20,637 cpm) occurred throughout Survey Area D with the exception of three areas: 1) the majority of the southern-most portion of the area; 2) along the western boundary of Survey Area D; and 3) within an area at the base of the mesa sidewall, directly south of mine site #1012. The maximum measurement (62,220 cpm) was three times greater than the IL and occurred at the base of the mesa sidewall downgradient from Disturbed Area 1. The majority of Survey Area D surface gamma IL exceedances were less than two times the IL. In addition, the majority of the surface gamma IL exceedances in the central and western portions of the Survey Area were within ten-percent of the IL.

- Survey Area E (refer to Figure 4-1f) – Surface gamma IL exceedances (greater than 21,864 cpm) primarily occurred in portions of the central drainage and two eastern drainages. The maximum measurement (117,875 cpm) was greater than 5 times the IL and occurred downgradient from Disturbed Area 1 in the eastern-most drainage, near the base of the mesa sidewall.

Figure 4-1d also compares Survey Area C to the surface gamma IL calculated for BG-6 (34,429 cpm; refer to Appendix D.1 and Table D.1-2), which represents the Wingate Sandstone portion of Survey Area C (refer to Section 2.2.2.2 and Figure 2-6a). Surface gamma measurements within the Wingate Sandstone that exceeded the BG-6 IL were detected downgradient from Disturbed Area 1 and in several discrete areas in the western portion of Survey Area C. Given that these areas did not exceed the Survey Area C IL (48,542 cpm)), these areas will be considered separately in the TENORM volume calculations (refer to Section 4.7).

Four potential data gaps were identified for the surface gamma survey, as listed below:

1. 10.1 acres of the Survey Area were not surveyed, because field personnel were unable to safely access these areas due to steep/unsafe terrain (refer to Figure 3-4).

2. The survey was not extended laterally from the potential haul roads where the gamma measurements were greater than the IL due to a miscommunication with field personnel.

3. The shoulders of some potential haul roads in the north-central portion of the Site were not surveyed due to a miscommunication with field personnel.

4. The gamma survey was not extended to the west of Survey Area B (the central portion of the mesa top) until gamma measurements reached background levels. This area was not surveyed based on professional judgement in the field that this area contained only NORM. However, review of high-resolution aerial images and historical documents following the survey suggested that some portions of this area (specifically Disturbed Area 4) may have been disturbed by mining-related activities. It is recommended that this data gap be addressed during future work.

4.2.1.2 Subsurface Gamma Survey

Surface and subsurface static gamma measurements were collected at all 44 borehole locations. Surface and subsurface static gamma measurement locations are shown in Figures 3-6a and 3-6b. Measurements and corresponding measurement depths are provided in Table 4-2 and are shown on the borehole logs in Appendix C.2. Subsurface static gamma ILs apply only to measurements from unconsolidated material; static gamma measurements detected within a bedrock interval are considered for informational purposes only. Surface and subsurface static gamma measurements from the boreholes are presented below by Survey Area:

- Survey Area A (refer to Figures 3-6a and 3-6b) – Two boreholes were completed in Survey Area A (S1011-SCX-008 and -SCX-017), one of which was terminated in bedrock (S1011-SCX-017). The highest subsurface static measurement from unconsolidated material (103,982 cpm) was detected in a borehole within Waste Pile 3 (S1011-SCX-008; 1.5 ft bgs). The highest measurement from bedrock (266,288 cpm in borehole S1011-SCX-017) was detected within a limestone interval at a depth of 1.0 ft bgs. Borehole S1011-SCX-017 was located within Disturbed Area 1. Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements in unconsolidated material increased in borehole S1011-SCX-008 from 57,060 at 0.5 ft bgs to 103,982 at the refusal depth of 1.5 ft bgs. When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole, static gamma measurements also increased with depth in both boreholes.

- Survey Area B (refer to Figures 3-6a and 3-6b) – 33 boreholes were completed in Survey Area B, of which 25 were terminated in bedrock. The Survey Area B subsurface static gamma IL (12,669 cpm) was exceeded in unconsolidated material in 28 boreholes. The highest subsurface static gamma measurement for Survey Area B and the Site (477,872 cpm) occurred in bedrock in a borehole that was within Disturbed Area 1 (S1011-SCX-019; 3.0 ft bgs). The highest subsurface static gamma measurement in unconsolidated material (352,526 cpm) for Survey Area B and the Site occurred in a borehole located within mine site #1035, approximately 100 feet southwest of the vertical mine shafts (S1011-SCX-028). Subsurface static gamma measurements and IL exceedances are considered with respect to mine site #1011, mine site #1035, Disturbed Area 1, and mine site #1012/Disturbed Area 2 within Survey Area B:

    - Mine site #1011 (refer to Figure 3-6b) – Nine boreholes were completed within the 100-ft buffer of mine site #1011 (S1011-SCX-009, -SCX-010, -SCX-011, -SCX-012, -SCX-013, -SCX-014, -SCX-039, -SCX-040, -SCX-044). Bedrock was encountered between 0.5 and 6.0 ft bgs, six of the nine boreholes terminated in bedrock, and the three others terminated due to hard material or refusal (unknown if it was bedrock). The Survey Area B IL (12,669 cpm) was exceeded in unconsolidated material in five boreholes. The highest subsurface static gamma measurement from unconsolidated material (72,575 cpm) was greater than five times the IL and was collected from borehole S1011-SCX-039 at the refusal depth of 0.2 ft bgs. The highest subsurface static gamma measurement from bedrock (41,294 cpm) was from borehole S1011-SCX-010 at a depth of 7.0 ft bgs. Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements in unconsolidated material generally decreased with depth in four boreholes

(S1011-SCX-009, -SCX-011, -SCX-012, and -SCX-014), increased with depth in one borehole (S1011-SCX-044) and fluctuated with depth in one borehole (S1011-SCX-010). When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole (0.5 to 1.0 ft bgs), static gamma measurements increased with depth in eight (out of nine) boreholes. One borehole (S1011-SCX-014) had static gamma measurements that decreased from 33,406 cpm at the surface to 10,820 cpm at 1.0 ft bgs, which was an indication of the potential presence of contaminated material near the surface in this area. Subsurface static gamma IL exceedances were observed in unconsolidated material to a maximum depth of 5 ft bgs (S1011-SCX-010).

- Mine site #1035 (refer to Figure 3-6b) – Eighteen boreholes were completed within mine site #1035 (S1011-SCX-021 through -SCX-038). Bedrock was encountered between 3.0 and 20.0 ft bgs and all boreholes terminated in bedrock. Subsurface static gamma measurements extended into bedrock in 15 of the 18 boreholes. The Survey Area B subsurface static gamma IL (12,669 cpm) was exceeded in unconsolidated material in all 18 boreholes, and exceedances in unconsolidated material extended to a maximum depth of 20 ft bgs. Subsurface static gamma measurements greater than two-times the IL were observed in unconsolidated material from six boreholes, of which two had measurements that were greater than five times the IL (S1011-SCX-028 and -SCX-031). The highest subsurface static gamma measurement from unconsolidated material (352,526 cpm) occurred in borehole S1011-SCX-028 (3.0 ft bgs), which was located approximately 100 ft southwest of the vertical mine shafts. The highest subsurface static gamma measurement from bedrock (39,254 cpm) occurred in borehole S1011-SCX-025 (8.0 ft bgs), which was located near the northern claim boundary. Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements in unconsolidated material increased with depth in two boreholes (S1011-SCX-022 and -SCX-029) and fluctuated with depth in the remaining 16 boreholes. When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole (0.5 to 1.0 ft bgs), static gamma measurements increased with depth in 14 boreholes, and decreased with depth in four boreholes (S1011-SCX-022, -SCX-024, -SCX-027 and -SCX-038).

- Disturbed Area 1 (refer to Figure 3-6b) – Three boreholes were completed within or near Disturbed Area 1 (S1011-SCX-018, -SCX-019, and -SCX-020). Bedrock was encountered between 2.5 and 5.0 ft bgs, and all three boreholes were terminated in bedrock. All subsurface static gamma measurements measured in unconsolidated material within the three boreholes exceeded the IL (12,669 cpm). Subsurface static gamma IL exceedances were observed in unconsolidated material to a maximum depth of 3 ft bgs (S1011-SCX-018) within Disturbed Area 1, and to a depth of 5.0 ft bgs in the borehole located just north of Disturbed Area 1(S1011-SCX-020). Subsurface static gamma measurements greater than ten times the IL were collected in unconsolidated material from boreholes S1011-SCX-018 and-SCX-019. The highest subsurface static gamma measurement from unconsolidated material (254,338 cpm) occurred in borehole S1011-SCX-019 (2.0 ft bgs). The highest subsurface static gamma measurement from bedrock for the Survey Area and the Site (477,872 cpm) also occurred in borehole S1011-SCX-019 (3.0 ft bgs). Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements in unconsolidated material increased with depth in two boreholes (S1011-SCX-019 and -SCX-020) and fluctuated with depth in borehole S1011-SCX-018. When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole (1.0 ft bgs), static gamma measurements increased with depth in all three boreholes.

- o Mine site #1012 and Disturbed Area 2 (refer to Figure 3-6b) – Three boreholes were completed within mine site #1012 or Disturbed Area 2 (S1011-SCX-007, -SCX-015, and -SCX-016). Bedrock was encountered between 1.5 and 3.0 ft bgs. Two of the boreholes were terminated in bedrock, and one borehole (S1011-SCX-007) was terminated on a hard surface (it is unknown if this was bedrock). The Survey Area B subsurface static gamma IL (12,669 cpm) was exceeded in unconsolidated material in two boreholes (S1011-SCX-007 and -SCX-016) and exceedances in unconsolidated material were observed to a maximum depth of 3.0 ft bgs (S1011-SCX-016). The one borehole where subsurface static gamma measurements did not exceed the IL was located in the debris pile, just north of mine site #1012. The highest subsurface static gamma measurement from unconsolidated material (20,893 cpm) was less than two times the IL, and was detected in a borehole located in the northern portion of mine site #1012 (S1011-SCX-007). Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements in unconsolidated material increased with depth in one borehole (S1011-SCX-016) and decreased with depth in one borehole (S1011-SCX-007). When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole (0.5 to 1.0 ft bgs), static gamma measurements increased with depth in one borehole (S1011-SCX-015), and decreased with depth in the remaining two boreholes.

- Survey Area C (refer to Figure 3-6a) – One borehole was completed within Survey Area C (S1011-SCX-006) and was located downslope from Waste Pile 3 and in the southern debris pile. The borehole was terminated in unconsolidated material due to refusal on hard rock. All subsurface static gamma measurements collected in S1011-SCX-006 exceeded the Survey Area C IL (6,387 cpm), and the highest subsurface static gamma measurement (154,588 cpm) occurred at a depth of 0.25 ft bgs. Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements decreased with depth. When comparing the static gamma measurement collected at the surface to the first measurement collected down-hole (0.25 ft bgs), static gamma measurements increased with depth.

- Survey Area D (refer to Figure 3-6a) – Three boreholes were completed in Survey Area D (S1011-SCX-041, -SCX-042, and -SCX-043) and all three were terminated in unconsolidated material (S1011-SCX-041 and -SCX-042 did not meet refusal, S1011-SCX-043 met refusal on rock). The subsurface static gamma IL (10,099 cpm) was exceeded in two boreholes (S1011-SCX-041 and -SCX-043), and IL exceedances were observed to a maximum depth of 2.5 ft bgs (S1011-SCX-041). The maximum subsurface static gamma measurement (17,072 cpm) was less than two times the IL and occurred in the western-most Survey Area D borehole, and in the deepest interval (S1011-SCX-041; 2.5 ft bgs). Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements generally increased with depth in one borehole (S1011-SCX-041) and decreased with depth in one borehole (S1011-SCX-042). When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole (0.25 to 1.0 ft bgs), static gamma measurements increased with depth in all three Survey Area D borehole locations.

- Survey Area E (refer to Figure 3-6a) – Five boreholes were completed in Survey Area E (S1011-SCX-001 through -SCX-005), of which all five terminated on hard rock or hard surfaces in unconsolidated material. All subsurface static gamma measurements collected in unconsolidated material exceeded the Survey Area E IL (11,450 cpm), and exceedances were observed at a maximum depth of 2.25 ft bgs (S1011-SCX-003). The maximum subsurface static gamma measurement (42,405 cpm) was greater than three times the IL and occurred in a borehole located near the base of the mesa sidewall, in the eastern-most drainage (S1011-SCX-001; 1.0 ft bgs). Subsurface static gamma measurements greater than two times the IL were also detected in the deepest intervals from two other boreholes (S1011-SCX-003; 1.5 to 2.25 ft bgs and -SCX-005; 2.0 ft bgs). Borehole S1011-SCX-003 was located in the eastern drainage, downgradient from S1011-SCX-001, and borehole S1011-SCX-004 was located in west-central drainage and was the most southern (i.e., distal to potential mining-related disturbances) borehole location. Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements increased with depth in four boreholes (S1011-SCX-002, -SCX-003, -SCX-004, and -SCX-005) and fluctuated with depth in one borehole (S1011-SCX-001). When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole (0.5 ft bgs) static gamma measurements increased with depth in four borehole locations, and decreased with depth in borehole S1011-SCX-005.

4.2.2 Gamma Correlation Results

The high-density surface gamma measurements and concentrations of Ra-226 in surface soils obtained from the Gamma Correlation Study (refer to Section 3.3.1.3) were used to develop a correlation equation, using regression analysis, between the mean gamma measurements and Ra-226 concentrations measured in the co-located composite surface soil samples. This correlation is meant to be used as a general screening tool and provides approximate predicted Ra-226 concentrations.

The correlation was developed as a potential field screening tool for future Removal or Remedial Action evaluations. Analytical results of the correlation samples, which were used to develop the correlation equation, are presented in Table 4-3. The mean value of the gamma survey results from the correlation plots, with their corresponding Ra-226 concentrations and a graph showing the linear regression line and adjusted Pearson's Correlation Coefficient (R^2) value for the correlation, are shown in
Figure 4-2a. The regression produced an adjusted R^2 value of 0.93, which is within the acceptance criterion of 0.8 to 1.0 described in the *RSE Work Plan* and indicates that surface gamma results correlate with Ra-226 concentrations in soil. The correlation model may have been influenced by environmental conditions and the limited number of correlation sample locations. Users of the regression equation should be aware of the limitations of the dataset and be cautious when estimating radium-226 concentrations. The correlation equation to convert gamma measurements in cpm to predicted surface soil Ra-226 concentrations in pCi/g for the Site is:

$$\text{Gamma (cpm)} = 5{,}822 \times \text{Surface Soil Ra-226 (pCi/g)} + 13{,}201$$

The predicted Ra-226 concentrations in soil, as calculated from the gamma measurements using the developed correlation equation, are shown in Figure 4-2a. Ra-226 concentrations predicted using gamma measurements lower than the minimum (21,632 cpm) and greater than the maximum (165,200 cpm) mean gamma measurements from the Gamma Correlation Study are extrapolated from the regression model and are therefore uncertain. Using the correlation equation, the predicted Ra-226 concentration associated with the minimum mean gamma measurement is 1.4 pCi/g and the concentration associated with the maximum mean gamma measurement is 26.1 pCi/g. Therefore, predicted Ra-226 concentrations less than 1.4 pCi/g and greater than 26.1 pCi/g should be limited to qualitative use only.

The correlation equation predicted Ra-226 concentrations that were less than zero for gamma survey measurements below 13,201 cpm. The predicted concentrations are shown in Figure 4-2a and the values less than zero are located along the mesa edge, west of the Site. The elevated predicted Ra-226 concentrations shown in Figure 4-2a occur in the same areas where the elevated surface gamma measurements occur (refer to Section 4.2.1 and Figure 4-1a). This is because the predicted Ra-226 concentrations are based on a direct correlation with the gamma measurements. Predicted Ra-226 concentrations in the Survey Area range from -0.8 to 126.4 pCi/g, with a mean of 3.3 pCi/g, and a standard deviation, of 4.9 pCi/g. Bin ranges in Figure 4-2a are based on these mean and standard deviation values.

The gamma correlation was not used for the Site Characterization, which instead relied on actual gamma radiation measurements and soil analytical results. However, predicted Ra-226 concentrations were compared to the Ra-226 laboratory concentrations measured in surface soil samples collected at surface and borehole locations, to evaluate the accuracy of the correlation for the Site, as shown in Figure 4-2b. The correlation results were also compared to investigation levels, as shown in Figure 4-2c. Per the Agencies, these comparisons can be used for site characterization and are one of many analyses that can be used to interpret the data (NNEPA, 2018).

When comparing the predicted Ra-226 concentrations to the Ra-226 laboratory concentrations, soil/sediment sample locations are generally not co-located with specific gamma measurement locations (refer to Figure 4-2b). Therefore, the measured Ra-226 laboratory concentrations can only be qualitatively compared to the nearby predicted Ra-226 concentrations. With the exception of 15 (out of 59) sample locations, the measured Ra-226 laboratory concentrations were within the applicable predicted Ra-226 bin ranges. In 12 of the 15 sample locations where the predicted Ra-226 concentration and the Ra-226 concentration detected in the soil/sediment sample did not agree, the predicted concentration was higher than the reported laboratory concentration detected in the soil/sediment sample. The majority of these sample locations (seven out of 12) were within mine site #1035. Three soil sample locations had predicted Ra-226 concentrations that were slightly lower than the laboratory Ra-226 concentration; these two samples were both located in the vicinity of mine site #1012. The differences observed between the predicted and actual Ra-226 values are likely a function of the natural heterogeneity in Ra-226 concentrations and gamma radiation measurements, which affects the correlation based on the five Gamma Correlation Study areas, and the predicted values, based on the subsequent gamma measurements. However, the correlation may be useful as a screening tool as it provides a representative estimate of Ra-226 concentrations across the Site similar to the actual results.

The predicted Ra-226 concentrations were also compared to the Ra-226 ILs from each Survey Area, as shown in Figure 4-2c. The symbols for surface sample locations and boreholes where Ra-226 concentrations in surface soil/sediment samples exceeded the IL are highlighted with yellow halos. The predicted Ra-226 concentrations exceeded the Ra-226 ILs for approximately 60 to 70 percent of the Site. Sample locations where laboratory Ra-226 concentrations exceeded the ILs were generally co-located with predicted Ra-226 concentrations that exceeded the ILs. The exceptions were five samples collected in the northeastern portion of the Site where the laboratory Ra-226 was less than the IL but the predicted Ra-226 value exceeded the IL. The area of the Site where predicted Ra-226 values exceeded the ILs is compared to surface gamma IL exceedances in the surface gamma survey in Section 4.5.

The correlation soil samples were also analyzed for thorium isotopes Th-232 and Th-228. The objectives of the thorium analyses were to assess the potential effects of Th-232 series radioisotopes on the correlation of gamma measurements to concentrations of Ra-226 in surface soils (i.e., to evaluate whether gamma-emitting radioisotopes in the Th-232 series are impacting gamma measurements at the Site). The justification for the analysis is provided in Section 3.3.1.3. A multivariate linear regression (MLR) model was performed by ERG to relate the gamma count rate to multiple soil radionuclides simultaneously. The MLR and results are described extensively in Appendix A. ERG identified that the thorium series radionuclides do not affect the prediction of concentrations of Ra-226 from gamma survey measurements at the Site.

4.2.2.1 Secular Equilibrium Results

The activities of Th-230 and Ra-226 were compared to consider whether the uranium series is in secular equilibrium at the Site (refer to Section 3.3.1.4 and Appendix A). A linear regression was performed on the dataset (refer to Appendix A Figure 9). The p-value for the regression slope is significant (i.e., $p < 0.05$) and the adjusted R^2 meets the study DQO (adjusted $R^2 > 0.8$), indicating that Ra-226 and Th-230 exist in equilibrium. However, when compared to a y=x line (this line represents a perfect 1:1 ratio between Th-230 and Ra-226, indicating secular equilibrium), the y=x line falls partially outside of the 95% UCL bands of the Th-230/Ra-226 regression, indicating Ra-226 and Th-230 are not in secular equilibrium at the Site (refer to figures in Appendix A). This may be a consideration in the future if a human health and/or ecological risk assessment is performed.

4.3 SOIL METALS AND RADIUM-226 ANALYTICAL RESULTS

A total of 59 surface soil/sediment grab samples (48 soil and 11 sediment) from 59 locations, and 64 subsurface soil/sediment grab samples (47 soil, 3 soil/bedrock, and 14 sediment) from 40 borehole locations were collected at the Site (refer to Table 3-2). The three soil/bedrock subsurface samples were all collected from three borehole locations in Survey Area B (S1011-SCX-018; 1.0-3.5 ft bgs, -SCX-021; 19.0-20.0 ft bgs, and -SCX-027; 6.0-8.5 ft bgs). These three samples included the top 0.5 ft of bedrock and, therefore, the analytical results may, in part, reflect the composition of the bedrock interval. The metals and Ra-226 analytical results for each Survey Area are compared to their respective ILs and presented in Tables 4-4a through 4-4e. Figures 4-3a through 4-3d present the spatial patterns, both laterally and vertically, of metals and Ra-226 detections and IL exceedances in the soil/sediment samples.

With the exception of one subsurface soil sample collected in the Survey Area D plains area (S1011-SCX-042), Ra-226 and/or metals concentrations exceeded their respective ILs in all surface and/or subsurface soil/sediment samples collected from Survey Areas A, C, and D. With the exception of five surface and 13 subsurface soil/sediment samples, Ra-226 and/or metals concentrations exceeded their respective ILs in all surface and/or subsurface samples collected from Survey Area B. With the exception of one subsurface sediment sample, Ra-226 and/or metals concentrations exceeded their respective ILs in all other surface and/or subsurface samples collected from Survey Area E. The maximum molybdenum detection occurred within a surface soil sample from Survey Area B collected in the reclaimed area within mine site #1035.The maximum Ra-226 and metals concentrations (excluding molybdenum) were detected in subsurface soil or soil/bedrock samples collected in Disturbed Area 1 located within Survey Areas A and B. Presented sample counts do not include duplicate samples. Surface and subsurface soil/sediment concentrations and IL exceedances for each analyte, and within each Survey Area are described below:

- Ra-226
  - Survey Area A – The Ra-226 IL (2.13 pCi/g) was exceeded in all eight (five surface and three subsurface) soil samples. Ra-226 concentrations ranged from 5.39 to 66.4 pCi/g and the maximum concentration was greater than 64 times the IL and occurred in a subsurface soil sample collected from borehole S1011-SCX-017, located within Disturbed Area 1. Ra-226 concentrations varied with depth in borehole S1011-SCX-008 located in Waste Pile 3, and increased with depth in borehole S1011-SCX-017.
  - Survey Area B – The Ra-226 IL (2.96 pCi/g) was exceeded in 20 (out of 42) surface and 16 (out of 47) subsurface soil/sediment samples and two out three soil/bedrock samples. Ra-226 concentrations in Survey Area B ranged from 0.57 to 80.2 pCi/g and the maximum concentration for Survey Area B and the Site occurred in a subsurface soil/bedrock sample collected from Disturbed Area 1, (S1011-SCX-018; 1.0-3.5 ft bgs). The maximum concentration in an unconsolidated sample (47.1 pCi/g) was greater than 15 times the IL and occurred in a subsurface soil sample collected from borehole S1011-SCX-028, located within mine site #1035 southwest of the possible portal or storage area. Ra-226 concentrations greater than ten times the IL were detected in one additional sample location; borehole S1011-SCX-019, which was collected from Disturbed Area 1. Ra-226 IL exceedances within Survey Area B are described below with respect to mine site #1011, mine site #1035, Disturbed Area 1, and mine site #1012/Disturbed Area 2:
    - Mine site #1011 (refer to Figures 3-6b and 4-3b) – The Survey Area B Ra-226 IL (2.96 pCi/g) was exceeded in four (out of 11) surface soil samples and one (out of seven) subsurface samples. Ra-226 concentrations ranged from 0.78 to 7.8 pCi/g. The maximum concentration was less than three times the IL and occurred in a

surface soil sample from borehole S1011-SCX-044. Ra-226 concentrations increased with depth in one borehole, decreased with depth in four boreholes, and fluctuated with depth in one borehole. No distinct spatial patterns were observed with respect to IL exceedances or concentration changes with depth.

- Mine site #1035 (refer to Figures 3-6b and 4-3a) – The Survey Area B Ra-226 IL (2.96 pCi/g) was exceeded in nine (out of 22) surface soil/sediment samples, nine (out of 34) subsurface soil/sediment samples, and one bedrock sample. Ra-226 concentrations ranged from 0.57 to 47.1 pCi/g; the maximum concentration was greater than 15 times the IL and occurred in a subsurface soil sample located approximately 100-ft southwest of the vertical mine shafts (S1011-SCX-028; 0.5-5.0 ft bgs). All other exceedances ranged from less than two times the IL, to less than five times the IL. Ra-226 concentrations Increased with depth in two borehole locations, decreased with depth in seven borehole locations and fluctuated with depth in nine locations. No distinct spatial patterns were observed with respect to IL exceedances or Ra-226 concentration changes with depth. A notable concentration change with depth occurred in borehole S1011-SCX-028 where the Ra-226 concentration increased from 1.9 pCi/g in the surface sample (0-0.5 ft bgs) to 47.1 pCi/g in the next sample interval (0.5-5.0 ft bgs), decreased to 10.6 and 13.8 pCi/g at 5.0 and 10.0 ft bgs, respectively, and were below the IL deeper than 10 ft bgs.

- Disturbed Area 1 (refer to Figures 3-6b and 4-3c) – The Survey Area B Ra-226 IL (2.96 pCi/g) was exceeded in all four sample locations and included four surface and two subsurface soil/sediment samples. Ra-226 concentrations ranged from 5.54 to 80.2 pCi/g; the maximum concentration for the area, Survey Area B, and the Site was greater than 37 times the IL and occurred in a subsurface soil/bedrock sample from borehole S1011-SCX-018 at a depth of 1.0-3.5 ft bgs. Subsurface soil sample S1011-SCX-019 (0.5-2.5 ft bgs) had a Ra-226 concentration (37.2 pCi/g) that exceeded the IL by more than ten times and the remaining samples had Ra-226 concentrations that ranged from less than two times the IL to less than ten times the IL. Ra-226 concentrations increased with depth in boreholes S1011-SCX-018 and -SCX-019 and remained constant in borehole S1011-SCX-020.

- Mine site #1012 and Disturbed Area 2 (Figures 3-6b and 4-3d) – The Survey Area B Ra-226 IL (2.96 pCi/g) was exceeded three (out of five) surface soil samples, and all four subsurface soil samples. Ra-226 concentrations ranged from 2.27 to 11.3 pCi/g; the maximum concentration less than four times the IL and occurred in a surface soil sample located east of the mine site #1012 boundary (S1011-CX-005). Ra-226 concentrations increased with depth in two boreholes and fluctuated with depth in one borehole.

- Survey Area C – The Ra-226 IL (1.49 pCi/g) was exceeded in all three soil samples (two surface and one subsurface). Ra-226 concentrations ranged from 5.64 to 24.3 pCi/g. The maximum concentration was greater than 16 times the IL and occurred in a surface soil sample located downgradient from Waste Pile 3, and within the debris pile at the base of the mesa sidewall (S1011-SCX-006). Ra-226 concentrations decreased with depth.

  - Survey Area D – The Ra-226 IL (1.49 pCi/g) was exceeded in one (out of three) surface soil samples and one (out of two) subsurface soil samples. Ra-226 concentrations ranged from 0.56 to 1.77 pCi/g. The maximum concentration was less than two times the IL and occurred in a surface soil sample located within the plains in the eastern portion of the Survey Area (S1011-SCX-043). Ra-226 concentrations increased with depth in one borehole and decreased with depth in the other borehole.

  - Survey Area E – The Ra-226 IL (0.839 pCi/g) was exceeded in six (out of seven) surface sediment samples and in seven (out of eight) subsurface sediment samples. The two sediment samples that did not exceed the IL were both located in the eastern-central portion of the plains (S1011-CX-009; -SCX-002, 0.5-1.5 ft bgs). Ra-226 concentrations ranged from 0.54 to 3.51 pCi/g. The maximum concentration was less than five times the IL and occurred in a subsurface sediment sample located downgradient from Waste Piles 2 and 3, and the debris pile near the base of the mesa sidewall (S1011-SCX-004; 1.5 to 2.0 ft bgs). Ra-226 concentrations increased with depth in four out of five boreholes and decreased with depth in one borehole.

- Uranium

  - Survey Area A – The uranium IL (3.23 mg/kg) was exceeded in all eight (five surface and three subsurface) soil samples. Uranium concentrations ranged from 5.3 to 230 mg/kg; the maximum concentration, for the Survey Area and the Site, was greater than 71 times the IL and occurred in a surface soil sample collected from Disturbed Area 1 (S1011-SCX-017). In general, the highest concentrations were detected in surface and subsurface soil samples collected from Disturbed Areas 1 or 2. Uranium concentrations generally decreased with depth in both Survey Area A boreholes.

  - Survey Area B – The uranium IL (3.34 mg/kg) was exceeded in 19 (out of 42) surface soil/sediment samples, 15 (out of 47) subsurface soil/sediment samples, and in one (out of 2) subsurface soil/bedrock sample and the one subsurface bedrock sample. Survey Area B uranium concentrations ranged from 0.35 to 200 mg/kg. The maximum concentration occurred in a subsurface soil/bedrock sample collected from Disturbed Area 1 (S1011-SCX-018; 1.0-3.5 ft bgs). Uranium concentrations greater than ten times the IL were detected in three additional sample locations including 1) borehole S1011-SCX-007 located within mine site #1012 and within Disturbed Area 2; 2) borehole S1011-SCX-019 which was within Disturbed Area 1; and 3) borehole S1011-SCX-037 located within mine site #1035 in the vicinity of the vertical mine shafts. Uranium IL exceedances within Survey Area B are described below with respect to mine site #1011, mine site #1035, Disturbed Area 1, and mine site #1012/Disturbed Area 2.

    - Mine site #1011 (refer to Figures 3-6b and 4-3b) – The Survey Area B uranium IL (3.34 mg/kg) was exceeded in four (out of 11) surface soil samples and in one (out of seven) subsurface soil samples. Uranium concentrations ranged from 0.48 to 7.1 mg/kg. The maximum concentration was less than three times the IL and occurred in subsurface soil sample S1011-SCX-044 at a depth of 0.2-0.7 ft bgs. Uranium concentrations increased with depth in one borehole, decreased with depth in four boreholes, and fluctuated with depth in one borehole. No distinct spatial patterns were observed with respect to IL exceedances or concentration changes with depth.

- Mine site #1035 (refer to Figures 3-6b and 4-3a) – The Survey Area B uranium IL (3.34 mg/kg) was exceeded in ten sample locations and included six (out of 22) surface soil/sediment samples, eight (out of 34) subsurface soil/sediment samples and one subsurface soil/bedrock samples. Uranium concentrations ranged from 0.35 to 68 mg/kg. The maximum concentration was 20 times the IL and occurred in a surface sediment sample that was located approximately100 ft southwest of the vertical mine shafts (S1011-SCX-037). Uranium concentrations increased with depth in five borehole locations, decreased with depth in nine borehole locations, and fluctuated with depth in four borehole locations. No distinct patterns were observed with respect to IL exceedances or concentration changes with depth. Two boreholes had notable uranium concentration changes with depth: (1) uranium concentrations in soil samples from borehole S1011-SCX-028 increased from 2.1 mg/kg (less than the IL) at the surface, to 28 and 11 mg/kg in the next two sample intervals (0.5-5.0 ft and 5.0–8.0 ft bgs, respectively), and then decreased back down to less than the IL in the last three sample intervals; and (2) the uranium concentration in soil samples from borehole S1011-SCX-037 decreased from 68 mg/kg in the surface sample to 2.3 mg/kg in the next sample interval (0.5-3.0 ft bgs).

- Disturbed Area 1 (refer to Figures 3-6b and 4-3c) – The Survey Area B uranium IL (3.34 mg/kg) was exceeded in all four sample locations and included all four surface and both subsurface soil samples. Uranium concentrations ranged from 4.5 to 200 mg/kg. The maximum concentration occurred in subsurface soil/bedrock sample S1011-SCX-018 (1.0-3.5 ft bgs). Detections greater than ten times the IL were also observed in the surface sample from this borehole, as well as in the subsurface soil sample in borehole S1011-SCX-019 (0.5-2.5 ft bgs); the uranium concentration in S1011-SCX-019 (140 mg/kg) was the highest concentration measured in soil in Disturbed Area 1. Uranium concentrations increased with depth in all three boreholes, the increases were much more substantial in the boreholes within Disturbed Area 1 (S1011-SCX-018 and -SCX-019) relative to the borehole located just north of Disturbed Area 1 (S1011-SCX-020).

- Mine site #1012 and Disturbed Area 2 (Figures 3-6b and 4-3d) - The Survey Area B uranium IL (3.34 mg/kg) was exceeded in all surface and subsurface soil samples. Uranium concentrations ranged from 4.9 to 41 mg/kg. The maximum concentration was greater than 12 time the IL and occurred in a subsurface soil sample located in the northern portion of mine site #1012 (S1011-SCX-007; 1.5-2.0 ft bgs). Uranium concentrations increased with depth in one borehole and decreased with depth in two boreholes.

- Survey Area C – The uranium IL (1.91 mg/kg) was exceeded in all three soil samples (two surface and one subsurface). Uranium concentrations ranged from 7.1 to 24 mg/kg. The maximum concentration was greater than 12 times the IL and occurred in a surface soil sample located downgradient from Waste Pile 3, and within the debris pile at the base of the mesa sidewall (S1011-SCX-006). Uranium concentrations decreased with depth.

- Survey Area D – The uranium IL (0.554 mg/kg) was exceeded in all three surface soil samples and in one (out of 2) subsurface soil samples. Uranium concentrations ranged from 0.38 to 2 mg/kg. The maximum concentration was less than five times the IL and occurred in a surface soil sample located within the plains (S1011-SCX-043). Uranium concentrations decreased with depth.

- Survey Area E – The uranium IL (0.691 mg/kg) was exceeded four (out of seven) surface sediment samples and in seven (out of eight) subsurface sediment samples. The three sample locations where the IL was not exceeded were all located in the southeastern-most portion of the plains. Uranium concentrations ranged from 0.4 to 15 mg/kg. The maximum concentration was greater than 21 times the IL and occurred in a subsurface sediment sample located downgradient from Waste Piles 2 and 3, and the debris pile near the base of the mesa sidewall (S1011-SCX-004; 1.5-2.0 ft bgs). The remaining IL exceedances ranged from less than two times the IL to less than five times the IL. Uranium concentrations increased with depth in two boreholes, decreased with depth in one borehole, and varied in two boreholes.

As a broader point of reference, a regional study of the Western US documented uranium concentrations in soil that ranged from 0.68 to 7.9 mg/kg, with a mean value of 2.5 mg/kg (USGS, 1984). Uranium concentrations were within the typical range of regional values for all Survey Area D samples. Uranium concentrations in soil/sediment exceeded the maximum regional value in seven Survey Area A samples, 16 Survey Area B samples, two Survey Area C samples, and one Survey Area E sample. All samples that exceeded the maximum regional value were associated with or downgradient from potential mining- or reclamation-related features or disturbances.

- Arsenic

  - Survey Area A – The arsenic IL (11.9 mg/kg) was not exceeded in any surface or subsurface soil samples. Arsenic concentrations ranged from 2.3 to 4.1 mg/kg. The maximum concentration occurred in a surface soil sample that was collected from the Disturbed Area 1 (S1011-SCX-017). Arsenic concentrations decreased with depth in both borehole locations.

  - Survey Area B – The arsenic IL (2.34 mg/kg) was exceeded in 18 (out of 42) surface soil/sediment samples, in 12 (out of 47) subsurface soil/sediment samples and in one (out of two) subsurface soil/bedrock samples. Survey Area B arsenic concentrations ranged from 1.1 to 12 mg/kg. The maximum concentration (12 mg/kg) for the Survey Area and the Site occurred in a subsurface soil/bedrock sample collected from Disturbed Area 1 (S1011-SCX-018; 1.0-3.5 ft bgs). Arsenic IL exceedances within Survey Area B are described below with respect to mine site #1011, mine site #1035, Disturbed Area 1, and mine site #1012/Disturbed Area 2.

    - Mine site #1011 (refer to Figures 3-6b and 4-3b) – The Survey Area B arsenic IL (2.34 mg/kg) was exceeded in two (out of 11) surface samples and one (out of seven) subsurface soil samples. Arsenic concentrations ranged between 1.3 and 2.9 mg/kg. All IL exceedances were less than two times the IL. In general, arsenic concentrations decreased or remained constant with depth. No distinct spatial patterns were observed with respect to IL exceedances or concentration changes with depth.

- Mine site #1035 (refer to Figures 3-6b and 4-3a) – The Survey Area B arsenic IL (2.34 mg/kg) was exceeded in nine (out of 22) surface soil/sediment samples and five (out of 36) subsurface samples. Arsenic concentrations ranged from 1.1 to 4.2 mg/kg and all IL exceedances were less than two times the IL. The maximum concentration (4.2 mg/kg) occurred in a subsurface soil sample located near the eastern claim boundary (S1011-SCX-021; 17.0-18.0 ft bgs). Twelve boreholes generally had decreasing arsenic concentrations with depth and six had fluctuating concentrations with depth. No distinct spatial patterns were observed with respect to exceedances or concentration changes with depth.

- Disturbed Area 1(refer to Figures 3-6b and 4-3c) – The Survey Area B IL (2.34 mg/kg) was exceeded in three (out of four) surface soil sample locations and both subsurface soil samples. Arsenic concentrations ranged from 1.9 to 12 mg/kg. The maximum concentration (12 mg/kg) for Disturbed Area 1, Survey Area B and the Site occurred in subsurface soil/bedrock sample from borehole S1011-SCX-018 (1.0-3.5 ft bgs). Arsenic concentrations in soil samples were all less than two times the IL. Arsenic concentrations increased with depth in all three boreholes.

- Mine site #1012 and Disturbed Area 2 (Figures 3-6b and 4-3d) – The Survey Area B arsenic IL (2.34 mg/kg) was exceeded in four (out of five) surface soil samples and in all four subsurface soil samples. Arsenic concentrations ranged from 2.3 to 5.9 mg/kg with all but one sample exceeding the IL by less than two times. The maximum concentration occurred in a surface soil sample from borehole S1011-SCX-016, located within Waste Pile 3. Arsenic concentrations decreased with depth in two boreholes and fluctuated with depth in one borehole.

- Survey Area C – The arsenic IL (4.99 mg/kg) was not exceeded in any of the three soil samples (two surface and one subsurface). Arsenic concentrations ranged from 1.2 to 1.3 mg/kg. The maximum concentration was from both of the surface soil samples (S1011-CX-006 and -SCX-006).

- Survey Area D – The arsenic IL (1.76 mg/kg) was not exceeded in any of the five soil samples (three surface and two subsurface). Arsenic concentrations ranged from 1.1 to 1.5 mg/kg. The maximum concentration was from a subsurface soil sample located in the plains southwest of mine site #1012 (S1011-SCX-041; 0.2-2.5 ft bgs). Arsenic concentrations increased with depth in one borehole and were unchanged with depth in the other borehole.

- Survey Area E – The arsenic IL (1.73 mg/kg) was not exceeded in any of the seven surface or eight subsurface sediment samples. Arsenic concentrations ranged from 0.56 to 1.3 mg/kg. The maximum concentration occurred in a surface sediment sample located in a drainage in the eastern-central portion of the plains (S1011-CX-009). Arsenic concentrations increased with depth in two boreholes, were relatively unchanged with depth in two boreholes, and decreased with depth in one borehole.

As a broader point of reference, a regional study of the Western US documented arsenic concentrations in soil that ranged from less than 0.10 to 97 mg/kg, with a mean value of 5.5 mg/kg (USGS, 1984). All arsenic concentrations were within the typical range of regional values in the soil/sediment samples from all Survey Areas.

- Molybdenum
  - Survey Area A – The molybdenum IL (2.26 mg/kg) was not exceeded in any surface or subsurface soil samples. Molybdenum concentrations ranged from 0.27 to 0.4 mg/kg. The maximum concentration occurred in a surface soil sample that was collected from within Disturbed Area 1 (S1011-SCX-017). Molybdenum concentrations decreased with depth in one borehole and fluctuated with depth in the other.
  - Survey Area B – The molybdenum IL (0.346 mg/kg) was exceeded in seven (out of 42) surface sample locations and in four (out of 47) subsurface samples. Molybdenum IL exceedances did not occur in either of the two subsurface soil/bedrock samples or the bedrock sample. Molybdenum concentrations ranged from 0.2 to 11 mg/kg. The maximum concentration (11 mg/kg) for the Survey Area and the Site was greater than ten times the IL and occurred in a surface soil sample located within mine site #1035 (S1011-SCX-038). The remaining exceedances ranged from less than two times the IL to under five times the IL. Molybdenum IL exceedances within Survey Area B are described below with respect to mine site #1011, mine site #1035, Disturbed Area 1, and mine site #1012/Disturbed Area 2.
    - Mine site #1011 (refer to Figures 3-6b and 4-3b) – The Survey Area B molybdenum IL (0.346 mg/kg) was exceeded in one (out of 11) surface soil samples and was not exceeded in any of the seven subsurface samples. Molybdenum was not detected in eight sample locations. Measurable molybdenum concentrations ranged from 0.22 to 0.4 mg/kg. The maximum concentration was less than two times the IL and occurred in surface soil sample S1011-SCX-011.
    - Mine site #1035 (refer to Figures 3-6b and 4-3a) – The Survey Area B molybdenum IL (0.346 mg/kg) was exceeded in two (out of 22) surface samples and in two (out of 34) subsurface soil samples. Molybdenum was not detected in nine sample locations. Measurable molybdenum concentrations ranged from 0.2 to 11 mg/kg. The maximum concentration for the area, Survey Area B and the Site occurred in a surface soil sample located approximately 50 feet southwest of the vertical mine shafts (S1011-SCX-038). The remaining three IL exceedances were less than three times the IL. Four boreholes had increasing molybdenum concentrations with depth, five had decreasing molybdenum concentrations with depth, and four had fluctuating molybdenum concentrations with depth. No distinct spatial patterns were observed with respect to exceedances or concentration changes with depth.
    - Disturbed Area 1(refer to Figures 3-6b and 4-3c) – The Survey Area B molybdenum IL (0.346 mg/kg) was not exceeded in any surface or subsurface sample locations. Molybdenum concentrations were below the detection limit for six out

of seven samples. The one detection (0.22 mg/kg) occurred in subsurface soil/bedrock sample S1011-SCX-018 (1.0-3.5 ft bgs).

- Mine site #1012 and Disturbed Area 2 (Figures 3-6b and 4-3d) – The Survey Area B molybdenum IL (0.346 mg/kg) was exceeded in four (out of five) surface soil samples and in two (out of four) subsurface samples. Molybdenum concentrations ranged from 0.21 to 0.73 mg/kg; the maximum concentration was less than three times the IL and occurred in a surface soil sample located within the debris pile north of mine site #1012 (S1011-SCX-015). The remaining IL exceedances were all less than two times the IL. Molybdenum concentrations decreased with depth in two boreholes and fluctuated with depth in one borehole.

- Survey Area C – Molybdenum was below detection limits in all surface and subsurface soil samples.

- Survey Area D – Molybdenum was below detection limits in all surface and subsurface soil samples.

- Survey Area E – An IL for molybdenum was not identified because molybdenum was not detected in the background reference area (BG-5). With the exception of one subsurface sediment sample, molybdenum was below detection limits in all surface and subsurface sediment samples. The one detection (0.2 mg/kg) occurred in a subsurface sediment sample located in the eastern-most drainage, near the base of the mesa sidewall (S1011-SCX-011; 0.5 to 1.5 ft bgs).

As a broader point of reference, a regional study of the Western US documented molybdenum concentrations in soil that ranged from less than 3 to 7 mg/kg, with a mean value of 0.85 mg/kg (USGS, 1984). Molybdenum concentrations were within the typical range of regional values in samples from Survey Areas A, C, D, and E. Molybdenum concentrations exceeded the maximum regional value in one Survey Area B soil sample.

- Selenium – ILs for selenium were not identified because selenium sample results were non-detect in all the background reference areas**.**

  - Survey Area A – With the exception of one subsurface soil sample, selenium was not detected in any surface soil samples or subsurface samples. The single selenium detection (1 mg/kg) occurred in a subsurface soil sample collected from Disturbed Area 1 (S1011-SCX-017; 0.5-1.0 ft bgs).

  - Survey Area B – With the exception of one subsurface sample, selenium was not detected in any surface or subsurface soil/sediment/bedrock samples. The single detection (1.2 mg/kg) occurred in a subsurface soil/bedrock sample collected from Disturbed Area 1 (S1011-SCX-018; 1.0-3.5 ft bgs).

  - Survey Area C – Selenium was below detection limits in all surface and subsurface soil samples.

- Survey Area D – Selenium was below detection limits in all surface and subsurface soil samples.

- Survey Area E – Selenium was below detection limits in all surface and subsurface sediment samples.

As a broader point of reference, a regional study of the Western US documented selenium concentrations in soil that typically ranged from less than 0.10 to 4.3 mg/kg, with a mean value of 0.23 mg/kg (USGS, 1984). Selenium concentrations were within the typical range of regional values in all Survey Areas.

- Vanadium
  - Survey Area A – The vanadium IL (27.3 mg/kg) was exceeded in three (out of five) surface soil samples and in one (out of three) subsurface samples. Survey Area A vanadium concentrations ranged from 16 to 310 mg/kg. The maximum concentration was 11 times greater than the IL and occurred in a surface soil sample collected from Waste Pile 2, located on the mesa sidewall (S1011-CX-012). Vanadium concentrations generally decreased with depth in one borehole location and remained unchanged with depth in the other borehole location.

  - Survey Area B – The vanadium IL (11.2 mg/kg) was exceeded in 34 (out of 42) surface soil/sediment samples and in 31 (out of 47) subsurface soil/sediment samples. Survey Area B vanadium concentrations ranged from 7.2 to 740 mg/kg. The highest concentration for the Survey Area and the Site (740 mg/kg) was detected in a subsurface soil/bedrock sample located in Disturbed Area 1 (S1011-SCX-018; 1.0 to 3.5 ft bgs). Approximately 81 percent of the vanadium exceedances (47 out of 58) were less than two times the Survey Area B IL. Vanadium IL exceedances within Survey Area B are described below with respect to mine site #1011, mine site #1035, Disturbed Area 1, and mine site #1012/Disturbed Area 2.

    - Mine site #1011 (refer to Figures 3-6b and 4-3b) – The vanadium IL (11.2 mg/kg) was exceeded in six (out of 11) surface soil samples and in six (out of seven) subsurface soil samples. Vanadium concentrations ranged from 7.2 to 17 mg/kg and IL exceedances were less than two times IL. The maximum concentration (17 mg/kg) occurred in a subsurface soil sample from borehole S1011-SCX-009 (0.5 to 2.0 ft bgs). Vanadium concentrations increased with depth in four boreholes, decreased with depth in one borehole, and fluctuated with depth in one borehole.

    - Mine site #1035 (refer to Figures 3-6b and 4-3a) – The vanadium IL (11.2 mg/kg) was exceeded in 19 (out of 22) surface soil or sediment samples and 19 (out of 34) subsurface soil or sediment samples. Vanadium concentrations ranged from 7.2 to 77 mg/kg. The maximum concentration was greater than six times the IL and occurred in a subsurface soil sample located near the eastern claim boundary (S1011-SCX-021; 12-13 ft bgs). Eighty percent (32 out of the 40) of the IL exceedances were less than two times the IL. Vanadium concentrations increased with depth in three boreholes, decreased with depth in seven boreholes, remained constant with depth in one borehole, and fluctuated with depth in six boreholes. No distinct spatial patterns were observed with respect to exceedances or concentration changes with depth.

- Disturbed Area 1 (refer to Figures 3-6b and 4-3c) – The vanadium IL (11.2 mg/kg) was exceeded in all surface and subsurface soil samples with concentrations that ranged from 49 to 380 mg/kg; the maximum concentration in soil was greater than 10 times the IL and occurred in the surface sample collected from the S1011-SCX-018 borehole. The maximum concentration in Survey Area B and the Site (740 mg/kg) occurred in subsurface soil bedrock sample from borehole S1011-SCX-018 (1.0-3.5 ft bgs). The remaining soil samples all had vanadium exceedances between four and ten times the Survey Area B IL. Vanadium concentrations increased with depth in all three boreholes.

- Mine site #1012 and Disturbed Area 2 (Figures 3-6b and 4-3d) – The vanadium IL (11.2 mg/kg) was exceeded in all surface and subsurface soil samples from all five sample locations. Concentrations ranged from 15 to 88 mg/kg; the maximum concentration was greater than eight times the IL and occurred in a surface soil sample collected from Waste Pile 3 (S1011-SCX-016). Six out of the nine surface and subsurface soil samples exceeded the vanadium IL by more than two times. Vanadium concentrations decreased with depth in two boreholes and fluctuated with depth in one borehole.

- Survey Area C – The vanadium IL (17.4 mg/kg) was exceeded in one (out of two) surface soil samples and was not exceeded in the one subsurface sample. Vanadium concentrations ranged from 12 to 43 mg/kg. The maximum concentration was less than three times the IL and occurred in a surface soil sample located on the mesa sidewall, downgradient from Disturbed Area 1 (S1011-CX-006). The vanadium concentrations increased with depth.

- Survey Area D – The vanadium IL (11.0 mg/kg) was exceeded in two (out of three) surface soil samples and was not exceeded in the two subsurface soil samples. Vanadium concentrations ranged from 8.4 to 20 mg/kg. The maximum concentration was less than two times the IL and occurred in a surface soil sample collected within the plains (S1011-SCX-043). The vanadium concentrations increased with depth in one borehole, and decreased with depth in the other.

- Survey Area E – The vanadium IL (10.7 mg/kg) was exceeded in two (out of seven) surface sediment samples and four (out of eight) subsurface sediment samples. Vanadium concentrations ranged from 4.1 to 85 mg/kg. The maximum concentration was greater than seven times the IL and occurred in a surface sediment sample located in the eastern-most drainage, near the base of the mesa sidewall (S1011-SCX-011). Vanadium concentrations generally increased with depth in four boreholes and decreased with depth in one borehole.

As a broader point of reference, a regional study of the Western US documented vanadium concentrations in soil that ranged from 7 to 500 mg/kg, with a mean value of 70 mg/kg (USGS, 1984). Vanadium concentrations in soil and sediment were within the typical range of regional values in all Survey Areas.

4.4 CONSTITUENTS OF POTENTIAL CONCERN

Based on the results presented in Sections 4.2 and 4.3, gamma radiation and concentrations of Ra-226, uranium, and vanadium in soil/sediment exceeded their respective ILs in Survey Areas A, B, C, D and E. In addition, concentrations of arsenic and molybdenum exceeded their respective ILs in Survey Area B. Therefore, gamma radiation, Ra-226, arsenic, molybdenum, uranium, and vanadium were confirmed as COPCs for the Site. Selenium was also confirmed as a COPC, because it was detected in soil samples from Survey Areas A, B, and E, but was non-detect in all background reference area samples.

4.5 AREAS THAT EXCEED THE INVESTIGATION LEVELS

The approximate lateral extent of surface gamma IL exceedances in soil/sediment is 69.7 acres, as shown in Figure 4-4a. To estimate this area, polygons were contoured around portions of the Site that had multiple, contiguous surface gamma IL exceedances and then the total area within the polygons was calculated. This area estimate is also inclusive of all surface and subsurface soil/sediment sample locations with the exception of S1011-SCX-009 in mine site #1011. Figures 4-4b through 4-4f show the five Survey Areas separately to better display those areas with multiple, contiguous surface gamma IL exceedances and the sample locations.

Figure 4-5 shows the vertical extent of IL exceedances in each borehole by incorporating information from each location, including: (1) depth to bedrock; (2) total borehole depth; and (3) depth range of IL exceedances. Table 4-5 lists the IL exceedances identified at each borehole location and Figure 4-5 shows the surface gamma IL exceedances for reference.

IL exceedances in metals and Ra-226 concentrations at surface and subsurface sample locations were typically co-located with surface gamma survey measurements and/or subsurface static gamma measurements that also exceeded their ILs, but not always. Variations occur due to natural variability and the different field methods. For example, a small piece of mineralized rock or petrified wood may have been collected in a soil sample but may not have been detected by the gamma meter in the gamma survey due to distance from the meter, the depth below ground surface, or because the gamma meter measures radiation over a larger area than the discrete soil sample location.

The lateral extent of the IL exceedances for surface gamma data shown in Figure 4-4a were compared to the lateral extent of the predicted Ra-226 concentrations that exceeded ILs in Figure 4-2c. The areas of predicted Ra-226 concentrations that exceeded the Ra-226 ILs were generally similar to the areas of gamma measurements that exceeded the surface gamma survey ILs. However, there were notable differences within Survey Areas B and C. Predicted Ra-226 concentrations in Survey Area C exceeded the IL over a larger area than the actual surface gamma survey, while the opposite was true for Survey Area B. The inconsistency between the predicted Ra-226 exceedances and the surface gamma exceedances within Survey Areas B and C may be the result of the surface gamma ILs being high (Survey Area C) or low (Survey Areas B) relative to the Ra-226 IL.

4.6 AREAS OF TENORM AND NORM

A multiple lines of evidence approach was used to evaluate the Site and distinguish areas of TENORM from areas of NORM within the Survey Area, as described in Section 3.3.3. Based on this evaluation, 72.2 acres out of the 101.3 acres of the Survey Area were estimated to contain TENORM at the Site. This estimate was inclusive of three areas: (1) portions of the mesa top; (2) the mesa sidewall; and (3) the plains, which included three of the drainages. The area containing TENORM is shown in relation to the lateral extent of IL exceedances in Figure 4-6 and in relation to the gamma measurements in Figure 4-7.

The RSE data that supports the delineation of TENORM at the Site includes:

- Historical Data Review Conclusions
  - USAEC records show ore production from "Section 26 (Hanosh) (Desidero Allotment)" occurred between 1952 and 1957 and 11,110 tons (approximately 22,220,000 pounds) of ore were produced. The ore contained 83,752 pounds of 0.38 percent U3O8 and 17,518 pounds of 0.12 percent V2O5. Given that in the USAEC records "Section 26" appeared to have included the three AUM claims from the Site as well as additional AUM claims from Sections 23 and 25, it is not known what volume of ore was produced exclusively from the Section 26 claims.
  - Historical document review indicated that the portal of an incline was present at the bottom of a 75-ft-long by 20-ft-deep box cut in the northeast portion of the Site. In addition, several open pits were present. The open pits were constructed as trenches up to 40 ft deep and 450 ft long.
  - Historical document review indicated that a PA was conducted at "The Desiderio Group Uranium Mines, also known as the Hanosh Mines Section 26", an area that occupied approximately 130 acres and extended into adjacent Section 23 and Section 25 (NSO, 1990). The PA findings identified the following known/potential problems for the PA site:(1) the presence of 91,962 cubic yards of low grade, radioactive uranium ore and tooled mine waste piles that were exposed, uncontained, and unlined;(2) the piles "were capable of producing leachate subject to migration into the atmosphere, groundwater and surface water systems."; (3)the presence of an unsecured155 ft inclined adit and unfenced open pits; (4) the exposed surface of the adit and surface pits were also capable of "producing leachate similar in composition to that released from the mine waste piles"; and (5)The possibility of exposure to local residents through: (a) radon gas emissions and ionizing radiation; and/or (b) direct contact of exposure through ingestion of windblown particulates contaminated with radioactive and heavy metal species.
  - Historical document review indicated that in 1991 the USEPA conducted an ERA at the Desidero Mines that included portions of the Site. The ERA activities included filling existing pits, covering an open adit, and regrading. As part of the ERA, USEPA filled in and regraded open pits and the adit using existing material on-site including ore piles, mine waste, and overburden that had been left behind at the mines

- A follow-up 1992 USEPA study compared aerial images acquired just before the ERA started to aerial images acquired during remediation to provide volumetric data regarding the ERA. The study area included areas of claims #1011 and #1035 and portions of the adjacent claims north and east of the Site. The report indicated that 24 waste piles with a total volume of 53,200 yd^3 had been removed or recapped, and 15 piles with a volume of 57,805 yd^3 still remained.

- Review of the RSE report prepared in 2014 by E&E for the AUM Section 26 mines indicated that E&E proposed excavation of approximately 9,737 yd^3 of impacted soil from areas within or adjacent to claims #1011 and #1035. E&E also recommended removing loose rocks with elevated gamma from the 2014 RSE site but did not provide a volume estimate for this material. In addition, E&E reported that areas south of mine site #1035 had elevated gamma measurements in the surface soil, but that the primary source of elevated gamma appeared to be associated with bedrock. E&E did not provide area or volume estimates for these locations.

- Geology/geomorphology

  - Bedrock at the Site consisted of three geologic formations:
    (1) the Todilto Limestone; (2) the Entrada Sandstone; and (3) the Wingate Sandstone. The Todilto Limestone was known to contain natural enrichments of uranium mineralization. Therefore, the geology and geomorphology of the Site was conducive to the presence of NORM.

  - Numerous sub-parallel ephemeral drainages are present on-site that drain either to the northeast (on the mesa top) or to the south (in the plains), where they then terminate. These drainages could transport NORM/TENORM to the northeast or south.

- Disturbance Mapping – Stantec field personnel observed the following features either during field activities or during review of the high resolution imagery:

  - Graded/disturbed reclaimed areas were mapped on claims #1011 and #1035. It is assumed that the areas were graded/disturbed as part of the 1991 ERA.

  - Two unsecured vertical mine shafts were observed in the graded/disturbed reclaimed area within mine site #1035. The two shafts, referred to as the primary shaft and secondary shaft, were approximately 28 and 8 ft in depth, respectively. It is unknown if the shafts were excluded from reclamation during the 1991 ERA, or if the reclamation-related backfilling of the shafts had collapsed.

  - A possible portal or storage area that had been backfilled and covered with wood debris was observed in mine site #1035.

  - Seven waste piles were observed throughout the Site. The waste piles all consisted of gray limestone of the Todilto Formation.

  - Potential waste rock was mapped along the eastern portion of the mesa edge.

  - Four potential mining disturbed areas were mapped at the Site. Two of the disturbed areas were mapped by Stantec field personnel and were located along the mesa rim.

The other two disturbed areas were identified using the high resolution aerial images, and are located on the mesa top, in the central portion of the Site.

- Two excavation areas were mapped along the mesa edge that were less than 10 ft deep, and were associated with Waste Pile 2 and Waste Pile 3.
- Numerous historical boreholes were observed on the mesa top. Several of the historical boreholes, located on mine site #1035, were unplugged and ranged from 6 to 8 inches in diameter, and ranged in depth from 5 ft to 34 ft.
- Several potential haul roads were mapped on the mesa top. The roads provided various access routes between each of the three Section 26 claims, as well as off-site to the north.
- Three debris piles were mapped at the Site. One debris pile was located at the base of the mesa, downgradient from mine site #1012 and a large waste pile. The second debris pile was located near the mesa edge and debris was piled in a shallow excavation. It is unknown whether the excavation is related to historical mining activities. The third was in the north central portion of the mesa top.

- Site Characterization
  - The mesa top was comprised of portions of Survey Area A and all of Survey Area B and included mine site #1011, mine site #1035, and the northern half of mine site #1012. The majority of the mapped disturbances were located on the mesa top, with the exception of portions of Waste Pile 2, Waste Pile 3, Waste Pile 7, the southern debris pile and the potential waste rock. Surface gamma IL exceedances occurred in the majority of the surveyed areas on the mesa top, including nearly 100 percent of the eastern half of the mesa top survey areas. Surface gamma measurements did not exceed the IL in the southern portion of mine site #1011, along portions of the western potential haul roads, and in the area west of Waste Pile 2 along the rim of the mesa. With the exception of three sample locations within mine site #1011 and one sample location within mine site #1035, one or more IL was exceeded in every soil/sediment sample location. Excluding molybdenum, the highest Ra-226 and metals concentrations (greater than 10 times the ILs) for the Site were measured in surface and/or subsurface soil or soil/bedrock samples that were collected within Disturbed Area 1. The highest molybdenum concentration was measured in a sample from the graded/reclaimed area within mine site #1035.
  - The mesa sidewall was comprised of Survey Area C, the southern portions of Survey Area A, and included the southern half of mine site #1012. Portions of Waste Pile 2, Waste Pile 3, Waste Pile 7, the potential waste rock, and the southern debris pile were located on the mesa sidewall. The majority of surface gamma IL exceedances on the mesa sidewall were coincident with, or downgradient from the waste piles and debris pile, or in areas downgradient from the eastern portion of Disturbed Area 1. The greatest surface gamma IL exceedances were associated with Waste Pile 2. In addition, two or more ILs were exceeded in every sample location, with the greatest exceedances detected in sample locations within Waste Pile 2 or downgradient from Waste Pile 3.
  - The plains were comprised of Survey Area D, Survey Area E, and the southern portion of Survey Area C. Surface gamma IL exceedances occurred throughout the plains. The

greatest surface gamma IL exceedances were located downgradient from Disturbed Area 1 and in the eastern portion of the plains. One or more Ra-226 or metals ILs were exceeded in every surface or subsurface soil/sediment sample location, with the greatest surface soil exceedances detected from locations in the eastern portion of the plains. Ra-226 and metals concentrations in sediments collected from the drainages decreased with distance from the mesa sidewall, but generally increased with depth at four of the five locations. The greatest Ra-226 and metals IL exceedances in the drainages were detected in the deepest sediment sample in the southern-most sample location (S1011-SCX-004). As a result of the notable IL exceedances in the deepest sample in S1011-SCX-004, the southern extent of the drainage is assumed to contain TENORM. Surface gamma survey measurements did not exceed the IL to the southern extent of the drainage. The gamma survey extended to 0.25 miles from the closest claim boundary (#1012) per the *RSE Work Plan*.

- Areas within the plains and on the mesa sidewall that had surface gamma measurements that exceeded the IL were determined to contain NORM. These areas were characterized by fewer surface gamma exceedances relative to other areas in the plains, as well as gamma measurements that exceeded the IL by less than 10 percent. These areas were generally located within the western- and southern-most portions of the plains, as well as within a centrally located strip that extended south from the rim of the mesa to the southern extent of the Site. The area along the mesa sidewall that was considered to be NORM was not downgradient from any potential mining-disturbed areas or waste piles suggesting that this area was likely not impacted.

- A portion of the mesa top that was located between the three claims had surface gamma IL exceedances, but did not show signs of mining-related disturbances. This suggests that this area was not impacted and is considered to contain NORM. However, due to the uncertainty in the historical activities that have occurred at this Site, a volume of “potential TENORM” is provided for this area in Section 4.7.

- Seven waste piles were mapped at the Site. All waste piles are estimated to contain waste rock. Elevated Ra-226 and metals concentrations were detected in samples from Waste Pile 3 (S1011-SCX-008) and Waste Pile 6 (S1011-SCX-024). It is identified as a data gap that subsurface samples were not collected from Waste Piles 1, 2, 4, 5, and 7. Elevated Ra-226 and metals concentrations and subsurface static gamma measurements collected from the following locations also indicated the potential presence of waste rock: (1) S1011-SCX-006 collected on mesa sidewall and downslope from Waste Pile 3; (2) -SCX-017, -SCX-018, and -SCX-019 located within the potential mining disturbed area on the southwest portion of the mesa top; and (3) the variable elevated analytical results and subsurface static gamma measurements in -SCX-028 and -SCX-031 in the western portion of the eastern graded/disturbed reclaimed area may be indicative of waste rock mixed with reclamation material.

- Metals concentrations in samples collected outside the area of TENORM (S1011-CX-015 and -SCX-042) were less than or within the regional concentration values.

- It is important to consider that with the exception of one location, the subsurface static gamma ILs were not the only evidence used to delineate the vertical extent of TENORM that exceeded the IL in borehole locations at the Site. In borehole S1011-SCX-031, Ra-226 and metals concentrations did not exceed their respective ILs. However, a subsurface static gamma measurement of 112,936 was recorded at 7.0 ft bgs and was coincident with the presence of debris/refuse material (e.g., cans, paper, and bottle caps). TENORM was estimated to exceed the ILs to approximately 10 ft bgs in the area of S1011-SCX-031.

The area of the Site considered to contain TENORM (i.e., multiple lines of evidence indicated or suggested the presence of mining-related impacts) was 72.2 acres, as shown on Figure 4-8a. Portions of the TENORM area contained one or more IL exceedance. Of the 72.2 acres that contain TENORM, 45.2 acres contain TENORM that exceeded the surface gamma ILs and TENORM that exceeded the ILs at all but one of the soil/sediment sample locations. One location, S1011-SCX-009 in mine site #1011 was not included in the area of surface gamma IL exceedances. TENORM that exceeded the ILs in Survey Areas A through E is shown on Figures 4-8b through 4-8f, respectively, and is compared to mining-related features in Figure 4-8g.

4.7 TENORM VOLUME ESTIMATE

The volume of TENORM that exceeds one or more IL is approximately 170,191 yd^3, as shown in Figure 4-9a. The volume and area of TENORM associated with specific mine features is listed in Table 3-3. This estimate was calculated using ESRI ArcGIS Desktop 10.3.1 Spatial Analyst Extension cut/fill tool (ESRI, 2017). The volume analysis also utilized the ground surface elevation contours developed from the orthophotographs coupled with hand-derived contours based on field personnel observations, other field personnel observations and mapping, depth to bedrock in boreholes, gamma measurements, sample analytical data, and historical mining documentation. Field observations included observations of disturbance, changes in vegetation, estimating/projecting the slope of underlying bedrock, and estimating the shape and topography of waste piles and/or soil deposits.

In some portions of the Site, Stantec was unable to determine whether TENORM was present. Given this uncertainty, a second volume was calculated for areas of potential TENORM exceeding the ILs. This volume included: (1) Group 14 – an area in the central portion of the mesa top that were not sampled because mining-related ground disturbance was not observed; (2) Group 15 – areas on the mesa sidewall that could not be surveyed due to steep or unsafe terrain (portions of Survey Areas A and C); and (3) Group 16 – areas within the Wingate Sandstone portion of Survey Area C that exceeded the BG-6 (Wingate) surface gamma IL, but did not exceed the Survey Area C surface gamma IL. The volume of potential TENORM that exceeds the ILs is 14,055 yd^3.

TENORM and potential TENORM exceeding the ILs at the Site was split into groups based on the depth or type of material to aid in analysis and describing the basis of the volumes. The locations, volume, and areas of these groups are shown in Figure 4-9a. The assumptions that were used to calculate the volume of TENORM with IL exceedances were as follows

General Assumptions

- It was assumed that subsurface bedrock encountered in boreholes was not previously modified by human activity and is therefore NORM.
- For areas of TENORM at the Site containing large cobble- or boulder-sized rocks at the surface whose heights exceeded the assumed depth of TENORM in that area (e.g., a 3-ft-tall boulder in an area where TENORM was assumed to extend 1 ft bgs), the additional volume of the cobble- or boulder-sized rocks was assumed to be accounted for by the TENORM depth estimates.
- Portions of the areas delineated as exposed bedrock within the TENORM area on Figure 4-9a contain small amounts of colluvium.
- With the exception of S1011-SCX-031 (refer to last bullet in Section 4.6), the subsurface static gamma IL values were not used as the only evidence to delineate the vertical extent of TENORM that exceeded the ILs in borehole locations at the Site.

Group Assumptions

- Group 1 (69,028 yd^3) – Group 1 consists of the reclamation area in the northeast portion of mine site #1035 (refer to Figures 4-9a). The vertical extent of TENORM exceeding ILs was variable throughout Group 1; Figure 4-9b provides a contour map of the estimated vertical extent in Group 1. Vertical extent was estimated based on: (1) subsurface data from 18 boreholes; (2) elevation profiles developed using topographic contours from the orthophotographs (Cooper, 2017); and (3) historical documents, photographs, and aerial images that described or depicted the lateral and vertical extent of disturbances. In addition, results from the geophysical survey (refer to Section 4.8) were generally used to support these assumptions. The topographic contours and depth to bedrock information were used to generate cross-sections (refer to Figures 2-8a and 2-8b) that provided scaled representations of the subsurface that aided in the volume calculations performed in GIS. The depth to bedrock was directly observed in the central portions of Group 1 during the drilling investigation, and some areas had TENORM exceeding ILs to depths up to 15 feet. However subsurface data were not obtained in areas along the boundaries of Group 1, and therefore depth to bedrock was assumed based on field observations (including depth to bedrock in nearby boreholes) and mapping (including estimating the slope of the underlying bedrock surface, and the topographic shape of waste piles or soil deposits), as well as historical information about pit depths and locations. The vertical extent of TENORM exceeding ILs around boundaries of Group 1 was estimated to be 5.0 thick.
- Group 2 (6,831 yd^3) – Group 2 consists of a portion of the reclamation area in the western portion of mine site #1011. The Group 2 polygon was best fit around visible areas of surface disturbance observed in the 1956 historical aerial photograph (refer to Figure 3-1b), as well as current aerial images. The vertical extent of TENORM exceeding ILs was estimated to be 4.0 ft deep over the polygon area based on subsurface data from seven boreholes in mine site #1011 (S1011-SCX-009, -SCX-010, -SCX-011, -SCX-012, -SCX-039, -SCX-040, and -SCX-044). This assumption was generally supported by the results from the geophysical investigations within mine site #1011 (refer to Section 4.8). Of note, field personnel using hand augers met refusal on hard rock at less than 1.0 ft below ground surface for three of the boreholes

(S1011-SCX-039, -SCX-040, and -SCX-044), but boreholes advanced with the drill rig encountered bedrock between 2.5 and 5.0 ft bgs in the area.

- Group 3 (3,942 yd^3) – Group 3 consists of portions of the mesa top within and near mine site #1011 that appeared to have been disturbed based on current and historical (1991) aerial photos (refer to Figure 3-1c), limited subsurface investigations, and field observations including changes in vegetation spacing and density due to re-seeding and variation in soil type. TENORM exceeding ILs in this area was assumed to extend to 1.0 ft bgs. At borehole S1011-SCX-014, elevated Ra-226 and metals concentrations and static gamma measurements were present in the surface soil sample, but concentrations and static gamma measurements decreased in the subsurface.

- Group 4 (245 yd^3) – Based on field observations that the potential haul roads followed existing topography (i.e., fill material was not used to create the road), TENORM exceeding ILs in the areas of the potential haul roads was assumed to extend to 0.5 ft bgs. If a potential haul road was within another group, the volume of the road was not counted twice.

- Group 5 (23,301 yd^3) – Group 5 consists of portions of the mesa top that did not appear to have undergone major disturbance or mining activities based on limited subsurface investigations and field observations that vegetation and the ground surface appeared to be generally undisturbed. TENORM exceeding ILs in this area was assumed to extend to 1.0 ft bgs.

- Group 6 (7,213 yd^3) – Group 6 consists of the eastern portions of the mesa edge that appear to have been disturbed by mining activities, and more recently used as a corral. The volume of TENORM exceeding ILs in Group 6 was based on field observations (including disturbance of outcrops at the mesa edge and lack of vegetation) and subsurface data from four boreholes (S1011-SCX-017 through -SCX-020) and was assumed to be 3.5 ft thick over the area of the polygon.

- Group 7 (4,390 yd^3) – Group 7 consists of the portions of Waste Pile 2, Waste Pile 3, and Waste Pile 7 that extend down the sidewall, all of which are located on the edge of the mesa and extend down the mesa sidewall. TENORM that exceeded ILs was assumed to be 3.0 ft thick over the polygon areas based on field observations of the general thicknesses of the piles and limited subsurface soil sampling (S1011-SCX-008 and -SCX-016) and gamma radiation surveys. Portions of Group 7 could not be accessed safely on foot, and drill rig access was not possible.

- Group 8 (3,003 yd^3) – Group 8 includes the excavation area within mine site #1012, as well as areas to the north that also appeared to have been disturbed, based on review of recent and historical (1956) aerial photographs. The volume of TENORM that exceeded ILs in Group 8 was primarily based on field observations of ground disturbance and to a lesser extent, subsurface data from four boreholes (S1011-SCX-007, -SCX-008, -SCX-015, and -SCX-016 extending between 1.5 and 3.0 ft bgs to bedrock). TENORM exceeding the ILs was assumed to be 4.0 ft deep over the area of the polygon.

- Group 9 (4,602 yd^3) – Group 9 includes the excavation area located west of mine site #1012, as well as the western portions of Disturbed Area 2. Bedrock outcrops at the surface across much of the Group 9 area and the disturbance appeared to be mostly surficial (e.g., the ground appears scraped on the mesa point west of #1012, but stockpiles and pits are not present). The volume of TENORM exceeding ILs in Group 9 was based on field observations and was assumed to be 1.0 ft thick over the area of the polygon.

- Group 10 (4,148 yd^3) – Group 10 includes areas on the mesa sidewall that are downgradient of potential mining-disturbed areas located along the edge of the mesa that were: (1) within the Entrada Sandstone in Survey Area C; and (2) gamma surveyed and measurements exceeded the IL. The volume of TENORM that exceeded ILs in Group 10 was calculated using a depth assumption of 1.0 ft over the area of the polygons. The depth assumption was based on subsurface data from the S1011-SCX-006 borehole (refusal at 1.25 ft bgs) and field observations of the general depth of soil/sediments present on the mesa sidewall.

- Group 11 (39,218 yd^3) – Group 11 includes the plains at the base of the mesa. The volume of TENORM that exceeded ILs in Group 11 was calculated based on field observations of potential transport paths from waste piles and disturbed areas on the mesa edge and mesa sidewall and subsurface data from three boreholes (S1011-SCX-041 through -SCX-043). TENORM was assumed to extend to 2.0 ft bgs over the area of the polygons.

- Group 12 (3,796 yd^3) – Group 12 includes three drainages that originate near the base of the mesa, and extend southward into the plains. The drainages are downgradient from Disturbed Area 1, the excavation areas, and Waste Piles 2, 3 and 7, which are located along the edge of the mesa. The volume estimate was calculated by assuming the vertical extent of TENORM exceeding ILs was 2.0 ft over the total area of Group 12 polygons. This depth assumption was based on field observations of alluvium present in the drainages and subsurface data from five boreholes (S1011-SCX-001 through -SCX-005).

- Group 13 (474 yd^3) – Group 13 includes Disturbed Area 3 and is assumed to be the area of the small prospect pit described in Section 2.1.4.1. The area was identified based on the visible change in density and type of vegetation on the high resolution aerial photograph. TENORM in the area of the polygon was assumed to extend to 1.0 ft bgs based on the description of 4-ft tall waste piles being present at either end of the prospect pit. The volume estimate for Group 13 is likely conservative considering the disturbed area is approximately 230 ft by 50 ft.

- Groups 14 (8,900 yd^3) – Group 14 includes the central portions of the mesa top that may contain TENORM, but there were not clear lines of evidence to support that the area was disturbed during mining. The area was gamma surveyed and includes both areas where gamma survey measurements exceed the ILs (eastern polygon) and areas that did not exceed the ILs (western polygon). The area was not sampled. The volume of Group 14 is being provided for informational purposes should this area be considered TENORM in future Removal or Remedial Action evaluations at the Site. However, it is important to consider that historical documentation describes a portion of this area as "undisturbed ground" (refer to Section 2.1.4.1). A general assumption was made that potential TENORM may extend to 1.0 ft bgs over the area of the polygon based on subsurface conditions observed in nearby boreholes.

- Group 15 (3,360 yd^3) – Group 15 includes portions of the mesa sidewall located downgradient from potential mining-disturbed areas that could not be surveyed or sampled due to steep or unsafe terrain. Given that no subsurface information is available to estimate the vertical extent of potential TENORM exceeding ILs, the Group 10 (areas of the mesa sidewall that exceeded the ILs) assumption of 1.0 ft may provide the best estimate for Group

15. In addition, approximately 75 percent of Group 15 contains areas mapped as bedrock. Therefore, the volume estimate was calculated by assuming 25 percent of the Group 15 polygon area contains potential TENORM that exceeded the ILs to a depth of 1.0 ft.

- Group 16 (1,795 yd^3) – Group 16 includes the portions of the Wingate Sandstone that exceeded the surface gamma IL for BG-6, but did not exceed the BG-3 IL used for Survey Area C. The Wingate Sandstone occurs near the base of the mesa sidewall at the transition from the sidewall to the plains. The volume estimate was calculated by assuming a vertical extent of potential TENORM that exceeds the ILs of 1.5 ft bgs over the total area of the Group 16 polygons. The vertical extent was assumed based on subsurface data from nearby boreholes.

4.7.1 Comparison of TENORM Volume Estimate and Ecology and Environmental Inc. (E&E) 2014 Removal Assessment

Below is a comparison of the differences between the findings of the 2014 E&E RSE (E&E, 2014) performed on behalf of USEPA, and the Trust RSE, and how those findings resulted in different TENORM volume estimates. The 2014 E&E RSE was generally limited to Survey Areas A and B of the Trust RSE.

Based on the 2014 RSE results, E&E proposed excavation of soil totaling approximately 9,737 yd^3 from the mesa top, as summarized in Section 2.1.4.5. The E&E Ra-226 ILs (2.29 pCi/g) was generally similar to the ILs defined for the Trust RSE (2.13 and 2.96 pCi/g for Survey Areas A and B, respectively). While the daily average background gamma values identified by E&E (20,425 to 22,005 cpm) were similar to the BG-2 IL (23,320 cpm) and greater than the BG-1 IL (16,829 cpm), E&E's gamma radiation IL was twice the daily average background level (40,000 cpm). The gamma survey results observed by E&E were generally similar to gamma results observed by the Trust (e.g., elevated gamma measurements were observed in the same areas).

The 2014 RSE volume estimate determined by E&E differs from the volume estimate provided in this RSE report for the following reasons:

- The E&E gamma IL was nearly two times the Trust RSE gamma IL in Survey Area B.
- E&E evaluated Ra-226 as their primary laboratory COPC, the Trust RSE evaluated Ra-226, uranium, arsenic, molybdenum, selenium, and vanadium.
- The E&E subsurface investigation was limited to 4.0 ft bgs, the Trust RSE investigation extended up to 37.0 ft bgs.
- E&E did not recommend any material in the following areas on the mesa top and near the mesa edge be addressed (refer to Figure 2-8): Disturbed Areas 1 through 4, mine site #1012, Waste Piles 1, 2, 3, and 7.
- E&E did not evaluate the mesa sidewall or plains areas of the Site.
- E&E did not observe any signs of reclamation on the Site, they did not review historical documentation of mining or reclamation activities that took place at the Site (refer to

Section 2.1.4 of this RSE report), and their report did not include review of historical photographs of the Site.

The depth of material that E&E recommended for removal is compared to the Trust TENORM depth estimates below (refer to Figure 4-9a for the Trust TENORM depth estimates):

- In the general area of mine site #1011, E&E recommended material be removed in limited areas up to 1.0 and 2.0 ft bgs (AUM26-RA-01 through RA-04 on Figure 4 of the E&E report). The E&E recommended removal areas are encompassed by Groups 2 and 3 of TENORM, where TENORM is assumed to extend to 1.0 and 4.0 ft bgs, respectively.

In the general area of mine site #1035, E&E recommended material be removed in limited areas up to 4.0 ft bgs in AUM26-RA-05 and up to 1.0 ft bgs in AUM26-RA-06 on Figure 4 of the E&E report. The E&E recommended removal areas are encompassed by the Trust RSE Groups 1 and 5 of TENORM. The depth of TENORM in Group 1 varies (refer to Figure 4-9b), but it extends up to 15.0 ft bgs in some areas. TENORM is assumed to extend to 1.0 ft bgs in Group 5.

4.8 GEOPHYSICAL SURVEY RESULTS

The results of the geophysical survey are provided in Appendix A.2. A summary of the interpretation of the geophysical survey results is presented below.

- Results of the electrical resistivity survey displayed a similar structure for each of the 13 survey lines, with a near-surface conductive layer associated with soil material, overlying a deeper resistive layer interpreted as bedrock.

- In general, it was not possible to differentiate between fill soil and native material in the geophysical profiles. Soil deposits in areas known to be disturbed based on historic aerial photographs, typically had a greater thickness of soil, suggesting these areas contain fill material.

- Results of the two geophysical surveys did not identify significant features that would indicate the presence of air-filled voids or tunnels at the Site.

- Highly conductive features were observed in the electrical resistivity geophysical profiles within mine site #1035 that suggest the possibility of backfilled or collapsed mine workings. While the conductive nature of these features excludes air-filled voids, they could be associated with backfilled or collapsed mine workings associated with the open shaft. However, it is more likely that the open shaft is acting as a conduit for surface water infiltration, leading to increased moisture content in the soils surrounding the area. The increased moisture content would decrease the resistivity value of the infiltrated soils, compared to the surrounding materials

- The depth to bedrock interpreted from the geophysical surveys generally correlates with the depth to bedrock observed during drilling activities (refer to Section 3.3.2.2). In survey lines 1 through 3, competent bedrock is generally observed as flat and shallow, ranging from within 1 ft of the surface to 20 ft bgs, though depth to weathered bedrock is likely shallower than 10 ft bgs based on drilling data. The interpreted depth to competent bedrock in mine site

#1035 ranges from less than 1 ft to approximately 40 ft bgs. The geophysical data in mine site #1035 showed unconsolidated material thickness generally increased from south to north.

- In the northern and eastern portions of mine site #1035 the increasing unconsolidated material thickness, hummocky surface topography, and increased heterogeneity in the electrical resistivity and MASW profiles are consistent with areas of known disturbance and fill.

- The MASW profiles for the eastern portion of the Site did not extend the entire length of the electrical resistivity line, in some cases, because the undulating topography in this area of the Site hindered the generation and transmission of the seismic waves and resulted in unreliable model results.

An important consideration is that the interpretations of geophysical survey data are based on a number of assumptions and minor physical variations in subsurface properties. Therefore, interpretation results should be considered "suggestive" of subsurface conditions. Interpretation of geophysical survey data requires the consideration of multiple lines of evidence, including a comparison to subsurface data collected during drilling activities. An assessment of the geophysical data on its own, without additional supporting investigation techniques, can lead to false or misleading conclusions. In instances where the results of geophysical surveys contradict with direct observations collected during drilling and sampling, the drilling data should be considered more reliable.

Results of the geophysical survey were used to inform the TENORM volume estimate, specifically supporting the depth to bedrock and thicknesses of potential mine-impacted fill. These results are presented in Sections 4.6 through 4.8.

4.9 POTENTIAL DATA GAPS AND SUPPLEMENTAL STUDIES

4.9.1 Data Gaps

Seven potential data gaps were identified based on the Site Clearance and RSE data collection and analyses for the Site, as described in Sections 3.3, 4.1, 4.2, and 4.6. These data gaps can be considered for subsequent evaluations in support of future Removal or Remedial Action evaluations at the Site.

1. 10.1 acres of the Survey Area were not surveyed, because field personnel were unable to safely access these areas due to steep/unsafe terrain (refer to Figure 3-4).

2. The area located in-between the northern-most boundary of mine sites #1011 and #1035 and the northern most fence line were not surveyed because the landowner north of these mine sites did not allow access.

3. The survey was not extended laterally from the potential haul roads where the gamma measurements were greater than the IL due to a miscommunication with field personnel.

4. The shoulders of some potential haul roads in the north-central portion of the Site were not surveyed due to a miscommunication with field personnel.

5. The gamma survey was not extended to the west of Survey Area B (the central portion of the mesa top) until gamma measurements reached background levels. This area was not surveyed based on the professional judgement in the field that this area contained only NORM. However, review of high-resolution aerial images and historical documents following the survey suggested that some portions of this area (specifically Disturbed Area 4) may have been disturbed by mining-related activities. It is recommended that this data gap be addressed during future work.

6. The collection of soil samples within BG-6 is warranted to better evaluate potential mining-related impacts in the Wingate Sandstone at the base of the mesa sidewall.

7. Subsurface samples were not collected in Waste Piles 1, 2, 4, 5, and 7.

4.9.2 Supplemental Studies

Following review of the RSE report data and discussions with the Agencies, a limited number of items were identified for supplemental work to be considered for subsequent evaluations in support of future Removal or Remedial Action evaluations at the Site, as follows:

1. On June 28, 2018, the USEPA provided a historical "Desidero waste piles map" that showed the locations and estimated area and volumes of uranium piles, soil overburden, and debris piles across the Site. The USEPA confirmed this map was part of a previously received report presenting a supplemental aerial photographic analysis of the Desidero mines (USEPA, 1992b), but the map was not included in the previous copy of the report. Due to the late receipt of this document, it could not be evaluated for this RSE report. A copy of the map is included in the attachment. Additional analysis of this map is warranted as part of future investigations at the Site.

2. Contents of the center debris pile included cans, bottles, car parts/car frames, metal scraps, wood scraps pallets, wire, general construction debris, and miscellaneous trash. Additional evaluation of the debris may be warranted in the future (refer to the *Multi-Agency Radiation Survey and Site Investigation Manual* [USEPA, 2009]).

3. The USEPA identified that there were potential discrepancies between the NNDWR database used for this study (received from NNDWR in 2016) and a 2018 version of the NNDWR database that the USEPA reviewed. The USEPA provided comment that the 2018 NNDWR database indicates well 16-2-6 is within one mile of mine site #1011 and that it may need to be addressed (the 2016 NNDWR database shows it outside the one-mile buffer). It is recommended that the two databases be compared (with additional field work, if necessary) to confirm the locations of water features.

4. Separate background reference areas were identified for the Quaternary deposits (BG-4) in the plains area and the Quaternary alluvium in the drainages (BG-5) within the plains area. The Agencies have suggested that additional study may be required to develop a background reference area for the plains area (NNEPA, 2018).

5. The gamma survey in BG-3 was limited due to steep terrain that could not be safely accessed, the sample size was low (80 measurements) and there was a notable difference between the UTL (48,542 cpm) and UCL (30,927 cpm) values (refer to Appendix D.1

Table D.1-2). Further evaluation of background for the Entrada Sandstone may be required in the future.

6. Boulders located along or at the base of the mesa sidewall were included in the area of the surface gamma survey but were not otherwise evaluated. Additional characterization of the boulders may be required prior in the future.

7. Subsurface samples were not collected in Disturbed Areas 3 and 4. Further evaluation of the Disturbed Areas may be required in the future.

8. Comparison of Ra-226 and Th-230 concentrations indicated that Ra-226 and Th-230 are in equilibrium, but not in secular equilibrium. This may be an important consideration in the future and further evaluation may be required if a human health and/or ecological risk assessment is performed.

9. Additional correlation studies may be needed to identify the relationship between gamma and Ra-226.

5.0 SUMMARY AND CONCLUSIONS

This report details the purpose and objectives, field investigation activities, findings, and conclusions of the Site Clearance and RSE activities conducted for the Site between August 2015 and September 2017. The Site is known as the Section 26 Desidero Group site and is also identified by the USEPA as an AUM claim that consists of three mine sites with identifications of #1011, #1012, and #1035 in the *2007 AUM Atlas*.

The primary objectives of the RSE are to provide data (e.g., review relevant information and collect data related to historical mining activities) required to evaluate relevant Site conditions and to support future Removal or Remedial Action evaluations at the Site. It is not intended to establish cleanup levels or determine cleanup options or potential remedies. The purpose of the RSE data are to determine the volume of TENORM at the Site in excess of ILs as a result of historical mining activities. ILs are based on the background gamma measurements (in cpm), and Ra-226 and metals concentrations, determined through statistical analyses, that are used to evaluate potential mining-related impacts. To meet these objectives, the RSE included historical data review, visual observations, surface gamma surveys, surface and subsurface static gamma measurements, and soil/sediment sampling and analyses. An estimate of areas containing TENORM was made based on an evaluation of the RSE information/data and multiple lines of evidence. The correlation between gamma measurements (in cpm) and concentrations of Ra-226 in surface soils (pCi/g) was developed as a potential field screening tool for future Removal or Remedial Action evaluations. The gamma correlation was not used for the Site Characterization, which relied instead on the actual gamma radiation measurements and soil/sediment analytical results. However, predicted Ra-226 concentrations were compared to the actual Ra-226 laboratory results and ILs from the surface soil/sediment samples at the Agencies' request.

The Site was located in the Grants Uranium Mining District, Ambrosia Lake Sub-district, and was in operation from 1952 to 1957. Historical mine workings on-site consisted of a 155-ft incline and several open pits. The USAEC reported total ore production from the "Section 26 (Hanosh) (Desidero Allotment)" between 1952 and 1957 was 11,110 tons (approximately 22,220,000 pounds) of ore that contained 83,752 pounds of 0.38 percent U_3O_8 and 17,518 pounds of 0.12 percent V_2O_5.

Between August 11, 1991 and September 19, 1991, the USEPA Region 9 Emergency Response Section conducted an Emergency Response Action (ERA at the three AUMs #1011, #1012, and #1035). Remediation activities included the following:

- Filled existing pits and covered open adits
- Regraded reclaimed areas until they were consistent with the surrounding terrain
- Graded areas were made to have proper water runoff

Eight potential background reference areas (BG-1 through BG-8) were considered. Five background reference areas (BG-1 through BG-5) were selected to develop surface gamma, subsurface gamma, Ra-226, and metals ILs for the five Survey Areas (Survey Areas A through E) at the Site.

Arsenic, molybdenum, selenium, uranium, vanadium, and Ra-226 concentrations and gamma radiation measurements exceeded their respective ILs and are confirmed as COPCs for the Site.

Surface gamma measurements and Ra-226 and metals concentrations were generally highest in areas on the mesa sidewall immediately downgradient of Waste Pile 3, and on the mesa top within Disturbed Area 1. The maximum gamma survey measurement was 749,127 cpm, which was more than 15 times the maximum IL and occurred just downgradient from Waste Pile 3. The highest Ra-226 and metals concentrations, and subsurface static gamma measurements were detected in surface/subsurface soil samples collected from Disturbed Area 1.

Results of the Gamma Correlation Study indicated that surface gamma survey results correlate with Ra-226 concentrations in soil. Therefore, gamma surveys could be used during site assessments as a field screening tool to estimate Ra-226 concentrations in soil. Additional correlation studies may be needed to identify the relationship between gamma and Ra-226.

Based on the data analysis performed for this RSE report along with the multiple lines of evidence, approximately 72.2 acres out of the 101.3 acres of the Survey Area were estimated to contain TENORM. This estimate is inclusive of areas on the mesa top, the mesa sidewall, and in the plains. The areas outside of the TENORM boundary showed no signs of disturbance related to mining and, therefore, are considered NORM (i.e., naturally occurring). Of the 72.2 acres that contain TENORM, 45.2 acres contain TENORM exceeding the surface gamma ILs and TENORM that exceeded the ILs at all but one of the soil/sediment sample locations. The volume of TENORM in excess of ILs was estimated to be 170,191 yd^3 (130,120 cubic meters) plus the volume of potential TENORM exceeding ILs was estimated to be 14,055 yds^3. It should be noted that the COPC measurements and concentrations in the area that contains TENORM that exceeded the ILs are generally higher than the COPC measurements and concentrations in the area of NORM located outside the TENORM boundary.

Seven potential data gaps were identified based on the Site Clearance and RSE data collection and analyses for the Site, as listed in Section 4.9. These data gaps can be taken into consideration for subsequent evaluations in support of future Removal or Remedial Action evaluations at the Site.

6.0 ESTIMATE OF REMOVAL SITE EVALUATION COSTS

The Section 26 RSE was performed in accordance with the requirements of the *Trust Agreement* to characterize existing site conditions. Project costs related to the RSE include the planning and implementation of the scope of work stipulated in the *Site Clearance Work Plan* and *RSE Work Plan* and community outreach. Stantec's costs associated with the Section 26 RSE were $975,100. Stantec's costs associated with interim actions (backfilled two shafts and nine boreholes and installed signage) were $63,000. In addition, Administrative costs provided by the Trust were estimated currently at $191,500[8,9]. Administrative costs will change due to continued community outreach and close out activities.

[8] This cost is based on an approved budget of May 8, 2018; Administrative work, including community communications, are not yet complete.
[9] Administrative costs were averaged across all Sites.

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TABLES

Table 3-1
Identified Water Features
Section 26
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Identified Water Feature	Source of Identified Water Feature	Water Feature Identification	USEPA Region 6 Provided Information[3]	Field Personnel Observations
Unknown	2007 AUM Atlas[1]	B01486[2]	USEPA Region 6 never sampled this well.	Field personnel were unable to assess this location because it was located on private land and access was behind a locked gate.
Unknown	2007 AUM Atlas[1]	B01486[2]	This well was drilled in December 2005 to a total depth of 460 feet.	Field personnel were unable to assess this location because it was located on private land and access was behind a locked gate.
Unknown	2007 AUM Atlas[1]	G01106	This location was a well permit application in 2000 that was then changed to B01486. The well was never drilled.	Field personnel were unable to assess this location because it was located on private land and access was behind a locked gate.
Unknown	2007 AUM Atlas[1]	B01480	Refer to water feature identification G01106.	Field personnel were unable to assess this location because it was located on private land and access was behind a locked gate.

Notes
USEPA - United States Environmental Protection Agency
[1] USEPA, 2007a
[2] This location is identified twice because it is associated with two different coordinates in USEPA, 2007a
[3] The USEPA provided this information to the Trust in an email dated September 12, 2017.

Table 3-2
Soil and Sediment Sampling Summary
Section 26
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Sample Location	Sample Depth (ft bgs)	Sample Media	Sample Category	Sample Collection Method	Survey Area	Sample Date	Easting ¹	Northing ¹	Sample Types: Metals, Total	Sample Types: Ra-226	Sample Types: Thorium
Background Reference Area Study - Background Area 1											
S1011-BG1-001	0 - 0.2	soil	SF	grab	NA	11/30/2016	784869.18	3914507.72	N	N	--
S1011-BG1-002	0 - 0.2	soil	SF	grab	NA	11/30/2016	784866.41	3914508.28	N	N	--
S1011-BG1-003	0 - 0.2	soil	SF	grab	NA	11/30/2016	784869.84	3914510.56	N	N	--
S1011-BG1-004	0 - 0.2	soil	SF	grab	NA	11/30/2016	784865.25	3914509.45	N	N	--
S1011-BG1-005	0 - 0.2	soil	SF	grab	NA	11/30/2016	784866.37	3914511.98	N;MS;MSD	N	--
S1011-BG1-006	0 - 0.2	soil	SF	grab	NA	11/30/2016	784868.91	3914512.18	N;FD	N;FD	--
S1011-BG1-007	0 - 0.2	soil	SF	grab	NA	11/30/2016	784862.31	3914509.37	N	N	--
S1011-BG1-008	0 - 0.2	soil	SF	grab	NA	11/30/2016	784860.86	3914511.96	N	N	--
S1011-BG1-009	0 - 0.2	soil	SF	grab	NA	11/30/2016	784862.03	3914514.07	N	N	--
S1011-BG1-010	0 - 0.2	soil	SF	grab	NA	11/30/2016	784864.52	3914514.51	N	N	--
S1011-BG1-011	0 - 0.2	soil	SF	grab	NA	3/25/2017	784866.57	3914510.88	N	N	--
S1011-BG1-011	0.5 - 0.7	soil	SB	grab	NA	3/25/2017	784866.57	3914510.88	N	N	--
Background Reference Area Study - Background Area 2											
S1011-BG2-001	0 - 0.2	soil	SF	grab	NA	11/30/2016	784865.63	3914687.31	N	N	--
S1011-BG2-002	0 - 0.2	soil	SF	grab	NA	11/30/2016	784864.84	3914691.41	N	N	--
S1011-BG2-003	0 - 0.2	soil	SF	grab	NA	11/30/2016	784863.17	3914693.72	N	N	--
S1011-BG2-004	0 - 0.2	soil	SF	grab	NA	11/30/2016	784860.43	3914691.53	N	N	--
S1011-BG2-005	0 - 0.2	soil	SF	grab	NA	11/30/2016	784859.56	3914688.46	N	N	--
S1011-BG2-006	0 - 0.2	soil	SF	grab	NA	11/30/2016	784862.40	3914686.99	N;FD	N;FD	--
S1011-BG2-007	0 - 0.2	soil	SF	grab	NA	11/30/2016	784857.33	3914687.17	N	N	--
S1011-BG2-008	0 - 0.2	soil	SF	grab	NA	11/30/2016	784854.66	3914688.03	N	N	--
S1011-BG2-009	0 - 0.2	soil	SF	grab	NA	11/30/2016	784854.81	3914691.78	N;MS;MSD	N	--
S1011-BG2-010	0 - 0.2	soil	SF	grab	NA	11/30/2016	784857.00	3914692.43	N	N	--
S1011-BG2-011	0 - 0.2	soil	SF	grab	NA	3/25/2017	784860.27	3914688.14	N	N	--
S1011-BG2-011	1.5 - 2.0	soil	SB	grab	NA	3/25/2017	784860.27	3914688.14	N	N	--
Background Reference Area Study - Background Area 3											
S1011-BG3-001	0 - 0.2	soil	SF	grab	NA	9/18/2017	784837.16	3914519.59	N	N	--
S1011-BG3-002	0 - 0.2	soil	SF	grab	NA	9/18/2017	784833.63	3914519.89	N;MS;MSD	N	--
S1011-BG3-003	0 - 0.2	soil	SF	grab	NA	9/18/2017	784836.97	3914517.15	N	N	--
S1011-BG3-004	0 - 0.2	soil	SF	grab	NA	9/18/2017	784836.97	3914514.72	N;FD	N;FD	--
S1011-BG3-005	0 - 0.2	soil	SF	grab	NA	9/18/2017	784838.15	3914513.01	N	N	--
S1011-BG3-006	0 - 0.2	soil	SF	grab	NA	9/18/2017	784834.69	3914516.25	N	N	--
S1011-BG3-007	0 - 0.2	soil	SF	grab	NA	9/18/2017	784836.55	3914513.30	N	N	--
S1011-BG3-008	0 - 0.2	soil	SF	grab	NA	9/18/2017	784838.01	3914511.30	N	N	--
S1011-BG3-009	0 - 0.2	soil	SF	grab	NA	9/18/2017	784839.32	3914511.42	N;FD	N;FD	--
S1011-BG3-010	0 - 0.2	soil	SF	grab	NA	9/18/2017	784840.38	3914509.61	N	N	--
S1011-BG3-011	0 - 0.2	soil	SF	grab	NA	9/19/2017	784840.05	3914512.82	N	N	--
Background Reference Area Study - Background Area 4											
S1011-BG4-001	0 - 0.2	soil	SF	grab	NA	9/19/2017	784829.11	3914106.05	N;MS;MSD	N	--
S1011-BG4-002	0 - 0.2	soil	SF	grab	NA	9/19/2017	784829.93	3914100.67	N	N	--
S1011-BG4-003	0 - 0.2	soil	SF	grab	NA	9/19/2017	784825.51	3914096.70	N;FD	N;FD	--
S1011-BG4-004	0 - 0.2	soil	SF	grab	NA	9/19/2017	784821.98	3914099.51	N	N	--
S1011-BG4-005	0 - 0.2	soil	SF	grab	NA	9/19/2017	784817.93	3914097.49	N	N	--
S1011-BG4-006	0 - 0.2	soil	SF	grab	NA	9/19/2017	784814.05	3914098.56	N	N	--
S1011-BG4-007	0 - 0.2	soil	SF	grab	NA	9/19/2017	784812.91	3914103.63	N	N	--
S1011-BG4-008	0 - 0.2	soil	SF	grab	NA	9/19/2017	784817.19	3914106.13	N	N	--
S1011-BG4-009	0 - 0.2	soil	SF	grab	NA	9/19/2017	784820.91	3914104.44	N;FD	N;FD	--
S1011-BG4-010	0 - 0.2	soil	SF	grab	NA	9/19/2017	784824.64	3914106.31	N	N	--
S1011-BG4-011	0 - 0.2	soil	SF	grab	NA	9/19/2017	784821.40	3914102.48	N	N	--
S1011-BG4-011	0.2 - 3.0	soil	SB	composite	NA	9/19/2017	784821.40	3914102.48	N	N	--

Notes

--	Not Sampled
N	Normal
FD	Field Duplicate
MS	Matrix Spike
MSD	Matrix Spike Duplicate
Ra-226	Radium 226
NA	Not Applicable
SB	Subsurface Sample
SF	Surface Sample
ft bgs	feet below ground surface

¹ Coordinate System: NAD 1983 UTM Zone 12N

Table 3-2
Soil and Sediment Sampling Summary
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Sample Location	Sample Depth (ft bgs)	Sample Media	Sample Category	Sample Collection Method	Survey Area	Sample Date	Easting [1]	Northing [1]	Sample Types Metals, Total	Ra-226	Thorium
Background Reference Area Study - Background Area 5											
S1011-BG5-001	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784827.40	3914010.80	N;MS;MSD	N	--
S1011-BG5-002	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784824.77	3914007.43	N;FD	N;FD	--
S1011-BG5-003	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784822.69	3914001.52	N	N	--
S1011-BG5-004	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784821.46	3913997.88	N	N	--
S1011-BG5-005	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784822.47	3913994.77	N	N	--
S1011-BG5-006	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784821.70	3913991.38	N	N	--
S1011-BG5-007	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784821.74	3913988.83	N	N	--
S1011-BG5-008	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784821.42	3913984.85	N	N	--
S1011-BG5-009	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784822.53	3913981.91	N;FD	N;FD	--
S1011-BG5-010	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784822.89	3913979.72	N	N	--
S1011-BG5-011	0 - 0.2	sediment	SF	grab	NA	9/19/2017	784822.45	3913991.77	N	N	--
S1011-BG5-011	0.2 - 2.0	sediment	SB	composite	NA	9/19/2017	784822.45	3913991.77	N	N	--
Correlation											
S1011-C01-001	0 - 0.5	soil	SF	5-point composite	NA	3/29/2017	785155.24	3914549.34	--	N	N
S1011-C02-001	0 - 0.5	soil	SF	5-point composite	NA	3/29/2017	785451.96	3914219.56	--	N	N
S1011-C03-001	0 - 0.5	soil	SF	5-point composite	NA	3/29/2017	785562.35	3914331.94	--	N	N
S1011-C04-001	0 - 0.5	soil	SF	5-point composite	NA	3/29/2017	785495.24	3914439.54	--	N	N
S1011-C05-001	0 - 0.5	soil	SF	5-point composite	NA	3/29/2017	785545.94	3914561.09	--	N	N
Characterization											
S1011-CX-001	0 - 0.2	soil	SF	grab	B	12/1/2016	785057.48	3914553.45	N	N	--
S1011-CX-002	0 - 0.2	soil	SF	grab	B	12/1/2016	785566.35	3914507.02	N	N	--
S1011-CX-003	0 - 0.2	soil	SF	grab	B	12/1/2016	785611.36	3914470.83	N	N	--
S1011-CX-004	0 - 0.2	soil	SF	grab	B	12/1/2016	785658.94	3914560.17	N;FD	N;FD	--
S1011-CX-005	0 - 0.2	soil	SF	grab	B	12/1/2016	785313.02	3914225.47	N	N	--
S1011-CX-006	0 - 0.5	soil	SF	grab	C	5/13/2017	785562.58	3914271.68	N	N	--
S1011-CX-007	0 - 0.5	soil	SF	grab	A	5/13/2017	785654.39	3914300.90	N	N	--
S1011-CX-008	0 - 0.5	sediment	SF	grab	E	5/13/2017	785538.93	3913923.98	N	N	--
S1011-CX-009	0 - 0.5	sediment	SF	grab	E	5/13/2017	785449.78	3913960.65	N	N	--
S1011-CX-010	0 - 0.5	soil	SF	grab	B	5/13/2017	785060.57	3914573.54	N	N	--
S1011-CX-011	0 - 0.5	soil	SF	grab	B	5/13/2017	785141.69	3914248.75	N	N	--
S1011-CX-012	0 - 0.5	soil	SF	grab	A	5/13/2017	785166.10	3914207.05	N	N	--
S1011-CX-013	0 - 0.5	soil	SF	grab	A	5/13/2017	785278.83	3914192.94	N;FD	N;FD	--
S1011-CX-014	0 - 0.5	soil	SF	grab	B	5/13/2017	785433.54	3914230.44	N	N	--
S1011-CX-015	0 - 0.5	soil	SF	grab	B	5/13/2017	785482.08	3914412.33	N;MS;MSD	N	--
S1011-SCX-001	0 - 0.5	sediment	SF	grab	E	5/12/2017	785487.09	3914060.74	N	N	--
S1011-SCX-001	0.5 - 1.5	sediment	SB	grab	E	5/12/2017	785487.09	3914060.74	N	N	--
S1011-SCX-002	0 - 0.5	sediment	SF	grab	E	5/12/2017	785452.75	3914047.77	N	N	--
S1011-SCX-002	0.5 - 1.5	sediment	SB	grab	E	5/12/2017	785452.75	3914047.77	N	N	--
S1011-SCX-003	0 - 0.5	sediment	SF	grab	E	5/12/2017	785501.04	3913974.17	N;FD	N;FD	--
S1011-SCX-003	0.5 - 1.5	sediment	SB	grab	E	5/12/2017	785501.04	3913974.17	N	N	--
S1011-SCX-003	1.5 - 2.25	sediment	SB	grab	E	5/12/2017	785501.04	3913974.17	N	N	--
S1011-SCX-004	0 - 0.5	sediment	SF	grab	E	5/12/2017	785203.77	3913866.68	N	N	--
S1011-SCX-004	0.5 - 1.5	sediment	SB	grab	E	5/12/2017	785203.77	3913866.68	N	N	--
S1011-SCX-004	1.5 - 2.0	sediment	SB	grab	E	5/12/2017	785203.77	3913866.68	N	N	--
S1011-SCX-005	0 - 0.5	sediment	SF	grab	E	5/12/2017	785220.84	3914043.34	N	N	--
S1011-SCX-005	0.5 - 1.5	sediment	SB	grab	E	5/12/2017	785220.84	3914043.34	N	N	--
S1011-SCX-005	1.5 - 2.0	sediment	SB	grab	E	5/12/2017	785220.84	3914043.34	N	N	--
S1011-SCX-006	0 - 0.5	soil	SF	grab	C	5/12/2017	785219.68	3914156.28	N	N	--
S1011-SCX-006	0.5 - 1.25	soil	SB	grab	C	5/12/2017	785219.68	3914156.28	N	N	--
S1011-SCX-007	0 - 0.5	soil	SF	grab	B	5/13/2017	785278.26	3914225.39	N;MS;MSD	N	--
S1011-SCX-007	0.5 - 1.0	soil	SB	grab	B	5/13/2017	785278.26	3914225.39	N	N	--
S1011-SCX-007	1.0 - 1.5	soil	SB	grab	B	5/13/2017	785278.26	3914225.39	N	N	--
S1011-SCX-008	0 - 0.5	soil	SF	grab	A	5/13/2017	785261.82	3914202.15	N	N	--
S1011-SCX-008	0.5 - 1.0	soil	SB	grab	A	5/13/2017	785261.82	3914202.15	N	N	--
S1011-SCX-008	1.0 - 1.5	soil	SB	grab	A	5/13/2017	785261.82	3914202.15	N	N	--

Notes

--	Not Sampled
N	Normal
FD	Field Duplicate
MS	Matrix Spike
MSD	Matrix Spike Duplicate
Ra-226	Radium 226
NA	Not Applicable
SB	Subsurface Sample
SF	Surface Sample
ft bgs	feet below ground surface

[1] Coordinate System: NAD 1983 UTM Zone 12N

Table 3-2
Soil and Sediment Sampling Summary
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Navajo Nation AUM Environmental Response Trust - First Phase

Sample Location	Sample Depth (ft bgs)	Sample Media	Sample Category	Sample Collection Method	Survey Area	Sample Date	Easting [1]	Northing [1]	Sample Types: Metals, Total	Sample Types: Ra-226	Sample Types: Thorium
Characterization continued											
S1011-SCX-009	0 - 0.5	soil	SF	grab	B	6/9/2017	785079.03	3914548.27	N;MS;MSD	N	--
S1011-SCX-009	0.5 - 2.0	soil	SB	composite	B	6/9/2017	785079.03	3914548.27	N	N	--
S1011-SCX-010	0 - 0.5	soil	SF	grab	B	6/9/2017	785051.56	3914563.92	N	N	--
S1011-SCX-010	0.5 - 3.0	soil	SB	composite	B	6/9/2017	785051.56	3914563.92	N	N	--
S1011-SCX-011	0 - 0.5	soil	SF	grab	B	6/9/2017	785086.49	3914565.57	N;FD	N;FD	--
S1011-SCX-011	0.5 - 3.0	soil	SB	composite	B	6/9/2017	785086.49	3914565.57	N	N	--
S1011-SCX-011	3.0 - 4.0	soil	SB	grab	B	6/9/2017	785086.49	3914565.57	N	N	--
S1011-SCX-012	0 - 0.5	soil	SF	grab	B	6/9/2017	785054.80	3914579.57	N	N	--
S1011-SCX-012	3.0 - 4.0	soil	SB	grab	B	6/9/2017	785054.80	3914579.57	N	N	--
S1011-SCX-013	0 - 0.5	soil	SF	grab	B	6/9/2017	785237.75	3914584.49	N	N	--
S1011-SCX-014	0 - 0.5	soil	SF	grab	B	6/9/2017	785312.17	3914564.97	N	N	--
S1011-SCX-014	0.5 - 4.0	soil	SB	composite	B	6/9/2017	785312.17	3914564.97	N	N	--
S1011-SCX-015	0 - 0.5	soil	SF	grab	B	6/10/2017	785273.11	3914269.22	N;FD	N;FD	--
S1011-SCX-015	0.5 - 1.5	soil	SB	grab	B	6/10/2017	785273.11	3914269.22	N	N	--
S1011-SCX-016	0 - 0.5	soil	SF	grab	B	6/10/2017	785251.00	3914237.41	N	N	--
S1011-SCX-016	2.5 - 3.0	soil	SB	grab	B	6/10/2017	785251.00	3914237.41	N	N	--
S1011-SCX-017	0 - 0.5	soil	SF	grab	A	6/10/2017	785591.45	3914306.10	N	N	--
S1011-SCX-017	0.5 - 1.0	soil	SB	grab	A	6/10/2017	785591.45	3914306.10	N	N	--
S1011-SCX-018	0 - 0.5	soil	SF	grab	B	6/10/2017	785608.82	3914315.71	N	N	--
S1011-SCX-018	1.0 - 3.5	soil/bedrock	SB	composite	B	6/10/2017	785608.82	3914315.71	N	N	--
S1011-SCX-019	0 - 0.5	soil	SF	grab	B	6/10/2017	785584.20	3914327.38	N;MS;MSD	N	--
S1011-SCX-019	0.5 - 2.5	soil	SB	composite	B	6/10/2017	785584.20	3914327.38	N	N	--
S1011-SCX-020	0 - 0.5	soil	SF	grab	B	6/10/2017	785611.50	3914344.48	N	N	--
S1011-SCX-020	0.5 - 4.0	soil	SB	composite	B	6/10/2017	785611.50	3914344.48	N	N	--
S1011-SCX-021	0 - 0.5	soil	SF	grab	B	6/10/2017	785627.18	3914465.39	N	N	--
S1011-SCX-021	12.0 - 13.0	soil	SB	grab	B	6/10/2017	785627.18	3914465.39	N	N	--
S1011-SCX-021	14.0 - 15.0	soil	SB	grab	B	6/10/2017	785627.18	3914465.39	N;FD	N;FD	--
S1011-SCX-021	17.0 - 18.0	soil	SB	grab	B	6/10/2017	785627.18	3914465.39	N	N	--
S1011-SCX-021	19.0 - 20.0	soil/bedrock	SB	grab	B	6/10/2017	785627.18	3914465.39	N	N	--
S1011-SCX-022	0 - 0.5	soil	SF	grab	B	6/10/2017	785626.97	3914511.24	N	N	--
S1011-SCX-022	5.0 - 7.0	soil	SB	composite	B	6/10/2017	785626.97	3914511.24	N	N	--
S1011-SCX-023	0 - 0.5	soil	SF	grab	B	6/10/2017	785649.40	3914554.88	N;MS;MSD	N	--
S1011-SCX-023	0.5 - 5.0	soil	SB	composite	B	6/10/2017	785649.40	3914554.88	N	N	--
S1011-SCX-023	13.5 - 14.5	soil	SB	grab	B	6/10/2017	785649.40	3914554.88	N	N	--
S1011-SCX-024	0 - 0.5	soil	SF	grab	B	6/11/2017	785657.64	3914569.55	N;FD	N;FD	--
S1011-SCX-024	3.0 - 4.0	soil	SB	grab	B	6/11/2017	785657.64	3914569.55	N	N	--
S1011-SCX-025	0 - 0.5	sediment	SF	grab	B	6/11/2017	785580.09	3914579.84	N	N	--
S1011-SCX-025	0.5 - 3.0	sediment	SB	composite	B	6/11/2017	785580.09	3914579.84	N	N	--
S1011-SCX-026	0 - 0.5	sediment	SF	grab	B	6/11/2017	785534.47	3914533.88	N	N	--
S1011-SCX-026	0.5 - 5.0	sediment	SB	composite	B	6/11/2017	785534.47	3914533.88	N	N	--
S1011-SCX-026	5.0 - 6.0	sediment	SB	grab	B	6/11/2017	785534.47	3914533.88	N	N	--
S1011-SCX-027	0 - 0.5	soil	SF	grab	B	6/11/2017	785581.12	3914553.94	N	N	--
S1011-SCX-027	0.5 - 3.0	soil	SB	composite	B	6/11/2017	785581.12	3914553.94	N	N	--
S1011-SCX-027	6.0 - 8.5	soil/bedrock	SB	composite	B	6/11/2017	785581.12	3914553.94	N	N	--
S1011-SCX-028	0 - 0.5	soil	SF	grab	B	6/11/2017	785561.16	3914509.68	N;MS;MSD	N	--
S1011-SCX-028	0.5 - 5.0	soil	SB	composite	B	6/11/2017	785561.16	3914509.68	N;FD	N;FD	--
S1011-SCX-028	5.0 - 8.0	soil	SB	composite	B	6/11/2017	785561.16	3914509.68	N	N	--
S1011-SCX-028	8.0 - 10.0	soil	SB	composite	B	6/11/2017	785561.16	3914509.68	N	N	--
S1011-SCX-028	10.0 - 12.0	soil	SB	composite	B	6/11/2017	785561.16	3914509.68	N	N	--
S1011-SCX-028	12.0 - 14.0	soil	SB	composite	B	6/11/2017	785561.16	3914509.68	N	N	--
S1011-SCX-029	0 - 0.5	soil	SF	grab	B	6/11/2017	785628.22	3914490.57	N	N	--
S1011-SCX-029	0.5 - 3.0	soil	SB	composite	B	6/11/2017	785628.22	3914490.57	N	N	--
S1011-SCX-030	0 - 0.5	soil	SF	grab	B	6/11/2017	785580.15	3914467.81	N	N	--
S1011-SCX-030	0.5 - 5.0	soil	SB	composite	B	6/11/2017	785580.15	3914467.81	N	N	--

Notes

--	Not Sampled
N	Normal
FD	Field Duplicate
MS	Matrix Spike
MSD	Matrix Spike Duplicate
Ra-226	Radium 226
NA	Not Applicable
SB	Subsurface Sample
SF	Surface Sample
ft bgs	feet below ground surface

[1] Coordinate System: NAD 1983 UTM Zone 12N

Sample Location	Sample Depth (ft bgs)	Sample Media	Sample Category	Sample Collection Method	Survey Area	Sample Date	Easting ¹	Northing ¹	Sample Types Metals, Total	Ra-226	Thorium
Characterization continued											
S1011-SCX-031	0 - 0.5	soil	SF	grab	B	6/11/2017	785554.61	3914489.47	N	N	--
S1011-SCX-031	0.5 - 5.0	soil	SB	composite	B	6/11/2017	785554.61	3914489.47	N	N	--
S1011-SCX-031	5.0 - 7.0	soil	SB	composite	B	6/11/2017	785554.61	3914489.47	N	N	--
S1011-SCX-031	7.0 - 10.0	soil	SB	composite	B	6/11/2017	785554.61	3914489.47	N	N	--
S1011-SCX-031	10.0 - 12.0	soil	SB	composite	B	6/11/2017	785554.61	3914489.47	N;FD	N;FD	--
S1011-SCX-032	0 - 0.5	soil	SF	grab	B	6/11/2017	785532.40	3914481.95	N	N	--
S1011-SCX-032	0.5 - 5.0	soil	SB	composite	B	6/11/2017	785532.40	3914481.95	N	N	--
S1011-SCX-032	5.0 - 9.0	soil	SB	composite	B	6/11/2017	785532.40	3914481.95	N	N	--
S1011-SCX-033	0 - 0.5	sediment	SF	grab	B	6/11/2017	785618.18	3914451.69	N;FD	N;FD	--
S1011-SCX-033	0.5 - 5.0	sediment	SB	composite	B	6/11/2017	785618.18	3914451.69	N	N	--
S1011-SCX-033	5.0 - 9.0	sediment	SB	composite	B	6/11/2017	785618.18	3914451.69	N	N	--
S1011-SCX-034	0 - 0.5	soil	SF	grab	B	6/12/2017	785596.46	3914489.26	N	N	--
S1011-SCX-034	0.5 - 5.0	soil	SB	composite	B	6/12/2017	785596.46	3914489.26	N	N	--
S1011-SCX-034	5.0 - 10.0	soil	SB	composite	B	6/12/2017	785596.46	3914489.26	N	N	--
S1011-SCX-035	0 - 0.5	soil	SF	grab	B	6/12/2017	785584.73	3914514.83	N;MS;MSD	N	--
S1011-SCX-035	0.5 - 5.0	soil	SB	composite	B	6/12/2017	785584.73	3914514.83	N	N	--
S1011-SCX-035	5.0 - 8.0	soil	SB	composite	B	6/12/2017	785584.73	3914514.83	N	N	--
S1011-SCX-036	0 - 0.5	soil	SF	grab	B	6/12/2017	785631.75	3914563.55	N;FD	N;FD	--
S1011-SCX-036	0.5 - 3.0	soil	SB	composite	B	6/12/2017	785631.75	3914563.55	N	N	--
S1011-SCX-037	0 - 0.5	soil	SF	grab	B	6/12/2017	785568.09	3914568.95	N	N	--
S1011-SCX-037	0.5 - 3.0	soil	SB	composite	B	6/12/2017	785568.09	3914568.95	N	N	--
S1011-SCX-038	0 - 0.5	soil	SF	grab	B	6/12/2017	785559.09	3914524.78	N	N	--
S1011-SCX-038	0.5 - 3.0	soil	SB	composite	B	6/12/2017	785559.09	3914524.78	N	N	--
S1011-SCX-038	3.0 - 10.0	soil	SB	composite	B	6/12/2017	785559.09	3914524.78	N	N	--
S1011-SCX-039	0 - 0.2	soil	SF	grab	B	9/19/2017	785066.82	3914558.93	N	N	--
S1011-SCX-040	0 - 0.2	soil	SF	grab	B	9/19/2017	785073.34	3914570.39	N	N	--
S1011-SCX-041	0 - 0.2	soil	SF	grab	D	9/19/2017	785168.70	3914011.94	N	N	--
S1011-SCX-041	0.2 - 2.5	soil	SB	composite	D	9/19/2017	785168.70	3914011.94	N	N	--
S1011-SCX-042	0 - 0.2	soil	SF	grab	D	9/19/2017	785343.45	3914012.62	N	N	--
S1011-SCX-042	0.2 - 2.0	soil	SB	composite	D	9/19/2017	785343.45	3914012.62	N;MS;MSD	N	--
S1011-SCX-043	0 - 0.2	soil	SF	grab	D	9/19/2017	785628.32	3914060.88	N;FD	N;FD	--
S1011-SCX-044	0 - 0.2	soil	SF	grab	B	9/19/2017	785065.46	3914556.94	N	N	--
S1011-SCX-044	0.2 - 0.7	soil	SB	grab	B	9/19/2017	785065.46	3914556.94	N	N	--

Notes

--	Not Sampled
N	Normal
FD	Field Duplicate
MS	Matrix Spike
MSD	Matrix Spike Duplicate
Ra-226	Radium 226
NA	Not Applicable
SB	Subsurface Sample
SF	Surface Sample
ft bgs	feet below ground surface

¹ Coordinate System: NAD 1983 UTM Zone 12N

Table 3-3
Mine Feature Samples and Area
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Mine Feature	Surface Samples	Subsurface Samples	Area (sq. ft)	Volume of TENORM exceeding ILs (yd^3)
Waste Pile 1	0	0	4,111	152
Waste Pile 2	1	0	15,302	1,063
Waste Pile 3	2	3	25,863	2,874
Waste Pile 4	0	0	207	8
Waste Pile 5	0	0	307	40
Waste Pile 6	1	1	581	108
Waste Pile 7	0	0	2,396	213
Central Debris Pile	0	0	5,719.3	847.0
Northern Debris Pile	0	0	498.6	*
Southern Debris Pile	1	1	29,915.6	*
Disturbed Area 1	3	3	73,217	5,690
Disturbed Area 2	5	3	146,811	7,906
Disturbed Area 3	1	0	12,789	474
Disturbed Area 4	0	0	**	**
Western Graded/Disturbed Reclaimed Area	10	5	146,081	16,817
Eastern Graded/Disturbed Reclaimed Area	19***	33***	242,120	70,512
Potential Waste Rock Area	2	0	119,405	8,647
Excavation 1	0	0	1,610	60
Excavation 2	1	2	283	37
Potential Haul Roads	5	9	**	--
Drainages	9	11	****	--

Notes

sq.ft	square feet
yd^3	cubic yards
TENORM	technologically enhanced naturally occurring radioactive material
--	Discrete volume was not identified for feature
*	Northern and southern debris piles contain car tires
**	Feature is not included in area of TENORM
***	Sample counts include samples collected within the potential haul roads and drainages mapped within the mining/reclaimed disturbed area
****	Area not determined because the width feature varies throughout the Site

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Table 4-1
Background Reference Area Soil Sample Analytical Results
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Location Identification	S1011-BG1-001	S1011-BG1-002	S1011-BG1-003	S1011-BG1-004	S1011-BG1-005	S1011-BG1-006	S1011-BG1-006 Dup	S1011-BG1-007	S1011-BG1-008	S1011-BG1-009
Date Collected	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016
Depth (feet)	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2
Analyte (Units)										
Metals[1] (mg/kg)										
Arsenic	2	2.2	2.5	5.2	11 J-	3.4	12	2	5.8	6.1
Molybdenum	<0.21	0.33	0.32	0.54	1.4 J	0.62	1.7	<0.21	0.49	0.6
Selenium	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<0.99	<1.1	<1.1	<1.1
Uranium	1.6	2.4	1.7	2.5	2.4	2	2.5	2.8	2.5	1.9
Vanadium	5.5	6.7	7.8	11	26 J-	10	18	7.6	14	13
Radionuclides (pCi/g)										
Radium-226	1.05 ± 0.25	1.34 ± 0.3	1.43 ± 0.27	1.71 ± 0.34	1.86 ± 0.33	1.34 ± 0.29	1.29 ± 0.29	1.62 ± 0.33	1.43 ± 0.31	1.57 ± 0.3

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
< Result not detected above associated laboratory reporting limit
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Table 4-1
Background Reference Area Soil Sample Analytical Results
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Location Identification	S1011-BG1-010	S1011-BG1-011	S1011-BG1-011	S1011-BG2-001	S1011-BG2-002	S1011-BG2-003	S1011-BG2-004	S1011-BG2-005	S1011-BG2-006	S1011-BG2-006 Dup
Date Collected	11/30/2016	3/25/2017	3/25/2017	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016	11/30/2016
Depth (feet)	0 - 0.2	0 - 0.2	0.5 - 0.7	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2
Analyte (Units)										
Metals[1] (mg/kg)										
Arsenic	4.3	3	2.4	1.4	1.3	1.8	1.6	1.9	2	2
Molybdenum	0.46	0.34	<0.2	<0.22	<0.22	<0.22	<0.21	<0.22	<0.2	0.23
Selenium	<1.1	<0.91	<1	<1.1	<1.1	<1.1	<1	<1.1	<1	<1.1
Uranium	2	2.1	2.9	1.5	1.6	1.9	1.5	1.5	1.6	1.6
Vanadium	14	11	11	7.7	7.6	9.6	8.6	10	9.2	9.1
Radionuclides (pCi/g)										
Radium-226	1.2 ± 0.29	1.62 ± 0.31 J-	1.51 ± 0.32	2.02 ± 0.37	2.7 ± 0.47	2.59 ± 0.43	1.89 ± 0.33	1.84 ± 0.36	1.92 ± 0.34	1.64 ± 0.34

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
< Result not detected above associated laboratory reporting limit
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Table 4-1
Background Reference Area Soil Sample Analytical Results
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Location Identification	S1011-BG2-007	S1011-BG2-008	S1011-BG2-009	S1011-BG2-010	S1011-BG2-011	S1011-BG2-011	S1011-BG3-001	S1011-BG3-002	S1011-BG3-003	S1011-BG3-004
Date Collected	11/30/2016	11/30/2016	11/30/2016	11/30/2016	3/25/2017	3/25/2017	9/18/2017	9/18/2017	9/18/2017	9/18/2017
Depth (feet)	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	1.5 - 2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2
Analyte (Units)										
Metals[1] (mg/kg)										
Arsenic	1.7	2	1.7	1.5	1.7	1.8	1.5	1	1	1.2
Molybdenum	<0.21	<0.22	0.22	0.33	<0.18	<0.2	0.37	<0.2	<0.18	<0.2
Selenium	<1.1	<1.1	<1.1	<1.1	<0.91	<0.99	<1	<1	<0.92	<0.98
Uranium	1.4	1.4	1.5 J+	3.4	1.3	1.2	1.4	0.82	0.75	0.82
Vanadium	8.8	9	8.6	6.7	7.9	9.6	15	10 J+	9.8	10
Radionuclides (pCi/g)										
Radium-226	1.73 ± 0.35	1.78 ± 0.37	2.15 ± 0.36	2.16 ± 0.39	2.03 ± 0.34	1.59 ± 0.32	1.21 ± 0.27	0.87 ± 0.25	0.82 ± 0.21 J-	0.88 ± 0.23

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
[1] Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
< Result not detected above associated laboratory reporting limit
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Location Identification Date Collected Depth (feet) Analyte (Units)	S1011-BG3-004 Dup 9/18/2017 0 - 0.2	S1011-BG3-005 9/18/2017 0 - 0.2	S1011-BG3-006 9/18/2017 0 - 0.2	S1011-BG3-007 9/18/2017 0 - 0.2	S1011-BG3-008 9/18/2017 0 - 0.2	S1011-BG3-009 9/18/2017 0 - 0.2	S1011-BG3-009 Dup 9/18/2017 0 - 0.2	S1011-BG3-010 9/18/2017 0 - 0.2	S1011-BG3-011 9/19/2017 0 - 0.2	S1011-BG4-001 9/19/2017 0 - 0.2
Metals[1] (mg/kg)										
Arsenic	1.1	1.4	1.2	1.3	1	1.3	1.4	5.2	1.2	1.2
Molybdenum	<0.19	<0.2	<0.2	0.21	<0.2	<0.21	0.2	0.26	0.2	<0.2
Selenium	<0.96	<0.99	<1	<1	<0.99	<1	<1	<0.99	<0.97	<1
Uranium	0.7	1	1.2	1.6	0.6	1.1	1.1	0.9	1.3	0.36
Vanadium	8.4	9.2	12	9.6	9.6	11	10	13	15	7.7
Radionuclides (pCi/g)										
Radium-226	0.78 ± 0.24	1.23 ± 0.29	0.83 ± 0.2	1.14 ± 0.25	0.71 ± 0.22	0.99 ± 0.27	1.15 ± 0.26	1 ± 0.23	1.16 ± 0.25	0.84 ± 0.24

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
< Result not detected above associated laboratory reporting limit
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Location Identification Date Collected Depth (feet) Analyte (Units)	S1011-BG4-002 9/19/2017 0 - 0.2	S1011-BG4-003 9/19/2017 0 - 0.2	S1011-BG4-003 Dup 9/19/2017 0 - 0.2	S1011-BG4-004 9/19/2017 0 - 0.2	S1011-BG4-005 9/19/2017 0 - 0.2	S1011-BG4-006 9/19/2017 0 - 0.2	S1011-BG4-007 9/19/2017 0 - 0.2	S1011-BG4-008 9/19/2017 0 - 0.2	S1011-BG4-009 9/19/2017 0 - 0.2	S1011-BG4-009 Dup 9/19/2017 0 - 0.2
Metals[1] (mg/kg)										
Arsenic	1.5	1.3	1.3	1.4	1.4	1.5	1.5	1.5	1.5	1.3
Molybdenum	<0.19	<0.2	<0.2	0.21	<0.2	<0.2	<0.2	<0.2	0.2	<0.19
Selenium	<0.96	<0.99	<1	<0.94	<1	<1	<0.99	<0.99	<0.97	<0.95
Uranium	0.42	0.39	0.41	0.47	0.47	0.46	0.49	0.47	0.45	0.43
Vanadium	9	8.2	8	9.3	9.8	9.2	9.8	9.7	9.3	8.5
Radionuclides (pCi/g)										
Radium-226	0.88 ± 0.23	0.72 ± 0.22	1.24 ± 0.27	1.14 ± 0.25	1.06 ± 0.24	1.27 ± 0.28	1.04 ± 0.27	1.11 ± 0.27	1.07 ± 0.25	0.9 ± 0.26

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
< Result not detected above associated laboratory reporting limit
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Table 4-1
Background Reference Area Soil Sample Analytical Results
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Location Identification	S1011-BG4-010	S1011-BG4-011	S1011-BG4-011	S1011-BG5-001	S1011-BG5-002	S1011-BG5-002 Dup	S1011-BG5-003	S1011-BG5-004	S1011-BG5-005	S1011-BG5-006
Date Collected	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017
Depth (feet)	0 - 0.2	0 - 0.2	0.2 - 3	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2
Analyte (Units)										
Metals[1] (mg/kg)										
Arsenic	1.3	1.6	1.3	1.2	1.3	1.1	1.5	1.1	1.1	1.3
Molybdenum	<0.2	<0.2	<0.19	<0.2	<0.2	<0.2	<0.2	<0.2	<0.19	<0.2
Selenium	<0.98	<1	<0.97	<0.98	<1	<1	<1	<1	<0.96	<1
Uranium	0.44	0.46	0.4	0.42 J	0.41	0.35	0.45	0.29	0.4	0.41
Vanadium	8.8	8.3	8.5	6.4	7.8	7	8.8	6.6	5.1	7.5
Radionuclides (pCi/g)										
Radium-226	1 ± 0.26	0.71 ± 0.23	0.56 ± 0.18	0.61 ± 0.24	0.55 ± 0.17	0.6 ± 0.25	0.52 ± 0.22	0.54 ± 0.17	0.65 ± 0.21	0.63 ± 0.19

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
< Result not detected above associated laboratory reporting limit
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Table 4-1
Background Reference Area Soil Sample Analytical Results
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Location Identification	S1011-BG5-007	S1011-BG5-008	S1011-BG5-009	S1011-BG5-009 Dup	S1011-BG5-010	S1011-BG5-011	S1011-BG5-011
Date Collected	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017
Depth (feet)	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0.2 - 2
Analyte (Units)							
Metals[1] (mg/kg)							
Arsenic	1.1	1.3	1.3	1.3	1.2	1.6	1.7
Molybdenum	<0.2	<0.19	<0.19	<0.2	<0.2	<0.2	<0.2
Selenium	<1	<0.96	<0.96	<0.98	<0.99	<0.99	<1
Uranium	0.68	0.35	0.39	0.36	0.35	0.41	0.43
Vanadium	8	6.7	7.6	7.3	6.6	9.4	9
Radionuclides (pCi/g)							
Radium-226	0.66 ± 0.2	0.79 ± 0.21	0.63 ± 0.18	0.72 ± 0.19	0.5 ± 0.19	0.63 ± 0.24	0.74 ± 0.22

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
< Result not detected above associated laboratory reporting limit
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Table 4-2
Static Gamma Measurement Summary
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Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-BG1-011	Background Area 1	*	0.0	soil	7,345
S1011-BG1-011	Background Area 1	*	0.7	soil	7,963**
S1011-BG2-011	Background Area 2	*	0.0	soil	10,200
S1011-BG2-011	Background Area 2	*	0.5	soil	12,551
S1011-BG2-011	Background Area 2	*	1.0	soil	12,840
S1011-BG2-011	Background Area 2	*	1.5	soil	13,268
S1011-BG2-011	Background Area 2	*	2.0	soil	12,669
S1011-BG3-011	Background Area 3	*	0.0	soil	6,390
S1011-BG3-011	Background Area 3	*	0.25	soil	6,387**
S1011-BG4-011	Background Area 4	*	0.0	soil	7,788
S1011-BG4-011	Background Area 4	*	0.5	soil	9,706
S1011-BG4-011	Background Area 4	*	1.0	soil	10,481
S1011-BG4-011	Background Area 4	*	1.5	soil	10,271
S1011-BG4-011	Background Area 4	*	2.0	soil	10,313
S1011-BG4-011	Background Area 4	*	2.5	soil	10,099
S1011-BG4-011	Background Area 4	*	3.0	soil	10,616
S1011-BG5-011	Background Area 5	*	0.0	sediment	8,008
S1011-BG5-011	Background Area 5	*	0.5	sediment	10,302
S1011-BG5-011	Background Area 5	*	1.0	sediment	11,450
S1011-BG5-011	Background Area 5	*	1.5	sediment	11,465
S1011-BG5-011	Background Area 5	*	2.0	sediment	11,496
S1011-SCX-008	A	--	0.0	soil	42,178
S1011-SCX-008	A	7,963	0.5	soil	57,060
S1011-SCX-008	A	7,963	1.0	soil	72,800
S1011-SCX-008	A	7,963	1.5	soil	103,982**
S1011-SCX-017	A	--	0.0	soil	105,490
S1011-SCX-017	A	7,963	1.0	soil	266,288
S1011-SCX-017	A	7,963	2.0	bedrock	102,426
S1011-SCX-017	A	7,963	3.0	unknown	16,794
S1011-SCX-017	A	7,963	3.5	unknown	15,000
S1011-SCX-007	B	--	0.0	soil	20,946
S1011-SCX-007	B	12,669	0.5	soil	20,893
S1011-SCX-007	B	12,669	1.0	soil	19,694
S1011-SCX-007	B	12,669	1.5	soil	16,236**

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
*	The subsurface gamma investigation levels are derived from the background area measurements, refer to Section 4.1 of the RSE report
**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-009	B	--	0.0	soil	8,544
S1011-SCX-009	B	12,669	1.0	soil	11,686
S1011-SCX-009	B	12,669	2.0	soil	10,692
S1011-SCX-009	B	12,669	3.0	bedrock	15,044
S1011-SCX-009	B	12,669	4.0	bedrock	17,232
S1011-SCX-009	B	12,669	5.0	bedrock	17,936
S1011-SCX-009	B	12,669	6.0	bedrock	19,196
S1011-SCX-010	B	--	0.0	soil	13,646
S1011-SCX-010	B	12,669	1.0	soil	27,136
S1011-SCX-010	B	12,669	2.0	soil	20,118
S1011-SCX-010	B	12,669	3.0	soil	25,594
S1011-SCX-010	B	12,669	4.0	soil	32,074
S1011-SCX-010	B	12,669	5.0	soil	42,308
S1011-SCX-010	B	12,669	6.0	bedrock	40,190
S1011-SCX-010	B	12,669	7.0	bedrock	41,294
S1011-SCX-010	B	12,669	8.0	bedrock	32,386
S1011-SCX-010	B	12,669	8.5	bedrock	29,706
S1011-SCX-011	B	--	0.0	soil	8,652
S1011-SCX-011	B	12,669	1.0	soil	11,026
S1011-SCX-011	B	12,669	2.0	soil	11,312
S1011-SCX-011	B	12,669	3.0	soil	10,428
S1011-SCX-011	B	12,669	4.0	soil	9,968
S1011-SCX-011	B	12,669	5.0	bedrock	16,896
S1011-SCX-011	B	12,669	6.0	bedrock	17,812
S1011-SCX-011	B	12,669	7.0	bedrock	13,242
S1011-SCX-011	B	12,669	8.0	bedrock	12,348
S1011-SCX-011	B	12,669	8.5	bedrock	13,386
S1011-SCX-012	B	--	0.0	soil	10,932
S1011-SCX-012	B	12,669	1.0	soil	14,594
S1011-SCX-012	B	12,669	2.0	soil	13,230
S1011-SCX-012	B	12,669	3.0	soil	11,274
S1011-SCX-012	B	12,669	4.0	soil	9,858
S1011-SCX-012	B	12,669	5.0	soil	12,308
S1011-SCX-012	B	12,669	6.0	bedrock	13,940
S1011-SCX-012	B	12,669	7.0	bedrock	11,776
S1011-SCX-012	B	12,669	8.0	bedrock	11,426
S1011-SCX-012	B	12,669	9.0	bedrock	10,814

Notes

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*	The subsurface gamma investigation levels are derived from the background area measurements, refer to Section 4.1 of the RSE report
**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Table 4-2
Static Gamma Measurement Summary
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Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-013	B	--	0.0	soil	8,736
S1011-SCX-013	B	12,669	1.0	bedrock	14,258
S1011-SCX-013	B	12,669	2.0	bedrock	16,410
S1011-SCX-013	B	12,669	3.0	bedrock	16,580
S1011-SCX-013	B	12,669	4.0	bedrock	18,010
S1011-SCX-013	B	12,669	5.0	bedrock	13,298
S1011-SCX-014	B	--	0.0	soil	33,406
S1011-SCX-014	B	12,669	1.0	soil	10,820
S1011-SCX-014	B	12,669	2.0	soil	9,438
S1011-SCX-014	B	12,669	3.0	soil	9,166
S1011-SCX-014	B	12,669	4.0	soil	10,578
S1011-SCX-014	B	12,669	5.0	bedrock	10,380
S1011-SCX-014	B	12,669	5.5	bedrock	18,802
S1011-SCX-015	B	--	0.0	soil	8,296
S1011-SCX-015	B	12,669	1.0	soil	9,484
S1011-SCX-015	B	12,669	2.0	bedrock	8,832
S1011-SCX-016	B	--	0.0	soil	10,728
S1011-SCX-016	B	12,669	1.0	soil	9,288
S1011-SCX-016	B	12,669	2.0	soil	11,334
S1011-SCX-016	B	12,669	3.0	soil	15,094**
S1011-SCX-018	B	--	0.0	soil	45,908
S1011-SCX-018	B	12,669	1.0	soil	136,354
S1011-SCX-018	B	12,669	2.0	soil	252,986
S1011-SCX-018	B	12,669	3.0	soil	187,496
S1011-SCX-018	B	12,669	4.0	bedrock	130,140
S1011-SCX-019	B	--	0.0	soil	40,179
S1011-SCX-019	B	12,669	1.0	soil	107,138
S1011-SCX-019	B	12,669	2.0	soil	254,338
S1011-SCX-019	B	12,669	3.0	bedrock	477,872
S1011-SCX-020	B	--	0.0	soil	20,449
S1011-SCX-020	B	12,669	1.0	soil	25,622
S1011-SCX-020	B	12,669	2.0	soil	28,812
S1011-SCX-020	B	12,669	3.0	soil	45,588
S1011-SCX-020	B	12,669	4.0	soil	76,812
S1011-SCX-020	B	12,669	5.0	soil	79,874
S1011-SCX-020	B	12,669	6.0	bedrock	118,858

Notes

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**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-021	B	--	0.0	soil	11,964
S1011-SCX-021	B	12,669	1.0	soil	14,878
S1011-SCX-021	B	12,669	2.0	soil	16,610
S1011-SCX-021	B	12,669	3.0	soil	16,712
S1011-SCX-021	B	12,669	4.0	soil	17,798
S1011-SCX-021	B	12,669	5.0	soil	17,462
S1011-SCX-021	B	12,669	6.0	soil	17,212
S1011-SCX-021	B	12,669	7.0	soil	16,554
S1011-SCX-021	B	12,669	8.0	soil	14,260
S1011-SCX-021	B	12,669	9.0	soil	13,470
S1011-SCX-021	B	12,669	10.0	soil	14,074
S1011-SCX-021	B	12,669	11.0	soil	16,628
S1011-SCX-021	B	12,669	12.0	soil	25,502
S1011-SCX-021	B	12,669	13.0	soil	30,366
S1011-SCX-021	B	12,669	14.0	soil	26,570
S1011-SCX-021	B	12,669	15.0	soil	22,026
S1011-SCX-021	B	12,669	16.0	soil	15,886
S1011-SCX-021	B	12,669	17.0	soil	17,180
S1011-SCX-021	B	12,669	18.0	bedrock	29,628
S1011-SCX-021	B	12,669	19.0	bedrock	37,786
S1011-SCX-021	B	12,669	20.0	bedrock	29,272
S1011-SCX-022	B	--	0.0	soil	11,584
S1011-SCX-022	B	12,669	1.0	soil	10,014
S1011-SCX-022	B	12,669	2.0	soil	10,162
S1011-SCX-022	B	12,669	3.0	soil	10,390
S1011-SCX-022	B	12,669	4.0	soil	10,572
S1011-SCX-022	B	12,669	5.0	soil	10,538
S1011-SCX-022	B	12,669	6.0	soil	10,160
S1011-SCX-022	B	12,669	7.0	soil	10,124
S1011-SCX-022	B	12,669	8.0	soil	11,216
S1011-SCX-022	B	12,669	9.0	soil	14,474
S1011-SCX-022	B	12,669	10.0	soil	16,838
S1011-SCX-022	B	12,669	11.0	soil	19,754
S1011-SCX-022	B	12,669	12.0	soil	21,062
S1011-SCX-022	B	12,669	13.0	soil	22,684
S1011-SCX-022	B	12,669	14.0	soil	21,010
S1011-SCX-022	B	12,669	15.0	soil	23,160
S1011-SCX-022	B	12,669	16.0	soil	23,892
S1011-SCX-022	B	12,669	17.0	soil	23,822
S1011-SCX-022	B	12,669	18.0	soil	26,782
S1011-SCX-022	B	12,669	19.0	soil	29,084
S1011-SCX-022	B	12,669	20.0	soil	33,188

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
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**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-023	B	--	0.0	soil	11,194
S1011-SCX-023	B	12,669	1.0	soil	12,954
S1011-SCX-023	B	12,669	2.0	soil	13,554
S1011-SCX-023	B	12,669	3.0	soil	13,538
S1011-SCX-023	B	12,669	4.0	soil	13,460
S1011-SCX-023	B	12,669	5.0	soil	12,650
S1011-SCX-023	B	12,669	6.0	soil	11,678
S1011-SCX-023	B	12,669	7.0	soil	12,514
S1011-SCX-023	B	12,669	8.0	soil	13,054
S1011-SCX-023	B	12,669	9.0	soil	13,532
S1011-SCX-023	B	12,669	10.0	soil	13,714
S1011-SCX-023	B	12,669	11.0	soil	14,780
S1011-SCX-023	B	12,669	12.0	soil	14,028
S1011-SCX-023	B	12,669	13.0	soil	13,874
S1011-SCX-023	B	12,669	14.0	soil	18,286
S1011-SCX-023	B	12,669	15.0	bedrock	26,014
S1011-SCX-024	B	--	0.0	soil	32,082
S1011-SCX-024	B	12,669	1.0	soil	26,124
S1011-SCX-024	B	12,669	2.0	soil	16,190
S1011-SCX-024	B	12,669	3.0	soil	15,480
S1011-SCX-024	B	12,669	4.0	soil	18,898
S1011-SCX-024	B	12,669	5.0	bedrock	22,238
S1011-SCX-024	B	12,669	6.0	bedrock	25,878
S1011-SCX-024	B	12,669	7.0	bedrock	27,094
S1011-SCX-025	B	--	0.0	sediment	14,636
S1011-SCX-025	B	12,669	1.0	sediment	23,846
S1011-SCX-025	B	12,669	2.0	sediment	18,968
S1011-SCX-025	B	12,669	3.0	sediment	17,256
S1011-SCX-025	B	12,669	4.0	sediment	17,846
S1011-SCX-025	B	12,669	5.0	sediment	17,792
S1011-SCX-025	B	12,669	6.0	sediment	20,898
S1011-SCX-025	B	12,669	7.0	bedrock	29,730
S1011-SCX-025	B	12,669	8.0	bedrock	39,254
S1011-SCX-026	B	--	0.0	sediment	11,826
S1011-SCX-026	B	12,669	1.0	sediment	16,592
S1011-SCX-026	B	12,669	2.0	sediment	18,044
S1011-SCX-026	B	12,669	3.0	sediment	16,534
S1011-SCX-026	B	12,669	4.0	sediment	16,388
S1011-SCX-026	B	12,669	5.0	sediment	15,326
S1011-SCX-026	B	12,669	6.0	sediment	15,000
S1011-SCX-026	B	12,669	7.0	bedrock	12,426
S1011-SCX-026	B	12,669	8.0	bedrock	12,886
S1011-SCX-026	B	12,669	8.5	bedrock	13,314

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
*	The subsurface gamma investigation levels are derived from the background area measurements, refer to Section 4.1 of the RSE report
**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-027	B	--	0.0	soil	14,552
S1011-SCX-027	B	12,669	1.0	soil	13,266
S1011-SCX-027	B	12,669	2.0	soil	13,404
S1011-SCX-027	B	12,669	3.0	soil	10,856
S1011-SCX-027	B	12,669	4.0	soil	9,462
S1011-SCX-027	B	12,669	5.0	soil	8,428
S1011-SCX-027	B	12,669	6.0	soil	8,884
S1011-SCX-027	B	12,669	7.0	soil	9,148
S1011-SCX-027	B	12,669	8.0	soil	8,580
S1011-SCX-027	B	12,669	9.0	bedrock	8,958
S1011-SCX-028	B	--	0.0	soil	13,424
S1011-SCX-028	B	12,669	1.0	soil	47,276
S1011-SCX-028	B	12,669	2.0	soil	208,490
S1011-SCX-028	B	12,669	3.0	soil	352,526
S1011-SCX-028	B	12,669	4.0	soil	103,780
S1011-SCX-028	B	12,669	5.0	soil	85,838
S1011-SCX-028	B	12,669	6.0	soil	123,720
S1011-SCX-028	B	12,669	7.0	boulder	174,166
S1011-SCX-028	B	12,669	8.0	boulder	223,904
S1011-SCX-028	B	12,669	9.0	soil	72,022
S1011-SCX-028	B	12,669	10.0	soil	34,166
S1011-SCX-028	B	12,669	11.0	soil	27,028
S1011-SCX-028	B	12,669	12.0	soil	24,992
S1011-SCX-028	B	12,669	13.0	soil	24,632
S1011-SCX-028	B	12,669	14.0	soil	21,364
S1011-SCX-028	B	12,669	15.0	bedrock	17,048
S1011-SCX-028	B	12,669	16.0	bedrock	16,304
S1011-SCX-028	B	12,669	17.0	bedrock	17,316
S1011-SCX-028	B	12,669	18.0	bedrock	24,485
S1011-SCX-028	B	12,669	18.5	bedrock	39,182
S1011-SCX-029	B	--	0.0	soil	11,734
S1011-SCX-029	B	12,669	1.0	soil	15,084
S1011-SCX-029	B	12,669	2.0	soil	20,564
S1011-SCX-029	B	12,669	3.0	soil	33,810**

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
*	The subsurface gamma investigation levels are derived from the background area measurements, refer to Section 4.1 of the RSE report
**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Table 4-2
Static Gamma Measurement Summary
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Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-030	B	--	0.0	soil	10,412
S1011-SCX-030	B	12,669	1.0	soil	11,078
S1011-SCX-030	B	12,669	2.0	soil	10,834
S1011-SCX-030	B	12,669	3.0	soil	11,048
S1011-SCX-030	B	12,669	4.0	soil	11,634
S1011-SCX-030	B	12,669	5.0	soil	12,246
S1011-SCX-030	B	12,669	6.0	soil	13,378
S1011-SCX-030	B	12,669	7.0	soil	14,020
S1011-SCX-030	B	12,669	8.0	soil	14,542
S1011-SCX-030	B	12,669	9.0	soil	16,164
S1011-SCX-030	B	12,669	10.0	soil	14,666
S1011-SCX-030	B	12,669	11.0	bedrock	14,218
S1011-SCX-030	B	12,669	12.0	bedrock	16,740
S1011-SCX-030	B	12,669	13.0	bedrock	17,184
S1011-SCX-030	B	12,669	13.5	bedrock	18,014
S1011-SCX-031	B	--	0.0	soil	10,658
S1011-SCX-031	B	12,669	1.0	soil	11,560
S1011-SCX-031	B	12,669	2.0	soil	12,288
S1011-SCX-031	B	12,669	3.0	soil	12,194
S1011-SCX-031	B	12,669	4.0	soil	13,318
S1011-SCX-031	B	12,669	5.0	soil	14,170
S1011-SCX-031	B	12,669	6.0	soil	23,174
S1011-SCX-031	B	12,669	7.0	soil	112,936
S1011-SCX-031	B	12,669	8.0	soil	46,570
S1011-SCX-031	B	12,669	9.0	soil	14,706
S1011-SCX-031	B	12,669	10.0	soil	12,666
S1011-SCX-031	B	12,669	11.0	soil	12,820
S1011-SCX-031	B	12,669	12.0	soil	13,212
S1011-SCX-031	B	12,669	13.0	soil	13,678
S1011-SCX-031	B	12,669	14.0	soil	14,856
S1011-SCX-031	B	12,669	15.0	soil	16,104
S1011-SCX-031	B	12,669	16.0	soil	16,732
S1011-SCX-031	B	12,669	17.0	soil	17,160**
S1011-SCX-032	B	--	0.0	soil	10,570
S1011-SCX-032	B	12,669	1.0	soil	14,382
S1011-SCX-032	B	12,669	2.0	soil	16,332
S1011-SCX-032	B	12,669	3.0	soil	14,894
S1011-SCX-032	B	12,669	4.0	soil	13,608
S1011-SCX-032	B	12,669	5.0	soil	13,554
S1011-SCX-032	B	12,669	6.0	soil	14,296
S1011-SCX-032	B	12,669	7.0	soil	14,250
S1011-SCX-032	B	12,669	8.0	soil	14,892
S1011-SCX-032	B	12,669	9.0	soil	17,310
S1011-SCX-032	B	12,669	10.0	bedrock	21,916
S1011-SCX-032	B	12,669	11.0	bedrock	23,336

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
*	The subsurface gamma investigation levels are derived from the background area measurements, refer to Section 4.1 of the RSE report
**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Table 4-2
Static Gamma Measurement Summary
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Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-033	B	--	0.0	sediment	12,994
S1011-SCX-033	B	12,669	1.0	sediment	18,482
S1011-SCX-033	B	12,669	2.0	sediment	18,922
S1011-SCX-033	B	12,669	3.0	sediment	18,392
S1011-SCX-033	B	12,669	4.0	sediment	20,686
S1011-SCX-033	B	12,669	5.0	sediment	23,166
S1011-SCX-033	B	12,669	6.0	sediment	24,122
S1011-SCX-033	B	12,669	7.0	sediment	22,206
S1011-SCX-033	B	12,669	8.0	sediment	22,044
S1011-SCX-033	B	12,669	9.0	sediment	23,926
S1011-SCX-033	B	12,669	10.0	bedrock	31,118
S1011-SCX-034	B	--	0.0	soil	10,216
S1011-SCX-034	B	12,669	1.0	soil	12,334
S1011-SCX-034	B	12,669	2.0	soil	10,874
S1011-SCX-034	B	12,669	3.0	soil	10,392
S1011-SCX-034	B	12,669	4.0	soil	10,602
S1011-SCX-034	B	12,669	5.0	soil	11,044
S1011-SCX-034	B	12,669	6.0	soil	11,470
S1011-SCX-034	B	12,669	7.0	soil	11,290
S1011-SCX-034	B	12,669	8.0	soil	12,642
S1011-SCX-034	B	12,669	9.0	soil	13,500
S1011-SCX-034	B	12,669	10.0	soil	13,430
S1011-SCX-034	B	12,669	11.0	soil	14,888
S1011-SCX-034	B	12,669	13.0	bedrock	18,172
S1011-SCX-034	B	12,669	14.0	bedrock	19,656
S1011-SCX-034	B	12,669	14.5	bedrock	21,210
S1011-SCX-035	B	--	0.0	soil	11,674
S1011-SCX-035	B	12,669	1.0	soil	14,782
S1011-SCX-035	B	12,669	2.0	soil	16,220
S1011-SCX-035	B	12,669	3.0	soil	16,496
S1011-SCX-035	B	12,669	4.0	soil	14,548
S1011-SCX-035	B	12,669	5.0	soil	13,084
S1011-SCX-035	B	12,669	6.0	soil	13,386
S1011-SCX-035	B	12,669	7.0	soil	13,298
S1011-SCX-035	B	12,669	8.0	soil	13,728
S1011-SCX-035	B	12,669	9.0	soil	13,652
S1011-SCX-035	B	12,669	10.0	soil	14,074
S1011-SCX-035	B	12,669	11.0	soil	13,990
S1011-SCX-035	B	12,669	12.0	soil	15,622
S1011-SCX-035	B	12,669	13.0	soil	15,690
S1011-SCX-035	B	12,669	14.0	soil	15,844
S1011-SCX-035	B	12,669	15.0	soil	17,532
S1011-SCX-035	B	12,669	16.0	soil	18,100
S1011-SCX-035	B	12,669	17.0	soil	17,820
S1011-SCX-035	B	12,669	18.0	bedrock	17,452

Notes

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**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

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Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-035 continued					
S1011-SCX-035	B	12,669	19.0	bedrock	29,954
S1011-SCX-035	B	12,669	20.0	bedrock	31,690
S1011-SCX-036	B	--	0.0	soil	13,564
S1011-SCX-036	B	12,669	1.0	soil	15,048
S1011-SCX-036	B	12,669	2.0	soil	14,742
S1011-SCX-036	B	12,669	3.0	soil	12,738
S1011-SCX-036	B	12,669	4.0	soil	11,068
S1011-SCX-036	B	12,669	5.0	bedrock	13,984
S1011-SCX-036	B	12,669	6.0	bedrock	21,554
S1011-SCX-036	B	12,669	7.0	bedrock	25,802
S1011-SCX-036	B	12,669	7.5	bedrock	22,384
S1011-SCX-037	B	--	0.0	sediment	14,226
S1011-SCX-037	B	12,669	1.0	sediment	18,620
S1011-SCX-037	B	12,669	2.0	sediment	13,508
S1011-SCX-037	B	12,669	3.0	sediment	13,690
S1011-SCX-037	B	12,669	4.0	bedrock	12,558
S1011-SCX-037	B	12,669	5.0	bedrock	13,066
S1011-SCX-038	B	--	0.0	soil	24,372
S1011-SCX-038	B	12,669	1.0	soil	17,094
S1011-SCX-038	B	12,669	2.0	soil	12,736
S1011-SCX-038	B	12,669	3.0	soil	16,092
S1011-SCX-038	B	12,669	4.0	soil	13,244
S1011-SCX-038	B	12,669	5.0	soil	11,722
S1011-SCX-038	B	12,669	6.0	soil	12,444
S1011-SCX-038	B	12,669	7.0	soil	13,204
S1011-SCX-038	B	12,669	8.0	soil	14,028
S1011-SCX-038	B	12,669	9.0	soil	14,446
S1011-SCX-038	B	12,669	10.0	soil	15,148
S1011-SCX-038	B	12,669	11.0	soil	14,630
S1011-SCX-038	B	12,669	12.0	soil	15,030
S1011-SCX-038	B	12,669	13.0	soil	15,232
S1011-SCX-038	B	12,669	14.0	soil	14,684
S1011-SCX-038	B	12,669	15.0	soil	13,868
S1011-SCX-038	B	12,669	16.0	soil	13,826
S1011-SCX-038	B	12,669	17.0	bedrock	14,336
S1011-SCX-038	B	12,669	18.0	bedrock	13,668
S1011-SCX-038	B	12,669	19.0	bedrock	12,206
S1011-SCX-038	B	12,669	19.5	bedrock	14,560
S1011-SCX-039	B	--	0.0	soil	25,341
S1011-SCX-039	B	12,669	0.2	soil	72,575**
S1011-SCX-040	B	--	0.0	soil	16,404
S1011-SCX-040	B	12,669	0.5	soil	24,374**

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
*	The subsurface gamma investigation levels are derived from the background area measurements, refer to Section 4.1 of the RSE report
**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S1011-SCX-044	B	--	0.0	soil	18,638
S1011-SCX-044	B	12,669	0.5	soil	32,807
S1011-SCX-044	B	12,669	0.8	soil	37,173**
S1011-SCX-006	C	--	0.0	soil	154,022
S1011-SCX-006	C	6,387	0.25	soil	154,588
S1011-SCX-006	C	6,387	1.0	soil	75,424
S1011-SCX-006	C	6,387	1.25	soil	47,582**
S1011-SCX-041	D	--	0.0	soil	8,725
S1011-SCX-041	D	10,099	0.5	soil	11,463
S1011-SCX-041	D	10,099	1.0	soil	14,067
S1011-SCX-041	D	10,099	1.5	soil	14,704
S1011-SCX-041	D	10,099	2.0	soil	16,358
S1011-SCX-041	D	10,099	2.5	soil	17,072
S1011-SCX-042	D	10,099	0.5	soil	9,653
S1011-SCX-042	D	10,099	1.0	soil	10,000
S1011-SCX-042	D	10,099	1.5	soil	9,725
S1011-SCX-042	D	10,099	2.0	soil	9,365
S1011-SCX-043	D	--	0.0	soil	10,128
S1011-SCX-043	D	10,099	0.25	soil	12,081**
S1011-SCX-001	E	--	0.0	sediment	18,116
S1011-SCX-001	E	11,450	0.5	sediment	40,869
S1011-SCX-001	E	11,450	1.0	sediment	42,405
S1011-SCX-001	E	11,450	1.5	sediment	34,807**
S1011-SCX-002	E	--	0.0	sediment	9,941
S1011-SCX-002	E	11,450	0.5	sediment	11,730
S1011-SCX-002	E	11,450	1.0	sediment	12,136
S1011-SCX-002	E	11,450	1.5	sediment	13,372**
S1011-SCX-003	E	--	0.0	sediment	10,529
S1011-SCX-003	E	11,450	0.5	sediment	16,417
S1011-SCX-003	E	11,450	1.0	sediment	21,117
S1011-SCX-003	E	11,450	1.5	sediment	27,011
S1011-SCX-003	E	11,450	2.0	sediment	30,415
S1011-SCX-003	E	11,450	2.25	sediment	34,453**
S1011-SCX-004	E	--	0.0	sediment	9,633
S1011-SCX-004	E	11,450	0.5	sediment	13,991
S1011-SCX-004	E	11,450	1.0	sediment	17,635
S1011-SCX-004	E	11,450	1.5	sediment	20,059
S1011-SCX-004	E	11,450	2.0	sediment	29,039**
S1011-SCX-005	E	--	0.0	sediment	14,559
S1011-SCX-005	E	11,450	0.5	sediment	12,706
S1011-SCX-005	E	11,450	1.0	sediment	13,934
S1011-SCX-005	E	11,450	1.5	sediment	17,422
S1011-SCX-005	E	11,450	2.0	sediment	22,217**

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
*	The subsurface gamma investigation levels are derived from the background area measurements, refer to Section 4.1 of the RSE report
**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Table 4-3
Gamma Correlation Study Soil Sample Analytical Results
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Location Identification	S1011-C01-001	S1011-C02-001	S1011-C03-001	S1011-C04-001	S1011-C05-001
Date Collected	3/29/2017	3/29/2017	3/29/2017	3/29/2017	3/29/2017
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Analyte (Units)					
Radionuclides (pCi/g)					
Radium-226	1.26 ± 0.3	25.2 ± 3.1	11 ± 1.4	1.83 ± 0.33	9 ± 1.2
Thorium-228	0.48 ± 0.1	0.341 ± 0.081	0.359 ± 0.084	0.52 ± 0.11	0.372 ± 0.085
Thorium-230	0.9 ± 0.17	15.5 ± 2.4	4.95 ± 0.79	1.4 ± 0.25	4.07 ± 0.66
Thorium-232	0.451 ± 0.092	0.335 ± 0.075	0.368 ± 0.08	0.48 ± 0.1	0.356 ± 0.078

Notes
Bold Bolded result indicates positively identified compound
pCi/g picocuries per gram

Table 4-4a
Site Characterization Soil Sample Analytical Results for Survey Area A
Section 26
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Location Identification		S1011-CX-007	S1011-CX-012	S1011-CX-013	S1011-CX-013 Dup	S1011-SCX-008	S1011-SCX-008	S1011-SCX-008	S1011-SCX-017	S1011-SCX-017
Date Collected		5/13/2017	5/13/2017	5/13/2017	5/13/2017	5/13/2017	5/13/2017	5/13/2017	6/10/2017	6/10/2017
Depth (feet)		0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.0	1.0 - 1.5	0 - 0.5	0.5 - 1.0
Sample Category		surface	surface	surface	surface	surface	subsurface	subsurface	surface	subsurface
Sample Collection Method		grab	grab	grab	grab	grab	grab	grab	grab	grab
Media		soil	soil	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)										
Metals[1] (mg/kg)	Investigation Level									
Arsenic	11.9	2.3	3.4	2.8	3.2	3.4	2.4	2.3	4.1	3.8
Molybdenum	2.26	0.27	0.27	0.32	0.37	0.35	0.34	0.36	0.4	0.32
Selenium	NA	<1	<0.94	<0.96	<0.94	<1	<1	<1	<1	1
Uranium	3.23	5.3	120	28	34	29	19	20	230 D	220 D
Vanadium	27.3	16	310	20	23	26	16	17	210	210
Radionuclides (pCi/g)										
Radium-226	2.13	5.39 ± 0.75	12.1 ± 1.5 J-	8.6 ± 1.1	8.3 ± 1.1	12 ± 1.5	6.61 ± 0.91	8.9 ± 1.2	64.4 ± 7.6 J-	66.4 ± 7.9

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
Shaded	Shaded result indicates analyte detected, where that analyte does not have an investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
NA	An investigation level is not identified because in BG-1 selenium sample results were all non-detect
1	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit
D	Sample dilution required for analysis; reported values reflect the dilution
J-	Data are estimated and are potentially biased low due to associated quality control data

Table 4-4b
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area B
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Location Identification		S1011-CX-001	S1011-CX-002	S1011-CX-003	S1011-CX-004	S1011-CX-004 Dup	S1011-CX-005	S1011-CX-010	S1011-CX-011	S1011-CX-014	S1011-CX-015	S1011-SCX-007	S1011-SCX-007	S1011-SCX-007	S1011-SCX-009
Date Collected		12/1/2016	12/1/2016	12/1/2016	12/1/2016	12/1/2016	12/1/2016	5/13/2017	5/13/2017	5/13/2017	5/13/2017	5/13/2017	5/13/2017	5/13/2017	6/9/2017
Depth (feet)		0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.2	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.0	1.0 - 1.5	0 - 0.5
Sample Category		surface	surface	surface	surface	surface	surface	surface	surface	surface	surface	surface	subsurface	subsurface	surface
Sample Collection Method		grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
Media		soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)	Investigation Level														
Metals[1] (mg/kg)															
Arsenic	2.34	1.8	2.3	2.8	2.6	2.6	3.2	1.9	2.3	1.9	1.9	3.5	2.8	3.9	2.3 J
Molybdenum	0.346	0.23	<0.21	<0.21	<0.26	0.27	0.4	<0.19	0.21	<0.19	<0.19	0.38	0.35	0.36	<0.21
Selenium	NA	<1.1	<1.1	<1	<1.3	<1.2	<1.1	<0.96	<0.96	<0.96	<0.96	<1	<1.1	<1.1	<1
Uranium	3.34	1.8	2.3	9.9	3.5	3.5	23	1.6	7.1	7.7	1.6 J	24 J	28	41	0.56
Vanadium	11.2	9.8	13	14	20	20	22	11	60	52	19	26 J-	22	33	13
Radionuclides (pCi/g)															
Radium-226	2.96	2.18 ± 0.38	2.35 ± 0.39	10.6 ± 1.4	4.24 ± 0.69 J+	4.81 ± 0.76 J+	11.3 ± 1.5 J+	2.39 ± 0.42	3.39 ± 0.5	5.54 ± 0.76 J-	1.66 ± 0.34	5.34 ± 0.76	3.74 ± 0.58	4.69 ± 0.67	0.88 ± 0.26

Bold Bolded result indicates positively identified compound
Shaded Shaded result indicates result greater than or equal to the investigation level
mg/kg milligrams per kilogram
pCi/g picocuries per gram
NA An investigation level is not identified because in BG-2 selenium sample results were all non-detect
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< Result not detected above associated laboratory reporting limit
D Sample dilution required for analysis; reported values reflect the dilution.
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Table 4-4b
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area B
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	Location Identification	S1011-SCX-009	S1011-SCX-010	S1011-SCX-010	S1011-SCX-011	S1011-SCX-011	S1011-SCX-011	S1011-SCX-011 Dup	S1011-SCX-012	S1011-SCX-012	S1011-SCX-013	S1011-SCX-014	S1011-SCX-014	S1011-SCX-015
	Date Collected	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/9/2017	6/10/2017
	Depth (feet)	0.5 - 2.0	0 - 0.5	0.5 - 3.0	0 - 0.5	0.5 - 3.0	3.0 - 4.0	0 - 0.5	0 - 0.5	3.0 - 4.0	0 - 0.5	0 - 0.5	0.5 - 4.0	0 - 0.5
	Sample Category	subsurface	surface	subsurface	surface	subsurface	subsurface	surface	surface	subsurface	surface	surface	subsurface	surface
	Sample Collection Method	composite	grab	composite	grab	composite	grab	grab	grab	grab	grab	grab	composite	grab
	Media	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)														
Metals[1] (mg/kg)	Investigation Level													
Arsenic	2.34	2.2	2.1	2	2.9	2.1	2.6	2.9	2.1	2.1	1.3	2.1	1.8	3.6
Molybdenum	0.346	<0.2	0.23	<0.21	0.4	<0.21	<0.2	0.43	<0.2	0.25	<0.2	<0.2	<0.2	0.73
Selenium	NA	<1	<1	<1	<0.99	<1.1	<1	<1	<0.99	<1	<1	<1	<1	<1
Uranium	3.34	0.48	3.6	2.4	0.8	0.49	1.2	0.93	2.2	1.4	2.3	6.8	0.81	7.6
Vanadium	11.2	17	11	12	15	13	14	16	11	12	7.2	12	15	53
Radionuclides (pCi/g)														
Radium-226	2.96	0.92 ± 0.24 J+	5.11 ± 0.73	2.36 ± 0.42	1.53 ± 0.33	0.78 ± 0.27 J+	1 ± 0.23	1.58 ± 0.31	2.6 ± 0.46	1.12 ± 0.27	2.5 ± 0.4	3.21 ± 0.52	0.81 ± 0.23	2.27 ± 0.39

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
NA	An investigation level is not identified because in BG-2 selenium sample results were all non-detect
1	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit
D	Sample dilution required for analysis; reported values reflect the dilution.
J	Data are estimated due to associated quality control data
J-	Data are estimated and are potentially biased low due to associated quality control data
J+	Data are estimated and are potentially biased high due to associated quality control data

Table 4-4b
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area B
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Location Identification		S1011-SCX-015	S1011-SCX-015 Dup	S1011-SCX-016	S1011-SCX-016	S1011-SCX-018	S1011-SCX-018	S1011-SCX-019	S1011-SCX-019	S1011-SCX-020	S1011-SCX-020	S1011-SCX-021	S1011-SCX-021	S1011-SCX-021
Date Collected		6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017
Depth (feet)		0.5 - 1.5	0 - 0.5	0 - 0.5	2.5 - 3.0	0 - 0.5	1.0 - 3.5	0 - 0.5	0.5 - 2.5	0 - 0.5	0.5 - 4.0	0 - 0.5	12.0 - 13.0	14.0 - 15.0
Sample Category		subsurface	surface	surface	subsurface	surface	subsurface	surface	subsurface	surface	subsurface	surface	subsurface	subsurface
Sample Collection Method		grab	grab	grab	grab	grab	composite	grab	composite	grab	composite	grab	grab	grab
Media		soil	soil	soil	soil	soil	soil/bedrock	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)														
Metals[1] (mg/kg)	Investigation Level													
Arsenic	2.34	2.5	2.9	5.9	3.6	3.5	12	3 J	3.9	2.4	2.9	1.5	2	1.5
Molybdenum	0.346	0.23	0.39	0.58	0.28	<0.19	0.22	<0.2	<0.21	<0.21	<0.2	<0.2	<0.2	0.3
Selenium	NA	<1	<1	<1	<1	<0.97	1.2	<1	<1	<1	<1	<0.98	<1	<1
Uranium	3.34	4.9	5.9	7	6.5	50	200 D	26	140 D	4.5	4.8	2.6	4.3	7.4
Vanadium	11.2	50	63	88	15	380	740	92 J	110	49	51	19	77	48
Radionuclides (pCi/g)														
Radium-226	2.96	3.59 ± 0.56	2.05 ± 0.34	2.93 ± 0.46	3.85 ± 0.54	19.8 ± 2.5 J-	80.2 ± 9.5	13.6 ± 1.8	37.2 ± 4.6	6.24 ± 0.88	6.23 ± 0.86 J+	3.02 ± 0.48	5.59 ± 0.74	3.99 ± 0.59

Bold Bolded result indicates positively identified compound
Shaded Shaded result indicates result greater than or equal to the investigation level
mg/kg milligrams per kilogram
pCi/g picocuries per gram
NA An investigation level is not identified because in BG-2 selenium sample results were all non-detect
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< Result not detected above associated laboratory reporting limit
D Sample dilution required for analysis; reported values reflect the dilution.
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Table 4-4b
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area B
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	Location Identification	S1011-SCX-021	S1011-SCX-021	S1011-SCX-021 Dup	S1011-SCX-022	S1011-SCX-022	S1011-SCX-023	S1011-SCX-023	S1011-SCX-023	S1011-SCX-024	S1011-SCX-024	S1011-SCX-024 Dup	S1011-SCX-025	S1011-SCX-025
	Date Collected	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/10/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017
	Depth (feet)	17.0 - 18.0	19.0 - 20.0	14.0 - 15.0	0 - 0.5	5.0 - 7.0	0 - 0.5	0.5 - 5.0	13.5 - 14.5	0 - 0.5	3.0 - 4.0	0 - 0.5	0 - 0.5	0.5 - 3.0
	Sample Category	subsurface	subsurface	subsurface	surface	subsurface	surface	subsurface	subsurface	surface	subsurface	surface	surface	subsurface
	Sample Collection Method	grab	grab	grab	grab	composite	grab	composite	grab	grab	grab	grab	grab	composite
	Media	soil	soil/bedrock	soil	soil	soil	soil	soil	soil	soil	soil	soil	sediment	sediment
Analyte (Units)														
Metals[1] (mg/kg)	Investigation Level													
Arsenic	2.34	4.2	1.4	1.4	1.9	1.7	1.7	1.9	1.1	2.6	2.5	2.9	1.6	1.5
Molybdenum	0.346	0.28	0.3	0.34	1	0.24	<0.2	<0.21	<0.2	0.31	0.45	0.3	<0.2	<0.21
Selenium	NA	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Uranium	3.34	8.3	10	7.2	4.4	0.6	1.1	0.97	0.76	8.9	8.8	9.1	3.3	7.3
Vanadium	11.2	54	34	49	38	8.1	21 J-	14	9.3	23	23	25	10	9.6
Radionuclides (pCi/g)														
Radium-226	2.96	5.76 ± 0.81	6.75 ± 0.91	4.15 ± 0.61	3.64 ± 0.54	0.78 ± 0.23	1.44 ± 0.31	0.84 ± 0.24	1.22 ± 0.3	9 ± 1.2 J+	10.2 ± 1.3	6.67 ± 0.95 J+	6.08 ± 0.84	3.32 ± 0.52

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
NA	An investigation level is not identified because in BG-2 selenium sample results were all non-detect
1	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit
D	Sample dilution required for analysis; reported values reflect the dilution.
J	Data are estimated due to associated quality control data
J-	Data are estimated and are potentially biased low due to associated quality control data
J+	Data are estimated and are potentially biased high due to associated quality control data

Location Identification		S1011-SCX-026	S1011-SCX-026	S1011-SCX-026	S1011-SCX-027	S1011-SCX-027	S1011-SCX-027	S1011-SCX-028	S1011-SCX-028	S1011-SCX-028 Dup	S1011-SCX-028	S1011-SCX-028	S1011-SCX-028	S1011-SCX-028
Date Collected		6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017
Depth (feet)		0 - 0.5	0.5 - 5.0	5.0 - 6.0	0 - 0.5	0.5 - 3.0	6.0 - 8.5	0 - 0.5	0.5 - 5.0	0.5 - 5.0	5.0 - 8.0	8.0 - 10.0	10.0 - 12.0	12.0 - 14.0
Sample Category		surface	subsurface	subsurface	surface	subsurface	subsurface	surface	subsurface	subsurface	subsurface	subsurface	subsurface	subsurface
Sample Collection Method		grab	composite	grab	grab	composite	composite	grab	composite	composite	composite	composite	composite	composite
Media		sediment	sediment	sediment	soil	soil	bedrock	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)	Investigation Level													
Metals[1] (mg/kg)														
Arsenic	2.34	1.8	2.5	2.1	2.1	2.2	1.7	2.9 J	2.6	2.6	2.4	1.7	1.7	1.8
Molybdenum	0.346	<0.2	0.22	0.27	<0.19	<0.2	0.34	0.27	0.33	0.25	0.4	<0.19	<0.2	<0.2
Selenium	NA	<0.98	<1	<1	<0.97	<1	<1	<1	<0.97	<0.98	<1	<0.97	<1	<0.98
Uranium	3.34	0.97	1.1	1.3	1	0.88	1.6	2.1 J-	28	11	11	1.1	2.4	1.5
Vanadium	11.2	9.5	16	14	14	14	17	14	18	14	15	9.1	12	9.8
Radionuclides (pCi/g)														
Radium-226	2.96	1.26 ± 0.29	1.48 ± 0.28	1.12 ± 0.28	1.74 ± 0.36	1.15 ± 0.32 J+	1.2 ± 0.25	1.91 ± 0.37	47.1 ± 5.6	45.8 ± 5.5	10.6 ± 1.4	13.8 ± 1.7	0.63 ± 0.22	1.36 ± 0.32

Bold Bolded result indicates positively identified compound
Shaded Shaded result indicates result greater than or equal to the investigation level
mg/kg milligrams per kilogram
pCi/g picocuries per gram
NA An investigation level is not identified because in BG-2 selenium sample results were all non-detect
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< Result not detected above associated laboratory reporting limit
D Sample dilution required for analysis; reported values reflect the dilution.
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Location Identification		S1011-SCX-029	S1011-SCX-029	S1011-SCX-030	S1011-SCX-030	S1011-SCX-031	S1011-SCX-031	S1011-SCX-031	S1011-SCX-031	S1011-SCX-031	S1011-SCX-031 Dup	S1011-SCX-032	S1011-SCX-032	S1011-SCX-032
Date Collected		6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/11/2017
Depth (feet)		0 - 0.5	0.5 - 3.0	0 - 0.5	0.5 - 5.0	0 - 0.5	0.5 - 5.0	5.0 - 7.0	7.0 - 10.0	10.0 - 12.0	10.0 - 12.0	0 - 0.5	0.5 - 5.0	5.0 - 9.0
Sample Category		surface	subsurface	surface	subsurface	surface	subsurface	subsurface	subsurface	subsurface	subsurface	surface	subsurface	subsurface
Sample Collection Method		grab	composite	grab	composite	grab	composite	composite	composite	composite	composite	grab	composite	composite
Media		soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)	Investigation Level													
Metals[1] (mg/kg)														
Arsenic	2.34	1.8	1.6	2.2	2.1	1.8	1.9	1.7	1.5	1.7	1.7	2.3	1.8	1.7
Molybdenum	0.346	0.2	<0.21	<0.2	<0.2	<0.2	<0.2	<0.19	<0.2	<0.19	<0.2	0.21	<0.2	0.28
Selenium	NA	<0.96	<1	<1	<1	<0.98	<1	<0.96	<1	<0.97	<1	<1	<1	<0.99
Uranium	3.34	2.2	2.1	0.62	0.58	0.89	0.8	1	0.49	0.61	0.58	0.76	0.81	1.1
Vanadium	11.2	20	13	12	14	11	11	8.7	7.6	8	7.4	13	9	12
Radionuclides (pCi/g)														
Radium-226	2.96	1.73 ± 0.3	2.87 ± 0.51 J+	1.16 ± 0.26	0.79 ± 0.22	0.98 ± 0.24	0.92 ± 0.24	0.69 ± 0.19	0.67 ± 0.22	0.57 ± 0.18	0.61 ± 0.2	1.44 ± 0.3	0.81 ± 0.2	1.01 ± 0.28

Bold Bolded result indicates positively identified compound
Shaded Shaded result indicates result greater than or equal to the investigation level
mg/kg milligrams per kilogram
pCi/g picocuries per gram
NA An investigation level is not identified because in BG-2 selenium sample results were all non-detect
[1] Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< Result not detected above associated laboratory reporting limit
D Sample dilution required for analysis; reported values reflect the dilution.
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Table 4-4b
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area B
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Location Identification		S1011-SCX-033	S1011-SCX-033	S1011-SCX-033	S1011-SCX-033 Dup	S1011-SCX-034	S1011-SCX-034	S1011-SCX-034	S1011-SCX-035	S1011-SCX-035	S1011-SCX-035	S1011-SCX-036	S1011-SCX-036	S1011-SCX-036 Dup
Date Collected		6/11/2017	6/11/2017	6/11/2017	6/11/2017	6/12/2017	6/12/2017	6/12/2017	6/12/2017	6/12/2017	6/12/2017	6/12/2017	6/12/2017	6/12/2017
Depth (feet)		0 - 0.5	0.5 - 5.0	5.0 - 9.0	0 - 0.5	0 - 0.5	0.5 - 5.0	5.0 - 10.0	0 - 0.5	0.5 - 5.0	5.0 - 8.0	0 - 0.5	0.5 - 3.0	0 - 0.5
Sample Category		surface	subsurface	subsurface	surface	surface	subsurface	subsurface	surface	subsurface	subsurface	surface	subsurface	surface
Sample Collection Method		grab	composite	composite	grab	grab	composite	composite	grab	composite	composite	grab	composite	grab
Media		sediment	sediment	sediment	sediment	soil	soil	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)	Investigation Level													
Metals[1] (mg/kg)														
Arsenic	2.34	2.1	2.2	1.5	2.2	2.8	1.7	1.5	3	2	1.9	2.8	2	2.9
Molybdenum	0.346	0.21	<0.2	0.31	0.25	<0.2	<0.2	0.3	0.22	<0.21	<0.2	0.22	<0.21	0.24
Selenium	NA	<1	<1	<1	<1	<1	<0.98	<0.99	<1	<1	<1	<1	<1	<1
Uranium	3.34	1.2	1.8	8.4	1.4	0.68	0.38	0.35	0.99 J	0.41	0.73	2.7	2	2.9
Vanadium	11.2	17	18	49	18	19	8.8	7.2	21	11	12	20	16	20
Radionuclides (pCi/g)														
Radium-226	2.96	1.75 ± 0.35	1.59 ± 0.35	3.31 ± 0.51	1.54 ± 0.29	1.26 ± 0.29	0.66 ± 0.18	0.65 ± 0.19	1.51 ± 0.3	0.94 ± 0.26	1.33 ± 0.3	3.79 ± 0.59	2.11 ± 0.42	3.74 ± 0.6

Bold Bolded result indicates positively identified compound
Shaded Shaded result indicates result greater than or equal to the investigation level
mg/kg milligrams per kilogram
pCi/g picocuries per gram
NA An investigation level is not identified because in BG-2 selenium sample results were all non-detect
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< Result not detected above associated laboratory reporting limit
D Sample dilution required for analysis; reported values reflect the dilution.
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Location Identification		S1011-SCX-037	S1011-SCX-037	S1011-SCX-038	S1011-SCX-038	S1011-SCX-038	S1011-SCX-039	S1011-SCX-040	S1011-SCX-044	S1011-SCX-044
Date Collected		6/12/2017	6/12/2017	6/12/2017	6/12/2017	6/12/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017
Depth (feet)		0 - 0.5	0.5 - 3.0	0 - 0.5	0.5 - 3.0	3.0 - 10.0	0 - 0.2	0 - 0.2	0 - 0.2	0.2 - 0.7
Sample Category		surface	subsurface	surface	subsurface	subsurface	surface	surface	surface	subsurface
Sample Collection Method		grab	composite	grab	composite	composite	grab	grab	grab	grab
Media		soil	soil	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)	Investigation Level									
Metals[1] (mg/kg)										
Arsenic	2.34	2.6	2.1	3.3	1.8	1.8	2.4	2.1	2.1	2.1
Molybdenum	0.346	<0.2	<0.19	11	0.28	<0.2	0.25	<0.19	0.22	0.22
Selenium	NA	<1	<0.97	<0.99	<1	<1	<1	<0.97	<1	<1
Uranium	3.34	68	2.3	8.7	1.6	1.1	5.2	2.3	6.5	7.1
Vanadium	11.2	15	13	12	9.3	10	12	12	12	11
Radionuclides (pCi/g)										
Radium-226	2.96	7.8 ± 1	1.28 ± 0.3	8.2 ± 1.1	0.73 ± 0.2	0.68 ± 0.19	6.9 ± 0.94	2.91 ± 0.47	7.8 ± 1	7.01 ± 0.94

Bold — Bolded result indicates positively identified compound
Shaded — Shaded result indicates result greater than or equal to the investigation level
mg/kg — milligrams per kilogram
pCi/g — picocuries per gram
NA — An investigation level is not identified because in BG-2 selenium sample results were all non-detect
[1] — Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< — Result not detected above associated laboratory reporting limit
D — Sample dilution required for analysis; reported values reflect the dilution.
J — Data are estimated due to associated quality control data
J- — Data are estimated and are potentially biased low due to associated quality control data
J+ — Data are estimated and are potentially biased high due to associated quality control data

Table 4-4c
Site Characterization Soil Sample Analytical Results for Survey Area C
Section 26
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

	Location Identification	S1011-CX-006	S1011-SCX-006	S1011-SCX-006
	Date Collected	5/13/2017	5/12/2017	5/12/2017
	Depth (feet)	0 - 0.5	0 - 0.5	0.5 - 1.25
	Sample Category	surface	surface	subsurface
	Sample Collection Method	grab	grab	grab
	Media	soil	soil	soil
Analyte (Units)				
Metals[1] (mg/kg)	Investigation Level			
Arsenic	4.99	1.3	1.3	1.2
Molybdenum	0.367	<0.19	<0.2	<0.21
Selenium	NA	<0.95	<1	<1
Uranium	1.91	7.1	24	16
Vanadium	17.4	43	12	17
Radionuclides (pCi/g)				
Radium-226	1.49	5.64 ± 0.78	24.3 ± 3	23.8 ± 2.9

Bold Bolded result indicates positively identified compound
Shaded Shaded result indicates result greater than or equal to the investigation level
mg/kg milligrams per kilogram
pCi/g picocuries per gram
NA An investigation level is not identified because in BG-3 selenium sample results were all non-detect
[1] Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< Result not detected above associated laboratory reporting limit
J- Data are estimated and are potentially biased low due to associated quality control data

Table 4-4d
Site Characterization Soil Sample Analytical Results for Survey Area D
Section 26
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification		S1011-SCX-041	S1011-SCX-041	S1011-SCX-042	S1011-SCX-042	S1011-SCX-043	S1011-SCX-043 Dup
Date Collected		9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017	9/19/2017
Depth (feet)		0 - 0.2	0.2 - 2.5	0 - 0.2	0.2 - 2.0	0 - 0.2	0 - 0.2
Sample Category		surface	subsurface	surface	subsurface	surface	surface
Sample Collection Method		grab	grab	grab	composite	grab	grab
Media		soil	soil	soil	soil	soil	soil
Analyte (Units)							
Metals[1] (mg/kg)	Investigation Level						
Arsenic	1.76	1.3	1.5	1.4	1.4	1.1	1.3
Molybdenum	0.210	<0.2	<0.2	<0.2	<0.2	<0.2	<0.19
Selenium	NA	<0.99	<0.98	<0.98	<0.99	<1	<0.97
Uranium	0.554	1.3	0.79	0.57	0.38	2	0.71
Vanadium	11.0	8.4	10	15	11 J+	20	13
Radionuclides (pCi/g)							
Radium-226	1.49	0.72 ± 0.22	1.66 ± 0.33	1.11 ± 0.28	0.56 ± 0.19	1.77 ± 0.32	1.99 ± 0.34

Bold — Bolded result indicates positively identified compound
Shaded — Shaded result indicates result greater than or equal to the investigation level
mg/kg — milligrams per kilogram
pCi/g — picocuries per gram
NA — An investigation level is not identified because in BG-4 selenium sample results were all non-detect
[1] — Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< — Result not detected above associated laboratory reporting limit
J+ — Data are estimated and are potentially biased high due to associated quality control data

Table 4-4e
Site Characterization Sediment Sample Analytical Results for Survey Area E
Section 26
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

	Location Identification	S1011-CX-008	S1011-CX-009	S1011-SCX-001	S1011-SCX-001	S1011-SCX-002	S1011-SCX-002	S1011-SCX-003	S1011-SCX-003	S1011-SCX-003	S1011-SCX-003 Dup	S1011-SCX-004
	Date Collected	5/13/2017	5/13/2017	5/12/2017	5/12/2017	5/12/2017	5/12/2017	5/12/2017	5/12/2017	5/12/2017	5/12/2017	5/12/2017
	Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.5	0 - 0.5	0.5 - 1.5	0 - 0.5	0.5 - 1.5	1.5 - 2.25	0 - 0.5	0 - 0.5
	Sample Category	surface	surface	surface	subsurface	surface	subsurface	surface	subsurface	subsurface	surface	surface
	Sample Collection Method	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
	Media	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment
Analyte (Units)												
Metals[1] (mg/kg)	Investigation Level											
Arsenic	1.73	0.84	1.3	1	1.2	0.94	0.85	0.81	0.87	0.94	0.97	0.56
Molybdenum	NA	<0.2	<0.23	<0.19	0.2	<0.19	<0.2	<0.2	<0.21	<0.21	<0.2	<0.19
Selenium	NA	<0.98	<1.1	<0.97	<1	<0.94	<1	<1	<1.1	<1	<1	<0.97
Uranium	0.691	0.58	0.68	1.1	1.3	0.48	0.4	0.72	0.7	2	1.5	0.81
Vanadium	10.7	9.9	52	85	13	8.3	9.3	8.7	13	21	28	4.1
Radionuclides (pCi/g)												
Radium-226	0.839	1.18 ± 0.25	0.72 ± 0.21	1.93 ± 0.35	2.48 ± 0.39	0.95 ± 0.23	0.54 ± 0.2	1.64 ± 0.28	2.23 ± 0.37	3.41 ± 0.5	1.55 ± 0.32	1.53 ± 0.31

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
Shaded	Shaded result indicates analyte detected, where that analyte does not have an investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
NA	An investigation level is not identified because in BG-5 selenium and molybdenum sample results were all non-detect
[1]	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit

Table 4-4e
Site Characterization Sediment Sample Analytical Results for Survey Area E
Section 26
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

	Location Identification	S1011-SCX-004	S1011-SCX-004	S1011-SCX-005	S1011-SCX-005	S1011-SCX-005
	Date Collected	5/12/2017	5/12/2017	5/12/2017	5/12/2017	5/12/2017
	Depth (feet)	0.5 - 1.5	1.5 - 2.0	0 - 0.5	0.5 - 1.5	1.5 - 2.0
	Sample Category	subsurface	subsurface	surface	subsurface	subsurface
	Sample Collection Method	grab	grab	grab	grab	grab
	Media	sediment	sediment	sediment	sediment	sediment
Analyte (Units)						
Metals[1] (mg/kg)	Investigation Level					
Arsenic	1.73	0.73	0.83	0.98	0.97	1
Molybdenum	NA	<0.2	<0.21	<0.19	<0.2	<0.2
Selenium	NA	<0.99	<1	<0.96	<0.98	<1
Uranium	0.691	2.9	15	1.9	1.7	1.9
Vanadium	10.7	5.8	35	6.8	6	9.2
Radionuclides (pCi/g)						
Radium-226	0.839	2.26 ± 0.39	3.51 ± 0.51	1.59 ± 0.31	1.9 ± 0.35	3.1 ± 0.46

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
Shaded	Shaded result indicates analyte detected, where that analyte does not have an investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
NA	An investigation level is not identified because in BG-5 selenium and molybdenum sample results were all non-detect
[1]	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit

Table 4-5
Summary of Investigation Level Exceedances in Soil at Borehole Locations
Section 26
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Sample Location	Survey Area	Investigation Level Exceedances
S1011-SCX-001[1]	E	Mo, U, V, Ra-226, Static Gamma
S1011-SCX-002	E	Ra-226, Static Gamma
S1011-SCX-003	E	U, V, Ra-226, Static Gamma
S1011-SCX-004	E	U, V, Ra-226, Static Gamma
S1011-SCX-005	E	U, Ra-226, Static Gamma
S1011-SCX-006	C	U, Ra-226, Static Gamma
S1011-SCX-007	B	As, Mo, U, V, Ra-226, Static Gamma
S1011-SCX-008	A	U, Ra-226, Static Gamma
S1011-SCX-009	B	V
S1011-SCX-010	B	U, V, Ra-226, Static Gamma
S1011-SCX-011	B	As, Mo, V
S1011-SCX-012	B	V, Static Gamma
S1011-SCX-014	B	U, V, Ra-226
S1011-SCX-015	B	As, Mo, U, V, Ra-226
S1011-SCX-016	B	As, Mo, U, V, Ra-226, Static Gamma
S1011-SCX-017[1]	A	Se, U, V, Ra-226, Static Gamma
S1011-SCX-018[1,2]	B	As, Se, U, V, Ra-226, Static Gamma
S1011-SCX-019	B	As, U, V, Ra-226, Static Gamma
S1011-SCX-020	B	As, U, V, Ra-226, Static Gamma
S1011-SCX-021	B	As, U, V, Ra-226, Static Gamma
S1011-SCX-022	B	Mo, U, V, Ra-226, Static Gamma
S1011-SCX-023	B	V, Static Gamma
S1011-SCX-024	B	As, Mo, U, V, Ra-226, Static Gamma
S1011-SCX-025	B	U, Ra-226, Static Gamma
S1011-SCX-026	B	As, V, Static Gamma
S1011-SCX-027[2]	B	Mo, V, Static Gamma
S1011-SCX-028	B	As, Mo, U, V, Ra-226, Static Gamma
S1011-SCX-029	B	V, Static Gamma
S1011-SCX-030	B	V, Static Gamma
S1011-SCX-031	B	Static Gamma
S1011-SCX-032	B	V, Static Gamma
S1011-SCX-033	B	U, V, Ra-226, Static Gamma
S1011-SCX-034	B	As, V, Static Gamma
S1011-SCX-035	B	As, V, Static Gamma
S1011-SCX-036	B	As, V, Ra-226, Static Gamma
S1011-SCX-037	B	As, U, V, Ra-226, Static Gamma
S1011-SCX-038	B	As, Mo, U, V, Ra-226, Static Gamma
S1011-SCX-039	B	As, U, V, Ra-226, Static Gamma
S1011-SCX-040	B	V, Static Gamma
S1011-SCX-041	D	U, Ra-226, Static Gamma
S1011-SCX-042	D	U, V
S1011-SCX-043	D	U, V, Ra-226, Static Gamma
S1011-SCX-044	B	U, V, Ra-226, Static Gamma

Notes
[1] Detections of Se and/or Mo included for reference, no IL was established for Se and/or Mo
[2] Includes a sample that crosses the soil to bedrock contact
IL - Investigation Level
As - Arsenic
Mo - Molybdenum
Ra-226 - Radium 226
Se - Selenium
U - Uranium
V - Vanadium

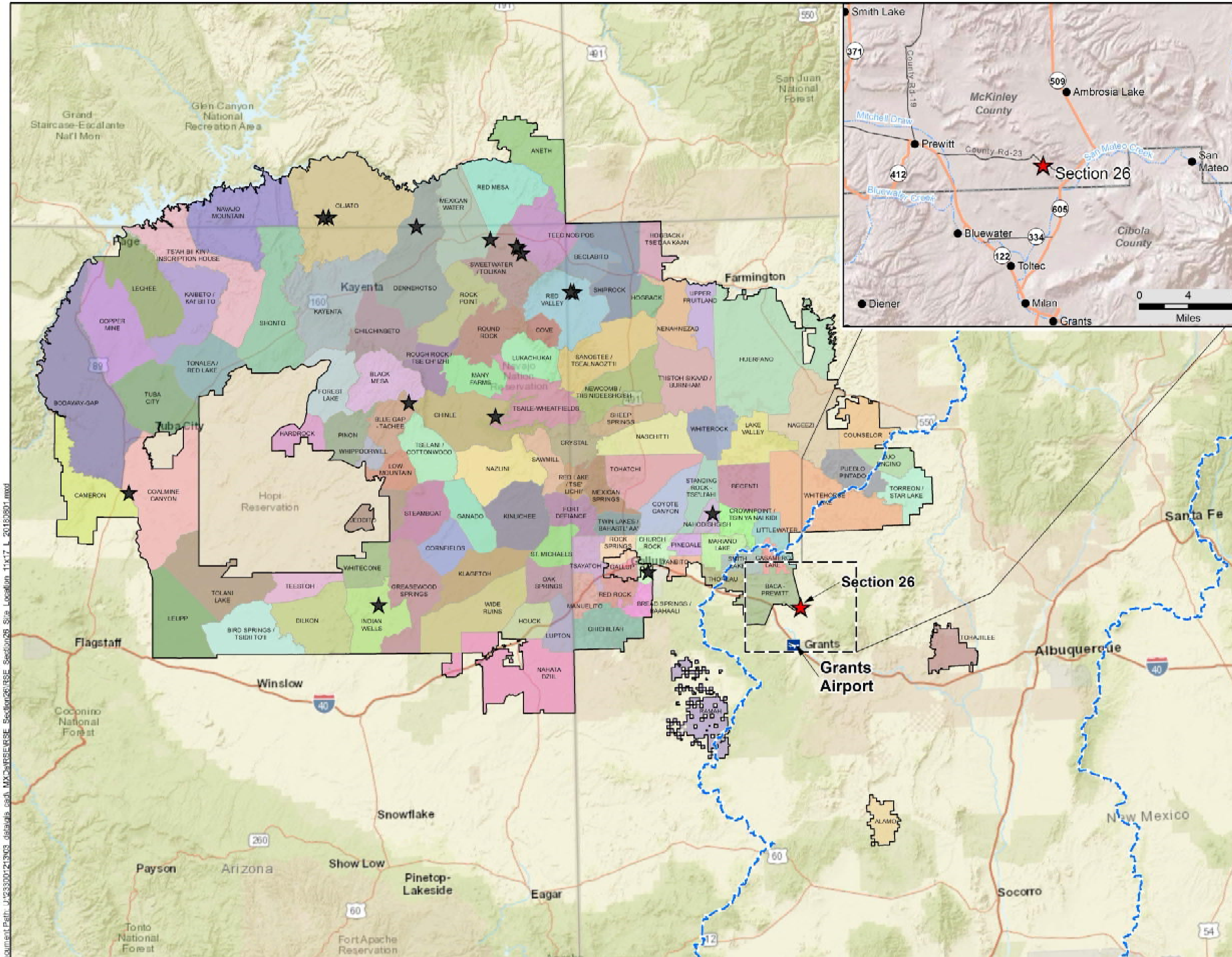
FIGURES

FIGURE ACRONYMS/ABBREVIATIONS

As	arsenic
BG	potential background reference area
bgs	below ground surface
cpm	counts per minute
ft	feet
IL	investigation level
mg/kg	milligrams per kilogram
Mo	molybdenum
NA	not applicable
NAD	North American Datum
NAVD88	North American Vertical Datum of 1988
pCi/g	picocuries per gram
Ra	radium-226
Ra-226	radium-226
Se	selenium
TENORM	Technologically Enhanced Naturally Occurring Radioactive Materials
uk	unknown
U	uranium
UTL	upper tolerance limit
UTM	Universal Transverse Mercator
V	vanadium

NOTE FOR FIGURES

Section 26 is located just within UTM Zone 13 North, but was projected and displayed in NAD 83 UTM Zone 12 North (meters) for data management and figure display purposes because the other 15 priority AUMs are located in UTM Zone 12 North



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Section 26 Mine Site
- Priority Abandoned Uranium Mine (AUM) Site
- Populated Place
- State Highway
- Major Road
- Intermittent Stream
- Rio Grande-Elephant Butte Watershed
- Navajo Nation Boundary
- Navajo Nation Chapter

Grants Airport, New Mexico Wind Rose (KGNT), 1996-2006

Windspeed (mph): >0 - 2; >2 - 4; >4 - 6; >6 - 8; >8

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap: ESRI World Street Map and World Shaded Relief accessed 08/2018.

Wind Rose: USEPA, 2007a

0 25 50
Miles

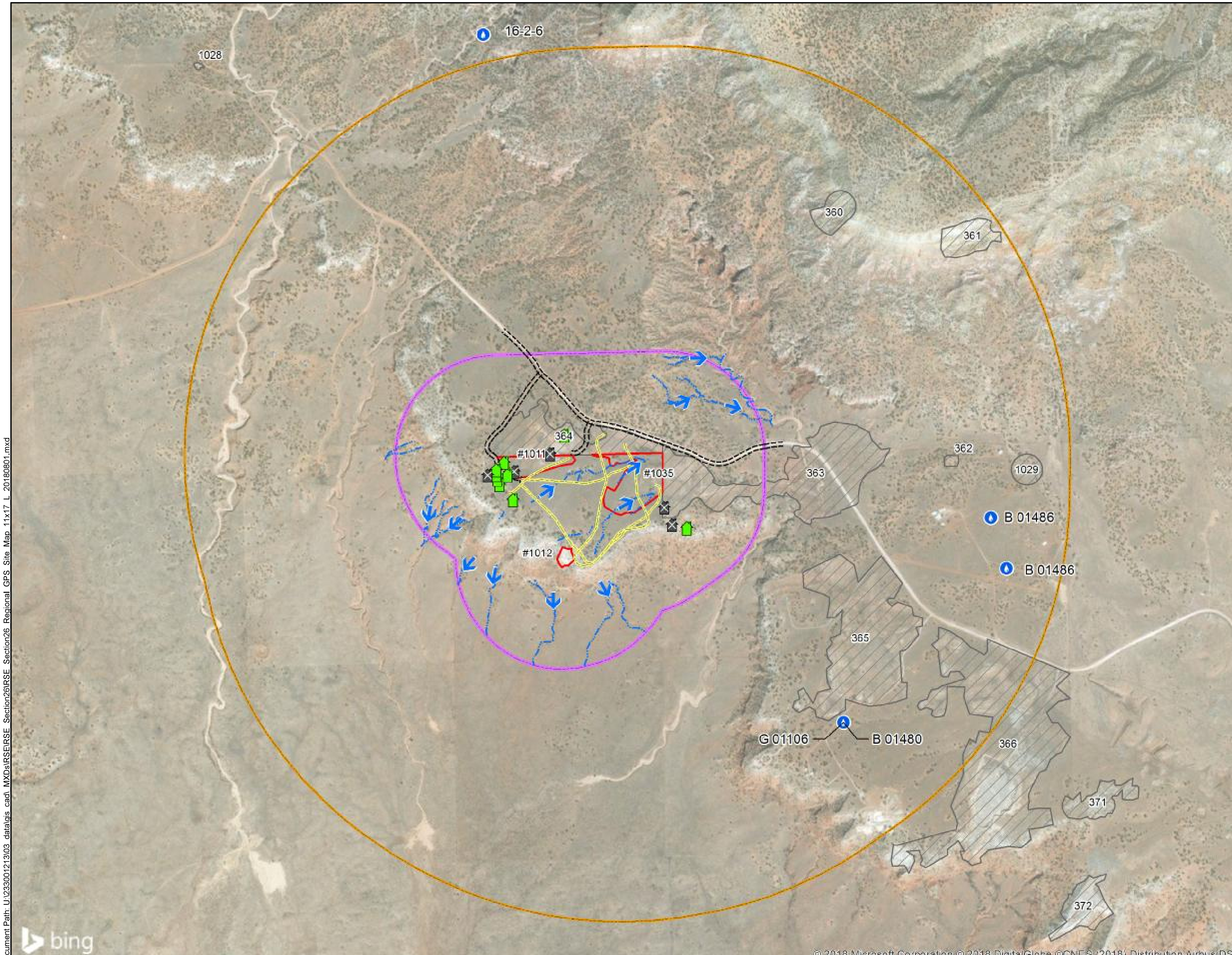
TITLE:

Site Location

PROJECT:

Removal Site Evaluation
Section 26 Mine Site

DATE: 8/2/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 1-1	



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Site Clearance Identified Water Feature[1]
- Habitable Building
- Uninhabitable Building
- Flow Direction
- Drainage
- Potential Haul Road
- Road
- Claim Boundary
- 1/4-Mile Claim Boundary Buffer
- 1-Mile Claim Boundary Buffer
- Other Claim Boundary

NOTES:

1. Water features and identification names identified in 2007 AUM Atlas.

2. Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N E S W

0 1,250 2,500
Feet

TITLE: Site Features

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 9/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 2-1

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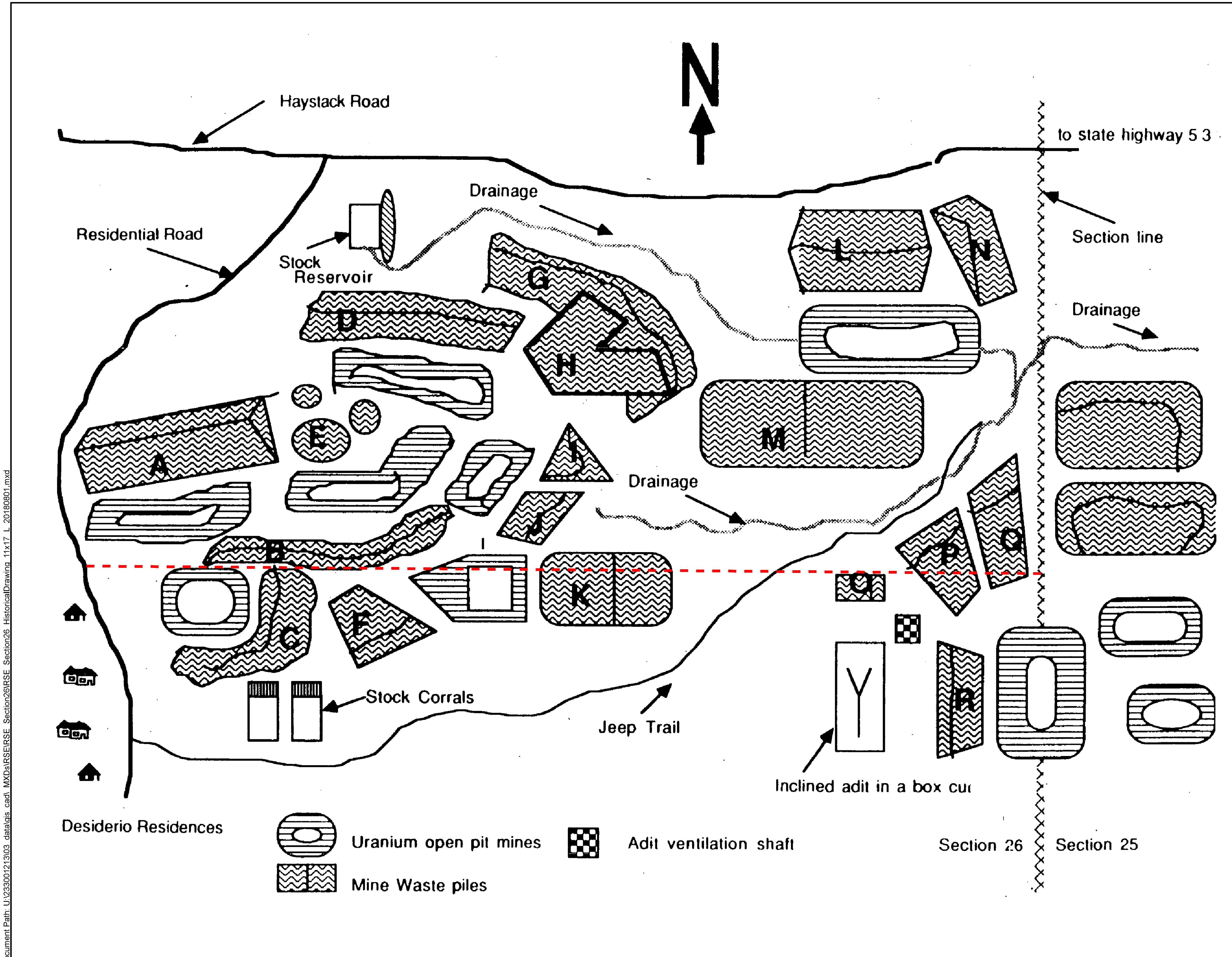

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Approximate Northern Boundaries of the Section 26 Mines #1011 and #1035

Mine Waste Pile	Volume (cubic yards)
A	21,600
B	600
C	1,575
D	8000
E	2,709
F	187
G	5,000
H	3,150
I	300
J	300
K	18,750
L	7,000
M	21,000
N	625
O	30
P	140
Q	120
R	875

REFERENCES:
Navajo Superfund Office (NSO), 1990. Preliminary Assessment Package for the Navajo-Desiderio Group Uranium Mines. Worksheet # 1 Estimation of Hazardous Waste

TITLE: Historical Mine Drawing

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 8/2/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: KJJ

Stantec

FIGURE: 2-2

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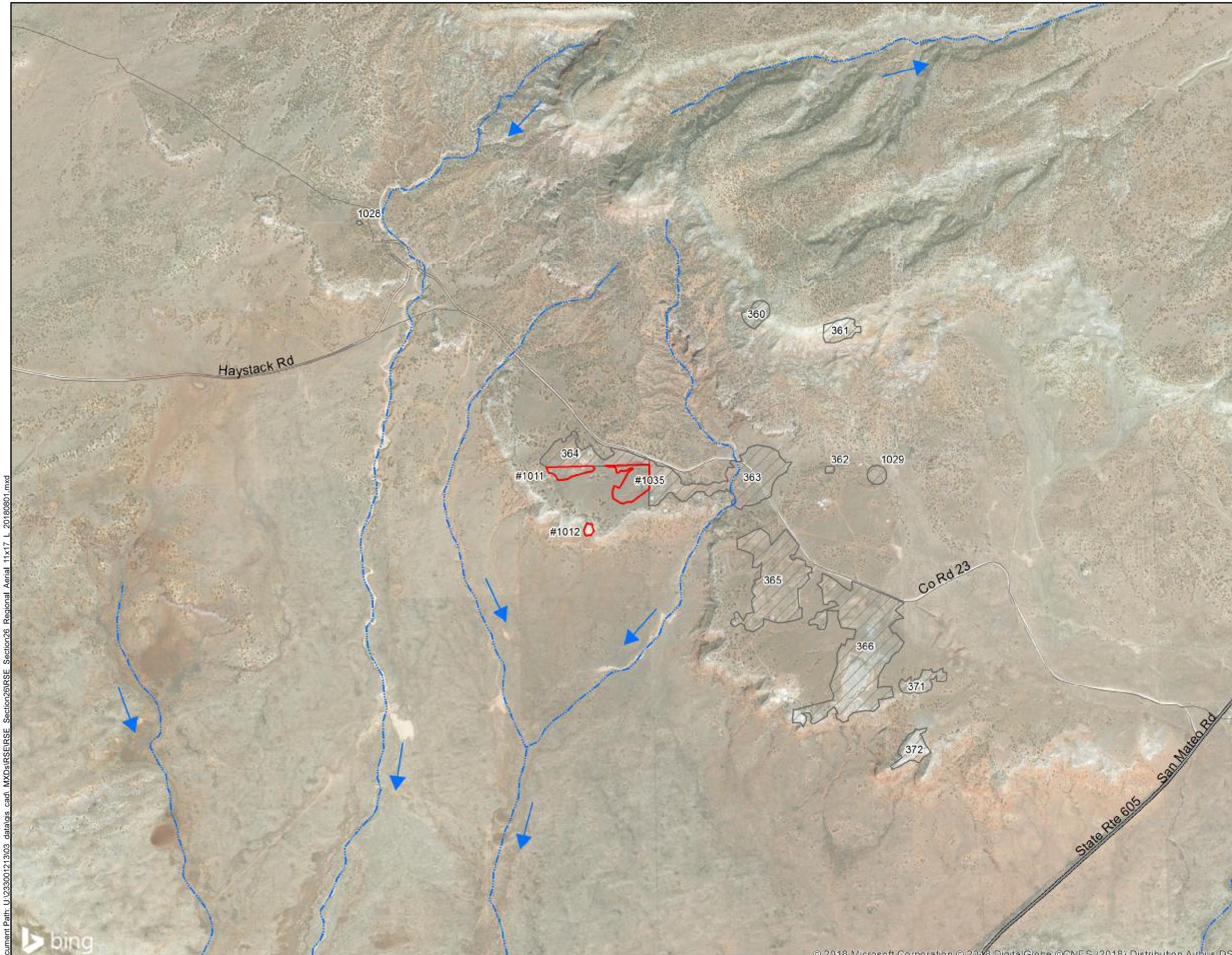

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Flow Direction
- Intermittent Stream/River
- State Highway
- County Road
- Local Road
- Claim Boundary
- Other Claim Boundary

NOTE:
Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

N W E S

0 2,000 4,000
Feet

TITLE:
Regional Aerial Photograph

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 8/1/2018

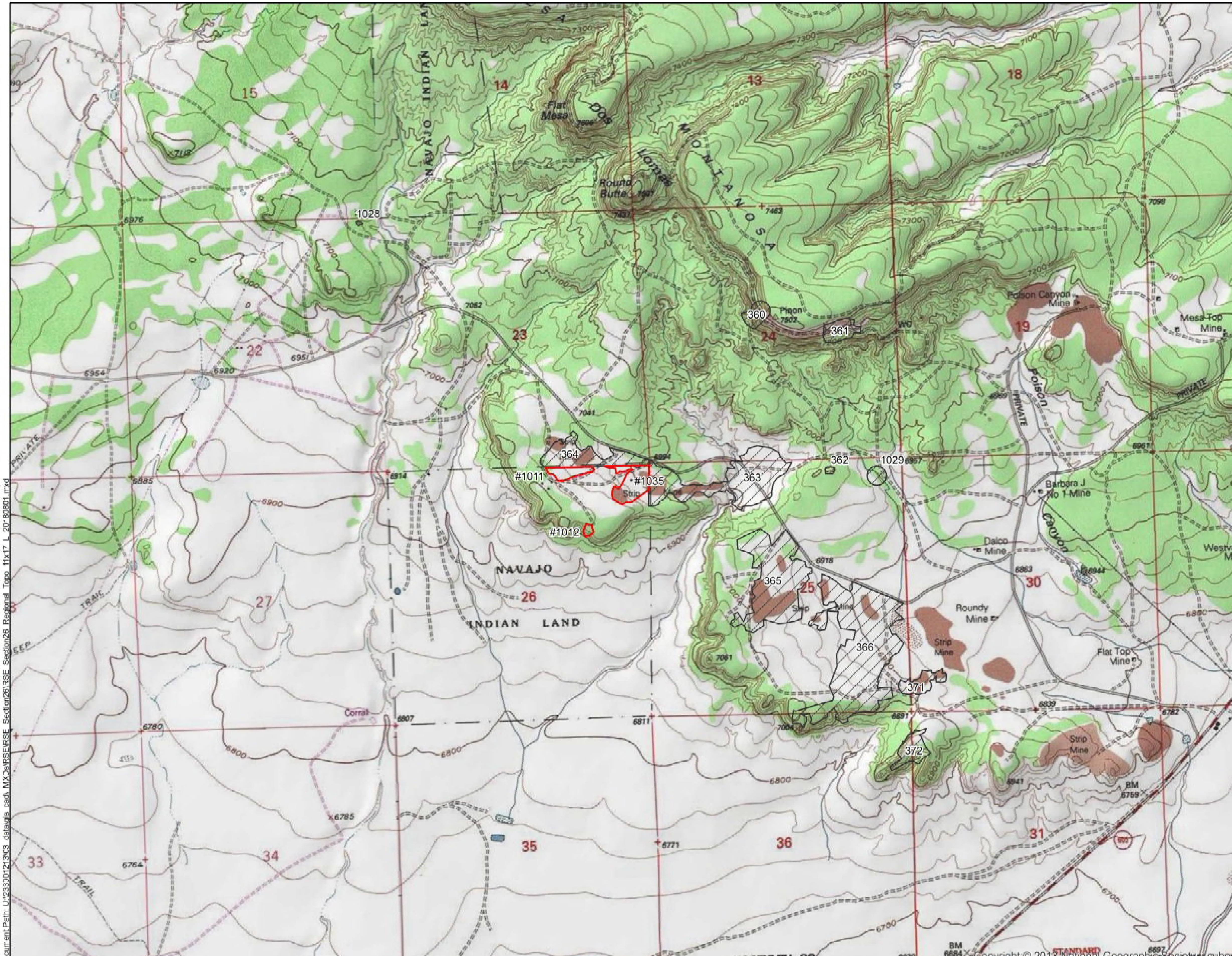
DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 2-3



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Claim Boundary
- Other Claim Boundary

NOTE:
Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap: ESRI USA Topo Maps service accessed 08/2018.

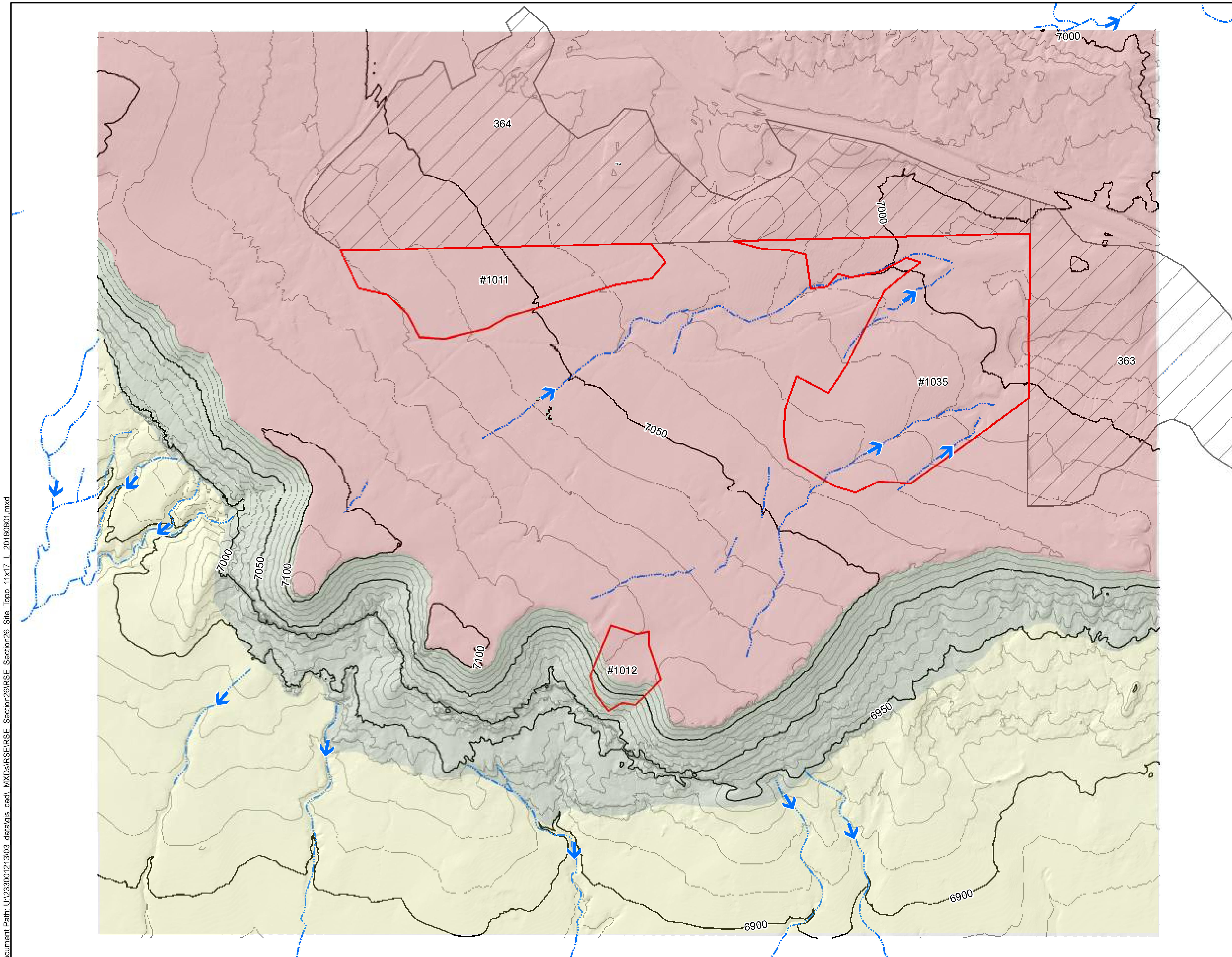
N
W E
S

0 2,000 4,000
Feet

TITLE: Regional Topographic Map

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE:	DOCUMENT NAME:	
8/1/2018	Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 2-4	



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Flow Direction
Drainage
Index Contour (50 ft Interval)
Intermediate Contour (10 ft Interval)
Claim Boundary
Other Claim Boundary

Geomorphology Features

Mesa Top
Mesa Sidewall
Plains

NOTES:

The extent of the basemap is based on the Cooper aerial surveys conducted on June 16, 2017.

Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:

Site-specific contours were generated as part of aerial surveys conducted on June 16, 2017.

Coordinate System: NAD 1983 UTM Zone 12N

N W E S

0 300 600
Feet

TITLE: Site Topography

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 8/1/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 2-5

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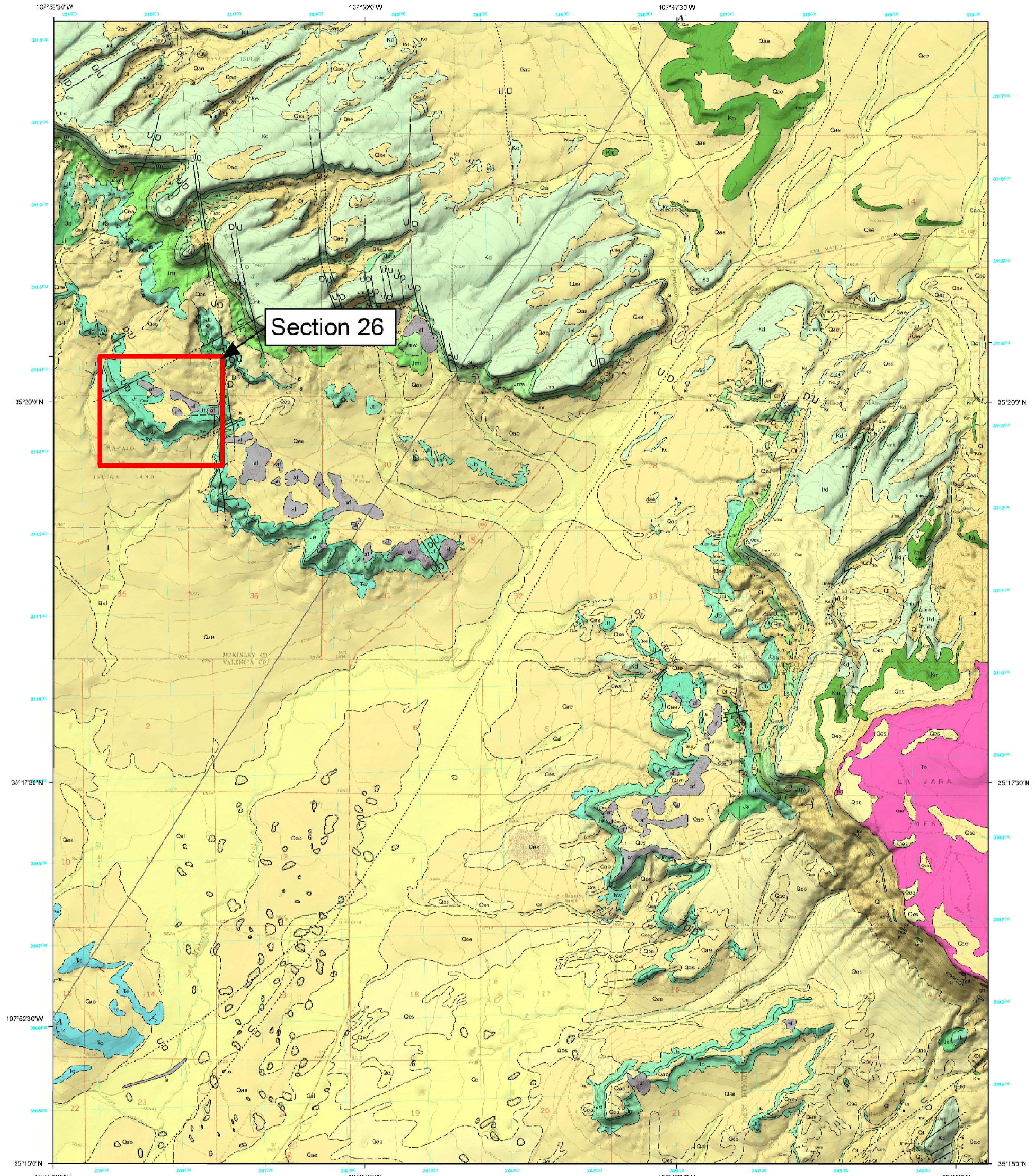


1:24,000

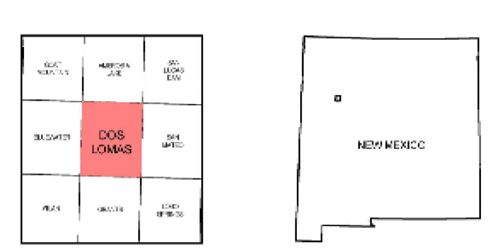
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0.5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

Magnetic Declination October 2010 9° 48' East At Map Center



QUADRANGLE LOCATION

New Mexico Bureau of Geology and Mineral Resources
Open-File Geologic Map 219

Mapping of this quadrangle was funded by a matching-funds grant from the STATEMAP program of the National Cooperative Geologic Mapping Act, administered by the U. S. Geological Survey, and by the New Mexico Bureau of Geology and Mineral Resources, (Dr. Peter Scholle, *Director and State Geologist*, Dr. J. Michael Timmons, *Geologic Mapping Program Manager*).

New Mexico Bureau of Geology and Mineral Resources
New Mexico Tech
801 Leroy Place
Socorro, New Mexico
87801-4796

[575] 835-5490

This and other STATEMAP quadrangles are available for free download in both PDF and ArcGIS formats at:

http://geoinfo.nmt.edu

Geologic map of the Dos Lomas quadrangle, Cibola and McKinley Counties, New Mexico.

June 2011

by
Steven Cather

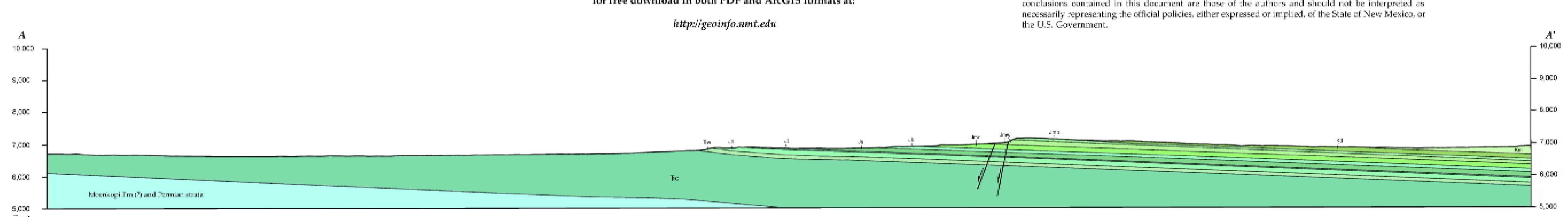
New Mexico Bureau of Geology and Mineral Resources, Socorro, NM, 87801

COMMENTS TO MAP USERS

A geologic map displays information on the distribution, nature, orientation, and age relationships of rock and deposits and the occurrence of structural features. Geologic and fault contacts are irregular surfaces that form boundaries between different types or ages of units. Data depicted on this geologic quadrangle map may be based on any of the following: reconnaissance field geologic mapping, compilation of published and unpublished work, and photogeologic interpretation. Locations of contacts are not surveyed, but are plotted by interpretation of the position of a given contact onto a topographic base map; therefore, the accuracy of contact locations depends on the scale of mapping and the interpretation of the geologist(s). Any enlargement of this map could cause misunderstanding in the detail of mapping and may result in erroneous interpretations. Site-specific conditions should be verified by detailed surface mapping or subsurface exploration. Topographic and cultural changes associated with recent development may not be shown.

Cross sections are constructed based upon the interpretations of the author made from geologic mapping, and available geophysical, and subsurface (drillhole) data. Cross-sections should be used as an aid to understanding the general geologic framework of the map area, and not be the sole source of information for use in locating or designing wells, buildings, roads, or other man-made structures.

The map has not been reviewed according to New Mexico Bureau of Geology and Mineral Resources standards. The contents of the report and map should not be considered final and complete until reviewed and published by the New Mexico Bureau of Geology and Mineral Resources. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the State of New Mexico, or the U.S. Government.



Map Unit Descriptions

QUATERNARY

Disturbed and/or artificial fill—Areas affected by human disturbances, mapped where deposits or extractions are areally extensive.

Alluvium (Holocene)—Sand, gravel, and mud in and adjacent to modern arroyo channels. Alluvium is typically at or near the grade of modern channels. 0–10 m thick. Numerous shallow (<2 m deep) pits are present in this unit and units **Qae**, **Qe**, and **Qes** near San Mateo Creek in the southwest part of the quadrangle. These pits (stippled areas on map) are largely the result of deflation, but some may be the result of soil collapse.

Eolian and alluvial deposits (Upper Pleistocene–Holocene)—Reddish-brown eolian sand and loessic silt locally reworked by alluvial processes. Deposits are stabilized by vegetation in most areas. Includes discontinuous eolian veneers on stable upland surfaces. 0–10 m thick.

Eolian sand (Upper Pleistocene-Holocene)—Sparsely-vegetated to unvegetated sand in active eolian dunes and sand sheets. 0–10 m thick

Semi-stabilized eolian sand (Upper Pleistocene–Holocene)—Eolian sand dunes and sand sheets stabilized by vegetation. 0–10 m thick

Talus and colluvium (Upper Pleistocene–Holocene)—Coarse mass-wasting deposits of sand to boulder size that mantle steep slopes adjacent to upland areas. 0–15 m thick.

Neogene

Basalt (Pliocene or Early Pleistocene?)—Flows of black to gray, medium-to fine-grained trachybasalt on La Jara Mesa. Flows contain sparse phenocrysts of olivine, plagioclase, and clinopyroxene. Erupted from vents on adjacent San Mateo quadrangle (McGraw et al., 2009). Unit is not dated. Maximum thickness is ~30 m. Corresponds to map units **Tyotb** and **Tymtb** of McGraw et al. (2009).

Rhyolite tuff of Grants Ridge (Pliocene)—White to pale pink, bedded pyroclastic fall, flow, and surge deposits on La Jara Mesa. Contains abundant clasts of obsidian, pumice, and lithics. Lithics consist of Precambrian granite and gneiss, chert, sandstone, and limestone. Unit is ~3.3 million years old. Maximum thickness is about 100 m.

UPPER CRETACEOUS

Mancos Shale, main body (Cenomanian–Turonian)—Medium to dark gray marine mudstone intercalated with thin-bedded sandstone. Only the lower ~80 m is exposed in quadrangle.

Dakota Sandstone (Cenomanian)—Yellowish-brown to light-gray shore-zone sandstone and gray mudstone. About 25 m thick.

JURASSIC

Morrison Formation (Kimmeridgian and Tithonian)

Brushy Basin Member—Grayish-green to bluish green fluvial mudstone and lenticular, light-gray sandstone 10–40 m thick.

Westwater Canyon Member—Light-yellowish to reddish-gray fluvial sandstone with subordinate greenish-gray mudstone. Includes units **Jmwl** and **Jmwu** of Thaden et al. (1967). 30–60 m thick.

Recapture Member—Variegated fluvial mudstone and interbedded sandstone. 40–75 m thick.

Bluff Sandstone (Oxfordian)—Light-gray, yellowish-gray and pale-orange crossbedded eolian sandstone. Includes units **Jb** and **Jsa** of Thaden et al. (1967). 30–100 m thick. Numerous sinkholes (small circular areas on map) are exposed in the Bluff Sandstone in the northwest part of the quadrangle. These are presumably the result of solution collapse in the underlying Todilto Formation.

Summerville Formation (Callovian and Oxfordian)—Variegated mudstone and tabular sandstone. 40–50 m thick.

Todilto Formation, Luciano Mesa Member (Callovian)—Olive-gray to pale-yellow, thin- to thick-bedded limestone deposited in a lacustrine or saline environment. About 10 m thick. Gypsum of the Tonque Arroyo Member is not present in the quadrangle.

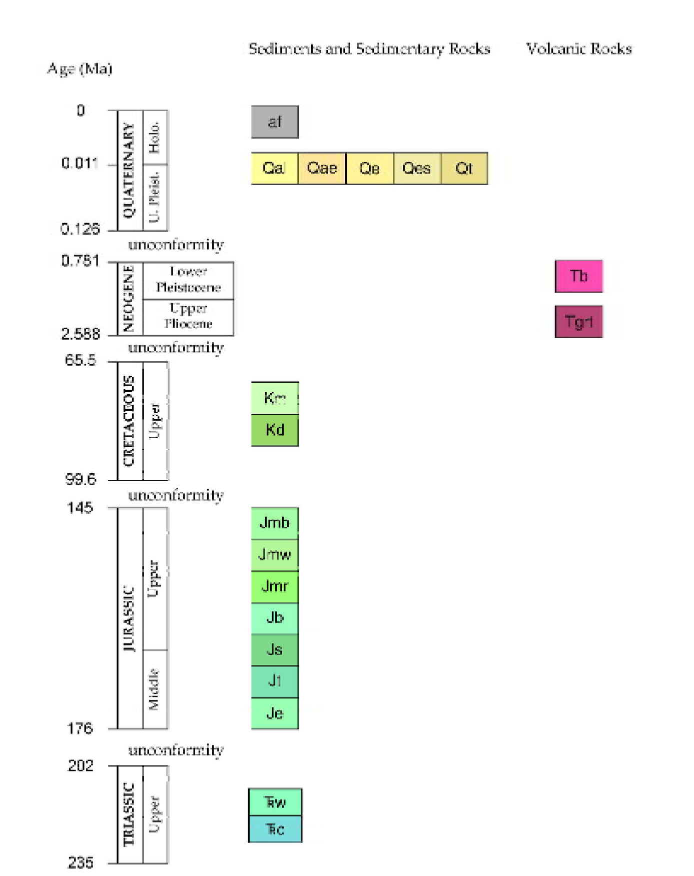
Entrada Sandstone (Callovian)—Light-brown, cross-bedded eolian sandstone and reddish brown, tabular-bedded siltstone. About 50 m thick. Includes units **Jem** and **Jeu** of Thaden et al. (1967).

TRIASSIC

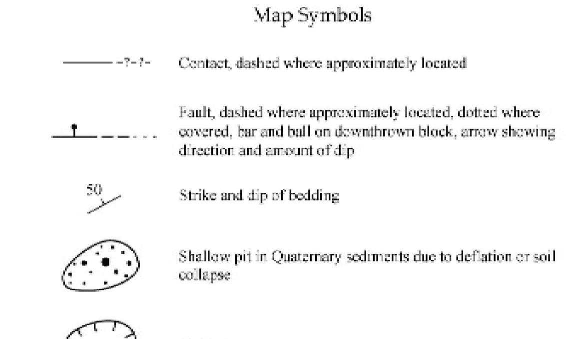
Wingate Sandstone (Rhaetian?)—Reddish-brown, cross-bedded eolian sandstone. About 30 m thick.

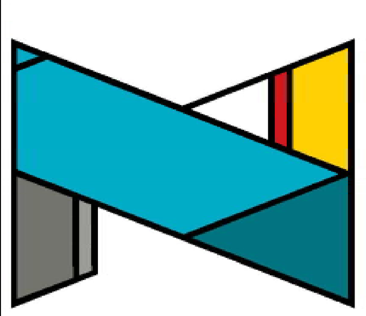
Chinle Group (Norian)—Dark red to bluish gray mudstone, lenticular sandstone, and thin-bedded limestone. About 400 m thick, although only the middle and uppermost parts are exposed on the quadrangle. Includes units **Trcs** and **Trcu** of Thaden et al. (1967).

Correlation Diagram

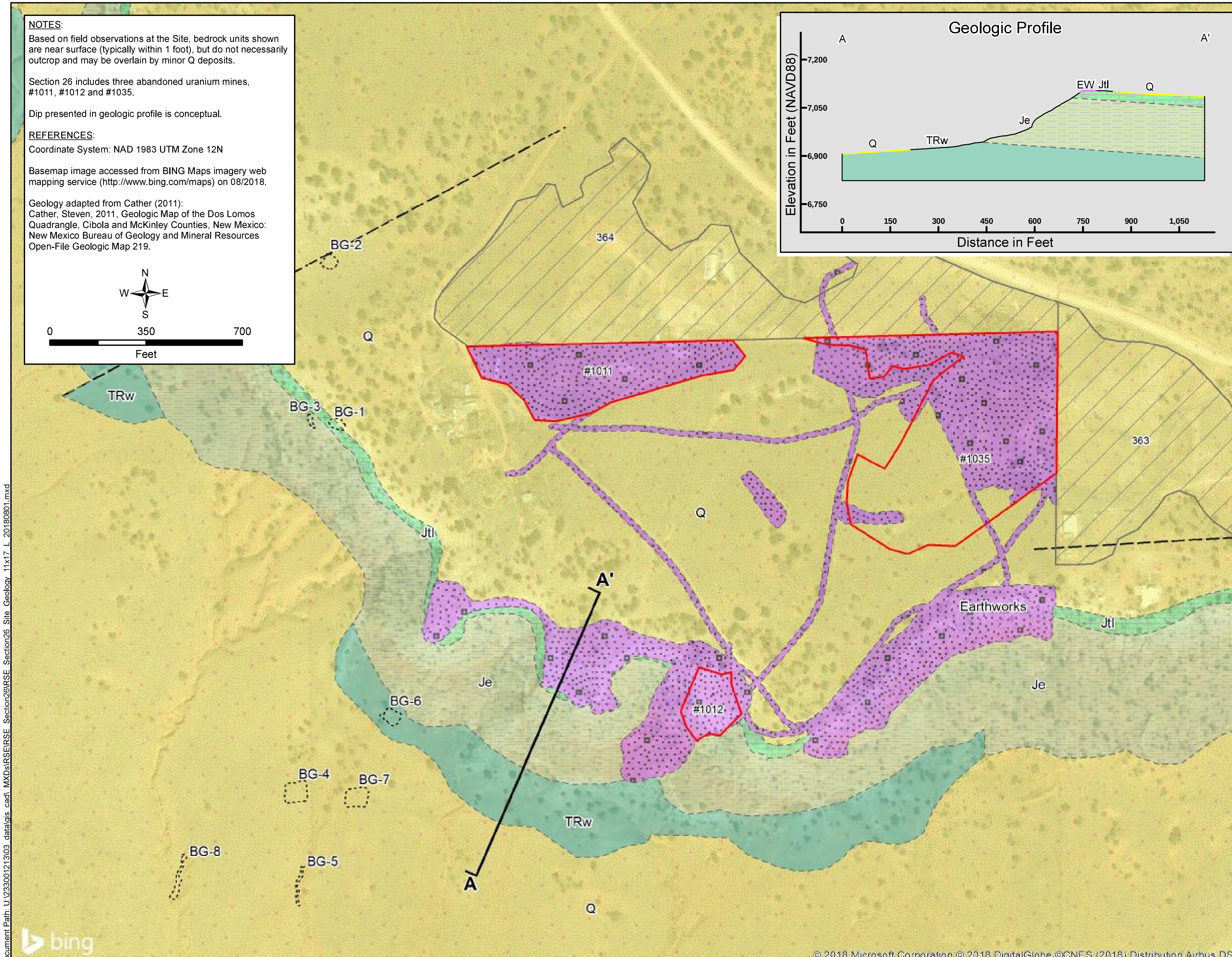


Map Symbols





TITLE:	Regional Geology
PROJECT:	Removal Site Evaluation Section 26 Mine Site
DATE: 8/1/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: EDZ / REVIEWER: CBB
	FIGURE: 2-6



NOTES:
Based on field observations at the Site, bedrock units shown are near surface (typically within 1 foot), but do not necessarily outcrop and may be overlain by minor Q deposits.

Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

Dip presented in geologic profile is conceptual.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

Geology adapted from Cather (2011):
Cather, Steven, 2011, Geologic Map of the Dos Lomos Quadrangle, Cibola and McKinley Counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-File Geologic Map 219.

N
W E
S
0 350 700
Feet

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Geologic Profile
Potential Background Reference Area
Claim Boundary
Other Claim Boundary
Geology Contact (Inferred)
Fault

Site Geology

HOLOCENE

Earthworks: Human-caused disturbance of the land surface potentially related to mining or reclamation.

Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly colluvial and alluvial deposits, and eolian sand deposits.

JURASSIC

Jtl: Luciano Mesa Member of the Todilto Formation (Upper Jurassic) – Olive-gray to pale-yellow, thin- to thick-bedded limestone deposited in a lacustrine or saline environment.

Je: Entrada Sandstone – (Upper and Middle Jurassic) – Reddish-orange to reddish-brown fine- to medium-grained eolian crossbedded sandstone and dark-reddish-brown clayey siltstone and very fine grained silty sandstone.

TRIASSIC

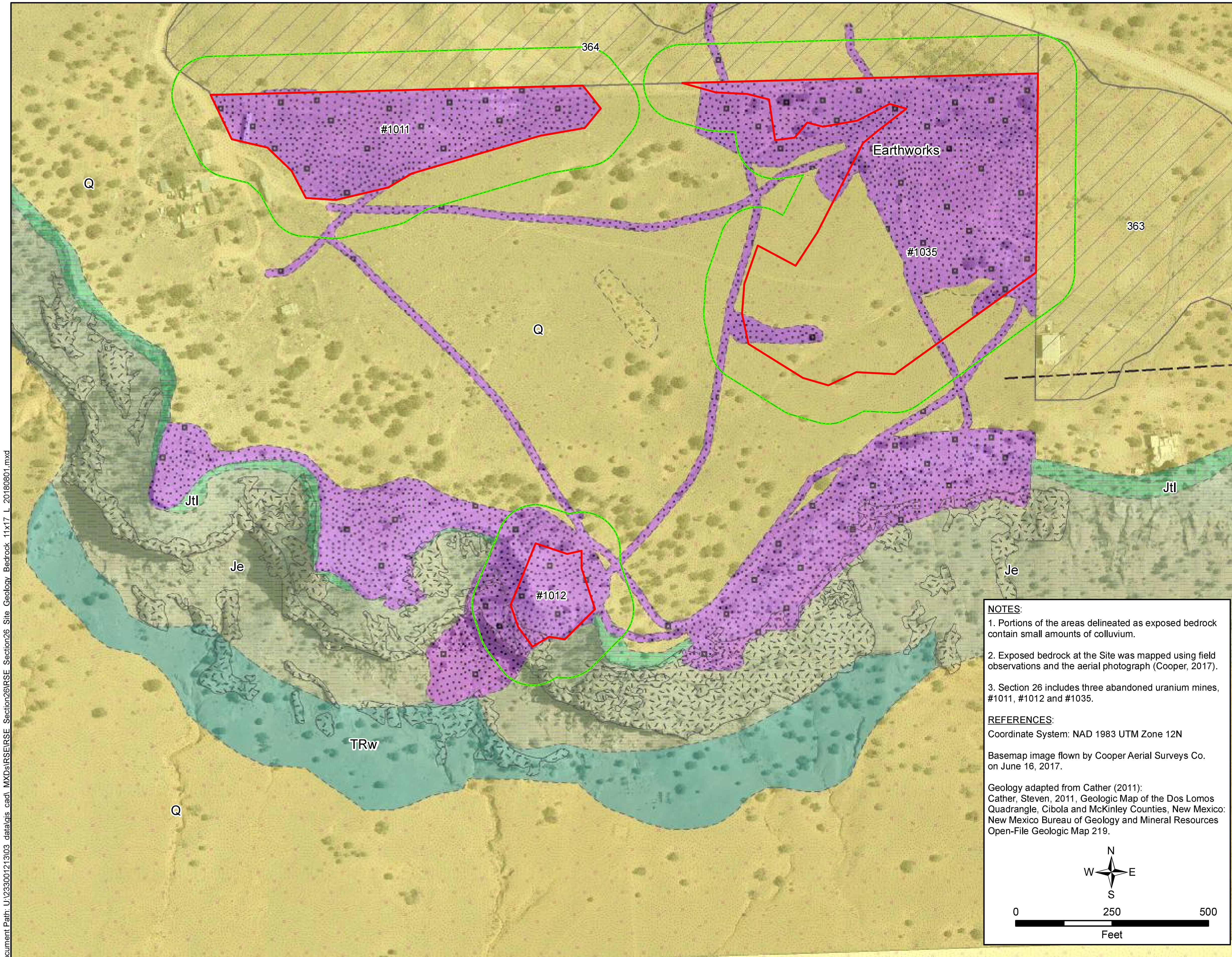
TRw: Wingate Sandstone (Upper Triassic) – Reddish-brown, fine- to medium-grained, cross-bedded eolian sandstone.

TITLE: Site Geology

PROJECT: Removal Site Evaluation
Section 26 Mine Site

DATE: 8/23/2018
DOCUMENT NAME: Removal Site Evaluation Report
AUTHOR: EDZ
REVIEWER: CBB
FIGURE: 2-7a

Stantec



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Claim Boundary
- 100-Foot Claim Buffer
- Other Claim Boundary
- Geology Contact (Inferred)
- Fault
- Exposed Bedrock[1]

Site Geology

HOLOCENE

Earthworks: Human-caused disturbance of the land surface potentially related to mining or reclamation.

Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly colluvial and alluvial deposits, and eolian sand deposits.

JURASSIC

Jtl: Luciano Mesa Member of the Todilto Formation (Upper Jurassic) – Olive-gray to pale-yellow, thin- to thick-bedded limestone deposited in a lacustrine or saline environment.

Je: Entrada Sandstone – (Upper and Middle Jurassic) – Reddish-orange to reddish-brown fine- to medium-grained eolian crossbedded sandstone and dark-reddish-brown clayey siltstone and very fine grained silty sandstone.

TRIASSIC

TRw: Wingate Sandstone (Upper Triassic) – Reddish-brown, fine- to medium-grained, cross-bedded eolian sandstone.

NOTES:

1. Portions of the areas delineated as exposed bedrock contain small amounts of colluvium.

2. Exposed bedrock at the Site was mapped using field observations and the aerial photograph (Cooper, 2017).

3. Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

Geology adapted from Cather (2011):
Cather, Steven, 2011, Geologic Map of the Dos Lomos Quadrangle, Cibola and McKinley Counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-File Geologic Map 219.

N W E S

0 250 500
Feet

TITLE: Site Exposed Bedrock

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 8/1/2018

DOCUMENT NAME: Removal Site Evaluation Report

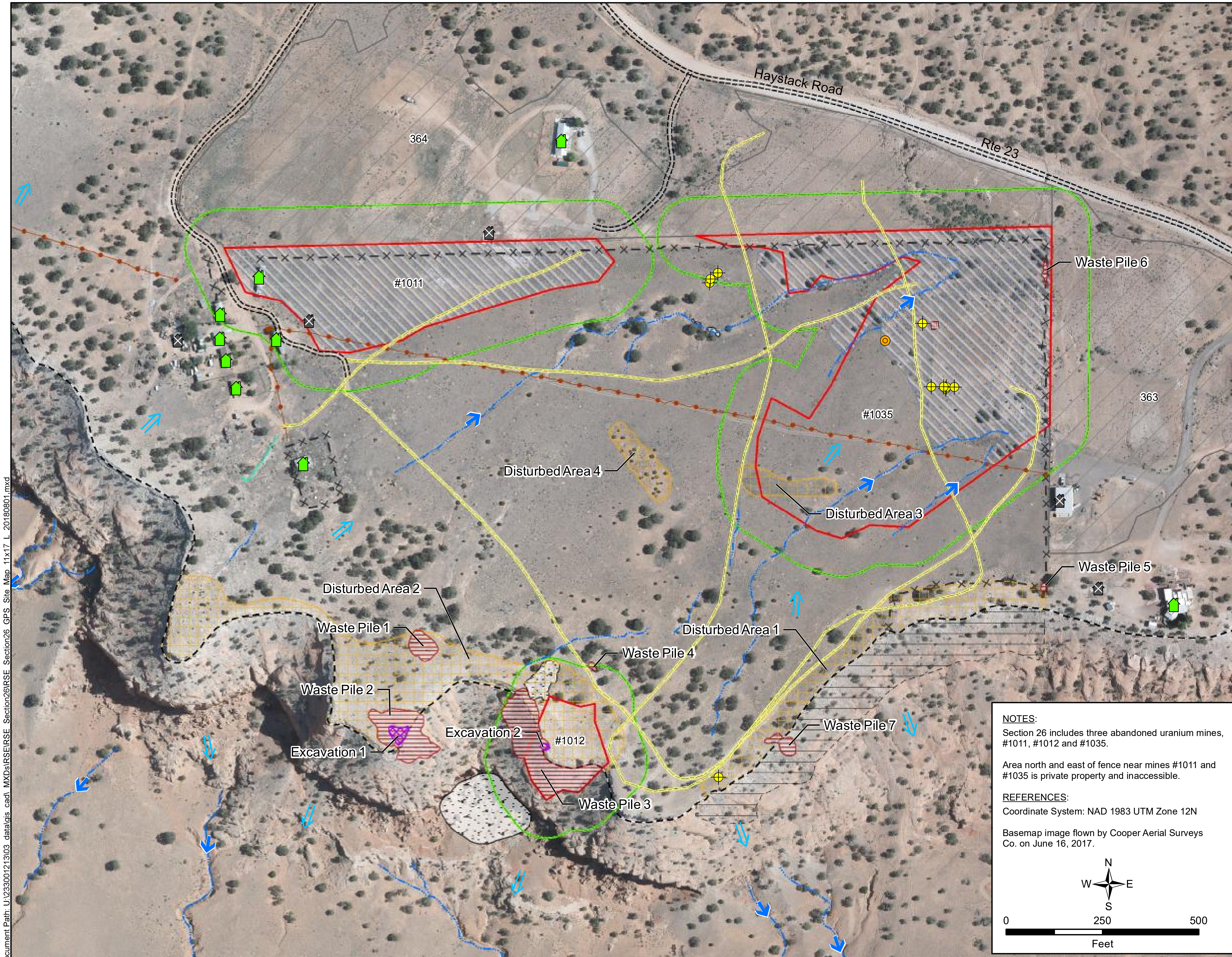
Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 2-7b

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Site_Geology_Bedrock_11x17_L_20180801.mxd



NOTES:

Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

Area north and east of fence near mines #1011 and #1035 is private property and inaccessible.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 250 500 Feet

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Habitable Building
- Uninhabitable Building
- Possible Portal or Storage Area
- Historical Borehole
- Flow Direction
- Approximate Overland Water Flow Direction
- Drainage
- Fence
- Potential Haul Road
- Power Line
- Road
- Water Line
- Approximate Edge of Mesa
- Debris
- Excavation
- Graded / Disturbed Reclaimed Area
- Potential Mining Disturbed Area
- Potential Waste Rock
- Waste Pile
- Vertical Mine Shafts
- Claim Boundary
- 100-Foot Claim Buffer
- Other Claim Boundary

TITLE: Site Map

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 8/2/2018

DOCUMENT NAME: Removal Site Evaluation Report

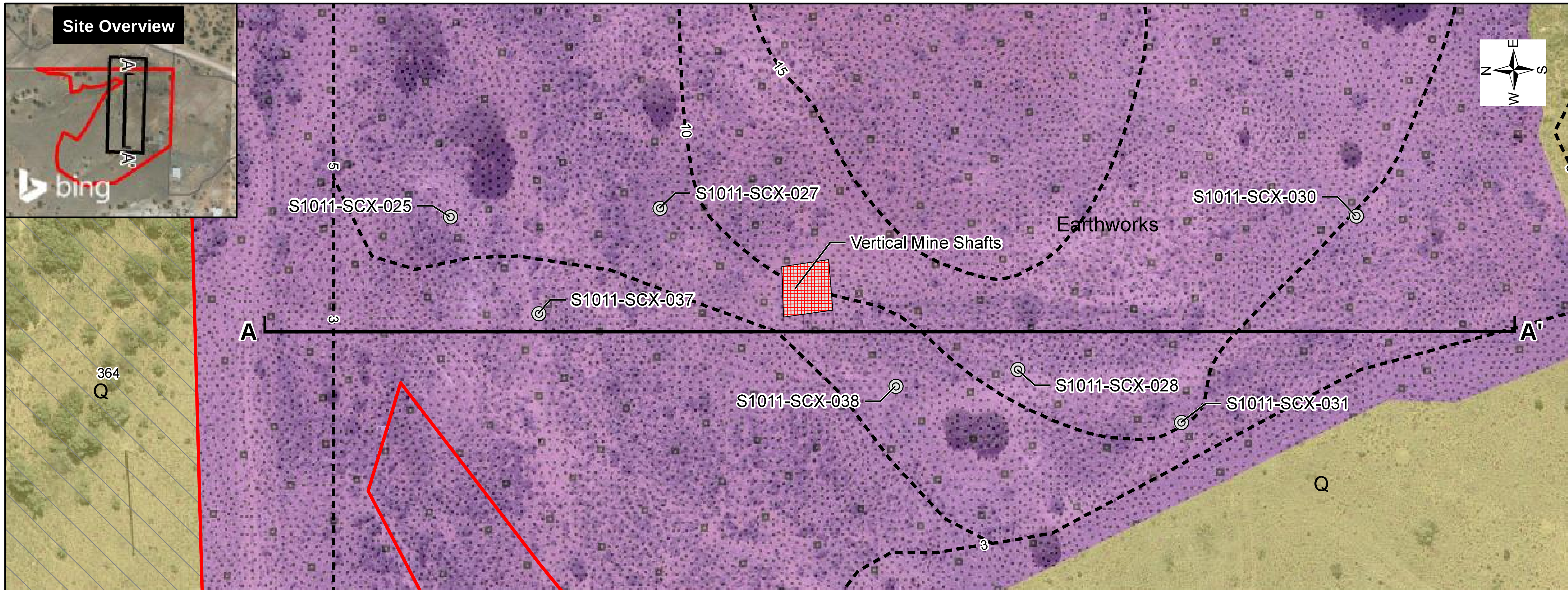
Stantec

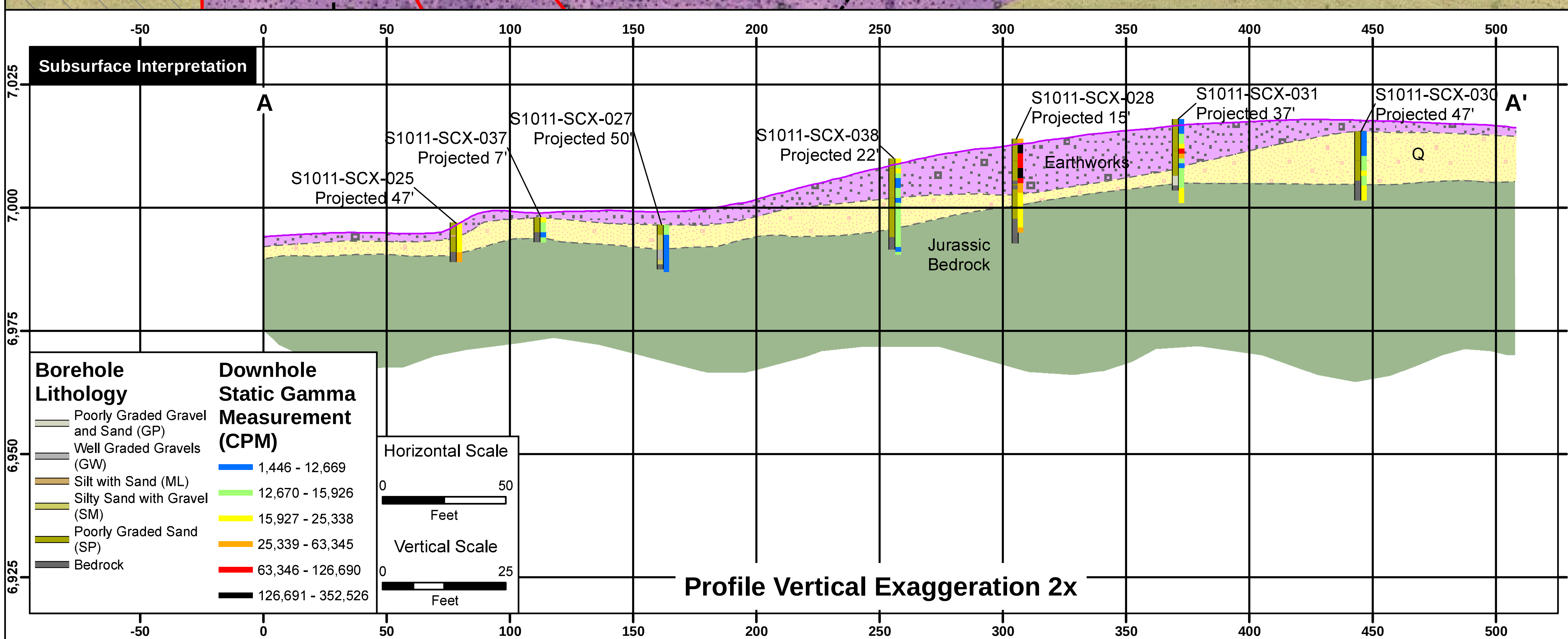
AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 2-8

Document Path: U:\123300121\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_GPS_Site_Map_11x17_L_20180801.mxd





NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Subsurface Borehole Location
- Cross Section
- Approximate Waste Pile Contour (thickness in feet)
- Vertical Mine Shafts
- Claim Boundary
- Other Claim Boundary
- Geologic Contact (Inferred)
- Earthworks: Human-caused disturbance of the land surface potentially related to mining or reclamation.
- Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly colluvial and alluvial deposits, and eolian sand deposits.
- J: Jurassic Bedrock - Luciano Mesa Member of the Todilto Formation (Upper Jurassic) – Olive –gray to pale -yellow, thin- to thick-bedded limestone and Entrada Sandstone – (Upper and Middle Jurassic) – Reddish-orange to reddish-brown fine - to medium –grained eolian cross bedded sandstone.

NOTES:

1. Projected distance indicates the distance the borehole was offset from the cross-section line in plan view (not depth) for boreholes that are not located on the cross-section line.

2. Surface and subsurface static gamma measurements were collected using a 2 x 2 inch NaI detector.

REFERENCES:

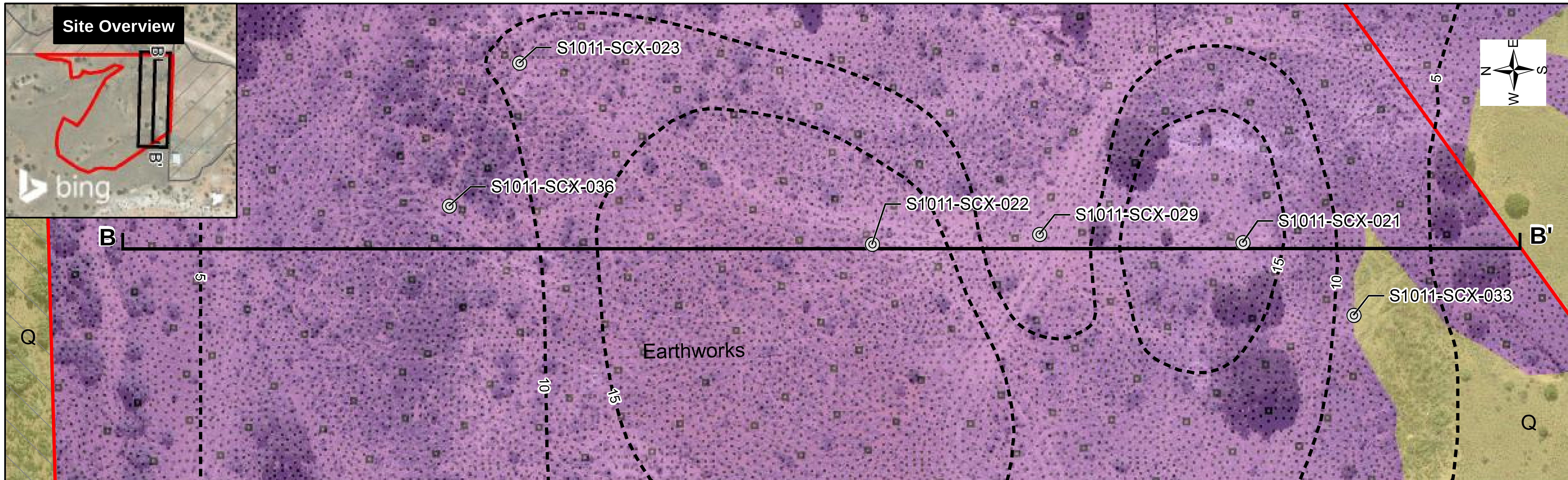
Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet

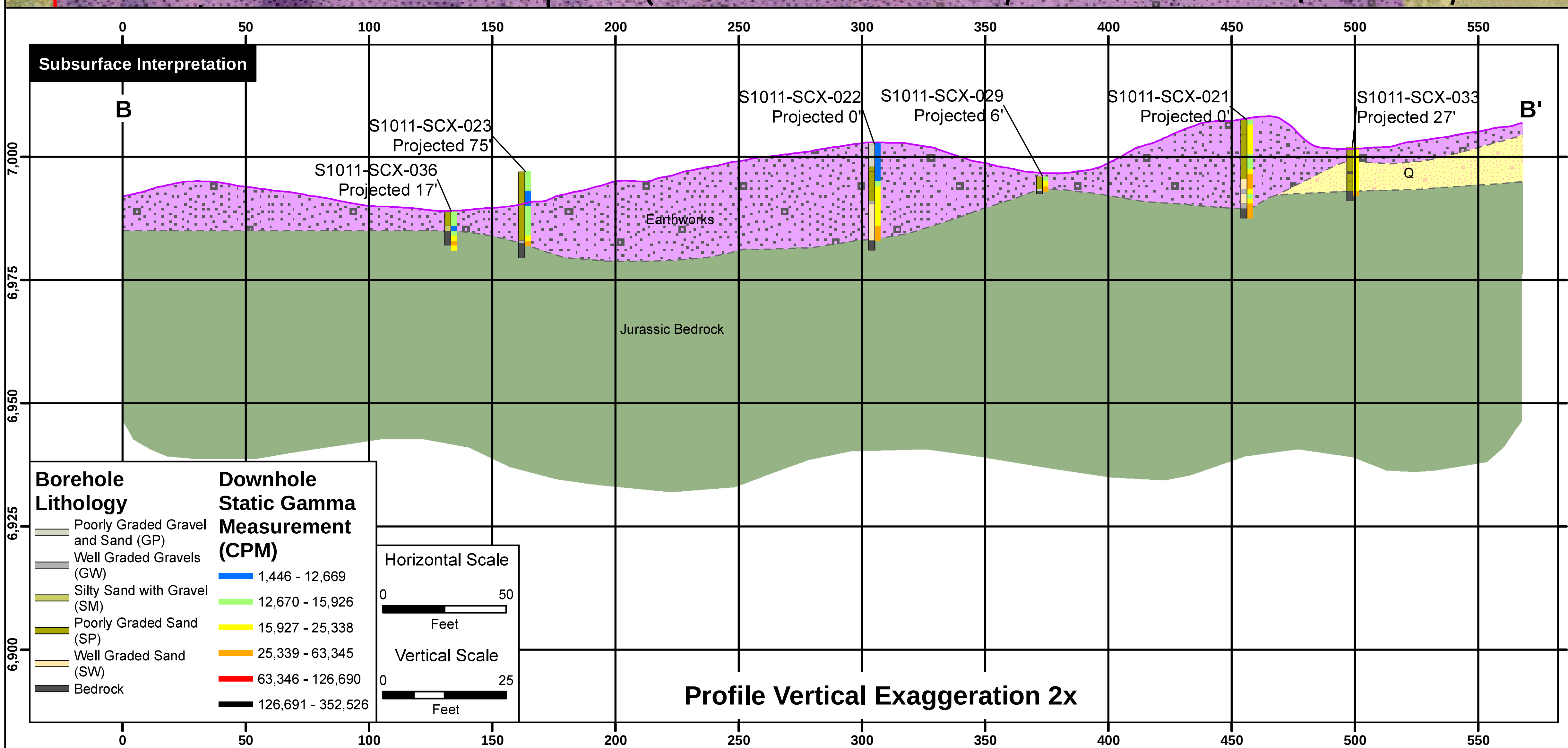
Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017

Geology adapted from Cather (2011): Cather, Steven, 2011, Geologic Map of the Dos Lomos Quadrangle, Cibola and McKinley Counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-File Geologic Map 219.

TITLE:	Cross Section A - A'
PROJECT:	Removal Site Evaluation Section 26 Mine Site
DATE: 8/1/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: EDZ; REVIEWER: CBB
	FIGURE: 2-9a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section_26_SectionA_Gamma_11x17_L_20180801.mxd





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NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Subsurface Borehole Location
- Cross Section
- Approximate Waste Pile Contour (thickness in feet)
- Claim Boundary
- Other Claim Boundary
- Geologic Contact (Inferred)
- Earthworks: Human-caused disturbance of the land surface potentially related to mining or reclamation.
- Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly colluvial and alluvial deposits, and eolian sand deposits.
- J: Jurassic Bedrock - Luciano Mesa Member of the Todilto Formation (Upper Jurassic) – Olive –gray to pale -yellow, thin- to thick-bedded limestone and Entrada Sandstone – (Upper and Middle Jurassic) – Reddish-orange to reddish-brown fine - to medium –grained eolian cross bedded sandstone.

NOTES:

1.Projected distance indicates the distance the borehole was offset from the cross-section line in plan view (not depth) for boreholes that are not located on the cross-section line.

2. Surface and subsurface static gamma measurements were collected using a 2 x 2 inch NaI detector.

REFERENCES:

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017

Geology adapted from Cather (2011): Cather, Steven, 2011, Geologic Map of the Dos Lomos Quadrangle, Cibola and McKinley Counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-File Geologic Map 219.

TITLE: Cross Section B - B'

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 8/1/2018

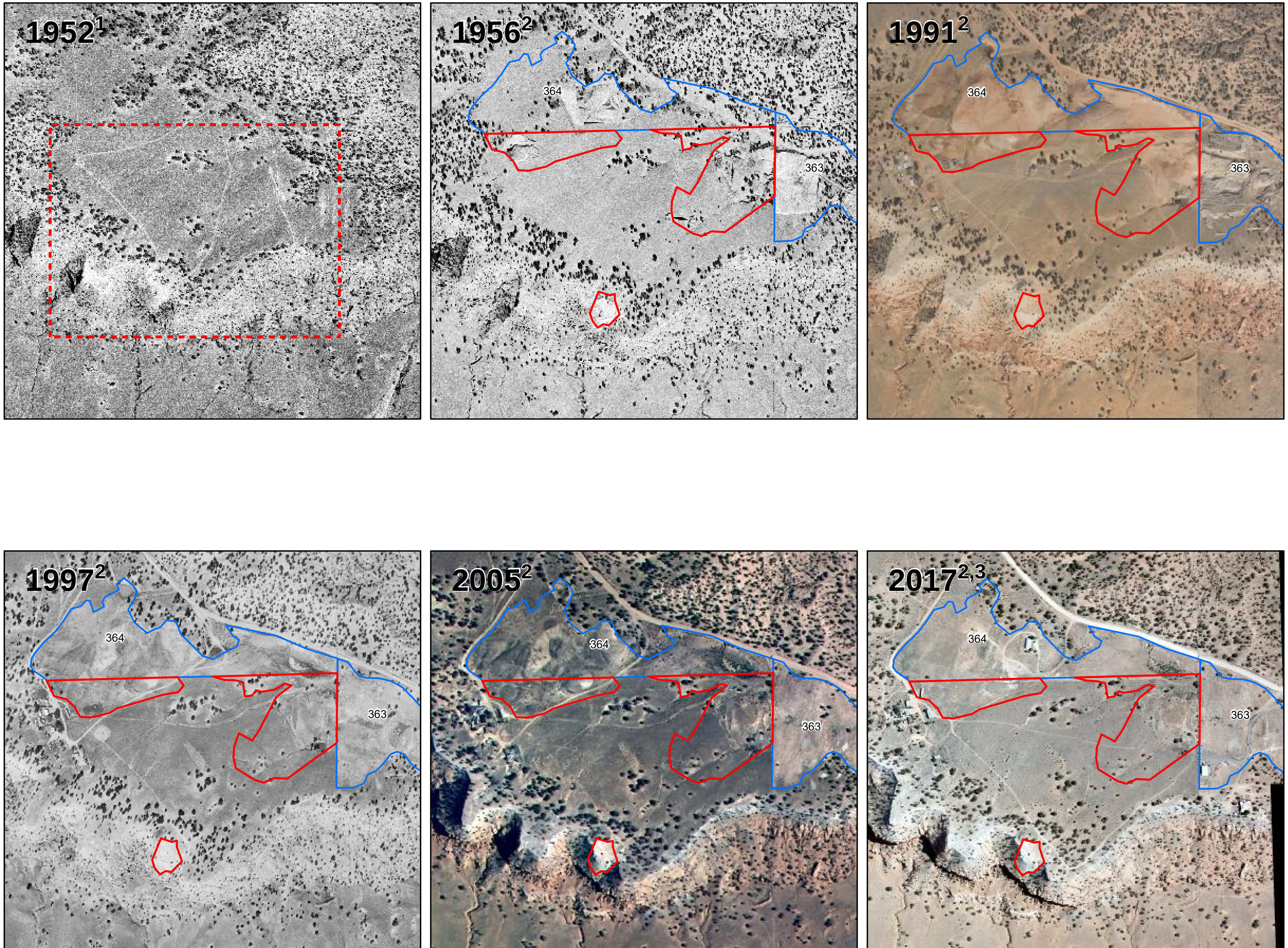
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 2-9b



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Section 26 Claim Boundary

Other Claim Boundary

Approximate Site Location, not georeferenced

NOTES:
1. Image is not georeferenced, scale not available.

2. Image is georeferenced. Scale bar applies to these image frames only.

3. Site-specific imagery flown by Cooper Aerail Surveys Co. on June 16, 2017.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Historical Aerial Imagery downloaded from https://earthexplorer.usgs.gov/ (01/2016)

N
W E
S

0 1,500 3,000
Feet

TITLE:
Historical Aerial Photograph Comparison

PROJECT:
Removal Site Evaluation Section 26 Mine Site

DATE: 8/1/2018

DOCUMENT NAME: Removal Site Evaluation Report

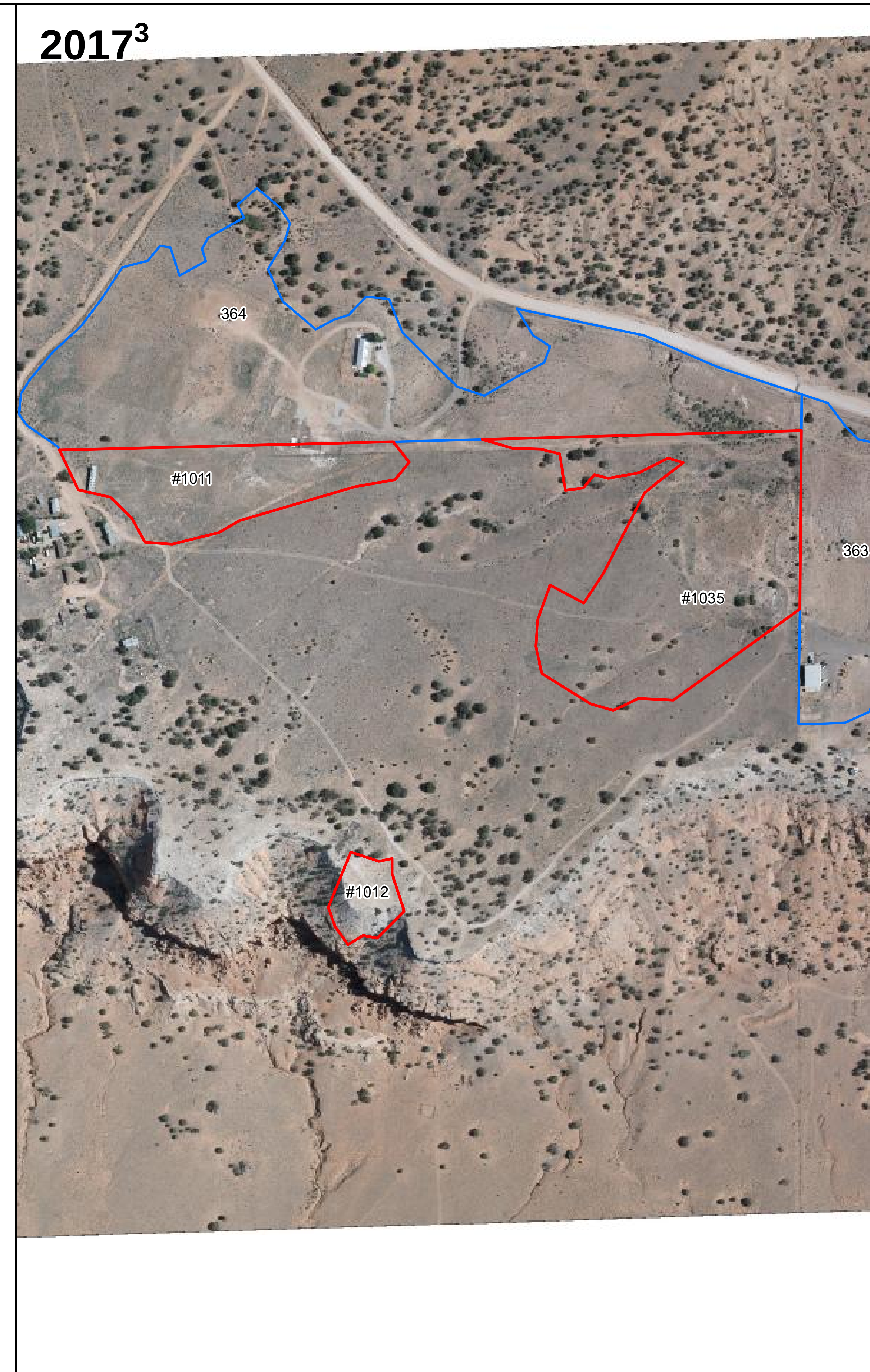
AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 3-1a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Historical_Aerial_Compilation_11x17_L_20180801.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Claim Boundary

Other Claim Boundary

NOTE:
Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:

1. Coordinate System: NAD 1983 UTM Zone 12N
2. 1956 aerial image downloaded from https://earthexplorer.usgs.gov/ (01/2016) and georeferenced using current image from BING (03/2016).
3. Site-specific imagery flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 400 800
Feet

TITLE:
1956 Historical Aerial Photograph Comparison

PROJECT:
Removal Site Evaluation Section 26 Mine Site

DATE: 8/1/2018

DOCUMENT NAME: Removal Site Evaluation Report

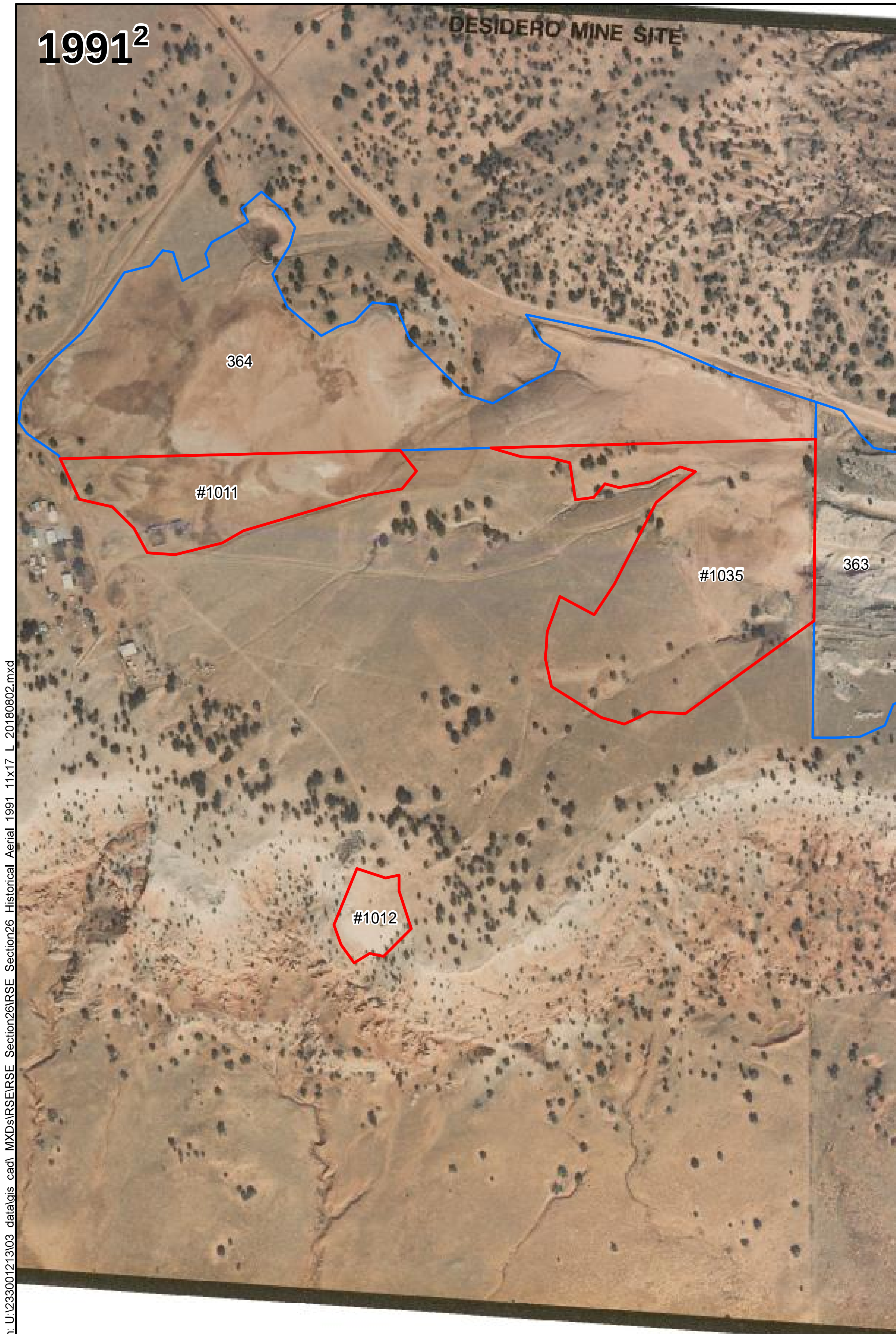
AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 3-1b

Stantec

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Section26\RSE Section26 Historical Aerial 1956 11x17 L 20180801.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Claim Boundary
- Other Claim Boundary

NOTE:
Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:
1. Coordinate System: NAD 1983 UTM Zone 12N

2. 1991 aerial image downloaded from https://earthexplorer.usgs.gov/ (01/2016) and georeferenced using current image from BING (03/2016).

3. Site-specific imagery flown by Cooper Aerial Surveys Co. on June 16, 2017.

N
W E
S

0 400 800
Feet

TITLE:
1991 Historical Aerial Photograph Comparison

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 8/2/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 3-1c	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Historical_Aerial_1991_11x17_L_20180802.mxd

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Potential Background Reference Area
- Claim Boundary
- Other Claim Boundary

NOTE:
Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 300 600
Feet

TITLE:
Potential Background Reference Areas

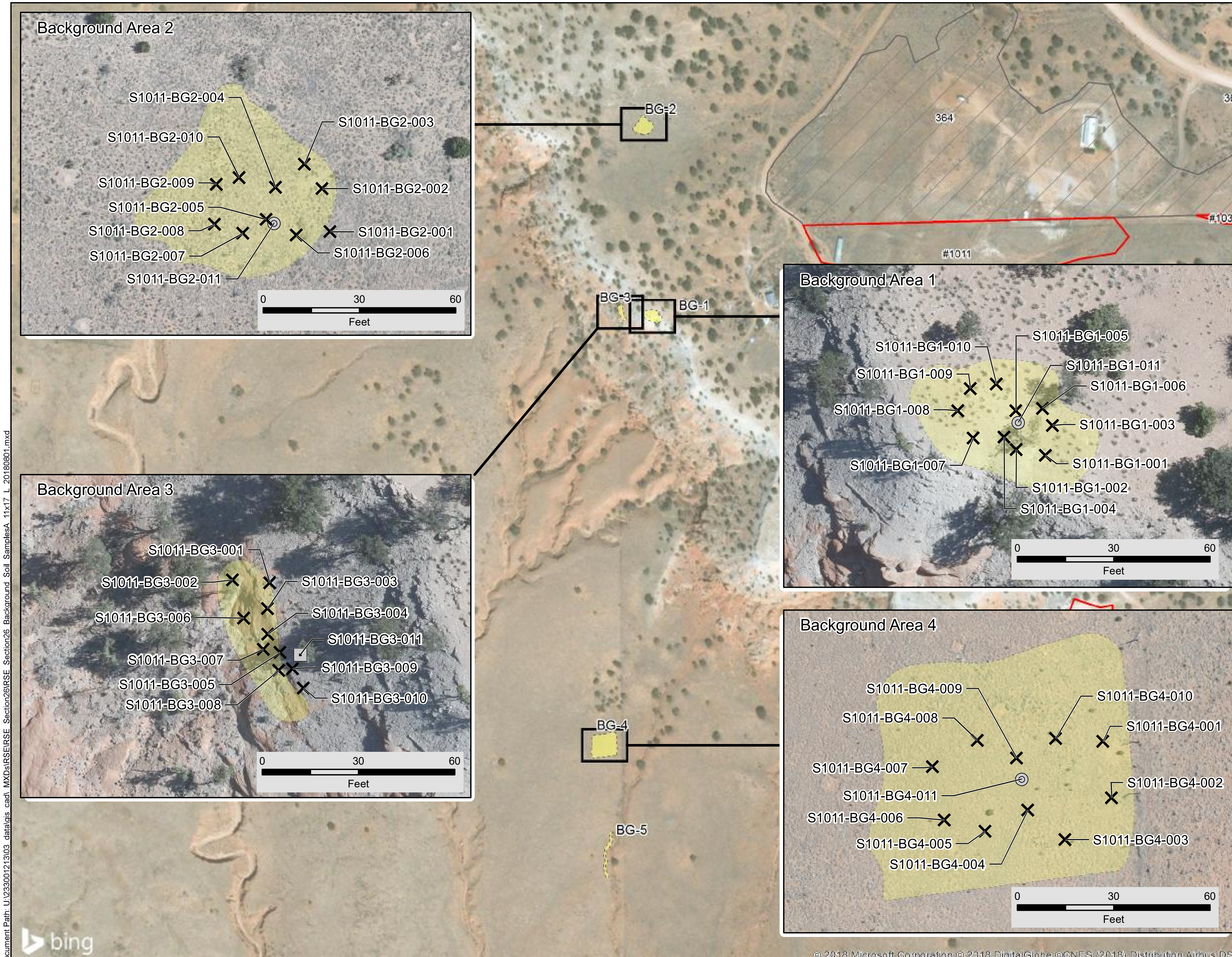
PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE:	DOCUMENT NAME:
8/23/2018	Removal Site Evaluation Report

Stantec

AUTHOR:	REVIEWER:
EDZ	CBB

FIGURE:
3-2



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Background Reference Area
- Claim Boundary
- Other Claim Boundary

NOTE:
Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Main display basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

Inset basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

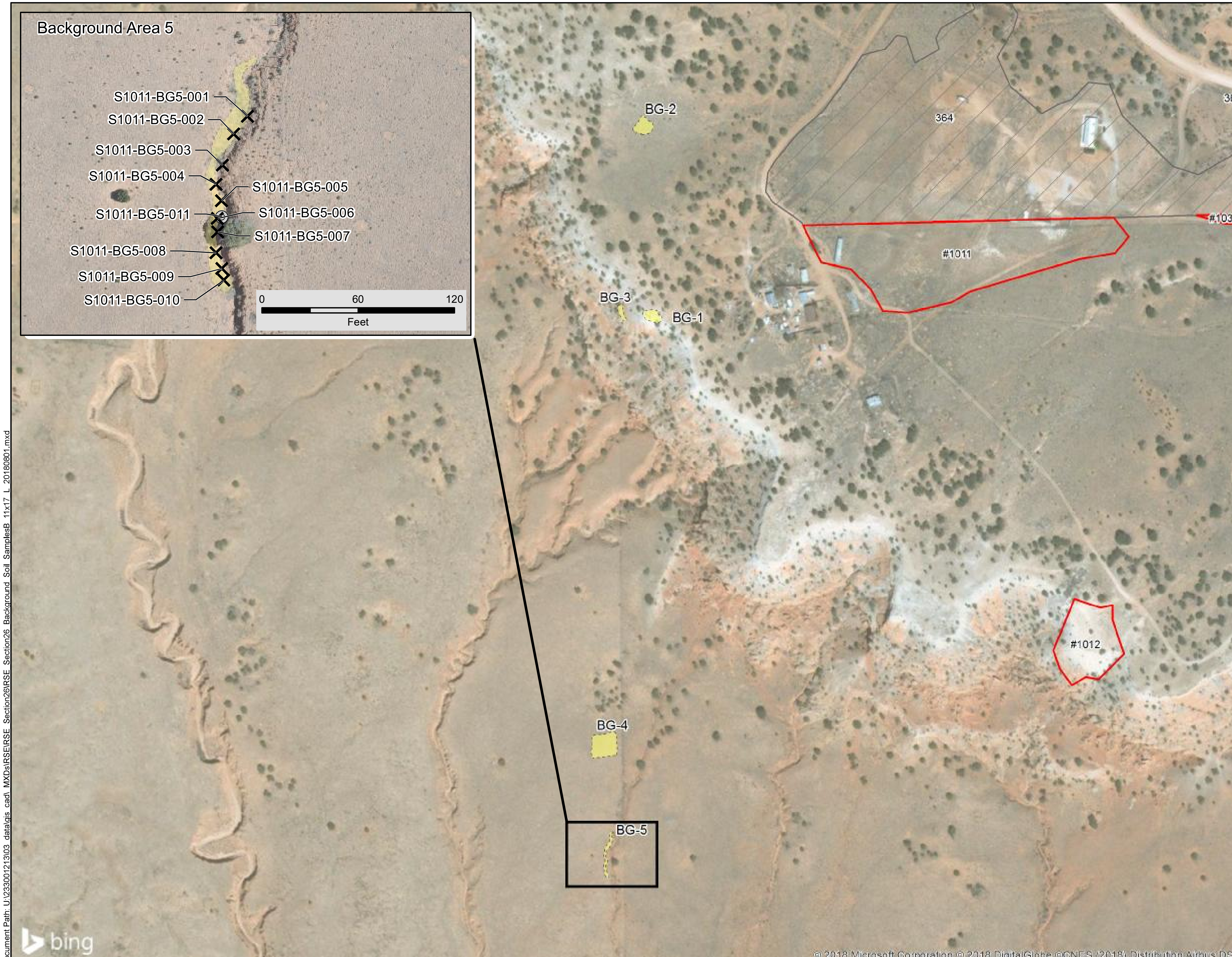
N W E S
0 300 600
Feet

TITLE:
Background Reference Areas (1-4) - Sample Locations

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 8/23/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: EDZ / REVIEWER: CBB
	FIGURE: 3-3a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Background_Soil_SamplesA_11x17_L_20180801.mxd



Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Background_Soil_SamplesB_11x17_L_20180801.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Background Reference Area
- Claim Boundary
- Other Claim Boundary

NOTE:
Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Main basemap image inset accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

Inset basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 300 600
Feet

TITLE:
Background Reference Area 5 - Sample Locations

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 8/23/2018

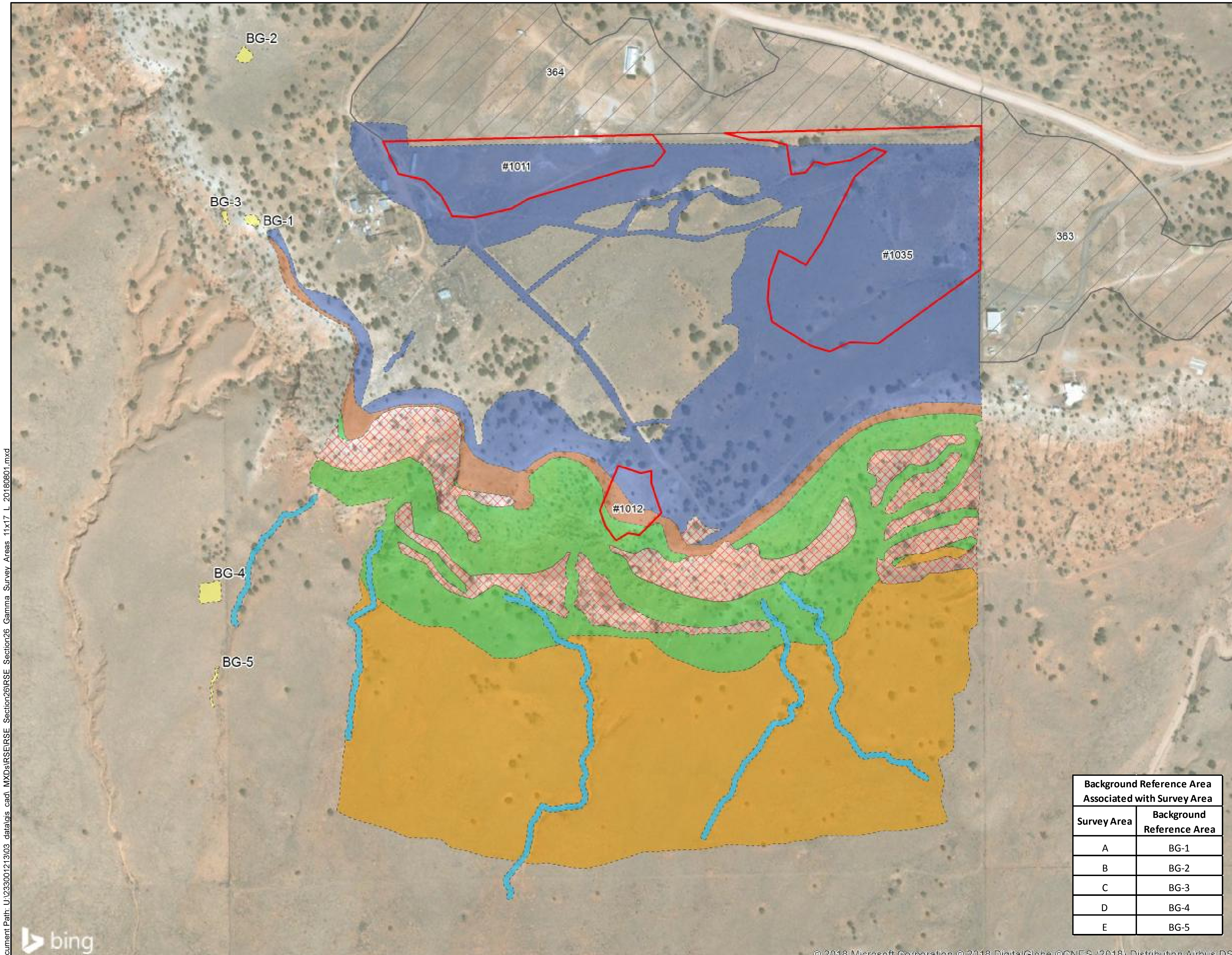
DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 3-3b



Background Reference Area Associated with Survey Area	
Survey Area	Background Reference Area
A	BG-1
B	BG-2
C	BG-3
D	BG-4
E	BG-5

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Background Reference Area
- Survey Area A
- Survey Area B
- Survey Area C
- Survey Area D
- Survey Area E
- Unsurveyed Area[1]
- Claim Boundary
- Other Claim Boundary

NOTES:

1. Areas within Survey Areas that were not surveyed (10.1 acres) due to steep/unsafe terrain.
2. Gamma survey area is approximately 101.3 acres.
3. Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.
4. Area north and east of fence near mines #1011 and #1035 is private property and inaccessible.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

N W E S

0 350 700
Feet

TITLE: Gamma Radiation Survey Areas

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 8/23/2018

DOCUMENT NAME: Removal Site Evaluation Report

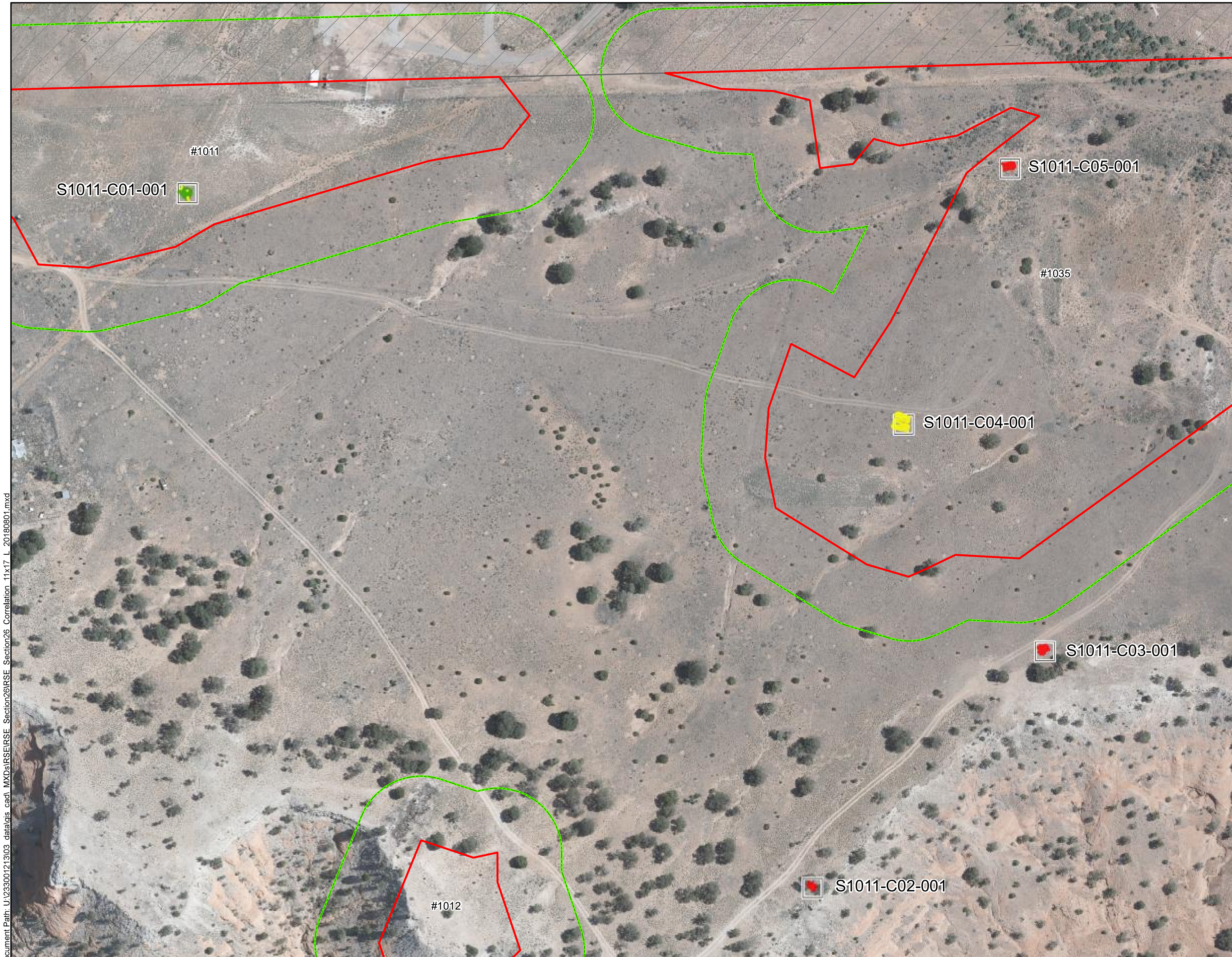
AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 3-4

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Gamma_Survey_Areas_11x17_L_20180801.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

S1011-C01-001 Correlation Location (30'x30')

Claim Boundary

100-Foot Claim Buffer

Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

19,390 - 23,320 (Minimum to BG-2 UTL)

23,321 - 46,640 (>BG-2 UTL to 2x BG-2 UTL)

46,641 - 190,264 (>2x BG-2 UTL to Maximum)

NOTES:

Surface gamma measurements were collected using a 3 x 3 inch detector.

Each correlation sample consists of five grab samples collected from 0.0 - 0.5 feet below ground surface, composited together for laboratory analysis.

Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 150 300

Feet

TITLE: Gamma Correlation Study Locations

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 8/2/2018

DOCUMENT NAME: Removal Site Evaluation Report

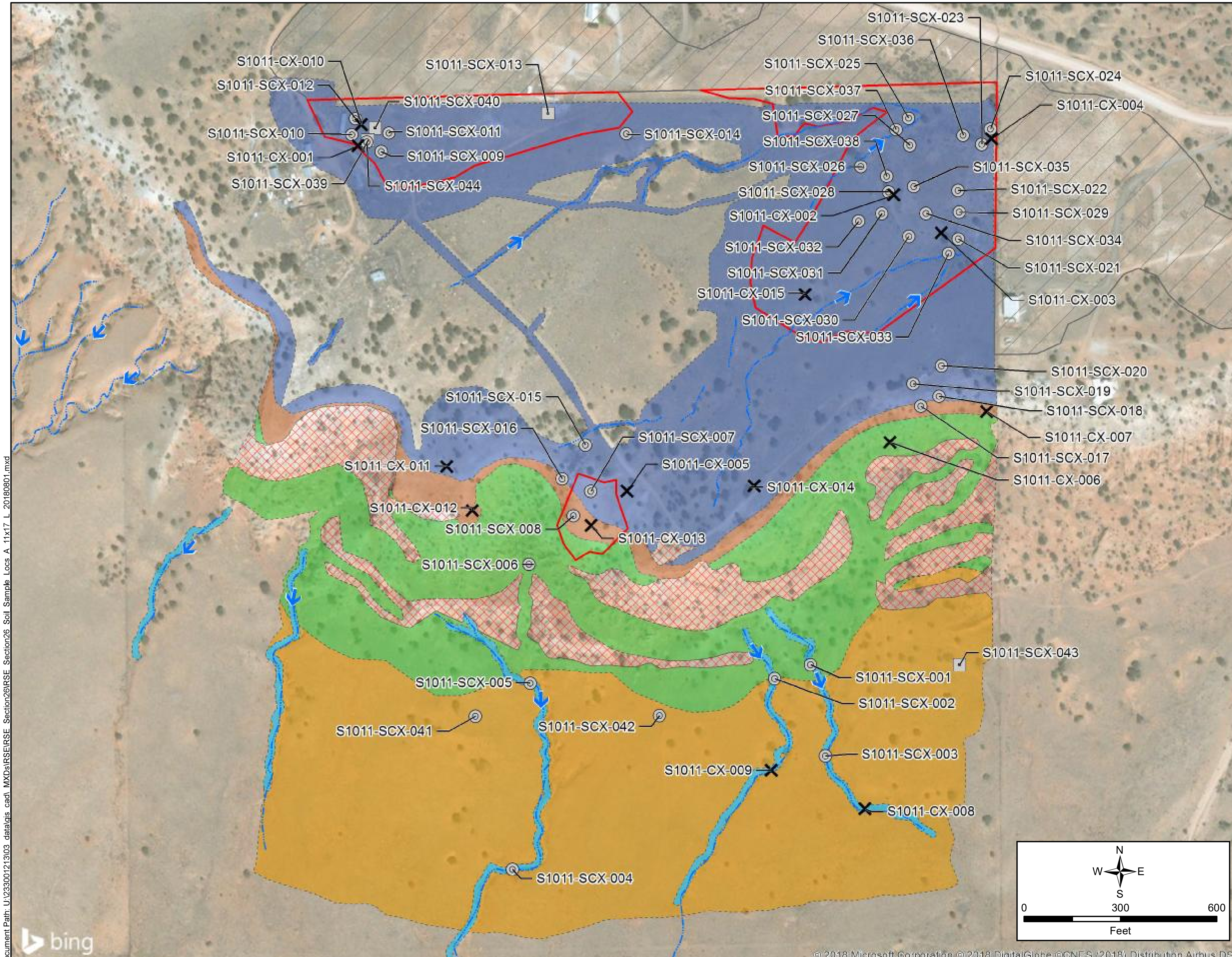
Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 3-5

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Correlation_11x17_L_20180801.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Flow Direction
- Drainage
- Survey Area A
- Survey Area B
- Survey Area C
- Survey Area D
- Survey Area E
- Unsurveyed Area
- Claim Boundary
- Other Claim Boundary

NOTES:

Surface and subsurface static gamma measurements were collected at all borehole locations with one exception; only subsurface static gamma measurements were collected at S1011-SCX-042.

Surface soil samples range from 0.0 - 0.5 feet below ground surface (ft bgs)

Subsurface soil samples range from 0.0 - 20.0 ft bgs

Static gamma measurements range from 0.0 - 20.0 ft bgs

Area north and east of fence near mines #1011 and #1035 is private property and inaccessible.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

TITLE:

Site Characterization Surface and Subsurface Sample Locations

PROJECT:

Removal Site Evaluation
Section 26 Mine Site

DATE: 8/23/2018

DOCUMENT NAME: Removal Site Evaluation Report

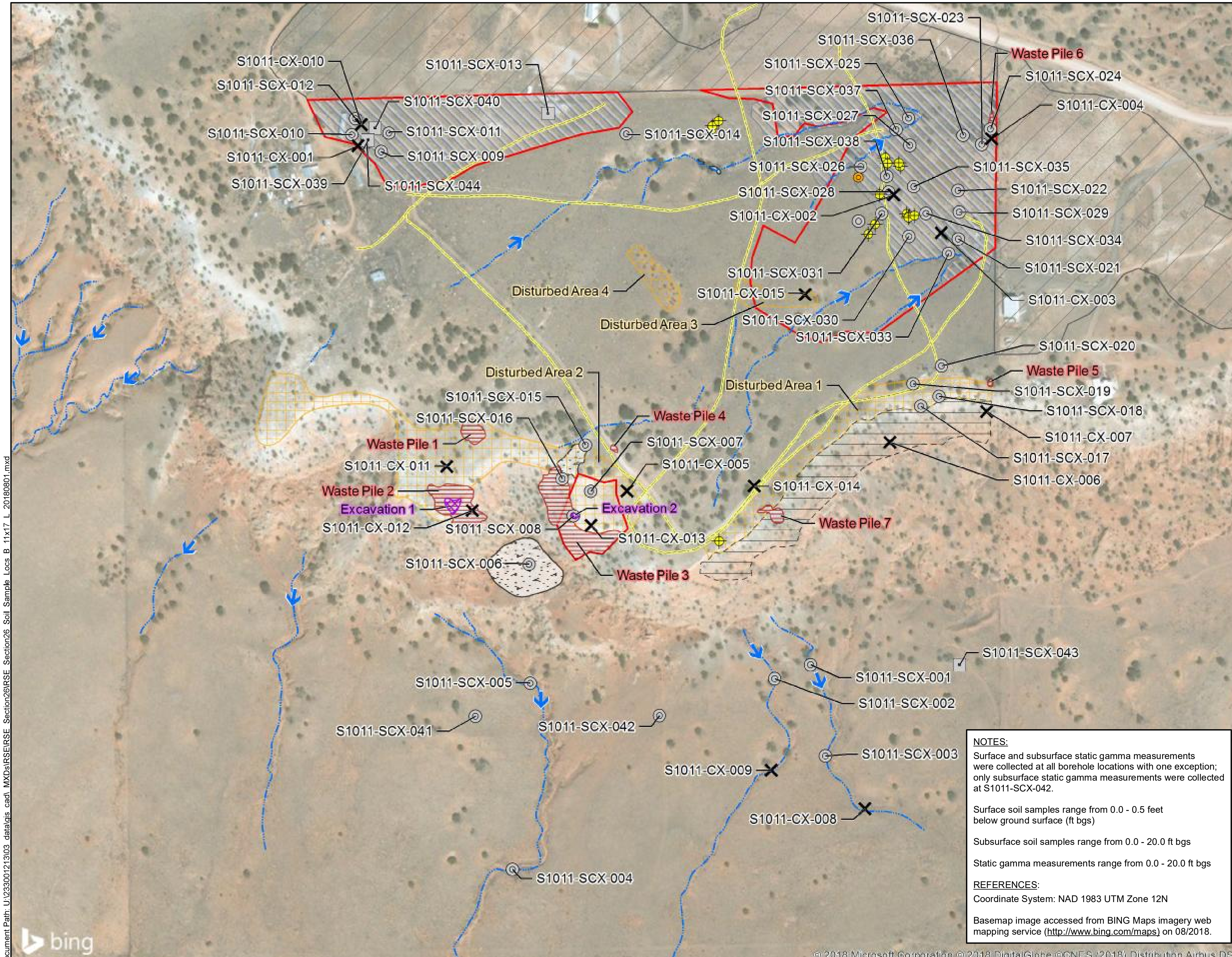
Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 3-6a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Soil_Sample_Locs_A_11x17_L_20180801.mxd



NOTES:

Surface and subsurface static gamma measurements were collected at all borehole locations with one exception; only subsurface static gamma measurements were collected at S1011-SCX-042.

Surface soil samples range from 0.0 - 0.5 feet below ground surface (ft bgs)

Subsurface soil samples range from 0.0 - 20.0 ft bgs

Static gamma measurements range from 0.0 - 20.0 ft bgs

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Flow Direction
- Possible Portal or Storage
- Historical Borehole
- Potential Haul Road
- Drainage
- Debris
- Excavation
- Graded / Disturbed Reclaimed Area
- Potential Mining Disturbed
- Potential Waste Rock
- Waste Pile
- Vertical Mine Shafts
- Claim Boundary
- Other Claim Boundary

N W E S

0 300 600

Feet

TITLE: Site Characterization Mining Features and Surface and Subsurface Sample Locations

PROJECT: Removal Site Evaluation Section 26 Mine Site

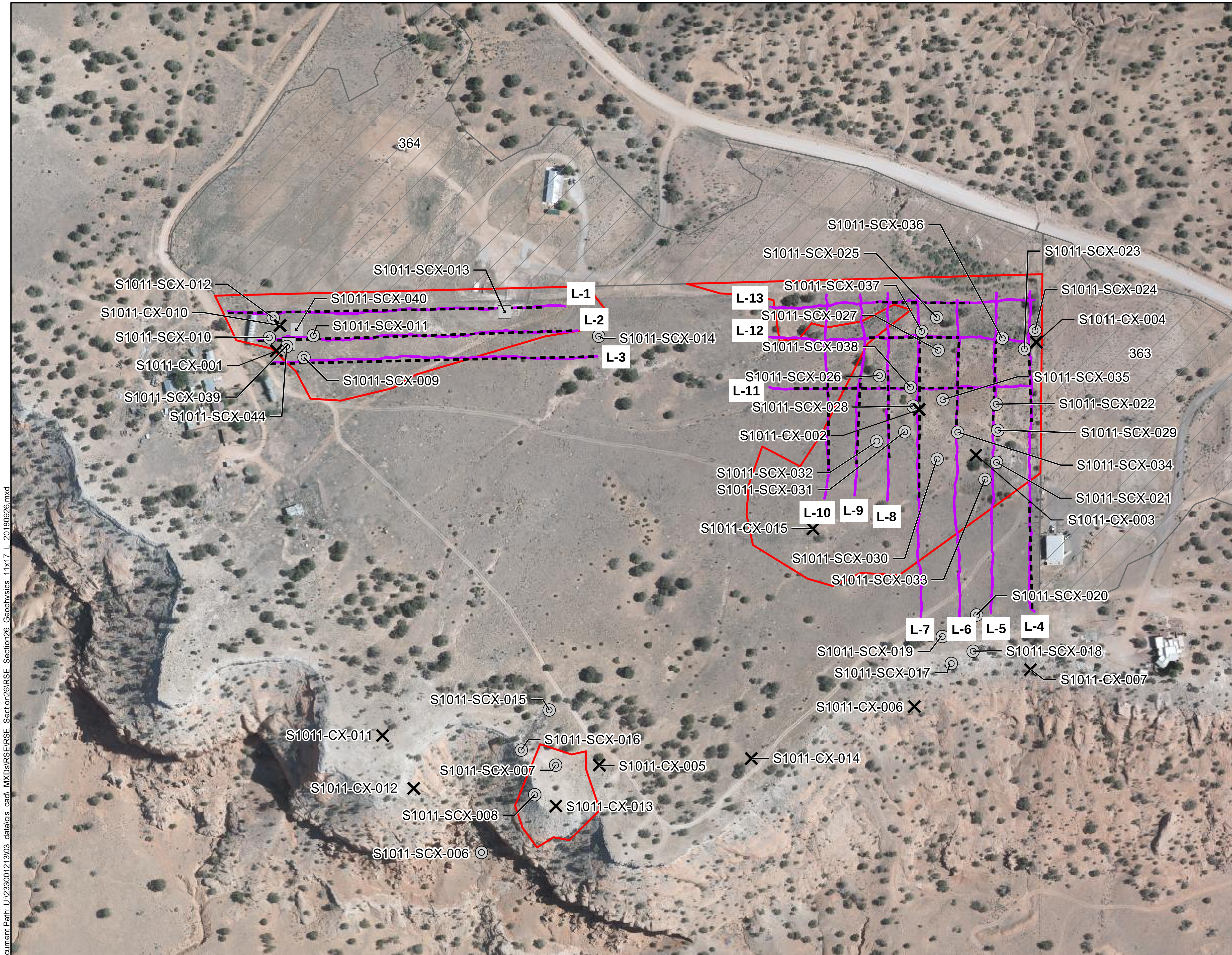
DATE:	DOCUMENT NAME:
8/23/2018	Removal Site Evaluation Report

Stantec

AUTHOR:	REVIEWER:
EDZ	CBB

FIGURE: 3-6b

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Soil_Sample_Locs_B_11x17_L_20180801.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- MASW Survey Line
- Resistivity Survey Line
- Claim Boundary
- Other Claim Boundary

NOTES:
MASW: multi-channel analysis of surface waves

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

Geophysical surveys were performed by Hydrogeophysics, Inc. The geophysical survey report is presented in Appendix A.

N W E S

0 250 500
Feet

TITLE: Geophysical Surveys

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

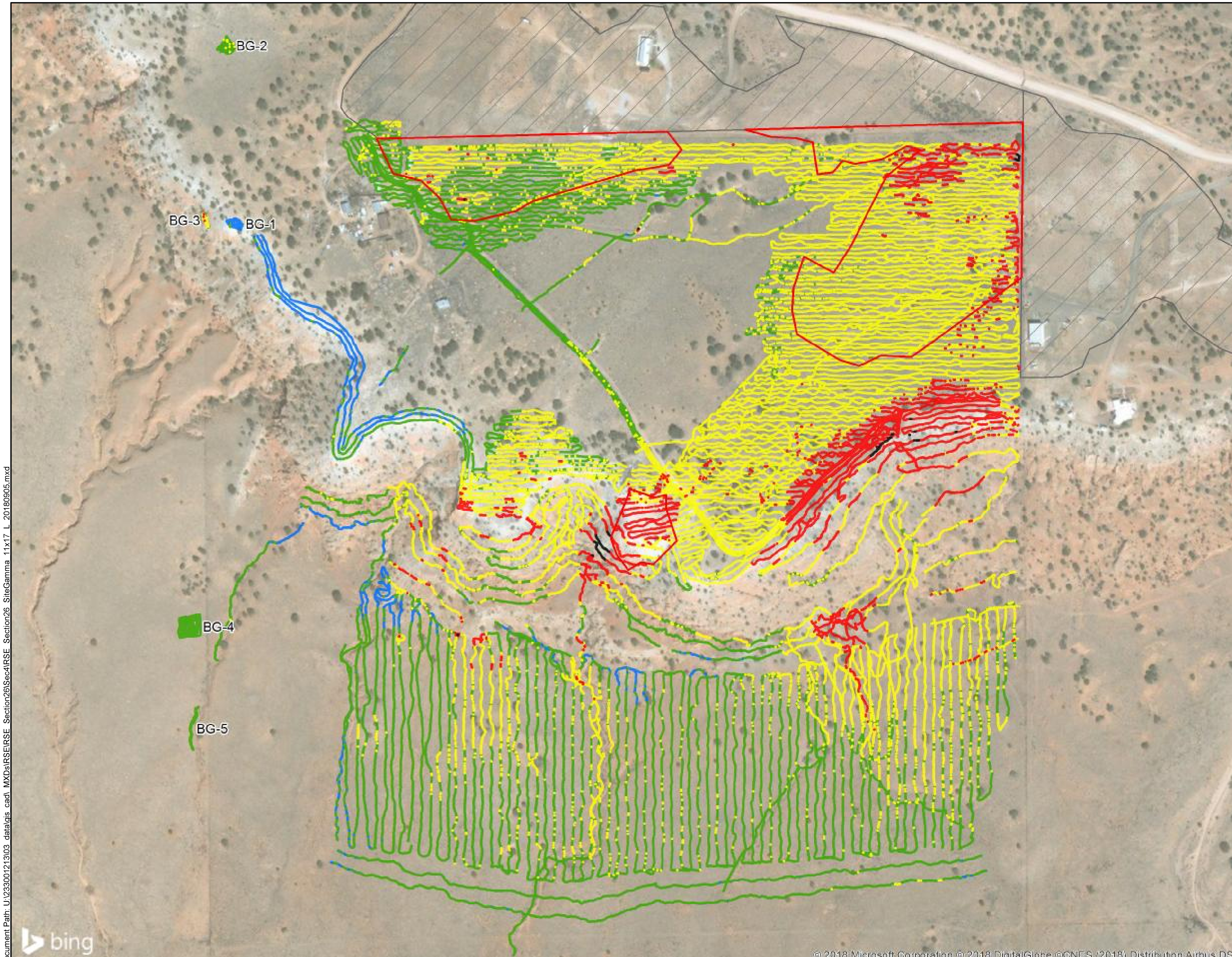
AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 3-7

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26_Geophysics_11x17_L_20180926.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Claim Boundary

Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 8,652 - 16,829 (Minimum to BG-1 IL)
- 16,830 - 23,320 (>BG-1 IL to BG-2 IL)
- 23,321 - 46,640 (>BG-2 IL to 2x BG-2 IL)
- 46,641 - 233,200 (>2x BG-2 IL to 10x BG-2 IL)
- 233,201 - 749,127 (>10x BG-2 IL to Maximum)

NOTES:
Surface gamma measurements were collected using a 3 x 3 inch detector.

Refer to Figure 3-4 for Survey Area delineation.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S

0 320 640
Feet

TITLE:
Gamma Radiation Survey Results for Site

PROJECT:
Removal Site Evaluation Section 26 Mine Site

DATE: 9/14/2018

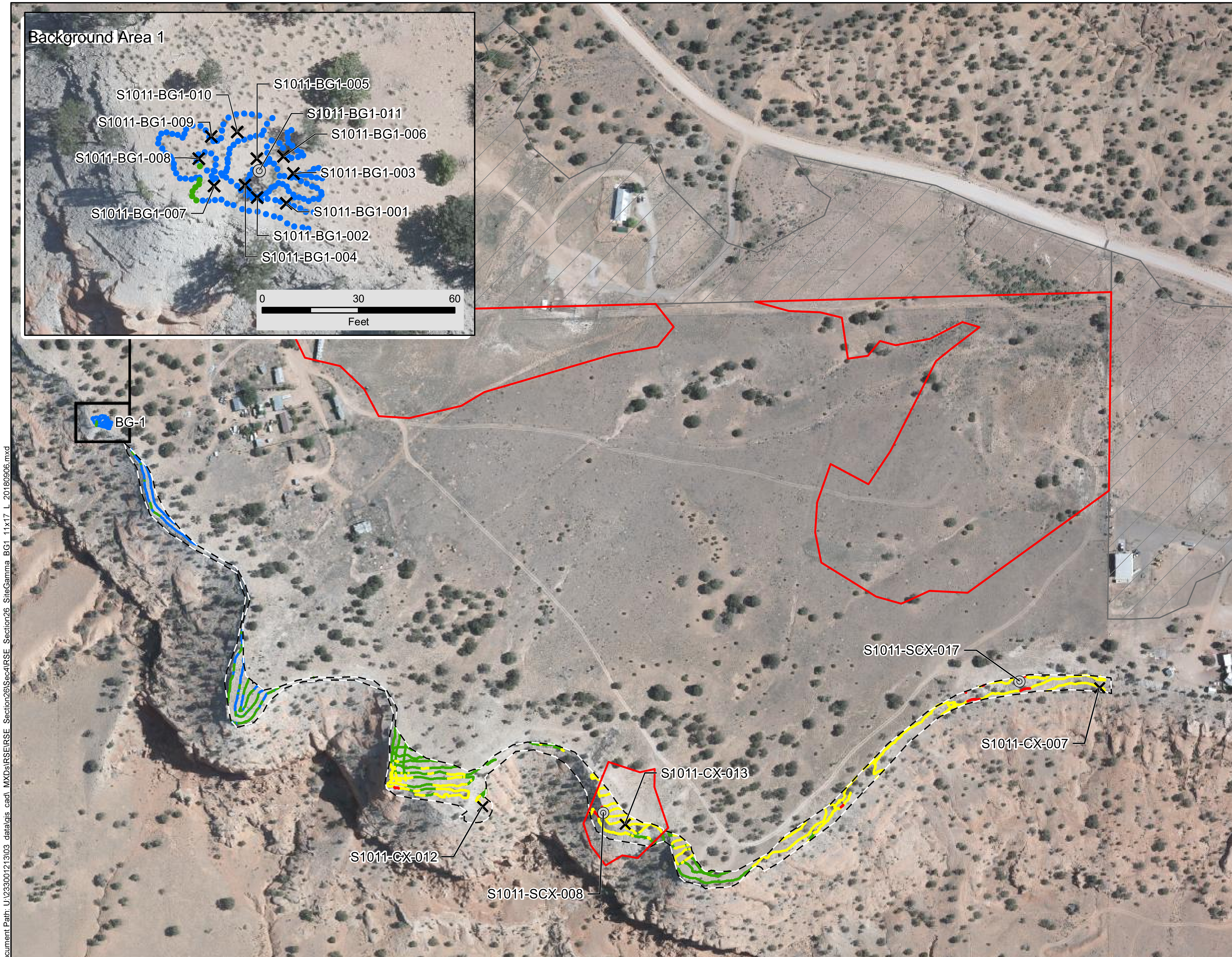
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-1a



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Survey Area A
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 11,058 - 16,829 (Minimum to BG-1 IL)
- 16,830 - 33,658 (>BG-1 IL to 2x BG-1 IL)
- 33,659 - 168,290 (>2x BG-1 IL to 10x BG-1 IL)
- 168,291 - 654,837 (>10x BG-1 IL to Maximum)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 250 500
Feet

TITLE:
Gamma Radiation Survey Results for Survey Area A

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/14/2018

DOCUMENT NAME: Removal Site Evaluation Report

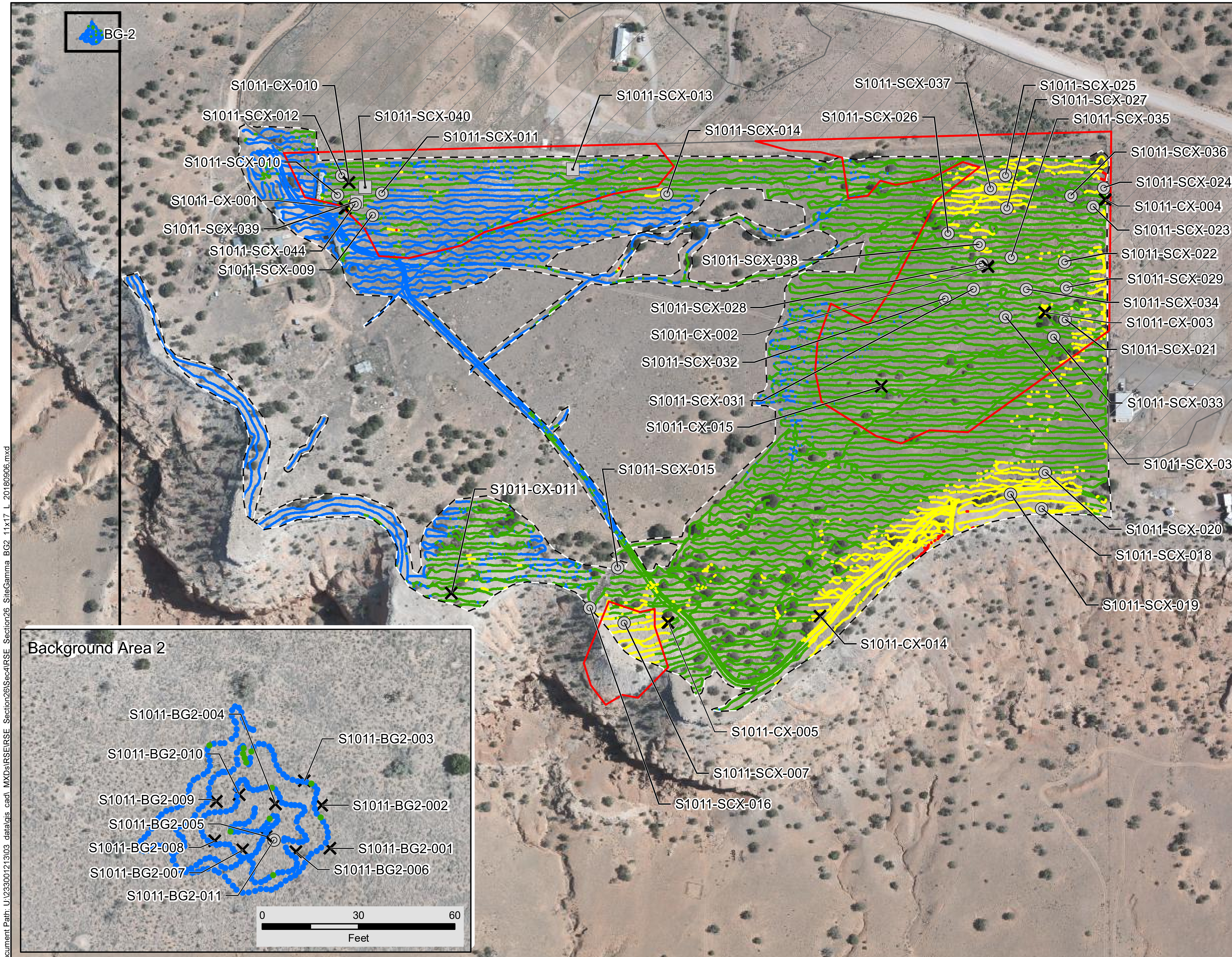
Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-1b

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_SiteGamma_BG1_11x17_L_20180906.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Survey Area
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 8,652 - 23,320 (Minimum to BG-2 IL)
- 23,321 - 46,640 (>BG-2 IL to 2x BG-2 IL)
- 46,641 - 233,200 (>2x BG-2 IL to 10x BG-2 IL)
- 233,201 - 633,057 (>10x BG-2 IL to Maximum)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

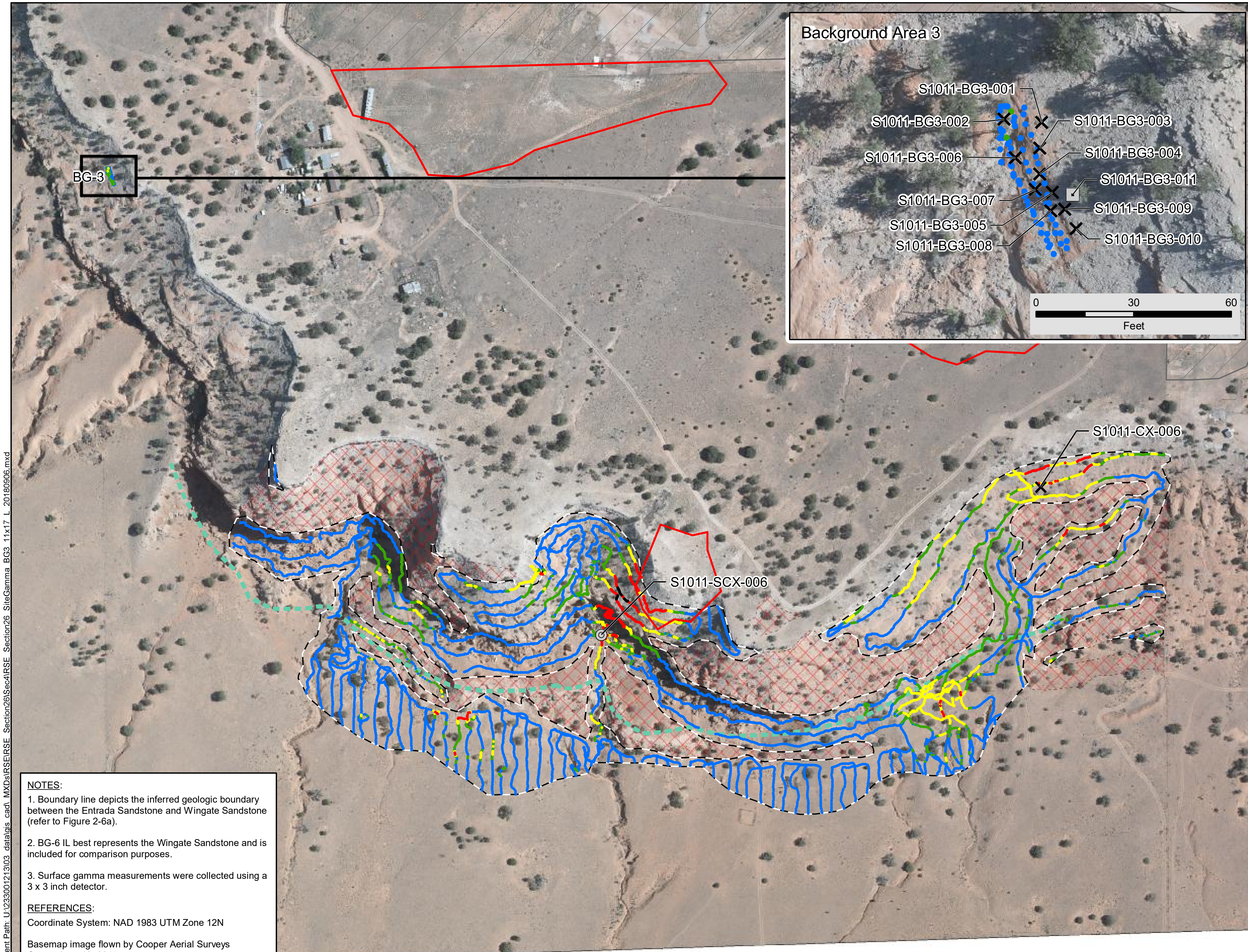
N W E S

0 250 500
Feet

TITLE:
Gamma Radiation Survey Results for Survey Area B

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE:	DOCUMENT NAME:	
9/6/2018	Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-1c	



NOTES:

1. Boundary line depicts the inferred geologic boundary between the Entrada Sandstone and Wingate Sandstone (refer to Figure 2-6a).

2. BG-6 IL best represents the Wingate Sandstone and is included for comparison purposes.

3. Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Wingate / Entrada Geologic Contact (inferred)[1]
- Unsurveyed Area
- Survey Area C
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 11,527 - 34,429 (Minimum to BG-6[2] IL)
- 34,430 - 48,542 (>BG-6 IL to BG-3 IL)
- 48,543 - 97,084 (>BG-3 IL to 2x BG-3 IL)
- 97,085 - 485,420 (>2x BG-3 IL to 10x BG-3 IL)
- 485,421 - 749,127 (>10x BG-3 IL to Maximum)

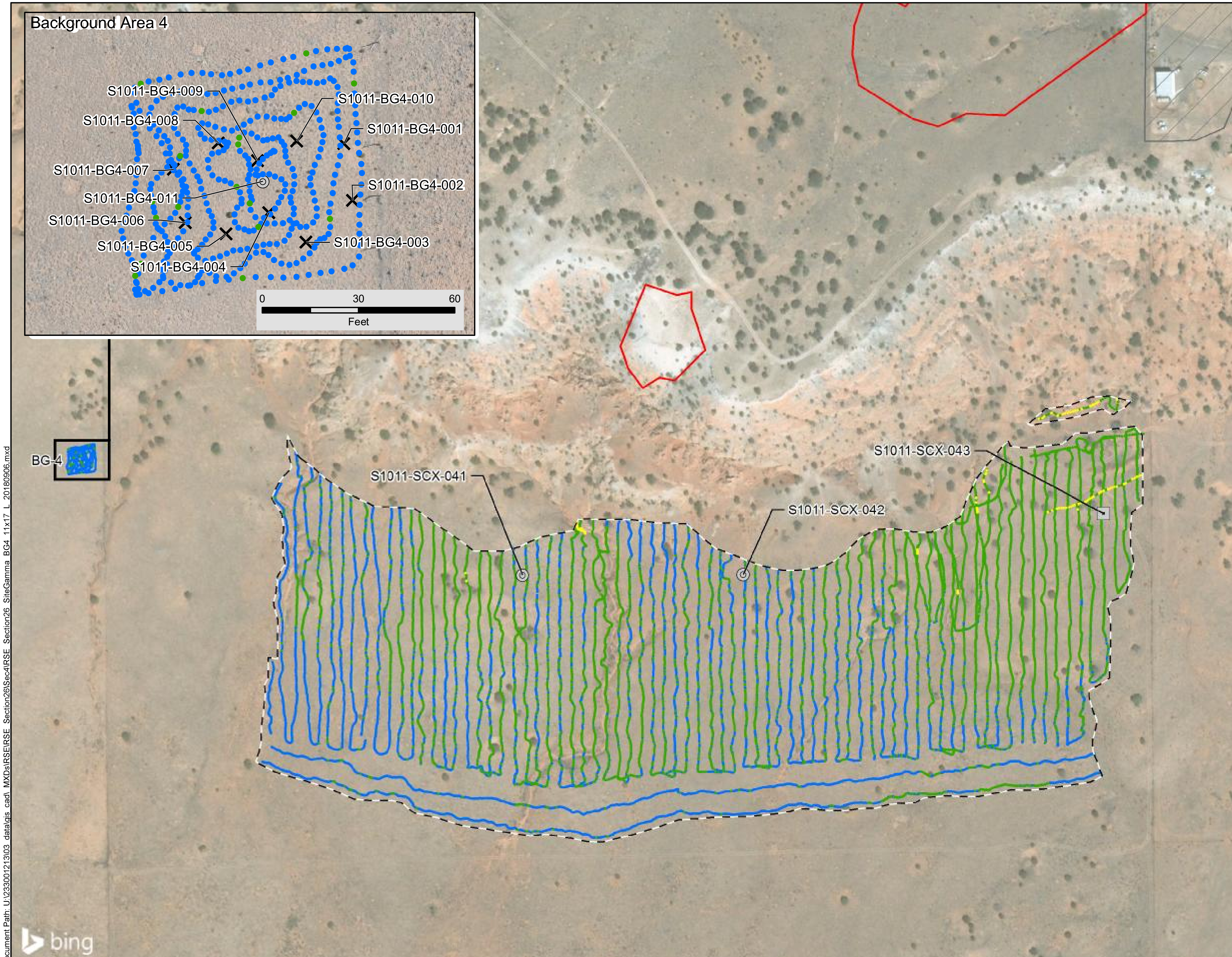
N W E S

0 250 500
Feet

TITLE:
Gamma Radiation Survey Results for Survey Area C

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE:	DOCUMENT NAME:	
9/14/2018	Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-1d	



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Survey Area
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 12,476 - 20,637 (Minimum to BG-4 IL)
- 20,638 - 41,274 (>BG-4 IL to 2x BG-4 IL)
- 41,275 - 62,220 (>2x BG-4 IL to Maximum)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Main display basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

Inset basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 250 500
Feet

TITLE:
Gamma Radiation Survey Results for Survey Area D

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/14/2018

DOCUMENT NAME: Removal Site Evaluation Report

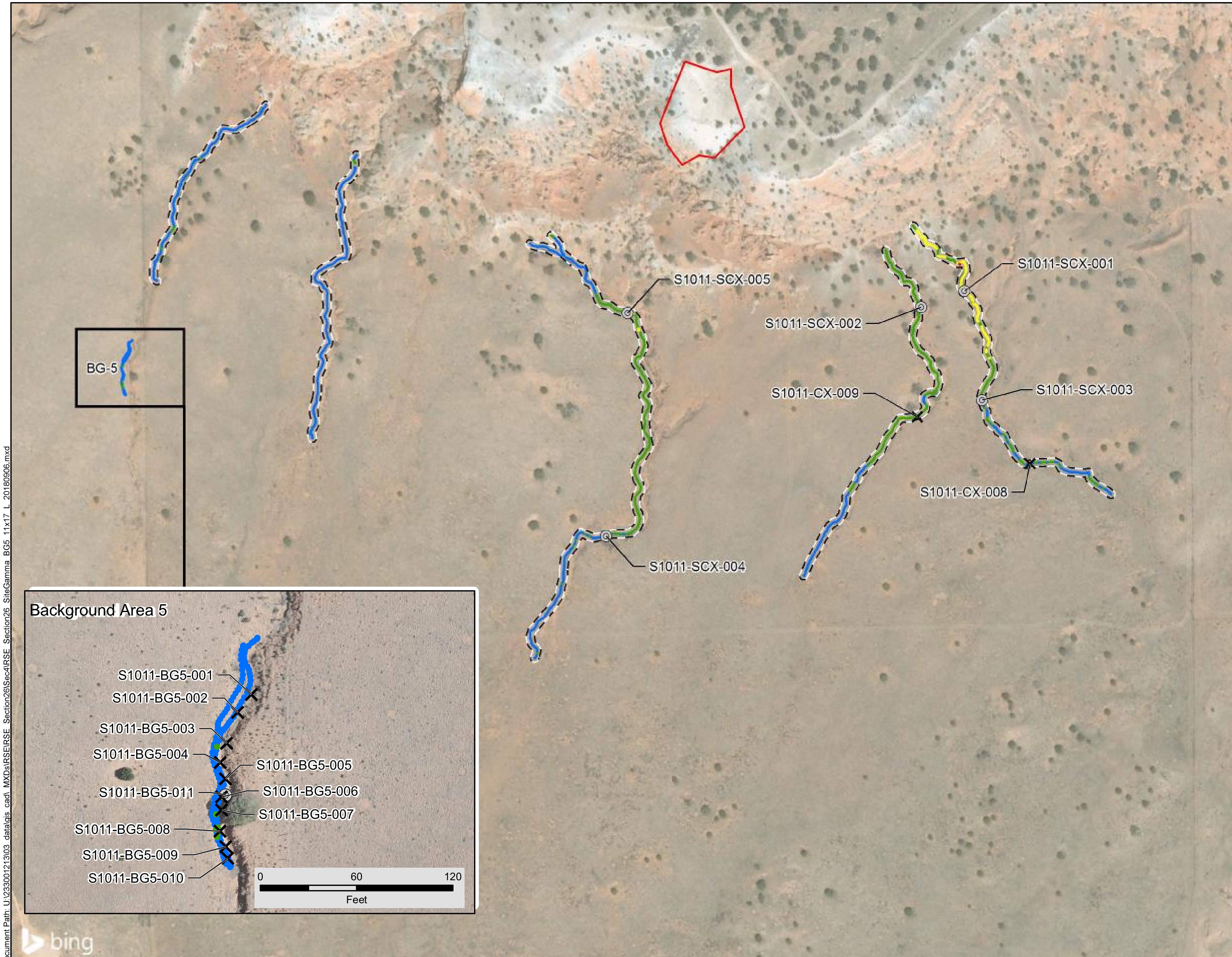
AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-1e

Stantec

Document Path: U:\123300121303_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_SiteGamma_BG4_11x17_L_20180906.mxd



Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_SiteGamma_BG5_11x17_L_20180906.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- ✕ Surface Sample
- ◎ Borehole Location - Surface and Subsurface Samples
- Survey Area
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 12,054 - 21,864 (Minimum to BG-5 IL)
- 21,865 - 43,728 (>BG-5 IL to 2x BG-5 IL)
- 43,729 - 109,320 (>2x BG-5 IL to 5x BG-5 IL)
- 109,321 - 117,875 (>5x BG-5 IL to Maximum)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Main display basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

Inset basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N
W E
S

0 250 500
Feet

TITLE:
Gamma Radiation Survey Results for Survey Area E

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/14/2018

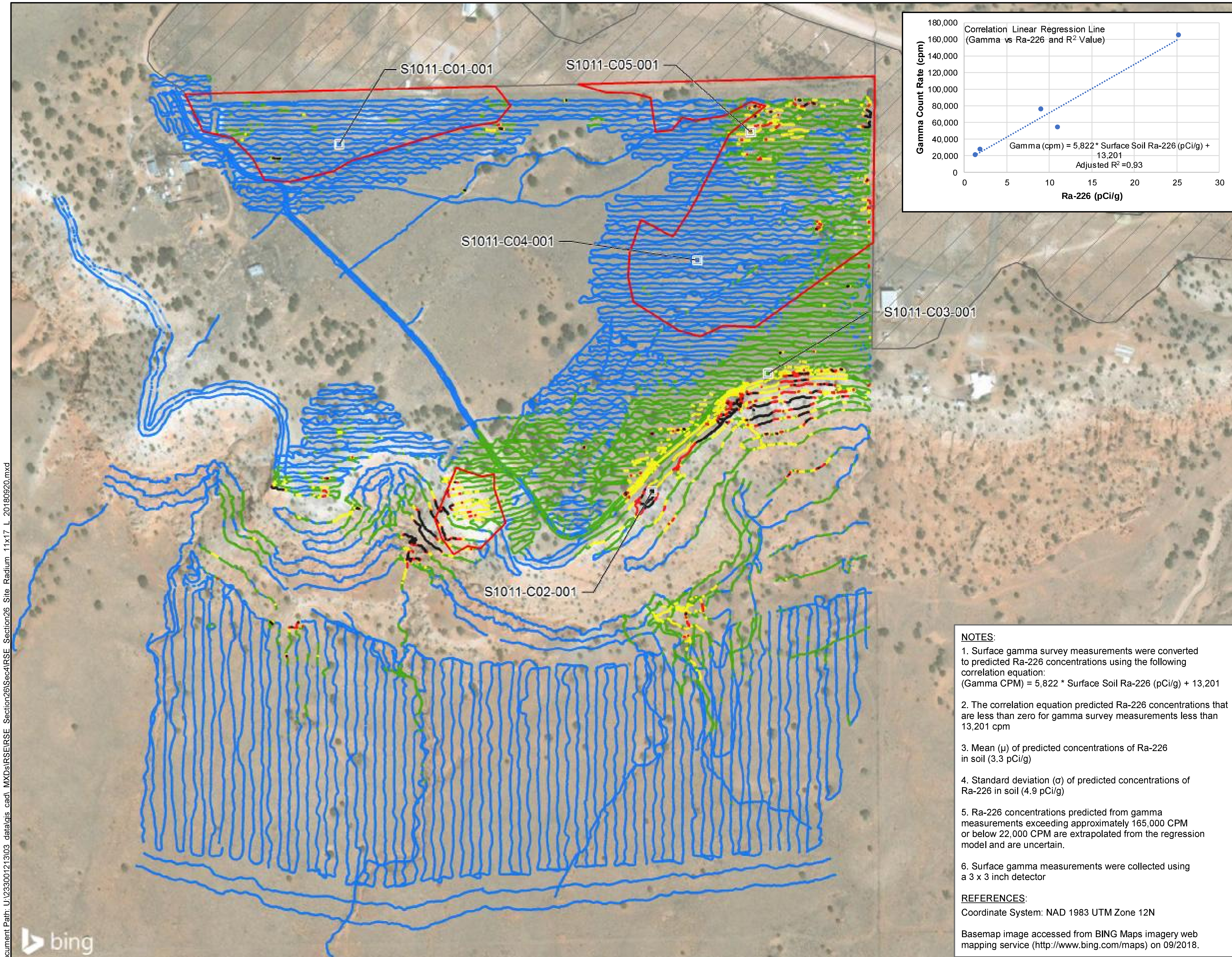
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-1f



Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_Radium_11x17_L_20180920.mxd

NOTES:

1. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
(Gamma CPM) = 5,822 * Surface Soil Ra-226 (pCi/g) + 13,201

2. The correlation equation predicted Ra-226 concentrations that are less than zero for gamma survey measurements less than 13,201 cpm

3. Mean (μ) of predicted concentrations of Ra-226 in soil (3.3 pCi/g)

4. Standard deviation (σ) of predicted concentrations of Ra-226 in soil (4.9 pCi/g)

5. Ra-226 concentrations predicted from gamma measurements exceeding approximately 165,000 CPM or below 22,000 CPM are extrapolated from the regression model and are uncertain.

6. Surface gamma measurements were collected using a 3 x 3 inch detector

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

S1011-C01-001 Correlation Location (30'x30')

Claim Boundary

Other Claim Boundary

Predicted Ra-226 Concentration[1] (pCi/g)

- Less than 0[2]
- 0 - 3.3 (μ)[3]
- 3.4 - 8.2 (μ + 1σ[4])
- 8.3 - 13.1 (μ + 2σ)
- 13.2 - 18.0 (μ + 3σ)
- 18.1 - 126.4[5]

Correlation Data		
Sample ID	Ra-226 (pCi/g)	Mean Gamma Count Rate (cpm)[1]
S1011-C01-001	1.26	21,632
S1011-C02-001	25.2	165,200
S1011-C03-001	11	55,042
S1011-C04-001	1.83	28,422
S1011-C05-001	9	76,851

1 Average gamma count rate for a correlation

N W E S

0 300 600
Feet

TITLE:
Predicted Concentrations of Ra-226 in Soil using the Correlation Equation

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/20/2018

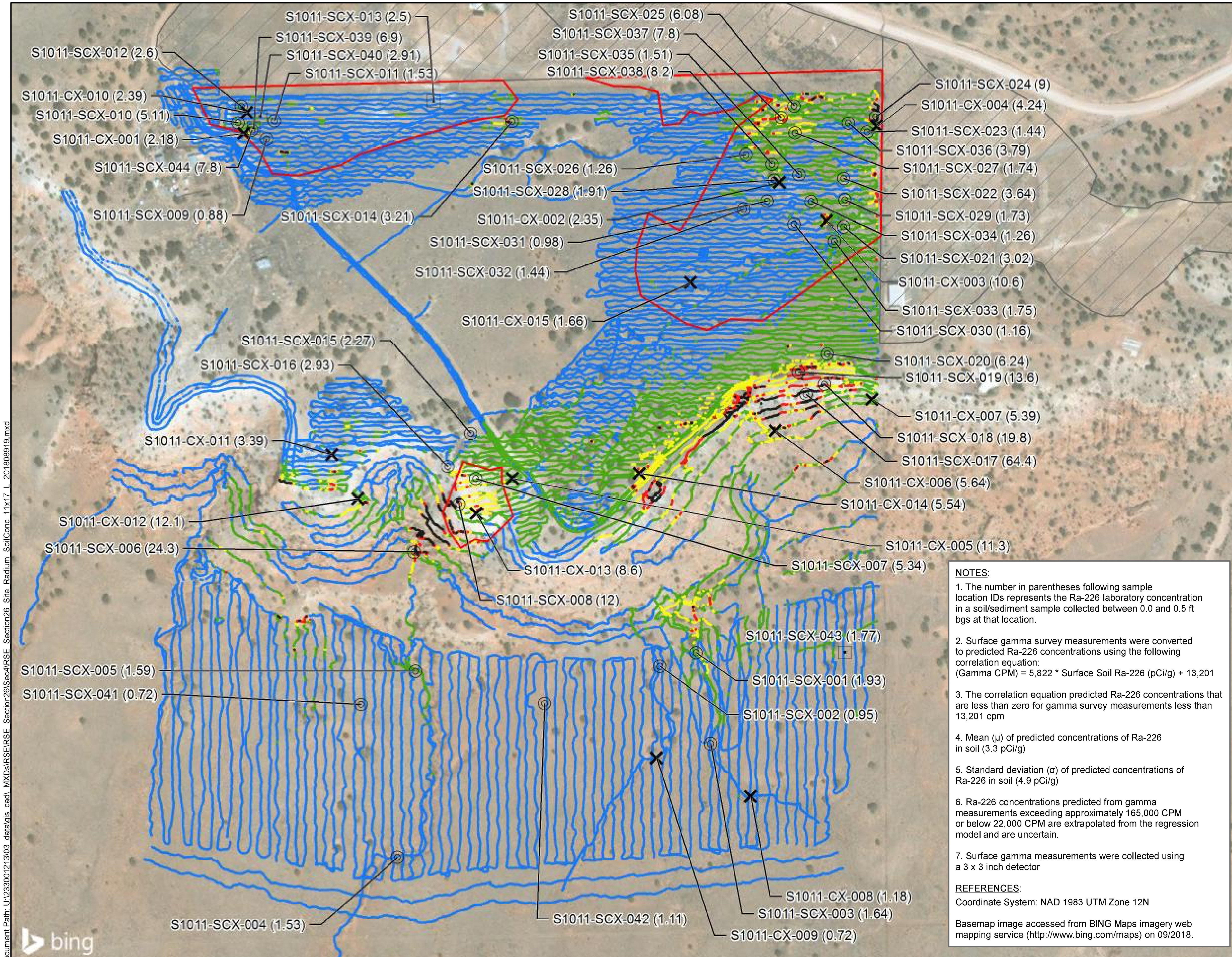
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-2a



NOTES:

1. The number in parentheses following sample location IDs represents the Ra-226 laboratory concentration in a soil/sediment sample collected between 0.0 and 0.5 ft bgs at that location.

2. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
(Gamma CPM) = 5,822 * Surface Soil Ra-226 (pCi/g) + 13,201

3. The correlation equation predicted Ra-226 concentrations that are less than zero for gamma survey measurements less than 13,201 cpm

4. Mean (μ) of predicted concentrations of Ra-226 in soil (3.3 pCi/g)

5. Standard deviation (σ) of predicted concentrations of Ra-226 in soil (4.9 pCi/g)

6. Ra-226 concentrations predicted from gamma measurements exceeding approximately 165,000 CPM or below 22,000 CPM are extrapolated from the regression model and are uncertain.

7. Surface gamma measurements were collected using a 3 x 3 inch detector

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Claim Boundary
- Other Claim Boundary

Predicted Ra-226 Concentration[2] (pCi/g)

- Less than 0[3]
- 0 - 3.3 (μ)[4]
- 3.4 - 8.2 (μ + 1σ[5])
- 8.3 - 13.1 (μ + 2σ)
- 13.2 - 18.0 (μ + 3σ)
- 18.1 - 126.4[6]

N W E S

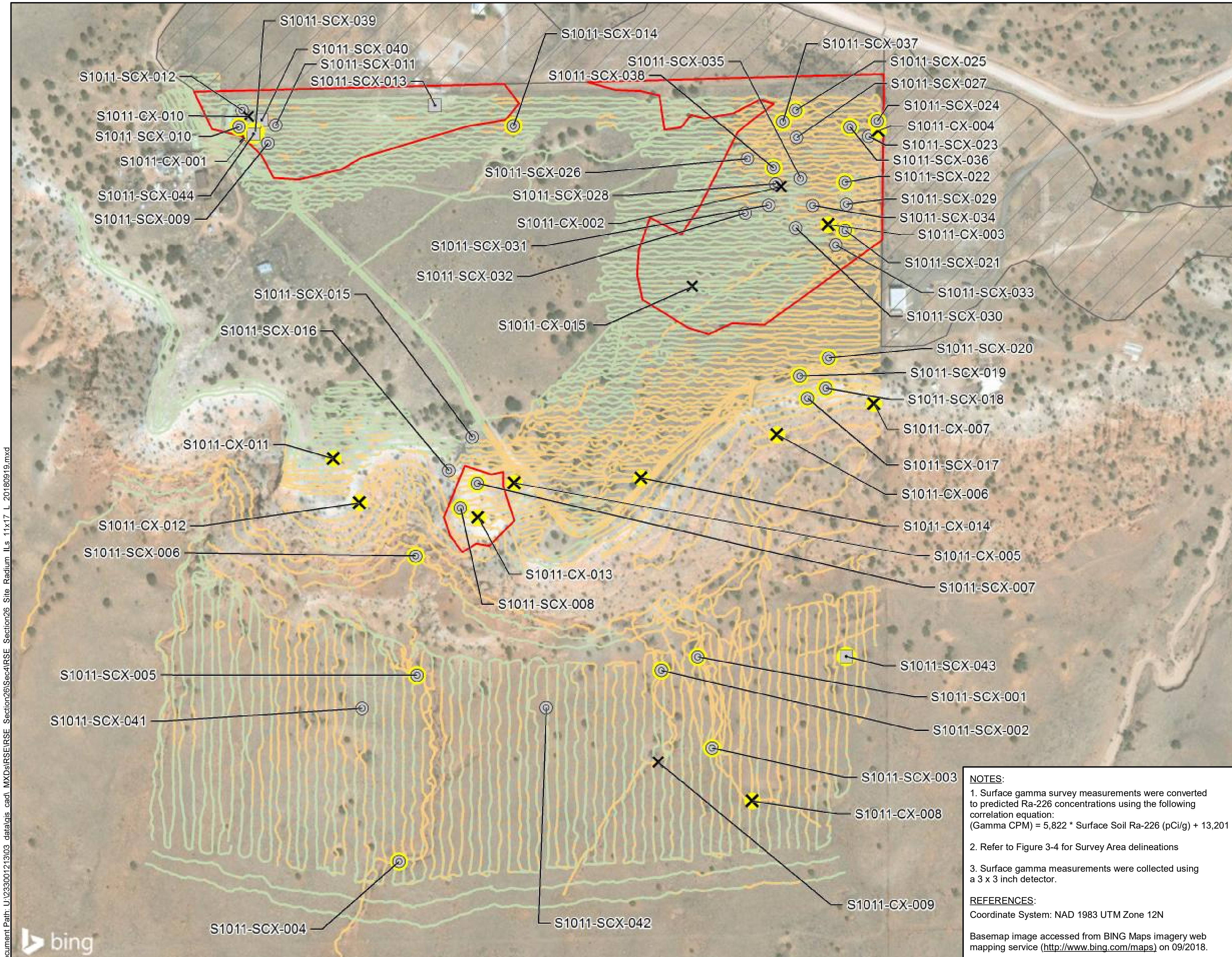
0 300 600
Feet

TITLE: Predicted Ra-226 Concentrations in Soil Compared to Ra-226 Concentrations in Surface Soil/Sediment

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 9/20/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: EDZ / REVIEWER: CBB
	FIGURE: 4-2b

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_Radium_SoilConc_11x17_L_20180919.mxd



NOTES:

1. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
(Gamma CPM) = 5,822 * Surface Soil Ra-226 (pCi/g) + 13,201

2. Refer to Figure 3-4 for Survey Area delineations

3. Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Ra-226 IL Exceedance in Surface Soil
- Claim Boundary
- Other Claim Boundary

Predicted RA-226 Concentration[1] (pCi/g)

IL Not Exceeded
Survey Area A: -0.37 - 2.13
Survey Area B: -0.78 - 2.96
Survey Area C: -0.29 - 1.49
Survey Area D: -0.12 - 1.49
Survey Area E: -0.21 - 0.84

IL Exceeded
Survey Area A: 2.14 - 110.21
Survey Area B: 2.97 - 106.47
Survey Area C: 1.50 - 126.40
Survey Area D: 1.50 - 8.42
Survey Area E: 0.85 - 17.98

N W E S

0 300 600
Feet

TITLE:
Predicted Ra-226 Concentrations in Surface Soil Compared to Ra-226 ILs

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-2c

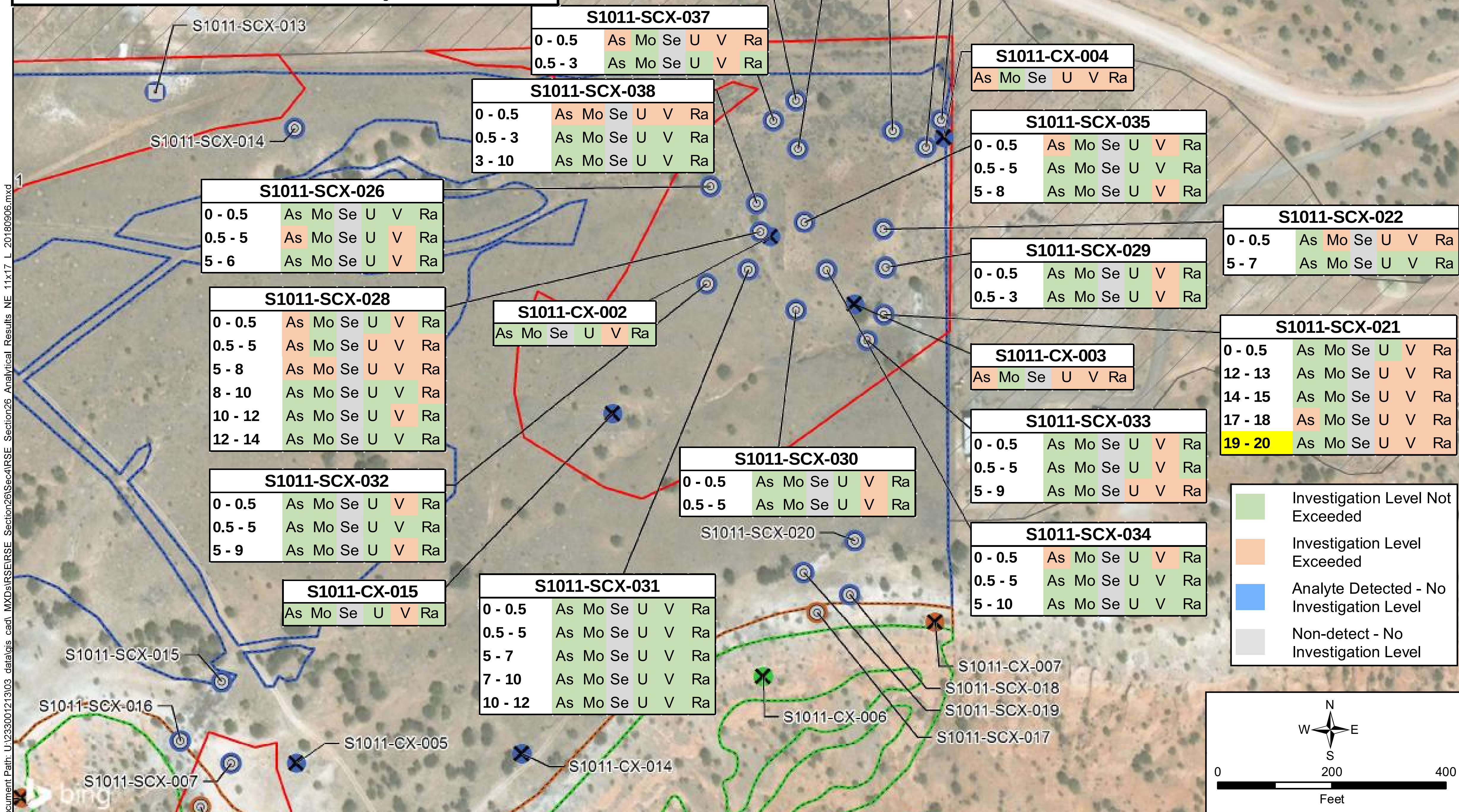
Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_Radium_ILs_11x17_L_20180919.mxd

Soil and Sediment Investigation Levels

Analyte (Units)	Investigation Level				
	Survey Area A	Survey Area B	Survey Area C	Survey Area D	Survey Area E
Metals (mg/kg)					
Arsenic	11.9	2.34	4.99	1.76	1.73
Molybdenum	2.26	0.346	0.367	0.210	NA[1]
Selenium	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
Uranium	3.23	3.34	1.91	0.554	0.691
Vanadium	27.3	11.2	17.4	11.0	10.7
Radionuclides (pCi/g)					
Radium-226	2.13	2.96	1.49	1.49	0.839

[1] No IL was established for Mo in Survey Area E because Mo was not detected in background reference area 5 (BG-5)

[2] No IL was established for Se because Se was not detected in background reference areas



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Survey Area A - Surface Sample Location
- Survey Area A - Borehole Location - Surface and Subsurface Samples
- Survey Area B - Surface Sample Location
- Survey Area B - Borehole Location - Surface and Subsurface Samples
- Survey Area B - Borehole Location - Surface Samples Only
- Survey Area C - Surface Sample Location
- Survey Area A
- Survey Area B
- Survey Area C
- Claim Boundary
- Other Claim Boundary

NOTES:

Sample Intervals (e.g. 0 - 0.5) are in ft bgs.

Surface gamma measurements were collected using a 3 x 3 inch detector.

Highlighted sample intervals are partially or completely within bedrock

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

TITLE:
Surface and Subsurface Metals and Ra-226 Analytical Results Northeast Quadrant

PROJECT:
Removal Site Evaluation Section 26 Mine Site

DATE: 9/14/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ
REVIEWER: CBB

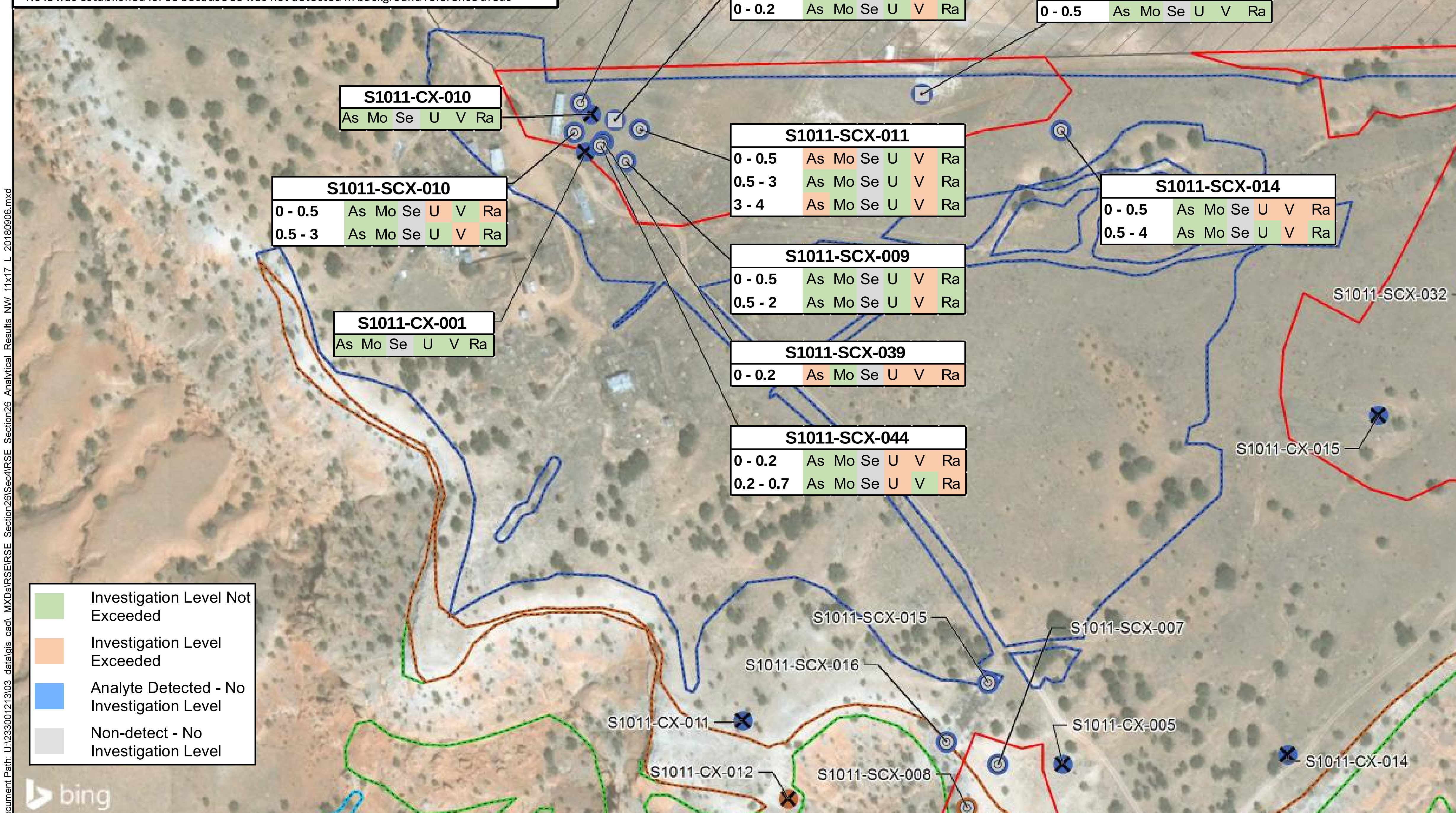
FIGURE: 4-3a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\RSE_Section26\Sec4\RSE_Section26_Analytical_Results_NE_11x17_L_20180906.mxd

Soil and Sediment Investigation Levels					
	Investigation Level				
Analyte (Units)	Survey Area A	Survey Area B	Survey Area C	Survey Area D	Survey Area E
Metals (mg/kg)					
Arsenic	11.9	2.34	4.99	1.76	1.73
Molybdenum	2.26	0.346	0.367	0.210	NA[1]
Selenium	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
Uranium	3.23	3.34	1.91	0.554	0.691
Vanadium	27.3	11.2	17.4	11.0	10.7
Radionuclides (pCi/g)					
Radium-226	2.13	2.96	1.49	1.49	0.839

[1] No IL was established for Mo in Survey Area E because Mo was not detected in background reference area 5 (BG-5)

[2] No IL was established for Se because Se was not detected in background reference areas



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Survey Area A - Surface Sample Location
- Survey Area A - Borehole Surface and Subsurface Sample Location
- Survey Area B - Surface Sample Location
- Survey Area B - Borehole Surface and Subsurface Sample Location
- Survey Area B - Borehole Surface Sample Location
- Survey Area A
- Survey Area B
- Survey Area C
- Survey Area E
- Claim Boundary
- Other Claim Boundary

NOTES:

Sample Intervals (e.g. 0 - 0.5) are in ft bgs.

Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S

0 200 400

Feet

TITLE:

Surface and Subsurface Metals and Ra-226 Analytical Results Northwest Quadrant

PROJECT:

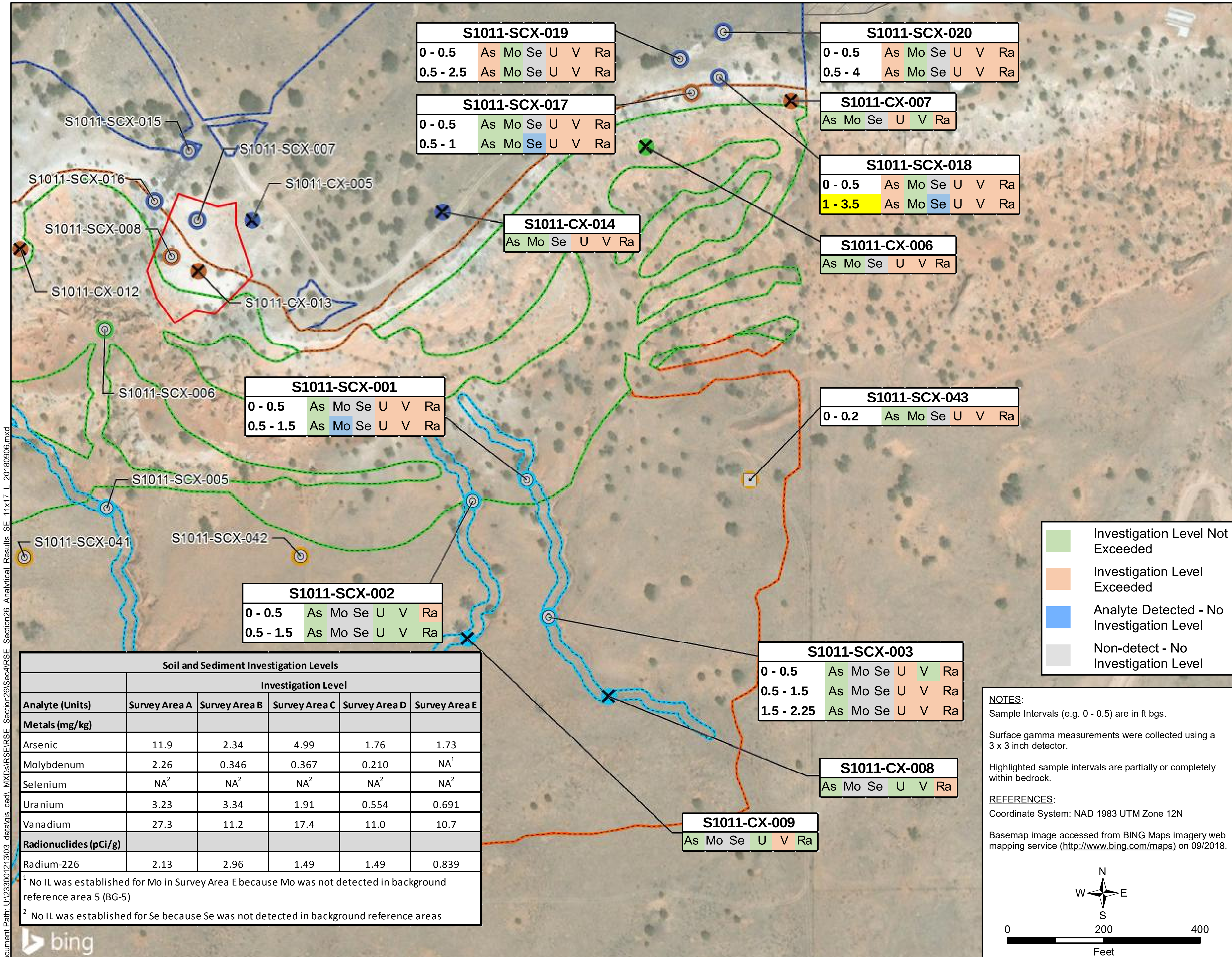
Removal Site Evaluation Section 26 Mine Site

DATE:	DOCUMENT NAME:
9/6/2018	Removal Site Evaluation Report

Stantec

AUTHOR:	REVIEWER:
EDZ	CBB

FIGURE: 4-3b



Soil and Sediment Investigation Levels

Analyte (Units)	Survey Area A	Survey Area B	Survey Area C	Survey Area D	Survey Area E
	Investigation Level				
Metals (mg/kg)					
Arsenic	11.9	2.34	4.99	1.76	1.73
Molybdenum	2.26	0.346	0.367	0.210	NA[1]
Selenium	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
Uranium	3.23	3.34	1.91	0.554	0.691
Vanadium	27.3	11.2	17.4	11.0	10.7
Radionuclides (pCi/g)					
Radium-226	2.13	2.96	1.49	1.49	0.839

[1] No IL was established for Mo in Survey Area E because Mo was not detected in background reference area 5 (BG-5)

[2] No IL was established for Se because Se was not detected in background reference areas

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Survey Area A - Surface Sample Location
- Survey Area A - Borehole Location - Surface and Subsurface Samples
- Survey Area B - Surface Sample Location
- Survey Area B - Borehole Location - Surface and Subsurface Samples
- Survey Area C - Surface Sample Location
- Survey Area C - Borehole Location - Surface and Subsurface Samples
- Survey Area D - Borehole Location - Surface and Subsurface Samples
- Survey Area D - Borehole Location - Surface Samples Only
- Survey Area E - Surface Sample Location
- Survey Area E - Borehole Location - Surface and Subsurface Samples
- Survey Area A
- Survey Area B
- Survey Area C
- Survey Area D
- Survey Area E
- Claim Boundary
- Other Claim Boundary

NOTES:
Sample Intervals (e.g. 0 - 0.5) are in ft bgs.

Surface gamma measurements were collected using a 3 x 3 inch detector.

Highlighted sample intervals are partially or completely within bedrock.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

TITLE: Surface and Subsurface Metals and Ra-226 Analytical Results Southeast Quadrant

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 9/17/2018

DOCUMENT NAME: Removal Site Evaluation Report

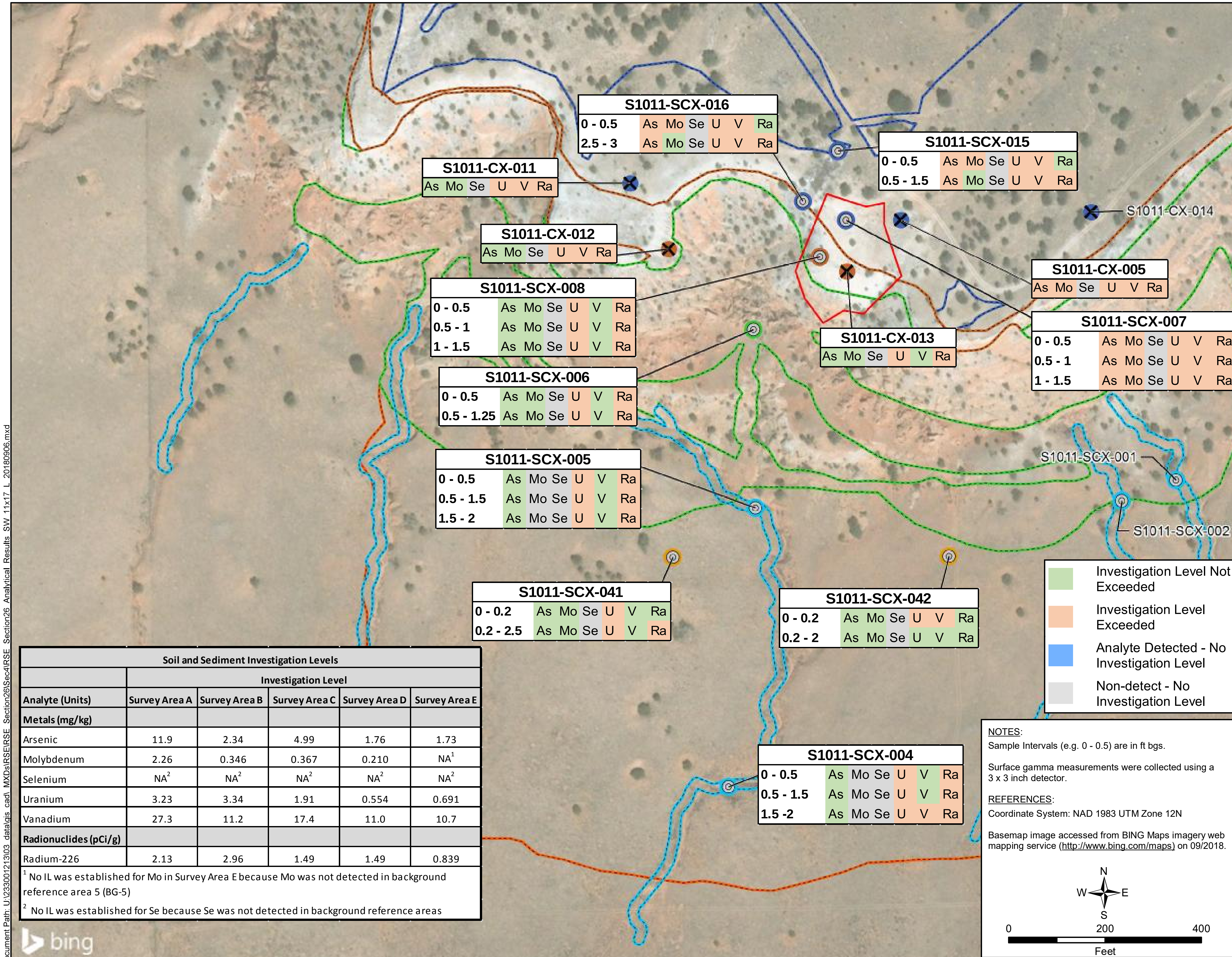
Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-3c

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Analytical_Results_SE_11x17_L_20180906.mxd



Soil and Sediment Investigation Levels

Analyte (Units)	Investigation Level				
	Survey Area A	Survey Area B	Survey Area C	Survey Area D	Survey Area E
Metals (mg/kg)					
Arsenic	11.9	2.34	4.99	1.76	1.73
Molybdenum	2.26	0.346	0.367	0.210	NA[1]
Selenium	NA[2]	NA[2]	NA[2]	NA[2]	NA[2]
Uranium	3.23	3.34	1.91	0.554	0.691
Vanadium	27.3	11.2	17.4	11.0	10.7
Radionuclides (pCi/g)					
Radium-226	2.13	2.96	1.49	1.49	0.839

[1] No IL was established for Mo in Survey Area E because Mo was not detected in background reference area 5 (BG-5)

[2] No IL was established for Se because Se was not detected in background reference areas

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Survey Area A - Surface Sample Location
- Survey Area A - Borehole Location - Surface and Subsurface Samples
- Survey Area B - Surface Sample Location
- Survey Area B - Borehole Location - Surface and Subsurface Samples
- Survey Area C - Borehole Location - Surface and Subsurface Samples
- Survey Area D - Borehole Location - Surface and Subsurface Samples
- Survey Area E - Surface Sample Location
- Survey Area E - Borehole Location - Surface and Subsurface Samples
- Survey Area A
- Survey Area B
- Survey Area C
- Survey Area D
- Survey Area E
- Claim Boundary

NOTES:
Sample Intervals (e.g. 0 - 0.5) are in ft bgs.

Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

TITLE: Surface and Subsurface Metals and Ra-226 Analytical Results Southwest Quadrant

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 9/17/2018

DOCUMENT NAME: Removal Site Evaluation Report

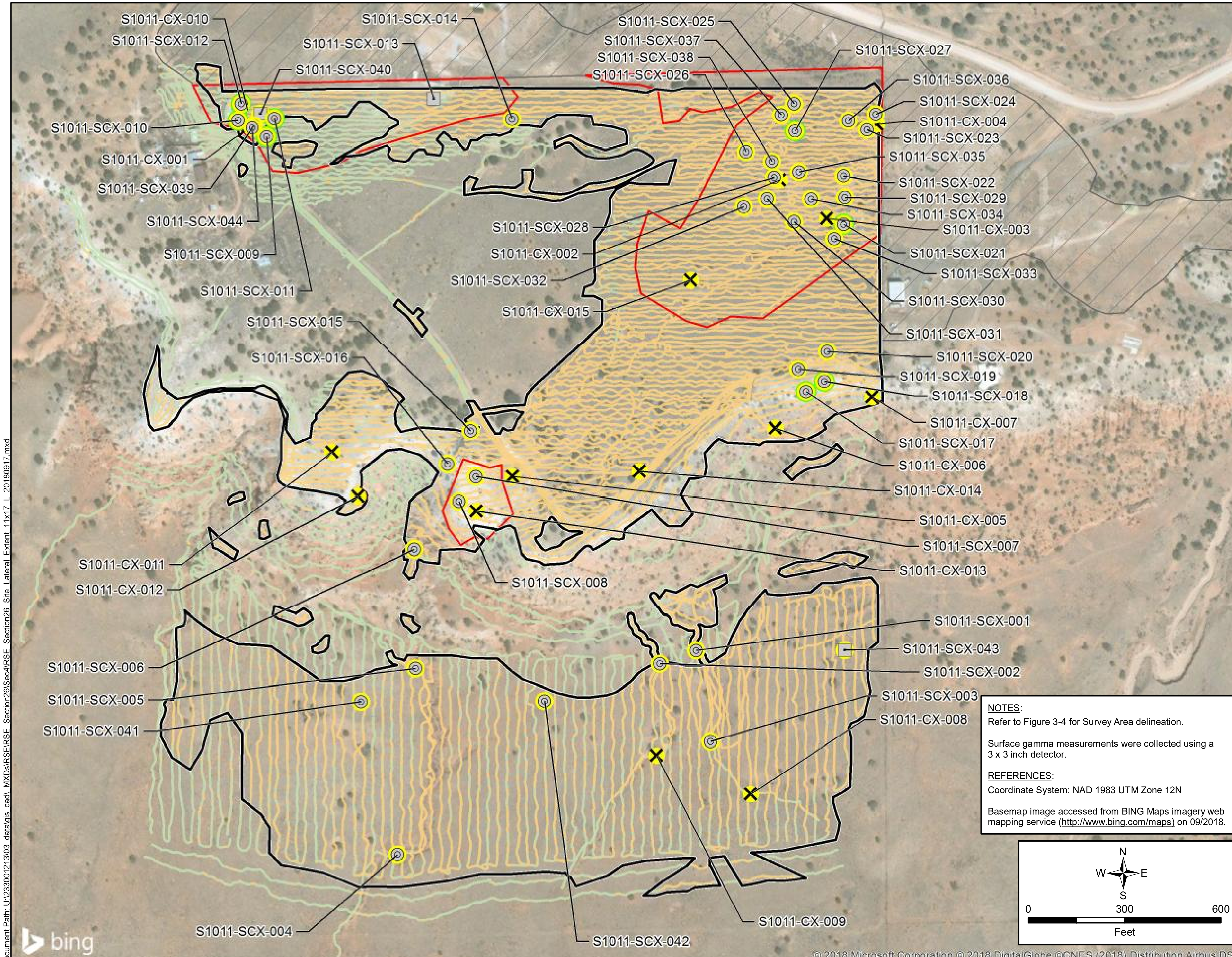
Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-3d

Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Analytical_Results_SW_11x17_L_20180906.mxd



NOTES:
Refer to Figure 3-4 for Survey Area delineation.

Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- IL Exceedance in Unconsolidated Material at Location
- IL Exceedance in Bedrock in Borehole
- Approximate Area where Surface Gamma ILs are Exceeded (69.7 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

IL Not Exeeded
Survey Area A: 11,058 - 16,829
Survey Area B: 8,652 - 23,320
Survey Area C: 11,527 - 48,542
Survey Area D: 12,476 - 20,637
Survey Area E: 12,001 - 21,864

IL Exceeded
Survey Area A: 16,830 - 654,837
Survey Area B: 23,321 - 633,057
Survey Area C: 48,543 - 749,127
Survey Area D: 20,638 - 62,220
Survey Area E: 21,865 - 117,575

TITLE:
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/17/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 4-4a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_Lateral_Extent_11x17_L_20180917.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- IL Exceedance in Unconsolidated Material at Location
- IL Exceedance in Bedrock in Borehole
- Approximate Area where Surface Gamma IL is Exceeded (3.0 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 11,058 - 16,829 (IL Not Exeeded)
- 16,830 - 654,837 (IL Exceeded)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

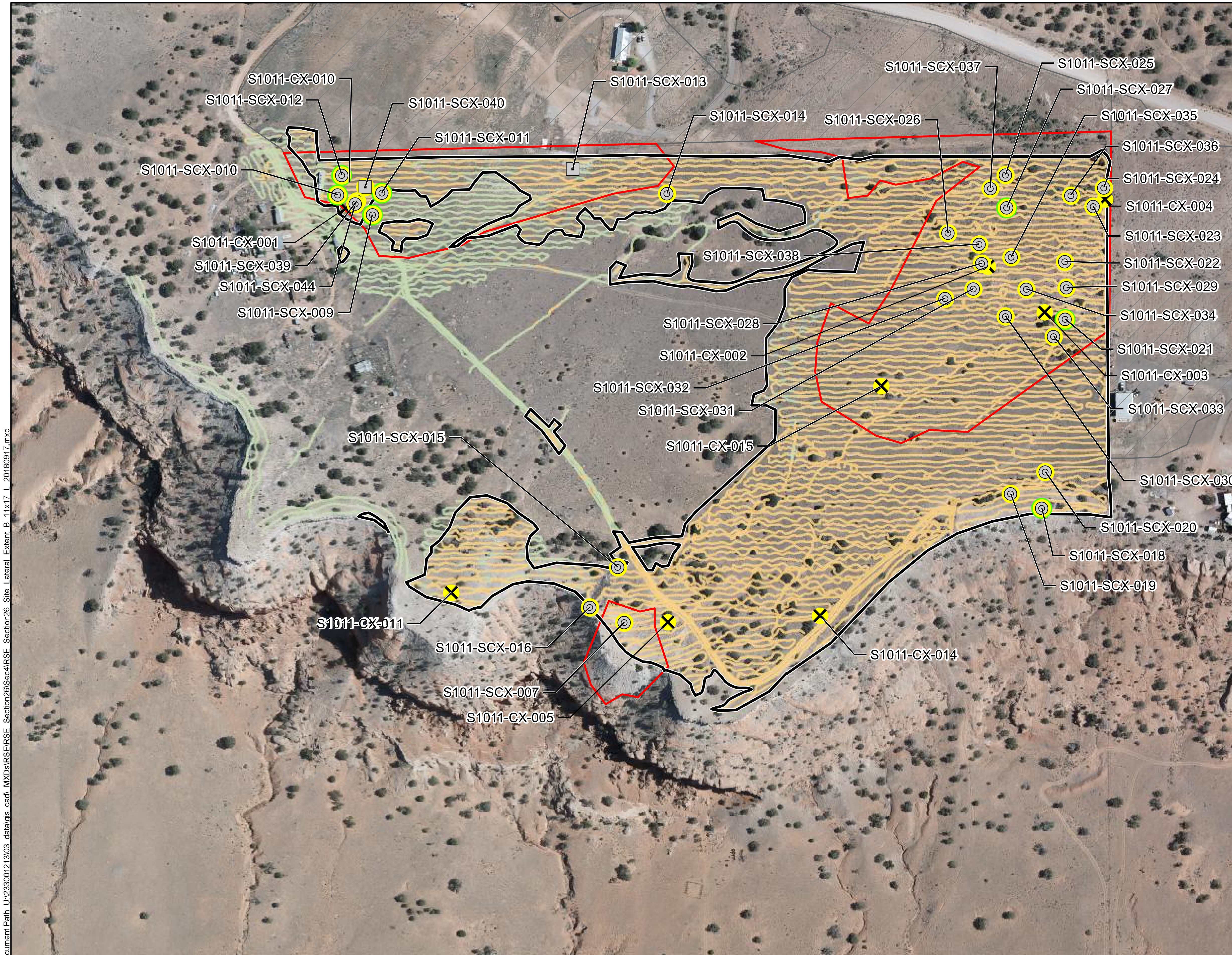
0 200 400
Feet

TITLE:
Survey Area A
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/17/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-4b	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_Lateral_Extent_A_11x17_L_20180917.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- IL Exceedance in Unconsolidated Material at Location
- IL Exceedance in Bedrock in Borehole
- Approximate Area where Surface Gamma IL is Exceeded (30.9 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)
- 8,652 - 23,320 (IL Not Exeeded)
- 23,321 - 633,057 (IL Exceeded)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 250 500
Feet

TITLE:
Survey Area B
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/17/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-4c	

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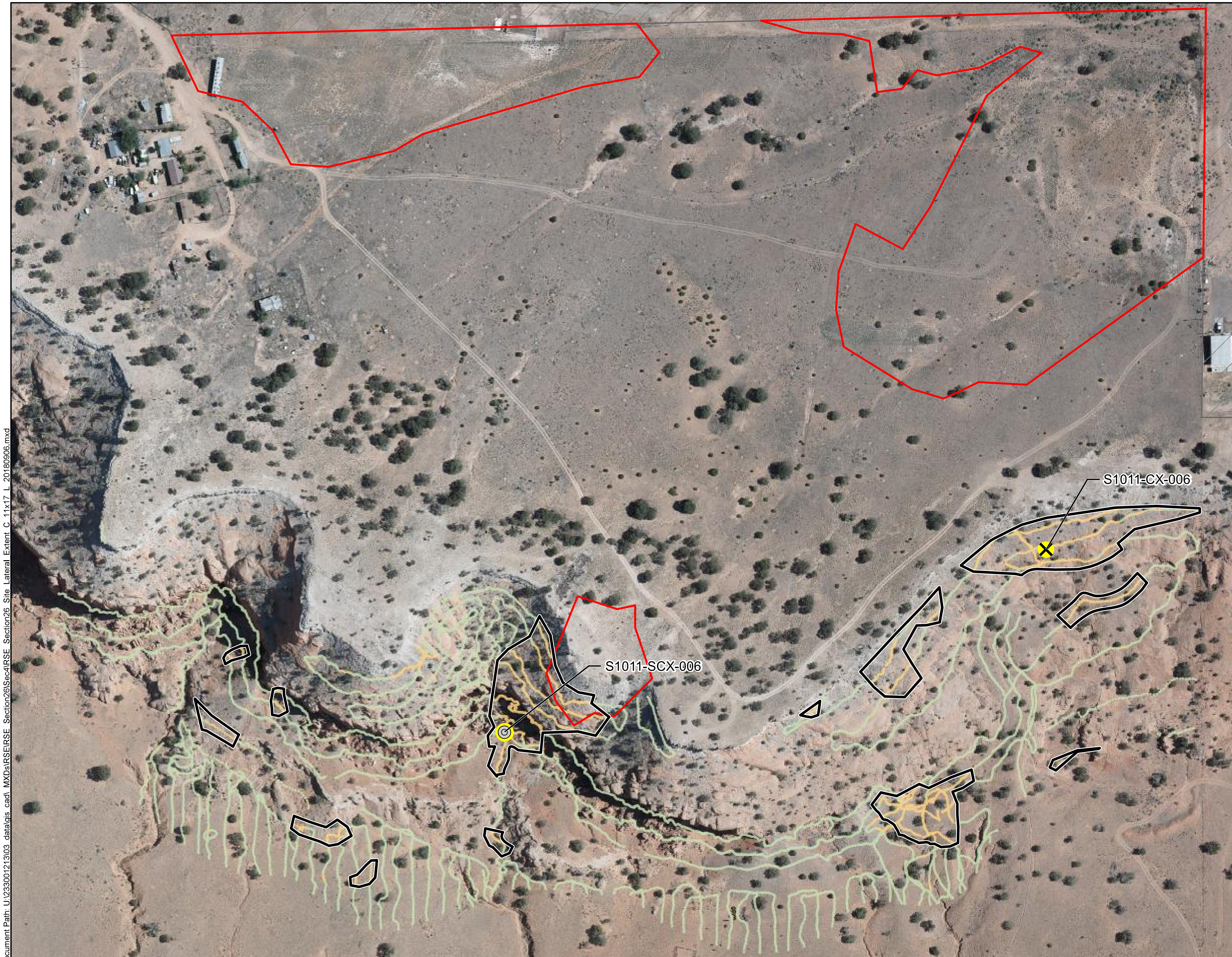

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma IL is Exceeded (2.9 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 11,527 - 48,542 (IL Not Exeeded)
- 48,543 - 749,127 (IL Exceeded)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 200 400
Feet

TITLE:
Survey Area C
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/17/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-4d

Stantec

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma IL is Exceeded (31.6 acres)
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)
- 12,476 - 20,637 (IL Not Exeeded)
- 20,638 - 62,220 (IL Exceeded)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S

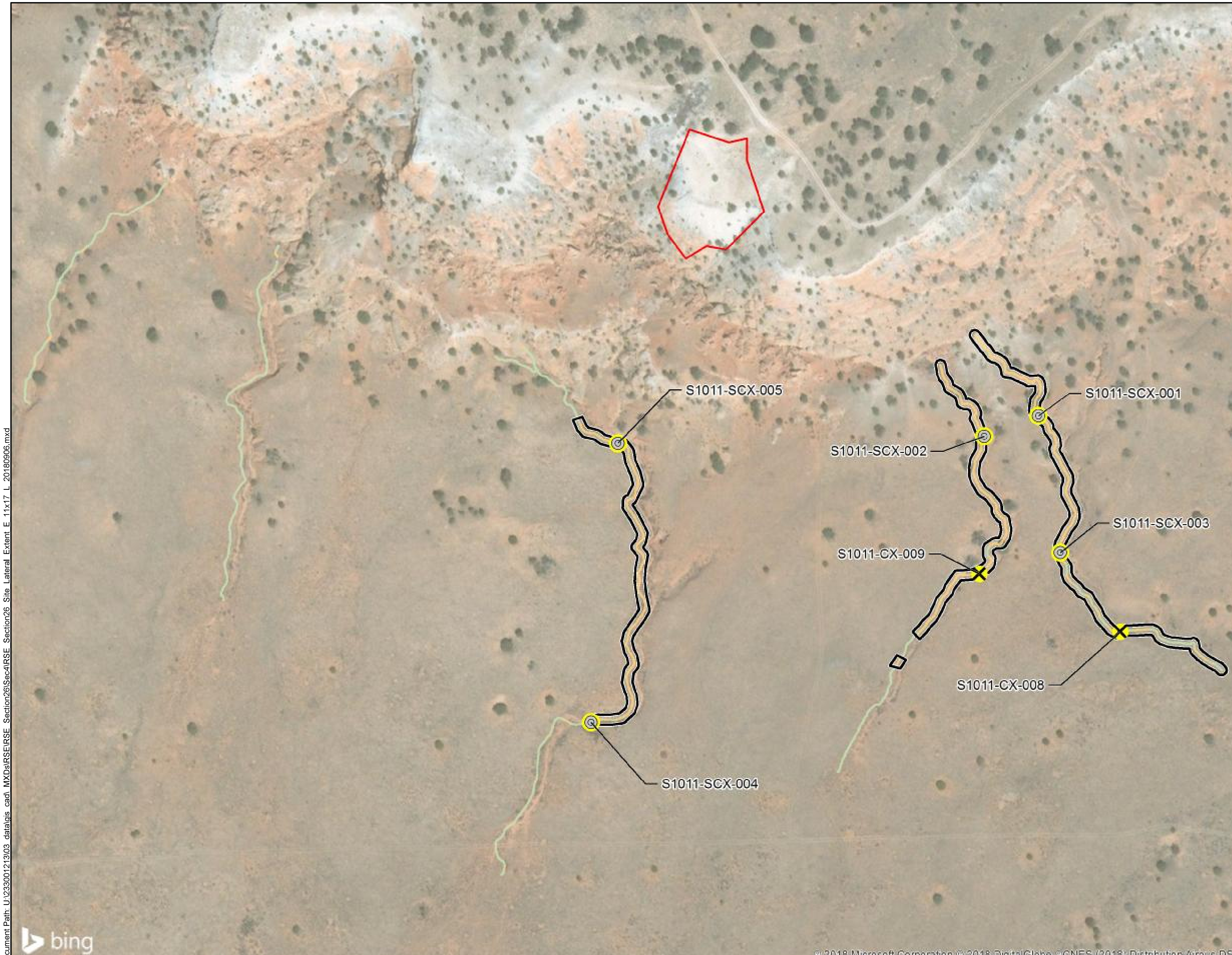
0 200 400
Feet

TITLE: Survey Area D
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT: Removal Site Evaluation
Section 26 Mine Site

DATE: 9/18/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-4e	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_Lateral_Extent_D_11x17_L_20180906.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma IL is Exceeded (1.3 acres)
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)
- 12,001 - 21,864 (IL Not Exeeded)
- 21,865 - 117,575 (IL Exceeded)

NOTE:
Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S

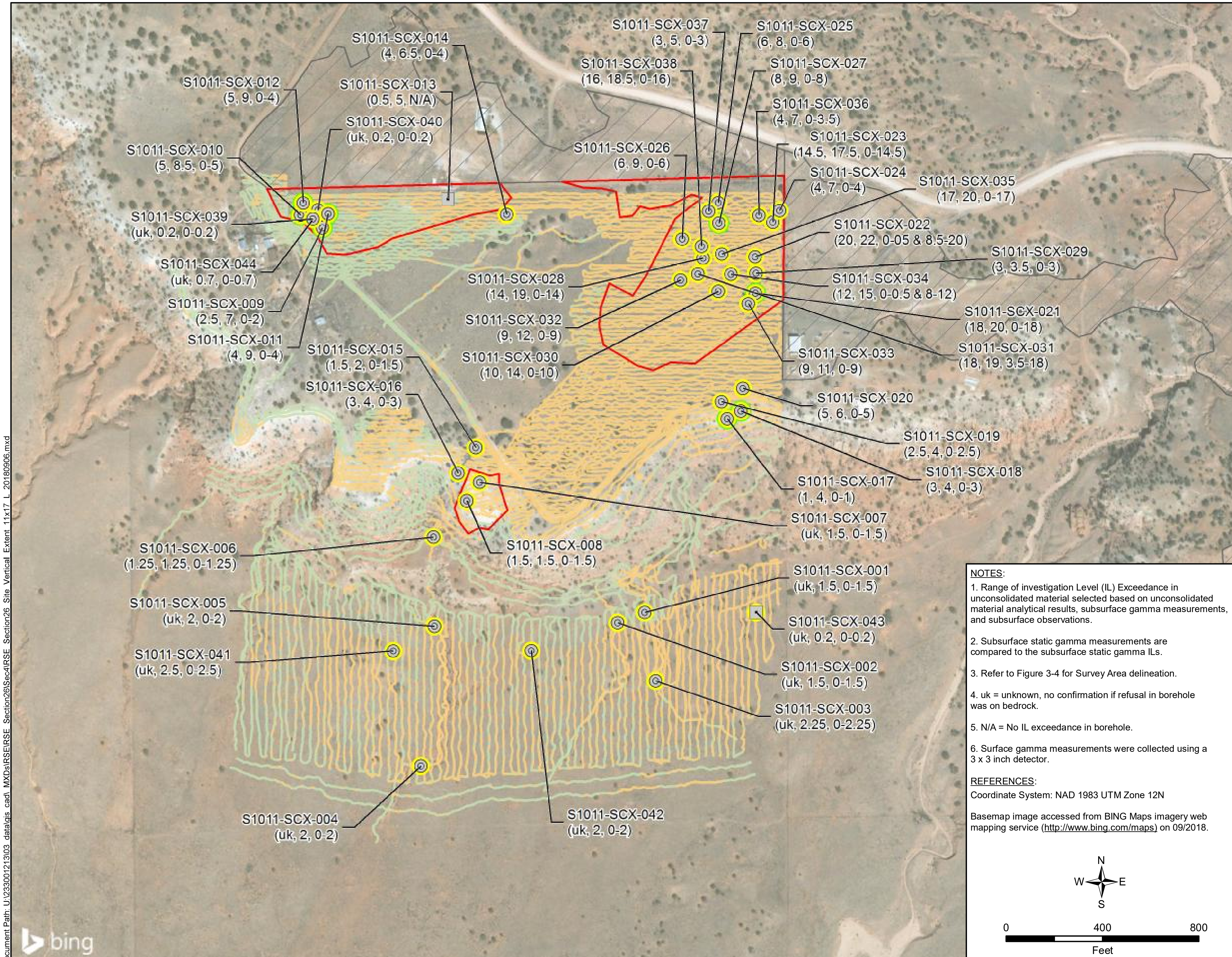
0 200 400
Feet

TITLE:
Survey Area E
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/18/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-4f	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_Lateral_Extent_E_11x17_L_20180906.mxd



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NOTES:

1. Range of investigation Level (IL) Exceedance in unconsolidated material selected based on unconsolidated material analytical results, subsurface gamma measurements, and subsurface observations.

2. Subsurface static gamma measurements are compared to the subsurface static gamma ILs.

3. Refer to Figure 3-4 for Survey Area delineation.

4. uk = unknown, no confirmation if refusal in borehole was on bedrock.

5. N/A = No IL exceedance in borehole.

6. Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Borehole Surface and Subsurface Sample Location (Depth of Bedrock, Borehole Depth, Depth Range of IL Exceedance in Unconsolidated Material[1])
- Borehole Surface Sample Location (Depth of Bedrock, Borehole Depth, Depth Range of IL Exceedance in Unconsolidated Material[1])
- IL Exceedance in Unconsolidated Material at Location
- IL Exceedance in Bedrock in Borehole
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

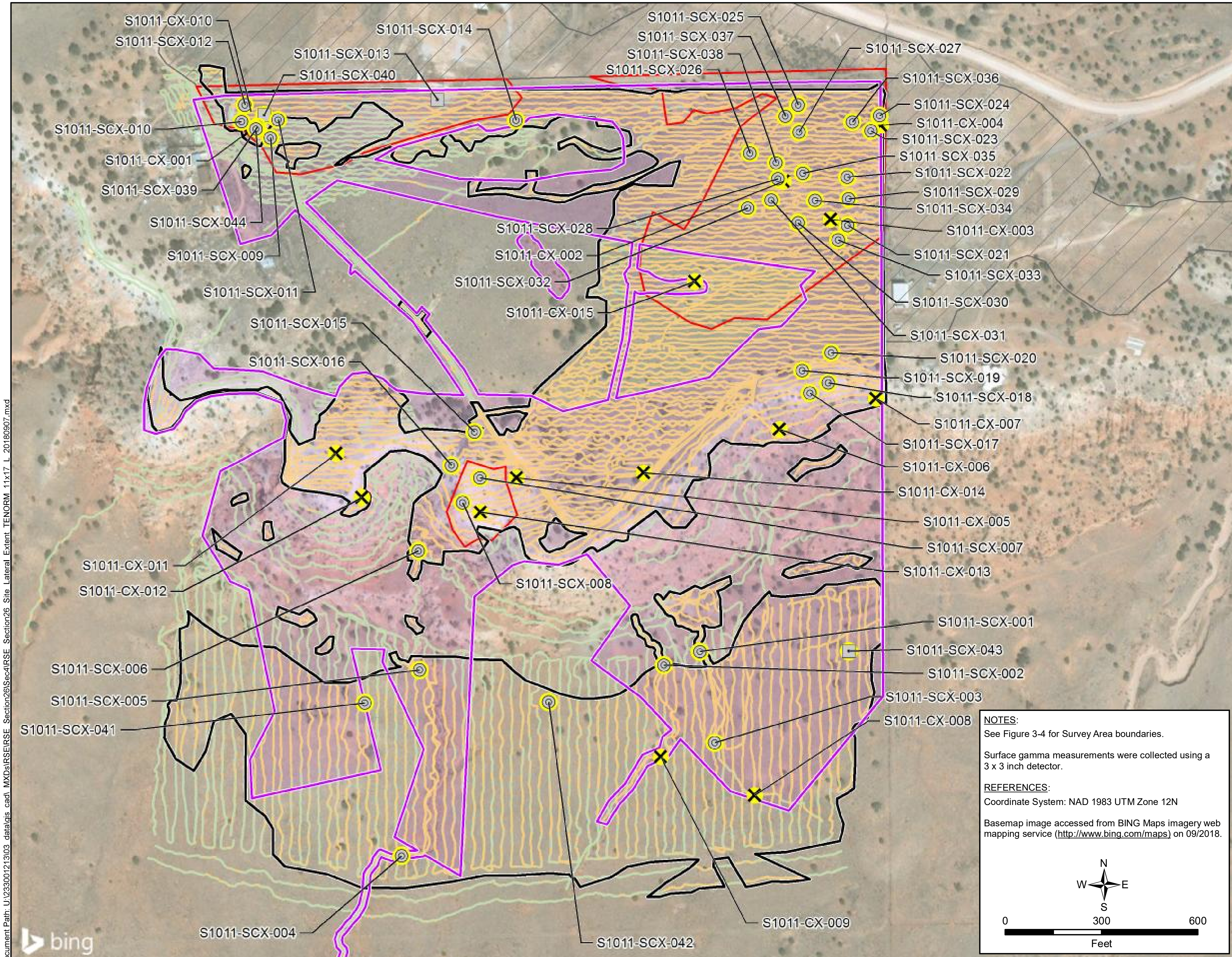
IL Not Exeeded
Survey Area A: 11,058 - 16,829
Survey Area B: 8,652 - 23,320
Survey Area C: 11,527 - 48,542
Survey Area D: 12,476 - 20,637
Survey Area E: 12,001 - 21,864

IL Exceeded
Survey Area A: 16,830 - 654,837
Survey Area B: 23,321 - 633,057
Survey Area C: 48,543 - 749,127
Survey Area D: 20,638 - 62,220
Survey Area E: 21,865 - 117,575

TITLE:
Vertical Extent of IL Exceedances in Unconsolidated Material

PROJECT:
Removal Site Evaluation Section 26 Mine Site

DATE:	DOCUMENT NAME:	
9/20/2018	Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-5	



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- IL Exceedance in Unconsolidated Material at Location
- TENORM (72.2 acres)
- Approximate Area where Surface Gamma IL is Exceeded (69.7 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

IL Not Exeeded
Survey Area A: 11058 - 16829
Survey Area B: 8652 - 23320
Survey Area C: 11527 - 48542
Survey Area D: 12476 - 20637
Survey Area E: 12001 - 21864

IL Exceeded
Survey Area A: 16830 - 654837
Survey Area B: 23321 - 633057
Survey Area C: 48543 - 749127
Survey Area D: 20638 - 62220
Survey Area E: 21865 - 117575

NOTES:
See Figure 3-4 for Survey Area boundaries.

Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N
W E
S

0 300 600
Feet

TITLE:
TENORM Compared to Lateral Extent of IL Exceedances

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/20/2018

DOCUMENT NAME: Removal Site Evaluation Report

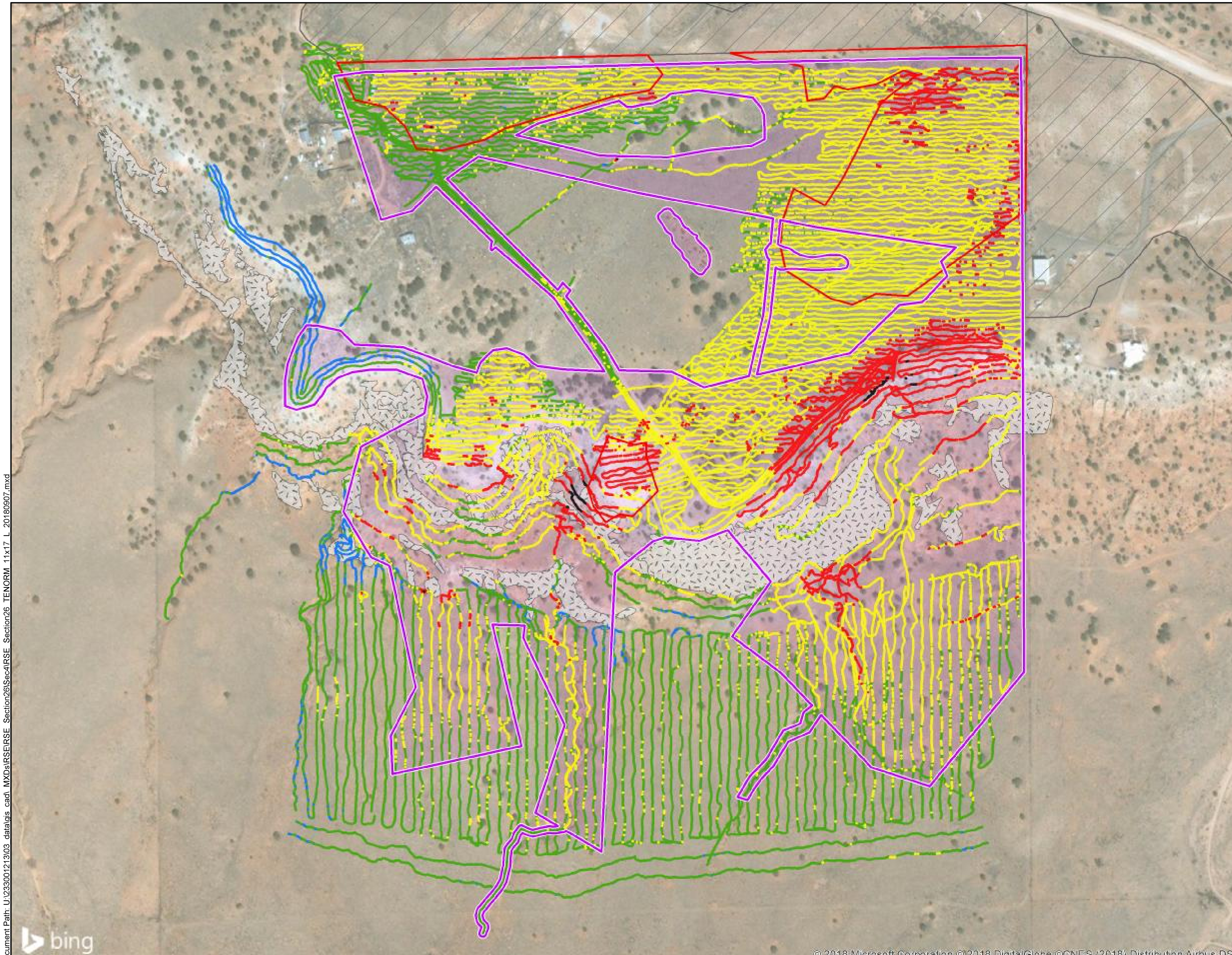
AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 4-6

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_Lateral_Extent_TENORM_11x17_L_20180907.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

TENORM (72.2 acres)
Exposed Bedrock[1]
Claim Boundary
Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 8,652 - 16,829 (Minimum to BG-1 IL)
- 16,830 - 23,320 (>BG-1 IL to BG-2 IL)
- 23,321 - 46,640 (>BG-2 IL to 2x BG-2 IL)
- 46,641 - 233,200 (>2x BG-2 IL to 10x BG-2 IL)
- 233,201 - 749,127 (>10x BG-2 IL to Maximum)

NOTES:

1. Portions of the areas delineated as exposed bedrock contain small amounts of colluvium.

2. Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S

0 300 600
Feet

TITLE:
TENORM Compared to Gamma Radiation Survey Results

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/20/2018

DOCUMENT NAME: Removal Site Evaluation Report

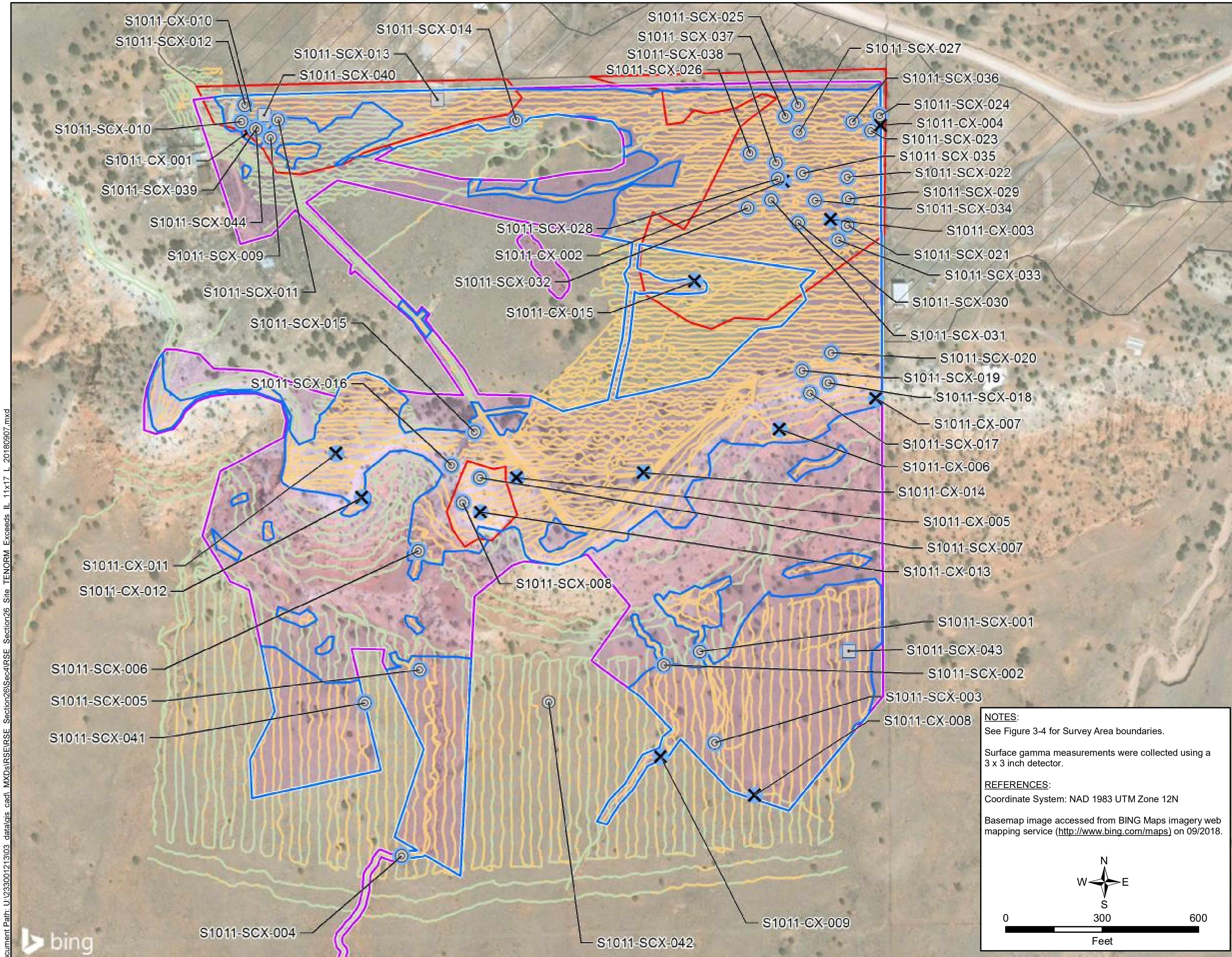
Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-7

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_TENORM_11x17_L_20180907.mxd



NOTES:
See Figure 3-4 for Survey Area boundaries.

Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S

0 300 600
Feet

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (45.2 acres)
- TENORM (72.2 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

IL Not Exeeded
Survey Area A: 11058 - 16829
Survey Area B: 8652 - 23320
Survey Area C: 11527 - 48542
Survey Area D: 12476 - 20637
Survey Area E: 12001 - 21864

IL Exceeded
Survey Area A: 16830 - 654837
Survey Area B: 23321 - 633057
Survey Area C: 48543 - 749127
Survey Area D: 20638 - 62220
Survey Area E: 21865 - 117575

TITLE:
TENORM that Exceed ILs

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/20/2018

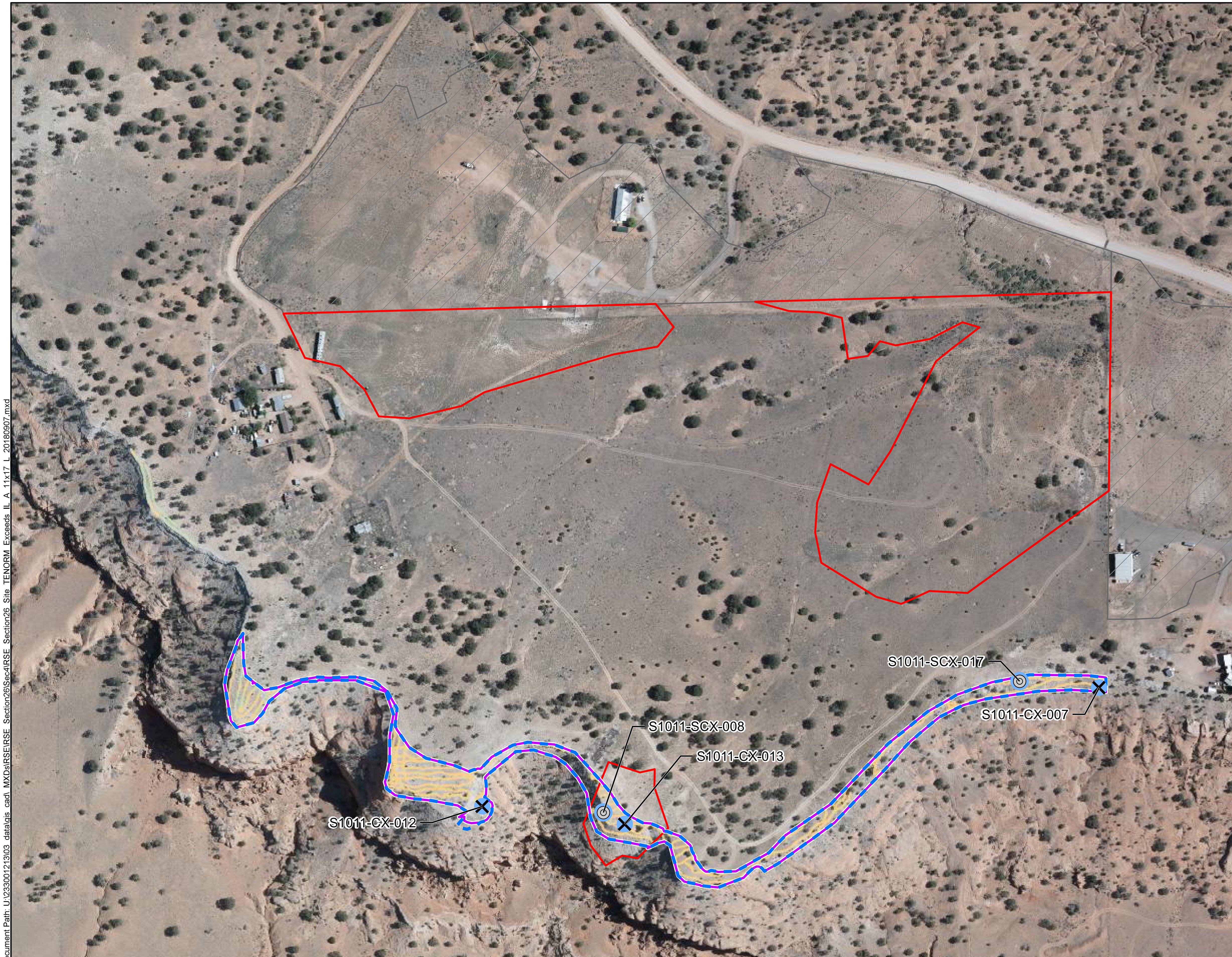
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-8a



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (3.0 acres)
- Area of Survey Area A that is TENORM (3.0 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 11,058 - 16,829 (IL Not Exeeded)
- 16,830 - 654,837 (IL Exceeded)

NOTES:
1. Gamma Survey Area A is approximately 3.3 acres.
2. Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 250 500
Feet

TITLE:
Survey Area A
TENORM that Exceed ILs

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

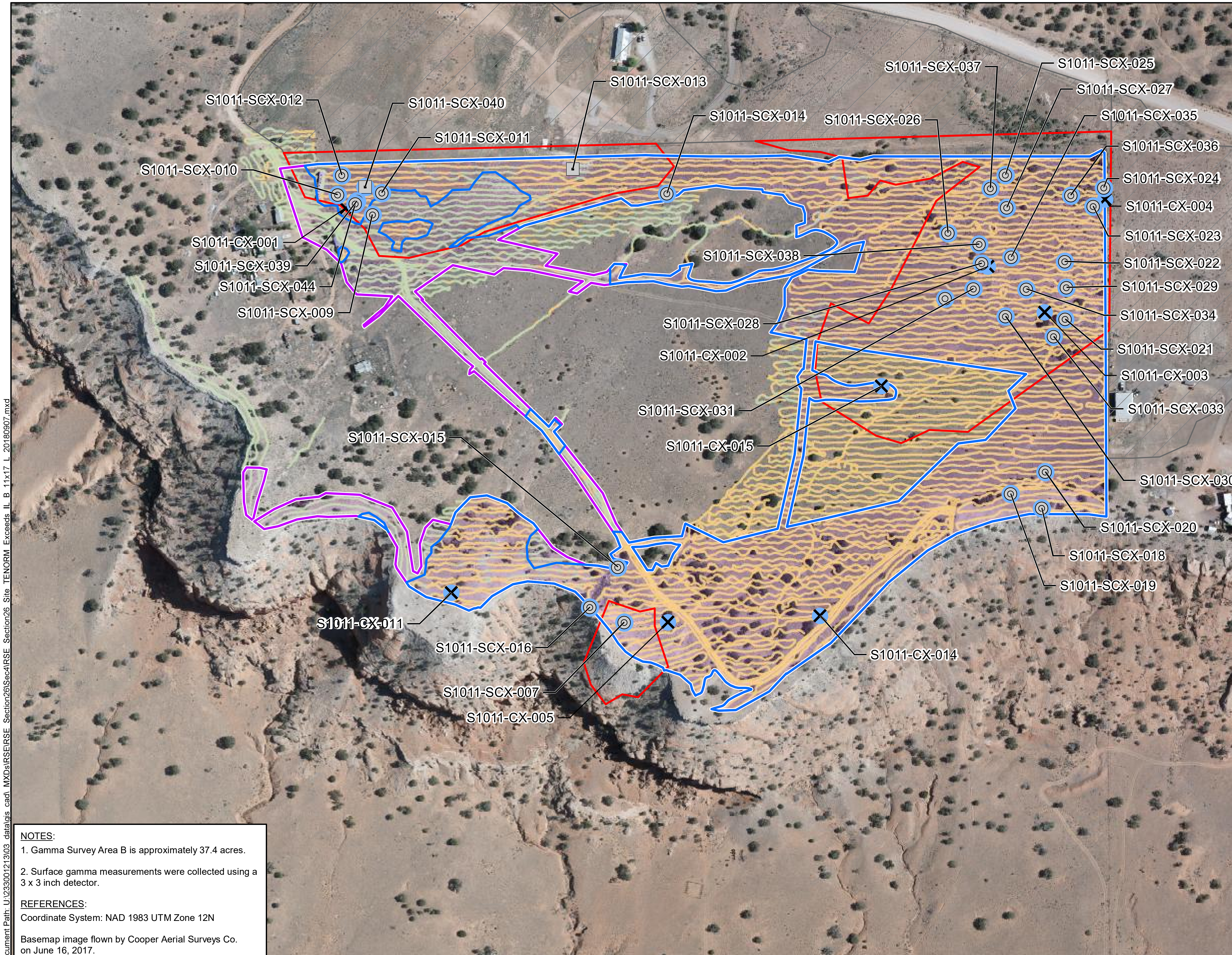
AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 4-8b

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_TENORM_Exceeds_IL_A_11x17_L_20180907.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (24.7 acres)
- Area of Survey Area B that is TENORM (28.9 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 8,652 - 23,320 (IL Not Exeeded)
- 23,321 - 633,057 (IL Exceeded)

NOTES:

1. Gamma Survey Area B is approximately 37.4 acres.
2. Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_TENORM_Exceeds_IL_B_11x17_L_20180907.mxd

TITLE: Survey Area B TENORM that Exceed ILs

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 9/20/2018

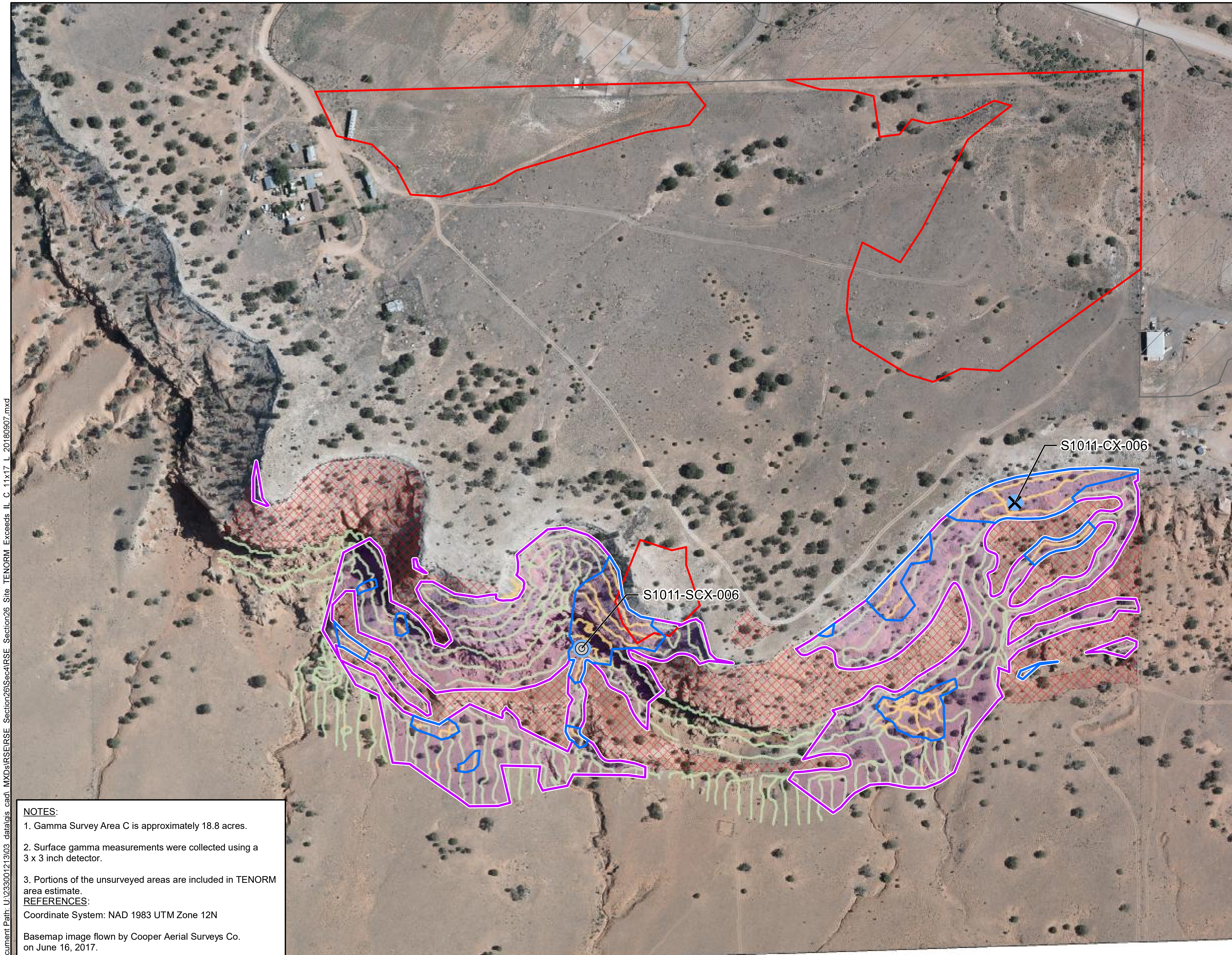
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-8c



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samplea
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (2.9 acres)
- Area of Survey Area C that is TENORM (15.0 acres)
- Unsurveyed Area (10.1 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 11,527 - 48,542 (IL Not Exeeded)
- 48,543 - 749,127 (IL Exceeded)

N W E S

0 250 500
Feet

NOTES:
1. Gamma Survey Area C is approximately 18.8 acres.

2. Surface gamma measurements were collected using a 3 x 3 inch detector.

3. Portions of the unsurveyed areas are included in TENORM area estimate.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

TITLE:
Survey Area C
TENORM that Exceed ILs

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/20/2018

DOCUMENT NAME: Removal Site Evaluation Report

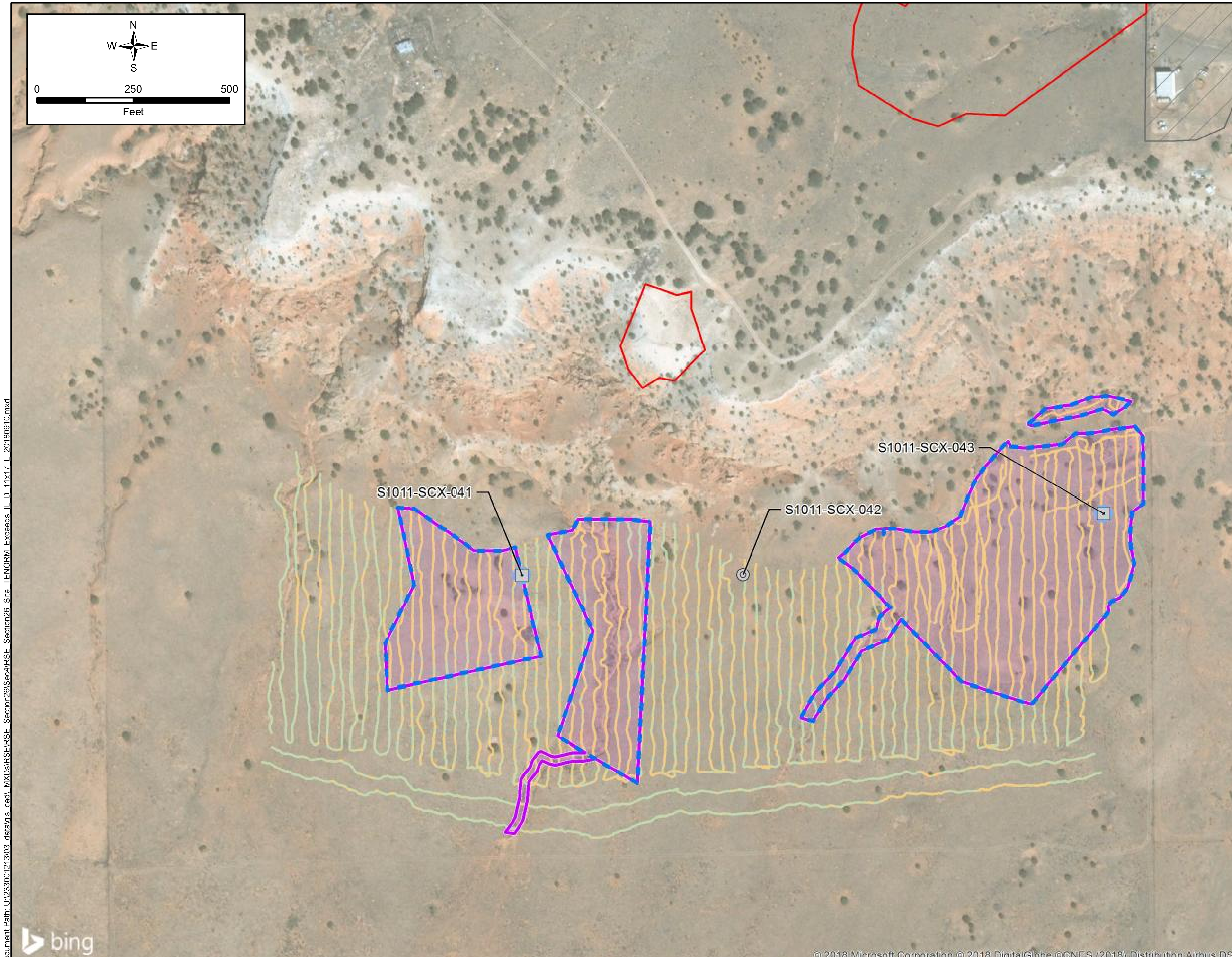
AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: 4-8d

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_TENORM_Exceeds_IL_C_11x17_L_20180907.mxd



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NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (13.4 acres)
- Area of Survey Area D that is TENORM (13.6 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

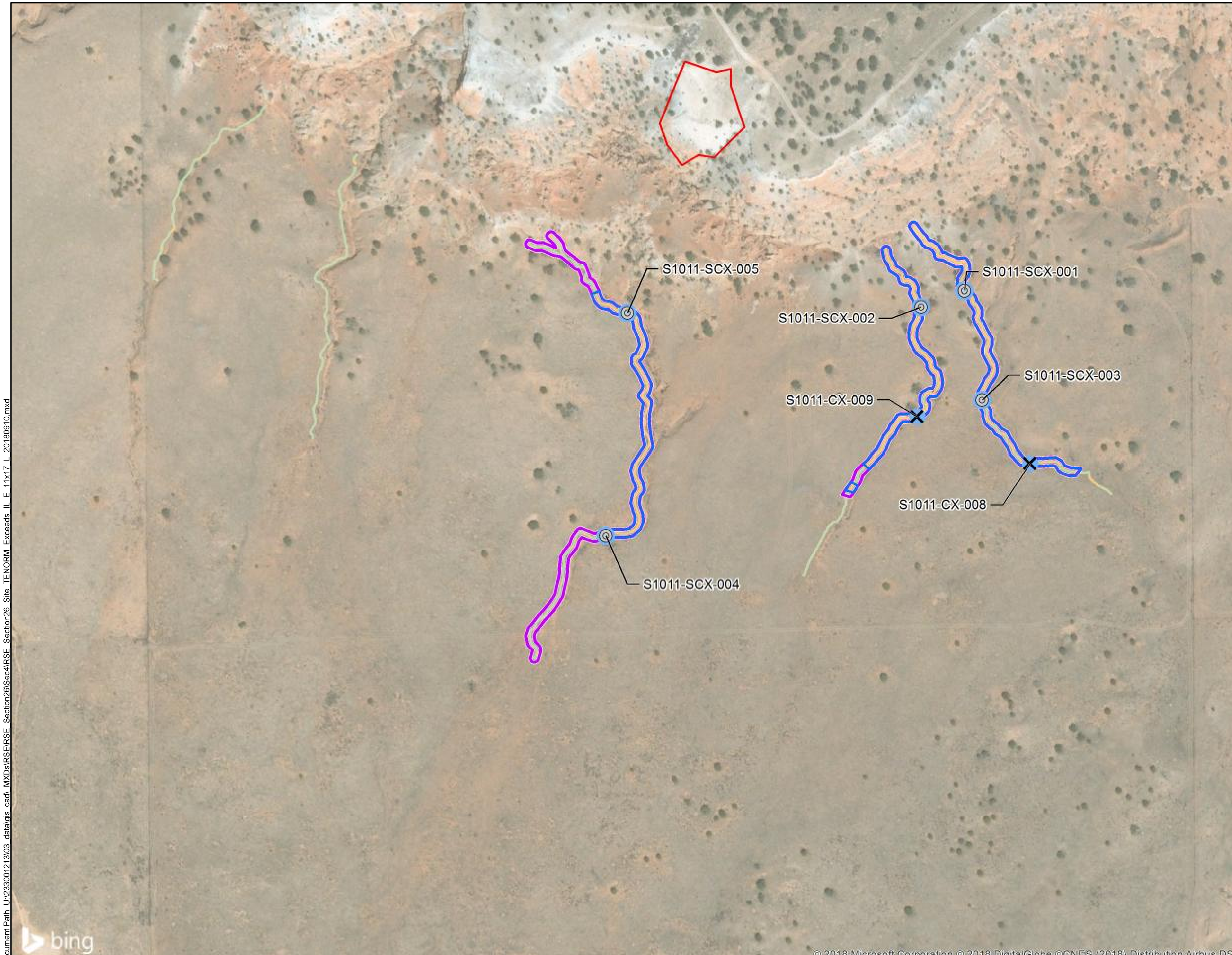
Counts per Minute (CPM)
- 12,476 - 20,637 (IL Not Exeeded)
- 20,638 - 62,220 (IL Exceeded)

NOTES:
1. Gamma Survey Area D is approximately 38.8 acres.
2. Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

TITLE:	Survey Area D TENORM that Exceed ILs
PROJECT:	Removal Site Evaluation Section 26 Mine Site
DATE: 9/20/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: EDZ; REVIEWER: CBB
	FIGURE: 4-8e



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NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (1.2 acres)
- Area of Survey Area E that is TENORM (1.6 acres)
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 12,001 - 21,864 (IL Not Exeeded)
- 21,865 - 117,575 (IL Exceeded)

NOTES:
1. Gamma Survey Area E is approximately 2.1 acres.
2. Surface gamma measurements were collected using a 3 x 3 inch detector.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N W E S

0 250 500
Feet

TITLE:
Survey Area E
TENORM that Exceed ILs

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/20/2018

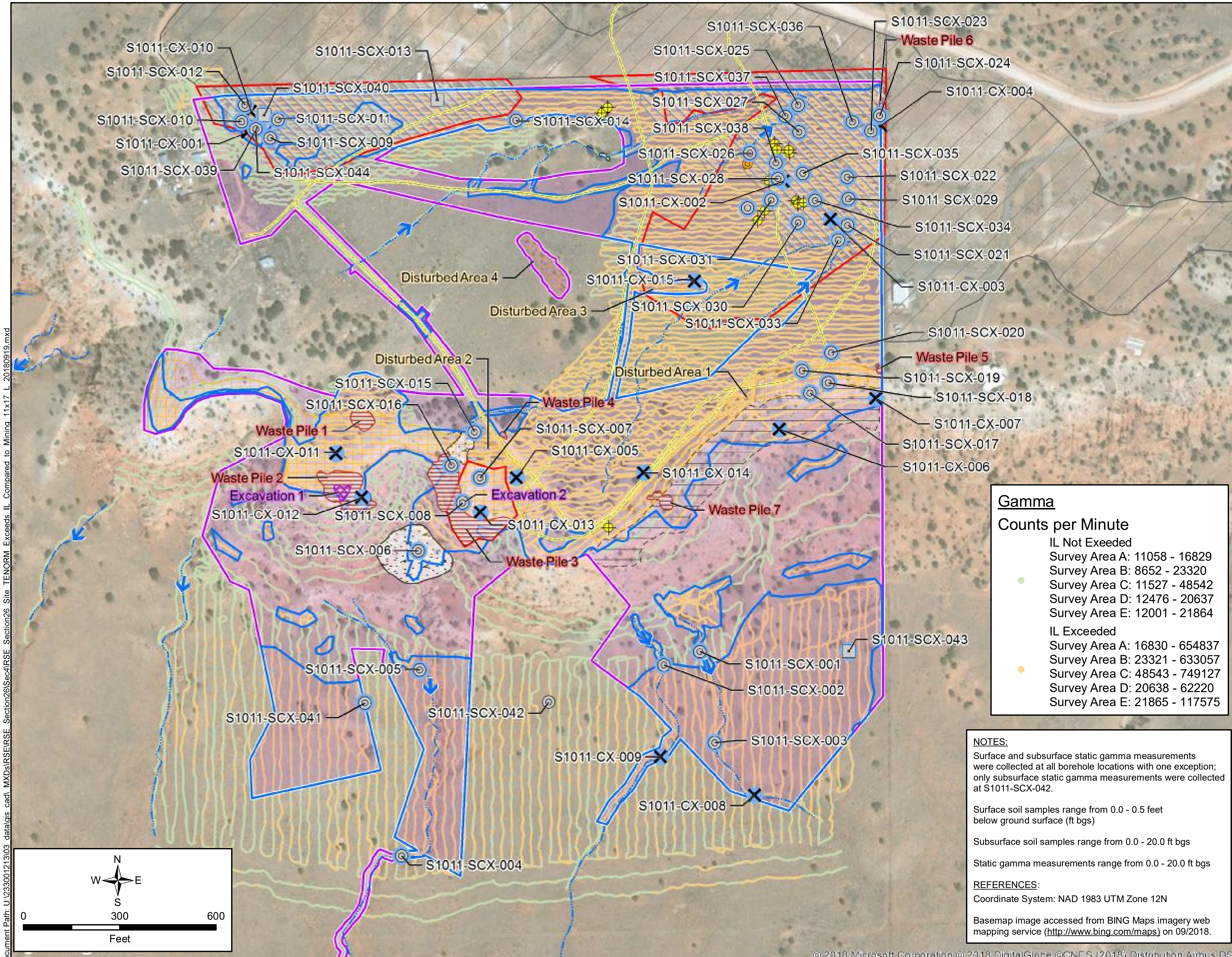
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 4-8f



Gamma

Counts per Minute

IL Not Exeeded
Survey Area A: 11058 - 16829
Survey Area B: 8652 - 23320
Survey Area C: 11527 - 48542
Survey Area D: 12476 - 20637
Survey Area E: 12001 - 21864

IL Exceeded
Survey Area A: 16830 - 654837
Survey Area B: 23321 - 633057
Survey Area C: 48543 - 749127
Survey Area D: 20638 - 62220
Survey Area E: 21865 - 117575

NOTES:

Surface and subsurface static gamma measurements were collected at all borehole locations with one exception; only subsurface static gamma measurements were collected at S1011-SCX-042.

Surface soil samples range from 0.0 - 0.5 feet below ground surface (ft bgs)

Subsurface soil samples range from 0.0 - 20.0 ft bgs

Static gamma measurements range from 0.0 - 20.0 ft bgs

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

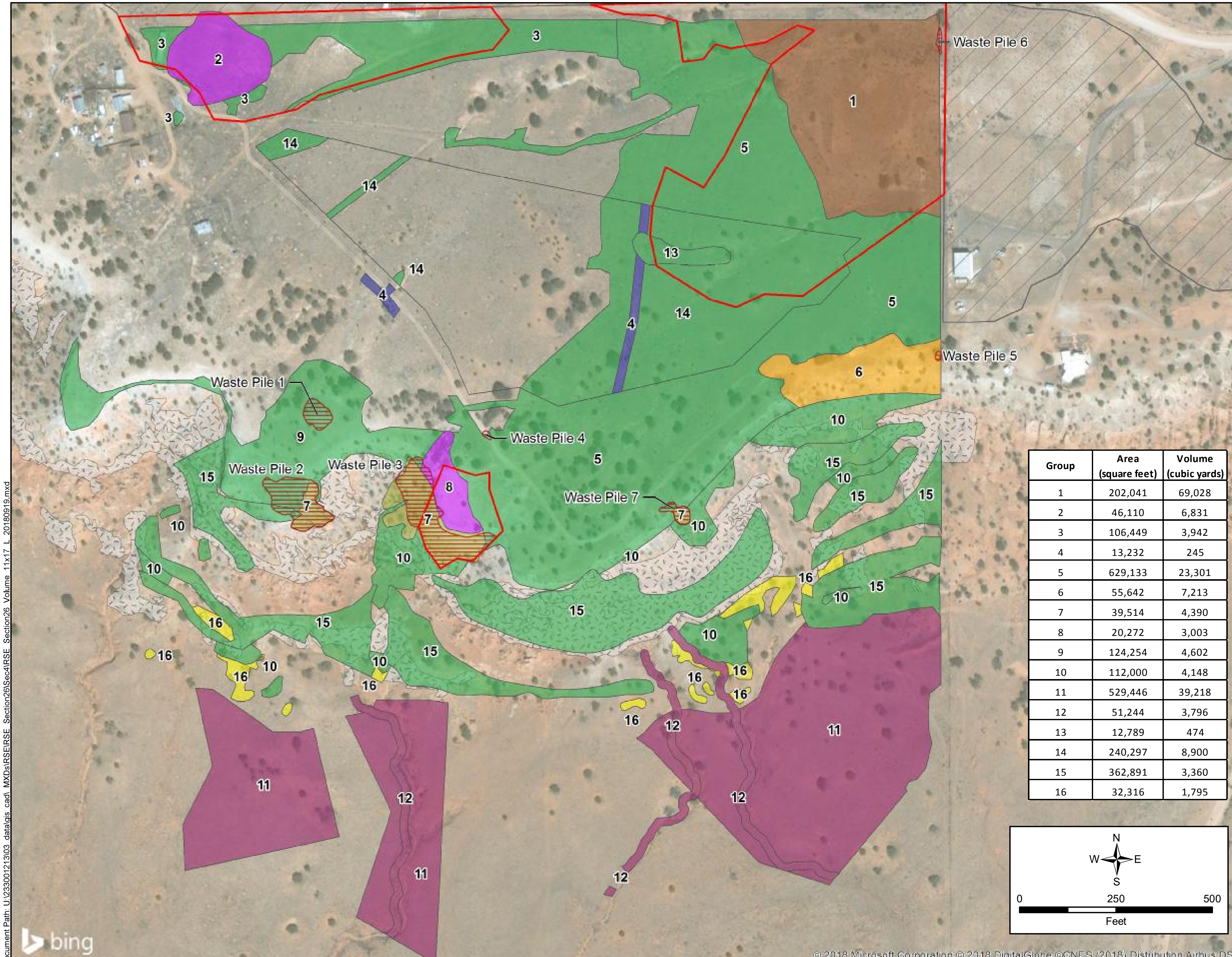
- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- TENORM Exceeding IL in Unconsolidated Material at Location
- Flow Direction
- Possible Portal or Storage
- Historical Borehole
- Potential Haul Road
- Drainage
- Debris
- Excavation
- Graded / Disturbed Reclaimed Area
- Potential Mining Disturbed
- Potential Waste Rock
- Waste Pile
- Vertical Mine Shafts
- TENORM Area Exceeding Surface Gamma ILs (45.2 acres)
- TENORM (72.2 acres)
- Claim Boundary
- Other Claim Boundary

TITLE:
TENORM that Exceed ILs Compared to Mining-Related Features

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/20/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-8g	

Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Site_TENORM_Exceeds_IL_Compared_to_Mining_11x17_L_20180919.mxd



Group	Area (square feet)	Volume (cubic yards)
1	202,041	69,028
2	46,110	6,831
3	106,449	3,942
4	13,232	245
5	629,133	23,301
6	55,642	7,213
7	39,514	4,390
8	20,272	3,003
9	124,254	4,602
10	112,000	4,148
11	529,446	39,218
12	51,244	3,796
13	12,789	474
14	240,297	8,900
15	362,891	3,360
16	32,316	1,795

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Waste Pile
- Claim Boundary
- Other Claim Boundary
- Exposed Bedrock[1]

Average Depth by Group (feet below ground surface)

- Variable[2] - Group 1
- 0.5 ft - Group 4
- 1.0 ft - Groups 3, 5, 9, 10, 13, 14, 15[3]
- 1.5 ft - Group 16
- 2.0 ft - Groups 11, 12
- 3.0 ft - Group 7
- 3.5 ft - Group 6
- 4.0 ft - Groups 2, 8

NOTES:

1. Portions of the areas delineated as exposed bedrock contain small amounts of colluvium.

2. See Figure 4-9b

3. Volume was calculated with the assumption that 75% of the area that could not be surveyed was exposed bedrock.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

TITLE:

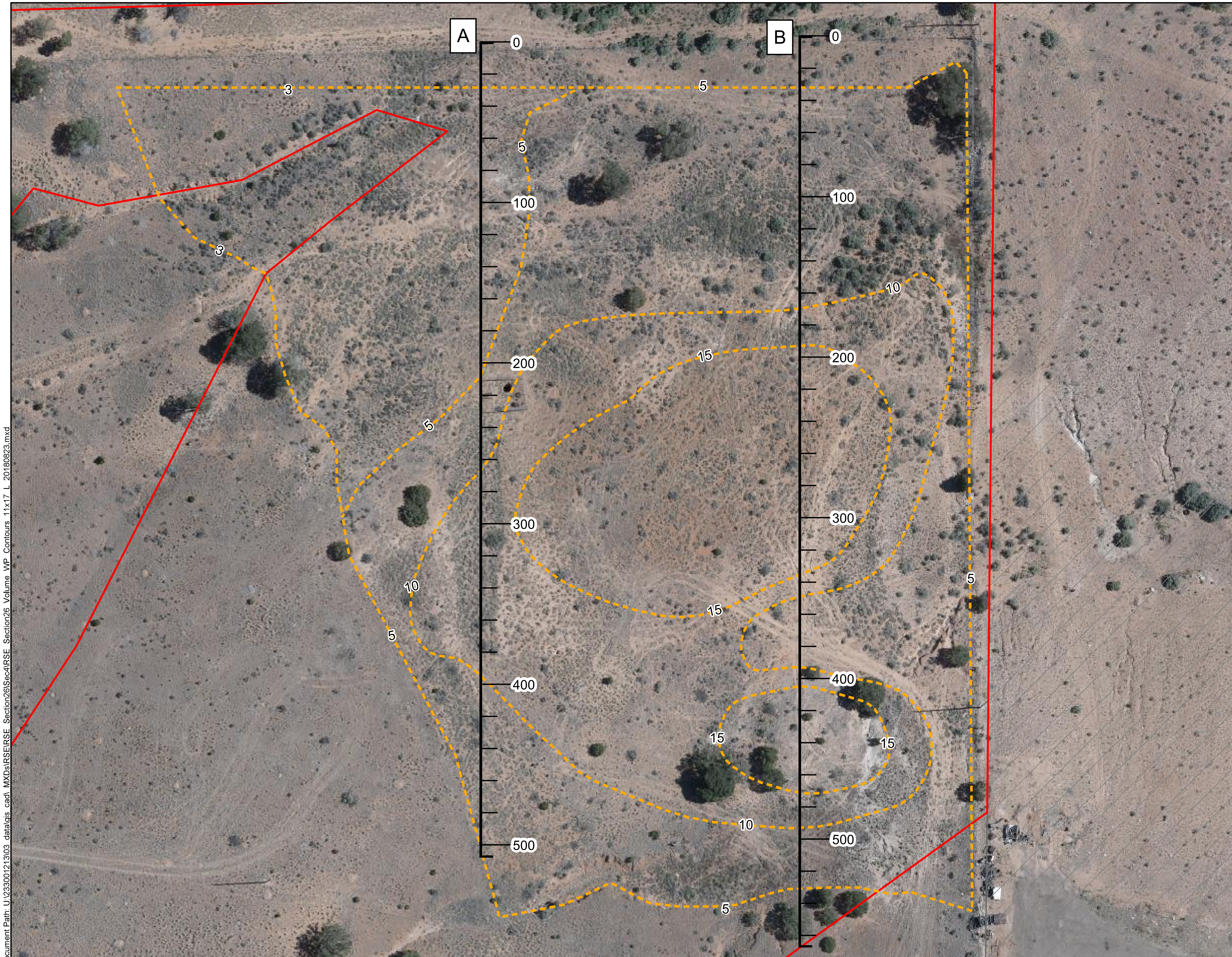
Volume Estimate of TENORM that Exceed ILs

PROJECT:

Removal Site Evaluation
Section 26 Mine Site

DATE: 9/19/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: EDZ · REVIEWER: CBB
	FIGURE: 4-9a

Document Path: U:\123300121\03_data\gis_cad_MXDs\RSE\RSE_Section26\Sec4\RSE_Section26_Volume_11x17_L_20180919.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Cross Section
- Approximate Waste Pile Contour (thickness in feet)
- Claim Boundary
- Other Claim Boundary

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 60 120
Feet

TITLE:
Group 1 Contours for Volume Estimates

PROJECT:
Removal Site Evaluation Section 26 Mine Site

DATE: 8/23/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: EDZ	REVIEWER: CBB
	FIGURE: 4-9b	

APPENDICES

Appendix A Subcontractor Reports

A.1 Radiological Characterization of the Section 26 Abandoned Uranium Mine

A.2 Geophysical Characterization of the Navajo Nation Section 26 Site

Radiological Characterization of the Section 26 (Desidero Group) Abandoned Uranium Mines

September 19, 2018

prepared for:

Stantec Consulting Services Inc.

2130 Resort Drive, Suite 350
Steamboat Springs, CO 80487

prepared by:

ERG

Environmental Restoration Group, Inc.

8809 Washington St. NE
Suite 150
Albuquerque, NM 87113

Contents

Tables

Figures

Appendices

Acronyms

ANSI	American National Standards Institute
AUM	abandoned uranium mine
BG1	Background Reference Area 1
BG2	Background Reference Area 2
BG3	Background Reference Area 3
BG4	Background Reference Area 4
BG5	Background Reference Area 5
cpm	counts per minute
DQOs	data quality objectives
ERG	Environmental Restoration Group, Inc.
ft	foot
GPS	global positioning system
m	meter
MDL	method detection limit
µR/h	microRoentgens per hour
pCi/g	picocuries per gram
R^2	Pearson's Correlation Coefficient
RSE	removal site evaluation
σ	standard deviation
Stantec	Stantec Consulting Services Inc.

Executive Summary

This report addresses the radiological characterization of the Section 26 (Desidero Group) abandoned uranium mines (AUMs) located in the Baca/Haystack Chapter of the Navajo Nation north of Milan, New Mexico. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. (ERG) of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase.

This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of the gamma count rates at these AUMs to exposure rates and concentrations of radium-226 in surface soils, and 3) an assessment of equilibrium in the uranium series. The field activities addressed in this report were conducted on March 25, 26, 28, and 29; June 29, and September 18 and 19, 2017. They included a GPS-based radiological survey of land surfaces over a Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, areas where the survey was extended; and correlation studies.

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in the "Section 26 Removal Site Evaluation Report" (Stantec, 2018).

The findings of the RSE pertaining to these activities are:

- The horizontal extent and magnitude of mining-related materials were delineated sufficiently to support additional characterization of the subsurface.

- Elevated count rates were associated with waste rock in each of the mine claims; i.e., in several small areas of the northwestern claim, the north and east edges of the northeastern claim, and the center of the southern claim. Elevated count rates also were observed outside the northeastern and southern claims along the edge of the mesa and continuing onto the valley floor below.

- Five potential Background Reference Areas were established.

- The relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface) is described by a linear regression model:

$$\text{Gamma Count Rate (cpm)} = 5822*[\text{Radium-226 (pCi/g)}] + 13201$$

- The distribution of concentrations of radium-226 in surface soils predicted using this model resembles a lognormal distribution. Using the correlation equation, the values in the Survey Area range from -0.8 to 126.4 pCi/g, with a central tendency (median) of 2.2 pCi/g.

- The thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226 from gamma count rates.

- There is evidence that radium-226 and thorium-230 are in equilibrium, but not secular equilibrium, at the site.

- The relationship between gamma count rates and exposure rates is described by a linear regression model:

Exposure Rate (microRoentgens per hour [μR/h]) = 2.66×10^{-4} x [Gamma Count Rate (cpm)] + 5.355

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 7.7 to 204.6 μR/h, with a central tendency (median) of 12.3 μR/h.

1.0 Introduction

This report addresses the radiological characterization of the Section 26 (Desidero Group) abandoned uranium mines (AUMs) located in the Baca/Haystack Chapter of the Navajo Nation north of Milan, New Mexico. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. (ERG) of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase.

This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of the gamma count rates at this AUM to exposure rates and concentrations of radium-226 in surface soils, and 3) an assessment of equilibrium in the uranium series. The field activities addressed in this report were conducted on March 25, 26, 28, and 29; June 29, and September 18 and 19, 2017. They included a GPS-based radiological survey of land surfaces over an approximately 101.3-acre Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, areas where the survey was extended, five potential Background Reference Areas; and correlation studies. Section 3.0 of the RSE Workplan provides the data quality objectives (DQOs) for the project.

A salient deviation to the RSE Work Plan was the use of 3-inch by 3-inch sodium iodide (NaI) detectors in lieu of the 2-inch by 2-inch detectors that were specified in the plan. The change was made such that the gamma count rate measurements could be compared to those made previously by others using 3-inch by 3-inch sodium iodide detectors (Ecology and Environment, 2014). A 3-inch by 3-inch will exhibit higher count rates and therefore higher sensitivity to gamma-emitting radionuclides in the soil as compared to a 2-inch by 2-inch detector i.e.; the volume of a 3-inch by 3- inch NaI detector is 344.8 cm3; the volume of a 2-inch by 2-inch NaI detector is 104.2 cm3. The larger volume, results in more gamma interactions within the 3-inch by 3-inch detector compared to the 2x2 inch detector for an identical source.

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in the "Section 26 Removal Site Evaluation Report" (Stantec, 2018).

Figure 1 shows the location of the AUM. Background information that is pertinent to the characterization of these AUMs is presented in the "Section 26 Removal Site Evaluation Report" (Stantec, 2018).

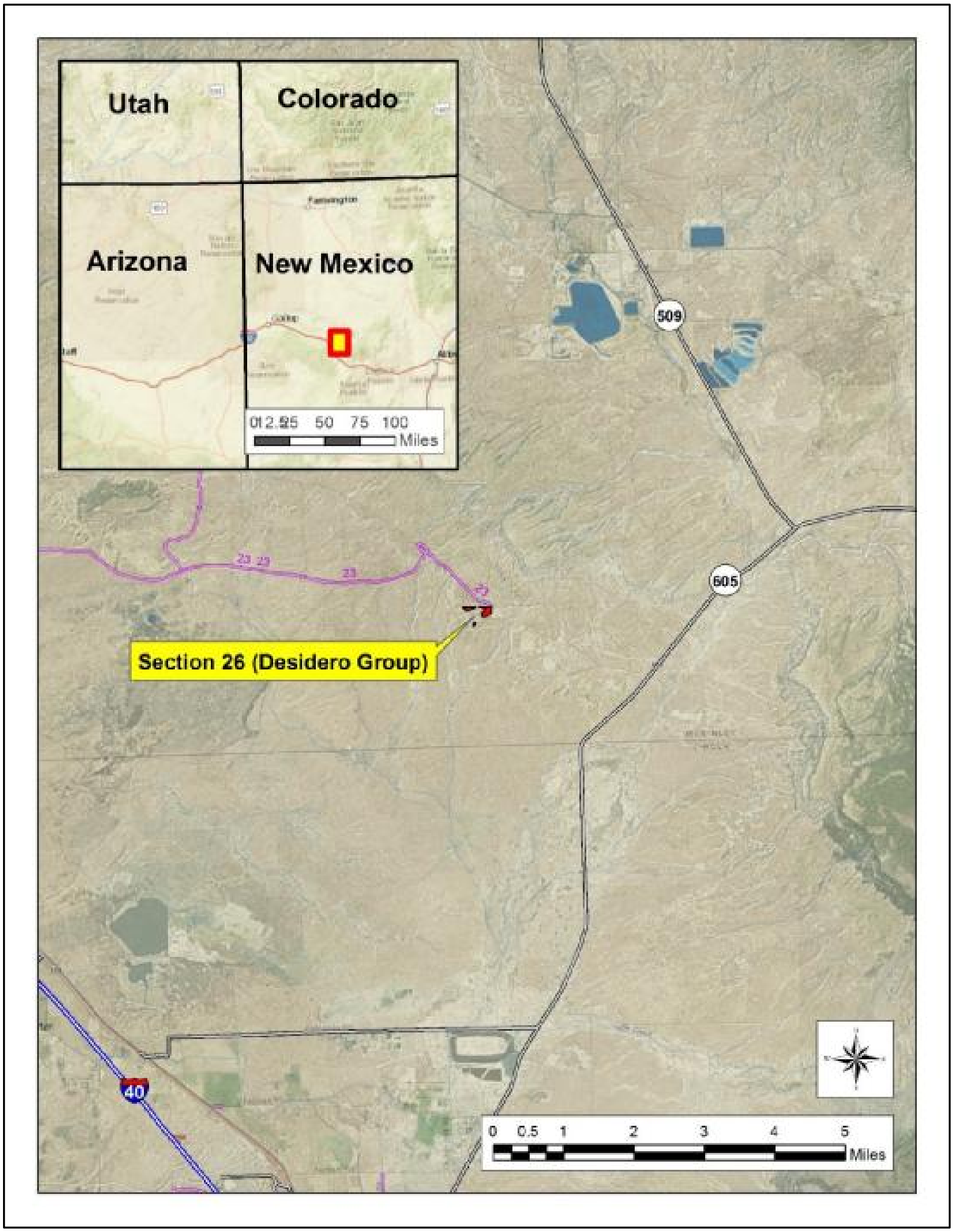


Figure 1. Location of the Section 26 (Desidero Group) Abandoned Uranium Mines

2.0 GPS-Based Gamma Survey

This section addresses the GPS-based surveys conducted in five potential Background Reference Areas and the Survey Area. The survey was extended to bound areas in which elevated count rates were observed. Table 1 lists the detection systems used in the survey. Pursuant to the approved RSE Workplan, detectors were function checked each day to ensure the instruments were stable to the limits prescribed by the Workplan. Detector normalization was not performed as it was not addressed by the RSE Workplan. Appendix A presents the completed function check forms and calibration certificates for the instruments. Standard operating procedures (SOPs) are discussed in Section 4.2 of the RSE Workplan and are provided in Appendix E therein.

The 3-inch by 3-inch NaI detectors used in this investigation are sensitive to sub-surface radium-226 decay products and other gamma emitting radionuclides. The purpose of the gamma correlation was to estimate radium-226 concentrations in the upper 15 cm of soil. Per the RSE Workplan, ERG selected correlation plots based on the range of gamma radiation levels observed. If subsurface soil concentrations of gamma emitting radionuclides were variable between correlation locations, this variability would be included in the regression model, and if the magnitude of the effect were sufficiently large, it would result in failure of the DQOs related to the regression analysis.

Table 1. Detection systems used in the GPS-Based gamma surveys.

Survey Area	Ludlum Model 44-20	Ludlum Model 2221 Ratemeter/Scaler
Potential Background Reference Areas	PR202073[a]	190166[a]
	PR213432	271435
	051517S	218564
Survey Area	051517P	262334
	PR202073[a]	190166[a]
	PR213432	271435
	PR269880	254772
	PR269985	254772
	PR262406	196086

Notes:
[a]Detection system used in the correlation studies described in Sections 3.1 and 3.3.

2.1 Potential Background Reference Areas

Five potential Background Reference Areas were surveyed, the locations and results of which are depicted on Figure 2. BG1, BG2, BG3, BG4, and BG5 in the figure are Background Reference Areas 1 through 5, respectively. Table 2 lists a summary of the gamma count rates, which in:

- BG1 ranged from 11,464 to 20,015 counts per minute (cpm), with a mean and median of 14,082 and 14,041 cpm, respectively.
- BG2 ranged from 18,508 to 25,542 cpm, with a mean and median of 21,269 and 21,227 cpm, respectively.
- BG3 ranged from 13,202 to 57,059 cpm, with a mean and median of 29,080 and 26,603 cpm, respectively.
- BG4 ranged from 15,868 to 22,772 cpm, with a mean and median of 18,804 and 18,780 cpm, respectively.
- BG5 ranged from 16,299 to 22,914 cpm, with a mean and median of 19,213 and 19,101 cpm, respectively.

Figure 3 depicts histograms of the gamma count rates in the potential Background Reference Areas. The red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could be expected if the distributions were normal or lognormal.

Table 2. Summary statistics for gamma count rates in the potential Background Reference Areas.

			Gamma Count Rate (cpm)			
Potential Background Reference Area	**n**	**Minimum**	**Maximum**	**Mean**	**Median**	**Standard Deviation**
1	171	11,464	20,015	14,082	14,041	1,483
2	288	18,508	25,542	21,269	21,227	1,139
3	80	13,202	57,059	29,080	26,603	9,927
4	442	15,868	22,772	18,804	18,780	1,035
5	138	16,299	22,914	19,213	19,101	1,412

Notes:
cpm = counts per minute

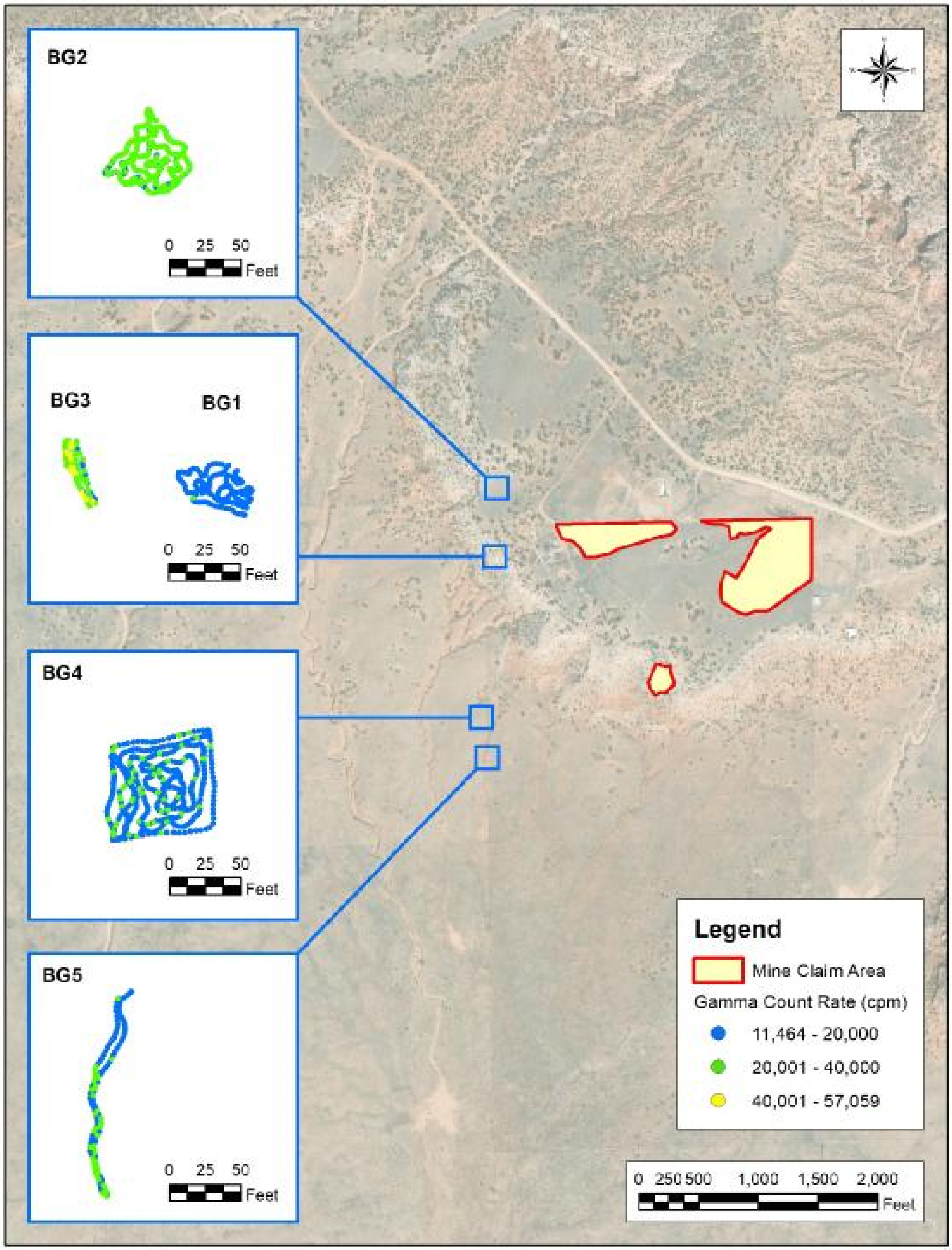
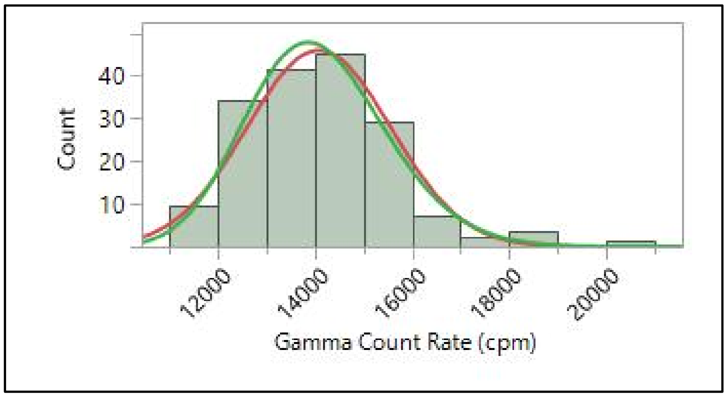
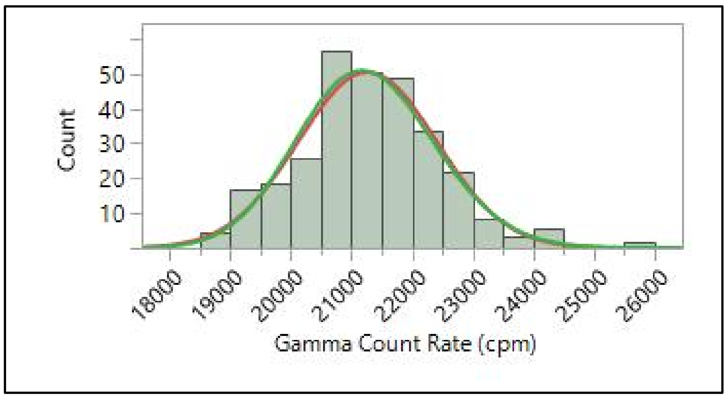


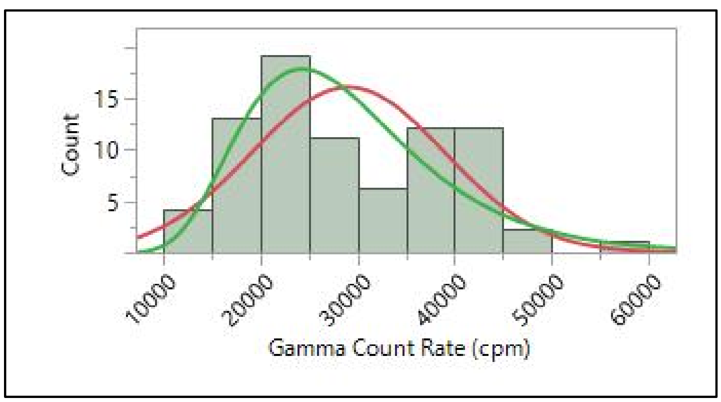
Figure 2. Gamma count rates in the potential Background Reference Areas.



a. Background Reference Area 1

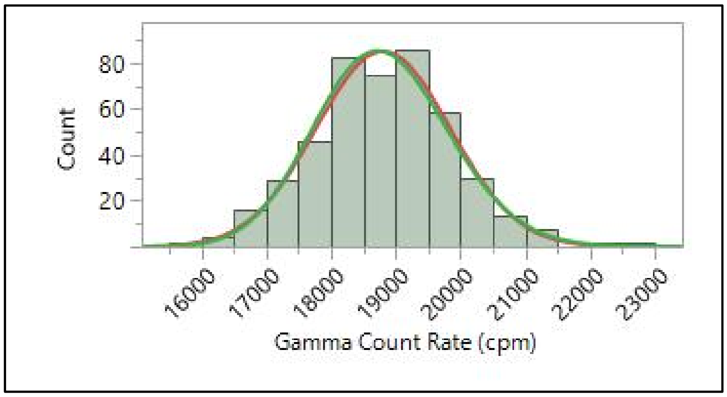


b. Background Reference Area 2

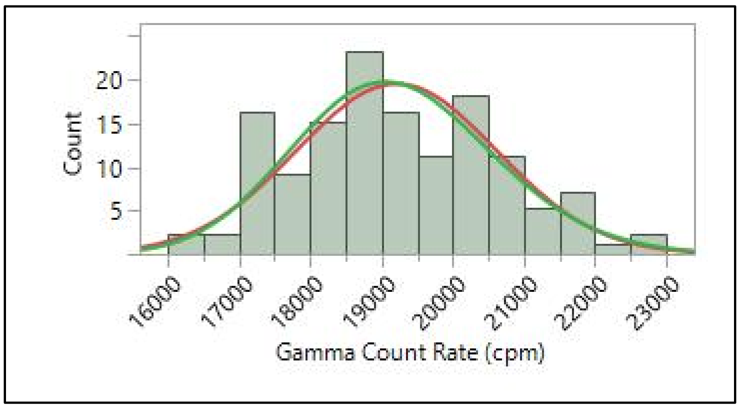


c. Background Reference Area 3

Figure 3 (1 of 2). Histograms of gamma count rates in the potential Background Reference Areas.



a. Background Reference Area 4



b. Background Reference Area 5

Figure 3 (2 of 2). Histograms of gamma count rates in the potential Background Reference Areas.

2.2 Survey Area

The gamma count rates observed in the Survey Area are depicted in Figure 4. Elevated count rates were associated with waste rock in each of the mine claims; i.e., in several small areas of the northwestern claim, the north and east edges of the northeastern claim, and the center of the southern claim. Elevated count rates also were observed outside the northeastern and southern claims along the edge of the mesa and continuing onto the valley floor below.

Figure 5 is a histogram of the gamma count rate measurements made in the Survey Area, including the area surveyed outside the 100-ft buffer. As stated in Section 2.1, the red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could

be expected if the distributions were normal or lognormal. The distribution of the right-tailed set of measurements, evaluated using U.S. Environmental Protection Agency software ProUCL (version 5.1.002), is not defined. The box plot in Figure 6 depicts cutoffs as horizontal bars, from bottom to top, for the following values or percentiles: minimum, 0.5, 2.5, 10, 25, 50, 75, 90, 97.5, 99.5, and maximum. The 25th, 50th, and 75th percentiles (the three horizontal lines of the box inside the box plot) are 21,267, 25,949, and 33,641 cpm, respectively.

Table 3 is a statistical summary of the measurements, which range from 8,652 to 749,127 cpm and have a central tendency (median) of 25,949 cpm.

Table 3. Summary statistics for gamma count rates in the Survey Area.

Parameter	Gamma Count Rate (cpm)
n	71,563
Minimum	8,652
Maximum	749,127
Mean	32,664
Median	25,949
Standard Deviation	28,212

Notes:
cpm = counts per minute

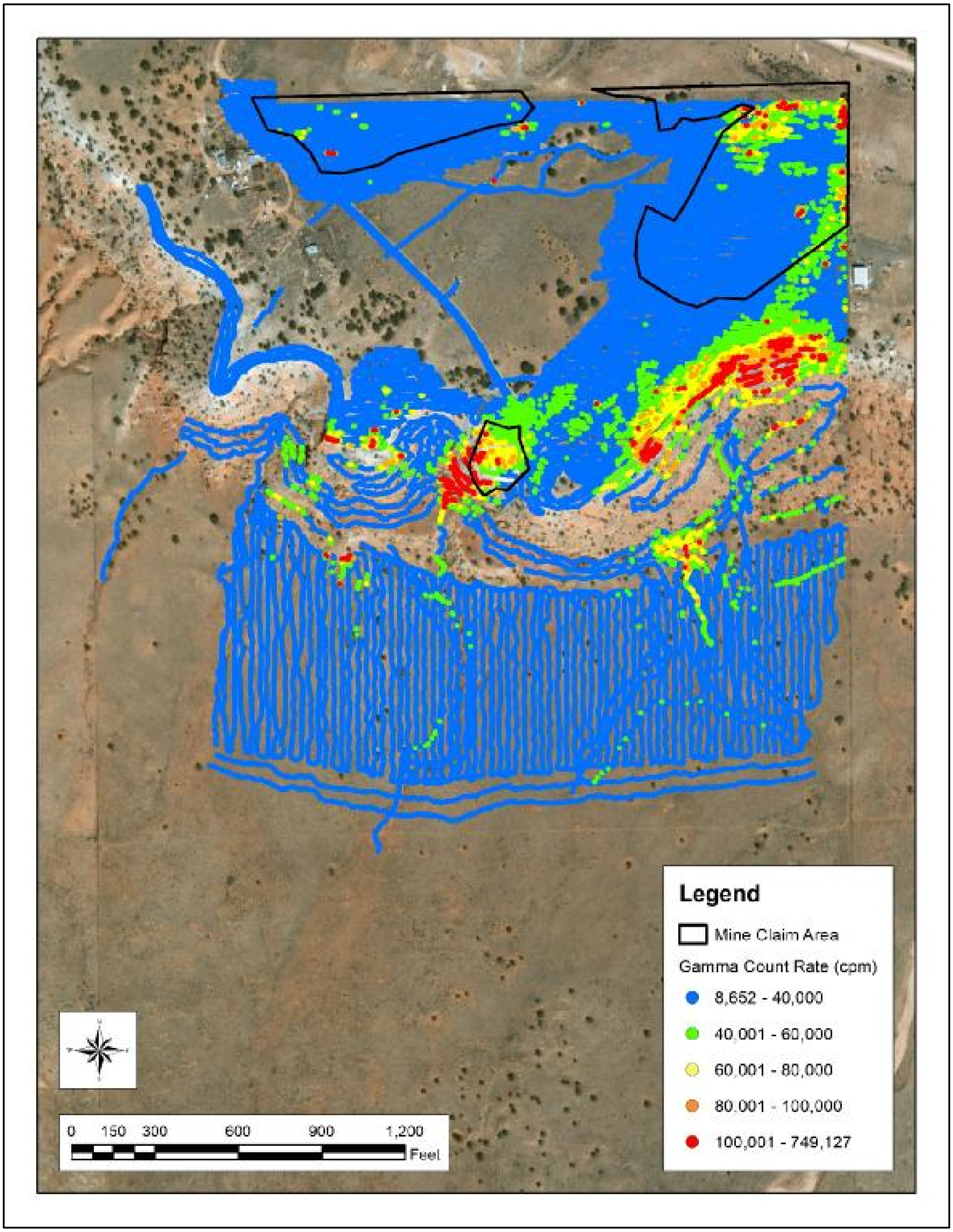


Figure 4. Gamma count rates in the Survey Area.

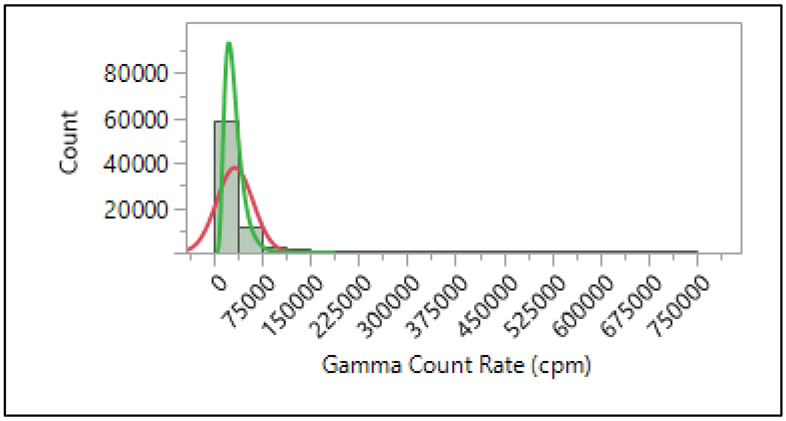


Figure 5. Histogram of gamma count rates in the Survey Area.

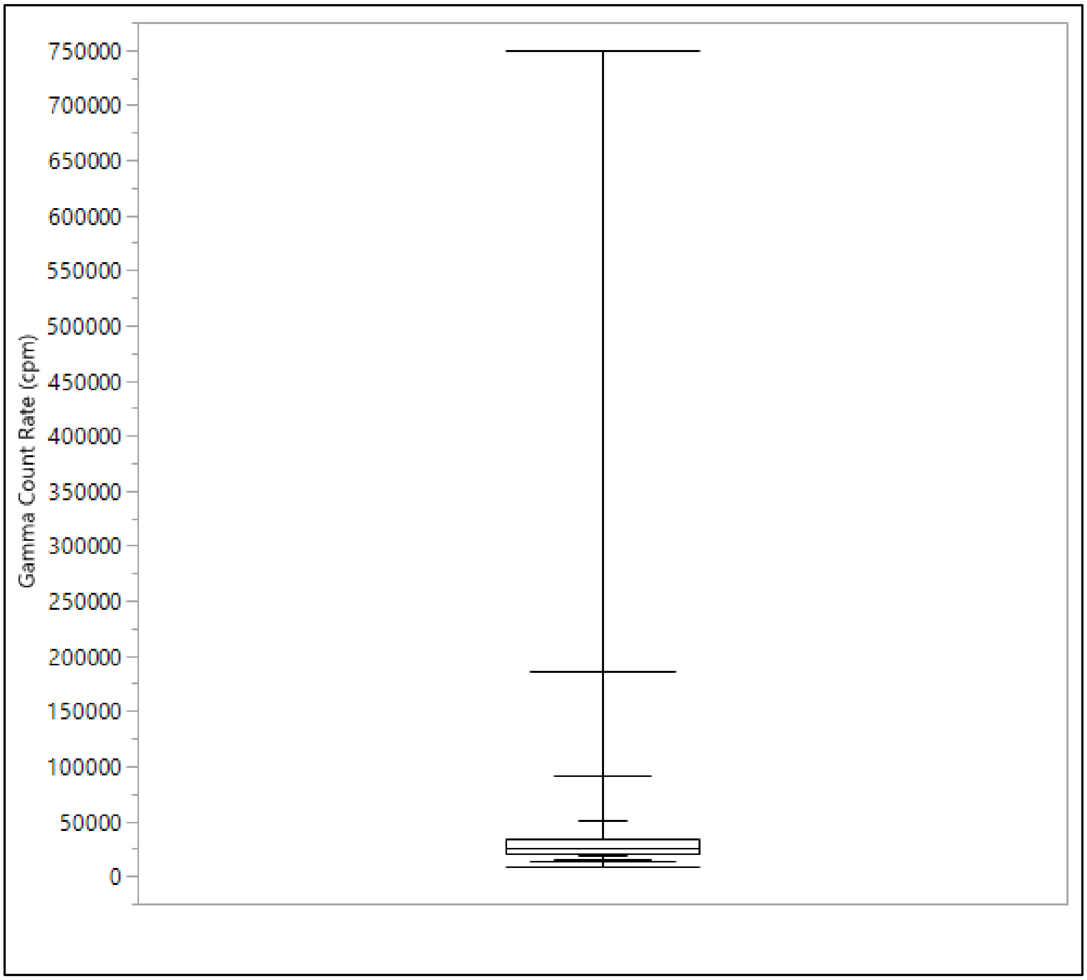


Figure 6. Box plot of gamma count rates in the Survey Area.

3.0 Correlation Studies

The following sections address the activities under two types of correlation studies outlined in the RSE Work plan: comparisons of 1) radium-226 concentrations in surface soils and gamma count rates and 2) exposure rates and gamma count rates. GPS-based gamma count rate measurements were made over small areas for the former study. The means of the measurements were used in this case. Static gamma count rate measurements, co-located with exposure rate measurements, were used in the latter study.

3.1 Radium-226 concentrations in surface soils and gamma count rates

On March 29, 2017 field personnel made GPS-based gamma count rate measurements and collected five-point composite samples of surface soils in each of the five areas at the AUM. These areas were selected using criteria established in the RSE Workplan. The activities were performed contemporaneously, by area and all 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 locations. Figure 7 shows the GPS-based gamma count rate measurements in the five areas (labeled with location identifiers).

The soil samples were analyzed by ALS Laboratories in Ft Collins, CO for radium-226 and isotopic thorium. The latter analysis was included to assess the potential effects of thorium series isotopes on the correlation and evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. Table 4 lists the results of the gamma count rate measurements and radium-226 concentrations in the soil samples. The means of the gamma count rate measurements range from 21,632 to 165,200 cpm. The concentrations of radium-226 in the soil samples range from 1.26 to 25.2 picocuries per gram (pCi/g).

Table 5 lists the concentrations of isotopes of thorium (thorium-228, -230, and -232) in the same soil samples.

Laboratory analyses are presented in Appendix F.2, Laboratory Analytical Data and Data Validation Report, in the “Section 26 Removal Site Evaluation Report” (Stantec, 2018).

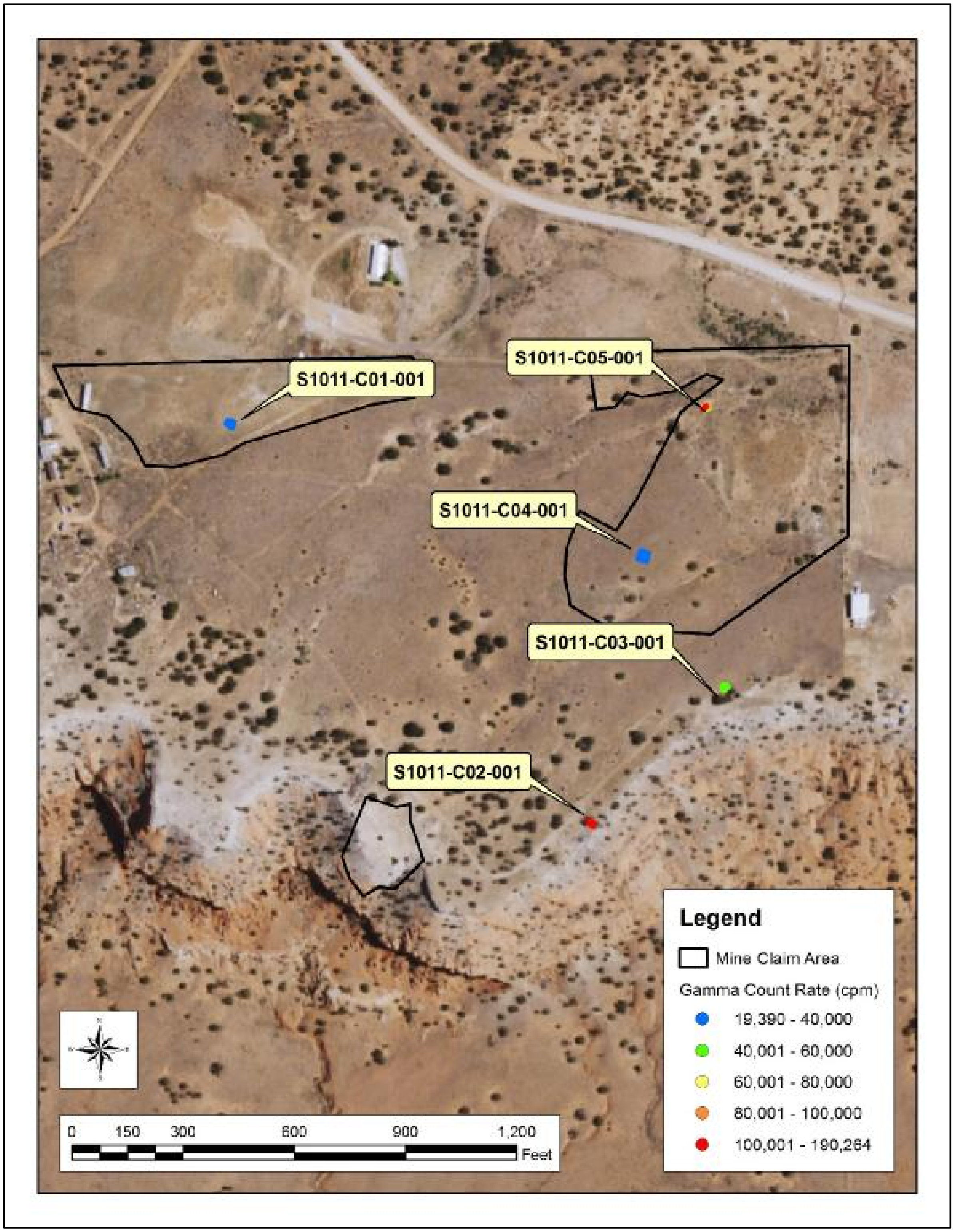


Figure 7. GPS-based gamma count rate measurements made for the correlation study.

Table 4. Gamma count rates and associated concentrations of radium-226 in samples of surface soils obtained in the correlation study.

		Gamma Count Rate (cpm)				Radium-226 (pCi/g)		
Location	Area (m^2)	Mean	Minimum	Maximum	σ	Result	Error ±2σ	MDC
S1011-C01-001	31.8	21,632	19,390	25,165	1,174	1.26	0.3	0.44
S1011-C02-001	14.3	165,200	136,070	190,264	14,389	25.2	3.1	1
S1011-C03-001	24.6	55,042	50,933	59,275	2,143	11	1.4	0.5
S1011-C04-001	65.8	28,422	25,883	30,438	975	1.83	0.33	0.08
S1011-C05-001	23.3	76,851	46,675	121,502	18,779	9	1.2	0.5

Notes:
cpm = counts per minute
m^2= square meters
MDC = minimal detectable concentration
pCi/g = picocuries per gram
σ = standard deviation

Table 5. Concentrations of isotopes of thorium in samples of surface soils obtained in the correlation study.

	Thorium-228 (pCi/g)			Thorium-230 (pCi/g)			Thorium-232 (pCi/g)		
Sample ID	Result	Error ± 2 σ	MDC	Result	Error ± 2 σ	MDC	Result	Error ± 2 σ	MDC
S1011-C01-001	0.48	0.1	0.1	0.9	0.17	0.1	0.451	0.092	0.021
S1011-C02-001	0.341	0.081	0.053	15.5	2.4	0.1	0.335	0.075	0.02
S1011-C03-001	0.359	0.084	0.056	4.95	0.79	0.08	0.368	0.08	0.025
S1011-C04-001	0.52	0.11	0.05	1.4	0.25	0.08	0.48	0.1	0.02
S1011-C05-001	0.372	0.085	0.05	4.07	0.66	0.08	0.356	0.078	0.019

Notes:
MDC = minimal detectable concentration
pCi/g = picocuries per gram
σ = standard deviation

A linear model was made of the results in Table 4, predicting the concentrations of radium-226 in surface soils from the mean gamma count rate in each area. The model, shown in Figure 8, is a strong, linear function with an adjusted Pearson's Correlation Coefficient (R^2) of 0.93, as expressed in the equation:

$$\text{Gamma Count Rate (cpm)} = 5822 * [\text{Radium-226 concentration (pCi/g)}] + 13201$$

The root mean square error and p-value for the model are $1.5X10^4$ and 0.0048, respectively; these parameters are not data quality objectives (DQOs) and are included only as information.

This equation was used to convert the gamma count rate measurements observed in the gamma surveys to predicted concentrations of radium-226. Table 6 presents summary statistics for the predicted concentrations of radium-226 in the Survey Area. The range of the predicted concentrations of radium-226 in the Survey Area is -0.8 to 126.4 pCi/g, with a mean and median of 3.3 and 2.2 pCi/g, respectively. While the gamma correlation equation can be used to convert gamma count rates to concentrations of radium-226 in soil, the resulting radium concentrations are highly uncertain estimates, as the wide prediction interval bands illustrated in Figure 8 demonstrate. Users of the regression equation should be aware of the limitations of the dataset and be cautious when estimating radium-226 concentrations.

Soil concentrations of potassium-40 (K-40) were not expected to be spatially variable within the site, and therefore this radionuclide was not separately accounted for in the RSE Workplan. If K-40 concentrations did vary, this variability would be included in the regression model and, if the magnitude of the effect were sufficiently large, would result in failure of DQOs related to the regression analysis.

A multivariate linear regression (MLR) was used to evaluate the influence of thorium-232 and thorium-228, isotopes in the thorium series, on the average gamma count rate in the correlation locations. The MLR model was first run using radium-226, thorium-232, and thorium-228 as predictors of gamma count rate. The model failed to produce results because thorium-232 and thorium-228 are colinear. The MLR model was subsequently run without thorium-228. For the second model, the p-values for radium-226 and thorium-232 were both greater than 0.05 (0.07 and 0.83 respectively) and therefore not significant predictors of gamma count rate collectively. Thorium-232 and radium-226 were then each modelled individually as a predictor of gamma count rate. The p-value for thorium-232 coefficient was 0.1 with an adjusted R^2 of 0.5. The thorium-232 coefficient is not significant and the R^2 value does not meet the project DQO. Subsequently it is concluded that thorium-232 and thorium-228 concentrations in soil are not significant predictors of gamma count rate. The p-value for radium-226 was significant as described above and the R^2 value met the project DQOs.

The depletion of radon-222 in surface soil due to environmental factors is assumed to be relatively constant across the correlation locations (i.e., the loss is a fixed fraction of the available source). Provided this is the case, any loss of radon-222 in surface soil is unimportant and accounted for within the statistical model. If the loss is not a consistent fraction at each correlation location, it is one of many potential correlation confounders that are all linked to spatial heterogeneity of the environmental conditions, and especially spatial heterogeneity of the soil matrix.

The presence of heterogeneous concentrations of gamma emitting radionuclides in sub-surface soil can affect the gamma correlation model. If subsurface soil concentrations of gamma emitting radionuclides were variable between correlation locations, this variability would be included in the regression model, and if the magnitude of the effect were sufficiently large, it would result in failure of the DQOs related to the regression analysis.

Figure 9 shows the predicted concentrations of radium-226, the spatial and numerical distribution of which mirror those depicted in Figure 4.

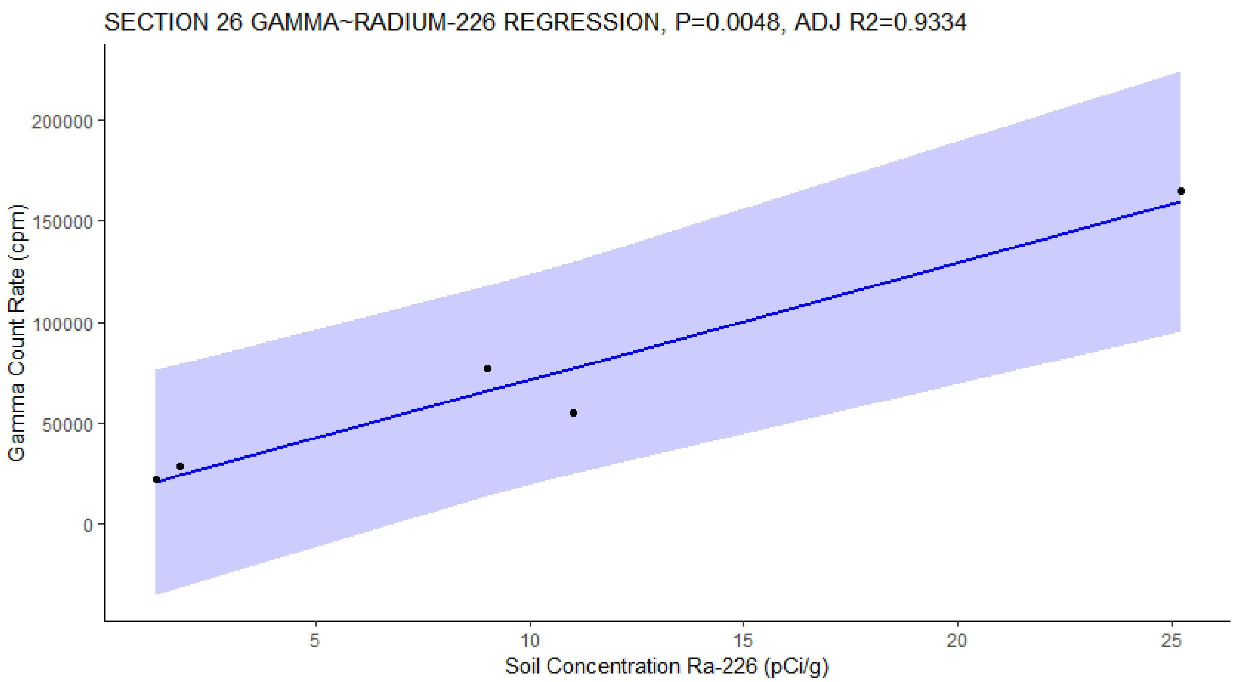


Figure 8. Correlation of gamma count rates and concentrations of radium-226 in surface soils.

Table 6. Predicted concentrations of radium-226 in the Survey Area.

Parameter	Radium-226 (pCi/g)
n	71,563
Minimum	-0.8
Maximum	126.4
Mean	3.3
Median	2.2
Standard Deviation	4.8

Notes:
pCi/g = picocuries per gram

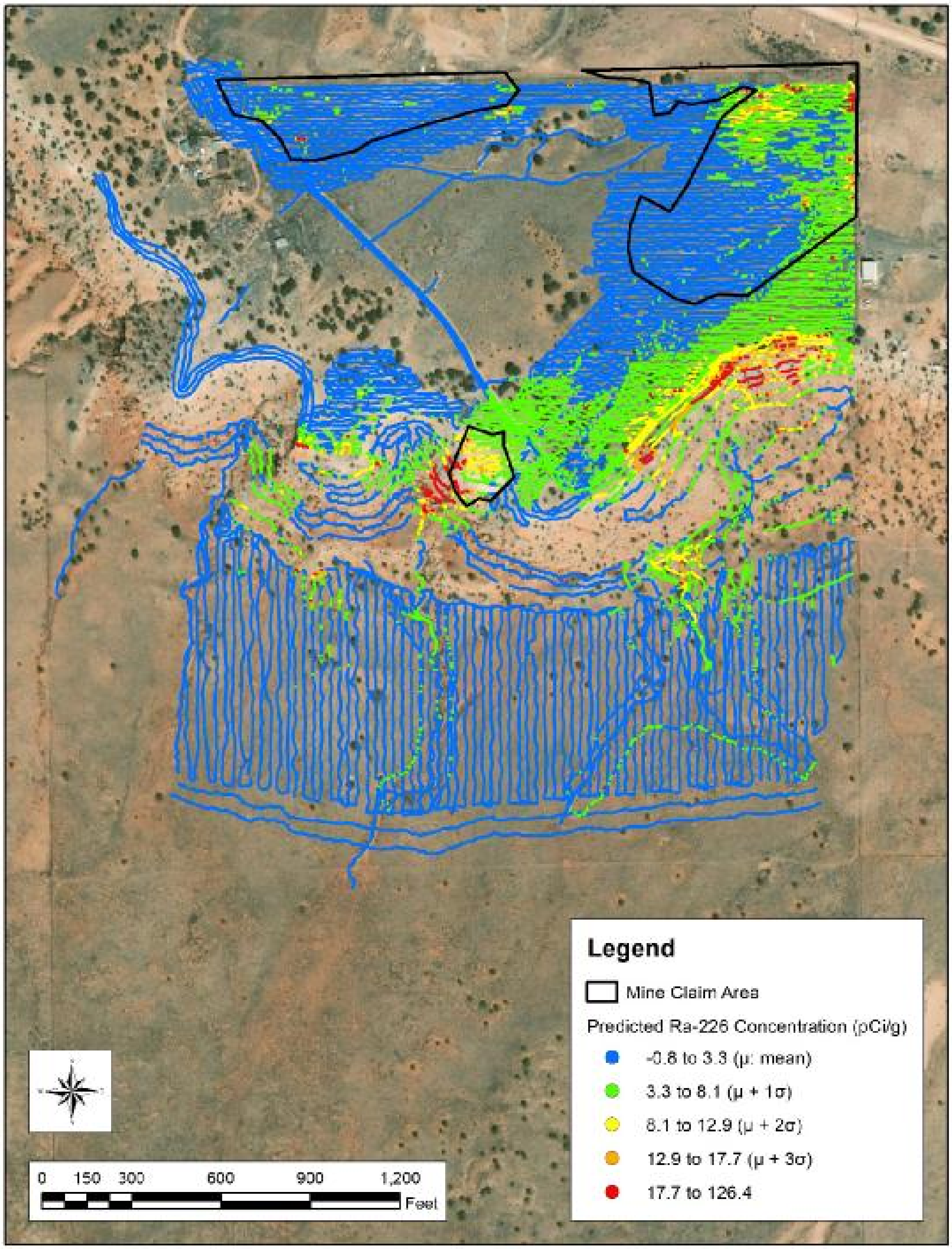


Figure 9. Predicted concentrations of radium-226 in the Survey Area.

3.2 Equilibrium in the uranium series

Secular equilibrium is a condition that occurs when the half-life of a decay-product nuclide is significantly shorter than that of its parent nuclide. After a period of ingrowth equal to approximately seven times the half-life of the decay product, the two nuclides effectively decay with the half-life of the parent. When two radionuclides are in secular equilibrium, their activities are equal.

Equilibrium, for the purpose of this report, is defined as a condition whereby a parent nuclide and its decay product are present in the environment at a fixed ratio, but this ratio – for whatever reason – is not a one-to-one relationship indicative of secular equilibrium. Most commonly, an equilibrium condition results from an environmental process which chemically selects for and transports one nuclide (parent or decay product) away from the other nuclide. Because a consistent fraction of one nuclide has been removed, the two nuclides are present at a fixed ratio other than one-to-one.

Determination of secular equilibrium for an AUM can be an important part of the risk assessment process, as the assumed fraction of radium-226 decay products present in the environment greatly influences a hypothetical receptor's radiation dose and mortality risk. However, it is also acceptable and conservative to assume secular equilibrium between radium-226 and its decay products for the purpose of risk assessment, and therefore to avoid the need to conclusively determine the secular equilibrium status of an AUM. Thus, an inconclusive result regarding secular equilibrium is not a study data gap, as the risk assessment phase may still proceed, provided that conservative assumptions are included regarding equilibrium concentrations of radium-226 decay products.

Regardless, the RSE Workplan specified that an evaluation of secular equilibrium would be made at each of the 16 Trust AUMs, and so a robust statistical examination of secular equilibrium status for radium-226 and its decay products at each AUM was conducted. The ratio of thorium-230 to radium-226 can be evaluated even though different analytic methods were used to measure activity concentrations. Radium-226 was measured by EPA method 901.1m, which is a total-activity method and thorium-230 was measured by alpha spectroscopy following digestion with hydrofluoric acid, which is also a total-activity method. Thus, it is appropriate to compare the two method results.

The evaluation of secular equilibrium for each mine site proceeded as follows:

1. Construction of a figure that depicts soil concentrations of thorium-230 plotted against soil concentrations of radium-226.
2. Simple linear regression is performed on the dataset; the p-value and the adjusted R^2 are recorded. The resulting linear model and the 95% UCL bands are plotted on the figure generated in step 1.
3. The line y=x is added to the figure generated in step 2 (this line represents a perfect 1:1 ratio between thorium-230 to radium-226, indicative of secular equilibrium).

4. An examination of the model and the figure is made sequentially:

    a. If the p-value for the regression slope is insignificant (i.e., $p > 0.05$) or the adjusted R^2 does not meet the study's data quality objective (adjusted $R^2 > 0.8$), ERG concludes that there is insufficient evidence to conclude that radium-226 and thorium-230 are in equilibrium (secular or otherwise).

    b. If the p-value for the regression slope is significant (i.e., $p < 0.05$) and the adjusted R^2 meets the DQO (Adjusted $R^2 > 0.8$) there are two possible conditions, which are evaluated via visual examination of the figure generated in step 3.

        i. If the y=x line falls fully within the bounds of the 95% UCL bands on the regression, ERG concludes that there is evidence that radium-226 and thorium-230 are in secular equilibrium at the site.

        ii. If the y=x line falls partially or completely outside the bounds of the 95% UCL bands on the regression, ERG concludes that there is evidence that radium-226 and thorium-230 are in equilibrium, but not secular equilibrium at the site.

Based on this method, ERG concludes that there is evidence that radium-226 and thorium-230 are in equilibrium, but not secular equilibrium at the site. (Figure 10).

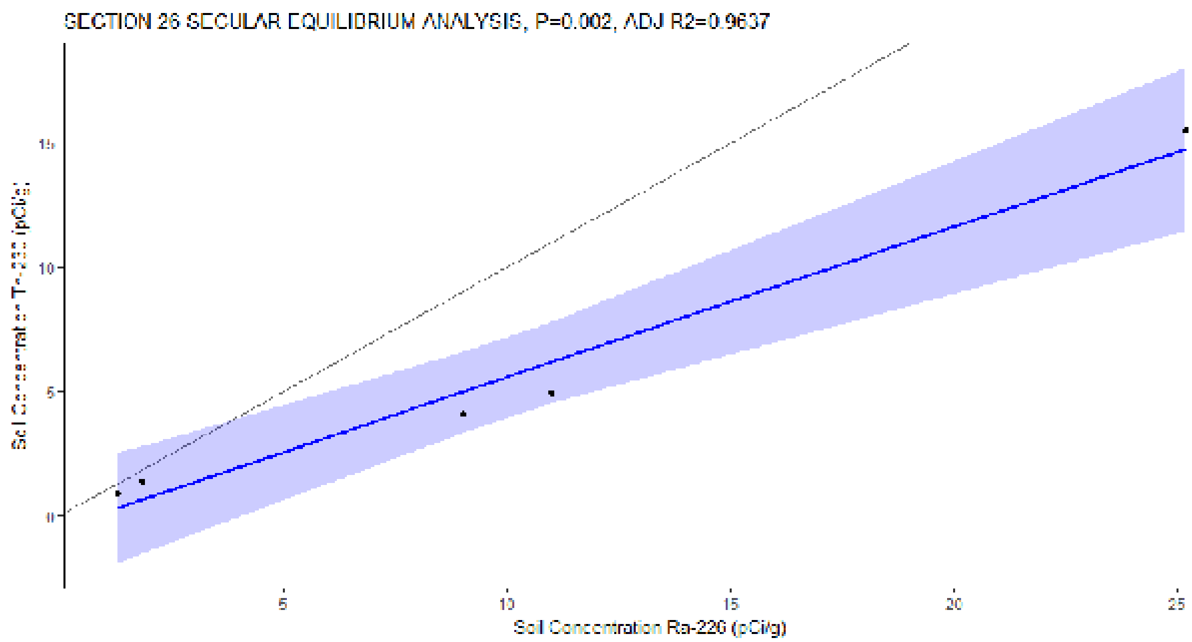


Figure 10. Evaluation of secular equilibrium in the uranium decay series.

3.3 Exposure rates and gamma count rates

On June 29, 2017 field personnel made co-located 1-minute static count rate and exposure rate measurements at five locations within the Survey Area, representing the range of gamma count rates obtained in the GPS-based gamma survey. Figure 7 shows the locations of the co-located measurements, which were made in the centers of the areas.

The gamma count rate and exposure rate measurements were made at 0.5 meters (m) and 1 m above the ground surface, respectively. The gamma count rate measurements were made using a Ludlum Model 44-20, 3-inch by 3-inch sodium iodide detector (NaI) coupled with a Ludlum Model 2221 ratemeter/scaler (Serial Numbers PR202073/190166). The exposure rate measurements were made using a Reuter Stokes Model RS-S131-200-ER000 (Serial Number 1000992) high pressure ionization chamber (HPIC) at 1-second intervals for about 10 minutes. The HPIC output the 1-second measurements as 1-minute averages. The exposure rate used in the comparison was the mean of these measurements, less those occurring in initial instrument warm-ups. The HPIC was in current calibration and function checked before and after use. Calibration forms for the HPIC are provided in Appendix A. Table 7 presents the results for the two types of measurements made at each of the five locations. Appendix B presents the 1-minute average exposure rate measurements.

The best predictive relationship between the measurements is linear with an R^2 of 0.97. The root mean square error and p-value for the model are 2.68 and 0.002, respectively; these parameters are not DQOs and are included only as information.

The following equation is the linear regression (shown in Figure 10) between the mean exposure rate and gamma count rate results in Table 7 that was generated using MS Excel:

Exposure Rate (microRoentgens per hour [µR/h]) = 2.66×10^{-4} x [Gamma Count Rate (cpm)] + 5.355

Figure 11 presents the exposure rates predicted from the gamma count rate measurements, the spatial and numerical distribution of which mirror those depicted in Figure 4.

Tables 8 and 9 present summary statistics for the predicted exposure rates in the five Background Reference Areas, respectively.

The range of predicted exposure rates at:

- BG1 is 8.4 to 10.7 µR/h, with a mean and median of 9.1 µR/h
- BG2 is 10.3 to 12.1 µR/h, with a mean and median of 11.0 µR/h
- BG3 is 8.9 to 20.5 µR/h, with a mean and median of 13.1 and 12.4 µR/h, respectively
- BG4 is 9.6 to 11.4 µR/h, with a mean and median of 10.4 µR/h
- BG5 is 9.7 to 11.4 µR/h, with a mean and median of 10.5 and 10.4 µR/h, respectively

The range of predicted exposure rates in the Survey Area is 7.7 to 204.6 µR/h, with a mean and median of 14.0 and 12.3 µR/h, respectively.

Table 7. Co-located gamma count rate and exposure rate measurements.

Location	Gamma Count Rate (cpm)	Exposure Rate (µR/h)
S1011-C01-001	19,139	11.9
S1011-C02-001	79,012	27.4
S1011-C03-001	30,008	13.8
S1011-C04-001	71,276	20.2
S1011-C05-001	147,023	45.6

Notes:
cpm = counts per minute
µR/h = microRoentgens per hour

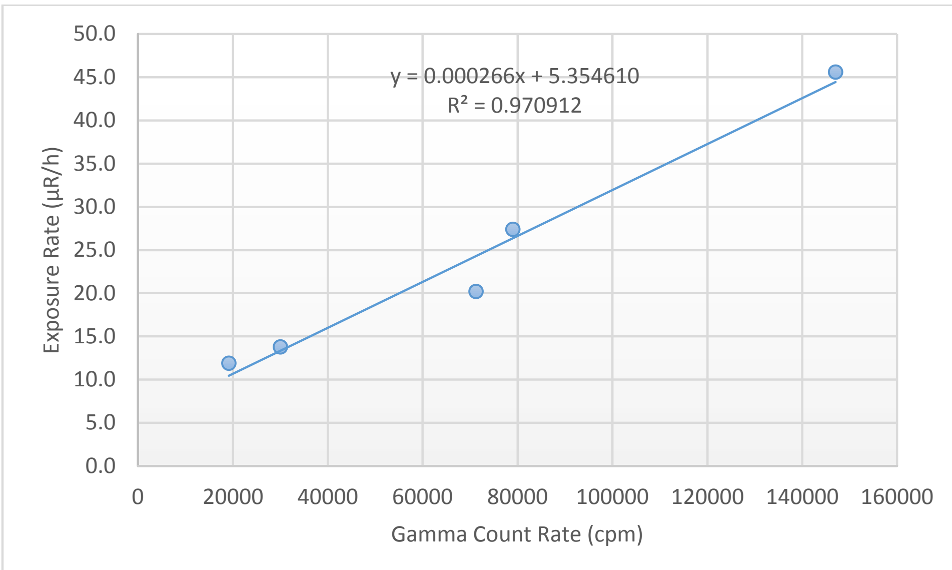


Figure 11. Correlation of gamma count rates and exposure rates.

Table 8. Predicted exposure rates in the potential Background Reference Areas.

Parameter	BG1	BG2	BG3	BG4	BG5
n	171	288	80	442	138
Minimum	8.4	10.3	8.9	9.6	9.7
Maximum	10.7	12.1	20.5	11.4	11.4
Mean	9.1	11.0	13.1	10.4	10.5
Median	9.1	11.0	12.4	10.4	10.4
Standard Deviation	0.4	0.3	2.6	0.3	0.4

Notes:
BG1 = Background Reference Area 1
BG2 = Background Reference Area 2
BG3 = Background Reference Area 3
BG4 = Background Reference Area 4
BG5 = Background Reference Area 5
μR/h = microRoentgens per hour

Table 9. Predicted exposure rates in the Survey Area.

Parameter	Exposure Rate (μR/h)
n	71,563
Minimum	7.7
Maximum	204.6
Mean	14.0
Median	12.3
Standard Deviation	7.5

Notes:
μR/h = microRoentgens per hour

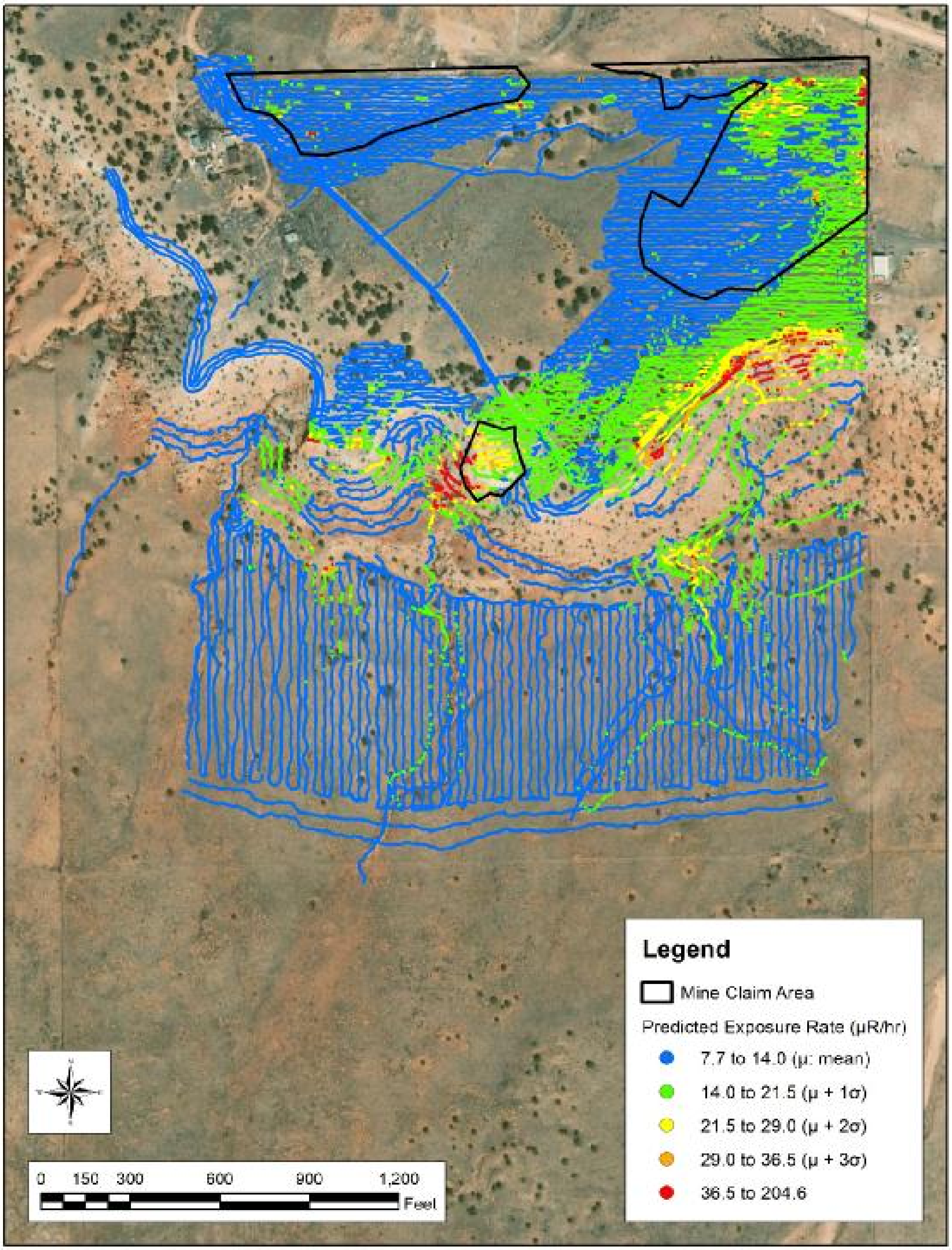


Figure 12. Predicted exposure rates in the Survey Area.

4.0 Deviations from the RSE Work Plan

The RSE Work Plan specifies that the comparison of gamma count rates and radium concentrations in surface soils was to occur in 900 square foot areas. Field personnel adjusted the areas as necessary, to minimize the variability of gamma count rates observed, particularly where the spatial distribution of waste rock was heterogeneous.

A second deviation to the RSE Work Plan was the use of 3-inch by 3-inch sodium iodide detectors in lieu of the 2-inch by 2-inch detectors that were specified in the plan. The change was made such that the gamma count rate measurements could be compared to those made previously by others using 3-inch by 3-inch sodium iodide detectors (Ecology and Environment, 2014).

5.0 Conclusions

The findings of the RSE pertaining to these activities are:

- The horizontal extent and magnitude of mining-related materials were delineated sufficiently to support additional characterization of the subsurface.

- Elevated count rates were associated with waste rock in each of the mine claims; i.e., in several small areas of the northwestern claim, the north and east edges of the northeastern claim, and the center of the southern claim. Elevated count rates also were observed outside the northeastern and southern claims along the edge of the mesa and continuing onto the valley floor below.

- Five potential Background Reference Areas were established.

- The relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface) is described by a linear regression model:

  Gamma Count Rate (cpm)=5822 * [Radium-226 concentration (pCi/g)] +13201

- The distribution of concentrations of radium-226 in surface soils predicted using this model resembles a lognormal distribution. The values in the Survey Area range from -0.8 to 126.4 pCi/g, with a central tendency (median) of 2.2 pCi/g.

- The thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226 from gamma count rates.

- There is evidence that radium-226 and thorium-230 are in equilibrium, but not secular equilibrium at the site.

- The relationship between gamma count rates and exposure rates is described by a linear regression model:

Exposure Rate (microRoentgens per hour [µR/h]) = 2.66×10^{-4} x [Gamma Count Rate (cpm)] + 5.355

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 7.7 to 204.6 µR/h, with a central tendency (median) of 12.3 µR/h.

- Further work is recommended to support a robust gamma correlation.

6.0 References

ANSI, 1997. Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments, American National Standards Institute (ANSI) Standard N232A. June 20, 2014.

Ecology and Environment, 2014. Removal Assessment Report, Tronox AUM Section 26, Baca/Haystack Chapter, Eastern Agency, Navajo Nation. February.

MWH, 2016. Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan, October 24, 2016.

Stantec, 2018. Section 26 Removal Site Evaluation Report, January 2018.

Appendix A Instrument calibration and completed function check forms

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	196086
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR262406

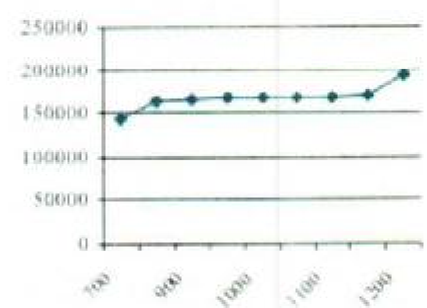
☐ Mechanical Check ☐ THR/WIN Operation HV Check (+/- 2.5%): ☐ 500 V ☐ 1000 V ☐ 1500 V
☐ F/S Response Check ☐ Reset Check Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:
☐ Geotropism ☐ Audio Check
☐ Meter Zeroed ☐ Battery Check (Min 4.4 VDC) Barometric Pressure: inches Hg
Source Distance: ☐ Contact ✔ 6 inches ☐ Other: Threshold: Temperature: °F
Source Geometry: ✔ Side ☐ Below ☐ Other: Window: Relative Humidity: %

Instrument found within tolerance: ✔ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

High Voltage	Source Counts	Background
700	144169	
800	162193	
900	166057	
950	167388	
1000	167489	21583
1050	167574	
1100	168254	
1150	170145	
1200	192327	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1000

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932
Fluke multimeter serial number: ☐ 87490128
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03
☐ Other Source:

Calibrated By: [signature] Calibration Date: 7 March 17 Calibration Due: 7 March 18

Reviewed By: [signature] Date: 3-7-17

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	254772
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR269980

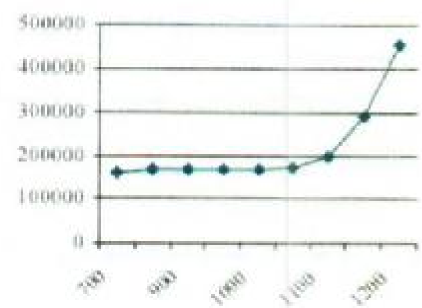
☐ Mechanical Check ☐ THR/WIN Operation HV Check (+/- 2.5%): ☐ 500 V ☐ 1000 V ☐ 1500 V
☐ F/S Response Check ☐ Reset Check Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:
☐ Geotropism ☐ Audio Check
☐ Meter Zeroed ☐ Battery Check (Min 4.4 VDC) Barometric Pressure: inches Hg
Source Distance: ☐ Contact ✔ 6 inches ☐ Other: Threshold: Temperature: °F
Source Geometry: ✔ Side ☐ Below ☐ Other: Window: Relative Humidity: %

Instrument found within tolerance: ✔ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

High Voltage	Source Counts	Background
700	162620	
800	168495	
900	170240	
950	170850	22731
1000	171277	
1050	172525	
1100	197371	
1150	291452	
1200	453265	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV =950

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932 Fluke multimeter serial number: ☐ 87490128
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03 ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03 ☐ Other Source:

Calibrated By: [signature] Calibration Date: 7 March 17 Calibration Due: 7 March 18

Reviewed By: [signature] Date: 3-7-17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

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8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
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ERG

Certificate of Calibration

Calibration and Voltage Plateau

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	271435
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR213432

✔ Mechanical Check ✔ THR/WIN Operation
✔ F/S Response Check ✔ Reset Check
✔ Geotropism ✔ Audio Check
✔ Meter Zeroed ✔ Battery Check (Min 4.4 VDC)
Source Distance: ☐ Contact ✔ 6 inches ☐ Other:
Source Geometry: ✔ Side ☐ Below ☐ Other:

HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:

Threshold: 10 mV
Window:

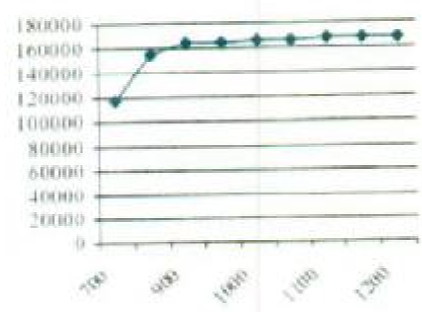
Barometric Pressure: 24.72 inches Hg
Temperature: 68 °F
Relative Humidity: 20 %

Instrument found within tolerance: ✔ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399058	400
x 1000	100	100	100		100
x 100	400	400	400	39908	400
x 100	100	100	100		100
x 10	400	400	400	3989	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	117585	
800	155051	
900	164169	
950	165480	
1000	166858	
1050	166722	
1100	168083	20644
1150	167659	
1200	168487	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1100

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932
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☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By:
Reviewed By:

Calibration Date: 7 March 17 Calibration Due: 7 March 18

Date: 3-7-17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	190166
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR269985

☑ Mechanical Check ☑ THR/WIN Operation
☑ F/S Response Check ☑ Reset Check
☑ Geotropism ☑ Audio Check
☑ Meter Zeroed ☑ Battery Check (Min 4.4 VDC)

Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Source Geometry: ☑ Side ☐ Below ☐ Other:

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch ☐ Other:

Threshold: 10 mV
Window:

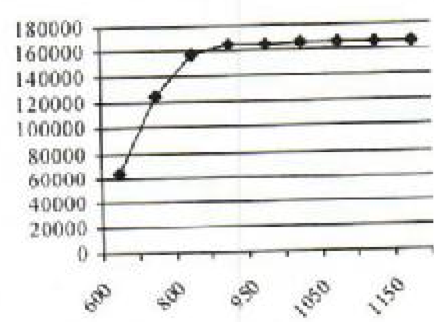
Barometric Pressure: 24.66 inches Hg
Temperature: 75 °F
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Coun
x 1000	400	400	400	399389	400
x 1000	100	100	100		100
x 100	400	400	400	39940	400
x 100	100	100	100		100
x 10	400	400	400	3999	400
x 10	100	100	100		100
x 1	400	400	400	400	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
600	64081	
700	125567	
800	157563	
900	165079	
950	164853	
1000	165840	21364
1050	166555	
1100	166593	
1150	166782	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1000

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
☐ Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12)
☐ Beta Source: Tc99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12)

Fluke multimeter serial number: ☐ 87490128
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By: [signature] Calibration Date: 5-12-17 Calibration Due: 5-12-18

Reviewed By: [signature] Date: 5/12/17

ERG Form ITC. 101.A

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Certificate of Calibration

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8809 Washington St NE, Suite 150
Albuquerque, NM 87113
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Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	190166
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR202073

Mechanical Check
F/S Response Check
Geotropism
Meter Zeroed

THR/WIN Operation
Reset Check
Audio Check
Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): 500 V 1000 V 1500 V
Cable Length: 39-inch ✔ 72-inch Other:

Barometric Pressure: inches Hg
Threshold: Temperature: °F
Window: Relative Humidity: %

Source Distance: Contact 6 inches Other:
Source Geometry: Side Below Other:

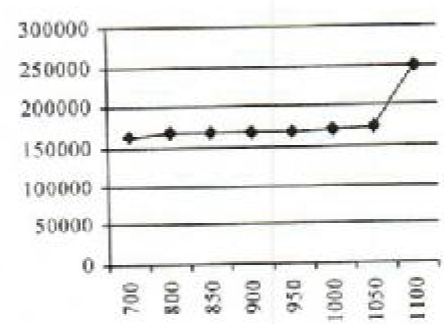
Instrument found within tolerance: ✔ Yes No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

See other (+) Sheet

High Voltage	Source Counts	Background
700	164061	
800	168372	
850	169017	
900	170276	24149
950	170410	
1000	170754	
1050	175368	
1100	250364	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 900

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 201932
Fluke multimeter serial number: 87490128
Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12)
✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12)
Other Source:

Calibrated By: Calibration Date: 6-14-17 Calibration Due: 6-14-18

Reviewed By: Date: 6-14-17

... conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	218564
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	051517S

Mechanical Check — THR/WIN Operation — HV Check (+/- 2.5%): 500 V 1000 V 1500 V

F/S Response Check — Reset Check — Cable Length: 39-inch ✔ 72-inch Other:

Geotropism — Audio Check

Meter Zeroed — Battery Check (Min 4.4 VDC) — Barometric Pressure: inches Hg

Source Distance: Contact ✔ 6 inches Other: — Threshold: 10 mV — Temperature: °F

Source Geometry: ✔ Side Below Other: — Window: — Relative Humidity: %

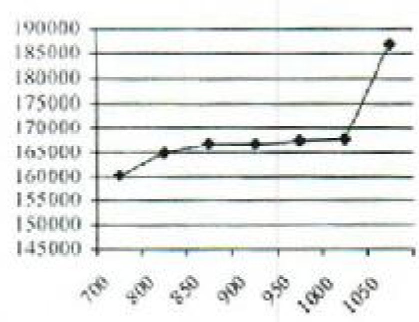
Instrument found within tolerance: ✔ Yes No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

See Ludlum Cal Sheet

High Voltage	Source Counts	Background
700	160304	
800	164819	
850	166661	
900	166927	23453
950	167592	
1000	167697	
1050	186865	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 900

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 ✔ 201932 — Fluke multimeter serial number: 87490128

Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12) — ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

Beta Source: ✔ Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12) — Other Source:

Calibrated By: — Calibration Date: 9-7-17 — Calibration Due: 9-7-18

Reviewed By: T. — Date: 09/08/17

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

of Scientific and Industrial Instruments

www.ludlums.com

CERTIFICATE OF CALIBRATION

501 Oak Street
325-235-5494
Sweetwater, TX 79556, U.S.A.

ACCREDITED
CERT # 4084.01

ORDER NO. 20315056/451872

Customer ERG

Mfg. Ludlum Measurements, Inc. Model 2221 Serial No. 218564

Mfg. Model Serial No.

Cal. Date 14-Jul-17 Cal Due Date 14-Jul-18 Cal. Interval 1 Year Meterface 202-159

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 47 % Alt 709.0 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☑ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck.
☑ Calibrated in accordance with LMI SOP 14.8 ☐ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set 1000 V Input Sens. 100 mV Det. Oper. ____ V at ____ mV Threshold Dial Ratio 100 = 10 mV

☐ HV Readout (2 points) Ref./Inst. 500 / 499 V Ref./Inst. 2000 / 2000 V

COMMENTS:

Calibrated with 39" cable
Firmware: 261027

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 1000	400 Kcpm	N/A	400
X 1000	100 Kcpm		100
X 100	40 Kcpm		400
X 100	10 Kcpm		100
X 10	4 Kcpm		400
X 10	1 Kcpm		100
X 1	400 cpm		400
X 1	100 cpm		100

ALL Range(s) Calibrated Electronically

*Uncertainty within ± 10% C.F. within ± 20%

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	400 Kcpm	N/A	40155 (6)
	40 Kcpm		4010
	4 Kcpm		401
	400 cpm		40
	40 cpm		4

Log Scale	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	500 Kcpm	N/A	500 Kcpm
	50 Kcpm		50
	5 Kcpm		5
	500 cpm		500 cpm
	50 cpm		50

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 ISO/IE 17025:2005(E) State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521 ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☐ Y982
☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☐ 2168CP ☐ Other

☐ Alpha S/N ☐ Beta S/N ☑ Multimeter S/N 92780460

☑ m 500 S/N 201934 ☐ Oscilloscope S/N

Calibrator Josie Ruiz Josie Ruiz Title Technician Date 14 July 17

QC'd By [signature] Title Service Dept QC Date 14 Jul 17

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

	Manufacturer:		Model Number:		Serial Number:	
Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	254772
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR269985

Mechanical Check | THR/WIN Operation | HV Check (+/- 2.5%): 500 V 1000 V 1500 V

F/S Response Check | Reset Check | Cable Length: 39-inch ✔ 72-inch Other:

Geotropism | Audio Check

Meter Zeroed | Battery Check (Min 4.4 VDC) | Barometric Pressure: inches Hg

Source Distance: Contact ✔ 6 inches Other: | Threshold: | Temperature: °F

Source Geometry: ✔ Side Below Other: | Window: | Relative Humidity: %

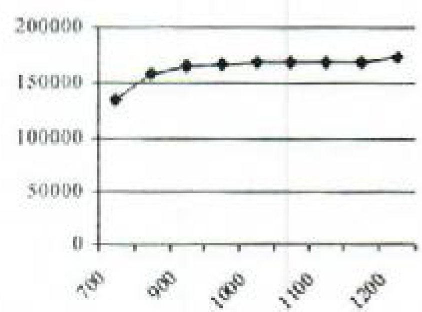
Instrument found within tolerance: Yes ✔ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

See Ludlum Cal Sheet

High Voltage	Source Counts	Background
700	133844	
800	158402	
900	164459	
950	166477	
1000	167466	
1050	167781	27111
1100	168169	
1150	168450	
1200	172562	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1050

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 201932 | Fluke multimeter serial number: 87490128

Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12) | ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12) | Other Source:

Calibrated By: [signature] Calibration Date: 9-7-17 Calibration Due: 9-7-18

Reviewed By: T. [signature] Date: 09/08/17

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

www.ludlums.com

of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

501 Oak Street
325-235-5494
Sweetwater, TX 79556, U.S.A.

ACCREDITED
CERT # 4084.01

ORDER NO. 20316590/452897

Customer ERG

Mfg. Ludlum Measurements, Inc. Model 2221 Serial No. 254772

Mfg. Model Serial No.

Cal. Date 11-Aug-17 Cal Due Date 11-Aug-18 Cal. Interval 1 Year Meterface 202-159

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 47 % Alt 698.0 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☑ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck.
☑ Calibrated in accordance with LMI SOP 14.8 ☐ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set 500 V Input Sens. 10 ~~100~~ JR mV Det. Oper. V at mV Threshold Dial Ratio 100 = 10 mV

☐ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 1500 / 1501 V

COMMENTS:

Firmware: 261027
Calibrated with Window in "OUT" position.
Calibrated with 39" cable.

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 1000	400 Kcpm	N/A	400
X 1000	100 Kcpm		100
X 100	40 Kcpm		400
X 100	10 Kcpm		100
X 10	4 Kcpm		400
X 10	1 Kcpm		100
X 1	400 cpm		400
X 1	100 cpm		100

ALL Range(s) Calibrated Electronically

*Uncertainty within ± 10% C.F. within ± 20%

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout	400 Kcpm	N/A	40156 (0)	Log Scale	500 Kcpm	N/A	500 Kcpm
	40 Kcpm		4011		50 Kcpm		50
	4 Kcpm		401		5 Kcpm		5
	400 cpm		40		500 cpm		500 cpm
	40 cpm		4		50 cpm		50

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 ISO/IE 17025:2005(E) State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521 ☐ 5-394 ☐ 5-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☐ Y982 ☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☐ 2168CP

☐ Alpha S/N ☐ Beta S/N ☐ Other

☑ m 500 S/N 201934 ☐ Oscilloscope S/N ☑ Multimeter S/N 92780460

Calibrator Josie Ruiz Josie Ruiz Title Technician Date 11 Aug 17

QC'd By Title Date 11 Aug 17

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	262334
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	051517P

✔ Mechanical Check ✔ THR/WIN Operation
✔ F/S Response Check ✔ Reset Check
✔ Geotropism ✔ Audio Check
✔ Meter Zeroed ✔ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
Cable Length: 39-inch ✔ 72-inch Other:

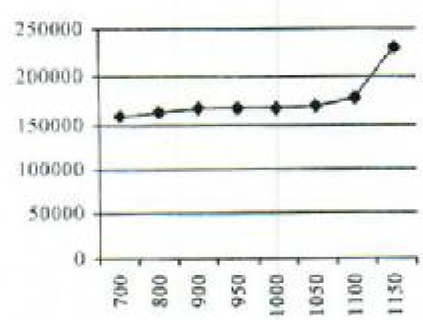
Barometric Pressure: 24.69 inches Hg
Source Distance: Contact ✔ 6 inches Other: Threshold: 10 mV Temperature: 75 °F
Source Geometry: ✔ Side Below Other: Window: Relative Humidity: 20 %

Instrument found within tolerance: ✔ Yes No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	398990	400
x 1000	100	100	100		100
x 100	400	400	400	39893	400
x 100	100	100	100		100
x 10	400	400	400	3986	400
x 10	100	100	100		100
x 1	400	400	400	398	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	159361	
800	163970	
900	166805	
950	167531	26434
1000	168157	
1050	169245	
1100	177000	
1150	229347	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 950

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 ✔ 201932
Fluke multimeter serial number: 87490128
Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12)
✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
Beta Source: ✔ Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12)
Other Source:

Calibrated By: [signature] Calibration Date: 9-7-17 Calibration Due: 9-7-18

Reviewed By: T. [signature] Date: 09/08/17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

Reuter-Stokes

Calibration Certificate

Reuter-Stokes certifies that the Environmental Radiation Monitor, identified below, has been calibrated for output using the shadow shield technique*, and calibrated with radiation sources traceable to the National Institute of Standards and Technology.

Sensor Type: 100 R/Hr

Serial Number: 1000992

Calibration Date: 03/16/2017

Sensitivity: -2.281E-8 A/R/h

Authorized Signature

*Calibration Procedure: RS-SOP 238.1

Reuter-Stokes

Calibration Data

Sensor Type:	100 R/Hr	Source (CS-137):	BB-400
Serial Number:	1000992	Date of Certification:	12/01/1994
Calibration Date:	03/16/2017	Exposure Rate at 1 meter:	4.226 mR/h

Customer Name: STOCK

Sensitivity (Ra-226): -2.281E-8 A/R/h

Distance		Exposure Rate	P+S+A	S+A	P	k(CS-137)
Feet	cm	µR/h	A	A	A	A/R/h
12	366	185.323	-5.403E-12	-1.164E-12	-4.239E-12	-2.287E-08
14	427	135.592	-4.135E-12	-1.012E-12	-3.123E-12	-2.303E-08
16	488	103.384	-3.294E-12	-9.029E-13	-2.391E-12	-2.313E-08
18	549	81.348	-2.708E-12	-8.209E-13	-1.887E-12	-2.319E-08

k(CS-137) = -2.306E-8 A/R/h

k = -2.306E-8 A/R/h

k(Ra-226) = 0.9892 k(CS-137)

σ = 1.39E-10 A/R/h

k(Ra-226) = -2.281E-8 A/R/h

$V = \frac{\sigma}{k} =$ -0.603%

By: John Lak

Date: 3-17-17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	196086
Cal. Due Date:	3-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR262406
Cal. Due Date:	3-7-18

Comments:

NNEAT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: N/A cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-25-17	0926	5.5	1005	100	94365	14878	79487	NW	Section 26 near trailer
3-25-17	1454	5.4	998	100	96316	13481	82835	NW	Section 26 near trailer
3-26-17	1035	5.5	1004	102	94314	14114	80200	NW	Section 26 near trailer
3-26-17	1401	5.3	999	100	93248	13531	79717	NW	Section 26 near trailer
3-28-17	0835	5.5	1005	101	96188	14430	81758	NW	Section 26 near trailer
3-28-17	1212	5.3	1003	101	103245	22269	80976	NW	Section 26 on road @ southern claim
3-29-17	0840	5.4	1005	101	95732	14653	81079	NW	Section 26 near trailer.
3-29-17	1232	5.2	1002	101	94834	15054	79780	NW	Section 26 near trailer
					NW				
					4-2-16				

Reviewed by: [signature] Review Date: 1/29/18

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	3-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-2U
Serial No.:	PR 269986 ~~SAS~~ NW
Cal. Due Date:	3-7-18

Comments:
NNERT

Source: Cs-137
Serial No.: 544-96
Activity: 4 uCi
Emission Rate: N/A cpm/emissions
Source Date: 4-18-96
Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-25-17	0931	5.7	952	100	96657	16184	80463	NW	Section 26, near trailer
3-25-17	1457	5.6	946	100	96139	14624	81515	NW	Section 26, near trailer
3-26-17	1031	5.7	952	100	95441	15227	80214	NW	Section 26, near trailer
3-26-17	1358	5.5	947	100	96336	14730	81606	NW	Section 26 near trailer
3-28-17	0840	5.6	952	101	96138	16340	79798	NW	Section 26, near trailer
3-28-17	1218	5.5	949	100	104022	23070	80952	NW	Section 26, road at southern claim
3-29-17	0837	5.6	952	101	96719	15960	80759	NW	Section 26, near trailer
3-29-17	1236	5.5	949	101	97836	15710	82126	NW	Section 26, near trailer
					NW				
						4-2-17			

Reviewed by: Michael Ar[signature]
Review Date: 1/29/18

(4)

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	271435
Cal. Due Date:	3-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR213432
Cal. Due Date:	3-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: N/A cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-25-17	0937	5.5	1055	102	94755	14061	80694	NW	Section 26 near trailer
3-25-17	1451	5.4	1051	101	94302	13177	81125	NW	Section 26 near trailer
3-26-17	1039	5.5	1057	102	92236	13069	79167	NW	Section 26 near trailer
3-26-17	1355	5.3	1051	101	93583	12884	80699	NW	Section 26 near trailer
3-28-17	0836	5.5	1058	102	95338	14043	81295	NW	Section 26 near trailer
3-28-17	1210	5.3	1055	102	101737	20756	80981	NW	Section 26 road at southern claim
3-29-17	0832	5.4	1057	102	94866	13882	81984	NW	Section 26 near trailer
3-29-17	1230	DID NOT USE							

NW 4-2-17

Reviewed by: [signature] Review Date: 1/29/18

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	190166
Cal. Due Date:	6-14-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR202073
Cal. Due Date:	6-14-18

Comments:
NNEAT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-29-17	0915	5.5	900	100	91966	13959	78007	NW	Section 26
6-30-17	0845	5.5	900	100	99374	21622	77752	NW	ERG office

7-5-17

Reviewed by: [signature]

Review Date: ~~1/19~~ 1/29/18

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	218564
Cal. Due Date:	9-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	0515173
Cal. Due Date:	9-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-19-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
9-18-17	0836	6.1	950	99	120544	41247	79297	NW	Section 26 @ corral
9-18-17	1502	6.0	947	99	88788	12852	75936	NW	Milan roadside
9-19-17	0824	6.0	950	99	92200	14959	77246	NW	Section 26 @ trailer
9-19-17	1400	6.0	947	99	113273	36312	76961	NW	Section 26 @ corral

9-23-17

Reviewed by: [illegible] Review Date: 10/9/17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	9-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR269995
Cal. Due Date:	9-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
9-18-17	0841	6.2	1053	100	120777	42659	78118	NW	Section 26 @ corral
9-15-17	1508	6.1	1046	100	90560	13975	76585	NW	Milan roadside

NW 9-23-17

Reviewed by: MM

Review Date: 10/9/17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
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(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	262334
Cal. Due Date:	9-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	051517P
Cal. Due Date:	9-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
9-18-17	0842	5.3	953	100	122187	41250	80937	NW	Section 26 @ corral
9-18-17	1505	5.3	945	100	90087	12767	77320	NW	Milan roadside

NW 9-21-17

Reviewed by: MA Review Date: 10/9/17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Reuter Stokes
Model:	RS-S131-200-ER000U
Serial No.:	1000992
Cal. Due Date:	3-16-18

DETECTOR	
Manufacturer:	Reuter Stokes
Model:	RS-S131-200-ER000U
Serial No.:	1000992
Cal. Due Date:	3-16-18

Comments:
NNERS - HPIC

Source: Cs-137 Activity: 4 uCi Source Date: 4-12-96 Distance to Source: Contact housing

Serial No.: S44-46 Emission Rate: NA cpm/emissions

← µR/h →

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-26-17	0630	8.18	401.2	NA	~14.2	~8.5	~5.7	NW	Home 2 Suites room! Farmington
6-26-17	2100	7.93	401.1	NA	~14.5	~8.6	~5.9	NW	Hilton Garden Inn room! Gallup
6-29-17	0950	8.25	401.3	NA	~18	~12.5	~5.5	NW	Section 26
6-30-17	0740	8.21	401.3	NA	~19	~13.4	~5.6	NW	ERG office

NW 6-30-17

Reviewed by: MB Review Date: 10/9/17

Appendix B Exposure Rate Measurements

Date and Time	Exposure Rate (mR/h)	Location
06/29/2017 9:50	0.0093	Correlation Location 1
06/29/2017 9:51	0.0116	Correlation Location 1
06/29/2017 9:52	0.0119	Correlation Location 1
06/29/2017 9:53	0.0121	Correlation Location 1
06/29/2017 9:54	0.0120	Correlation Location 1
06/29/2017 9:55	0.0119	Correlation Location 1
06/29/2017 9:56	0.0123	Correlation Location 1
06/29/2017 9:57	0.0118	Correlation Location 1
06/29/2017 9:58	0.0118	Correlation Location 1
06/29/2017 9:59	0.0121	Correlation Location 1
06/29/2017 10:19	0.0227	Correlation Location 2
06/29/2017 10:20	0.0279	Correlation Location 2
06/29/2017 10:21	0.0276	Correlation Location 2
06/29/2017 10:22	0.0270	Correlation Location 2
06/29/2017 10:23	0.0271	Correlation Location 2
06/29/2017 10:24	0.0275	Correlation Location 2
06/29/2017 10:25	0.0277	Correlation Location 2
06/29/2017 10:26	0.0268	Correlation Location 2
06/29/2017 10:27	0.0274	Correlation Location 2
06/29/2017 10:28	0.0276	Correlation Location 2
06/29/2017 10:42	0.0095	Correlation Location 3
06/29/2017 10:43	0.0135	Correlation Location 3
06/29/2017 10:44	0.0141	Correlation Location 3
06/29/2017 10:45	0.0140	Correlation Location 3
06/29/2017 10:46	0.0138	Correlation Location 3
06/29/2017 10:47	0.0144	Correlation Location 3

Date and Time	Exposure Rate (mR/h)	Location
06/29/2017 10:48	0.0139	Correlation Location 3
06/29/2017 10:49	0.0135	Correlation Location 3
06/29/2017 10:50	0.0135	Correlation Location 3
06/29/2017 10:51	0.0134	Correlation Location 3
06/29/2017 10:52	0.0137	Correlation Location 3
06/29/2017 11:05	0.0130	Correlation Location 4
06/29/2017 11:06	0.0194	Correlation Location 4
06/29/2017 11:07	0.0207	Correlation Location 4
06/29/2017 11:08	0.0206	Correlation Location 4
06/29/2017 11:09	0.0202	Correlation Location 4
06/29/2017 11:10	0.0206	Correlation Location 4
06/29/2017 11:11	0.0194	Correlation Location 4
06/29/2017 11:12	0.0206	Correlation Location 4
06/29/2017 11:13	0.0201	Correlation Location 4
06/29/2017 11:14	0.0201	Correlation Location 4
06/29/2017 11:27	0.0191	Correlation Location 5
06/29/2017 11:28	0.0399	Correlation Location 5
06/29/2017 11:29	0.0450	Correlation Location 5
06/29/2017 11:30	0.0456	Correlation Location 5
06/29/2017 11:31	0.0456	Correlation Location 5
06/29/2017 11:32	0.0462	Correlation Location 5
06/29/2017 11:33	0.0459	Correlation Location 5
06/29/2017 11:34	0.0453	Correlation Location 5
06/29/2017 11:35	0.0462	Correlation Location 5
06/29/2017 11:36	0.0451	Correlation Location 5
06/29/2017 11:37	0.0453	Correlation Location 5

Appendix C Technical Memo from ERG to Stantec. "Statistical Analysis of the Navajo Trustee Mines Dataset: Multivariate Linear Regression for Evaluation of Gamma Correlation with Ra-226 and Evaluation of Secular Equilibrium Between Ra-226 and Th-230".

Environmental Restoration Group, Inc.
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Memo

To: Kirsty Woods, Program Director, Stantec

From: Liz Ruedig, PhD, CHP, and Mike Schierman, CHP, Environmental Restoration Group

Date: 7/31/2018

Re: Statistical Analysis of the Navajo Trustee Mines Dataset: Multivariate Linear Regression for Evaluation of Gamma Correlation with Ra-226 and Evaluation of Secular Equilibrium Between Ra-226 and Th-230

Multivariate Linear Regression for Evaluation of Gamma Count Rate with Ra-226 Concentrations in Surface Soil

Due to a large number of reviewer comments at the sixteen Navajo Trust Abandoned Uranium Mines (AUMs) concerning the influence of gamma-emitting radionuclides not within the uranium-238 decay series on the correlation between dynamic gamma count rate and soil concentration of radium-226, Environmental Restoration Group has performed multivariate linear regression (MLR), relating gamma count rate to multiple soil radionuclides simultaneously. MLR models the influence of a set of predictor variables (in this case, soil concentrations of several gamma-emitting radionuclides, or surrogates for these radionuclides) on a single response variable (in this case, dynamic gamma count rate), accounting for the influence of each predictor variable upon the response variable independently of the other predictor variables within the set.

In a MLR, it is possible to distinguish from a large set of variables the subset that significantly predicts a response variable. This is done by evaluating potential models on a number of criteria:

1. **The multi-collinearity of predictor variables.**

   Predictor variables that are linearly related to each other (i.e., variables y and x, where y may also be mathematically expressed as some multiple of x) produce a condition known as multicollinearity, where the matrix math used to solve the multivariate linear regression becomes irreducible. A physical example of multicollinearity occurs when modelling the influence of two radionuclides in equilibrium with each other (e.g., Th-230 and Ra-226) on a single response variable (e.g., gamma count rate). In order to compute a mathematical solution to the regression model, one of the multicollinear variables must be removed from the regression matrix. The multicollinear variables are identifiable by a large variance inflation factor (VIF), typically greater than 7, but in cases of near-perfect multicollinearity, often much greater than this value (e.g., > 100).

   It is also possible to identify multicollinear predictor variables by regressing two suspect variables upon each other. A high degree of correlation (i.e., $p < 0.05$ and high adjusted R^2) between the two variables suggests that the predictor variables are multicollinear, and that one variable should be eliminated from the multivariate regression prior to analysis.

2. **The p-value of predictor variables**

   For a variable to be considered a significant predictor of the response variable, the p-value of its slope (as calculated in an ANOVA table) must be significant (i.e., $p < 0.05$). In a MLR, the adjusted R^2 value for individual predictor variables is not indicative of overall model quality.

For the Navajo Trust AUMs there are three potential gamma-contributing radionuclides (defined as radionuclides that emit gamma radiation, or whose short-lived decay products emit gamma radiation) present in soil: thorium-232, radium-226 and, thorium-228. Thorium-230, which does not emit gamma radiation, was excluded as a potentially significant gamma-contributing radionuclide.

A MLR model: gamma = radium-226 + thorium-228 + thorium-232 was run for each AUM. For 15 of the 16 mines, thorium-232 and thorium-228 were multicollinear. On this basis, thorium-228 was excluded from the MLR. No multicollinearity was detected at Barton 3. However, none of the predictor variables was a significant predictor of gamma count rate ($p > 0.05$) for the complete model. As such, analysis for all 16 AUMs proceeded by removing thorium-228 from the set of predictor variables and running a new MLR model: gamma = radium-226 + thorium-232. None of the 16 models exhibited multicollinearity with the reduced model. After accounting for the effect of radium-226, thorium-232 was not a significant predictor of gamma count rate at any of the 16 AUMs. Radium-226 was a significant predictor ($p < 0.05$) of gamma count rate (after accounting for the influence of thorium-232 and thorium-228) at some of the AUMs (six of 16 AUMs).

Since neither predictor variable (thorium-232 or radium-226) was unambiguously a predictor in the MLR, two univariate regression models were performed as a final step: gamma = radium-226 and gamma = thorium-232. Thorium-232 was a significant predictor of gamma count rate ($p < 0.05$) only at Standing Rock, which is not unexpected given the geological conditions at this AUM. At all other sites, thorium-232 (and thorium-228 by association) were not significant predictors of gamma count rate ($p > 0.05$). By way of contrast, radium-226 was a significant predictor of the gamma count rate ($p < 0.05$) at 13 of the 16 AUMs. At three AUMs (Mitten, NA-0928, and Tsosie 1) none of the measured radionuclides significantly predicted the gamma count rate. Additionally, the adjusted R^2 values for the correlation models at the three AUMs, plus Claim 28, fail to meet the specified data quality objective (DQO) of greater than 0.8.

The failure to construct statistically defensible correlation models at four AUMs has been identified as a data gap in the relevant AUM report. The unsatisfactory correlation result at these locations is likely due to the small number of correlation locations, or environmental conditions at the AUMs (e.g., spatial heterogeneity in radionuclide concentration in soil, topographic features influencing gamma count rate, etc.), or some combination thereof.

Note that while the statistical measures (i.e., conformance with the study DQO of $R^2 > 0.8$) associated with these regressions can be improved by fitting a power curve to the data, and reporting unadjusted R^2 values, with only five data points at each AUM, ERG does not believe that any statistical correlation model is sufficiently robust to make meaningful inferences concerning soil radium-226 concentration from the gamma scanning data. ERG believes that linear functions – not power curves – best mimic the conceptual model for the physical processes governing the observed data. Fitting any other function in an effort to achieve the study DQO for R^2 is not a statistically rigorous approach, and improving R^2 does not commensurately improve a statistical model's predictive ability. Figure *1* compares the result of fitting a linear versus a power function to the available correlation data for one AUM (Hoskie Tso); the other AUM results are similar.

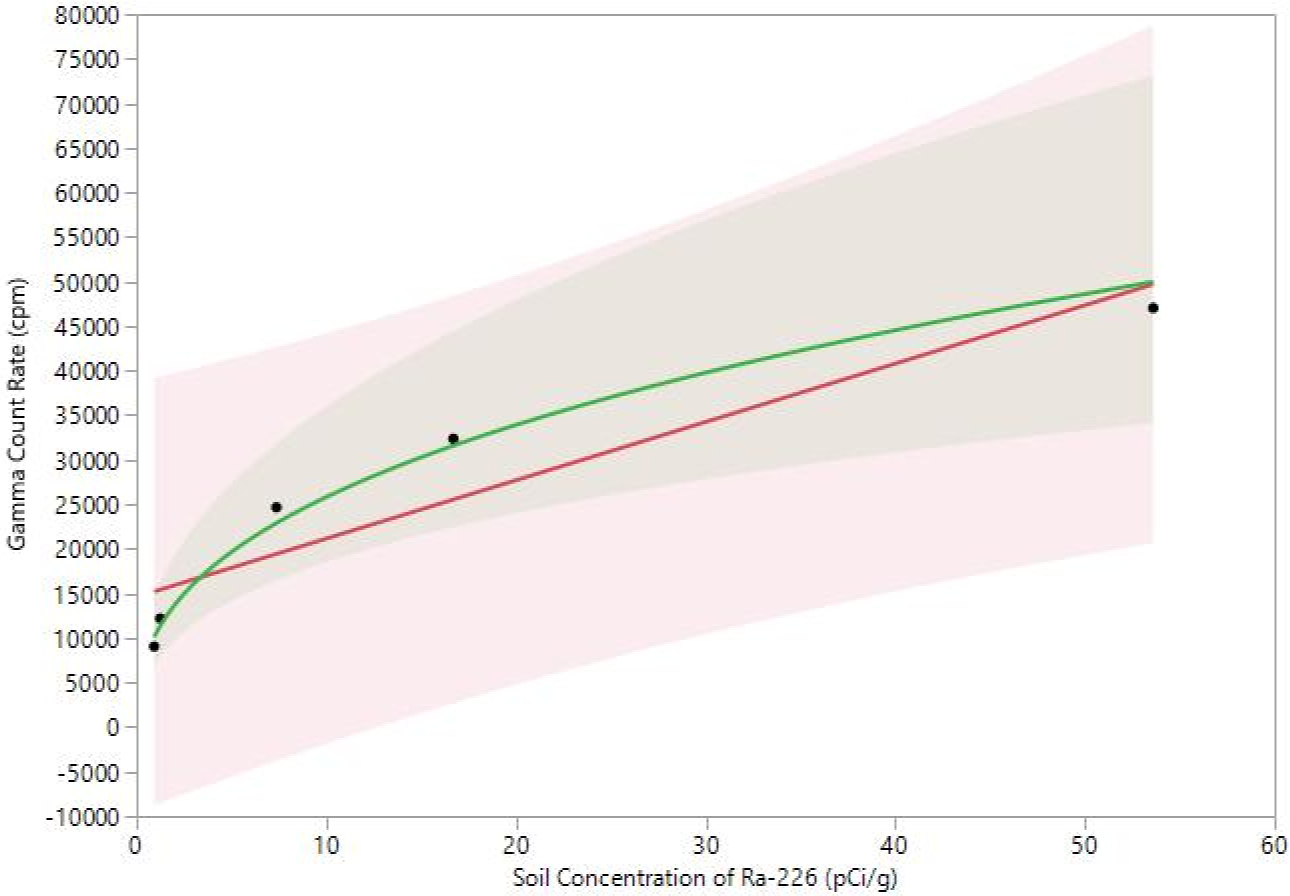


Figure 1. Regression models (linear versus power curve) for gamma count rate regressed on radium-226 showing 95% UPLs (upper prediction limits). Both models meet the study DQO for adjusted R^2 (greater than 0.8). Gamma count rate is not an especially strong predictor of soil concentration of radium-226 for either function.

ERG has updated the individual AUM reports with linear correlation functions and reported the more robust measures of statistical performance described in this memo.

Evaluation of Secular Equilibrium Between Ra-226 and Th-230

Secular equilibrium is a condition that occurs when the half-life of a decay-product nuclide is significantly shorter than that of its parent nuclide. After a period of ingrowth equal to approximately seven times the half-life of the decay product, the two nuclides effectively decay with the half-life of the parent. When two radionuclides are in secular equilibrium, their activities are equal.

Equilibrium, for the purpose of this report, is defined as a condition whereby a parent nuclide and its decay product are present in the environment at a fixed ratio, but this ratio – for whatever reason – is not a one-to-one relationship indicative of secular equilibrium. Most commonly, an equilibrium condition results from an environmental process which chemically selects for and transports one nuclide (parent or decay product) away from the other nuclide. Because a consistent fraction of one nuclide has been removed, the two nuclides are present at a fixed ratio other than one-to-one.

Determination of secular equilibrium for an AUM can be an important part of the risk assessment process, as the assumed fraction of radium-226 decay products present in the environment greatly influences a hypothetical receptor's radiation dose and mortality risk. However, it is also acceptable and conservative to assume secular equilibrium between radium-226 and its decay products for the purpose of risk assessment, and therefore to avoid the need to conclusively determine the secular equilibrium status of an AUM. Thus, an inconclusive result regarding secular equilibrium is not a study data gap, as the risk assessment phase may still proceed, provided that conservative assumptions are included regarding equilibrium concentrations of radium-226 decay products.

Regardless, the Navajo Nation AUM Environmental Response Trust RSE workplan specified that an evaluation of secular equilibrium would be made at each of the 16 Trust AUMs, and so a robust statistical examination of secular equilibrium status for radium-226 and its decay products at each AUM was conducted. One method of evaluating equilibrium between Ra-226 and Th-230 is to calculate the ratio (φ) between the two nuclides for each soil sample location, i.e.,

$$\varphi = \frac{\left[{}^{226}Ra\right]}{\left[{}^{230}Th\right]}$$

When φ is unity, the two nuclides may be said to be in secular equilibrium. Sometimes, φ is averaged over a number of locations, and if the average is unity, the population of measurement locations is said to be in secular equilibrium. Similarly, if φ is consistently some number other than one, it may be concluded that the measured population is in equilibrium. This approach does not account for the statistical uncertainty associated with making inferences across a population, nor the bias introduced into the measurement by averaging a potentially large number of ratios. It is also difficult to establish defensible cutoffs for whether Ra-226 and Th-230 are in secular equilibrium at a particular site using a ratio approach, as there is no objective basis for concluding, e.g., that φ must be between 0.8 and 1.2 (versus any other range of values for φ) for secular equilibrium to occur.

Due to a large number of reviewer comments concerning secular equilibrium within the RSE reports, Environmental Restoration Group opted to re-evaluate equilibrium at each mine site using a more robust statistical method: simple linear regression. This was done after confirming the methods to analyze Ra-226 (EPA Method 901.1) and Th-230 (alpha spectroscopy following sample digestion with hydrofluoric acid) are both total-activity methods with comparable results (L. Steere, ALS personal email communication, July 25, 2018). Evaluation of secular equilibrium for each mine site proceeded as follows:

1. Construction of a figure that depicts soil concentrations of Th-230 plotted against soil concentrations of Ra-226.

2. Simple linear regression is performed on the dataset; the p-value and the adjusted R^2 are recorded. The resulting linear model and the 95% UCL (upper confidence limit) bands are plotted on the figure generated in step 1.

3. The line y=x is added to the figure generated in step 2 (this line represents a perfect 1:1 ratio between Th-230 to Ra-226, indicative of secular equilibrium).

4. An examination of the model and the figure is made sequentially:

    a. If the p-value for the regression slope is insignificant (i.e., $p > 0.05$) or the adjusted R^2 does not meet the study's data quality objective (Adjusted $R^2 > 0.8$), ERG concludes that there is insufficient evidence to conclude that Ra-226 and Th-230 are in equilibrium (secular or otherwise) therefore, it is listed as inconclusive (no equilibrium). Figure *2* depicts the regression result for an AUM (Mitten) that failed to meet the p-value and adjusted R^2 criteria.

    b. If the p-value for the regression slope is significant (i.e., $p < 0.05$) and the adjusted R^2 meets the DQO (Adjusted $R^2 > 0.8$) there are two possible conditions, which are evaluated via visual examination of the figure generated in step 3.

        i. If the y=x line falls fully within the bounds of the 95% UCL bands on the regression, ERG concludes that there is evidence that Ra-226 and Th-230 are in secular equilibrium at the site. Figure *3* depicts the regression result for an AUM (Harvey Blackwater) where there is evidence that Ra-226 and Th-230 are in secular equilibrium.

        ii. If the y=x line falls partially or completely outside the bounds of the 95% UCL bands on the regression, ERG concludes that there is evidence that Ra-226 and Th-230 are in equilibrium, but not secular equilibrium at the site. Figure *4* depicts the regression result for an AUM (Alongo Mines) where there is evidence that Ra-226 and Th-230 are in equilibrium, but not secular equilibrium.

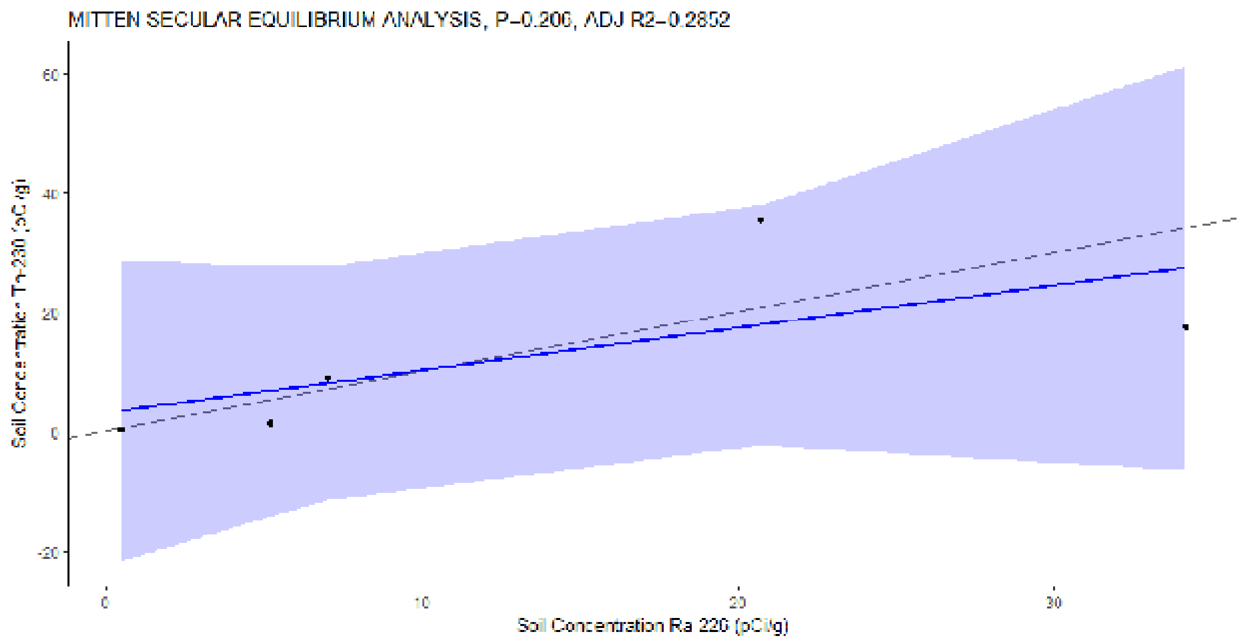


Figure 2. Result for Mitten secular equilibrium analysis, showing failure to meet p-value and adjusted R^2 criteria, i.e., the data are poorly correlated.

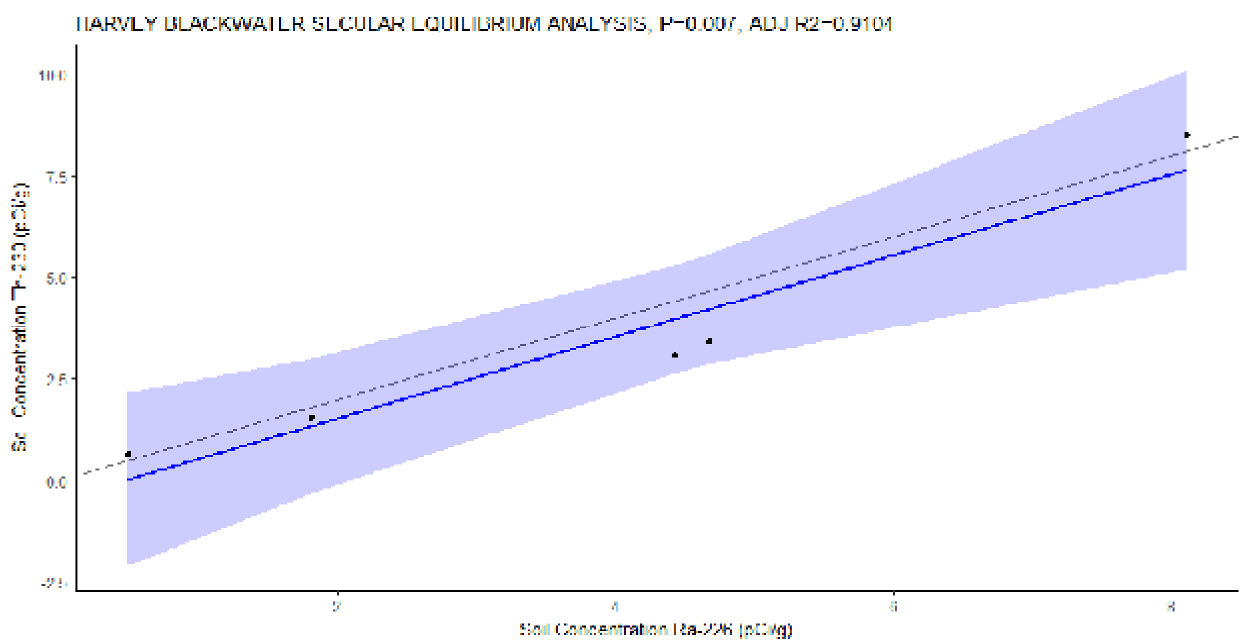


Figure 3. Result for Harvey Blackwater secular equilibrium analysis, showing excellent correlation between the data and the y=x line, i.e., Th-230 and Ra-226 are in secular equilibrium.

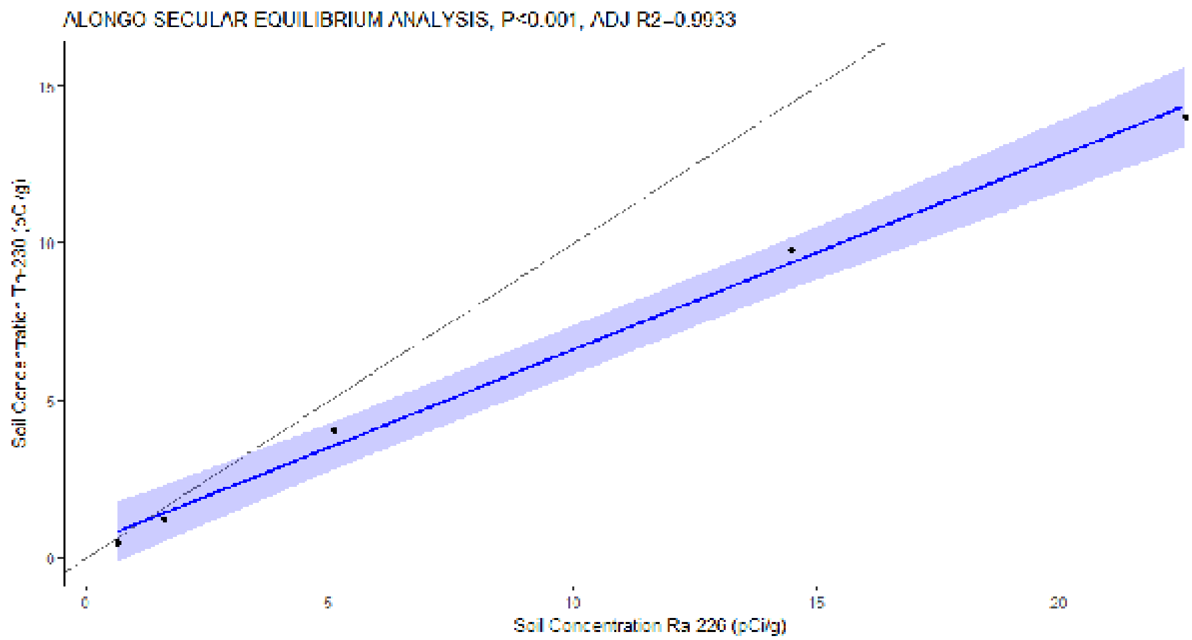


Figure 4. Result for Alongo Mines secular equilibrium analysis, showing excellent correlation between the data, but poor agreement with the y=x line, i.e., Th-230 and Ra-226 are in equilibrium, but not secular equilibrium.

ERG tested for secular equilibrium at each of the 16 Navajo AUMs using the process described above. The results are summarized in Table 1 and in the RSE report for each AUM, respectively. ERG concluded that the data provide evidence that that Ra-226 and Th-230 are in secular equilibrium in soils at two mines (Harvey Blackwater and NA-0928). At one mine (Mitten) there was insufficient evidence to draw any conclusions regarding equilibrium. At the remaining sites, there is evidence that Ra-226 and Th-230 are in equilibrium.

Table 1. Results of secular equilibrium analysis for each of the 16 Navajo Trust AUMs.

Mine	p-value	Adjusted R^2	Conclusion
Alongo Mine	<0.001	0.99	Equilibrium
Barton 3	<0.001	0.98	Equilibrium
Boyd Tisi	<0.001	0.99	Equilibrium
Charles Keith	<0.001	0.99	Equilibrium
Claim 28	<0.001	0.99	Equilibrium
Eunice Becenti	<0.001	0.99	Equilibrium
Harvey Blackwater	0.008	0.91	Secular Equilibrium
Hoskie Tso	<0.001	0.99	Equilibrium
Mitten	0.2	0.29	No Equilibrium
NA-0904	0.001	0.98	Equilibrium
NA-0928	0.002	0.97	Secular Equilibrium
Oak 124-125	<0.001	0.99	Equilibrium
Occurrence B	<0.001	0.98	Equilibrium
Section 26	0.002	0.96	Equilibrium
Standing Rock	0.008	0.91	Equilibrium
Tsosie 1	0.02	0.86	Equilibrium

Appendix D Preliminary Report "Radiological Characterization of the Section 26 (Desidero Group) Abandoned Uranium Mines "

Disclaimer: Data and analytical methods used in this Preliminary Report are superseded by the Final Report.

Radiological Characterization of the Section 26 (Desidero Group) Abandoned Uranium Mines

Preliminary

February 20, 2018

prepared for:

Stantec Consulting Services Inc.

2130 Resort Drive, Suite 350
Steamboat Springs, CO 80487

prepared by:

ERG

Environmental Restoration Group, Inc.

8809 Washington St. NE
Suite 150
Albuquerque, NM 87113

Contents

Tables

Figures

Appendices

Acronyms

ANSI	American National Standards Institute
AUM	abandoned uranium mine
BG1	Background Reference Area 1
BG2	Background Reference Area 2
BG3	Background Reference Area 3
BG4	Background Reference Area 4
BG5	Background Reference Area 5
cpm	counts per minute
DQOs	data quality objectives
ERG	Environmental Restoration Group, Inc.
ft	foot
GPS	global positioning system
m	meter
MDL	method detection limit
µR/h	microRoentgens per hour
pCi/g	picocuries per gram
R^2	Pearson's Correlation Coefficient
RSE	removal site evaluation
σ	standard deviation
Stantec	Stantec Consulting Services Inc.

Executive Summary

This report addresses the radiological characterization of the Section 26 (Desidero Group) abandoned uranium mines (AUMs) located in the Baca/Haystack Chapter of the Navajo Nation north of Milan, New Mexico. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase.

This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of the gamma count rates at these AUMs to exposure rates and concentrations of radium-226 in surface soils, and 3) an assessment of equilibrium in the uranium series. The field activities addressed in this report were conducted on March 25, 26, 28, and 29; June 29, and September 18 and 19, 2017. They included a GPS-based radiological survey of land surfaces over a Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, areas where the survey was extended; and correlation studies.

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in "Section 26 Removal Site Evaluation Report" (Stantec, 2018).

The findings of the RSE pertaining to these activities are:

- The horizontal extent and magnitude of mining-related materials were delineated sufficiently to support additional characterization of the subsurface.

- Elevated count rates were associated with waste rock in each of the mine claims; i.e., in several small areas of the northwestern claim, the north and east edges of the northeastern claim, and the center of the southern claim. Elevated count rates also were observed outside the northeastern and southern claims along the edge of the mesa and continuing onto the valley floor below.

- Five potential Background Reference Areas were established.

- The relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface) is described by a linear regression model:

$$\text{Radium-226 Concentration (picocuries per gram [pCi/g])} = 2\times10^{-4}\,\text{(Gamma Count Rate in counts per minute [cpm])} - 1.6716$$

- The distribution of concentrations of radium-226 in surface soils predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 0.1 to 148, with a central tendency (median) of 3.5 pCi/g.

- The thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226 from gamma count rates.

- The uranium series radionuclides appear not to be in secular equilibrium.

- The relationship between gamma count rates and exposure rates is described by a linear regression model:

  Exposure Rate (microRoentgens per hour [μR/h]) = Gamma Count Rate (cpm) x $2x10^{-4}$ + 11.736

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 13.5 to 162, with a central tendency (median) of 16.9 μR/h.

1.0 Introduction

This report addresses the radiological characterization of the Section 26 (Desidero Group) abandoned uranium mines (AUMs) located in the Baca/Haystack Chapter of the Navajo Nation north of Milan, New Mexico. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase.

This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of the gamma count rates at these AUMs to exposure rates and concentrations of radium-226 in surface soils, and 3) an assessment of equilibrium in the uranium series. The field activities addressed in this report were conducted on March 25, 26, 28, and 29; June 29, and September 18 and 19, 2017. They included a GPS-based radiological survey of land surfaces over an approximately 28-acre Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, areas where the survey was extended, five potential Background Reference Areas; and correlation studies.

A salient deviation to the RSE Work Plan was the use of 3-inch by 3-inch sodium iodide detectors in lieu of the 2-inch by 2-inch detectors that were specified in the plan. The change was made such that the gamma count rate measurements could be compared to those made previously by others using 3-inch by 3-inch sodium iodide detectors (Ecology and Environment, 2014).

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in “Section 26 Removal Site Evaluation Report” (Stantec, 2018).

Figure 1 shows the location of the AUMs. Background information that is pertinent to the characterization of these AUMs is presented in “Section 26 Removal Site Evaluation Report” (Stantec, 2018).

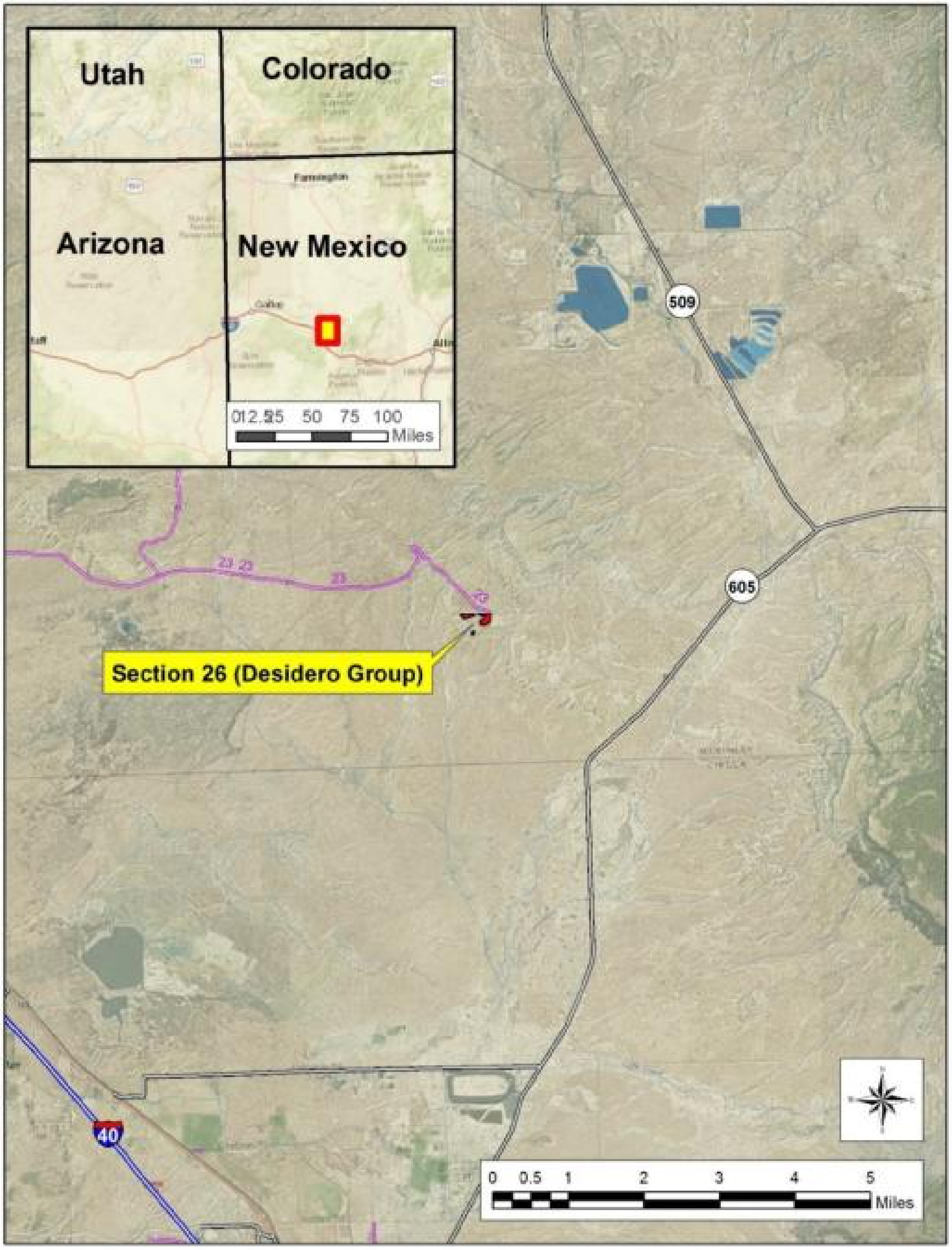


Figure 1. Location of the Section 26 (Desidero Group) Abandoned Uranium Mines

2.0 GPS-Based Gamma Survey

This section addresses the GPS-based surveys conducted in five potential Background Reference Areas and the Survey Area. The survey was extended to bound areas in which elevated count rates were observed. Table 1 lists the detection systems used in the survey, which were function-checked before and after each day of use and within calibration, in accordance with American National Standards Institute (ANSI) Standard N232A (ANSI, 1997). Appendix A presents the completed function check forms and calibration certificates for the instruments.

Table 1. Detection systems used in the GPS-Based gamma surveys.

Survey Area	Ludlum Model 44-20	Ludlum Model 2221 Ratemeter/Scaler
Potential Background Reference Areas	PR202073[a]	190166[a]
	PR213432	271435
	051517S	218564
Survey Area	051517P	262334
	PR202073[a]	190166[a]
	PR213432	271435
	PR269880	254772
	PR269985	254772
	PR262406	196086

Notes:
[a]Detection system used in the correlation studies described in Sections 3.1 and 3.3.

2.1 Potential Background Reference Areas

Five potential Background Reference Areas were surveyed, the locations and results of which are depicted on Figure 2. BG1, BG2, BG3, BG4, and BG5 in the figure are Background Reference Areas 1 through 5, respectively. Table 2 lists a summary of the gamma count rates, which in:

- BG1 ranged from 11,464 to 20,015 counts per minute (cpm), with a mean and median of 14,082 and 14,041 cpm, respectively.
- BG2 ranged from 18,508 to 25,542 cpm, with a mean and median of 21,269 and 21,227 cpm, respectively.
- BG3 ranged from 13,202 to 57,059 cpm, with a mean and median of 29,080 and 26,603 cpm, respectively.
- BG4 ranged from 15,868 to 22,772 cpm, with a mean and median of 18,804 and 18,780 cpm, respectively.

- BG5 ranged from 16,299 to 22,914 cpm, with a mean and median of 19,213 and 19,101 cpm, respectively.

Figure 3 depicts histograms of the gamma count rates in the potential Background Reference Areas. The red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could be expected if the distributions were normal or lognormal.

Table 2. Summary statistics for gamma count rates in the potential Background Reference Areas.

			Gamma Count Rate (cpm)			
Potential Background Reference Area	**n**	**Minimum**	**Maximum**	**Mean**	**Median**	**Standard Deviation**
1	171	11,464	20,015	14,082	14,041	1,483
2	288	18,508	25,542	21,269	21,227	1,139
3	80	13,202	57,059	29,080	26,603	9,927
4	442	15,868	22,772	18,804	18,780	1,035
5	138	16,299	22,914	19,213	19,101	1,412

Notes:
cpm = counts per minute

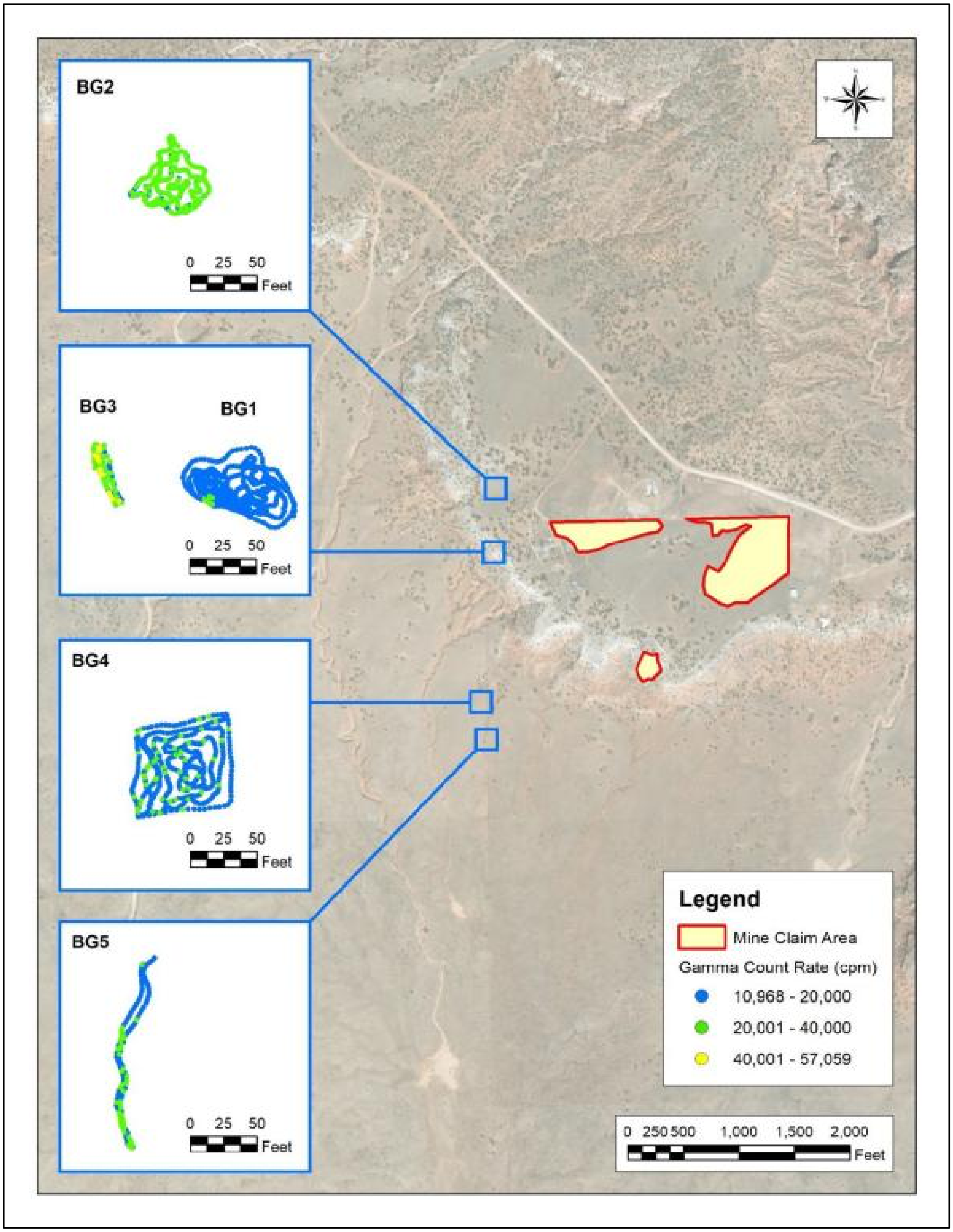
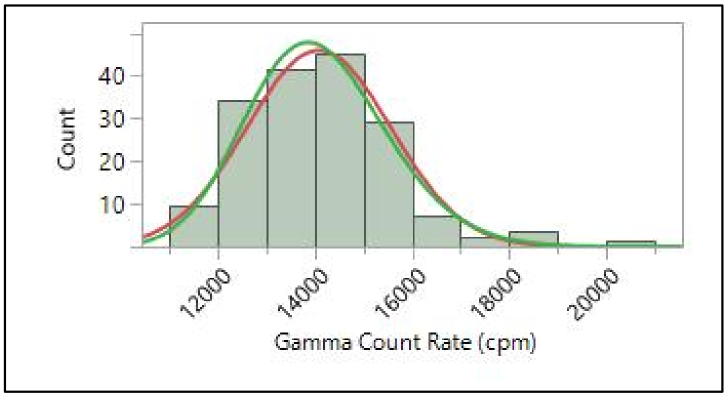
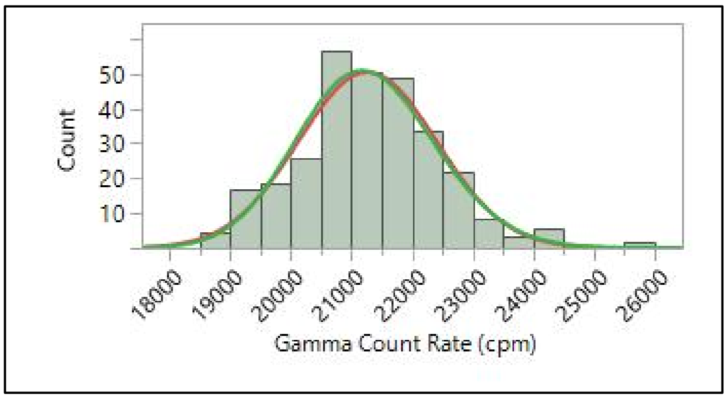


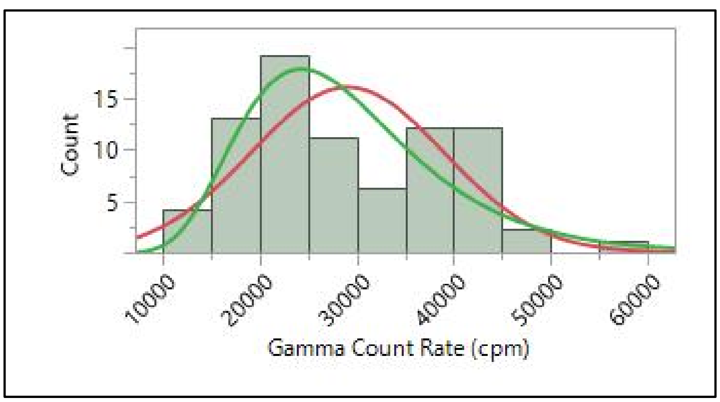
Figure 2. Gamma count rates in the potential Background Reference Areas.



a. Background Reference Area 1

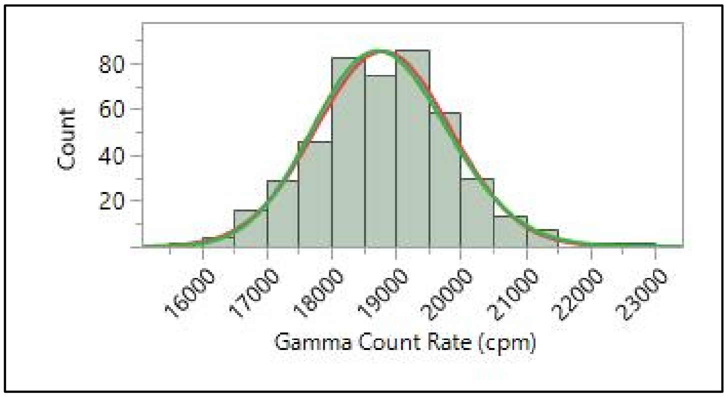


b. Background Reference Area 2

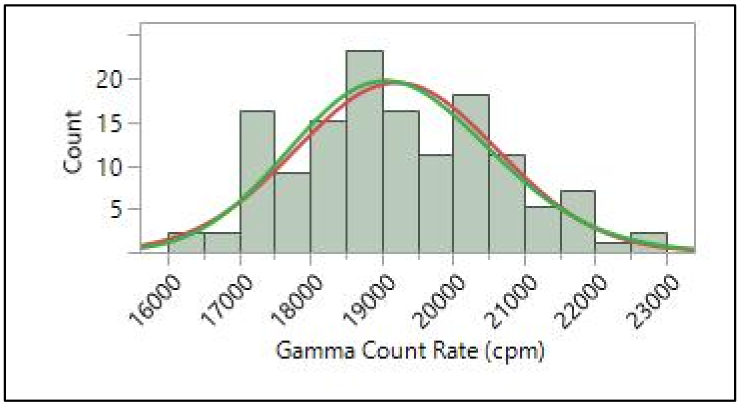


c. Background Reference Area 3

Figure 3 (1 of 2). Histograms of gamma count rates in the potential Background Reference Areas.



a. Background Reference Area 4



b. Background Reference Area 5

Figure 3 (2 of 2). Histograms of gamma count rates in the potential Background Reference Areas.

2.2 Survey Area

The gamma count rates observed in the Survey Area are depicted in Figure 4. Elevated count rates were associated with waste rock in each of the mine claims; i.e., in several small areas of the northwestern claim, the north and east edges of the northeastern claim, and the center of the southern claim. Elevated count rates also were observed outside the northeastern and southern claims along the edge of the mesa and continuing onto the valley floor below.

Figure 5 is a histogram of the gamma count rate measurements made in the Survey Area, including the area surveyed outside the 100-ft buffer. As stated in Section 2.1, the red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could

be expected if the distributions were normal or lognormal. The distribution of the right-tailed set of measurements, evaluated using U.S. Environmental Protection Agency software ProUCL (version 5.1.002), is not defined; i.e., neither normal or logarithmic. The box plot in Figure 6 depicts cutoffs as horizontal bars, from bottom to top, for the following values or percentiles: minimum, 0.5, 2.5, 10, 25, 50, 75, 90, 97.5, 99.5, and maximum. The 25th, 50th, and 75th percentiles (the three horizontal lines of the box inside the box plot) are 21,267, 25,949, and 33,641 cpm, respectively.

Table 3 is a statistical summary of the measurements, which range from 8,652 to 749,127 cpm and have a central tendency (median) of 25,949 cpm.

Table 3. Summary statistics for gamma count rates in the Survey Area.

Parameter	Gamma Count Rate (cpm)
n	71,563
Minimum	8,652
Maximum	749,127
Mean	32,664
Median	25,949
Standard Deviation	28,212

Notes:
cpm = counts per minute

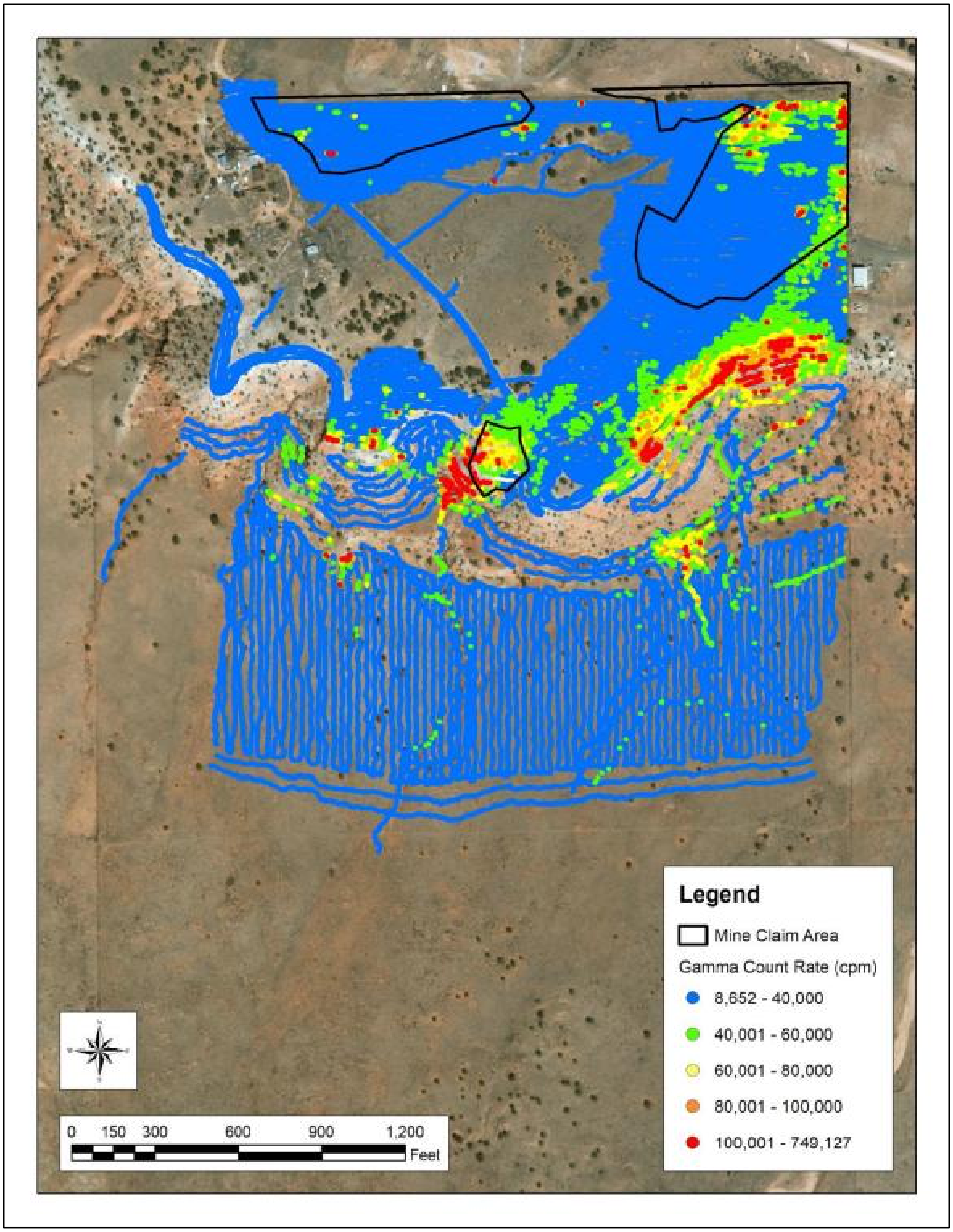


Figure 4. Gamma count rates in the Survey Area.

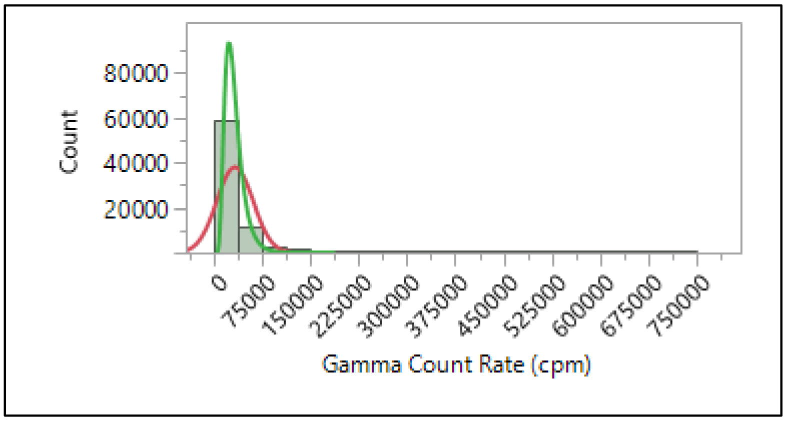


Figure 5. Histogram of gamma count rates in the Survey Area.

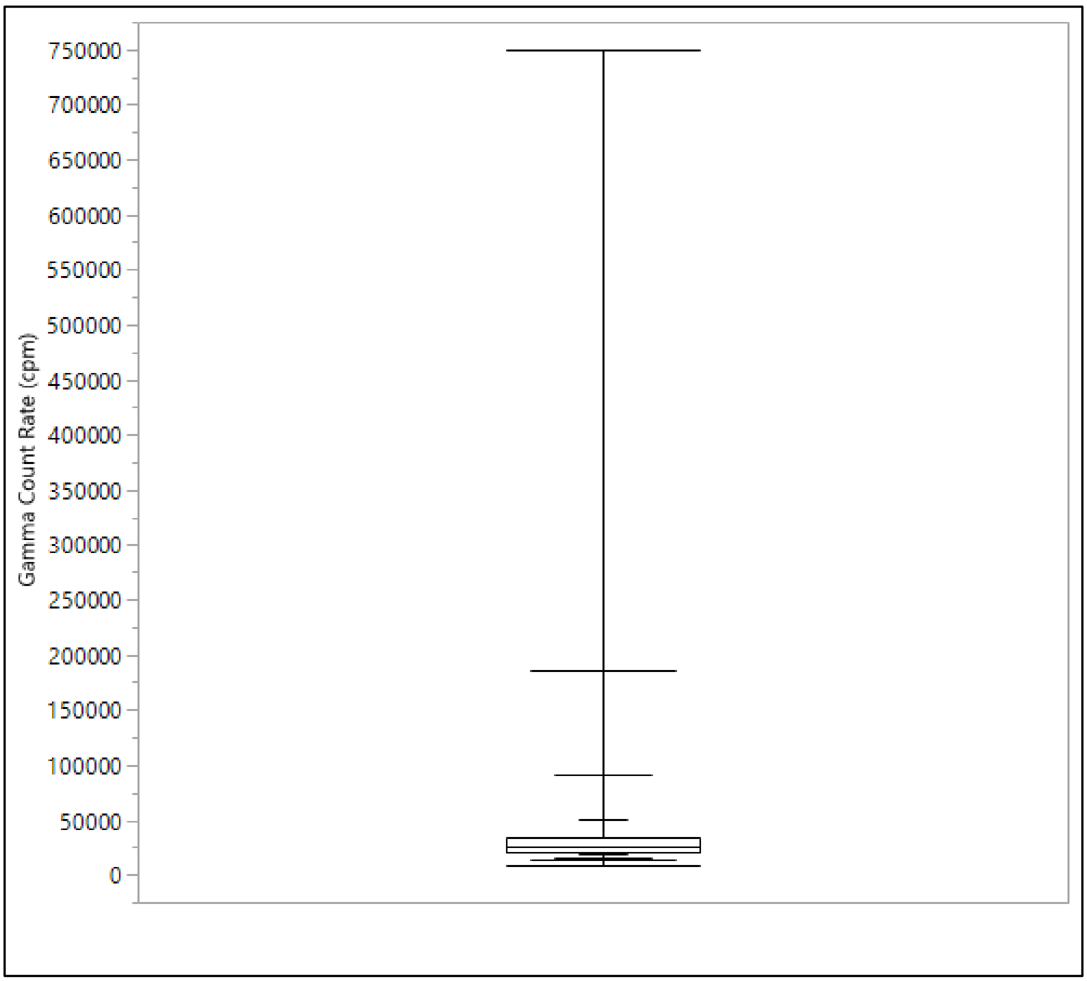


Figure 6. Box plot of gamma count rates in the Survey Area.

3.0 Correlation Studies

The following sections address the activities under two types of correlation studies outlined in the RSE Work Plan: comparisons of 1) radium-226 concentrations in surface soils and gamma count rates and 2) exposure rates and gamma count rates. GPS-based gamma count rate measurements were made over small areas for the former study. The means of the measurements were used in this case. Static gamma count rate measurements, co-located with exposure rate measurements, were used in the latter study.

3.1 Radium-226 concentrations in surface soils and gamma count rates

On March 29, 2017 field personnel made GPS-based gamma count rates measurements and collected five-point composite samples of surface soils in each of five areas at the AUMs. The activities were performed contemporaneously, by area and all 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 locations. Figure 7 shows the GPS-based gamma count rate measurements in the five areas (labeled with location identifiers).

The soil samples were analyzed by ALS Laboratories in Ft Collins, CO for radium-226 and isotopic thorium. The latter analysis was included to assess the potential effects of thorium series isotopes on the correlation and evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. Table 4 lists the results of the gamma count rate measurements and radium-226 concentrations in the soil samples. The means of the gamma count rate measurements range from 28,568 to 165,200 cpm. The concentrations of radium-226 in the soil samples range from 1.26 to 25.2 picocuries per gram (pCi/g).

Table 5 lists the concentrations of isotopes of thorium (thorium-228, -230, and -232) in the same soil samples.

Laboratory analyses are presented in Appendix D, Laboratory Analytical Data and Data Usability Report, in “Section 26 Removal Site Evaluation Report” (Stantec, 2018).

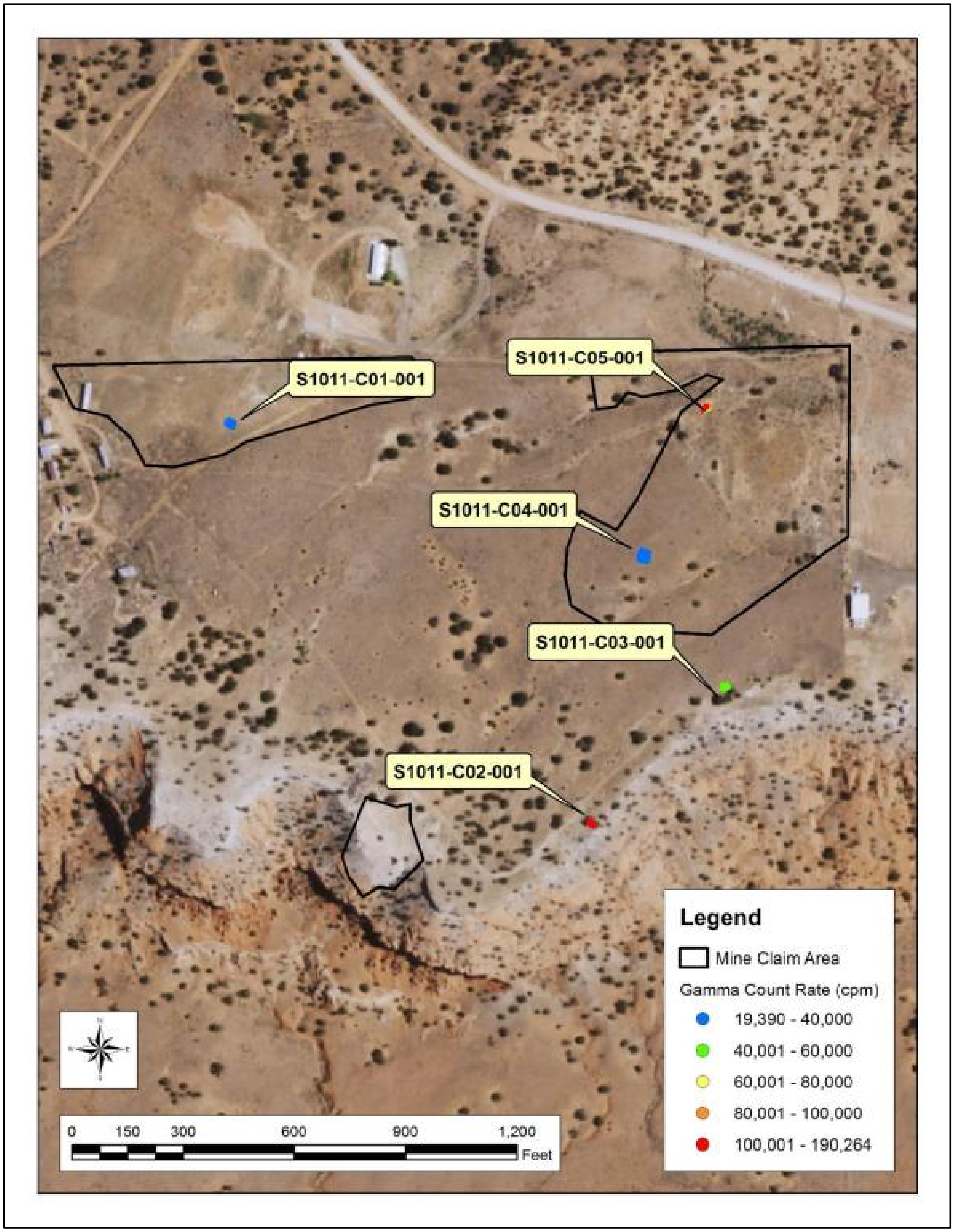


Figure 7. GPS-based gamma count rate measurements made for the correlation study.

Table 4. Gamma count rates and associated concentrations of radium-226 in samples of surface soils obtained in the correlation study.

	Gamma Count Rate (cpm)				Ra-226 (pCi/g)		
Location	Mean	Minimum	Maximum	σ	Result	Error ±1σ	MDL
S1011-C01-001	21,632	19,390	25,165	1,174	1.26	0.3	0.3
S1011-C02-001	165,200	136,070	190,264	14,389	25.2	3.1	3.1
S1011-C03-001	55,042	50,933	59,275	2,143	11	1.4	1.4
S1011-C04-001	28,422	25,883	30,438	975	1.83	0.33	0.33
S1011-C05-001	76,851	46,675	121,502	18,779	9	1.2	1.2

Notes:
cpm = counts per minute
MDL = method detection limit
pCi/g = picocuries per gram
σ = standard deviation

Table 5. Concentrations of isotopes of thorium in samples of surface soils obtained in the correlation study.

	Thorium-228 (pCi/g)			Thorium-230 (pCi/g)			Thorium-232 (pCi/g)		
Sample ID	Result	Error ± 1 σ	MDL	Result	Error ± 1 σ	MDL	Result	Error ± 1 σ	MDL
S1011-C01-001	0.51	0.11	0.05	0.87	0.16	0.07	0.49	0.096	0.011
S1011-C02-001	0.341	0.081	0.053	15.5	2.4	0.1	0.335	0.075	0.02
S1011-C03-001	0.359	0.084	0.056	4.95	0.79	0.08	0.368	0.08	0.025
S1011-C04-001	0.52	0.11	0.05	1.4	0.25	0.08	0.48	0.1	0.02
S1011-C05-001	0.372	0.085	0.05	4.07	0.66	0.08	0.356	0.078	0.019

Notes:
MDL = method detection limit
pCi/g = picocuries per gram
σ = standard deviation

A model was made of the results in Table 4, predicting the concentrations of radium-226 in surface soils from the mean gamma count rate in each area. The best predictive relationship between the measurements, shown in **Figure 8,**, is a strong, linear function with a Pearson's Correlation Coefficient (R^2) of 0.95, as expressed in the equation:

$$\text{Radium-226 concentration (pCi/g)} = 2 \times 10^{-4} \times \text{Gamma Count Rate (cpm)} - 1.6716$$

R^2 is a measure of the dependence between two variables and is expressed as a value between -1 and +1 where +1 is a positive correlation, 0 is no correlation, and -1 is a negative correlation. The root mean square error and p-value for the model are 2.500962 and 0.0048, respectively; these parameters are not data quality objectives (DQOs) and are included only as information.

The concentrations of thorium-232 and thorium-228, isotopes in the thorium series, in the correlation samples are similar and at most 0.52 pCi/g. Given these low concentrations and the high R^2 of the linear function, the thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226, using gamma count rates.

This equation was used to convert the gamma count rate measurements observed in the gamma surveys to predicted concentrations of radium-226. Table 6 presents summary statistics for the predicted concentrations of radium-226 in the Survey Area. The range of the predicted concentrations of radium-226 in the Survey Area is 0.1 to 148 pCi/g, with a mean and median of 4.9 and 3.5 pCi/g, respectively. Note that the radium-226 concentrations predicted from gamma count rate measurements exceeding approximately 165,000 cpm are extrapolated from the regression model and are uncertain.

Figure 9 shows the predicted concentrations of radium-226, the spatial and numerical distribution of which mirror those depicted in Figure 4.

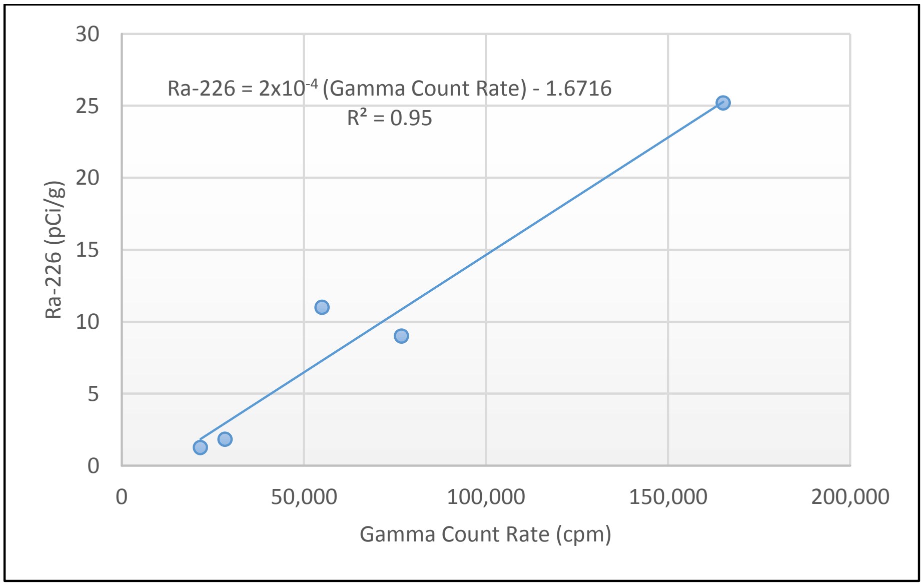


Figure 8. Correlation of gamma count rates and concentrations of radium-226 in surface soils.

Table 6. Predicted concentrations of radium-226 in the Survey Area.

Parameter	Radium-226 (pCi/g)
n	71,563
Minimum	0.1
Maximum	148
Mean	4.9
Median	3.5
Standard Deviation	5.6

Notes:
pCi/g = picocuries per gram

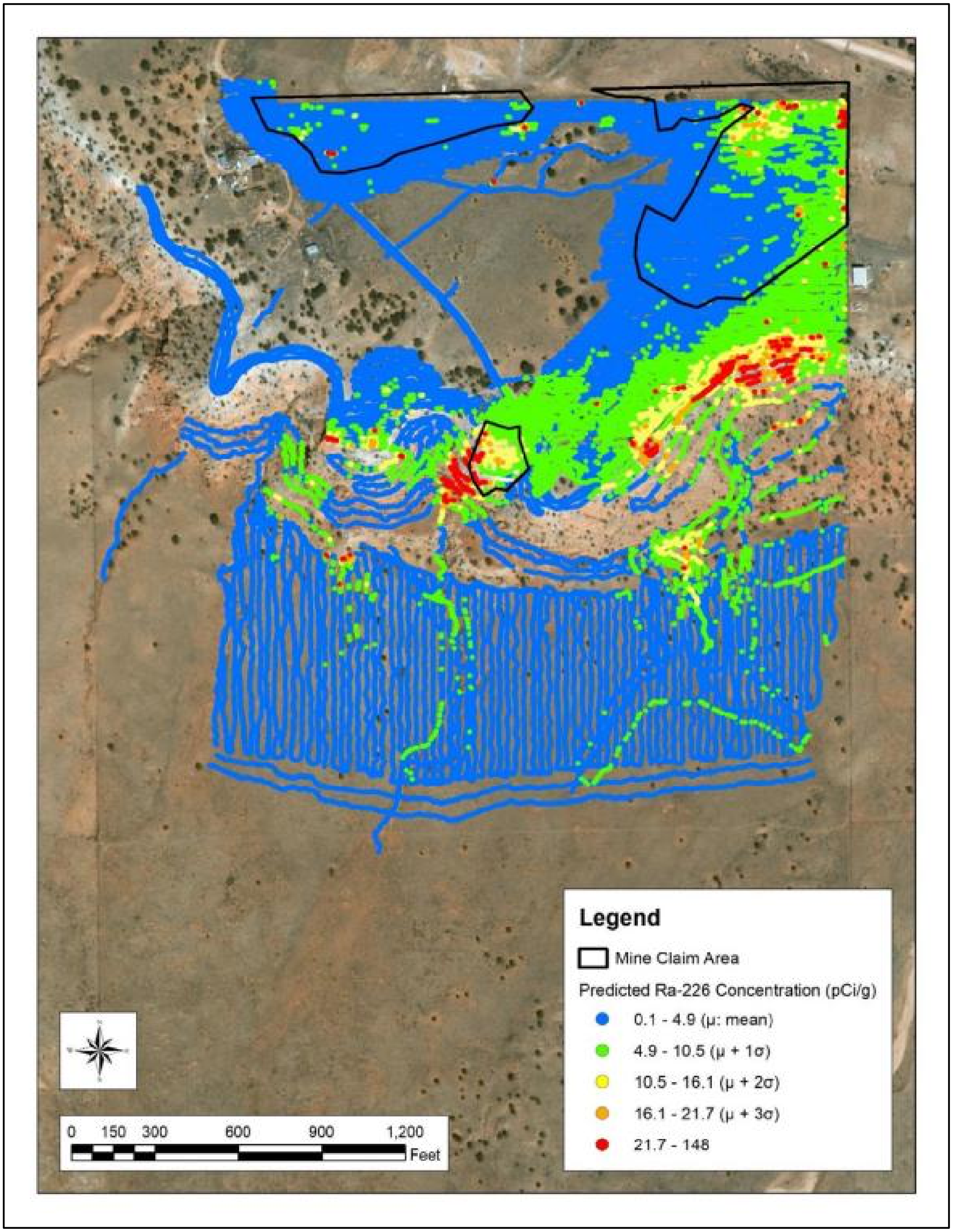

Legend
Mine Claim Area
Predicted Ra-226 Concentration (pCi/g)
0.1 - 4.9 (μ: mean)
4.9 - 10.5 (μ + 1σ)
10.5 - 16.1 (μ + 2σ)
16.1 - 21.7 (μ + 3σ)
21.7 - 148
0 150 300 600 900 1,200
Feet

Figure 9. Predicted concentrations of radium-226 in the Survey Area.

3.2 Equilibrium in the uranium series

Secular equilibrium occurs when the activities of a parent radionuclide and its decay product are equal. This can occur in a closed system, when the half-life of the parent radionuclide is much larger than that of the decay product.

The ratio of the concentrations of radium-226 to thorium-230 can be used as an indicator of the status of equilibrium in the uranium series. The half-lives of thorium-230 and radium-226 are 77,000 and 1,600 years, respectively. The ratios in the five correlation samples are 1.5 (Sample S1011-C01-001), 1.6 (Sample S1011-C02-001), 2.2 (Sample S1011-C03-001), 1.3 (Sample S1011-C04-001), and 2.2 (Sample S1011-C05-001) indicating that thorium-230 is depleted in relation to radium-226 and, by extrapolation, the uranium series itself is not in secular equilibrium.

Note this observation is based on the results of five samples, subject to differing analytical methods. Gamma spectroscopy, the method used to determine the concentration of radium-226, assesses an intact portion of the whole sample as it was collected. The concentration of thorium-230 was determined by alpha spectroscopy of an acid-leached aliquot of the sample.

This evaluation is not related to the correlation of radium-226 concentrations in surface soils and gamma count rates. It may be used for a future risk assessment.

3.3 Exposure rates and gamma count rates

On June 29, 2017 field personnel made co-located 1-minute static count rate and exposure rate measurements at five locations within the Survey Area, representing the range of gamma count rates obtained in the GPS-based gamma survey. Figure 7 shows the locations of the co-located measurements, which were made in the centers of the areas.

The gamma count rate and exposure rate measurements were made at 0.5 meters (m) and 1 m above the ground surface, respectively. The gamma count rate measurements were made using a Ludlum Model 44-20 3-inch by 3-inch sodium iodide detector coupled with a Ludlum Model 2221 ratemeter/scaler (Serial Numbers PR202073/190166). The exposure rate measurements were made using a Reuter Stokes Model RS-S131-200-ER000 (Serial Number 1000992) high pressure ionization chamber (HPIC) at 1-second intervals for about 10 minutes. The HPIC output the 1-second measurements as 1-minute averages. The exposure rate used in the comparison was the mean of these measurements, less those occurring in initial instrument warm-ups. The HPIC was in current calibration and function checked before and after use. Calibration forms for the HPIC are provided in Appendix A. **Table 7** presents the results for the two types of measurements made at each of the five locations. Appendix B presents the 1-minute average exposure rate measurements.

The best predictive relationship between the measurements is linear with a R^2 of 0.7983, indicating a positive correlation. The root mean square error and p-value for the model are 7.065987 and 0.0410, respectively; these parameters are not DQOs and are included only as information.

The correlation is weaker than those observed at the other AUMs addressed in the RSE Work Plan, given that the sources of elevated gamma count rates at Locations S1011-C01-001, S1011-C02-001, S1011-C04-001, and S1011-C05-001 were heterogenous and caused by waste rock scattered on the ground surface.

The following equation is the linear regression (shown in **Figure 10**) between the mean exposure rate and gamma count rate results in Table 7 that was generated using MS Excel:

Exposure Rate (microRoentgens per hour [µR/h]) = 2×10^{-4} x Gamma Count Rate (cpm) + 11.736

Figure 11 presents the exposure rates predicted from the gamma count rate measurements, the spatial and numerical distribution of which mirror those depicted in Figure 4.

Tables 8 and 9 present summary statistics for the predicted exposure rates in the five Background Reference Areas and AUMs, respectively.

The range of predicted exposure rates at:

- BG1 is 14.0 to 15.7 µR/h, with a mean and median of 14.6 and 14.5 µR/h, respectively
- BG2 is 15.4 to 16.8 µR/h, with a mean and median of 16.0 µR/h
- BG3 is 14.4 to 23.1 µR/h, with a mean and median of 17.5 and 17.1 µR/h, respectively
- BG4 is 14.9 to 16.3 µR/h, with a mean and median of 15.5
- BG5 is 15.0 to 16.3 µR/h, with a mean and median of 15.6

The range of predicted exposure rates in the Survey Area is 13.5 to 162 µR/h, with a mean and median of 18.3 and 16.9 µR/h, respectively.

Table 7. Co-located gamma count rate and exposure rate measurements.

Location	Gamma Count Rate (cpm)	Exposure Rate (µR/h)
S1011-C01-001	19,139	11.9
S1011-C02-001	30,713	27.4
S1011-C03-001	9,893	13.8
S1011-C04-001	71,276	20.2
S1011-C05-001	147,023	45.6

Notes:
cpm = counts per minute
µR/h = microRoentgens per hour

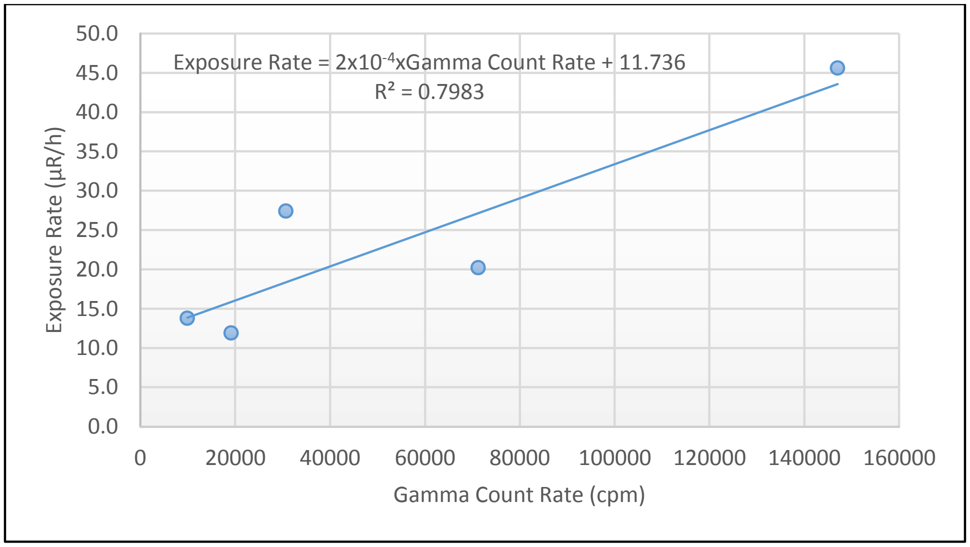


Figure 10. Correlation of gamma count rates and exposure rates.

Table 8. Predicted exposure rates in the potential Background Reference Areas.

Potential Background Reference Area	BG1	BG2	BG3	BG4	BG5
Parameter	Exposure Rate (µR/h)				
N	171	288	80	442	138
Minimum	14.0	15.4	14.4	14.9	15.0
Maximum	15.7	16.8	23.1	16.3	16.3
Mean	14.6	16.0	17.5	15.5	15.6
Median	14.5	16.0	17.1	15.5	15.6
Standard Deviation	0.3	0.2	2.0	0.2	0.3

Notes:
BG1 = Background Reference Area 1
BG2 = Background Reference Area 2
BG3 = Background Reference Area 3
BG4 = Background Reference Area 4
BG5 = Background Reference Area 5
µR/h = microRoentgens per hour

Table 9. Predicted exposure rates in the Survey Area.

Parameter	Exposure Rate (µR/h)
n	71,563
Minimum	13.5
Maximum	162
Mean	18.3
Median	16.9
Standard Deviation	5.6

Notes:
µR/h = microRoentgens per hour

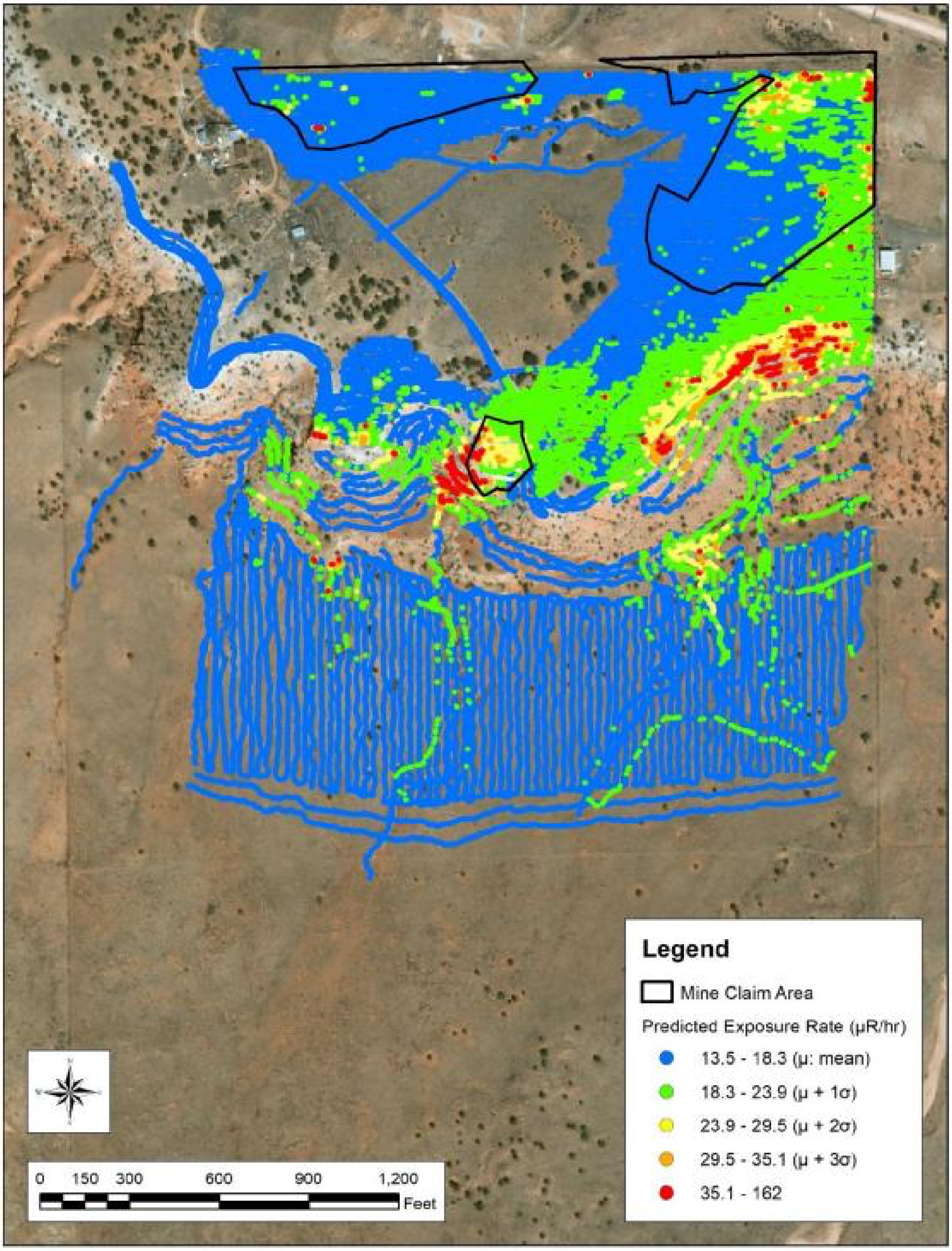


Figure 11. Predicted exposure rates in the Survey Area.

4.0 Deviations to RSE Work Plan

The RSE Work Plan specifies that the comparison of gamma count rates and radium concentrations in surface soils was to occur in 900 square foot areas. Field personnel adjusted the areas as necessary, to minimize the variability of gamma count rates observed, particularly where the spatial distribution of waste rock was heterogeneous.

A second deviation to the RSE Work Plan was the use of 3-inch by 3-inch sodium iodide detectors in lieu of the 2-inch by 2-inch detectors that were specified in the plan. The change was made such that the gamma count rate measurements could be compared to those made previously by others using 3-inch by 3-inch sodium iodide detectors (Ecology and Environment, 2014).

5.0 Conclusions

The findings of the RSE pertaining to these activities are:

- The horizontal extent and magnitude of mining-related materials were delineated sufficiently to support additional characterization of the subsurface.
- Elevated count rates were associated with waste rock in each of the mine claims; i.e., in several small areas of the northwestern claim, the north and east edges of the northeastern claim, and the center of the southern claim. Elevated count rates also were observed outside the northeastern and southern claims along the edge of the mesa and continuing onto the valley floor below.
- Five potential Background Reference Areas were established.
- The relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface) is described by a linear regression model:

  Radium-226 Concentration (pCi/g) = 2×10^{-4} (Gamma Count Rate in cpm) – 1.6716

- The distribution of concentrations of radium-226 in surface soils predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 0.1 to 148, with a central tendency (median) of 3.5 pCi/g.
- The thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226 from gamma count rates.
- The uranium series radionuclides appear not to be in secular equilibrium.
- The relationship between gamma count rates and exposure rates is described by a linear regression model:

Exposure Rate (µR/h) = Gamma Count Rate (cpm) x $2x10^{-4}$ + 11.736

The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 13.5 to 162, with a central tendency (median) of 16.9 µR/h.

6.0 References

ANSI, 1997. Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments, American National Standards Institute (ANSI) Standard N232A. June 20, 2014.

Ecology and Environment, 2014. Removal Assessment Report, Tronox AUM Section 26, Baca/Haystack Chapter, Eastern Agency, Navajo Nation. February.

MWH, 2016. Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan, October 24, 2016.

Stantec, 2018. Section 26 Removal Site Evaluation Report, January 2018.

Appendix A Instrument calibration and completed function check forms

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

	Manufacturer:		Model Number:		Serial Number:	
Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	196086
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR262406

☐ Mechanical Check ☐ THR/WIN Operation
☐ F/S Response Check ☐ Reset Check
☐ Geotropism ☐ Audio Check
☐ Meter Zeroed ☐ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☐ 500 V ☐ 1000 V ☐ 1500 V
Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:

Source Distance: ☐ Contact ✔ 6 inches ☐ Other:
Source Geometry: ✔ Side ☐ Below ☐ Other:

Threshold:
Window:

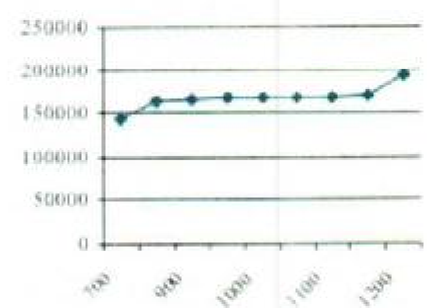
Barometric Pressure: inches Hg
Temperature: °F
Relative Humidity: %

Instrument found within tolerance: ✔ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

High Voltage	Source Counts	Background
700	144169	
800	162193	
900	166057	
950	167388	
1000	167489	21583
1050	167574	
1100	168254	
1150	170145	
1200	192327	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1000

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By: [signature] Calibration Date: 7 March 17 Calibration Due: 7 March 18

Reviewed By: [signature] Date: 3-7-17

ERG Form ITC, 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer: Ludlum	Model Number:	2221r	Serial Number:	254772
Detector:	Manufacturer: Ludlum	Model Number:	44-20	Serial Number:	PR269980

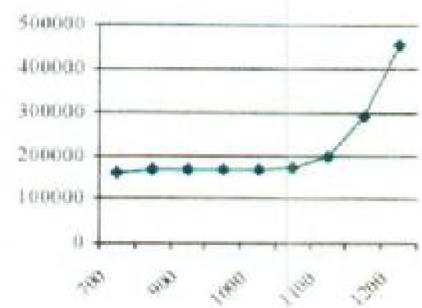
☐ Mechanical Check ☐ THR/WIN Operation HV Check (+/- 2.5%): ☐ 500 V ☐ 1000 V ☐ 1500 V
☐ F/S Response Check ☐ Reset Check Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:
☐ Geotropism ☐ Audio Check
☐ Meter Zeroed ☐ Battery Check (Min 4.4 VDC) Barometric Pressure: inches Hg
Source Distance: ☐ Contact ✔ 6 inches ☐ Other: Threshold: Temperature: °F
Source Geometry: ✔ Side ☐ Below ☐ Other: Window: Relative Humidity: %

Instrument found within tolerance: ✔ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

High Voltage	Source Counts	Background
700	162620	
800	168495	
900	170240	
950	170850	22731
1000	171277	
1050	172525	
1100	197371	
1150	291452	
1200	453265	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV =950

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By: [signature] Calibration Date: 7 March 17 Calibration Due: 7 March 18

Reviewed By: [signature] Date: 3-7-17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	271435
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR213432

✓ Mechanical Check ✓ THR/WIN Operation
✓ F/S Response Check ✓ Reset Check
✓ Geotropism ✓ Audio Check
✓ Meter Zeroed ✓ Battery Check (Min 4.4 VDC)

Source Distance: ☐ Contact ✓ 6 inches ☐ Other:
Source Geometry: ✓ Side ☐ Below ☐ Other:

HV Check (+/- 2.5%): ✓ 500 V ✓ 1000 V ✓ 1500 V
Cable Length: ☐ 39-inch ✓ 72-inch ☐ Other:

Threshold: 10 mV
Window:

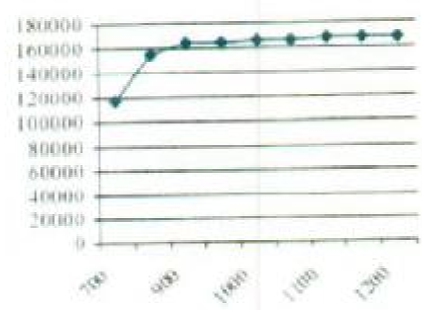
Barometric Pressure: 24.72 inches Hg
Temperature: 68 °F
Relative Humidity: 20 %

Instrument found within tolerance: ✓ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399058	400
x 1000	100	100	100		100
x 100	400	400	400	39908	400
x 100	100	100	100		100
x 10	400	400	400	3989	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	117585	
800	155051	
900	164169	
950	165480	
1000	166858	
1050	166722	
1100	168083	20644
1150	167659	
1200	168487	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1100

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✓ 201932
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
✓ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By:
Reviewed By:

Calibration Date: 7 March 17 Calibration Due: 7 March 18

Date: 3-7-17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

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Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	190166
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR269985

- ☑ Mechanical Check
- ☑ F/S Response Check
- ☑ Geotropism
- ☑ Meter Zeroed
- ☑ THR/WIN Operation
- ☑ Reset Check
- ☑ Audio Check
- ☑ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V

Cable Length: ☐ 39-inch ☑ 72-inch ☐ Other:

Source Distance: ☐ Contact ☑ 6 inches ☐ Other:

Source Geometry: ☑ Side ☐ Below ☐ Other:

Threshold: 10 mV

Window:

Barometric Pressure: 24.66 inches Hg

Temperature: 75 °F

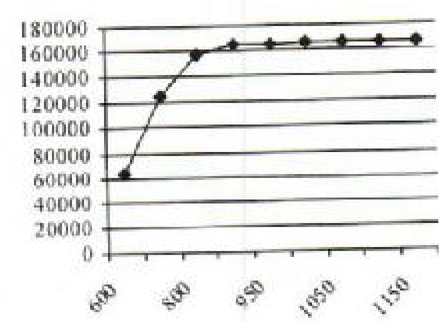
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Coun
x 1000	400	400	400	399389	400
x 1000	100	100	100		100
x 100	400	400	400	39940	400
x 100	100	100	100		100
x 10	400	400	400	3999	400
x 10	100	100	100		100
x 1	400	400	400	400	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
600	64081	
700	125567	
800	157563	
900	165079	
950	164853	
1000	165840	21364
1050	166555	
1100	166593	
1150	166782	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1000

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932

Fluke multimeter serial number: ☐ 87490128

☐ Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12)

☐ Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12)

☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

☐ Other Source:

Calibrated By:

Calibration Date: 5-12-17

Calibration Due: 5-12-18

Reviewed By:

Date: 5/12/17

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	190166
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR202073

Mechanical Check
F/S Response Check
Geotropism
Meter Zeroed

THR/WIN Operation
Reset Check
Audio Check
Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): 500 V 1000 V 1500 V
Cable Length: 39-inch ✔ 72-inch Other:

Barometric Pressure: inches Hg
Temperature: °F
Relative Humidity: %

Source Distance: Contact 6 inches Other: Threshold:
Source Geometry: Side Below Other: Window:

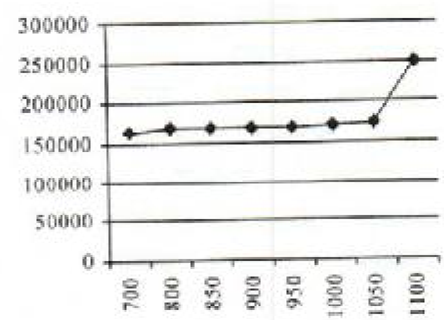
Instrument found within tolerance: ✔ Yes No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

See other (+) Sheet

High Voltage	Source Counts	Background
700	164061	
800	168372	
850	169017	
900	170276	24149
950	170410	
1000	170754	
1050	175368	
1100	250364	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 900

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 201932
Fluke multimeter serial number: 87490128
Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12)
✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12)
Other Source:

Calibrated By: Calibration Date: 6-14-17 Calibration Due: 6-14-18

Reviewed By: Date: 6-14-17

Certificate of Calibration

Calibration and Voltage Plateau

ERG
Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	218564
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	051517S

Mechanical Check — THR/WIN Operation — HV Check (+/- 2.5%): 500 V 1000 V 1500 V

F/S Response Check — Reset Check — Cable Length: 39-inch ✔ 72-inch Other:

Geotropism — Audio Check

Meter Zeroed — Battery Check (Min 4.4 VDC) — Barometric Pressure: inches Hg

Source Distance: Contact ✔ 6 inches Other: — Threshold: 10 mV — Temperature: °F

Source Geometry: ✔ Side Below Other: — Window: — Relative Humidity: %

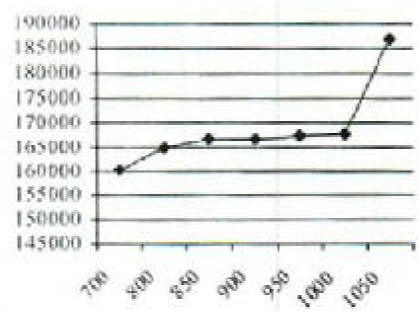
Instrument found within tolerance: ✔ Yes No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

See Ludlum Cal Sheet

High Voltage	Source Counts	Background
700	160304	
800	164819	
850	166661	
900	166927	23453
950	167592	
1000	167697	
1050	186865	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 900

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 ✔ 201932 — Fluke multimeter serial number: 87490128

Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12) — ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12) — Other Source:

Calibrated By: [signature] — Calibration Date: 9-7-17 — Calibration Due: 9-7-18

Reviewed By: T. [signature] — Date: 09/08/17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

www.ludlums.com

of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

501 Oak Street
325-235-5494
Sweetwater, TX 79556, U.S.A.

ACCREDITED
CERT # 4084.01

ORDER NO. 20315056/451872

Customer ERG

Mfg. Ludlum Measurements, Inc. Model 2221 Serial No. 218564

Mfg. Model Serial No.

Cal. Date 14-Jul-17 Cal Due Date 14-Jul-18 Cal. Interval 1 Year Meterface 202-159

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 47 % Alt 709.0 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ~~☐ Requiring Repair~~ ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☑ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck.
☑ Calibrated in accordance with LMI SOP 14.8 ☐ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set 1000 V Input Sens. 100 mV Det. Oper. ____ V at ____ mV Threshold Dial Ratio 100 = 10 mV

☐ HV Readout (2 points) Ref./Inst. 500 / 499 V Ref./Inst. 2000 / 2000 V

COMMENTS:

Calibrated with 39" cable
Firmware: 261027

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 1000	400 Kcpm	N/A	400
X 1000	100 Kcpm		100
X 100	40 Kcpm		400
X 100	10 Kcpm		100
X 10	4 Kcpm		400
X 10	1 Kcpm		100
X 1	400 cpm		400
X 1	100 cpm		100

ALL Range(s) Calibrated Electronically

*Uncertainty within ± 10% C.F. within ± 20%

Digital Readout REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
400 Kcpm	N/A	40155 (6)
40 Kcpm		4010
4 Kcpm		401
400 cpm		40
40 cpm		4

Log Scale REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
500 Kcpm	N/A	500 Kcpm
50 Kcpm		50
5 Kcpm		5
500 cpm		500 cpm
50 cpm		50

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 ISO/IE 17025:2005(E) State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 069 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521 ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☐ Y982 ☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☐ 2168CP

☐ Alpha S/N ☐ Beta S/N ☐ Other

☑ m 500 S/N 201934 ☐ Oscilloscope S/N ☑ Multimeter S/N 92780460

Calibrator Josie Ruiz [signature] Title Technician Date 14 July 17

QC'd By [signature] Title Service Dept QC Date 14 Jul 17

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

This certificate shall not be reproduced except in full, without the written approval of Ludlum Measurements, Inc.

FORM SC22A 12/12/2016 Page 1 of 1

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	254772
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	PR269985

Mechanical Check — THR/WIN Operation — HV Check (+/- 2.5%): 500 V 1000 V 1500 V

F/S Response Check — Reset Check — Cable Length: 39-inch ✔ 72-inch Other:

Geotropism — Audio Check

Meter Zeroed — Battery Check (Min 4.4 VDC) — Barometric Pressure: inches Hg

Source Distance: Contact ✔ 6 inches Other: — Threshold: — Temperature: °F

Source Geometry: ✔ Side Below Other: — Window: — Relative Humidity: %

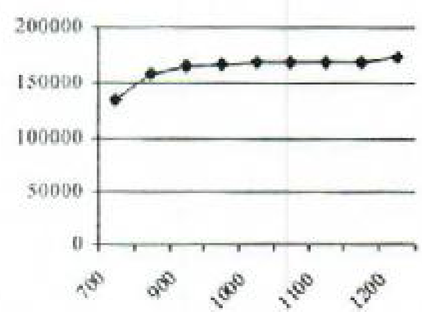
Instrument found within tolerance: Yes ✔ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

See Ludlum Cal Sheet

High Voltage	Source Counts	Background
700	133844	
800	158402	
900	164459	
950	166477	
1000	167466	
1050	167781	27111
1100	168169	
1150	168450	
1200	172562	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1050

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 201932 — Fluke multimeter serial number: 87490128

Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12) — ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12) — Other Source:

Calibrated By: [signature] — Calibration Date: 9-7-17 — Calibration Due: 9-7-18

Reviewed By: T. [signature] — Date: 09/08/17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

LUDLUM MEASUREMENTS, INC. Designer and Manufacturer of Scientific and Industrial Instruments

www.ludlums.com

CERTIFICATE OF CALIBRATION

501 Oak Street
325-235-5494
Sweetwater, TX 79556, U.S.A.

ACCREDITED CERT # 4084.01

ORDER NO. 20316590/452897

Customer ERG

Mfg. Ludlum Measurements, Inc. Model 2221 Serial No. 254772

Mfg. ______ Model ______ Serial No. ______

Cal. Date 11-Aug-17 Cal Due Date 11-Aug-18 Cal. Interval 1 Year Meterface 202-159

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 47 % Alt 698.0 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☑ Input Sens. Linearity

☑ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism

☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck.

☑ Calibrated in accordance with LMI SOP 14.8 ☐ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set 500 V Input Sens. 10 ~~100~~ JR mV Det. Oper. ______ V at ______ mV Threshold Dial Ratio 100 = 10 mV

☐ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 1500 / 1501 V

COMMENTS:

Firmware: 261027
Calibrated with Window in "OUT" position.
Calibrated with 39" cable.

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 1000	400 Kcpm	N/A	400
X 1000	100 Kcpm		100
X 100	40 Kcpm		400
X 100	10 Kcpm		100
X 10	4 Kcpm		400
X 10	1 Kcpm		100
X 1	400 cpm		400
X 1	100 cpm		100

ALL Range(s) Calibrated Electronically

*Uncertainty within ± 10% C.F. within ± 20%

Digital Readout REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
400 Kcpm	N/A	40156 (0)
40 Kcpm		4011
4 Kcpm		401
400 cpm		40
40 cpm		4

Log Scale REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
500 Kcpm	N/A	500 Kcpm
50 Kcpm		50
5 Kcpm		5
500 cpm		500 cpm
50 cpm		50

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 ISO/IE 17025:2005(E) State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521 ☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☐ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☐ Y982

☐ Alpha S/N ______ ☐ Beta S/N ______ ☐ Other ______

☑ m 500 S/N 201934 ☐ Oscilloscope S/N ______ ☑ Multimeter S/N 92780460

Calibrator Josie Ruiz Josie Ruiz Title Technician Date 11 Aug 17

QC'd By [signature] Title ______ Date 11 Aug 17

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed: ______

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	262334
Detector:	Manufacturer:	Ludlum	Model Number:	44-20	Serial Number:	051517P

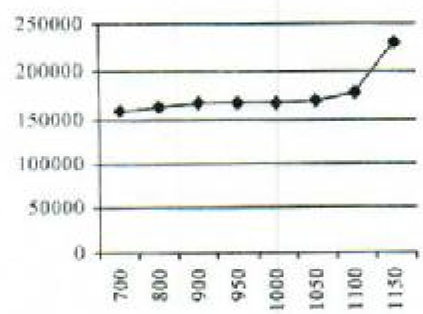
✔ Mechanical Check ✔ THR/WIN Operation HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
✔ F/S Response Check ✔ Reset Check Cable Length: 39-inch ✔ 72-inch Other:
✔ Geotropism ✔ Audio Check
✔ Meter Zeroed ✔ Battery Check (Min 4.4 VDC) Barometric Pressure: 24.69 inches Hg
Source Distance: Contact ✔ 6 inches Other: Threshold: 10 mV Temperature: 75 °F
Source Geometry: ✔ Side Below Other: Window: Relative Humidity: 20 %

Instrument found within tolerance: ✔ Yes No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	398990	400
x 1000	100	100	100		100
x 100	400	400	400	39893	400
x 100	100	100	100		100
x 10	400	400	400	3986	400
x 10	100	100	100		100
x 1	400	400	400	398	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	159361	
800	163970	
900	166805	
950	167531	26434
1000	168157	
1050	169245	
1100	177000	
1150	229347	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 950

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 ✔ 201932 Fluke multimeter serial number: 87490128
Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12) ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
Beta Source: ✔ Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12) Other Source:

Calibrated By: Calibration Date: 9-7-17 Calibration Due: 9-7-18

Reviewed By: T. [signature] Date: 09/08/17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

Reuter-Stokes

Calibration Certificate

Reuter-Stokes certifies that the Environmental Radiation Monitor, identified below, has been calibrated for output using the shadow shield technique*, and calibrated with radiation sources traceable to the National Institute of Standards and Technology.

Sensor Type:	100 R/Hr
Serial Number:	1000992
Calibration Date:	03/16/2017
Sensitivity:	-2.281E-8 A/R/h

Richard J. Betley
Authorized Signature

*Calibration Procedure: RS-SOP 238.1

Reuter-Stokes

Calibration Data

Sensor Type:	100 R/Hr	Source (CS-137):	BB-400
Serial Number:	1000992	Date of Certification:	12/01/1994
Calibration Date:	03/16/2017	Exposure Rate at 1 meter:	4.226 mR/h

Customer Name: STOCK

Sensitivity (Ra-226): -2.281E-8 A/R/h

Distance		Exposure Rate	P+S+A	S+A	P	k(CS-137)
Feet	cm	µR/h	A	A	A	A/R/h
12	366	185.323	-5.403E-12	-1.164E-12	-4.239E-12	-2.287E-08
14	427	135.592	-4.135E-12	-1.012E-12	-3.123E-12	-2.303E-08
16	488	103.384	-3.294E-12	-9.029E-13	-2.391E-12	-2.313E-08
18	549	81.348	-2.708E-12	-8.209E-13	-1.887E-12	-2.319E-08

k(CS-137) = -2.306E-8 A/R/h

k(Ra-226) = 0.9892 k(CS-137)

k(Ra-226) = -2.281E-8 A/R/h

k = -2.306E-8 A/R/h

σ = 1.39E-10 A/R/h

$V = \frac{\sigma}{k} =$ -0.603%

By: John Lak

Date: 3-17-17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	196086
Cal. Due Date:	3-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR262406
Cal. Due Date:	3-7-18

Comments:
NNERT

Source: Cs-137
Serial No.: 544-96
Activity: 4 uCi
Emission Rate: N/A cpm/emissions
Source Date: 4-18-96
Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-25-17	0926	5.5	1005	100	94365	14878	79487	NW	Section 26 near trailer
3-25-17	1454	5.4	998	100	96316	13481	82835	NW	Section 26 near trailer
3-26-17	1035	5.5	1004	102	94314	14114	80200	NW	Section 26 near trailer
3-26-17	1401	5.3	999	100	93248	13531	79717	NW	Section 26 near trailer
3-28-17	0833	5.5	1005	101	96188	14430	81758	NW	Section 26 near trailer
3-28-17	1212	5.3	1003	101	103245	22269	80976	NW	Section 26 on road @ southern claim
3-29-17	0840	5.4	1005	101	95732	14653	81079	NW	Section 26 near trailer.
3-29-17	1232	5.2	1002	101	94834	15054	79780	NW	Section 26 near trailer
					NW 4-2-16				

Reviewed by: [signature]

Review Date: 1/29/18

ERG Form ITC.201.A

(1)

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Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	3-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-2U
Serial No.:	PR 269986 ~~578~~ OPW NW
Cal. Due Date:	3-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: N/A cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-25-17	0931	5.7	952	100	96657	16184	80463	NW	Section 26, near trailer
3-25-17	1457	5.6	946	100	96139	14624	81515	NW	Section 26, near trailer
3-26-17	1031	5.7	952	100	95441	15227	80214	NW	Section 26, near trailer
3-26-17	1358	5.5	947	100	96336	14730	81606	NW	Section 26 near trailer
3-28-17	0840	5.6	952	101	96138	16340	79798	NW	Section 26, near trailer
3-28-17	1218	5.5	949	100	104022	23070	80952	NW	Section 26, road at southern chain
3-29-17	0837	5.6	952	101	96719	15960	80759	NW	Section 26, near trailer
3-29-17	1236	5.5	949	101	97836	15710	82126	NW	Section 26, near trailer
					NW 4-2-17				

Reviewed by: [signature] Review Date: 1/29/18

(4)

Environmental Restoration Group, Inc
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(505) 298-4224

ERG

Single-Channel Function Check Log

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	271435
Cal. Due Date:	3-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR213432
Cal. Due Date:	3-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: N/A cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-25-17	0937	5.5	1055	102	94755	14061	80694	NV	Section 26 near trailer
3-25-17	1451	5.4	1051	101	94302	13177	81125	NV	Section 26 near trailer
3-26-17	1039	5.5	1057	102	92236	13069	79167	NV	Section 26 near trailer
3-26-17	1355	5.3	1051	101	93583	12884	80699	NV	Section 26 near trailer
3-28-17	0836	5.5	1058	102	95338	14043	81295	NV	Section 26 near trailer
3-28-17	1210	5.3	1055	102	101737	20756	80981	NV	Section 26 road at southern claim
3-29-17	0832	5.4	1057	102	94866	13882	81984	NV	Section 26 near trailer
3-29-17	1230	DID NOT USE							

NV 4-2-17

Reviewed by: Michael [signature] Review Date: 1/29/18

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	190166
Cal. Due Date:	6-14-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR202073
Cal. Due Date:	6-14-18

Comments:
NNEAT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-29-17	0915	5.5	900	100	91966	13959	78007	NW	Section 26
6-30-17	0845	5.5	900	100	99374	21622	77752	NW	ERG office

7-5-17

Reviewed by: [signature] Review Date: ~~1/19~~ 1/29/18

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	218564
Cal. Due Date:	9-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	0515173
Cal. Due Date:	9-7-18

Comments:
NNEAT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
9-18-17	0836	6.1	950	99	120544	41247	79297	NW	Section 26 @ corral
9-18-17	1502	6.0	947	99	88788	12852	75936	NW	Milan roadside
9-19-17	0824	6.0	950	99	92200	14959	77246	NW	Section 26 @ trailer
9-19-17	1400	6.0	947	99	113273	36312	76961	NW	Section 26 @ corral

9-23-17

Reviewed by: [signature] Review Date: 10/9/17

(2)

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	9-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	PR269995
Cal. Due Date:	9-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
9-18-17	0841	6.2	1053	100	120777	42659	78118	NW	Section 26 @ corral
9-15-17	1508	6.1	1046	100	90560	13975	76585	NW	Milan roadside

NW 9-23-17

Reviewed by: [signature] Review Date: 10/9/17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	262334
Cal. Due Date:	9-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-20
Serial No.:	051517P
Cal. Due Date:	9-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
9-18-17	0842	5.3	953	100	122187	41250	80937	NW	Section 26 @ corral
9-18-17	1505	5.3	945	100	90087	12767	77320	NW	Milan roadside
					NW 9-27-17				

Reviewed by: MM Review Date: 10/9/17

Single-Channel Function Check Log

ERG

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Reuter Stokes
Model:	RS-S131-200-ER000U
Serial No.:	1000992
Cal. Due Date:	3-16-18

DETECTOR	
Manufacturer:	Reuter Stokes
Model:	RS-S131-200-ER000U
Serial No.:	1000992
Cal. Due Date:	3-16-18

Comments:
NNERT-HPIC

Source: Cs-137 Activity: 4 uCi Source Date: 4-12-96 Distance to Source: Contact housing

Serial No.: S44-46 Emission Rate: NA cpm/emissions

← μR/h →

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-26-17	0630	8.18	401.2	NA	~14.2	~8.5	~5.7	NW	Home 2 Suites room! Farmington
6-26-17	2100	7.93	401.1	NA	~14.5	~8.6	~5.9	NW	Hilton Garden Inn room! Gallup
6-29-17	0950	8.25	401.3	NA	~18	~12.5	~5.5	NW	Section 26
6-30-17	0740	8.21	401.3	NA	~19	~13.4	~5.6	NW	ERG office

NW 6-30-17

Reviewed by: MH Review Date: 10/9/17

Appendix B Exposure Rate Measurements

Date and Time	Exposure Rate (mR/h)	Location
06/29/2017 9:50	0.0093	Correlation Location 1
06/29/2017 9:51	0.0116	Correlation Location 1
06/29/2017 9:52	0.0119	Correlation Location 1
06/29/2017 9:53	0.0121	Correlation Location 1
06/29/2017 9:54	0.0120	Correlation Location 1
06/29/2017 9:55	0.0119	Correlation Location 1
06/29/2017 9:56	0.0123	Correlation Location 1
06/29/2017 9:57	0.0118	Correlation Location 1
06/29/2017 9:58	0.0118	Correlation Location 1
06/29/2017 9:59	0.0121	Correlation Location 1
06/29/2017 10:19	0.0227	Correlation Location 2
06/29/2017 10:20	0.0279	Correlation Location 2
06/29/2017 10:21	0.0276	Correlation Location 2
06/29/2017 10:22	0.0270	Correlation Location 2
06/29/2017 10:23	0.0271	Correlation Location 2
06/29/2017 10:24	0.0275	Correlation Location 2
06/29/2017 10:25	0.0277	Correlation Location 2
06/29/2017 10:26	0.0268	Correlation Location 2
06/29/2017 10:27	0.0274	Correlation Location 2
06/29/2017 10:28	0.0276	Correlation Location 2
06/29/2017 10:42	0.0095	Correlation Location 3
06/29/2017 10:43	0.0135	Correlation Location 3
06/29/2017 10:44	0.0141	Correlation Location 3
06/29/2017 10:45	0.0140	Correlation Location 3
06/29/2017 10:46	0.0138	Correlation Location 3
06/29/2017 10:47	0.0144	Correlation Location 3

Date and Time	Exposure Rate (mR/h)	Location
06/29/2017 10:48	0.0139	Correlation Location 3
06/29/2017 10:49	0.0135	Correlation Location 3
06/29/2017 10:50	0.0135	Correlation Location 3
06/29/2017 10:51	0.0134	Correlation Location 3
06/29/2017 10:52	0.0137	Correlation Location 3
06/29/2017 11:05	0.0130	Correlation Location 4
06/29/2017 11:06	0.0194	Correlation Location 4
06/29/2017 11:07	0.0207	Correlation Location 4
06/29/2017 11:08	0.0206	Correlation Location 4
06/29/2017 11:09	0.0202	Correlation Location 4
06/29/2017 11:10	0.0206	Correlation Location 4
06/29/2017 11:11	0.0194	Correlation Location 4
06/29/2017 11:12	0.0206	Correlation Location 4
06/29/2017 11:13	0.0201	Correlation Location 4
06/29/2017 11:14	0.0201	Correlation Location 4
06/29/2017 11:27	0.0191	Correlation Location 5
06/29/2017 11:28	0.0399	Correlation Location 5
06/29/2017 11:29	0.0450	Correlation Location 5
06/29/2017 11:30	0.0456	Correlation Location 5
06/29/2017 11:31	0.0456	Correlation Location 5
06/29/2017 11:32	0.0462	Correlation Location 5
06/29/2017 11:33	0.0459	Correlation Location 5
06/29/2017 11:34	0.0453	Correlation Location 5
06/29/2017 11:35	0.0462	Correlation Location 5
06/29/2017 11:36	0.0451	Correlation Location 5
06/29/2017 11:37	0.0453	Correlation Location 5

RPT-2017-033, Rev. 0

GEOPHYSICAL CHARACTERIZATION OF THE SECTION 26 HISTORIC URANIUM MINING SITE – NAVAJO NATION, NM

N. Crook, Ph.D.
M. McNeill

hydroGEOPHYSICS
2302 N. Forbes Blvd, Tucson, AZ 85745 USA

Date Published
July 2017

Prepared for:

Stantec

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

This report documents the results of a geophysical characterization survey conducted at the Section 26 Site, in June 2017, under contract to Stantec by hydroGEOPHYSICS, Inc. (HGI). The geophysical survey consisted of electrical resistivity and multi-channel analysis of surface wave (MASW) surveying, and was conducted along thirteen coincident survey lines to characterize this historic uranium mining area within the Navajo Nation.

1.2 LOCATION

The Section 26 Site is located approximately 13 miles north of the town of Grants, NM, in McKinley County. Figure 1 shows the location of the Section 26 Site geophysical survey area; the electrical resistivity and MASW survey lines are overlaid onto the satellite image in Figure 2.

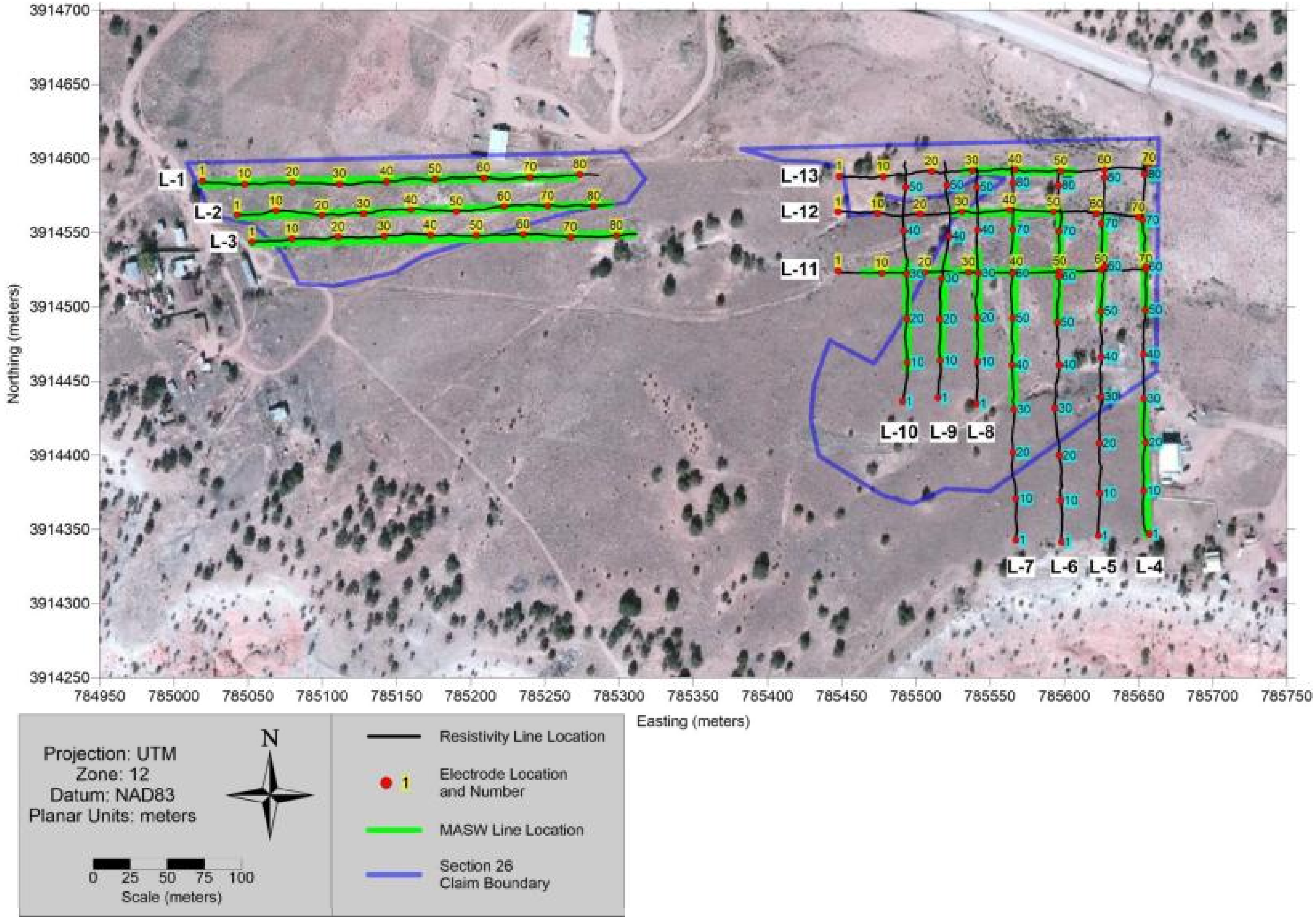
1.3 OBJECTIVE OF INVESTIGATION

The objectives of the geophysical investigation were to determine the presence of any underlying void spaces and thickness of the soil or overburden at the site.

The methods were selected to take advantage of physical property contrasts that are reflective of site conditions. For example, it was expected that the void spaces would be of significantly higher resistivity and lower acoustic velocity compared to the background bedrock or overburden. In addition, it was anticipated that the soil or overburden would present a contrast in geophysical parameters compared to the underlying bedrock strata.

Figure 1. General Location Map of the Section 26 Site - Geophysical Survey Area.

Figure 2. General Site Map with Electrical Resistivity and Multi-Channel Analysis of Surface Wave Survey Lines.



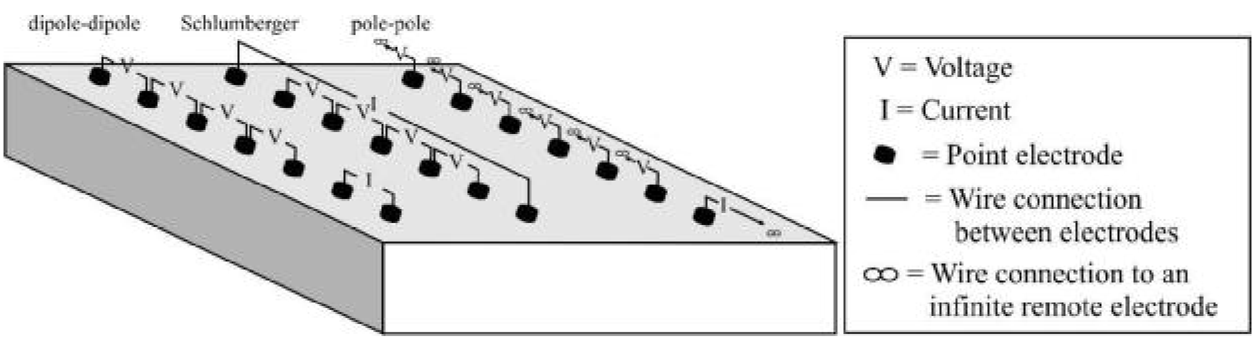
2.0 GEOPHYSICAL THEORY

2.1 ELECTRICAL RESISTIVITY

Electrical resistivity is a volumetric property that describes the resistance of electrical current flow within a medium (Rucker et al., 2011; Telford et al., 1990). Direct electrical current is propagated in rocks and minerals by electronic or electrolytic means. Electronic conduction occurs in minerals where free electrons are available, such as the electrical current flow through metal. Electrolytic conduction, on the other hand, relies on the dissociation of ionic species within a pore space and is more common in the partially saturated sandy alluvium and fractured bedrock. With electrolytic conduction, the movement of electrons varies with the mobility, concentration, and the degree of dissociation of the ions. Competent rock free of fissures and fractures will have a higher resistivity compared to less competent rock.

Mechanistically, the resistivity method uses electric current (I) that is transmitted into the earth through one pair of electrodes (transmitting dipole) that are in contact with the soil. The resultant voltage potential (V) is then measured across another pair of electrodes (receiving dipole). Numerous electrodes can be deployed along a transect (which may be anywhere from feet to miles in length), or within a grid. Figure 3 shows examples of electrode layouts for surveying. The figure shows transects with a variety of array types (dipole-dipole, Schlumberger, pole-pole). A complete set of measurements occurs when each electrode (or adjacent electrode pair) passes current, while all other adjacent electrode pairs are utilized for voltage measurements. Modern equipment automatically switches the transmitting and receiving electrode pairs through a single multi-core cable connection. Rucker et al. (2009) describe in more detail the methodology for efficiently conducting an electrical resistivity survey.

Figure 3. Possible Arrays for use in Electrical Resistivity Characterization



The modern application of the resistivity method uses numerical modeling and inversion theory to estimate the electrical resistivity distribution of the subsurface given the known quantities of electrical current, measured voltage, and electrode positions. A common resistivity inverse method incorporated in commercially available codes is the regularized least squares optimization method (Sasaki, 1989; Loke, et al., 2003). The objective function within the optimization aims to minimize the difference between measured and modeled potentials (subject to certain constraints, such as the type and degree of spatial smoothing or regularization) and the optimization is conducted iteratively due to the nonlinear nature of the model that describes the potential distribution. The relationship between the subsurface resistivity (ρ) and the measured voltage is given by the following equation (from Dey and Morrison, 1979):

$$-\nabla \cdot \left[\frac{1}{\rho(x,y,z)} \nabla V(x,y,z) \right] = \left(\frac{I}{U} \right) \delta(x-x_s)\,\delta(y-y_s)\,\delta(z-z_s) \qquad (1)$$

where I is the current applied over an elemental volume U specified at a point (x_s, y_s, z_s) by the Dirac delta function.

Equation (1) is solved many times over the volume of the earth by iteratively updating the resistivity model values using either the L_2-norm smoothness-constrained least squares method, which aims to minimize the square of the misfit between the measured and modeled data (de Groot-Hedlin & Constable, 1990; Ellis & Oldenburg, 1994):

$$\left(J_i^T J_i + \lambda_i W^T W \right) \Delta r_i = J_i^T g_i - \lambda_i W^T W r_{i-1} \qquad (2)$$

or the L_1-norm that minimizes the sum of the absolute value of the misfit:

$$\left(J_i^T R_d J_i + \lambda_i W^T R_m W \right) \Delta r_i = J_i^T R_d g_i - \lambda_i W^T R_m W r_{i-1} \qquad (3)$$

where g is the data misfit vector containing the difference between the measured and modeled data, J is the Jacobian matrix of partial derivatives, W is a roughness filter, R_d and R_m are the weighting matrices to equate model misfit and model roughness, Δr_i is the change in model parameters for the i^{th} iteration, r_i is the model parameters for the previous iteration, and λ_i = the damping factor.

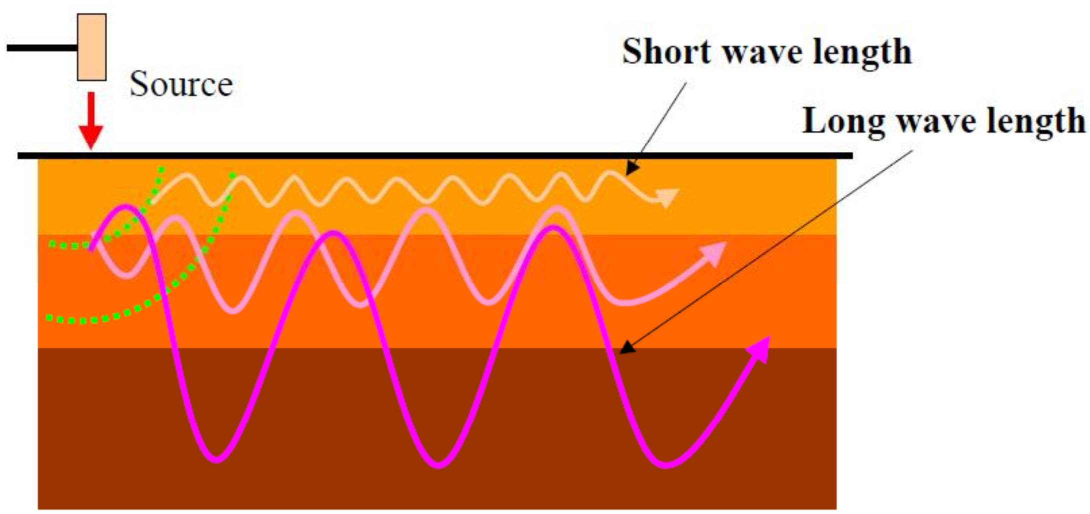
2.2 MULTI-CHANNEL ANALYSIS OF SURFACE WAVES (MASW)

Dispersion, or change in phase velocity with frequency, is the fundamental property utilized in surface-wave methods. Phase velocity of surface-wave is sensitive to the shear wave velocity (Vs); phase velocity of surface-wave is typically 90-95% that of the shear wave velocity. Surface wave dispersion can be significant in the presence of velocity layering, which is common in the near-surface environment. There are other types of surface waves, or waves that travel along a surface, but in this application we are concerned with the Rayleigh wave, which is also called "ground roll" since the Rayleigh wave is the dominant component of ground roll.

"Active source" surface-wave surveying means that seismic energy is intentionally generated at a specific location relative to the geophone spread and recording begins when the source energy is imparted into the ground. This is in contrast to "passive source" surveying, also called "microtremor" surveying, or sometimes referred to as "refraction microtremor" (or the commercial term "ReMi") surveying, where there is no time break and motion from ambient energy generated by cultural noise, wind, wave motion, etc. at various, and usually unknown, locations relative to the geophone spread is recorded.

Surface-wave energy decays exponentially with depth beneath the surface. Longer wavelength (that is, longer-period and lower-frequency) surface waves travel deeper and thus contain more information about deeper velocity structure (Figure 4). Shorter wavelength (that is, shorter-period and higher-frequency) surface waves travel shallower and thus contain more information about shallower velocity structure. In this context, by their nature and proximity to the geophone spread, it can be said that higher frequency active source surface waves resolve the shallower velocity structure and lower frequency passive source surface waves resolve the deeper velocity structure.

Figure 4. Example of Surface Wave Dispersion Produce During Multi-Channel Analysis of Surface Wave Surveying



MASW surveys are conducted using the same source and seismograph equipment as the more common P-wave seismic refraction surveys, requiring only a change to lower frequency geophones (typically 4.5Hz). They are much easier to conduct than shear wave surveys, and benefit from increasing source power efficiency (for each sledgehammer blow 67% of the energy produced is in the form of surface-waves, 26% shear waves, and 7% P-waves) and consequently improved signal to noise. The techniques works best in soft rock geology conditions with minimal or constant topography change across the spread.

Shear wave velocity is one of the elastic constants and closely related to Young's modulus. Under most circumstances, shear wave velocity is a direct indicator of the ground strength (stiffness) and therefore can be used to derive load-bearing capacity.

3.0 METHODOLOGY

3.1 SURVEY AREA AND LOGISTICS

A geophysical survey, including electrical resistivity and MASW, was completed at the Section 26 Site between the 12th and 19th of June, 2017. The geophysical survey consisted of thirteen coincident survey lines of electrical resistivity and MASW. Figure 2 shows a detailed line layout for the geophysical surveying.

3.2 EQUIPMENT

3.2.1 Equipment for Electrical Resistivity Surveying

Data were collected using a Supersting™ R8 multichannel electrical resistivity system (Advanced Geosciences, Inc. (AGI), Texas) and associated cables, electrodes, and battery power supply. The Supersting™ R8 meter is commonly used in surface geophysical projects and has proven itself to be reliable for long-term, continuous acquisition. The stainless steel electrodes were laid out along lines with a constant electrode spacing of approximately 10 feet (3 meters). Multi-electrode systems allow for automatic switching through preprogrammed combinations of four electrode measurements.

Electrode locations were determined based on the distance along the cable length, with a handheld Garmin GPS used to survey in the electrode locations along each line.

3.2.2 Equipment for MASW Surveying

Two Geode Ultra-Light Exploration 24 –Channel Seismographs (Geometrics Inc., San Jose, CA) were used for MASW surveying, providing a total of 48-channels. 4.5Hz geophone placement was every 10 feet (approximately 3 meters), shot point spacing was 20 feet (approximately 6 meters) located at the midpoint of geophone positions along the spread, with off-end shots at either 25 or 30 feet (approximately 7.5 and 9 meters) beyond the first and last geophones. The seismic source consisted of a 16-lb sledgehammer and polyethylene strike plate. The Geodes ran from a laptop in order to view each shot to ensure acceptable data quality. Additional hammer blows forming a new “stack” of data were added until the desired data quality was achieved. The shot record (seismogram) was also saved to the computer and stored for subsequent processing. A real-time noise monitor showing all geophones was carefully scrutinized during shots to ensure that noise levels were at a minimum for each shot. This included waiting for breaks in wind noise, drilling activities, and other sources of noise.

3.3 DATA PROCESSING

3.3.1 Quality Control – Onsite

Data for each survey method were given a preliminary assessment for quality control (QC) in the field to assure quality of data before progressing the survey. Following onsite QC, the data were transferred to the HGI server for storage and detailed data processing and analysis.

3.3.2 Electrical Resistivity Processing

3.3.2.1 Resistivity Data Editing

The geophysical data for the resistivity survey, including measured voltage, current, measurement (repeat) error, and electrode position, were recorded digitally with the AGI SuperSting R8 resistivity meter. Each line of acquisition was recorded with a separate file name. Following field data collection, the raw resistivity data files were transmitted to the HGI server located in Tucson, Arizona. Data quality was inspected and checked for consistency with respect to adjacent line results, then data files were saved to designated folders on the server. The server was backed up nightly and backup tapes were stored at an offsite location on a weekly and monthly basis.

The raw data were evaluated for measurement noise. Those data that appeared to be extremely noisy and fell outside the normal range of accepted conditions were removed. Examples of conditions that would cause data to be removed include: negative or very low voltages, high-calculated apparent resistivity, extremely low current, and high repeat measurement error.

3.3.2.2 2D Resistivity Inversion

RES2DINVx64 software (Geotomo, Inc.) was used for inverting individual lines in two dimensions. RES2DINVx64 is a commercial resistivity inversion software package available to the public from www.geoelectrical.com. An input file was created from the edited resistivity data and inversion parameters were chosen to maximize the likelihood of convergence. It is important to note that up to this point, no resistivity data values had been manipulated or changed, such as smoothing routines or box filters. Noisy data had only been removed from the general population.

The inversion process followed a set of stages that utilized consistent inversion parameters to maintain consistency between each model. Inversion parameter choices included the starting model, the inversion routine (robust or smooth), the constraint defining the value of smoothing and various routine halting criteria that automatically determined when an inversion was complete. Convergence of the inversion was judged whether the model achieved an RMS of less than 5% within three to five iterations.

3.3.2.3 2D Resistivity Plotting

The inverted data were output from RES2DINVx64 into an .XYZ data file and were then gridded and color contoured in Surfer (Golden Software, Inc.). Electrode locations and other relevant line features were plotted on the resistivity sections to assist in data analysis. Qualified in-house inversion experts subjected each profile to a final review.

3.3.3 MASW Processing

The data processing flow for the MASW used the SeisImager (Geometrics Inc., San Jose, CA) seismic processing software. Any geometry changes to correct for errors made during the field acquisition were conducted within the SeisImager software called Pickwin (Version 4.2.0.0). Topography variations across all the MASW profiles collected were smooth and kept to a minimum between geophones (<1 foot) for the chosen survey line locations.

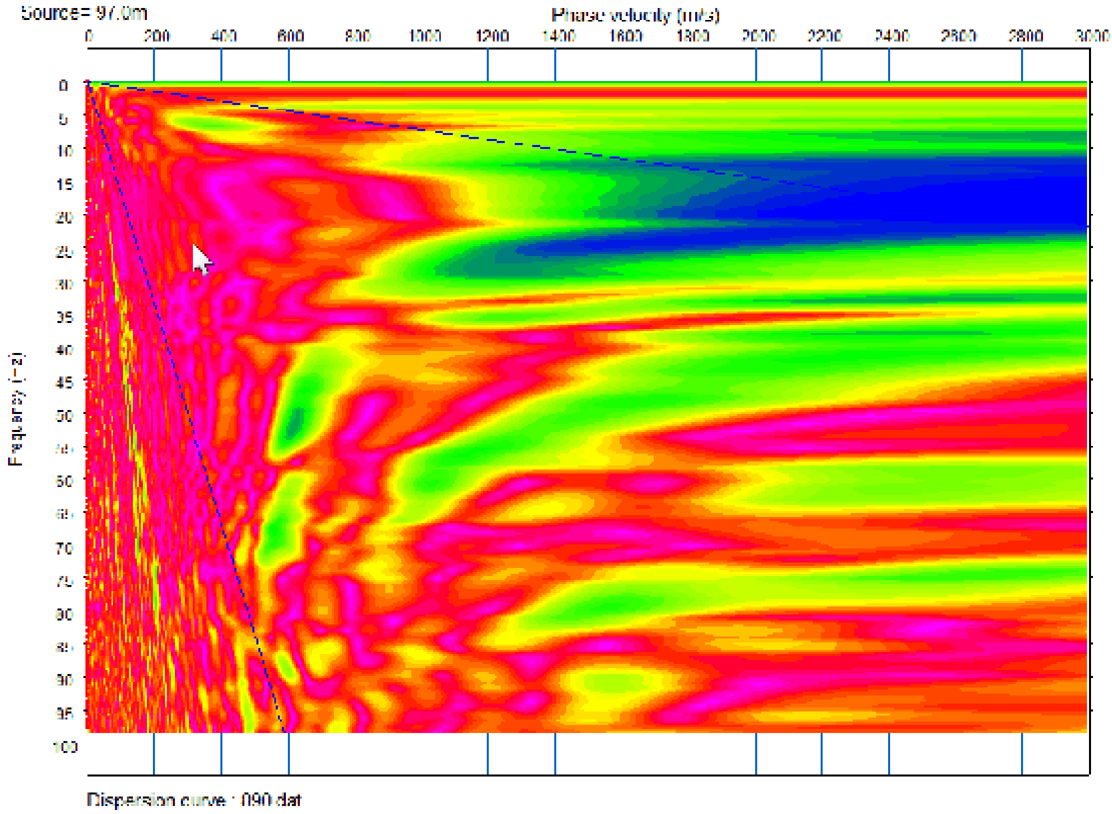
SeisImager’s Pickwin was then used to calculate the Common Mid-Point (CMP) cross-correlation gathers, a bin size of 20 feet was used for the collected profiles. SeisImager’s WaveEq module was used to generate the dispersion curves and run the inversion to produce the shear wave velocity profile. A multichannel field record is first decomposed via Fast Fourier Transformation (FFT) into individual frequency component, and then amplitude normalization is applied to the each component. Then, for a given testing phase velocity in a certain range, the necessary amount of phase shifts are calculated to compensate for the time delay corresponding to a specific offset, applied to individual components, and all of them are summed together. This is repeated for different frequency components. Display of all summed energy in frequency-phase velocity space will show patterns of energy accumulation that represents the dispersion curve as shown in Figure 5.

The inversion is then performed within SeisImager’s WaveEq module using a non-linear least square method to iteratively seek the 2D shear wave velocity profile, with the goal of minimizing the root-mean squared (RMS) error between the observed and calculated velocity curves. Convergence of the inversion was judged whether the model achieved an RMS of less than 5% within five to seven iterations.

3.3.3.1 MASW Plotting

The inverted data were output from SeisImager’s WaveEq into an .XYZ data file and were then gridded and color contoured in Surfer (Golden Software, Inc.). Qualified in-house inversion experts subjected each profile to a final review.

Figure 5. Example Dispersion Curve.



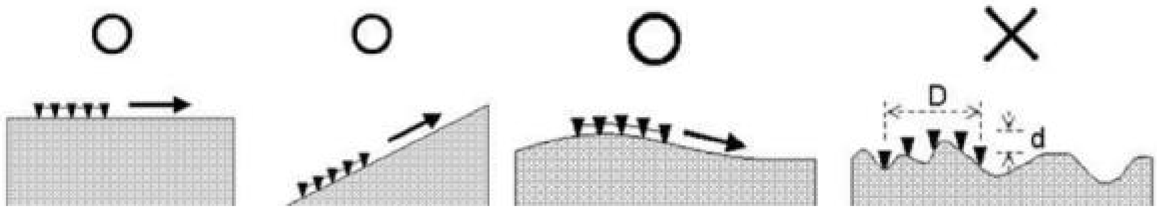
3.4 SURVEY LIMITATIONS

A number of survey limitations were encountered with respect to the MASW surveying:

- For all the MASW profiles collected at the site the frequency range in the dispersion curves generally had a high end cut off around 25 - 30 Hz. This may have been a result of the near-surface materials not being conducive to producing or significantly attenuating higher frequencies. This likely resulted in a decrease in the resolution of the near-surface velocity structure in the presented model results, since as stated earlier the higher frequency active source surface waves resolve the shallower velocity structure and lower frequency passive source surface waves resolve the deeper velocity structure.

- The MASW profiles for the eastern area of the Section 26 site (Lines 4 through 13) do not extend across the entire electrical resistivity survey line in each case. This was a result of the significant topography variations along the electrical resistivity survey lines in this area. Undulating topography, as illustrated in Figure 6, can hinder the generation of surface waves, resulting in poor quality data and unreliable model results. Therefore, after consultation with the client it was decided to limit the MASW coverage along these lines to better target section conducive to surface wave generation.

Figure 6. Typical terrain conditions favorable and unfavorable for the MASW survey.



4.0 RESULTS & INTERPRETATION

The inverse model results for the electrical resistivity and MASW lines are presented in Figures 9 through 21. Separate common color contouring scales are used for each technique for all of the lines to highlight any features that may be indicative of void features or fill material and provide the ability to compare intensity of targets from line to line. Electrically conductive (low resistivity) or low shear-wave velocity subsurface regions are represented by cool hues (pinks to blues) and electrically resistive or high shear-wave velocity regions are represented by warm hues (reds to browns). Other notes of interest about the site where present, either observed by or relayed to HGI, are also annotated on the profiles.

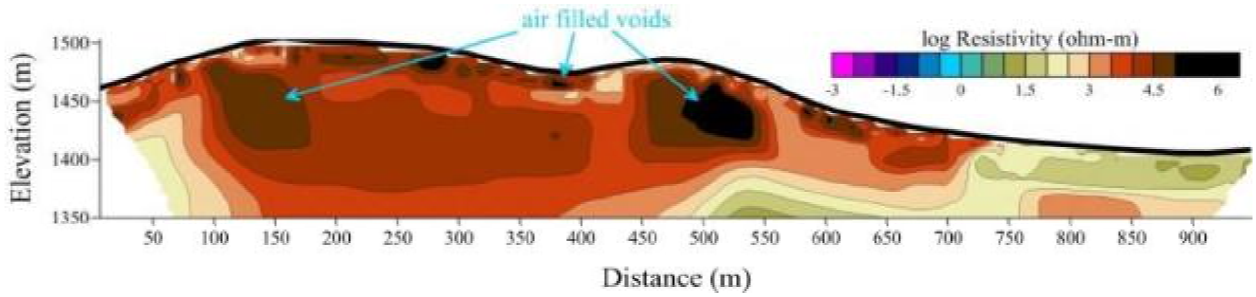
The objective of the survey was to geophysically characterize areas that indicate features representative of subsurface voids, depth to bedrock, or fill material associated with the historic mining activities. Therefore, in the case of air-filled voids, the targets for the electrical resistivity survey would be regions of high resistivity (low conductivity) based on the assumption that the void space would have increased resistivity compared to the surrounding bedrock or sediments. The case for sediment-filled or collapsed voids would differ significantly since the material in the voids would tend to be more conductive, if the surrounding material were bedrock or stiff soil for example. Therefore, the collapsed or infilled void space would likely be regions of low resistivity (high conductivity) based on the assumption that the materials in the void space would have increased conductivity compared to the surrounding strata.

The contrast in resistivity between the native material and subsurface voids will depend on a number of factors, including the depth to the voids, the fill material of the void (air, sea-water, a mixture), dimensions of the void, and the nature of the slag material (massive, granular, combination, weathered). An example of a resistivity survey HGI performed looking for subsurface voids over the Kartchner Caverns State Park in Arizona is shown in Figure 7. The known air filled voids show up as resistive features, displaying resistivity values of the order of 1,000’s to 10,000’s of ohm-m, within a background of limestone bedrock, displaying resistivity values of 100’s of ohm-m. There is a fair amount of variability in resistivity value depending on the dimensions of and depths to the subsurface voids. The background material in this example is fairly resistive, similar to the upper bedrock in this area.

We anticipate that the contrast in resistivity between the fill materials associated with the historic mining activities would be more conductive than the underlying bedrock across the site. Therefore, areas where the mining waste material or pits were backfilled would likely be regions of low resistivity (high conductivity) compared to the resistive bedrock. However, it may be difficult to differentiate the fill material from native soils across the site, based on their likely unconsolidated and heterogeneous nature, by geophysical methods alone.

The MASW technique was chosen to complement the electrical resistivity to help better constrain the interpretations. The MASW technique will work in a similar manner to the electrical resistivity, with the void spaces and fill materials creating a measurable contrast in properties, shear wave velocity in this case. Therefore, in the case of subsurface voids the targets for the MASW survey would be regions of low seismic velocity based on the assumption that the void space, whether air- or water-filled, would have decreased seismic velocity compared to the native material. The contrast in seismic velocity between the native material and subsurface voids will depend on a number of factors, including the depth to the voids, the fill material of the void (air, sediments, or a mix of both), dimensions of the void, and the nature of the surrounding materials.

Figure 7. Electrical Resistivity Profile over the Kartchner Caverns State Park, AZ. The Air Filled Voids and the Caverns and Passageways show up as Resistive Features in the more Conductive Limestone Bedrock Background.



4.1 LINE 1

Figure 9 displays the resistivity and MASW model results for Line 1, which runs in a west to east direction. The resistivity model results display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which is on average 30 feet thick, with a more conductive layer extending to the depth limits of the model beneath this. A number of boreholes were drilled and logged across the site (Figure 8); these were typically extended a short way into the bedrock which tended to be either limestone or marl based on the geological logs. The geological logs for boreholes S1011-SCX-015 through -018 indicate that the limestone bedrock in this area is very close to the ground surface, with less than a foot of gravelly soil cover in some cases. These boreholes are located towards the southern end of Lines 5 through 7, where a highly resistive layer is observed approaching the ground surface. This would indicate that the resistive layer in the resistivity model results represents the limestone bedrock unit for these lines, and therefore likely represents the shallow bedrock in the model results from across the site. Therefore, the resistive layer running across this profile is interpreted to be a response to the bedrock, with the geological logs from S1011-SCX-012 indicating marl and sandstone in this area.

The geological logs from borehole S1011-SCX-012, which is located approximately 115 feet along the line and approximately 15-20 feet to the south, indicates approximately 5 feet of fine-grained sediments overlying the marl and sandstone bedrock. Therefore, the near-surface conductive layer is likely a response to the overlying soils and unconsolidated materials. This layer is approximately 20 feet in thickness between 0 and 200 feet along the line, which corresponds to the approximate borehole location, displaying some discrepancy to the 5 feet thickness indicated by the geological logs. This could be a result of variations in the unconsolidated material thickness across the area.

Therefore, the near-surface conductive layer, representing the unconsolidated materials, either native soil or fill material, is approximately 20 feet thick between 0 and 200 feet along the line, indicated by the dashed red line in Figure 9. As mentioned earlier, it will likely be difficult to differentiate the native soils from the fill material associated with the historic mining activities based on the electrical resistivity or seismic properties. It then decreases to approximately 8 to 10 feet in thickness, and remains similar along the rest of the line. There are a number of regions, notably between 465 and 510, and 590 and 625 feet along the line, where the conductive layer appears to thicken. Increasing to approximately 20 feet thick between 465 and 510 feet along the line. The region between 590 and 625 feet along the line is associated with a conductive break in the underlying resistive layer. This could represent a more fractured region of the bedrock, which tends to reduce the resistivity of a material due to the damaged nature of the bedrock and potential higher moisture content from infiltration. This break appears to extend down to the lower conductive layer, possibly representing a more conductive underlying bedrock layer, although it is difficult to be certain what depth the break actually ends based on the similar resistivity values of this feature and the underlying layer. Beyond 675 feet along the line the resistive layer again appears to display a number of breaks, and since the resistivity values of the bedrock layer in this area is generally lower it may represent a more fractured region of the bedrock.

The MASW results display a narrow range in shear wave velocities, between approximately 2,000 and 2,600 ft/sec, falling within the dense soil or weathered bedrock category for the majority of the line. There are a number of near-surface regions, for example between 100 and 200 feet along the line, that display shear-wave velocities towards the lower end of the range which corresponds to the thicker conductive layer, suggesting thicker layer of unconsolidated materials. In addition, the conductive break in the resistive layer, between 600 and 700 feet along the line, correlates to a vertical region of lower shear-wave velocity, which would agree with the interpretation that this represent a more fractured region of the bedrock.

4.2 LINE 2

Figure 10 displays the resistivity and MASW model results for Line 2, which runs in a west to east direction. The resistivity model results again display a three-layer structure; with a thin conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which is on average 25 feet thick, with a more conductive layer extending to the depth limits of the model beneath this.

Based on the interpretations for Line 1, the resistive layer would tend to represent the upper bedrock unit across the site. The geological logs from boreholes S1011-SCX-010 and -011, which are located 30 and 140 feet along the line respectively, indicate approximately 5 feet of fine-grained sediments overlying the limestone bedrock. This correlates well to the approximate thickness of the near-surface conductive layer in these locations, suggesting again that this layer represents the unconsolidated materials, either native soils or fill materials.

The near-surface conductive layer is approximately 20 feet thick between 50 and 105 feet along the line, before decreasing significantly to approximately 5 feet thickness between 105 and 290 feet along the line, indicated by the dashed red line in Figure 10. The resistive layer appears to approach the ground surface between 290 and 330 feet along the line, with little indication of the conductive layer, likely indicating shallow bedrock. The conductive layer then increases to an average of 10 feet thickness for the remainder of the line. The thicker section of the conductive layer at the beginning of the line corresponds to a significant low shear wave velocity region in the MASW results, which extends from 0 to 165 feet along the line, and could represent the unconsolidated materials. There appears to be a similar low shear wave velocity region beneath this, at a depth of 75 feet below ground surface (bgs), which could indicate a void space or heavily fractured bedrock, unfortunately we cannot correlate this to the resistivity model results due to the lack of coverage in this area. The remainder of the MASW model result appears to display small fluctuations in the shear wave velocity, likely indicating variations in competency of the soils or bedrock materials. We do observed a number of decreases in shear wave velocity associated with conductive breaks in the resistive layer, between 400 to 430 and 675 to 700 feet along the line for example. Again, these could represent a more fractured or weathered region of the bedrock.

4.3 LINE 3

Figure 11 displays the resistivity and MASW model results for Line 3, which runs in a west to east direction. The resistivity model results again display a three-layer structure; with a thin conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which is on average 20 feet thick and appears more discontinuous along this line, with a more conductive layer extending to the depth limits of the model beneath this. The geological logs from boreholes S1011-SCX-0009, which is located 100 feet along the line, indicate approximately 2.5 feet of fine-grained sediments overlying the limestone bedrock. This correlates well to the approximate thickness of the near-surface conductive layer in these locations, suggesting again that this layer represents unconsolidated materials at the site.

The near-surface conductive layer is approximately 10 feet thick between 0 and 90 feet along the line. The layer decreases in thickness to approximately 5 feet between 90 and 175 feet along the line, before increasing gradually to approximately 10 feet thick between 175 and 245 feet along the line, where the resistive layer appears to pinch out or has potentially been excavated and backfilled with more conductive material. Between 245 and 265 feet along the line there appears to be an isolated resistive region, with only a thin veneer of the conductive layer overlying this. The resistive layer again appears to be absent between 265 and 315 feet along the line, where the near-surface conductive layer is approximately 15 feet thick, again potentially indicating a more fractured or weathered region of bedrock. The near-surface conductive layer becomes a thin veneer between 315 and 430 feet along the line, where the resistive layer, representing the limestone bedrock, approaches the ground surface. The conductive layer then increases in thickness between 430 and 525 feet, to a maximum thickness of approximately 10 feet. A conductive break in the resistive layer is observed between 500 and 555 feet along the line, again potentially indicating less competent/more fractured bedrock areas. The conductive layer then decreases in thickness, to approximately 5 feet by 585 feet along the line, remaining a similar thickness until the end of the line.

The majority of the MASW model results displays a fairly narrow range in shear wave velocity, between approximately 2,300 to 2,600 ft/sec, falling within the dense soil or weathered bedrock category for the majority of the line. There are a number of near-surface lower velocity regions, for example between 135 to 240 and 400 to 470 feet along the line, which could indicate less competent unconsolidated materials. A deeper low shear-wave velocity region is observed between 40 and 100 feet along the line, and at a depth of approximately 35 feet (bgs). The observed velocity contrast would not tend to indicate an air-filled void space, although could relate to a collapsed/infilled void space or heavily fractured bedrock, unfortunately we cannot correlate to the resistivity model results due to the lack of coverage in this area.

4.4 LINE 4

Figure 12 displays the resistivity and MASW model results for Line 4, which runs in a south to north direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which is on average 30 feet thick although appears to thicken significantly towards the middle of the line, with a more conductive layer extending to the depth limits of the model beneath this. The geological logs from boreholes S1011-SCX-021 and -023, which are located 680 and 730 feet along the line respectively, indicate approximately 18 and 20 feet of fine-grained sediments overlying the limestone bedrock. This significant increase in the overburden correlates well to the approximate thickness of the near-surface conductive layer in these locations, suggesting again that this layer represents unconsolidated materials at the site.

The near-surface conductive layer is approximately 5 to 8 feet thick between 0 and 280 feet along the line, and likely corresponds to an undisturbed soil layer overlying the limestone bedrock, which from nearby boreholes is very shallow in this area. Between 280 and 365 feet along the line, the resistive layer appears to approach the ground surface. However, there are two regions located at approximately 290 and 350 feet along the line where the conductive layer appears to thicken significantly to 20 feet. The conductive layer then remains on average approximately 10 feet thick, between 365 and 560 feet along the line. A significant conductive break is observed at 510 feet along the line, which cuts through the underlying resistive layer. This potentially indicates a region that has been excavated down into the bedrock, with more unconsolidated material now present. Alternatively, since this location is coincident with a drainage channel it could indicate an area of less competent/more fractured bedrock that appears more conductive due to weathering and increase moisture content.

Beyond 560 feet along the line the near-surface conductive layer thickens significantly, to between 20 and 25 feet, towards the end of the line. This correlates well to the borehole information in this area and potentially reflects an increase in unconsolidated material. There is a region in the near-surface between 630 and 660 feet along the line that appears more resistive than the surrounding layer, which could indicate coarser grained material or broken bedrock present in this location.

Due to the significant variations in topography across the survey lines in the eastern area of the site, the MASW coverage was limited to avoid the worst of the undulating terrain. Line 4A was collected along the first 230 feet of the resistivity line to confirm the presence of bedrock in the near-surface. The results indicate a higher range of shear wave velocities, between approximately 2,600 and 3,000 ft/sec, which would tend to indicate more competent material than previous survey lines, as would be expected with the underlying shallow limestone bedrock. In contrast, Line 4C displays a similar range of shear wave velocity as observed in the previous survey lines, indicating the presence of the overlying unconsolidated material and potentially more weathered bedrock. The line crosses the location of the conductive break in the resistive layer, however we don't observe a significant reduction in shear wave velocity likely suggesting the resistivity feature is not a response to an excavated region. We do observed a general decrease in shear-wave velocity coincident with the increase in the near-surface conductive layer thickness, potentially suggesting this is associated with unconsolidated material in this area.

4.5 LINE 5

Figure 13 displays the resistivity and MASW model results for Line 5, which runs in a south to north direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which varies between 25 and 30 feet in thickness, with a more conductive layer extending to the depth limits of the model beneath this.

A number of boreholes are located along or in close proximity to Line 5, including S1011-SCX-019, -027, -020, and -034, which are located 405, 475, 540, and 715 feet along the line. The majority of the geological logs indicate less than 8 feet of fine-grained sediments overlying the limestone bedrock. The depth to bedrock does not correlate well to the approximate thickness of the near-surface conductive layer in these locations, which tends to indicate approximately 10 feet of unconsolidated materials. In most cases the discrepancy is small and likely suggests variations associated with the offsets between resistivity line and drill locations. The geological log from S1011-SCX-034 indicates 12 feet of fine-grained sediments overlying the limestone bedrock, which correlates well to the thickness of the conductive layer, suggesting again that this layer represents unconsolidated material at the site.

The near-surface conductive layer is almost absent between 0 and 190 feet along the line, with just a thin veneer visible in places, which agrees well with the geological logs in this area that indicate typically less than 2 feet of cover over the limestone bedrock. Between 190 and 290 feet along the line, the conductive layer is approximately 6 feet thick, before appearing to pinch out as the resistive layer approaches the ground surface again. The geological logs closest to this area tend to indicate the bedrock is within 2 to 3 feet of the ground surface, correlating well to the apparent lack of the conductive layer. The conductive layer becomes apparent again at 355 feet along the line, where it gradually thickens from approximately 10 feet to a maximum of 25 feet at 630 feet along the line. A conductive break in the resistive layer is observed between 620 and 640 feet along the line, potentially indicating the thickening of the conductive layer is associated with a greater amount of unconsolidated material above the underlying bedrock. Additional smaller conductive breaks in the resistive layer are observed at 330 and 505 feet along the line, again potentially indicating regions with increased thickness of unconsolidated material or alternatively relating to less competent/more fractured bedrock areas. Beyond 630 feet along the line, the conductive layer decreases in thickness abruptly, to approximately 10 feet, before thickening once more towards the end of the line, ending at an approximate thickness of 20 feet.

The MASW results, associated with between 470 and 712 feet along the resistivity line, again display a similar narrow range of shear-wave velocity to previous lines, falling within the dense soil or weathered bedrock category along the majority of the line. The region of lower shear wave velocity, centered on approximately 550 feet along the line, tends to be associated with one of the mound features seen across this area of the site. This could be associated with unconsolidated material in this area.

4.6 LINE 6

Figure 14 displays the resistivity and MASW model results for Line 6, which runs in a south to north direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which varies between approximately 20 and 30 feet thick although appears to thicken significantly towards the middle of the line, with a more conductive layer extending to the depth limits of the model beneath this. The geological logs from borehole S1011-SCX-032, which is located 485 feet along the line, indicate approximately 9 feet of fine-grained sediments overlying the marl bedrock. The depth to bedrock does not correlates well to the approximate thickness of the near-surface conductive layer in this location, which tends to indicate approximately 20 feet of unconsolidated materials. This discrepancy could be related to the bedrock material, with the marl potentially being more conductive than the limestone based on the texture or weathering of the materials. There does appear to be a transition around 10 feet (bgs) depth in the conductive layer which may reflect this difference, with the deeper interface with the resistive layer, at 20 feet (bgs), potentially reflecting a contact with the limestone bedrock.

The near-surface conductive layer is almost absent between 0 and 170 feet along the line, with just a thin veneer visible in places, which agrees well with the geological logs in this area that indicate typically less than 2 feet of cover over the limestone bedrock. Between 170 and 310 feet along the line, the conductive layer is approximately 6 feet thick, before appearing to pinch out as the resistive layer approaches the ground surface again, potentially indicating shallow bedrock. The conductive layer becomes apparent again at 335 feet along the line, where it is approximately 10 feet thick, with an abrupt increase in thickness occurring at 370 feet along the line, to approximately 20 feet thick. This increase in thickness could be related to an excavation based on the abrupt nature of the change. It remains a constant thickness until 505 feet along the line, where the conductive layer appears to thin over a hump feature in the resistive layer, located between 505 and 610 feet along the line. This feature is associated with another significant conductive break in the underlying resistive layer, located between 530 and 560 feet along the line, again potentially relating to less competent/more fractured bedrock areas. Beyond 550 feet along the line, the conductive layer increases in thickness, to approximately 25 feet at 625 feet along the line, remaining a similar thickness until the end of the line.

The MASW results, associated with between 480 and 720 feet along the resistivity line, on average displays a lower range of shear-wave velocity to previous lines, although still within the dense soil or weathered bedrock category. Again, the lower shear-wave velocities are associated with the near-surface materials, potentially indicating unconsolidated materials in these areas. The MASW line location passes across the region associated with the conductive break in the resistivity results, located between 530 and 560 feet along the line. The MASW results appear to indicate a decrease in the shear-wave velocity at depth associated with this location, compared to the surrounding velocities at this depth, which could correlate to lithology changes or increased fracturing/weathering interpretation of this feature.

4.7 LINE 7

Figure 15 displays the resistivity and MASW model results for Line 7, which runs in a south to north direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which varies between approximately 25 and 30 feet thick although appears to thicken significantly towards the middle of the line, with a more conductive layer, evident between 150 and 500 feet along the line, extending to the depth limits of the model beneath this. In addition, Line 7 passes to the immediate west of the fenced enclosure around the vertical open mine shaft (located approximately 10 feet to the east of the line), at 640 feet along the line.

A number of boreholes are located along or in close proximity to Line 7, including S1011-SCX-028, -026, -036, and -035, which are located 410, 545, 600, and 740 feet along the line. The geological logs from S1011-SCX-028 and -035 indicate approximately 14 and 17 feet of fine-grained sediments overlying the marl and limestone bedrock respectively. This correlates well to the approximate thickness of the near-surface conductive layer in these locations, suggesting again that this layer represents unconsolidated materials at the site. The remaining two boreholes indicate a much thinner sediment cover, between 4 and 6 feet, over the bedrock. This does not correlate well to the approximate thickness of the near-surface conductive layer in these locations, which tends to indicate almost 30 feet of soil cover or fill materials. These discrepancies could be related to the scale of the features observed in resistivity results, potentially related to small-scale excavations in the bedrock, which do not have extensive lateral limits and which the drilling could miss.

The near-surface conductive layer is almost absent between 0 and 100 feet along the line with just a thin veneer visible in places, which agrees well with the geological logs in this area that indicate typically less than 2 feet of cover over the limestone bedrock. Between 100 and 325 feet along the line, the conductive layer is approximately 7 to 10 feet thick, before increasing in thickness between 325 and 395 feet, to a maximum of 25 feet. It gradually decreases back to approximately 10 feet thickness, between 395 and 500 feet along the line. At 500 feet along the line, this layer increases in a stepwise manner to approximately 55 feet thickness, extending to 535 feet along the line. This abrupt increase in thickness could be related to an excavation based on the sharp nature of the change. Beyond 535 feet along the line, the conductive layer decreases in thickness, to approximately 30 feet at 550 feet along the line, remaining a similar thickness until the end of the line. We do not observe any anomalous resistive features around 640 feet along the line that could be related to air-filled voids associated with the open shaft. However, there does appear to be a more conductive feature associated with the near-surface in this region that extends vertically downwards before branching out to the north and south at an approximate depth of 20 feet (bgs). While this could be related to a region of finer grained sediments in this layer, its shape reflects what we might expect for mining activity and could be a response to increased moisture in the subsurface related to drainage down the shaft or to backfilled/collapsed mine workings in the subsurface.

The MASW results, associated with between 305 and 745 feet along the resistivity line, in general displays a higher shear wave velocity range than the majority of previous lines, between approximately 2,600 and 3,100 ft/sec, falling within the weathered to competent bedrock category. The main feature of this line is a near-surface reduced shear-wave velocity region, located between 450 and 650 feet along the line. The velocity contrast associated with this region is likely not significant enough to indicate air-filled void spaces, but could indicate less competent or unconsolidated materials. The location correlates to the potential excavated region in the resistivity results, between 500 and 535 feet along the line, and also incorporates the resistivity feature associated with the open shaft area. While we do not observe a similar shaped feature in the MASW results, this could be related to the lowered resolution of the seismic method that suffered at this site due to the lack of higher frequencies in the dispersion curves. Therefore, the lower shear-wave velocity region may be averaged response to the backfilled or collapsed regions associated with these features in the resistivity results.

4.8 LINE 8

Figure 16 displays the resistivity and MASW model results for Line 8, which runs in a south to north direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which is on average 55 feet thick, with a more conductive layer just apparent at the base of the model results beneath this (due to the shorter length of Lines 8 to 10 the imaging depth is reduced accordingly). The geological logs from boreholes S1011-SCX-030 and -024, which are located 155 and 320 feet along the line respectively, indicate approximately 10 and 4 feet of fine-grained sediments overlying the marl bedrock. We observe a good agreement with the approximate thickness of the near-surface conductive layer associated with the S1011-SCX-030 location, suggesting again that this layer represents unconsolidated materials at the site. However, the S1011-SCX-024 location displays a significant discrepancy, with an approximate 20 feet conductive layer thickness. This could be a results of the borehole locations being approximately 30 feet to the west of the line, thus undulations in the thickness of the overlying unconsolidated materials would lead to discrepancies. Alternately, the marl bedrock may present as conductive in the resistivity results, either due to its texture or weathered nature, resulting in this thickening of the conductive layer.

The near-surface conductive layer has a fairly consistent thickness between 0 and 400 feet along the line, increasing slightly from approximately 20 to 25 feet. At 400 feet along the line, there is an abrupt step, decreasing the thickness of the conductive layer to approximately 10 feet. This change in thickness could be related to an excavation based on the abrupt nature of the change. The thickness of the conductive layer then increases gradually to the end of line, where it is approximately 15 feet thick. There is another highly conductive region within this layer, between 300 and 395 feet along the line, which correlates well to the location of a similar feature associated with the open shaft location in Line 7. This again could reflect a response to increased moisture in the tunnels or backfilled/collapsed shafts associated with historic mining activities in the subsurface.

The MASW results, associated with between 100 and 350 feet along the resistivity line, on average displays a lower range of shear-wave velocity to previous lines, although still within the dense soil or weathered bedrock category. A region of lower shear wave velocities is observed towards the beginning of this line, with a shear-wave velocity range of 1,600 to 1,800 ft/sec, located between 100 and 150 feet along the line and extending to a depth of 30 feet (bgs). This is associated with a resistive region, at a depth of approximately 30 feet (bgs) in the resistivity results, and could potentially be related to an air-filled void. However, the velocity contrast would tend to indicate this is likely related to increased weathering or fracturing of the bedrock material in this region. We only observe a very subtle decrease in the shear wave velocity of the region associated with the highly conductive feature in the resistivity results, potentially indicating this is a response to finer grained sediments in the near-surface conductive layer.

4.9 LINE 9

Figure 17 displays the resistivity and MASW model results for Line 9, which runs in a south to north direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which ranges between 30 and 50 feet thick, with a more conductive layer apparent at the base of the model results beneath this (due to the shorter length of Lines 8 to 10 the imaging depth is reduced accordingly). The closest geological logs are from boreholes S1011-SCX-030 and -024 again, which are located 140 and 320 feet along the line respectively, although are offset approximately 45 feet to the east of the line in each case. The geological logs indicate approximately 10 and 4 feet of fine-grained sediments overlying the marl bedrock respectively. We observe a good agreement with the approximate thickness of the near-surface conductive layer associated with both locations along this line, suggesting that this layer represents unconsolidated materials at the site.

The near-surface conductive layer has a consistent thickness of approximately 15 feet, between 0 and 200 feet along the line. At 200 feet along the line, the conductive layer decreases in thickness, to approximately 10 feet, with a similar thickness observed through to 260 feet along the line. The resistive layer appears to approach the ground surface between 260 and 340 feet along the line, which tends to be confirmed from the geological logs of S1011-SCX-024 located in this area. We observe what appears to be undercutting of the resistive layer along this section of the line, with conductive material apparent on the south and north sides of this shallow resistive feature, located at 275 and 345 feet along the line respectively. This potentially indicates regions within the bedrock that are less competent/more fractured. The undercutting area on the north side is associated with an increase in the conductive layer thickness, to approximately 20 feet, which extends to 370 feet along the line. The conductive layer decreases in thickness significantly between 370 and 390 feet along the line, to approximately 5 feet thick. It then gradually increases in thickness towards the end of the line at 505 feet, where it is approximately 15 feet thick.

The MASW results, associated with between 95 and 325 feet along the resistivity line, in general displays a higher shear wave velocity range than the majority of previous lines, between approximately 2,600 and 2,900 ft/sec falling within the weathered to competent bedrock category. This would tend to indicate the majority of this section of the line is representative of the limestone bedrock and correlates well to the indication that the resistive layer approaches the ground surface in this area. The main feature of this line is a near-surface lower shear-wave velocity region located between 95 and 140 feet along the line, which is likely a response to the thicker near-surface layer representing the unconsolidated materials.

4.10 LINE 10

Figure 18 displays the resistivity and MASW model results for Line 10, which runs in a south to north direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which is on average approximately 35 feet thick, with a more conductive layer apparent at the base of the model results beneath this (due to the shorter length of Lines 8 to 10 the imaging depth is reduced accordingly). There are no boreholes within proximity to Line 10.

The near-surface conductive layer has a consistent thickness between 0 and 80 feet along the line, of approximately 15 feet. Between 80 and 130 feet along the line, the conductive layer appears to increase significantly in thickness, to approximately 30 feet, before decreasing back to approximately 10 feet thickness. The conductive layer then remains a constant thickness until 400 feet along the line, where it increases gradually in thickness towards the end of the line, to approximately 15 feet thick. The exception to this trend occurs between 205 and 230 feet along the line, where the conductive layer abruptly increases in thickness to approximately 20 feet. These abrupt increases in thickness potentially indicate regions that have been excavated or alternatively relating to less competent/more fractured bedrock areas. Both of the increases in thickness described share a similar shape, and likely represent unconsolidated material in this area.

The MASW results, associated with between 80 and 315 feet along the resistivity line, in general displays two layer structure, with a higher shear-wave velocity lower layer, displaying a velocity range between approximately 2,600 and 2,900 ft/sec falling within the weathered to competent bedrock category. The upper layer display on average a lower shear-wave velocity range and tends to correlate with the conductive layer in the resistivity results, and is likely a response to the unconsolidated materials. In addition, the thinning of the near-surface conductive layer between 130 and 280 feet along the line in the resistivity results tends to correlate with an increase in the shear-wave velocity of the near-surface layer in the MASW results. This would suggest the bedrock again is approaching the ground surface as with previous lines, potentially indicating a bedrock high or ridge in this area.

4.11 LINE 11

Figure 19 displays the resistivity and MASW model results for Line 11, which runs in a west to east direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which ranges between 40 and 65 feet thick, with a more conductive layer apparent at the base of the model results beneath this (due to the shorter length of Lines 11 to 13 the imaging depth is reduced accordingly). The closest geological log is from borehole S1011-SCX-036, which is located 360 feet along the line, which indicates approximately 4 feet of fine-grained sediments overlying the marl bedrock. The depth to bedrock does not correlates well to the approximate thickness of the near-surface conductive layer in these locations, which tends to indicate approximately 20 feet of fine-grained sediments. This discrepancy could be related to the bedrock material, as with previous survey lines where the bedrock is indicated to be marl it is potentially more conductive than the limestone based on texture of the materials. Alternatively, since the borehole does not coincide directly with the survey line and the bedrock topography has been observed to vary significantly over short distances, this could lead to these discrepancies.

The near-surface conductive layer is approximately 7 to 10 feet thick between 0 and 220 feet along the line, and based on the location likely corresponds to unconsolidated materials overlying the bedrock. Between 220 and 280 feet along the line, the conductive layer increases in thickness to approximately 25 feet. This region also corresponds to a significant conductive break in the underlying resistive layer, extending between 235 and 260 feet along the line. Again, this break could indicate regions of less competent/more fractured bedrock, or represent a fault trace in the near surface. From 280 to 425 feet along the line, the conductive layer increases in thickness, to approximately 30 feet, before gradually decreasing in thickness towards the end of line, where it is approximately 15 feet thick. Line 11 crosses close to the open shaft at 400 feet along the line, approximately 15 feet to the south of the fenced enclosure. This location corresponds to a more conductive feature in the near-surface layer, at a depth of approximately 20 feet (bgs). While this is not the anticipated response for an air-filled void it could relate to enhanced moisture in the subsurface around this shaft based on run off of precipitation and drainage down the shaft, or relate to collapsed or backfilled mine workings leading off the shaft that contain finer gained material or enhanced moisture content based on porosity.

The MASW results, associated with between 70 and 480 feet along the resistivity line, in general displays a shear-wave velocity range between approximately 2,300 to 2,600 ft/sec, falling into the dense soil or weathered bedrock category. A near-surface lower velocity region is observed between 280 and 480 feet along the line, with the velocity contrast likely indicating unconsolidated materials, which correlates well to the thickening of the conductive layer observed in the resistivity results.

4.12 LINE 12

Figure 20 displays the resistivity and MASW model results for Line 12, which runs in a west to east direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which ranges between 30 and 60 feet thick, with a more conductive layer apparent at the base of the model results beneath this (due to the shorter length of Lines 11 to 13 the imaging depth is reduced accordingly). The geological logs from boreholes S1011-SCX-035, -034, and -021, which are located approximately 395, 600, and 660 feet along the line respectively, indicate approximately 17, 12, and 18 feet of fine-grained sediments overlying the marl and limestone bedrock. In general, we observe a good agreement with the approximate thickness of the near-surface conductive layer associated with the first two borehole locations along this line, suggesting that this layer represents unconsolidated materials at the site. We do not have coverage for the location of S1011-SCX-021 due to the position towards the end of the line, where the imaging depth is limited.

The near-surface conductive layer is approximately 5 to 8 feet thick between 0 and 290 feet along the line, and based on the location likely corresponds to unconsolidated materials overlying the bedrock. At 290 feet along the line, there is an abrupt increase in the thickness of the conductive layer, to approximately 30 feet. This region corresponds to a significant conductive break in the underlying resistive layer, extending between 290 and 315 feet along the line. Again, this break could indicate regions of less competent/more fractured bedrock, or based on the offset of the resistive layer could represent a fault trace in the near surface, similar to the conductive break observed in Line 11. Between 290 and 410 feet along the line, the conductive layer remains approximately 30 feet in thickness, before decreasing to approximately 20 feet in thickness between 410 and 540 feet along the line. At 540 feet along the line, the conductive layer begins to decrease in thickness, to approximately 10 feet thick at 575 feet along the line, before appearing to increase in thickness towards the end of the line. The section of the conductive layer between 415 and 550 feet along the line appears highly conductive, compared to the surrounding regions. This could be a response to an area of finer grained material, potentially clay rich sediments, or alternatively a region of increased soil moisture.

The MASW results, associated with between 270 and 505 feet along the resistivity line, in general displays a homogeneous shear-wave velocity above approximately 350 feet along the profile, with a anomalously low velocity below this. The MASW results did not converge well for this inversion model run, relating to the poor data quality of the shot points along this line, and consequently our confidence in the structure tends to be low for this survey line.

4.13 LINE 13

Figure 21 displays the resistivity and MASW model results for Line 13, which runs in a west to east direction. The resistivity model results again display a three-layer structure; with a conductive near-surface layer, which varies in thickness across the profile. This overlies a resistive layer, which appears on average approximately 65 feet thick, with a more conductive layer apparent at the base of the model results beneath this (due to the shorter length of Lines 11 to 13 the imaging depth is reduced accordingly). There are no boreholes within proximity to Line 13.

The near-surface conductive layer is approximately 15 feet thick between 0 and 75 feet along the line. It gradually increases in thickness between 75 and 215 feet along the line, to a maximum thickness of 25 feet, where it remains between 20 and 25 feet thick along the remainder of the survey line. The one exception is between 285 and 325 feet along the line, where a bedrock ridge type feature decreases the conductive layer thickness to approximately 15 feet. A significant conductive break in the underlying resistive layer is observed extending between approximately 400 and 450 feet along the line. This may relate to regions of less competent/more fractured bedrock or represent a fault trace in the near surface, although we do not observe any offset in the resistive layer for this survey line. The section of the conductive layer between approximately 520 feet along the line and the end of the line appears highly conductive, compared to the surrounding regions. This could be a response to an area of finer grained material, potentially clay rich sediments, or alternatively a region of increased soil moisture.

The MASW results, associated with between 270 and 505 feet along the resistivity line, in general displays a homogeneous shear wave velocity model, with a very narrow range of between 2,400 and 2,600 ft/sec, falling into the dense soil or weathered bedrock category. There is a subtle decrease in shear wave velocity at around 410 feet along the profile, which correlates to the conductive break in the resistive layer of the resistivity model results. This would tend to confirm this features is related to a higher degree of fracturing in the bedrock or a fault location, where the competency of the bedrock is likely reduced.

Figure 8. Survey Layout for the Electrical Resistivity and MASW, with the Drilling Location Overlaid.

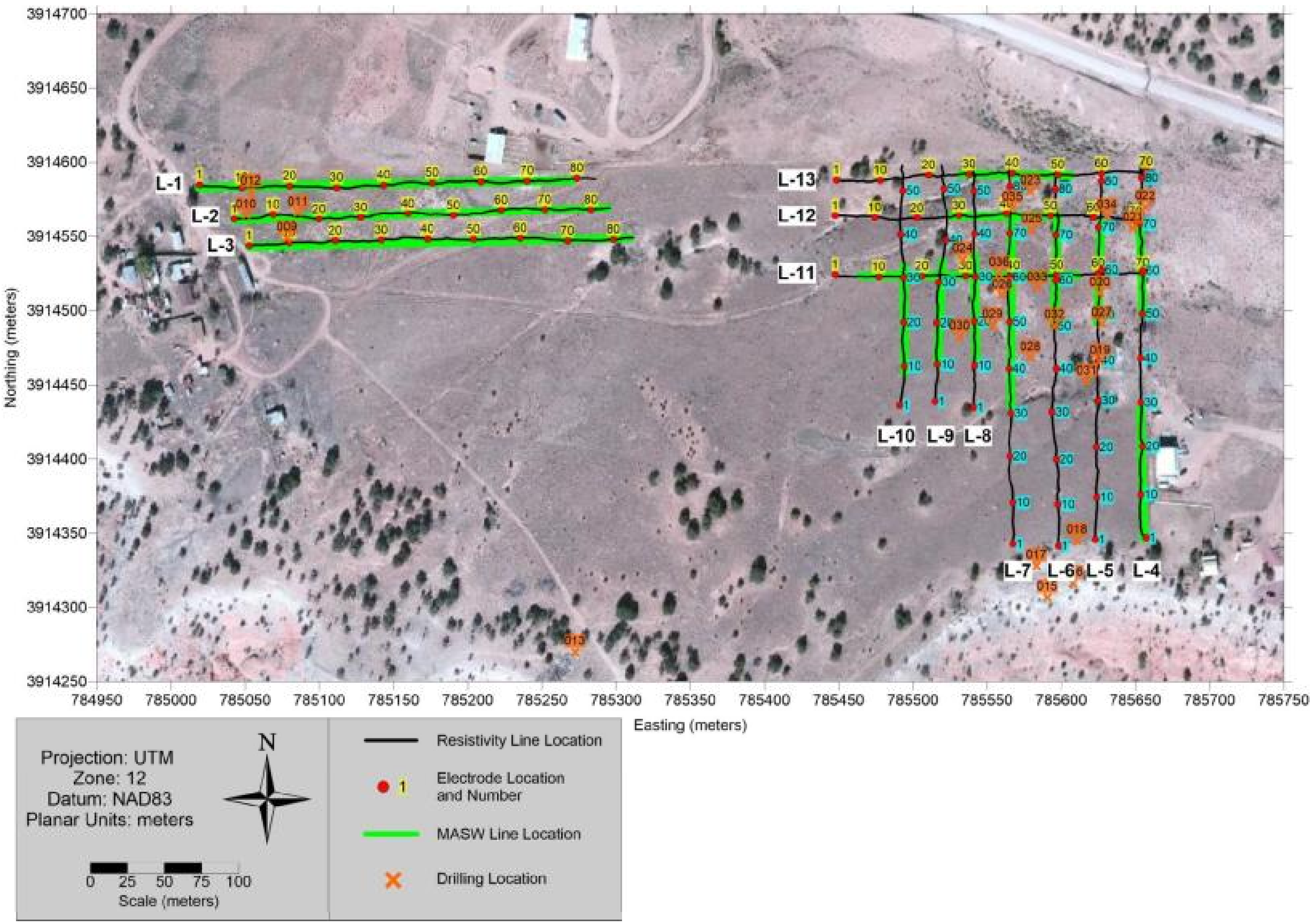


Figure 9. Line 1 Electrical Resistivity and MASW Model Results.

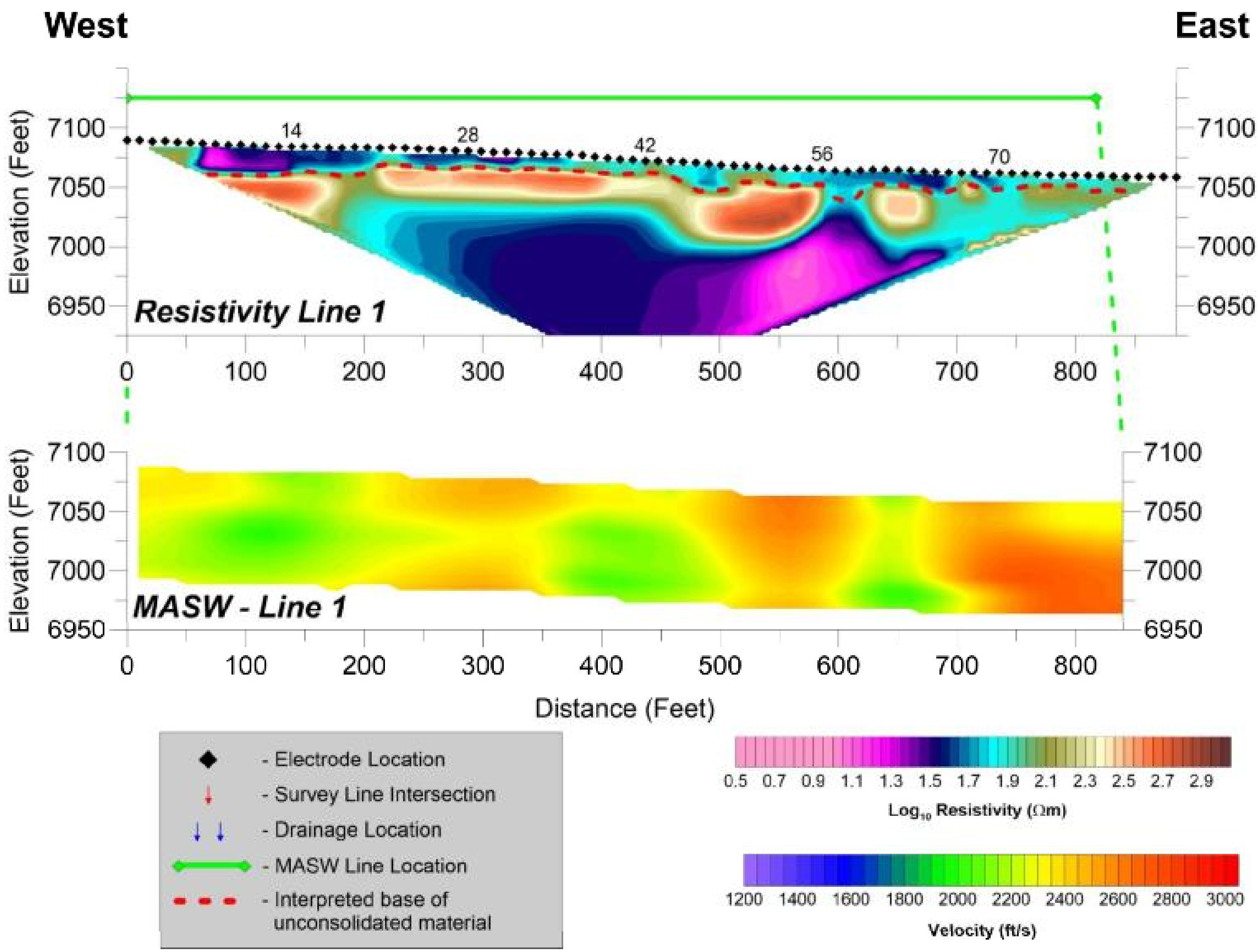


Figure 10. Line 2 Electrical Resistivity and MASW Model Results.

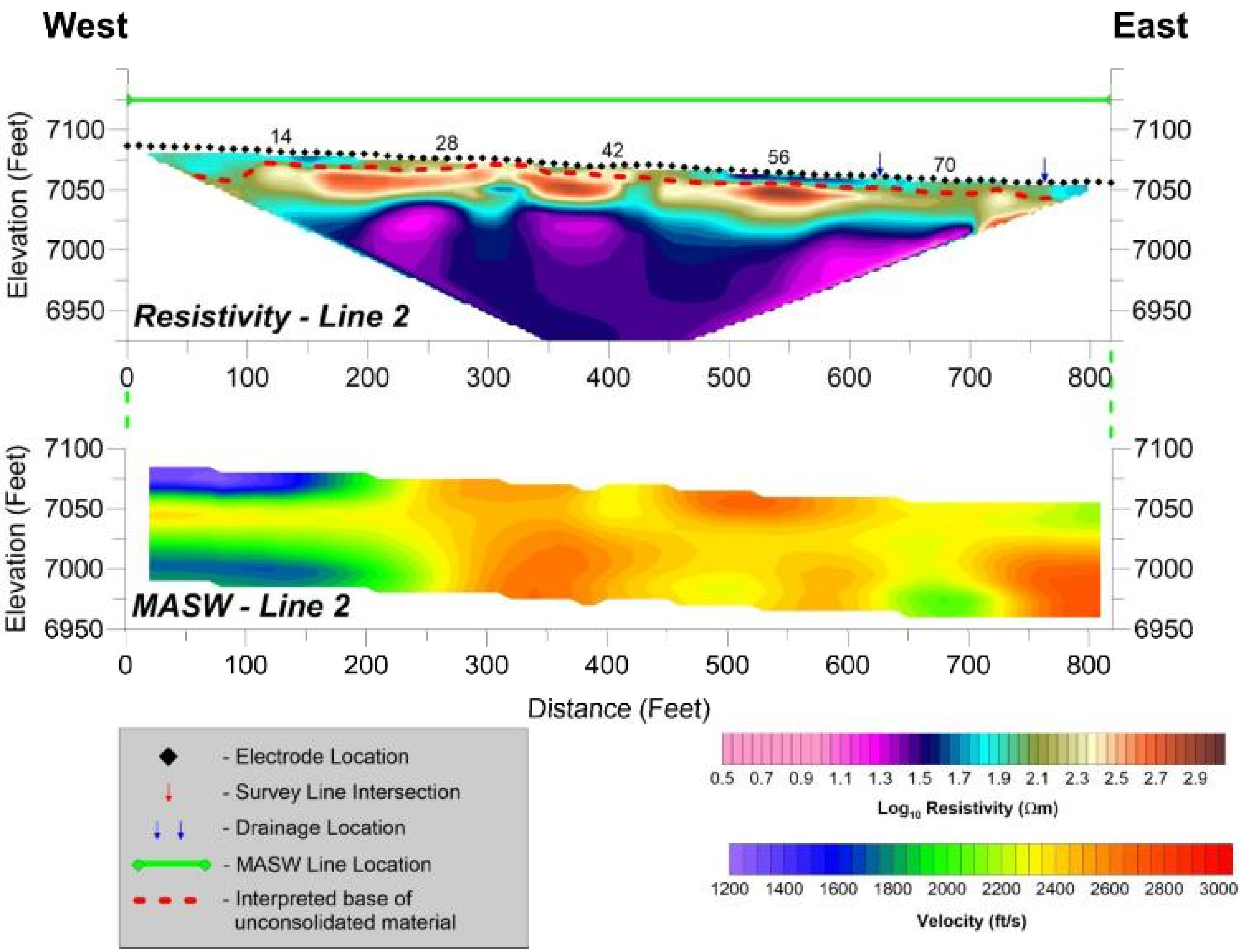


Figure 11. Line 3 Electrical Resistivity and MASW Model Results.

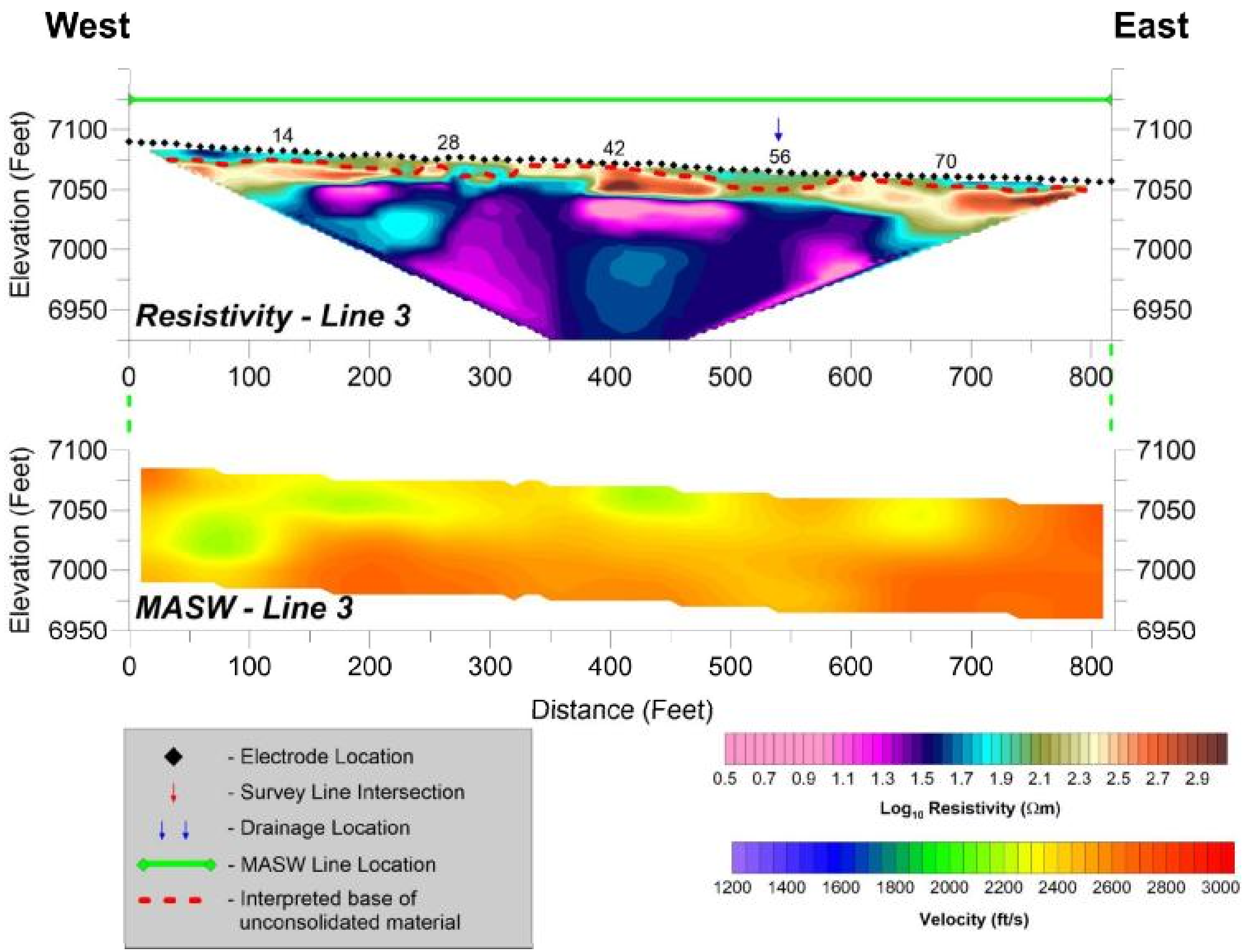


Figure 12. Line 4 Electrical Resistivity and MASW Model Results.

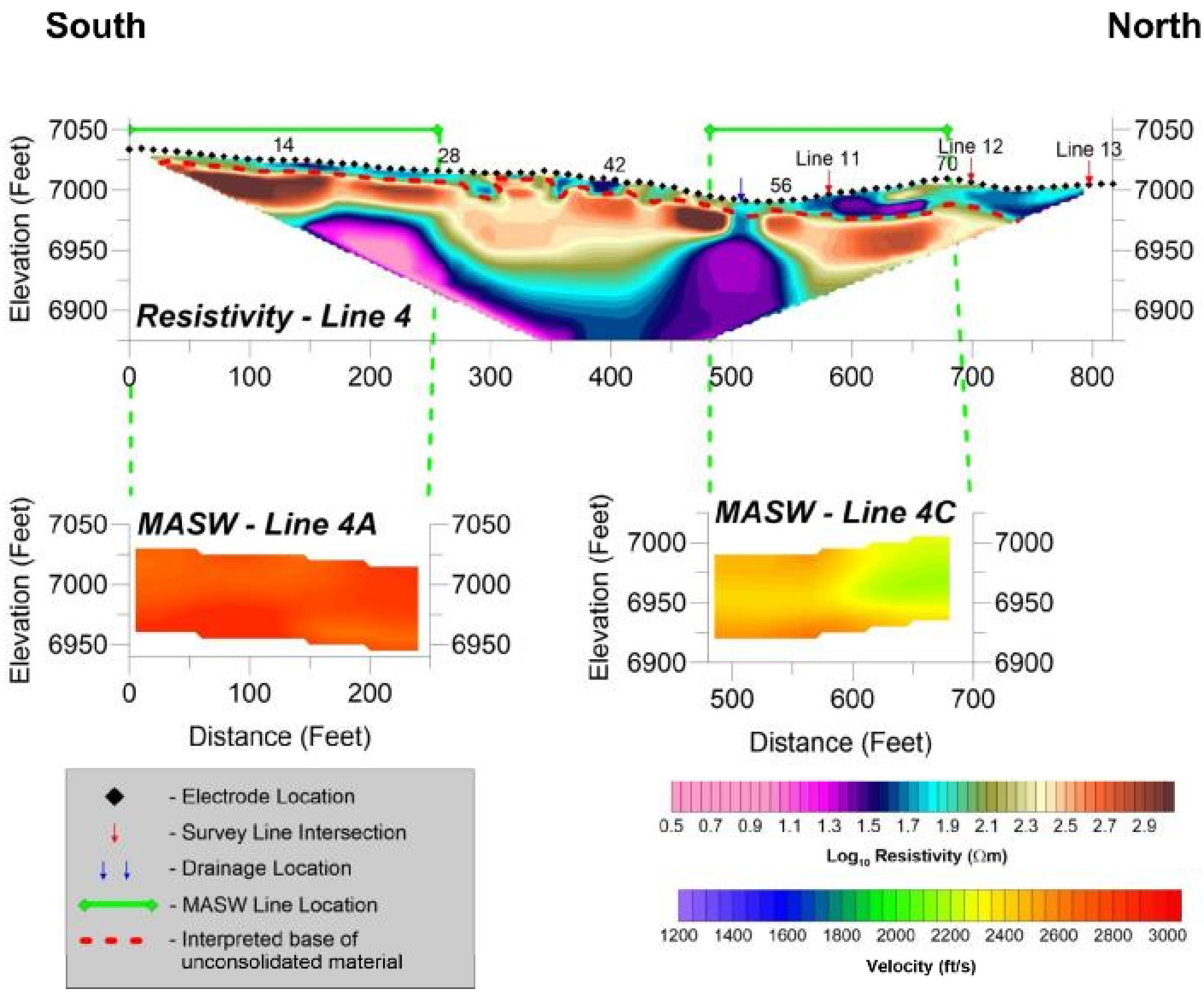


Figure 13. Line 5 Electrical Resistivity and MASW Model Results.

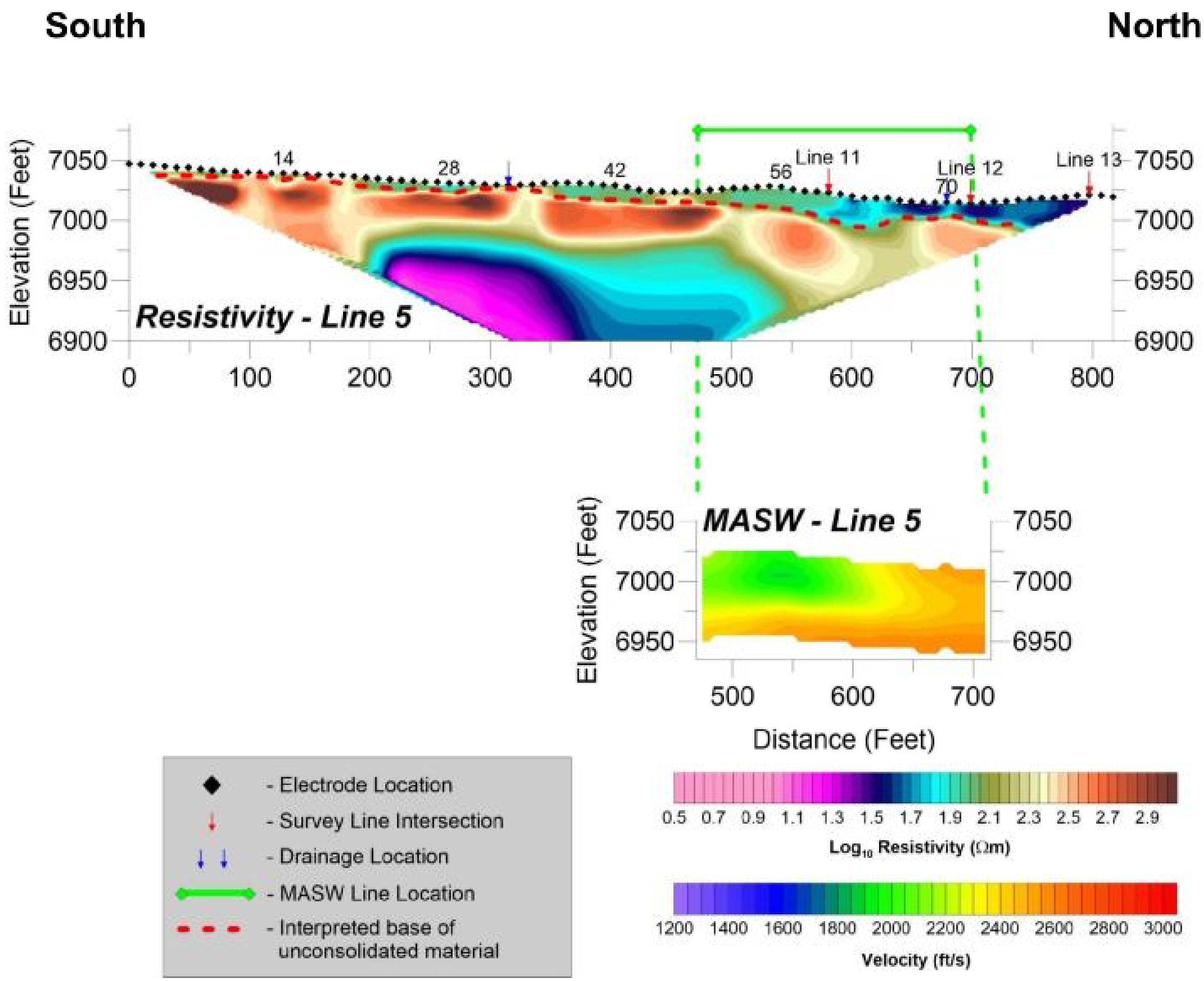


Figure 14. Line 6 Electrical Resistivity and MASW Model Results.

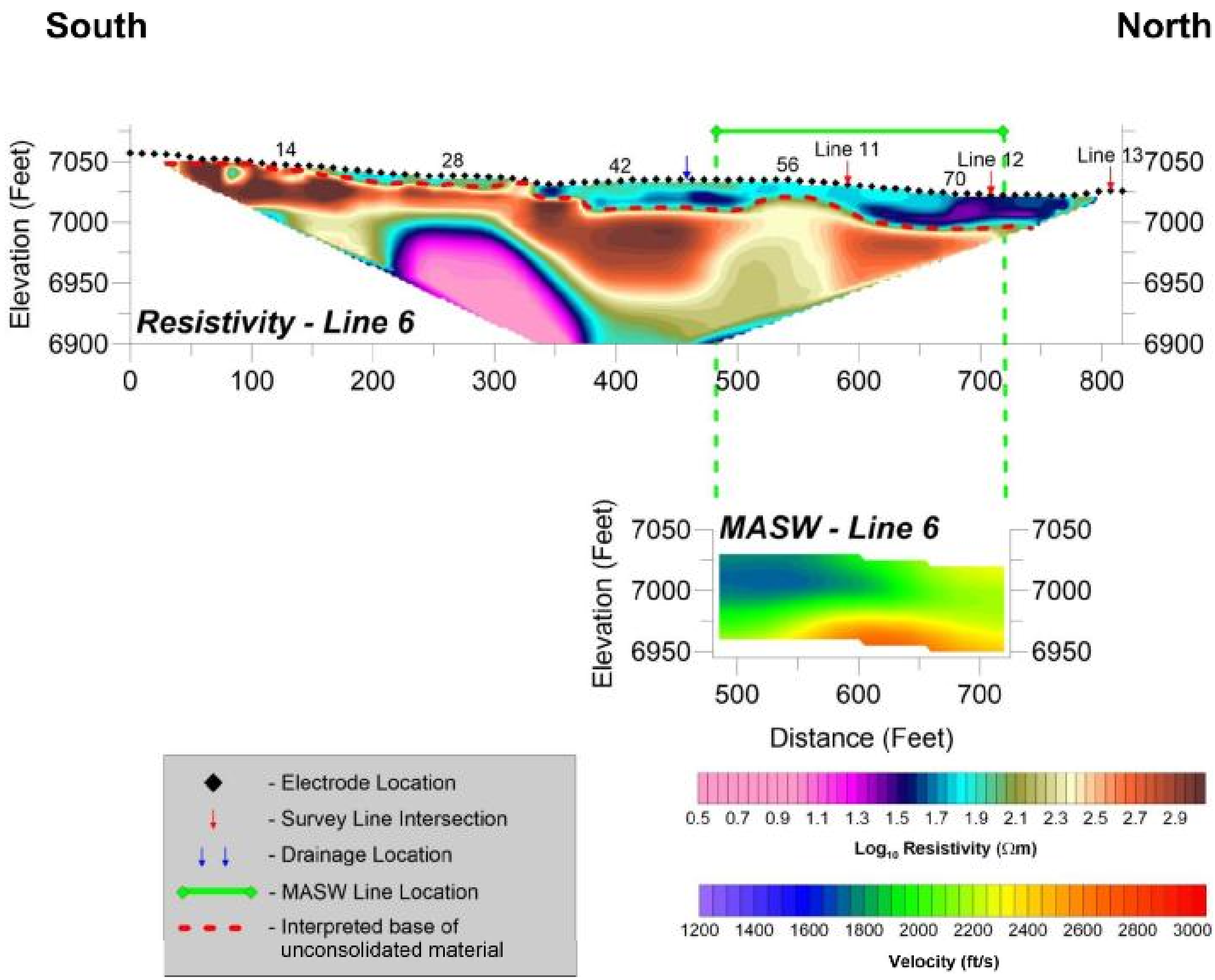


Figure 15. Line 7 Electrical Resistivity and MASW Model Results.

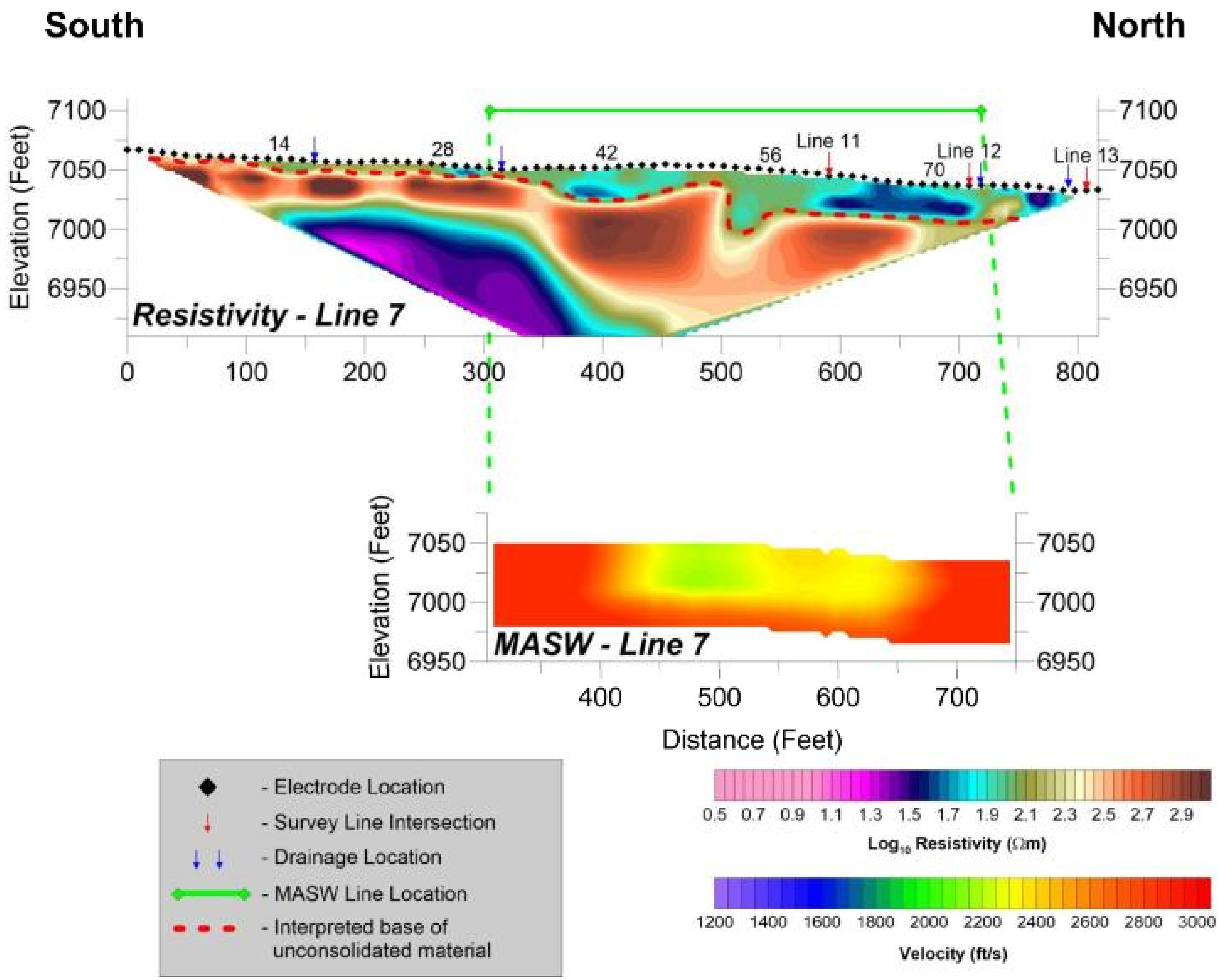


Figure 16. Line 8 Electrical Resistivity and MASW Model Results.

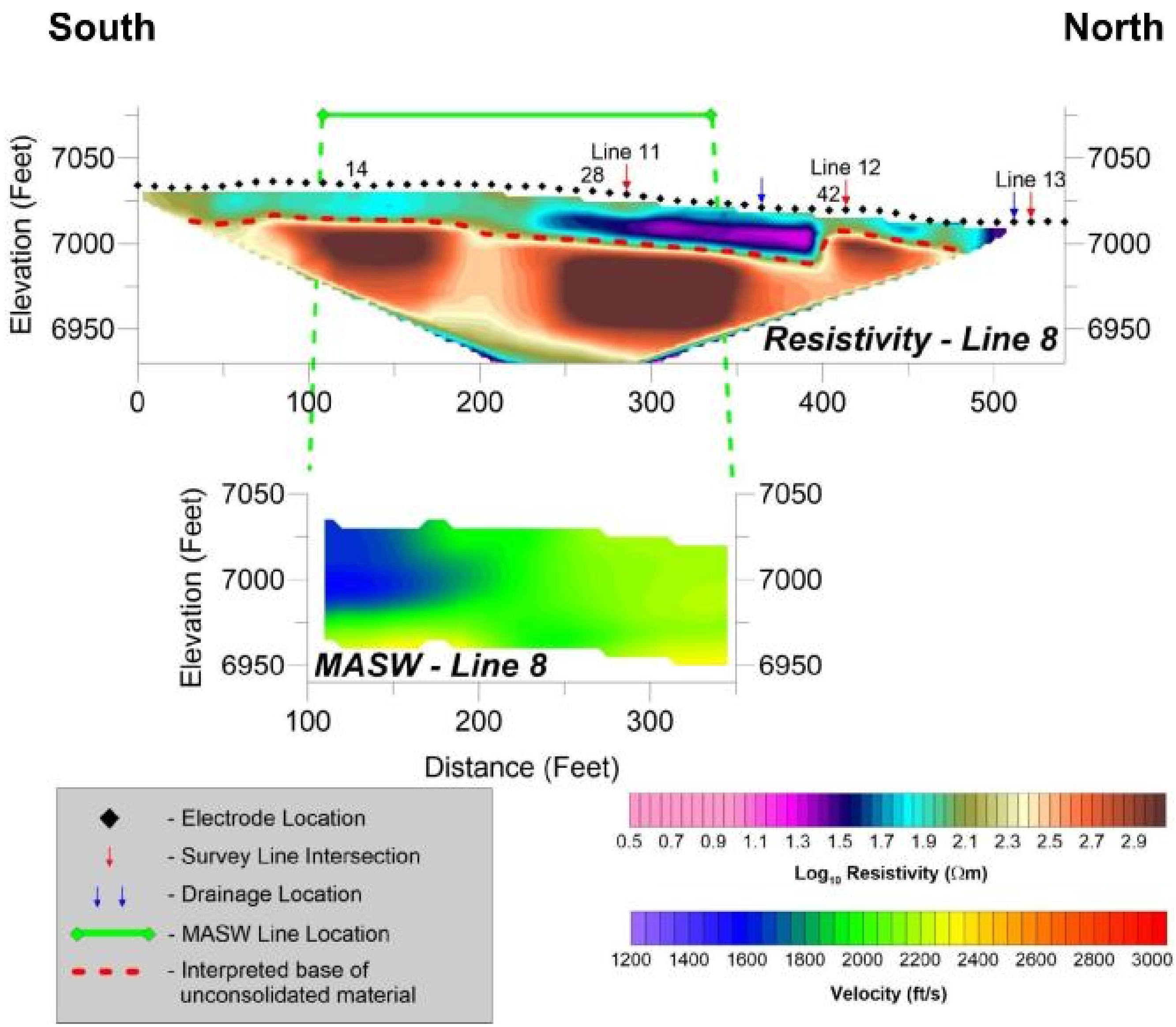


Figure 17. Line 9 Electrical Resistivity and MASW Model Results.

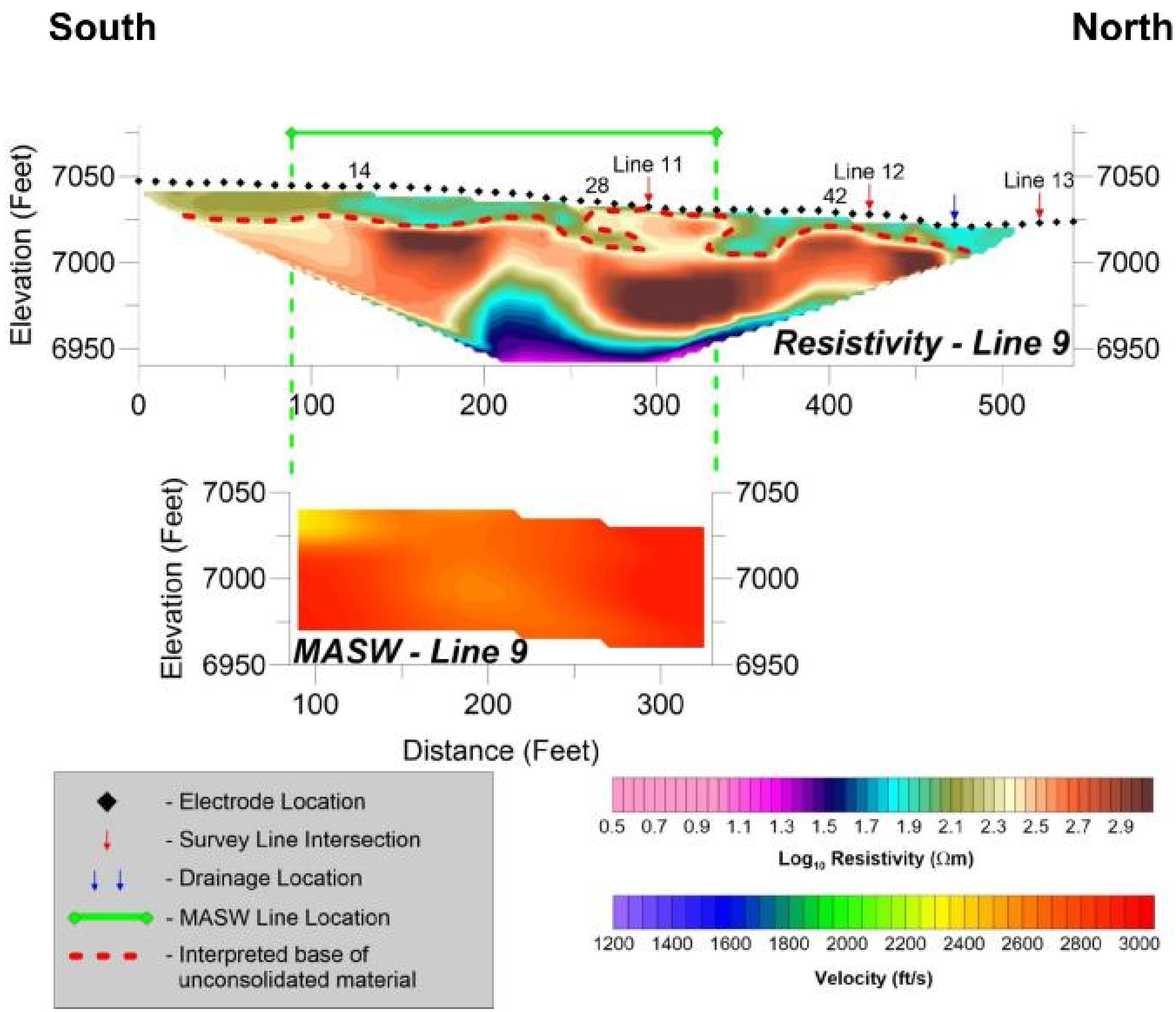


Figure 18. Line 10 Electrical Resistivity and MASW Model Results.

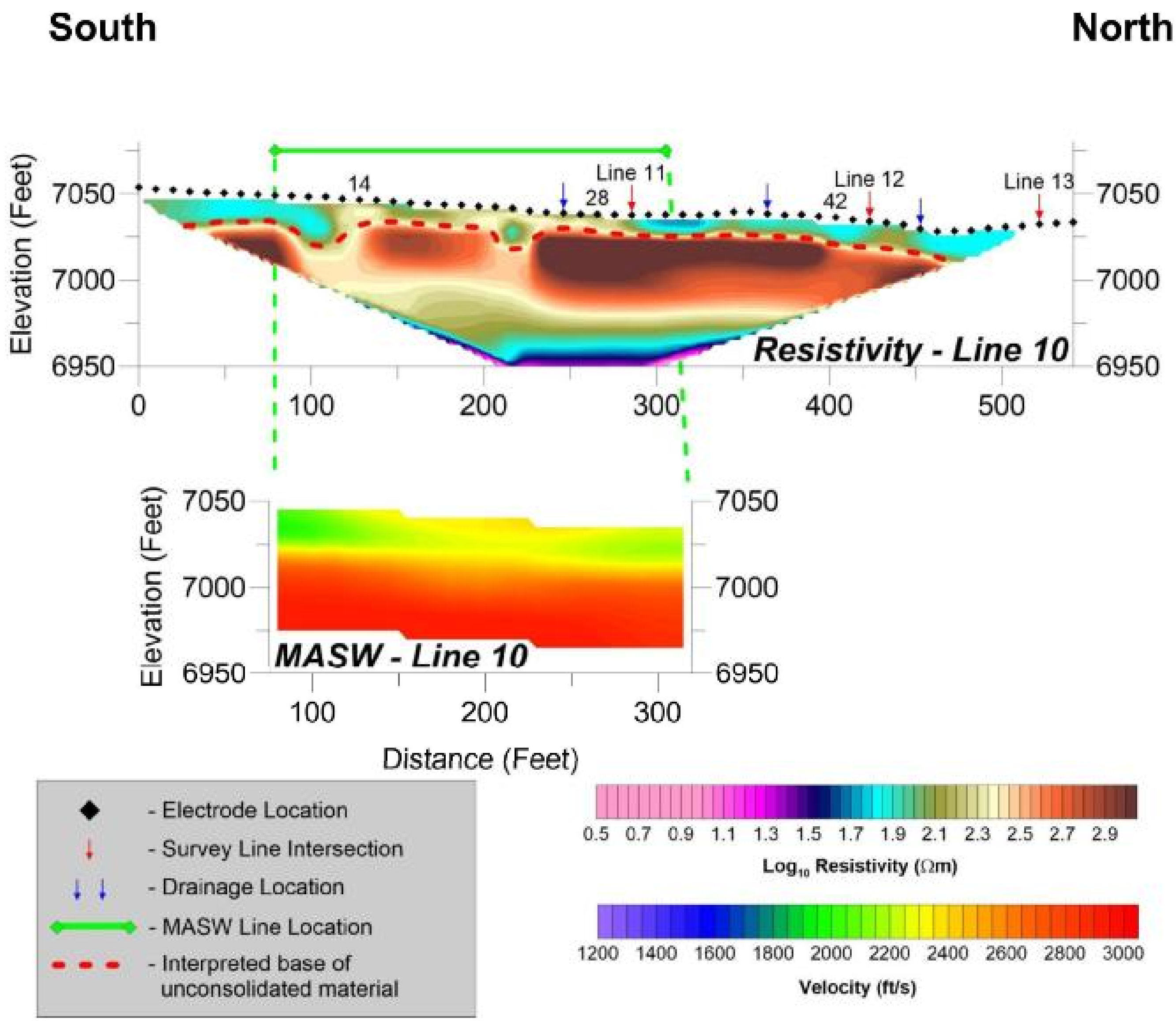


Figure 19. Line 11 Electrical Resistivity and MASW Model Results.

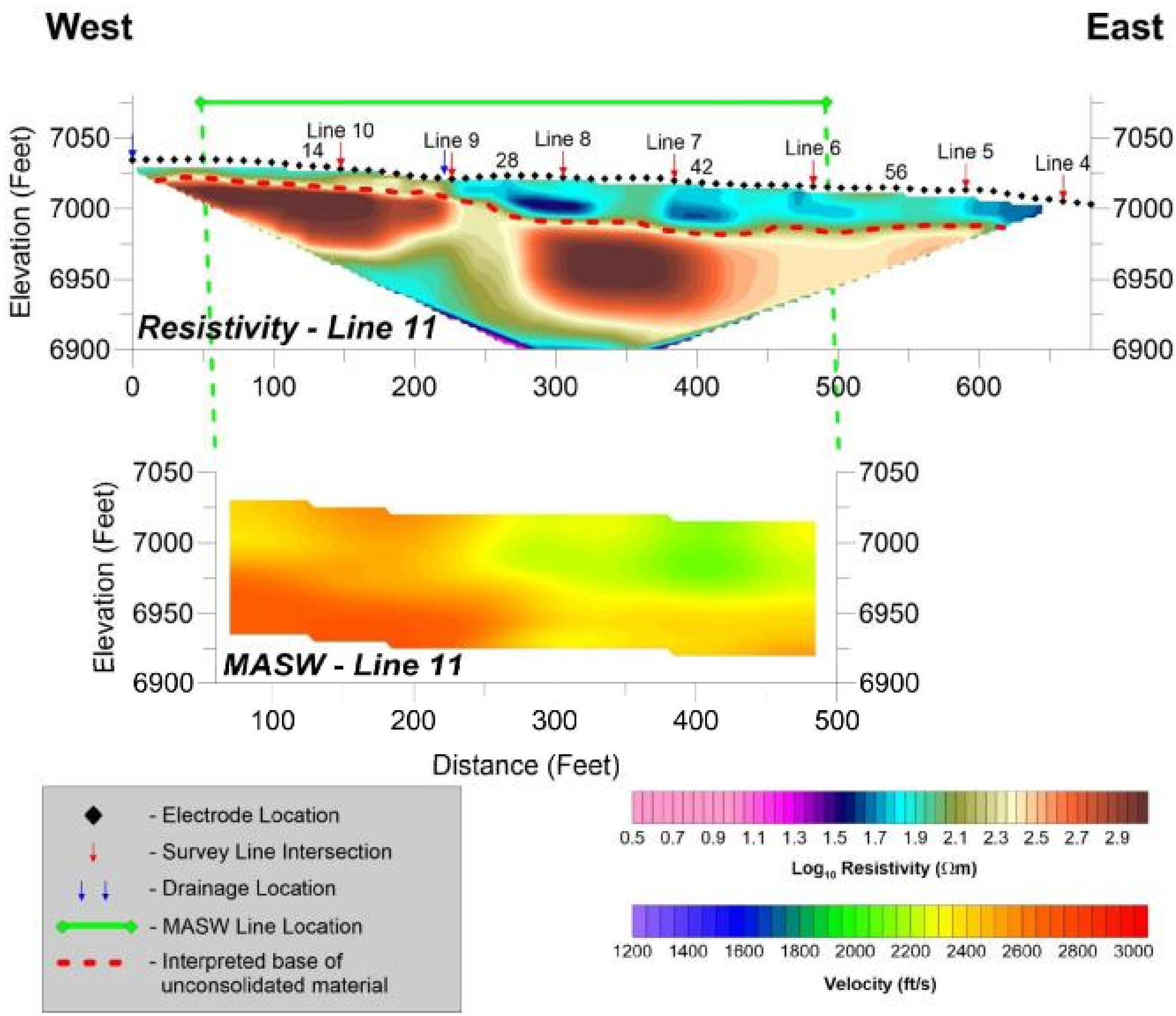


Figure 20. Line 12 Electrical Resistivity and MASW Model Results.

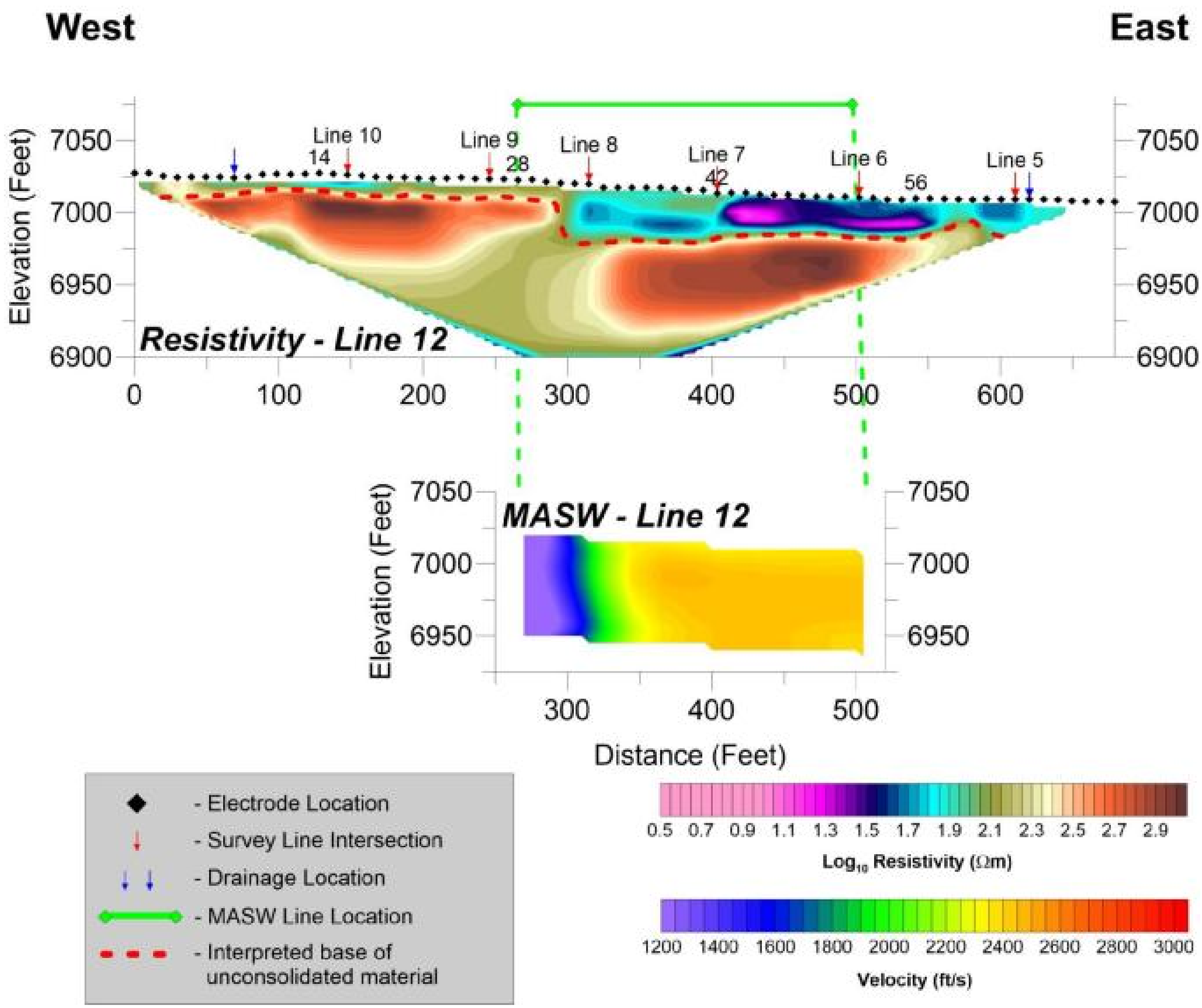
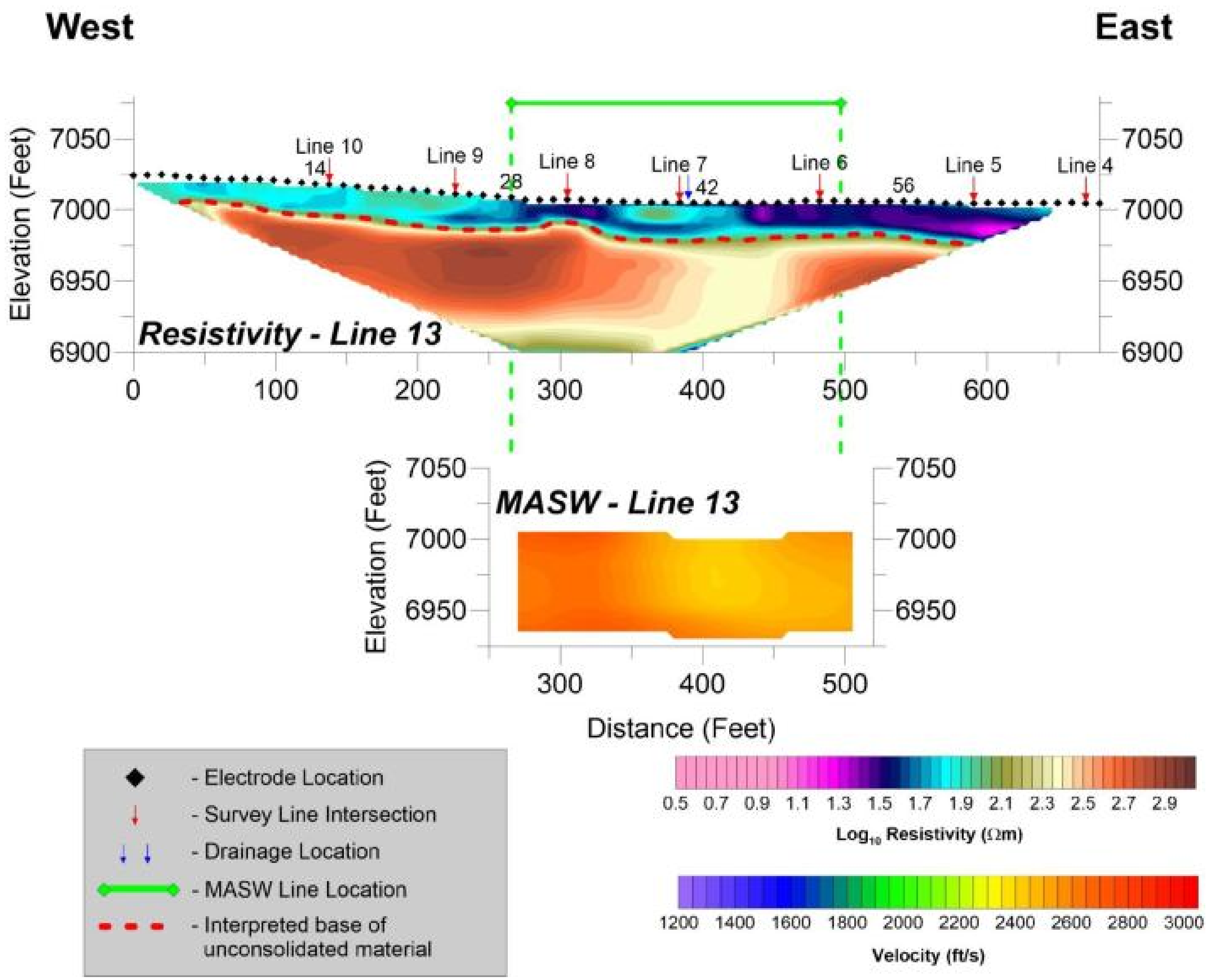


Figure 21. Line 13 Electrical Resistivity and MASW Model Results.



5.0 SUMMARY

Geophysical characterization, which included thirteen coincident lines of electrical resistivity and multi-channel analysis of surface waves (MASW), was completed at the Section 26 Site. Data were acquired between the 12th and 19th of June, 2017.

The objectives of the geophysical investigation were to determine the presence of any underlying void spaces and thickness of historic mining material overlying the bedrock at the site.

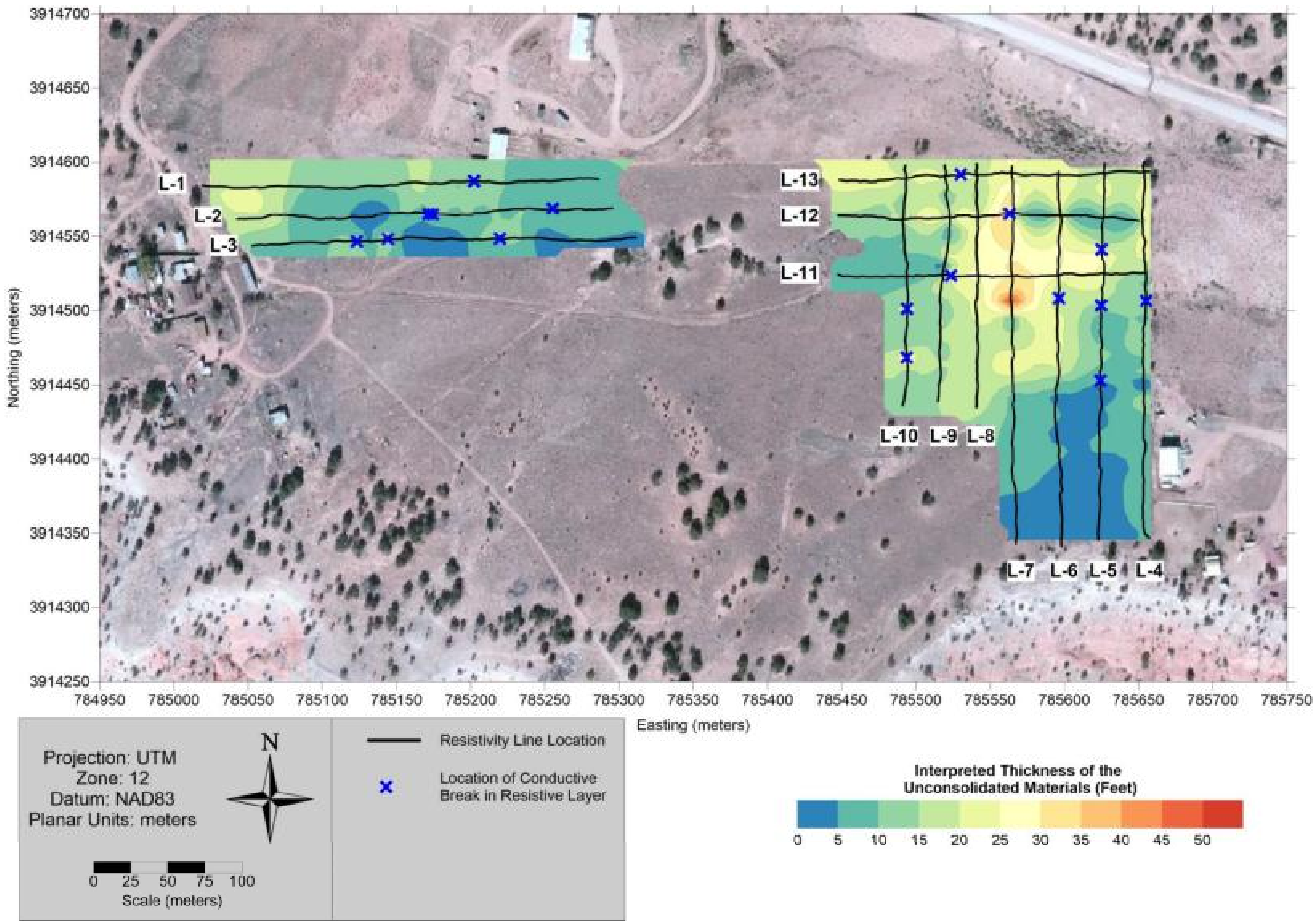
In summary;

- There were no significant features within the electrical resistivity or MASW model results that would indicate the presence of air-filled voids associated with historic mine workings or shafts across the site. We do observe a number of highly conductive features in the electrical resistivity lines that align with the fenced enclosure surrounding the open mine shaft in the eastern area of the site. These were observed in Lines 7, 8, 11, and potentially 12. While the conductive nature of these features precludes air-filled voids, they could be associated with backfilled or collapsed mine workings associated with the open shaft. Alternatively, and potentially more likely is that the open shaft is acting as a conduit for infiltration, leading to increased moisture content in the sediments surrounding this area. The increased moisture content would decrease the resistivity value of the affected sediments, compared to the surrounding materials. Only one of these conductive features, in Line 7, correlates to a decrease in shear-wave velocity, as we might expect for backfilled or collapsed workings. This would lead us to conclude the likely cause of the conductive features relates to an increase in soil moisture or finer grained material in these regions.
- The electrical resistivity model results displayed a similar structure for each survey line, with a near-surface conductive layer interpreted to represent the native soil cover or possibly fill material associated with the historic mining activities. This overlies a resistive layer, which was interpreted to represent the upper limestone or marl bedrock unit, with a more conductive layer extending to the depth limits of the model beneath this. In general, the near-surface layer displayed lower shear-wave velocities, relating to the unconsolidated soils or fill material, in the MASW model results. The thickness of the near-surface layer associated with the native soil or historic mining activity was estimated along each survey line, with the contoured results presented in Figure 22. As previously stated, it was not possible to differentiate between the native soils and the fill material associated with the mining geophysically. However, we can see that in general the areas where known mining activity took place, for example the northeastern area of site from historic aerial photographs, we observe much greater thicknesses of fill

material. In contrast, the undisturbed soils tend to have a smaller thickness (for example <10 feet). This information can be used to provide an estimate of the volume of the fill material associated with the historic uranium mining at the site.

- An additional feature of interest in the model results was related to the conductive breaks observed in the resistive layer, representing the limestone or marl bedrock layer, the locations of which are highlighted in Figure 22. It is likely these are related to increased weathering or highly fractured regions of the bedrock material, either allowing for increased moisture content in the bedrock or finer grained material based on the breakdown of the bedrock.

Figure 22. Interpreted Thickness of the Unconsolidated Materials at the Section 26 Site.



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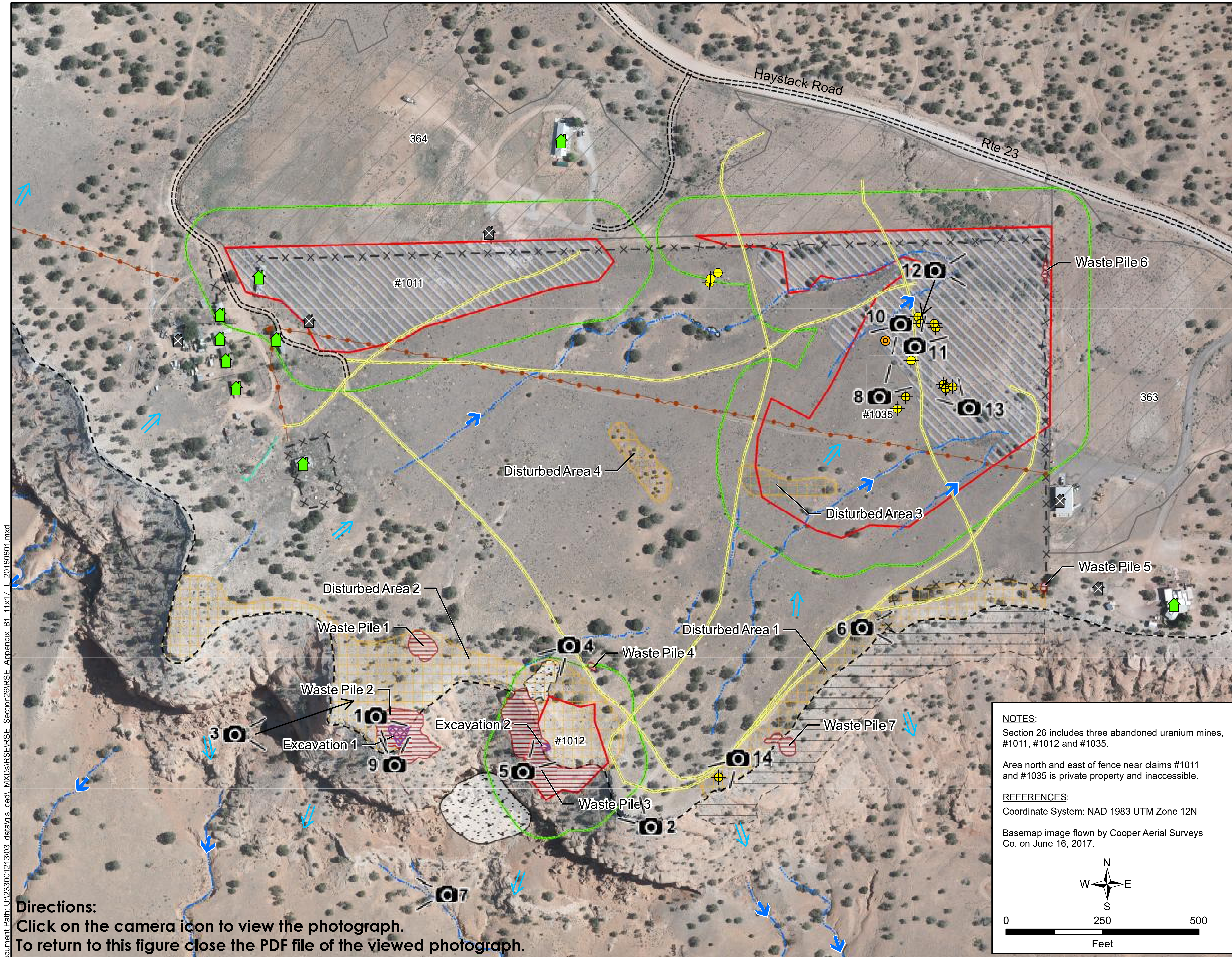
Appendix B Site Photographs

B.1 Site Photographs

B.2 Regional Photographs



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Photograph Indicating Direction Taken
- Habitable Building
- Uninhabitable Building
- Possible Portal or Storage
- Historical Borehole
- Flow Direction
- Approximate Overland Water Flow Direction
- Drainage
- Fence
- Potential Haul Road
- Power Line
- Road
- Water Line
- Approximate Edge of Mesa
- Debris
- Excavation
- Graded / Disturbed Reclaimed Area
- Potential Mining Disturbed
- Potential Waste Rock
- Waste Pile
- Vertical Mine Shafts
- Claim Boundary
- 100-Foot Claim Buffer
- Other Claim Boundary

NOTES:

Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

Area north and east of fence near claims #1011 and #1035 is private property and inaccessible.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 250 500
Feet

TITLE: Site Photographs

PROJECT: Removal Site Evaluation Section 26 Mine Site

DATE: 8/2/2018

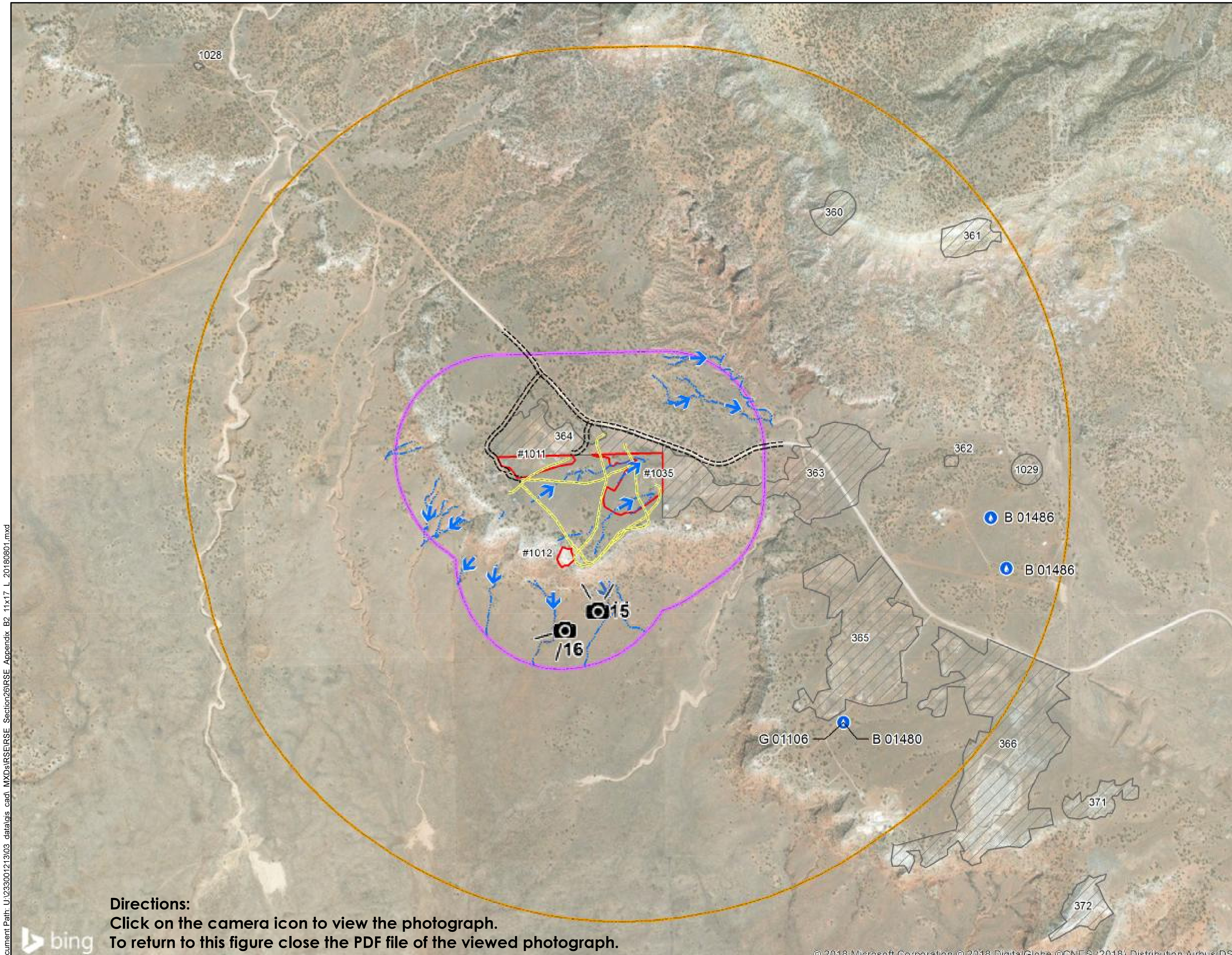
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: B-1



Directions:
Click on the camera icon to view the photograph.
To return to this figure close the PDF file of the viewed photograph.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Photograph Indicating Direction Taken
- Site Clearance Identified Water Feature[1]
- Flow Direction
- Drainage
- Potential Haul Road
- Road
- Claim Boundary
- 1/4-Mile Claim Boundary Buffer
- 1-Mile Claim Boundary Buffer
- Other Claim Boundary

NOTES:
1. Water features and identification names identified in 2007 AUM Atlas.

2. Section 26 includes three abandoned uranium mines, #1011, #1012 and #1035.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

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0 1,250 2,500
Feet

TITLE:
Regional Site Photographs

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE:	DOCUMENT NAME:
8/2/2018	Removal Site Evaluation Report
AUTHOR: EDZ	REVIEWER: CBB
Stantec	FIGURE: B-2

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSERSE_Section26\RSE_Appendix_B2_11x17_L_20180801.mxd

Appendix C Field Activity Forms

C.1 Soil Sample Field Forms

C.2 Drilling and Hand Auger Borehole Logs

C.1 Soil Sample Field Forms

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG1-001

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1030

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS Sunny windy, 20°

FIELD USCS DESCRIPTIONS Gray silty sand, minor clay, trace md sands

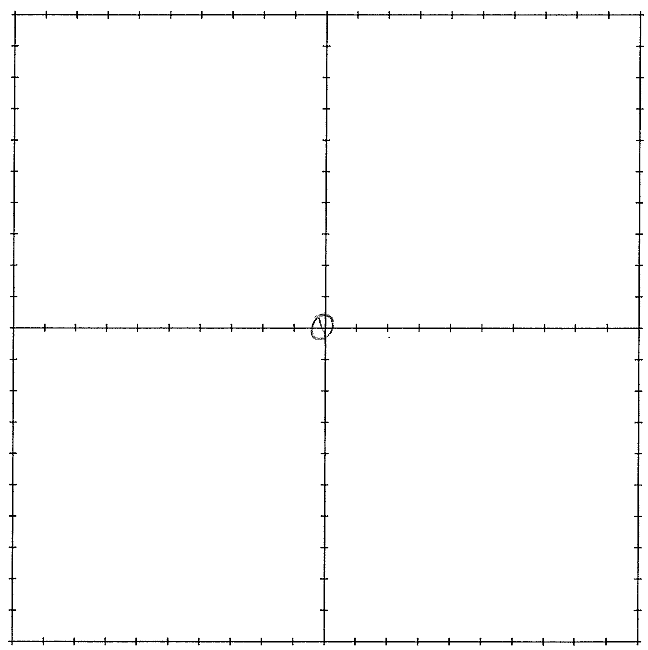
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☑ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG1-002

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1045

SAMPLE COLLECTED BY L Lee

WEATHER CONDITIONS Sunny Windy 20's

FIELD USCS DESCRIPTIONS Fine gray silty sand, minor clay

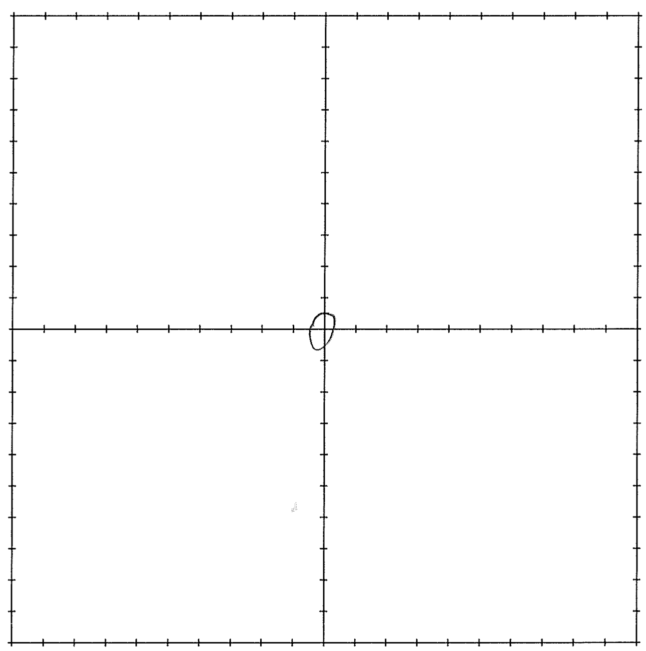
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☑ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☑ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG1-003

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1050

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine gray silty sand, minor clay,

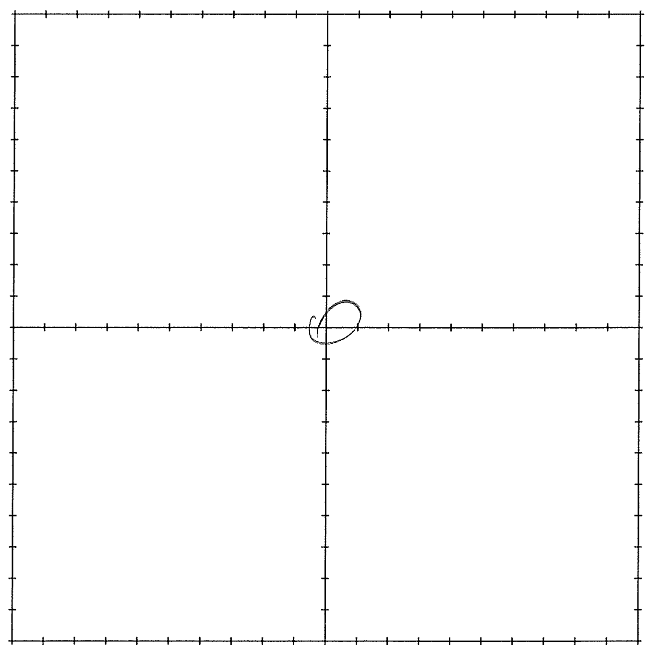
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1001 (Secti 26)

SAMPLE I.D. S1011-BG1-0041

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1105

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine red silty sand, trace clay

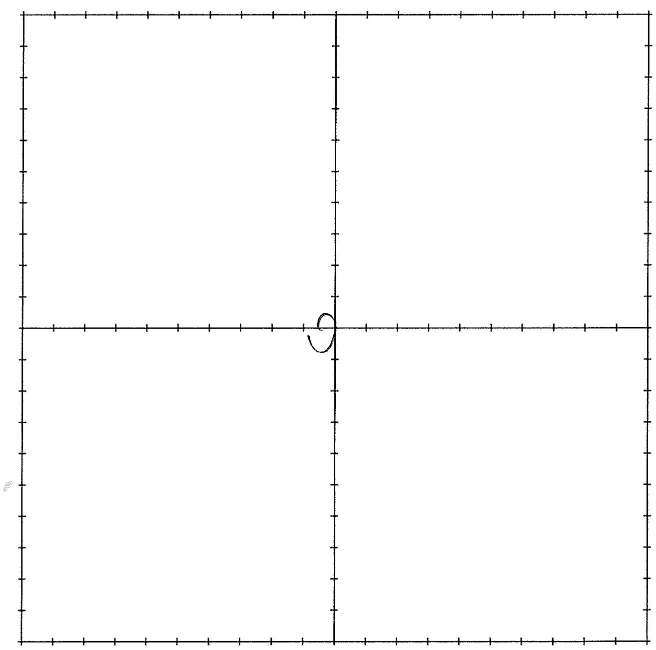
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG1-005 MS, MSD

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1115

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy, 70's

FIELD USCS DESCRIPTIONS Fine and sand, minor flaky coarse sands, trace clay

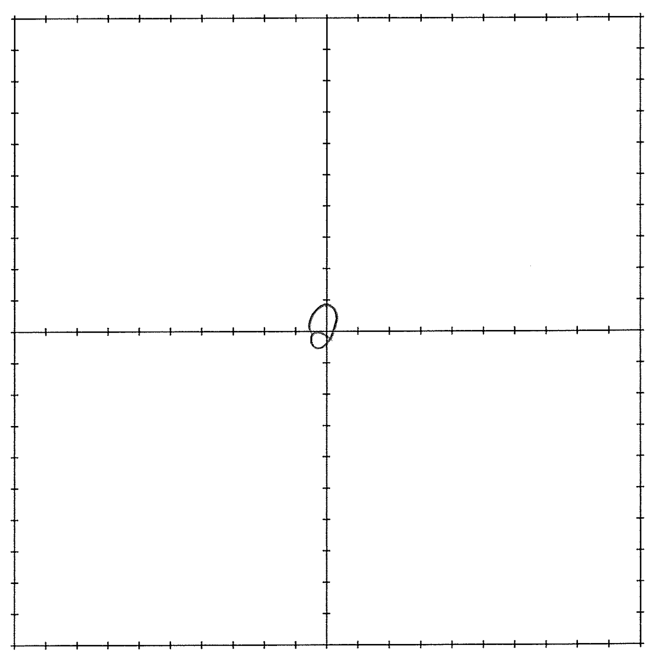
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011 - BG1 - 006

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1120

SAMPLE COLLECTED BY LR

WEATHER CONDITIONS 20-30°F, windy

FIELD USCS DESCRIPTIONS Fine gray/red sand, well-sorted

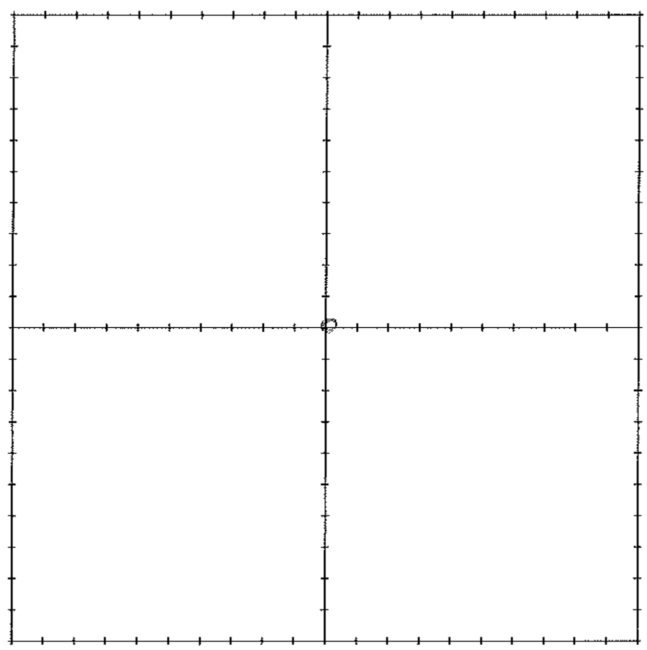
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG1-007

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1130

SAMPLE COLLECTED BY L Lee

WEATHER CONDITIONS Sunny, windy, 20's

FIELD USCS DESCRIPTIONS Fine well/grad sand, minor small, coarse sand

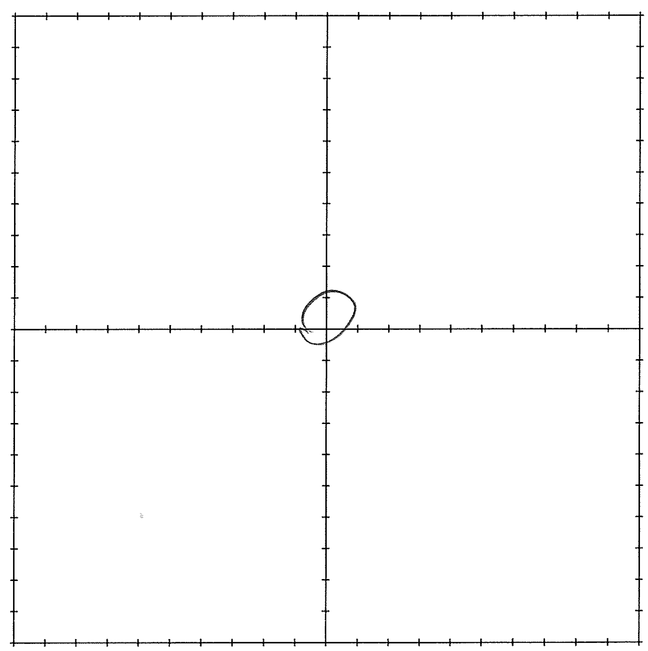
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG1-008

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1140

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny Windy 20's

FIELD USCS DESCRIPTIONS Brown/red fine sand, trace gray fines

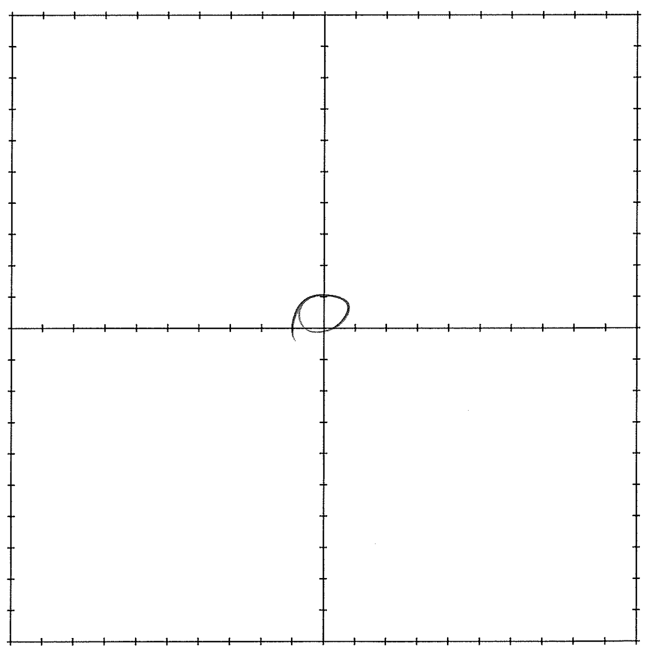
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG1-009

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1145

SAMPLE COLLECTED BY L Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Brown/tan fine sand, trace gray fines

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra-226, Metals

MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S6011 (Section 26)

SAMPLE I.D. S1011 - B61 - 010

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1200

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny Windy 20's

FIELD USCS DESCRIPTIONS Red fine sand, trace clay

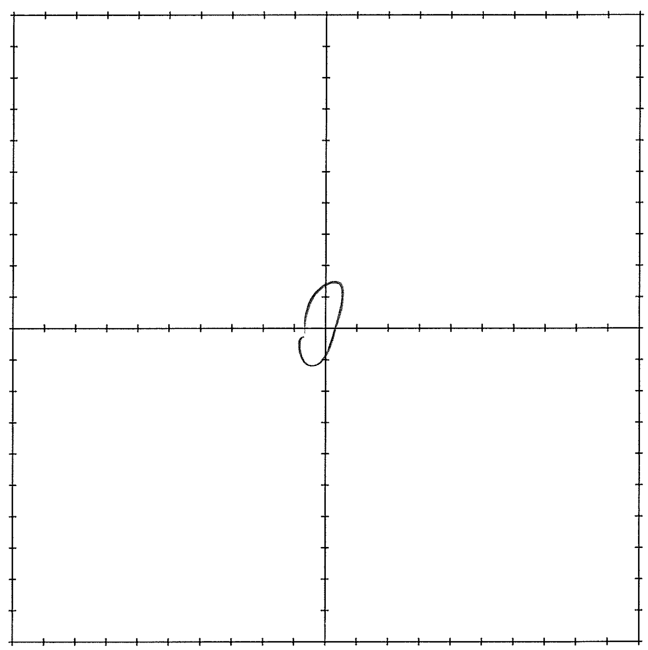
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☑ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG2-001

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1210

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine red sand

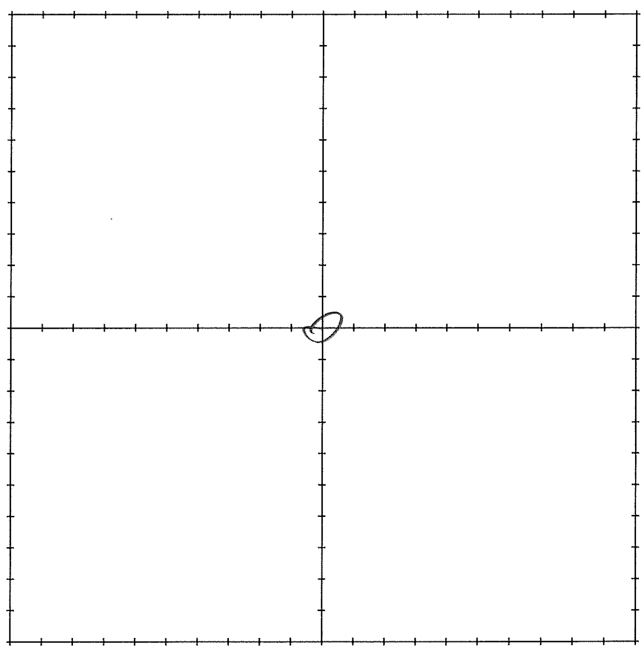
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG2-002

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1215

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine md sand, trace clay

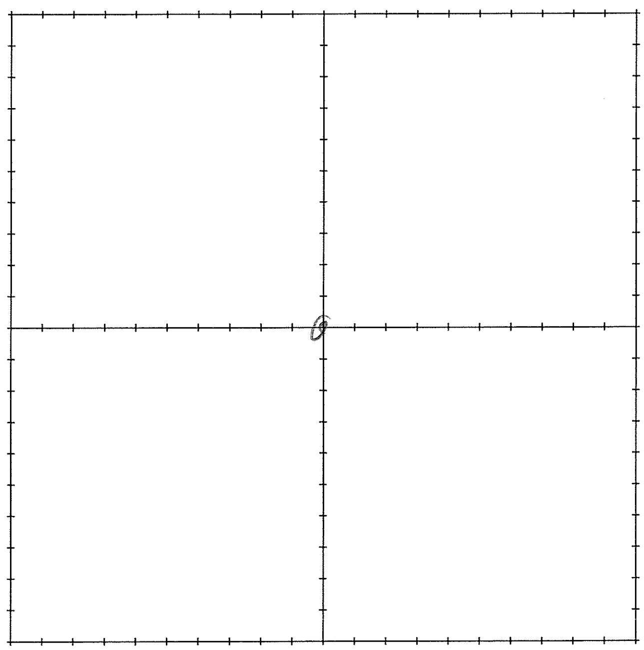
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG2-003

SAMPLE COLLECTION DATE 11/30/10

SAMPLE COLLECTION TIME 1220

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy, 70's

FIELD USCS DESCRIPTIONS Fine red sand, trace clay

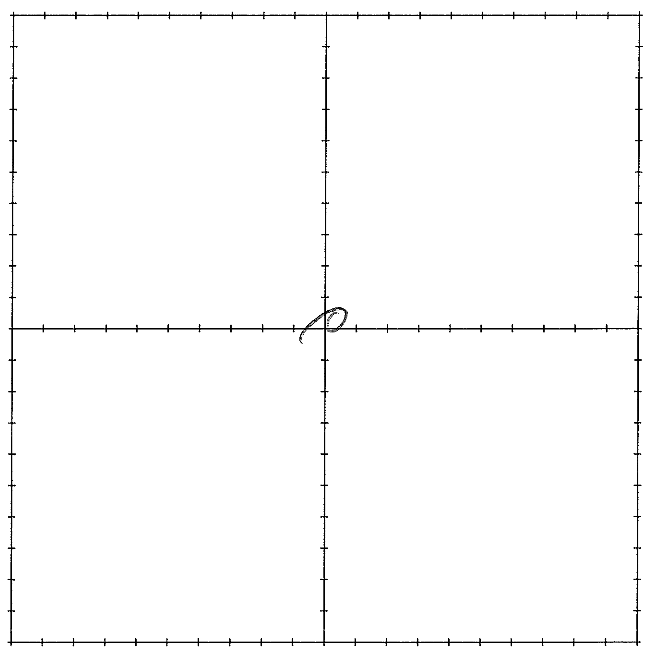
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG2-004

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1225

SAMPLE COLLECTED BY L Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine med sand, some clay

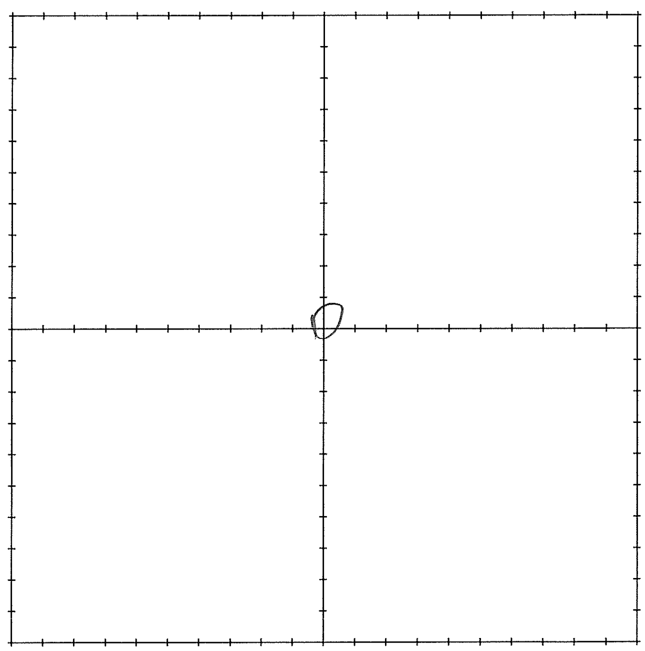
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 zipper

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG2-005

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1230

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS Sunny, Windy, 70's

FIELD USCS DESCRIPTIONS Fine med sand, trace clay

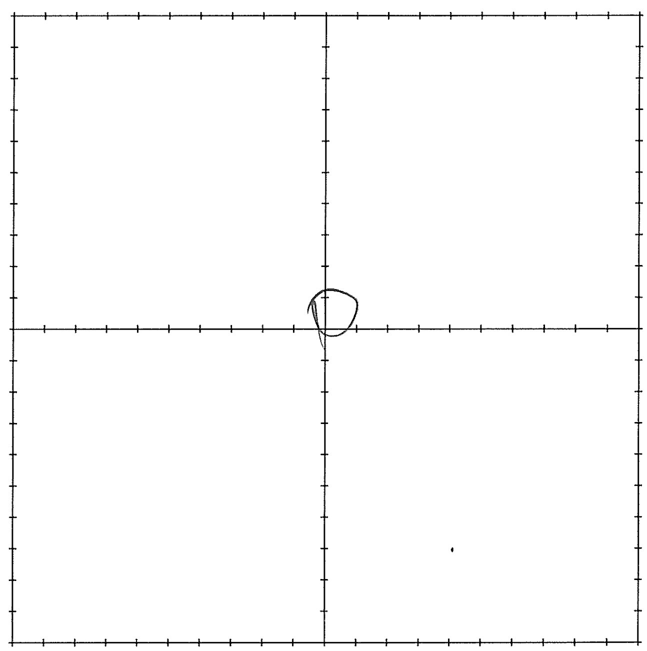
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 206)

SAMPLE I.D. S1011-BG2-006, 206

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1235

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine red sand, trace clay

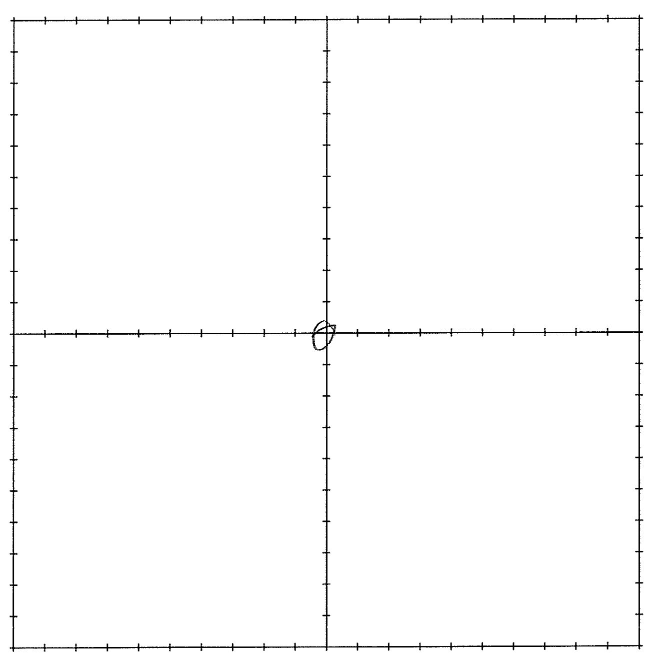
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☑ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☑ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-B62-607

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1240

SAMPLE COLLECTED BY L. Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine red Sand

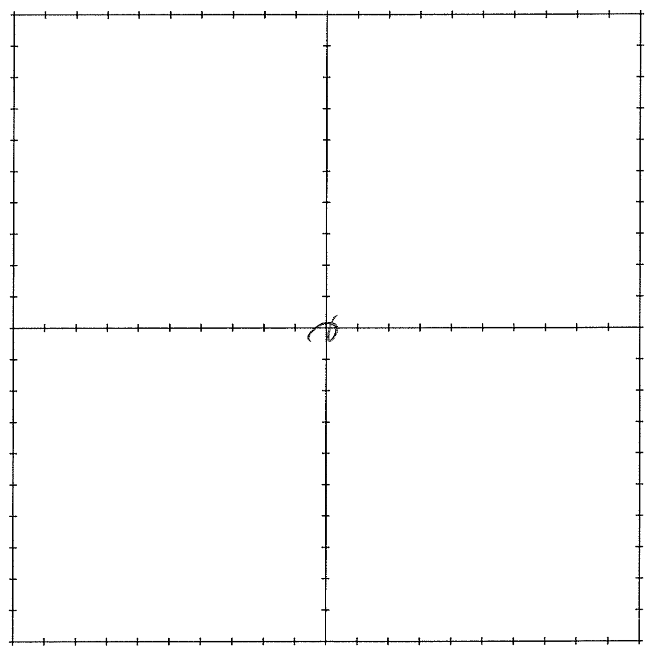
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BG2-008

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1245

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy, 20's

FIELD USCS DESCRIPTIONS Fine red sand, trace clays

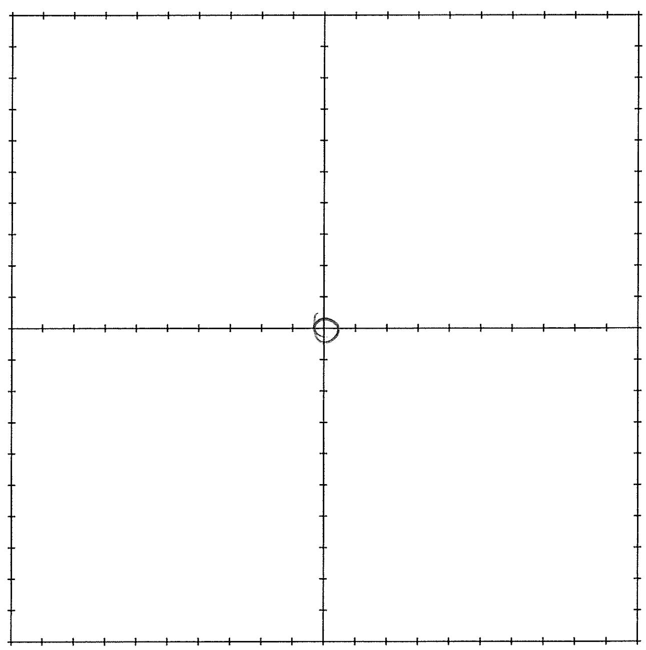
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-BGR-009 MS MSD

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1250

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy 20's

FIELD USCS DESCRIPTIONS Fine red sand, trace clay

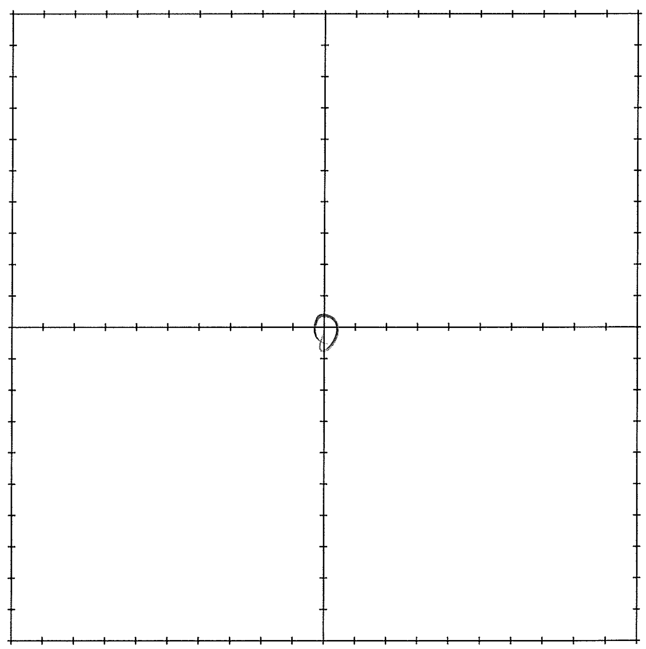
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Safi 26)

SAMPLE I.D. S1011-BG2-010

SAMPLE COLLECTION DATE 11/30/16

SAMPLE COLLECTION TIME 1300

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny, Windy, 70's

FIELD USCS DESCRIPTIONS Fine red sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals

MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - BG-3 - 001 - 0

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1020

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny ~~[illegible]~~ 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand with gravel (SP) Light gray (5 YR 7/1), dry, Loose, medium to coarse sand

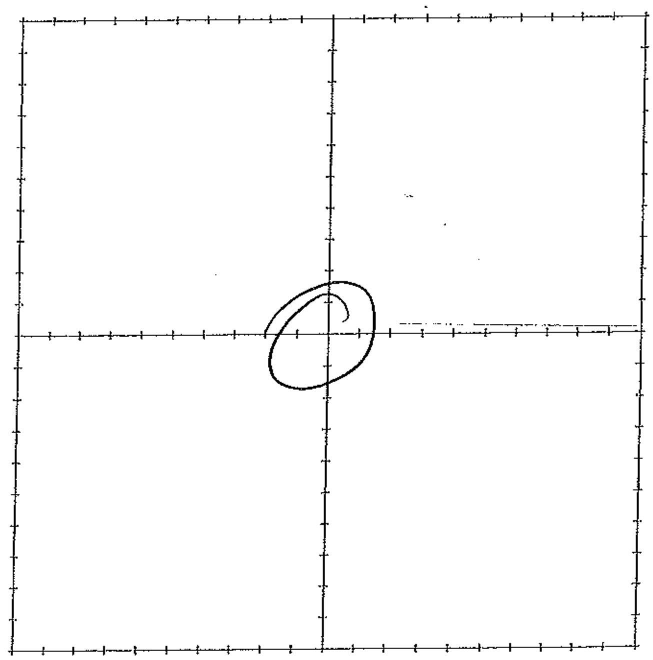
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☒ MEDIUM ☒ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME section 26

SAMPLE I.D. S1011 - BG-3 -002

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1034

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand with gravel (SP), Light gray (5 YR 7/1), loose, dry, medium to coarse sand

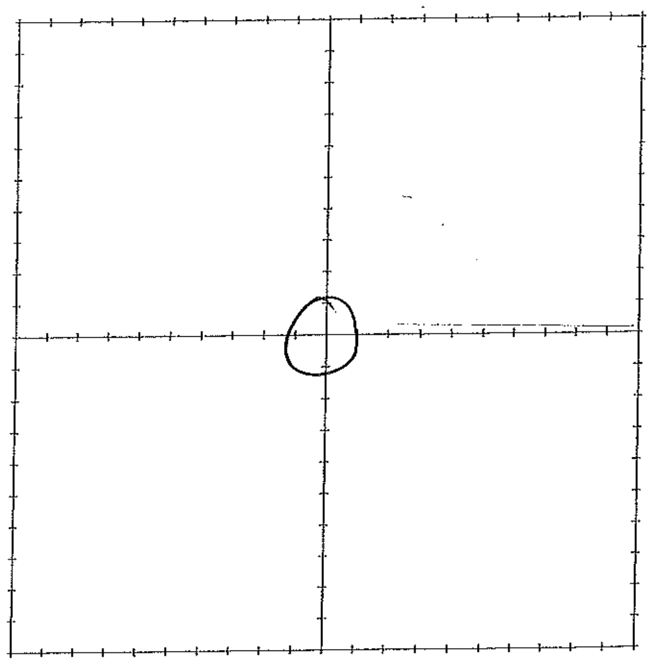
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☑ MEDIUM ☑ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 226

SAMPLE I.D. S1011-BG3-007

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1047

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand with gravel (SP), light gray (5YR 7/1), loose, dry, medium to coarse sand

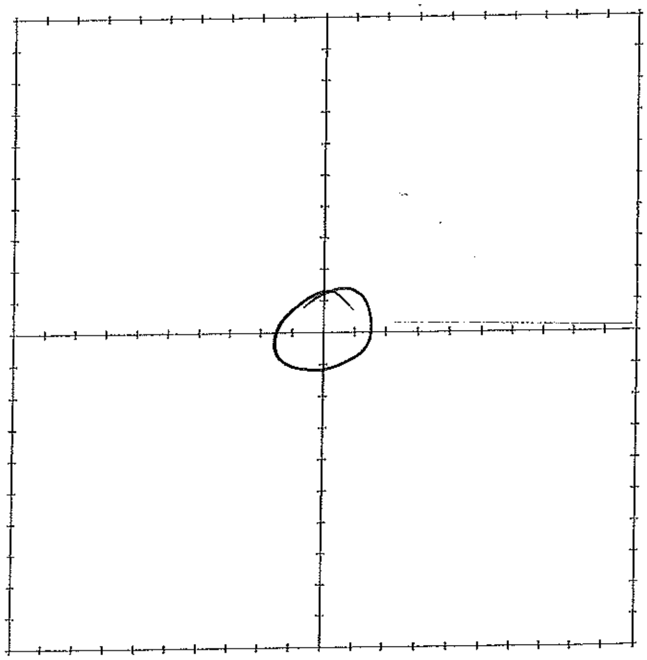
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☑ MEDIUM ☑ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags,

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: Section 26

SAMPLE I.D.: S104 - ~~SCX~~ 8G3 - 004

SAMPLE COLLECTION DATE: 9/18/17

SAMPLE COLLECTION TIME: 1056

SAMPLE COLLECTED BY: CL

WEATHER CONDITIONS: Sunny 75°F

FIELD USCS DESCRIPTIONS: Poorly graded sand with gravel (SP) Light gray (5YR 7/1), Loose, dry, medium to coarse sand

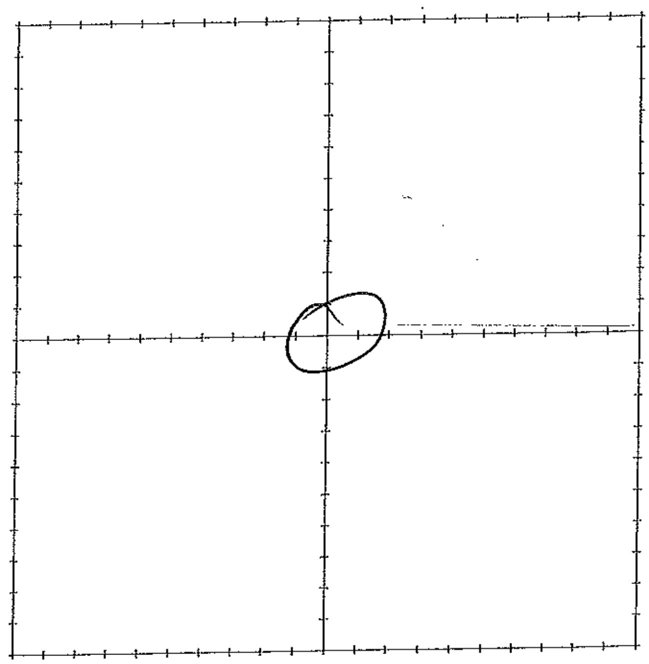
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☒ MEDIUM ☒ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE): 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 2B

SAMPLE I.D. S1011-BG3-005

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1108

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny, 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand with gravel (SP), light gray (5YR 7/1), loose, dry, med-coarse sand

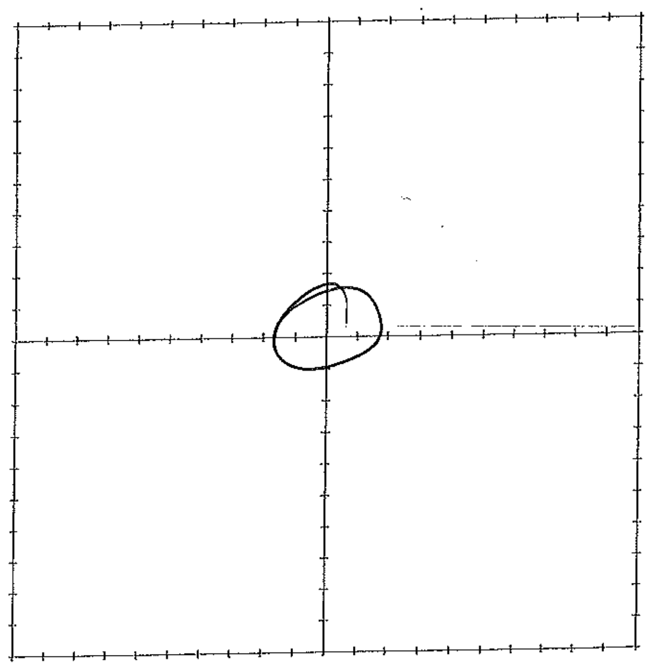
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☑ MEDIUM ☑ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - BG3-006

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1120

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand with gravel (SP), light gray (5 YR 7/1), dry, loose, med-coarse sand

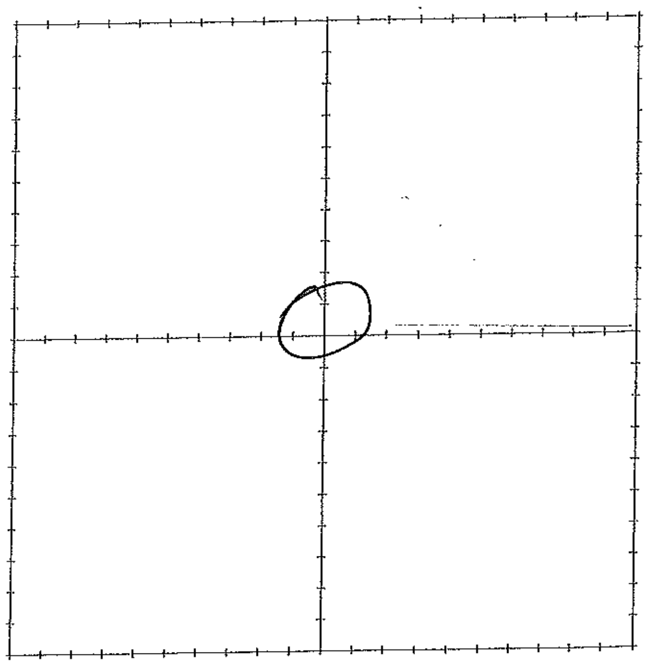
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☑ MEDIUM ☑ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-8G3-007

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1130

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand with gravel (SP), light gray (5YR 7/1), loose, dry, med-coarse sand

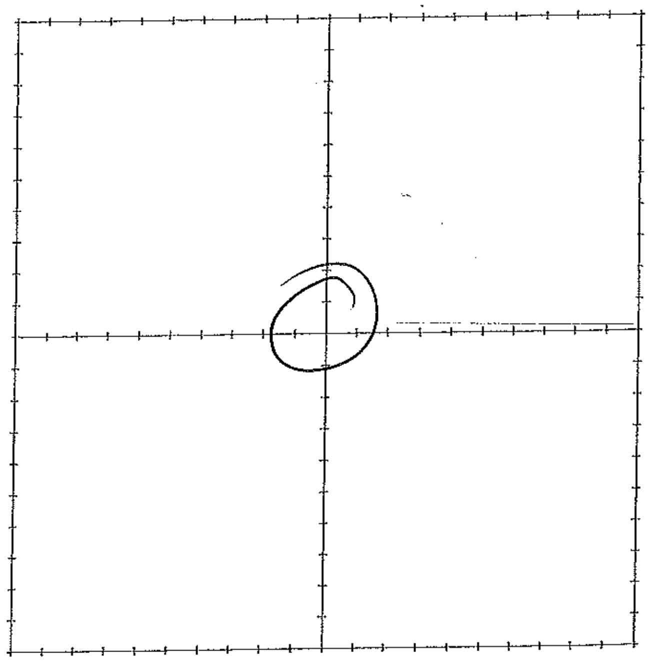
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☒ MEDIUM ☒ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: Section 26

SAMPLE I.D.: S1011 - BG3 - 008

SAMPLE COLLECTION DATE: 9/18/17

SAMPLE COLLECTION TIME: 1143

SAMPLE COLLECTED BY: CL

WEATHER CONDITIONS: Sunny 75° F

FIELD USCS DESCRIPTIONS: Poorly graded Sand with gravels (SP) Light gray (5YR 7/1), loose, dry, med - coarse Sand

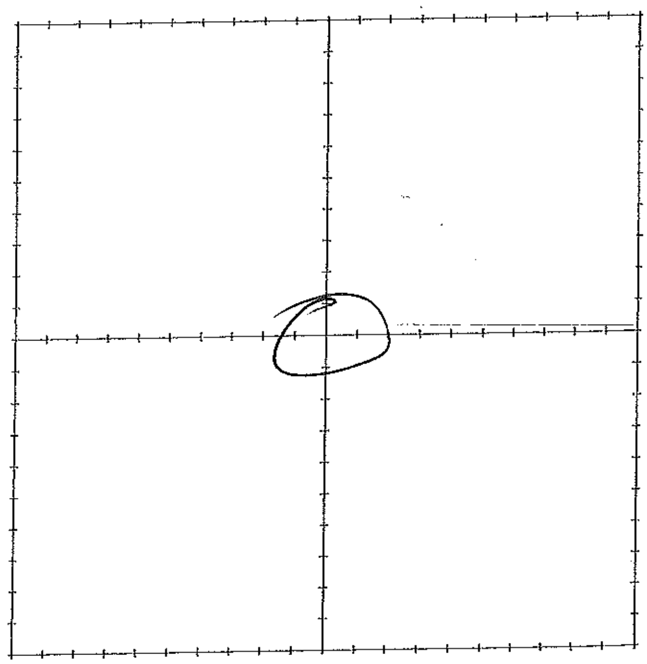
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☑ MEDIUM ☑ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE): 2 Ziplock bags

ANALYSES: RA - 226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-BG3-009

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1153

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS poorly graded sand with gravel (SP), light gray (5YR 7/1), loose, dry, med - coarse sand

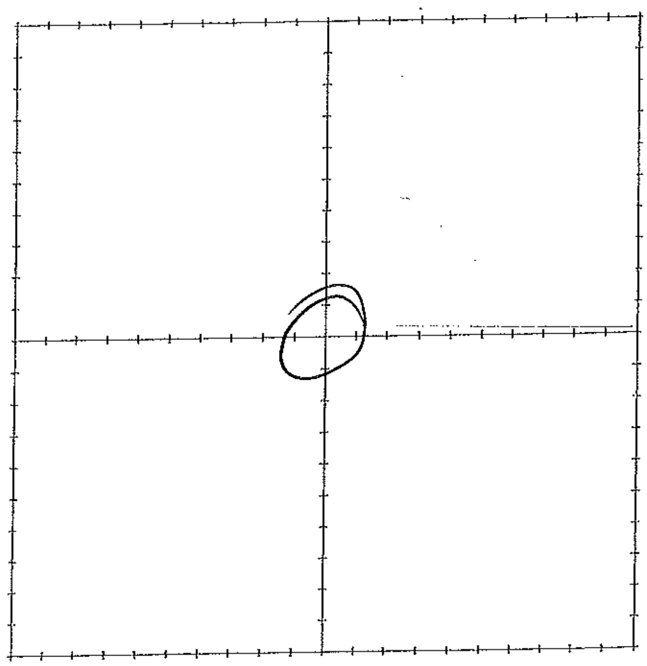
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☑ MEDIUM ☑ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - 863 - 010

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1202

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny, 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand with gravels (SP) light gray (5 YR 7/1), loose, dry, med - coarse sand,

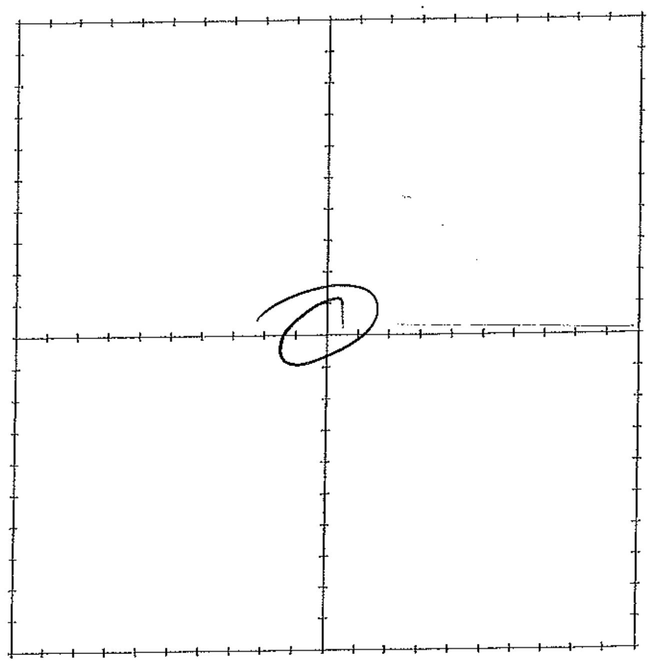
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☑ MEDIUM ☑ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA - 226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - 8G4 - 001

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1023

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80 °F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP) strong brown (7.5 YR 5/8) fine to med sand, loose, dry,

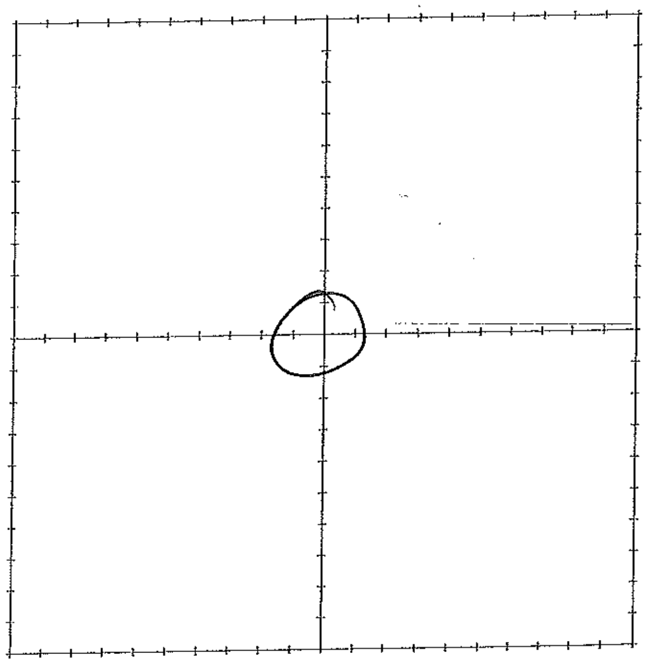
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☒ FINE ☒ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - 8G4 - 002

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1028

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 7/1), loose, dry, fine - med sand

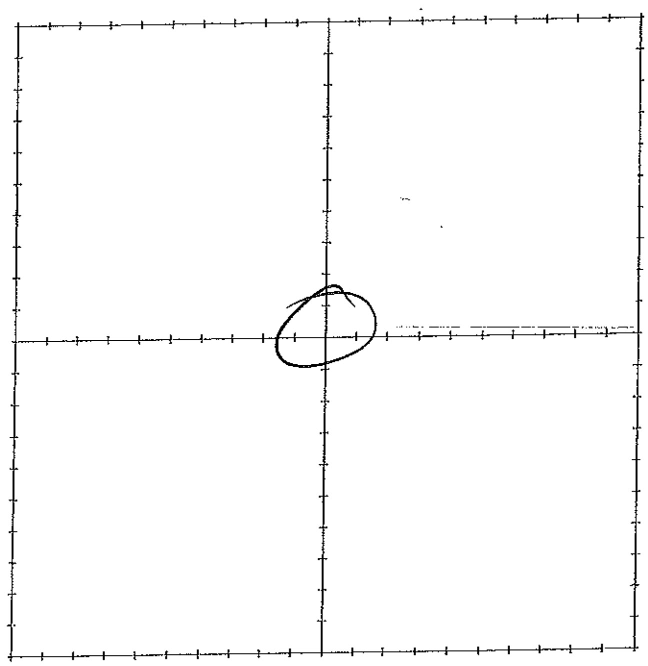
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-BG4-003

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1032

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP) strong brown (7.5 YR 5/8), loose, dry, fine-med. sand

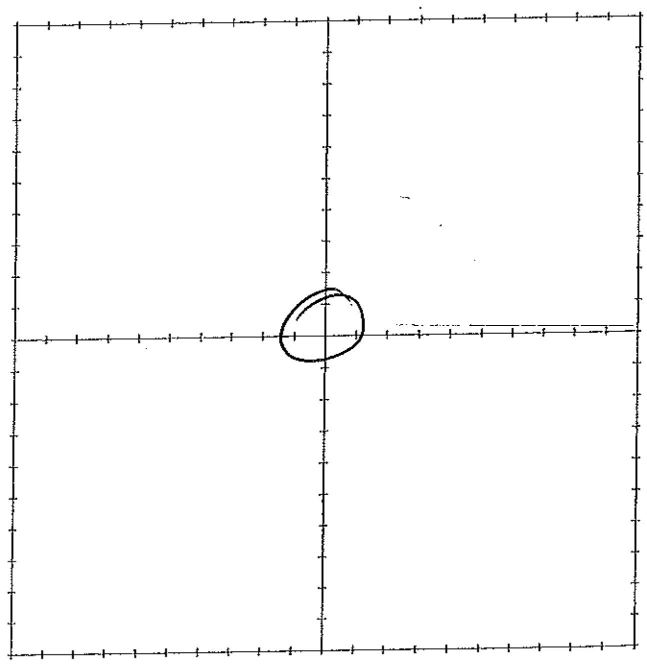
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-8G-4-004

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1034

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8), loose, dry, fine–med sand.

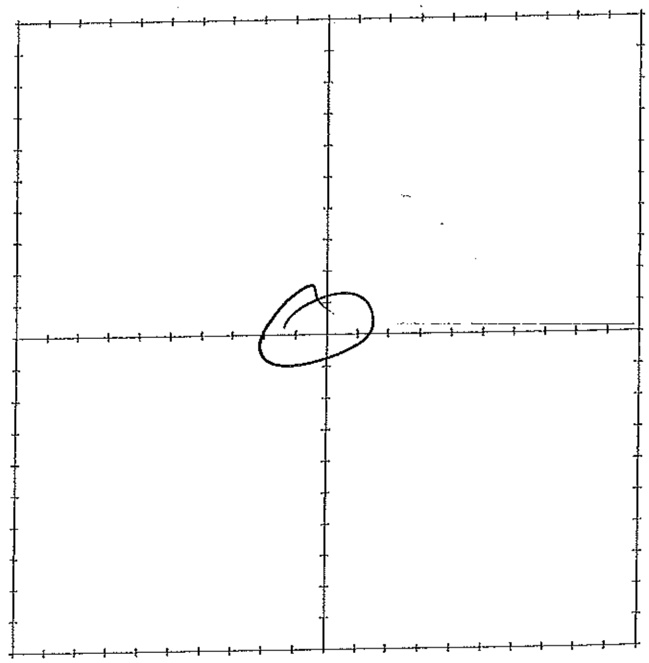
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - BG-4 - 005

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1038

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (5 YR 8/8), Loose, dry, fine-med. sand,

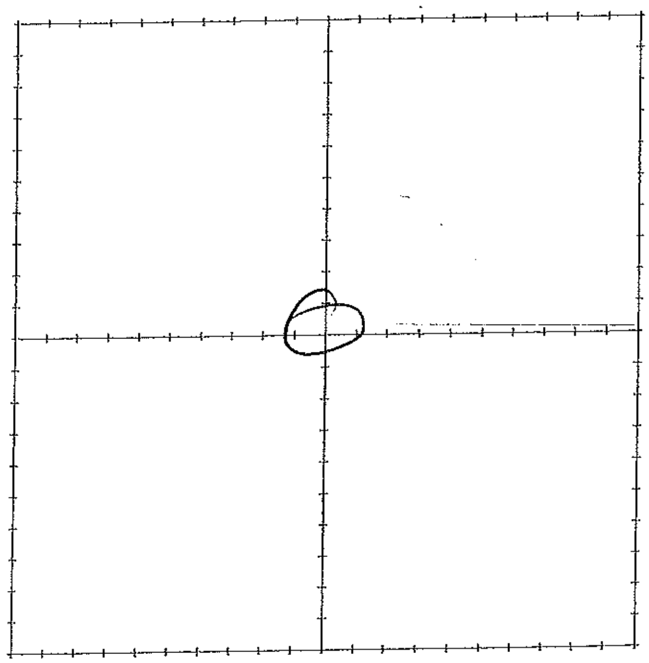
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. 51011-8G4-006

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1040

SAMPLE COLLECTED BY IR

WEATHER CONDITIONS Sunny 80 °F

FIELD USCS DESCRIPTIONS Poorly graded Sand (SP), strong brown (7.5 YR 5/8), Loose, dry, med-fine sand

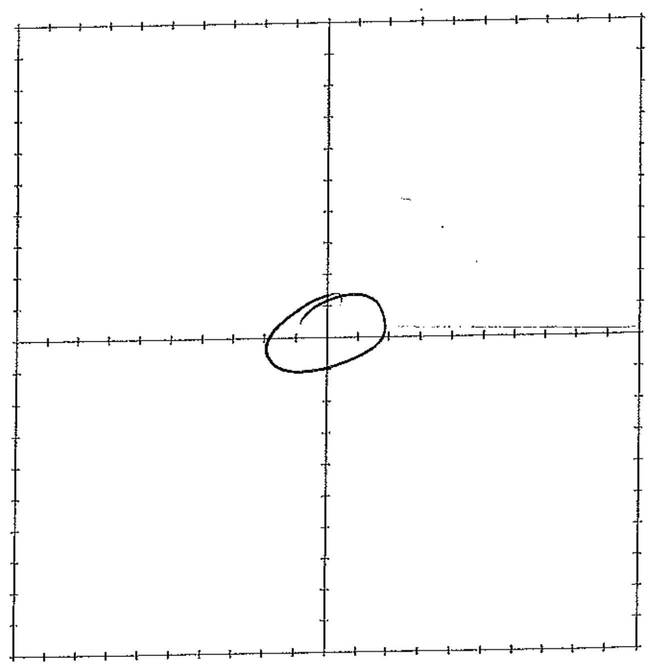
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - BG-4 - 007

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1043

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny, 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8), loose, dry, fine - med. sand

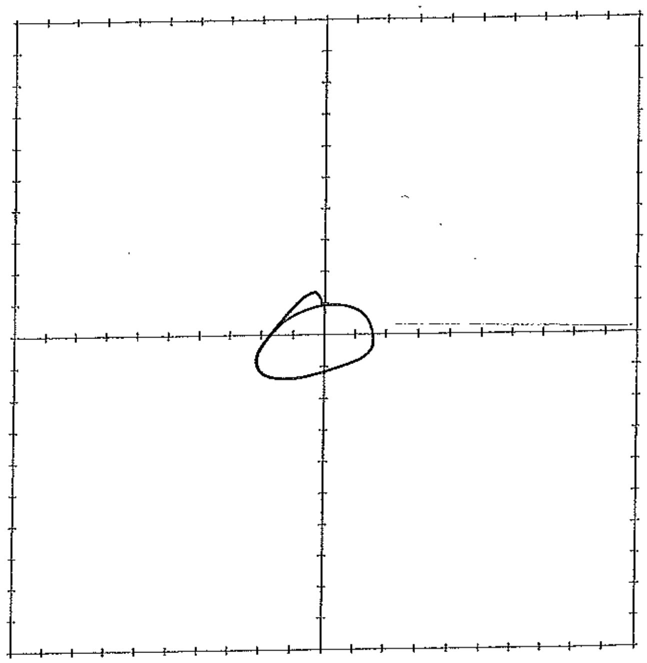
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-8G4-008

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1045

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8), dry, loose, med-fine sand,

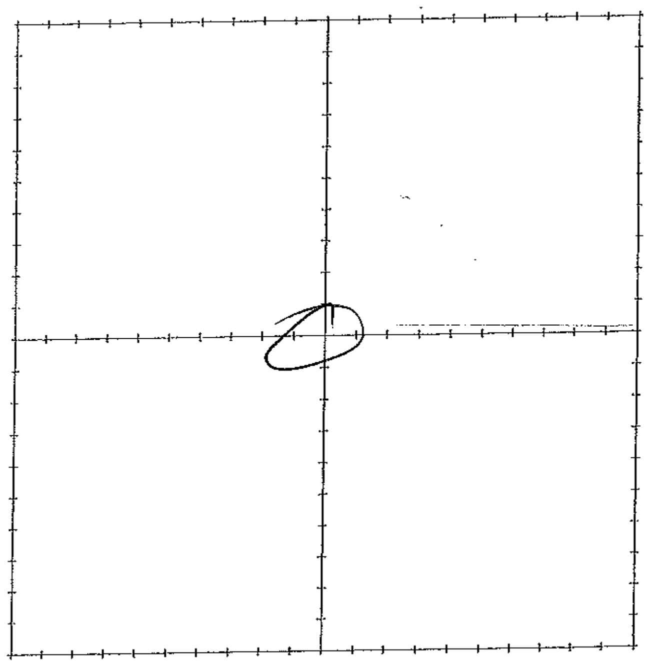
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-864-009

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1047

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8), loose, dry, med-fine sand,

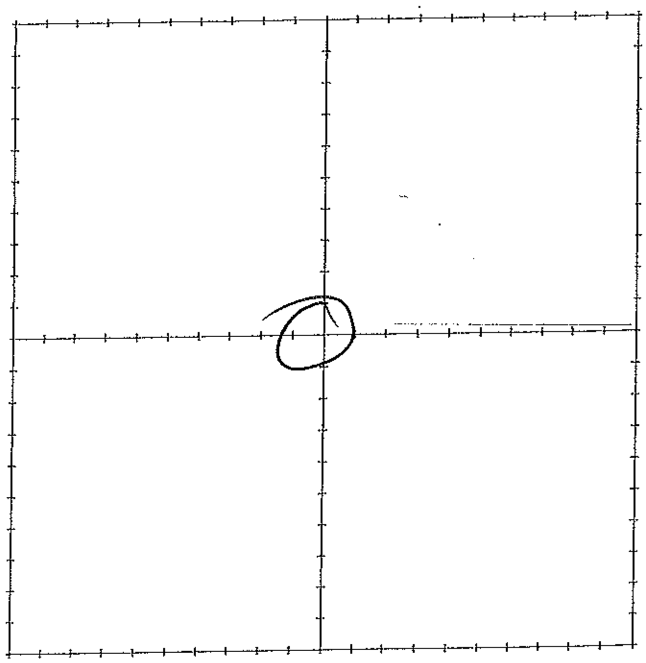
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: Section 26

SAMPLE I.D.: S1011-BG4-010

SAMPLE COLLECTION DATE: 9/19/17

SAMPLE COLLECTION TIME: 1052

SAMPLE COLLECTED BY: JR

WEATHER CONDITIONS: Sunny 80 °F

FIELD USCS DESCRIPTIONS: Poorly graded Sand (SP), strong brown (7.5 YR 5/8), Loose, dry, med-fine Sand.

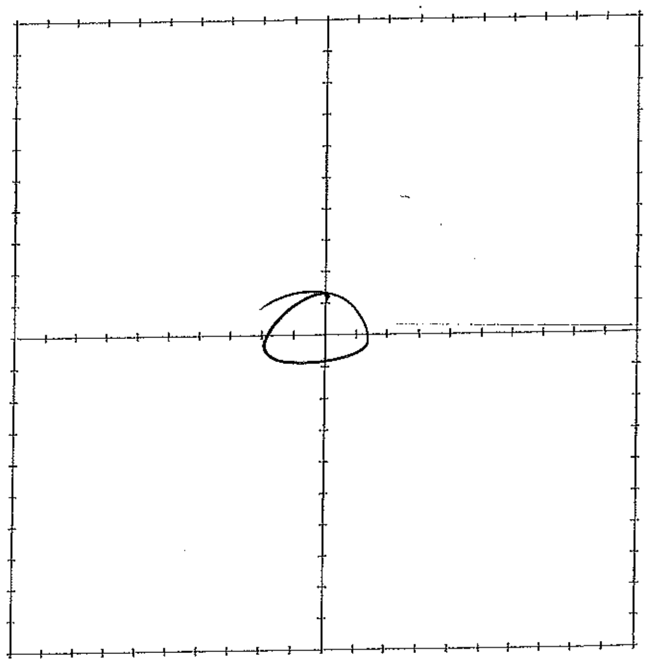
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☒ FINE ☒ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE): 2 Ziplock bags

ANALYSES: RA-226, Metals.



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. 51011-8G5-001

SAMPLE COLLECTION DATE 9/19/18

SAMPLE COLLECTION TIME 1118

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8), loose, dry, fine - med.

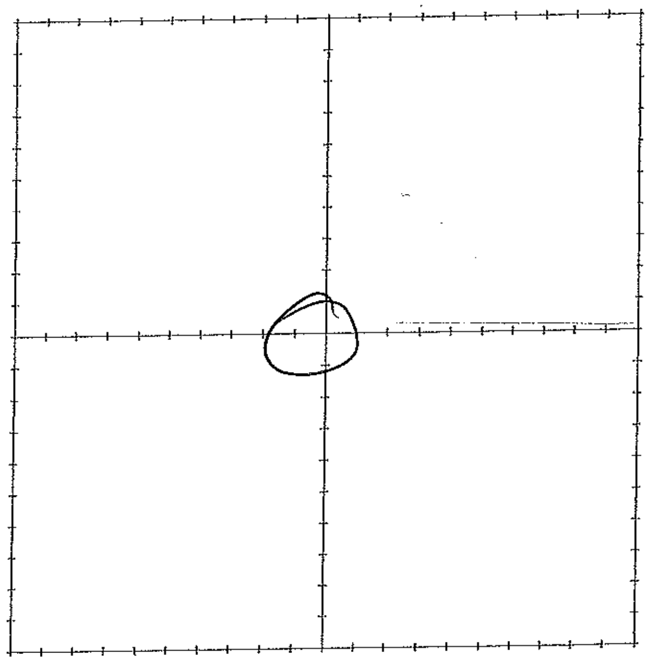
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME section 26

SAMPLE I.D. S1011-BG5-002

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1122

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8), loose, dry, fine - med sand

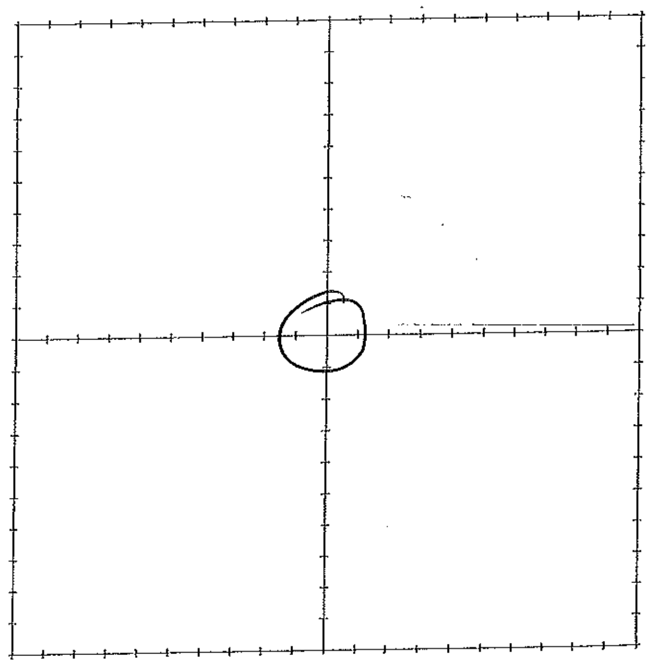
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-BGS-003

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1125

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8) ~~loose~~, dry, fine-med. sand.

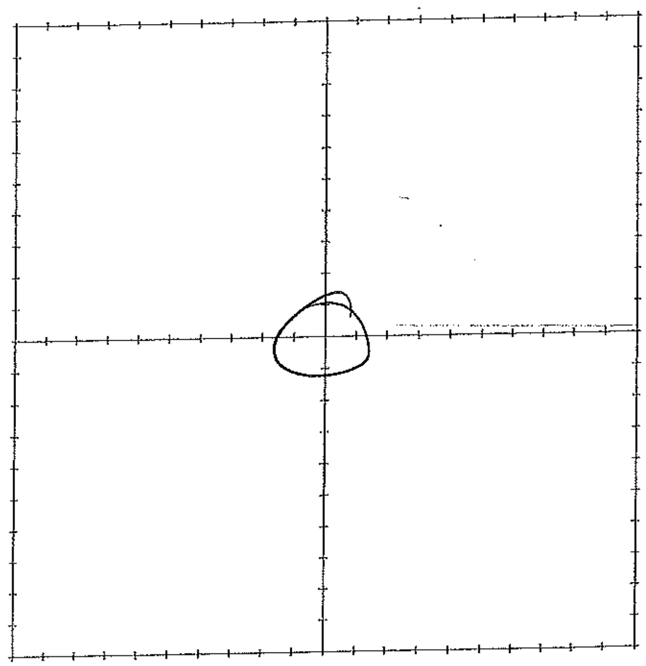
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - BGS - 004

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1131

SAMPLE COLLECTED BY SR

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8), loose, dry, fine - med sand.

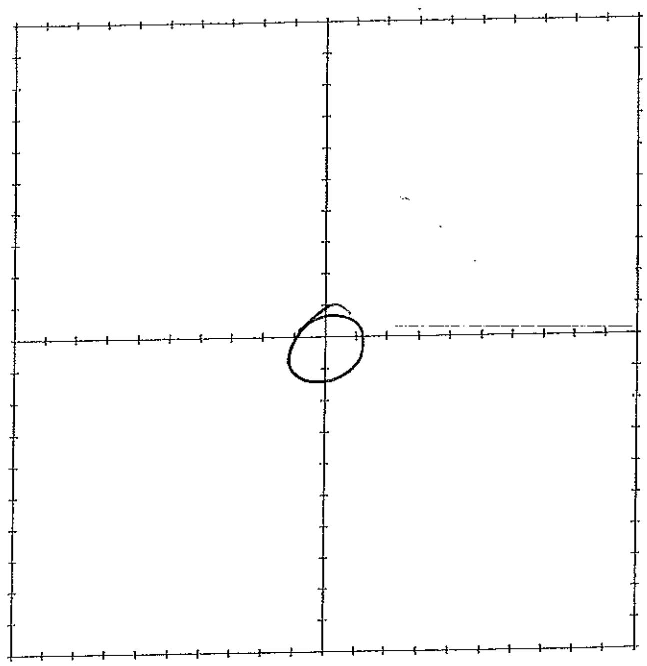
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags.

ANALYSES: RA - 226, - Metals.



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-8G5-005

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1134

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8) loose, dry, fine-med sand.

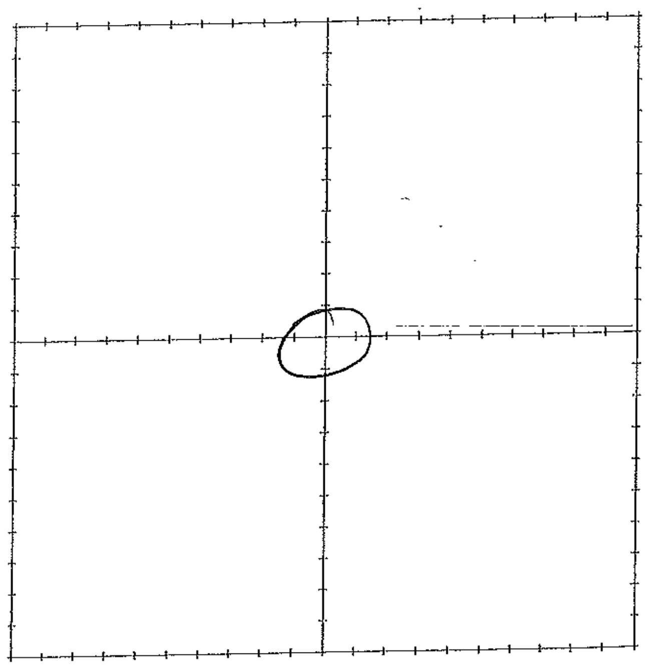
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME section 26

SAMPLE I.D. S1011-805-006

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1037

SAMPLE COLLECTED BY SR

WEATHER CONDITIONS Sunny 80 °F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), Strong brown (7.5YR 5/8) Loose, dry, fine-med. sand

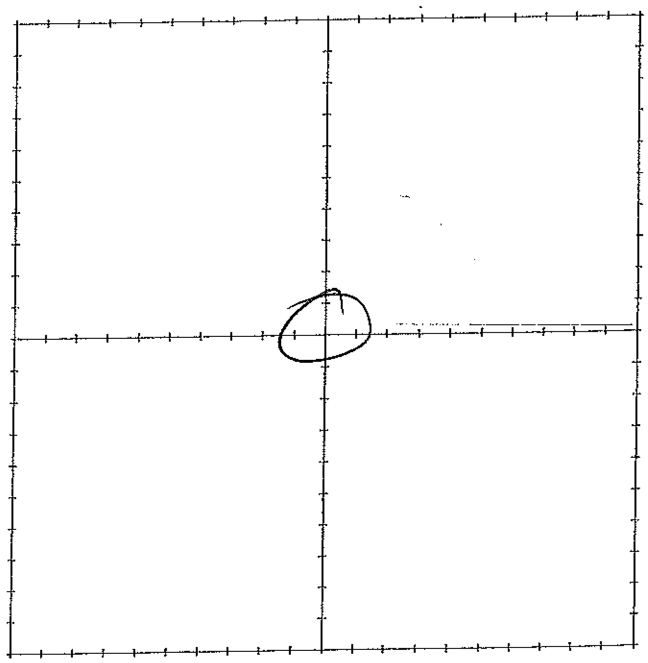
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: section 26

SAMPLE I.D.: S1011-BG5-007

SAMPLE COLLECTION DATE: 9/19/17

SAMPLE COLLECTION TIME: 1142

SAMPLE COLLECTED BY: JR

WEATHER CONDITIONS: Sunny 80 °F

FIELD USCS DESCRIPTIONS: Poorly graded sand (SP) strong brown (7.5 YR 5/8), dry, loose, fine-med, sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC

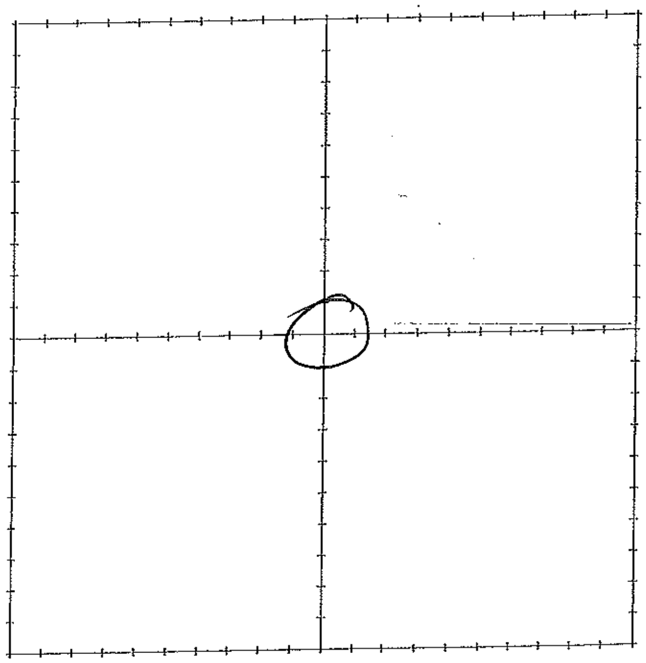
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE): 2 ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: Section 26

SAMPLE I.D.: S1011-BGS-008

SAMPLE COLLECTION DATE: 9/19/17

SAMPLE COLLECTION TIME: 1146

SAMPLE COLLECTED BY: JR

WEATHER CONDITIONS: Sunny 80 °F

FIELD USCS DESCRIPTIONS: Poorly graded Sand (SP) strong brown (7.5 YR 5/8), Loose, dry, Fine - med., sand

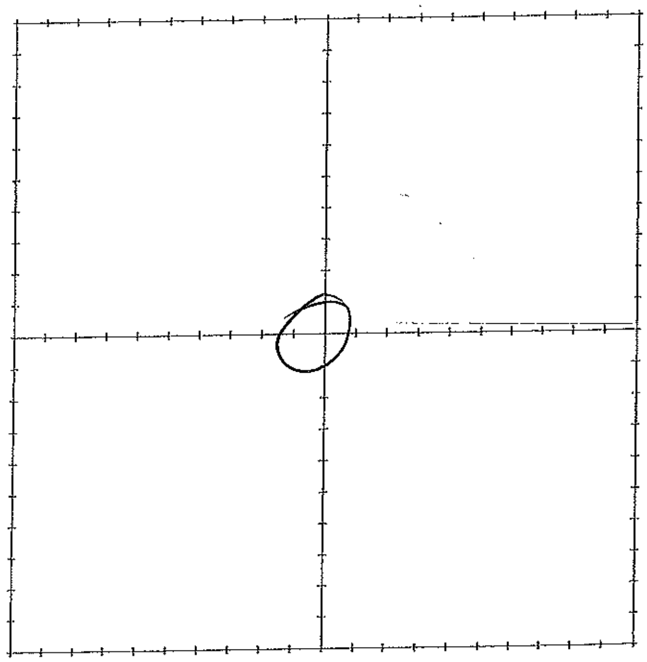
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☒ FINE ☒ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE): 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011-8G5-009

SAMPLE COLLECTION DATE 9/19/17

SAMPLE COLLECTION TIME 1150

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny, 80 °F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), strong brown (7.5 YR 5/8), loose, dry, fine-med. sand

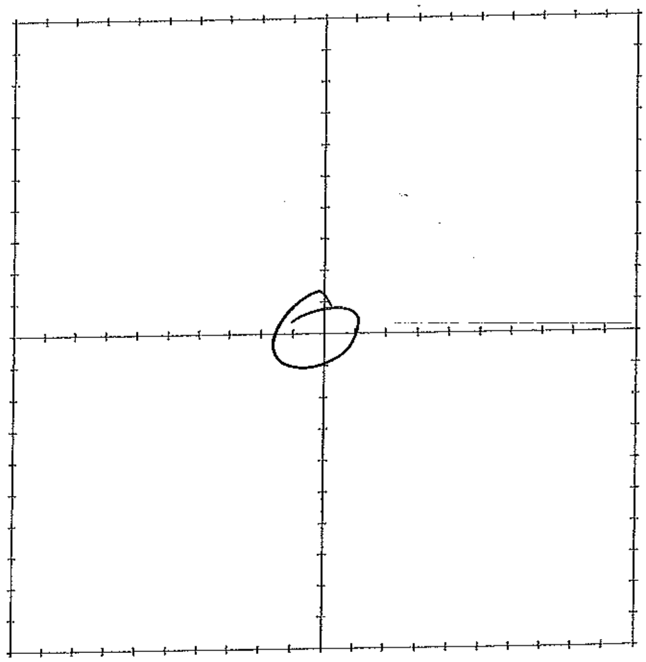
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☑ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: Section 26

SAMPLE I.D.: S1011-BGS-010

SAMPLE COLLECTION DATE: 9/19/17

SAMPLE COLLECTION TIME: 1156

SAMPLE COLLECTED BY: JR

WEATHER CONDITIONS: Sunny 80°F

FIELD USCS DESCRIPTIONS: Poorly graded sand (SP), strong brown (7.5 YR 5/8) Loose, dry, fine-med, sand

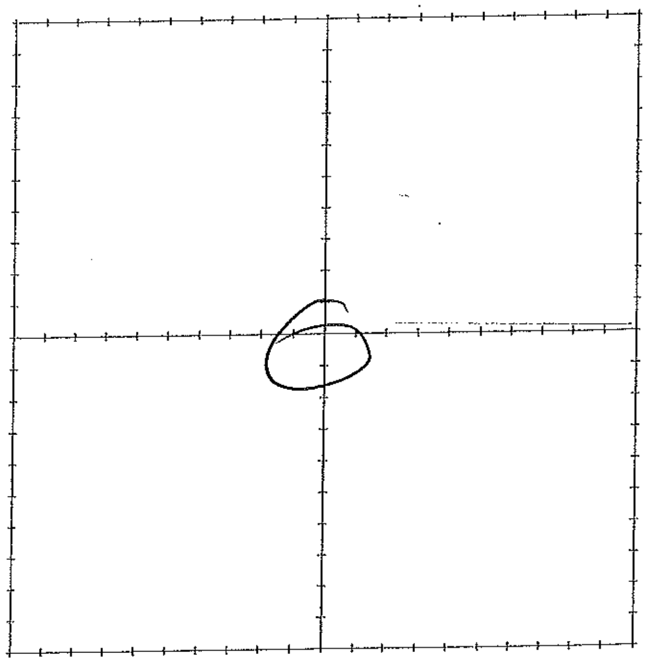
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☒ FINE ☒ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE): 2 Ziplock bags.

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011-C01+001

SAMPLE COLLECTION DATE 3/29/17

SAMPLE COLLECTION TIME 0920

SAMPLE COLLECTED BY Chee

WEATHER CONDITIONS 35°F, Sunny

FIELD USCS DESCRIPTIONS Silty Sand, moist at surface, brown/tan, minor gravels

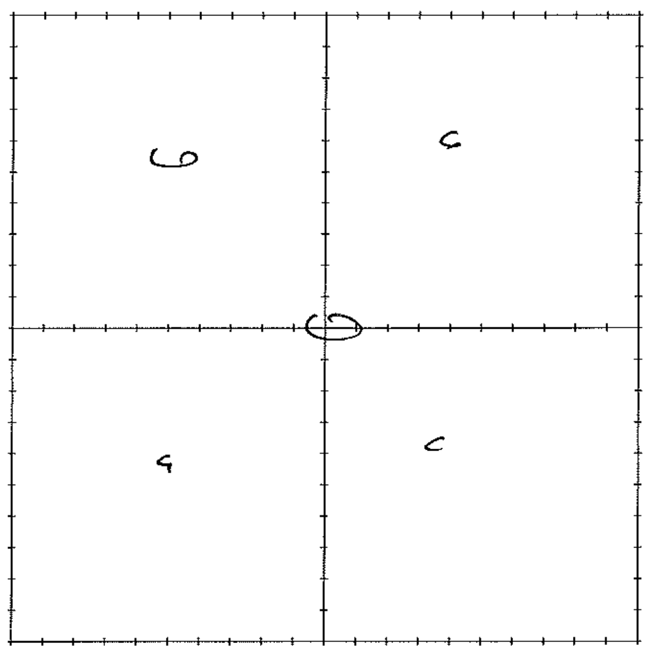
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☒ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26

SAMPLE I.D. S1011 - C02-001

SAMPLE COLLECTION DATE 3/29/17

SAMPLE COLLECTION TIME 1000

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS 35°F, sunny

FIELD USCS DESCRIPTIONS Silty sand w/25% gravels, brownish orange

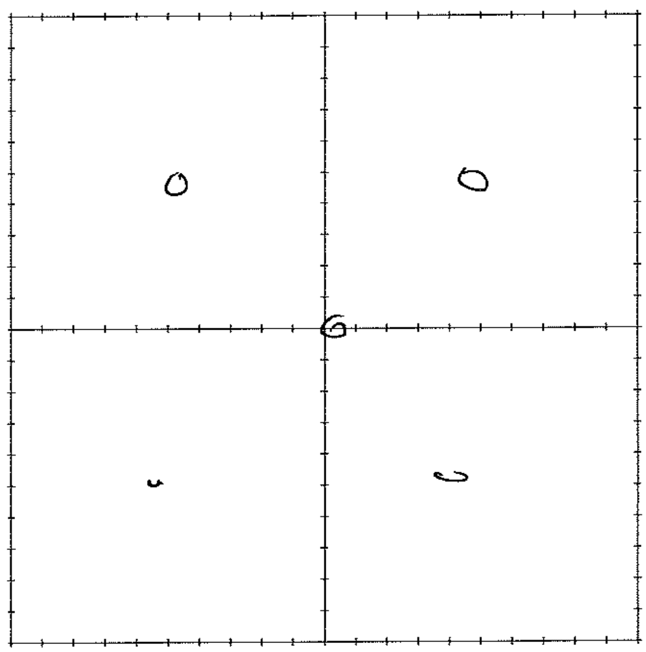
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☒ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☒ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011-C03-001

SAMPLE COLLECTION DATE 3/29/17

SAMPLE COLLECTION TIME 1030

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 35°F, Sunny

FIELD USCS DESCRIPTIONS Sandy clay w/ minor gravel, med. plast., moist

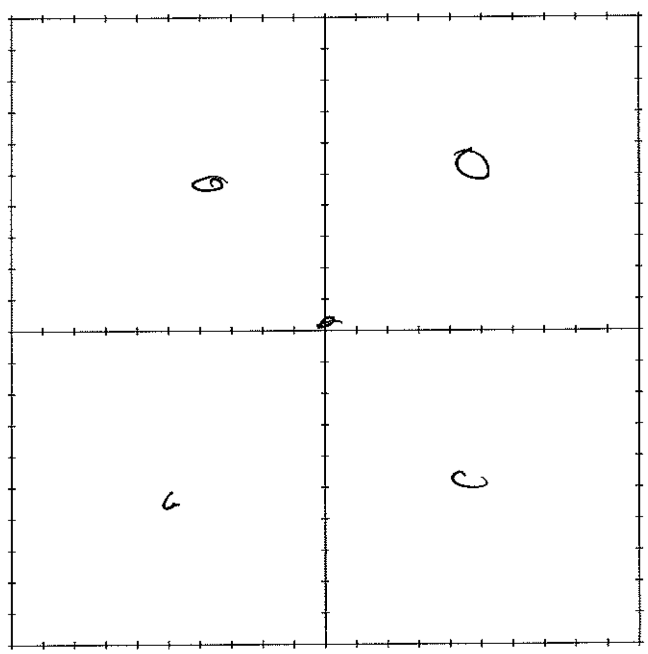
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☒ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011-C04-001

SAMPLE COLLECTION DATE 3/29/17

SAMPLE COLLECTION TIME 1055

SAMPLE COLLECTED BY L. Lee

WEATHER CONDITIONS 35°F, Sunny

FIELD USCS DESCRIPTIONS Sandy clay, w/minor gravel, med. plast., moist

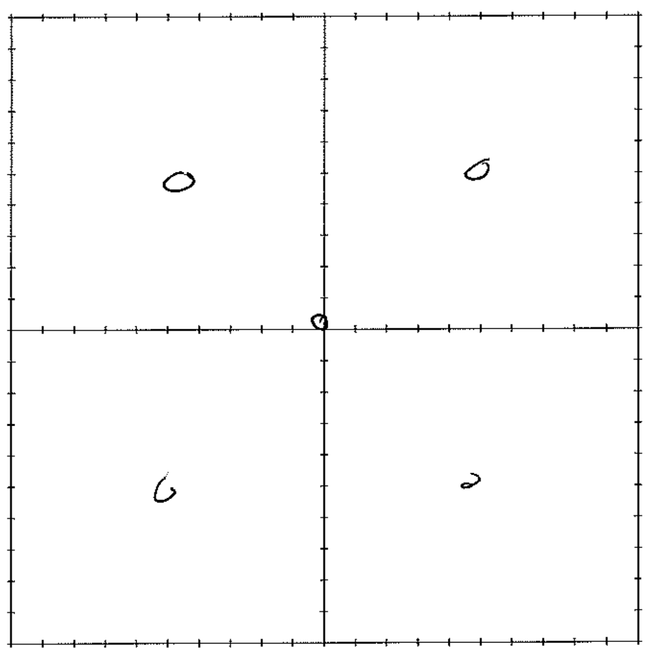
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☒ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☒ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011-C05-001

SAMPLE COLLECTION DATE 3/29/17

SAMPLE COLLECTION TIME 1118

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 35°F, Sunny

FIELD USCS DESCRIPTIONS Clayey sand, minor gravel, reddish brown, moist

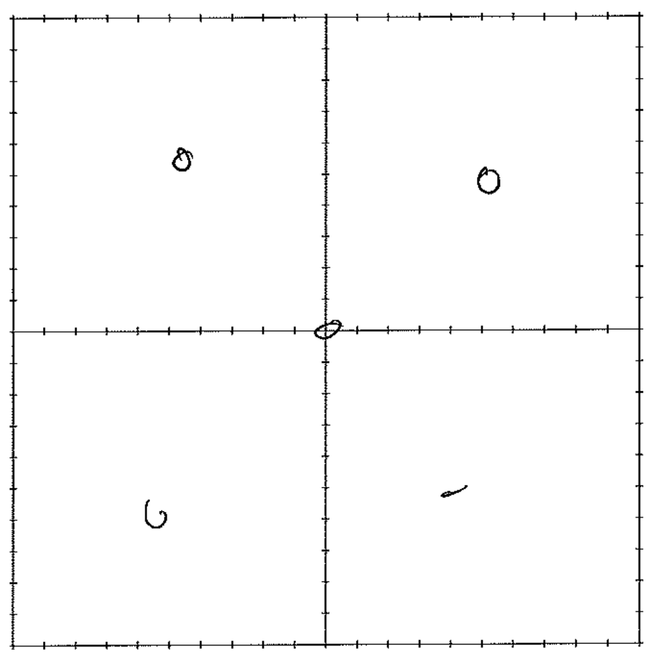
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☒ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-GC-001

SAMPLE COLLECTION DATE 12/1/16

SAMPLE COLLECTION TIME 1010

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Cloudy, 30's

FIELD USCS DESCRIPTIONS Fine red sand, trace clay

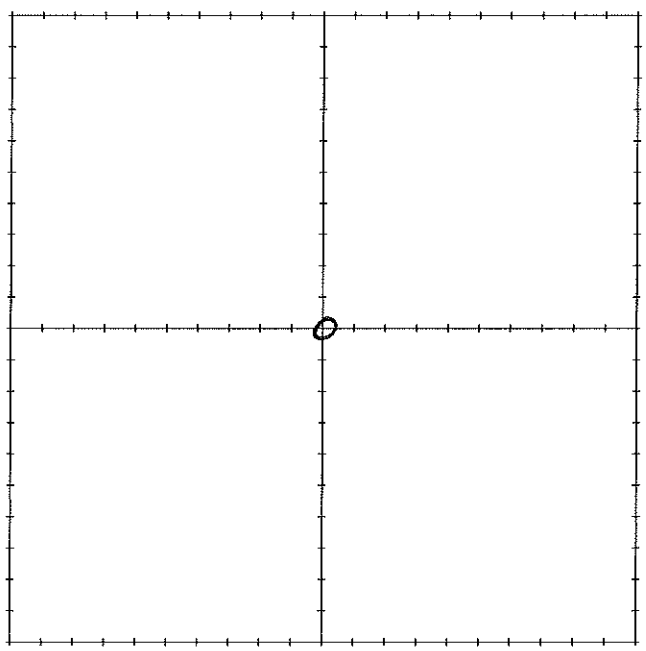
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-GX-002

SAMPLE COLLECTION DATE 12/1/16

SAMPLE COLLECTION TIME 1035

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS Cloudy, 30's

FIELD USCS DESCRIPTIONS Fine red sand

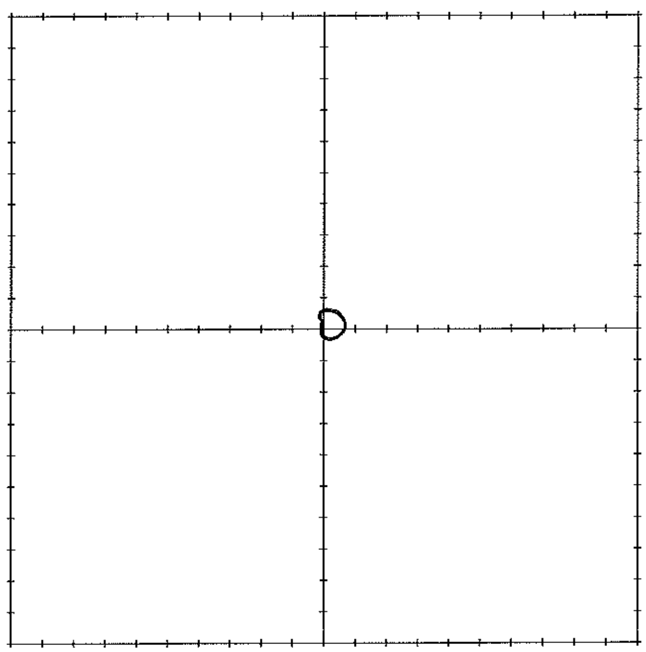
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-CX-003

SAMPLE COLLECTION DATE 12/1/16

SAMPLE COLLECTION TIME 1045

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS Cloudy, 30's

FIELD USCS DESCRIPTIONS Fine red sand, minor coarse gray sand (~10-20%)

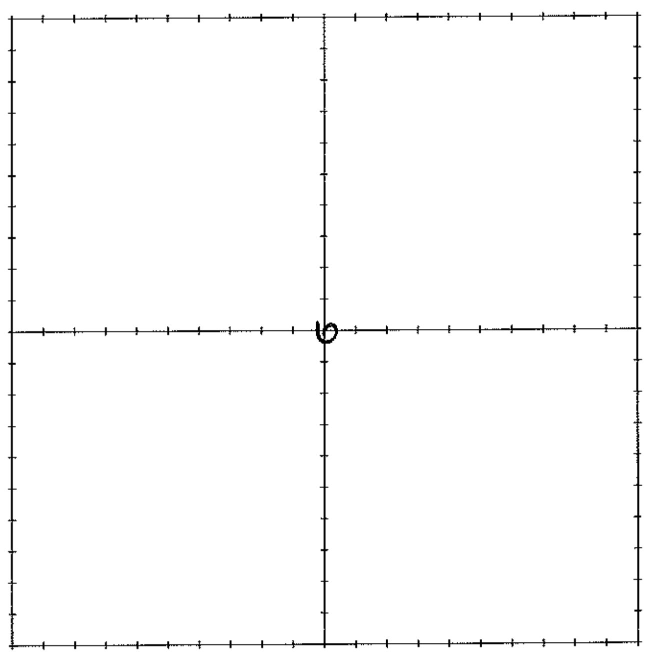
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011-CX-0044, 2044

SAMPLE COLLECTION DATE 12/1/16

SAMPLE COLLECTION TIME 1105

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Cloudy, 30's

FIELD USCS DESCRIPTIONS Brown/red fine sand, minor clay, trace coarse sand

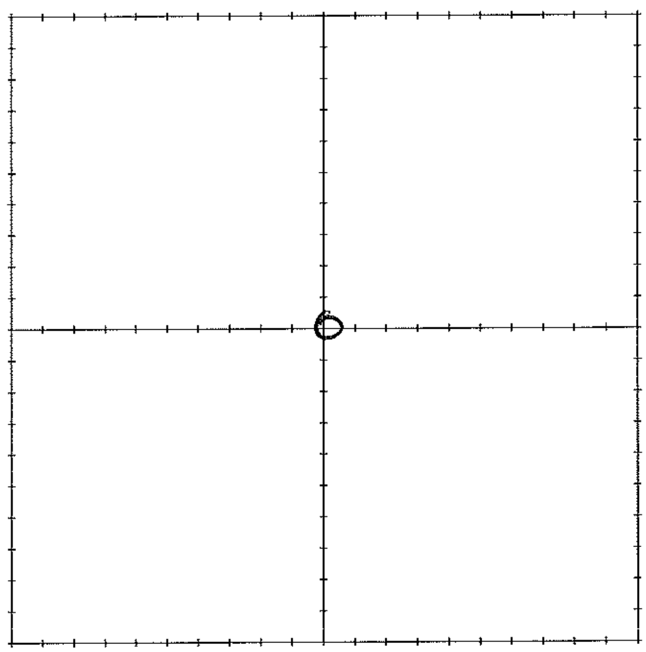
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S1011 (Section 26)

SAMPLE I.D. S1011 - CX-005

SAMPLE COLLECTION DATE 12/1/16

SAMPLE COLLECTION TIME 1135

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS Cloudy, 30's

FIELD USCS DESCRIPTIONS Fine brown/red sand, minor clay, trace coarse sand

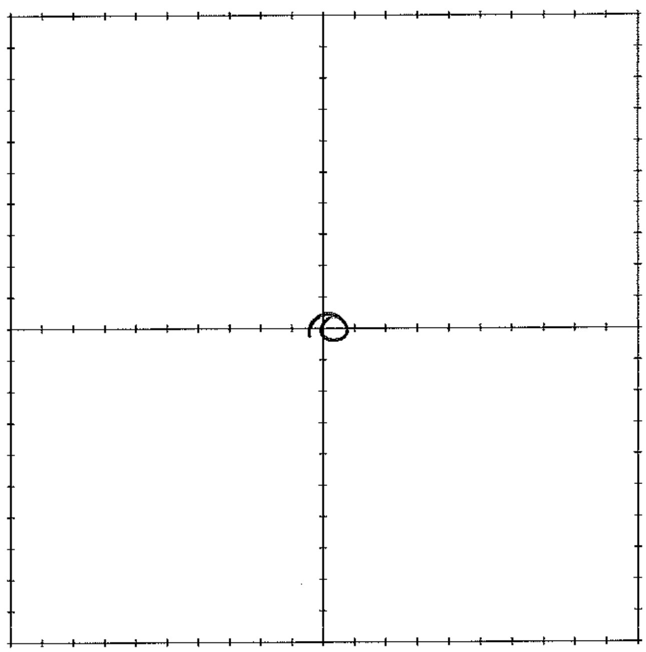
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011 - CX-006

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1124

SAMPLE COLLECTED BY MW/CC

WEATHER CONDITIONS 70's, windy

FIELD USCS DESCRIPTIONS Fine red sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals

MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011-CX-007

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1138

SAMPLE COLLECTED BY MW/LH

WEATHER CONDITIONS Fine grav sand

FIELD USCS DESCRIPTIONS 70's, windy

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

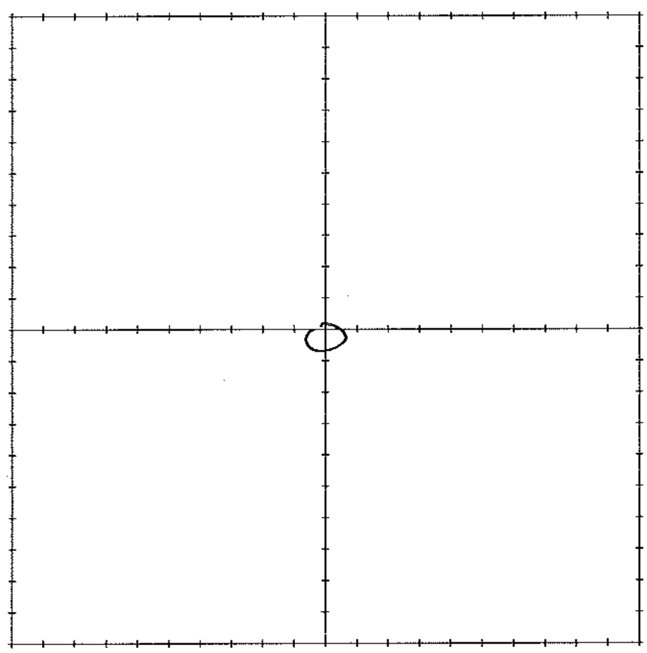
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: Section 26 (S1011)

SAMPLE I.D.: S1011-CX-008

SAMPLE COLLECTION DATE: 5/13/17

SAMPLE COLLECTION TIME: 1150

SAMPLE COLLECTED BY: MW/CL

WEATHER CONDITIONS: 70s wind

FIELD USCS DESCRIPTIONS: Fine red sand from drainage

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

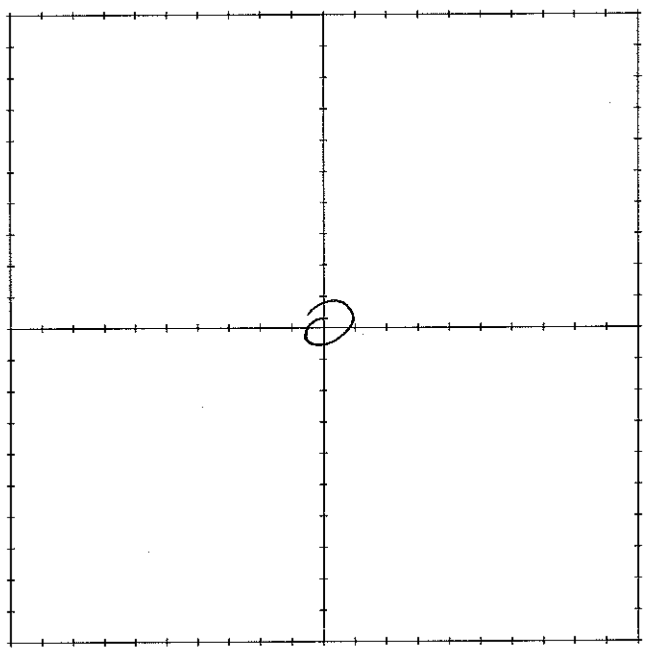
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR: —

SAMPLE CONTAINERS (NUMBER AND TYPE): 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011 - CX - 009

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1158

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 70's, windy

FIELD USCS DESCRIPTIONS Fine med sand from Drainage

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

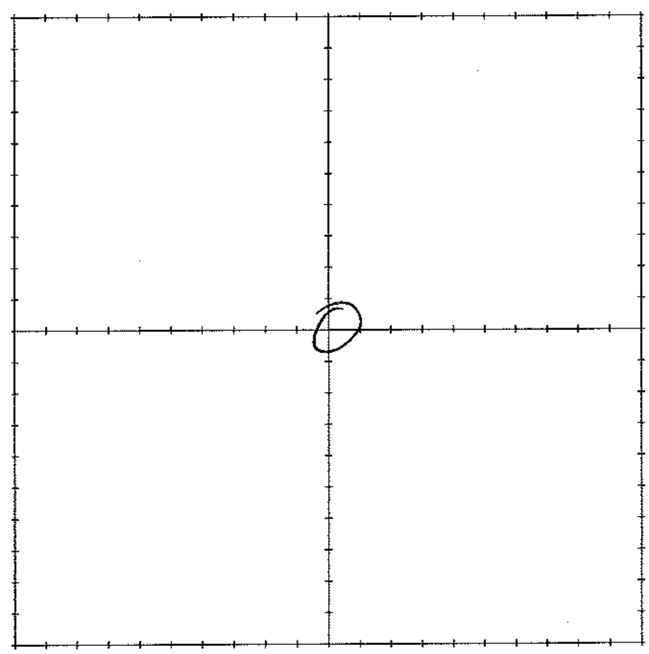
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011-CK-010

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1334

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 70's, windy

FIELD USCS DESCRIPTIONS Fine light brown sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

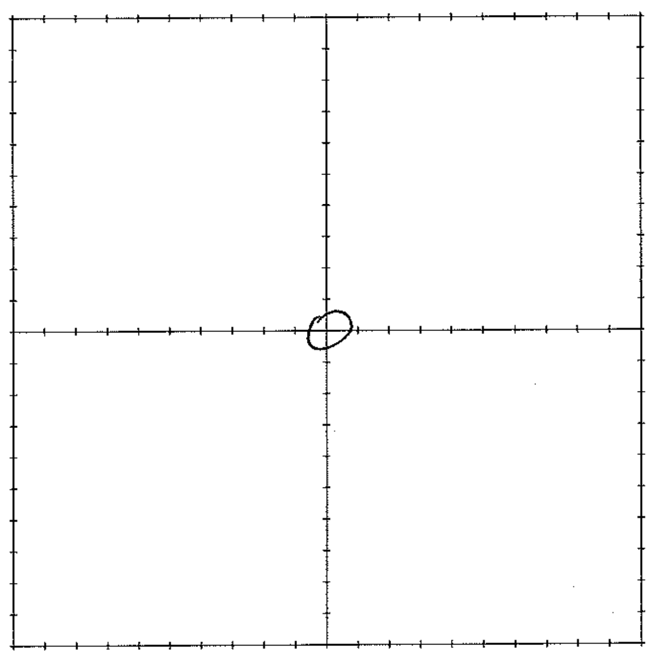
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Sector 26 (S1011)

SAMPLE I.D. S1011 - ~~CX-001~~ ~~CX-006~~ CX-011

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1020

SAMPLE COLLECTED BY MW / CL

WEATHER CONDITIONS 70's, windy

FIELD USCS DESCRIPTIONS Fine gray sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

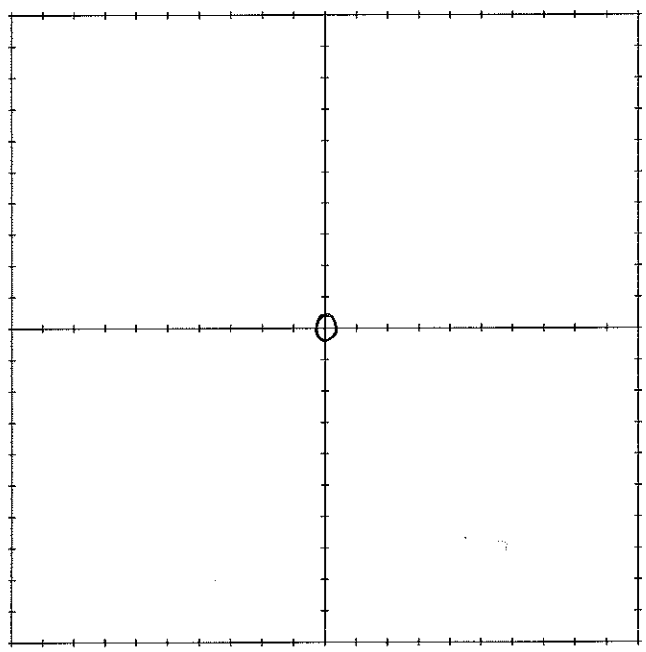
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME ~~S1011~~ Section 26 (S1011)

SAMPLE I.D. S1011 - CC - ~~002~~ ~~007~~ ~~00~~ 012

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1027

SAMPLE COLLECTED BY MW / CL

WEATHER CONDITIONS 70's, windy

FIELD USCS DESCRIPTIONS Rock flour, very fine, gray,

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

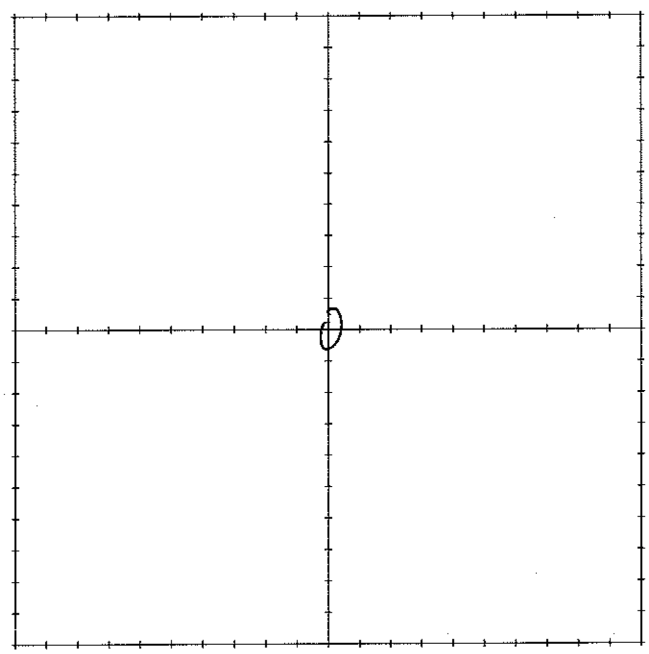
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 ~~[illegible]~~ (S1011)

SAMPLE I.D. S1011-CX-~~003~~, ~~203~~ 013, 213

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1052

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 70's, windy

FIELD USCS DESCRIPTIONS Fine tan/gray sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

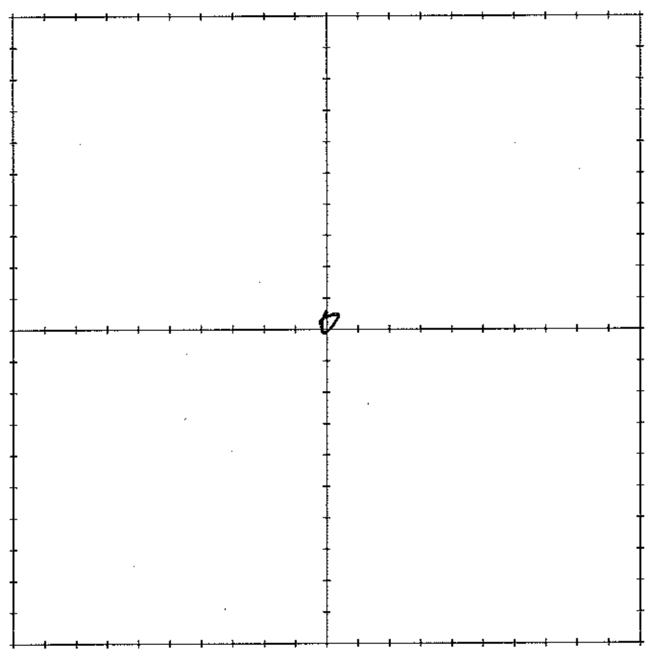
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011 - CK-~~004~~ 014 ck

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1059

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS Fine light brown sand, <10% fine gravels,

FIELD USCS DESCRIPTIONS ck 70's windy

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

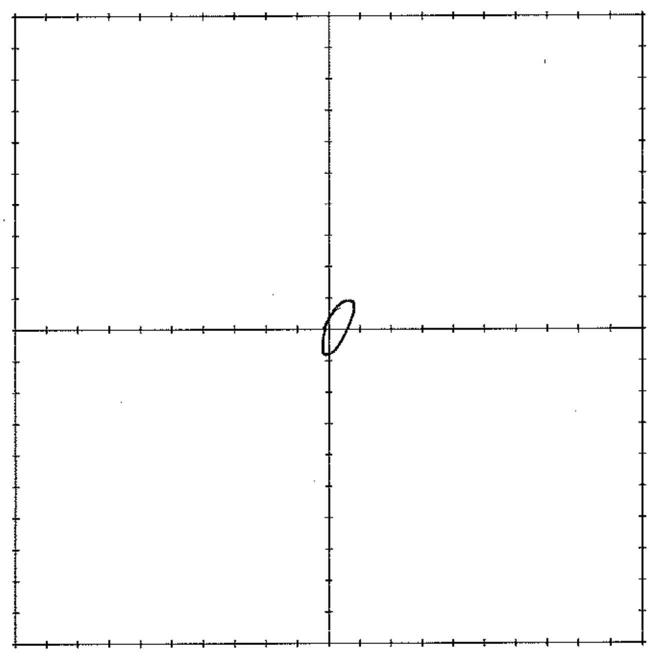
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplocs

ANALYSES: Ra-226 Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Section 26 (S1011)

SAMPLE I.D. S1011 - CX - ~~005~~ 015 MS/MSD

SAMPLE COLLECTION DATE 5/13/17

SAMPLE COLLECTION TIME 1109

SAMPLE COLLECTED BY CL / MW

WEATHER CONDITIONS 70's windy

FIELD USCS DESCRIPTIONS Fine light brown sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

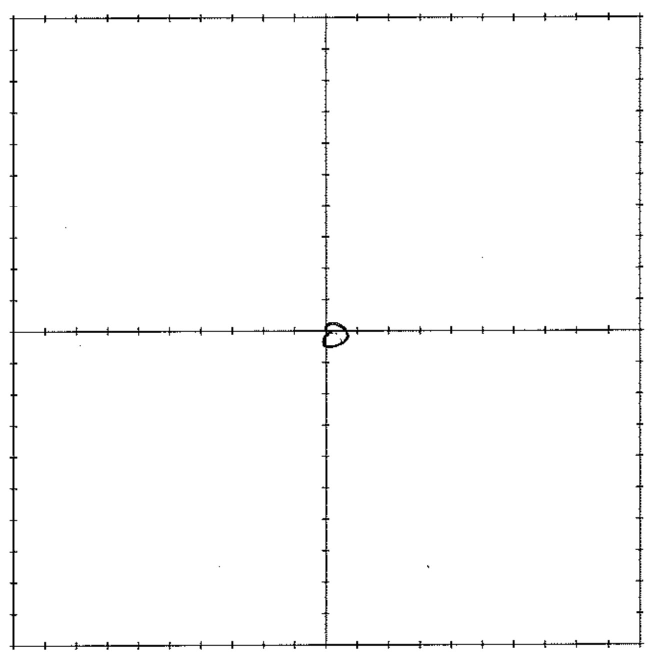
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

C.2 Drilling and Hand Auger Borehole Logs

BOREHOLE ID:	**S1011-BG1-011**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec
DRILLING METHOD:	Hand auger
DRILLING EQUIPMENT:	Hand auger
SAMPLING METHOD:	Regular hand auger, 3 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 13N	
EASTING:	784866.57	NORTHING:	3914510.88
DATE STARTED:	3/25/2017	DATE STARTED:	3/25/2017
TOTAL DEPTH (ft.):	0.9	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		SILTY SAND (SM): light brown, fine grained sand, moist.	7345	S1011-BG1-011-1	0-0.2	grab	1.62
			7963	S1011-BG1-011-2	0.5-0.7	grab	1.51
1		Terminated hand auger borehole at 0.9 ft. below ground surface. Refusal on bedrock.					
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-BG2-011**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec
DRILLING METHOD:	Hand auger
DRILLING EQUIPMENT:	Hand auger
SAMPLING METHOD:	Regular hand auger, 3 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 13N	
EASTING:	784860.27	NORTHING:	3914688.14
DATE STARTED:	3/25/2017	DATE STARTED:	3/25/2017
TOTAL DEPTH (ft.):	2	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm) (0 – 25000 – 50000 – 75000 – 100000)
0	SILTY SAND (SM): light brown, fine grained sand, moist.	10200
0.5		12551
1		12840
1.5		13268
2	Terminated hand auger borehole at 2 ft. below ground surface. Borehole was terminated as the depth reached met the approved RSE Work Plan requirement.	12669
3		
4		
5		

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-BG2-011-1	0-0.2	grab	2.03
S1011-BG2-011-3	1.5-2	grab	1.59

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S1011-BG3-011**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

Stantec

NAVAJO NATION AUM Environmental Response Trust-First Phase

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N
DRILLING METHOD:	Hand auger	EASTING: 784838.27	NORTHING: 3914513.01
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 9/19/2017	DATE STARTED: 9/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 0.25	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Michael Ward	

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED GRAVEL WITH SAND (GP): reddish brown (5YR 5/3), gravels are angular to subangular, hard, dry, loose. Very limited sampling.	6390	S1011-BG3-011-1	0-0.2	grab	1.16
		Terminated hand auger borehole at 0.25 ft. below ground surface. Refusal on sandstone.	6387				
1							
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S1011-BG4-011**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec
DRILLING METHOD:	Hand auger
DRILLING EQUIPMENT:	Hand auger
SAMPLING METHOD:	Regular hand auger, 3 inch diameter

COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N		
EASTING:	784820.16	NORTHING:	3914103.04
DATE STARTED:	9/19/2017	DATE STARTED:	9/19/2017
TOTAL DEPTH (ft.):	3	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED SAND WITH GRAVEL (SP): strong brown (7.5YR 5/6), medium grained sand, loose, dry, few gray gravels.	7788
		9706
1		10481
		10271
2		10313
		10099
3	Terminated hand auger borehole at 3.0 ft. below ground surface. Borehole was terminated as the depth reached met the approved RSE Work Plan requirement.	10616
4		
5		

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-BG4-011-1	0-0.2	grab	0.71
S1011-BG4-011-2	0.2-3	comp	0.56

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S1011-BG5-011**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N
DRILLING METHOD:	Hand auger	EASTING: 784820.87	NORTHING: 3913992.27
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 9/19/2017	DATE STARTED: 9/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 2	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Michael Ward

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–2	POORLY GRADED SAND (SP): strong brown (7.5YR 5/6), fine to medium grained sand, loose, dry. Sampled in dry incised drainage.
2	Terminated hand auger borehole at 2.0 ft. below ground surface. Refusal on hard surface.

Gamma (cpm) (scale 0, 25000, 50000, 75000, 100000)

Depth (feet)	Gamma (cpm)
0	8008
0.5	10302
1	11450
1.5	11465
2	11496

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-BG5-011-1	0-0.2	grab	0.63
S1011-BG5-011-2	0.2-2	comp	0.74

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec	NAVAJO NATION AUM Environmental Response Trust-First Phase	BOREHOLE ID:	**S1011-SCX-001**
		CLIENT:	NNAUMERT
		PROJECT:	Removal Site Evaluation
		SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N		
DRILLING METHOD:	Hand auger	EASTING:	785487.09	NORTHING:	3914060.74
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	5/12/2017	DATE STARTED:	5/12/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	1.5	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL (SP): red, fine grained sand.	18116	S1011-SCX-001-1	0-0.5	grab	1.93
		40% gravel.	40869				
1			42405	S1011-SCX-001-2	0.5-1.5	grab	2.48
		Terminated hand auger borehole at 1.5 ft. below ground surface. Refusal on hard rock.	34807				
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram

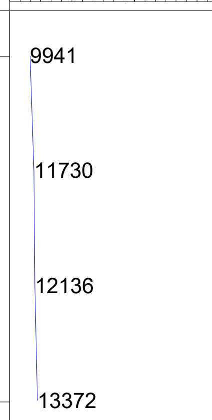
grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec	NAVAJO NATION AUM Environmental Response Trust-First Phase	BOREHOLE ID:	**S1011-SCX-002**
		CLIENT:	NNAUMERT
		PROJECT:	Removal Site Evaluation
		SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N		
DRILLING METHOD:	Hand auger	EASTING:	785452.75	NORTHING:	3914047.76
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	5/12/2017	DATE STARTED:	5/12/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	1.5	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): red, brown, fine grained sand.	9941	S1011-SCX-002-1	0-0.5	grab	0.95
			11730				
1			12136	S1011-SCX-002-2	0.5-1.5	grab	0.54
1.5		Terminated hand auger borehole at 1.5 ft. below ground surface. Refusal on hard rock.	13372				
2							
3							
4							
5							



Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-003**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec
DRILLING METHOD:	Hand auger
DRILLING EQUIPMENT:	Hand auger
SAMPLING METHOD:	Regular hand auger, 3 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 13N	
EASTING:	785501.03	NORTHING:	3913974.16
DATE STARTED:	5/12/2017	DATE STARTED:	5/12/2017
TOTAL DEPTH (ft.):	2.25	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED SAND (SP): brown, medium grained sand.	10529
0.5	less than 10% gravels.	16417
1		21117
1.5	10% to 15% gravels.	27011
2		30415
2.25	Terminated hand auger borehole at 2.25 ft. below ground surface. Refusal on hard rock.	34453

Gamma (cpm) scale: 0, 25000, 50000, 75000, 100000

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-003-1 S1011-SCX-203-1	0-0.5	grab	1.64 1.55
S1011-SCX-003-2	0.5-1.5	grab	2.23
S1011-SCX-003-3	1.5-2.25	grab	3.41

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-004**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

Stantec — NAVAJO NATION AUM Environmental Response Trust-First Phase

DRILLING CONTRACTOR:	Stantec
DRILLING METHOD:	Hand auger
DRILLING EQUIPMENT:	Hand auger
SAMPLING METHOD:	Regular hand auger, 3 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 13N	
EASTING:	785203.77	NORTHING:	3913866.67
DATE STARTED:	5/12/2017	DATE STARTED:	5/12/2017
TOTAL DEPTH (ft.):	2	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	POORLY GRADED SAND (SP): red, fine grained sand.	9633	S1011-SCX-004-1	0-0.5	grab	1.53
0.5	less than 5% gravels.	13991	S1011-SCX-004-2	0.5-1.5	grab	2.26
1		17635				
1.5	less than 10% gravels.	20059	S1011-SCX-004-3	1.5-2	grab	3.51
2	Terminated hand auger borehole at 2 ft. below ground surface. Refusal on hard surface.	29039				

Gamma scale: 0, 25000, 50000, 75000, 100000. Depth scale: 0, 1, 2, 3, 4, 5.

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-005**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec
DRILLING METHOD:	Hand auger
DRILLING EQUIPMENT:	Hand auger
SAMPLING METHOD:	Regular hand auger, 3 inch diameter

COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N		
EASTING:	785220.83	NORTHING:	3914043.33
DATE STARTED:	5/12/2017	DATE STARTED:	5/12/2017
TOTAL DEPTH (ft.):	2	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 – 25000 – 50000 – 75000 – 100000
0	POORLY GRADED SAND (SP): red, brown, fine grained sand.	14559
0.5		12706
1		13934
1.5	less than 10% gravels.	17422
2	Terminated hand auger borehole at 2 ft. below ground surface. Refusal on hard rock.	22217
3		
4		
5		

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-005-1	0-0.5	grab	1.59
S1011-SCX-005-2	0.5-1.5	grab	1.90
S1011-SCX-005-3	1.5-2	grab	3.10

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-006**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N		
DRILLING METHOD:	Hand auger	EASTING:	785219.67	NORTHING:	3914156.27
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	5/12/2017	DATE STARTED:	5/12/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	1.25	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 – 100000 – 200000 – 300000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): brown, fine grained sand.	154022				
			154588	S1011-SCX-006-1	0-0.5	grab	24.30
		with tan and gray sand.					
				S1011-SCX-006-2	0.5-1.25	grab	23.80
1			75424				
		Terminated hand auger borehole at 1.25 ft. below ground surface. Refusal on hard rock.	47582				
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec	NAVAJO NATION AUM Environmental Response Trust-First Phase	BOREHOLE ID:	**S1011-SCX-007**
		CLIENT:	NNAUMERT
		PROJECT:	Removal Site Evaluation
		SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:		NAD 1983 UTM Zone 13N	
DRILLING METHOD:	Hand auger	EASTING:	785278.25	NORTHING:	3914225.38
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	5/13/2017	DATE STARTED:	5/13/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	1.5	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL (SP): red, fine grained sand, 20% gravel, gravels are 0.25 inch to 2.0 inch diameter, subrounded.	20946	S1011-SCX-007-1	0-0.5	grab	5.34
0.5		tan, red sands, 10% gravels.	20893	S1011-SCX-007-2	0.5-1	grab	3.74
1		tan, 10% gravels, moist.	19694	S1011-SCX-007-3	1-1.5	grab	4.69
1.5		Terminated hand auger borehole at 1.5 ft. below ground surface. Refusal on hard surface.	16236				
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-008**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec
DRILLING METHOD:	Hand auger
DRILLING EQUIPMENT:	Hand auger
SAMPLING METHOD:	Regular hand auger, 3 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 13N	
EASTING:	785261.82	NORTHING:	3914202.15
DATE STARTED:	5/13/2017	DATE STARTED:	5/13/2017
TOTAL DEPTH (ft.):	1.5	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED SAND (SP): tan, red, fine grained sand.	42178
0.5		57060
1		72800
1.5	Terminated hand auger borehole at 1.5 ft. below ground surface. Refusal on rock.	103982
2		
3		
4		
5		

Gamma (cpm) scale: 0, 50000, 100000, 150000, 200000

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-008-1	0-0.5	grab	12.00
S1011-SCX-008-2	0.5-1	grab	6.61
S1011-SCX-008-3	1-1.5	grab	8.90

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-009**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785237.74	NORTHING: 3914584.48
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/9/2017	DATE STARTED: 6/9/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 7	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION
0–2		POORLY GRADED FINE SAND WITH GRAVEL (SP): red brown (5YR 5/4), 70% sand, 30% gravel, gravels are subangular to subrounded, minor roots and organic material.
2–2.5		WELL GRADED GRAVEL AND SAND (GW): light red gray (5YR 7/4), gravel are 0.25 inch to 2.0 inch, subangular to subrounded,
2.5–7		SHALE: green to grey, with thin discontinuous lamination, some mottled zones.
7		Terminated borehole at 7 ft. below ground surface in bedrock.

Gamma (cpm)

0 25000 50000 75000 100000

DEPTH (feet)	Gamma (cpm)
0	8544
1	11686
2	10692
3	15044
4	17232
5	17936
6	19196

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-009-001	0-0.5	grab	0.88
S1011-SCX-009-002	0.5-2	comp	0.92

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-010**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785312.16	NORTHING: 3914564.96
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/9/2017	DATE STARTED: 6/9/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 8.5	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION
0–3		POORLY GRADED SAND WITH GRAVEL (SP): red brown (5YR 5/4), loose, dry, alluvial.
3–5		WELL GRADED GRAVEL AND SAND (GW): white, with angular to subangular limestone gravels, coarse to fine sand.
5–8.5		SHALE: grey, with some limestone clasts.
8.5		Terminated borehole at 8.5 ft. below ground surface in bedrock.

Gamma (cpm)

0 25000 50000 75000 100000

DEPTH (feet)	Gamma (cpm)
0	13646
1	27136
2	20118
3	25594
4	32074
5	42308
6	40190
7	41294
8	32386
8.5	29706

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-010-001	0-0.5	grab	5.11
S1011-SCX-010-002	0.5-3	comp	2.36

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-011**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785079.02	NORTHING: 3914548.27
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/9/2017	DATE STARTED: 6/9/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 9	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED FINE SAND (SP): red (5YR 5/6), loose, dry, with minor organics (0-1 ft.), alluvial.	8652
1		11026
2		11312
3	WELL GRADED GRAVEL AND SAND (GW): light red (2.5YR 6/4), angular to subangular.	10428
4	SHALE: green, red, thin discontinuous laminations.	9968
5		16896
5.5	with interbedded limestone concretions.	
6		17812
7		13242
8	green and light red, thinly laminated.	12348
8.5		13386
9	Terminated borehole at 9 ft. below ground surface in bedrock.	
10		

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-011-001 S1011-SCX-011-201	0-0.5	grab	1.53 1.58
S1011-SCX-011-002	0.5-3	comp	0.78
S1011-SCX-011-003	3-4	grab	1.00

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S1011-SCX-012**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Section 26

DRILLING CONTRACTOR: Cascade Drilling
DRILLING METHOD: Rotary Sonic
DRILLING EQUIPMENT: Geoprobe 8140LC
SAMPLING METHOD: Sonic Core Barrel, 4 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 785051.55 NORTHING: 3914563.92
DATE STARTED: 6/9/2017 DATE STARTED: 6/9/2017
TOTAL DEPTH (ft.): 9 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED FINE SAND (SP): red (5YR 5/4), loose, dry.	10932
1		14594
1.5	dense to medium dense, red (5YR5/4).	
2		13230
3		11274
3.5	WELL GRADED GRAVEL WITH SAND (GW): subangular to subrounded, gravels are 0.25 inch to 3 inch diameter.	
4	WELL GRADED SAND AND GRAVEL (SW): subangular to subrounded, 0.25 inch to 1 inch diameter.	9858
5	CLAYSTONE: green, light red, interbedded marl and shale.	12308
6		13940
6.5	SANDSTONE: white, fine to medium grained.	
7		11776
8		11426
9	Terminated borehole at 9 ft. below ground surface in bedrock.	10814
10		

Gamma (cpm) scale: 0, 25000, 50000, 75000, 100000

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-012-001	0-0.5	grab	2.60
S1011-SCX-012-002	3-4	grab	1.12

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S1011-SCX-013**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Section 26

DRILLING CONTRACTOR:	Cascade Drilling
DRILLING METHOD:	Rotary Sonic
DRILLING EQUIPMENT:	Geoprobe 8140LC
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 785086.48 NORTHING: 3914565.56
DATE STARTED: 6/9/2017 DATE STARTED: 6/9/2017
TOTAL DEPTH (ft.): 5 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED FINE SAND (SP)
0.5	CLAYSTONE: green, light red, interbedded marl and shales.
4	SANDSTONE: white, fine grained.
5	Terminated borehole at 5 ft. below ground surface in competent sandstone.

Gamma (cpm), scale 0 – 25000 – 50000 – 75000 – 100000

DEPTH (feet)	Gamma (cpm)
0	8736
1	14258
2	16410
3	16580
4	18010
5	13298

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-013-001	0-0.5	grab	2.50

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-014**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling
DRILLING METHOD:	Rotary Sonic
DRILLING EQUIPMENT:	Geoprobe 8140LC
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
EASTING:	785054.8	NORTHING:	3914579.57
DATE STARTED:	6/9/2017	DATE STARTED:	6/9/2017
TOTAL DEPTH (ft.):	6.5	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED SAND WITH GRAVEL (SP): red (5YR 6/4), dry.	33406
1		10820
2		9438
3		9166
4	SANDSTONE: white, with sandy limestone.	10578
5		10380
5.5		18802
6.5	Terminated borehole at 6.5 ft. below ground surface in competent sandstone.	

Gamma (cpm) scale: 0, 25000, 50000, 75000, 100000

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-014-001	0-0.5	grab	3.21
S1011-SCX-014-002	0.5-4	comp	0.81

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust - First Phase

BOREHOLE ID:	**S1011-SCX-015**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling
DRILLING METHOD:	Rotary Sonic
DRILLING EQUIPMENT:	Geoprobe 8140LC
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
EASTING:	785273.11	NORTHING:	3914269.22
DATE STARTED:	6/10/2017	DATE STARTED:	6/10/2017
TOTAL DEPTH (ft.):	2	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm) (0 – 100000)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	POORLY GRADED GRAVEL WITH SAND AND COBBLE (GP): gray (10YR 7/2). Interval contains metal refuse from existing surface waste dump next to borehole (refer to Appendix B-1, photograph number 4).	8296	S1011-SCX-015-001 S1011-SCX-015-201	0-0.5	grab	2.27 2.05
0.5	POORLY GRADED GRAVEL WITH SAND (GP): light brown (10YR 7/4).	9484	S1011-SCX-015-002	0.5-1.5	grab	3.59
1.5	LIMESTONE: gray.	8832				
2	Terminated borehole at 2 ft. below ground surface in competent limestone.					

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-016**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
DRILLING METHOD:	Rotary Sonic	EASTING:	785251	NORTHING:	3914237.4
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED:	6/10/2017	DATE STARTED:	6/10/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.):	4	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 / 25000 / 50000 / 75000 / 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	WELL GRADED GRAVEL WITH SAND (GW): gray, 80% gravels and 20% sand, gravels are subangular limestone.	10728	S1011-SCX-016-001	0-0.5	grab	2.93
1		9288				
2		11334				
2.5			S1011-SCX-016-002	2.5-3	grab	3.85
3	LIMESTONE: light gray.	15094				
4	Terminated borehole at 4 ft. below ground surface in competent limestone.					
5						

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec

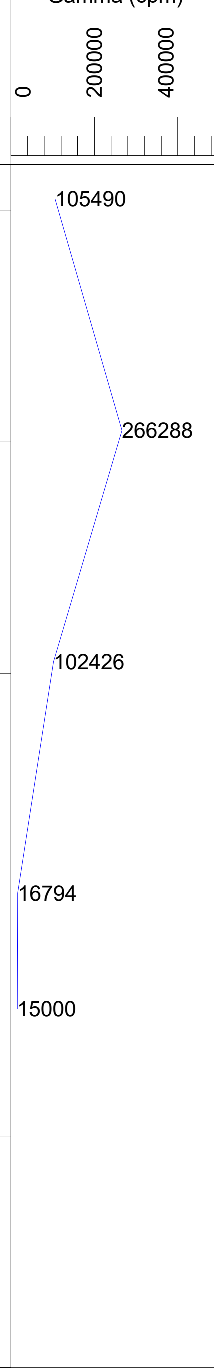
NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-017**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785591.45	NORTHING: 3914306.09
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/10/2017	DATE STARTED: 6/10/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 4	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–1	POORLY GRADED GRAVEL WITH SAND (GP): gray, gravels 80%, sand 20%, gravels are angular to subangular limestone with minor amounts of yellow Carnotite filling fractures.
1–2	LIMESTONE: gray, with minor amounts of yellow Carnotite filling fractures.
2–4	No sample recovery. Core lost from broken sample bag.
4	Terminated borehole at 4 ft. below ground surface in competent limestone.

Gamma (cpm)



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-017-001	0-0.5	grab	64.40
S1011-SCX-017-002	0.5-1	grab	66.40

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

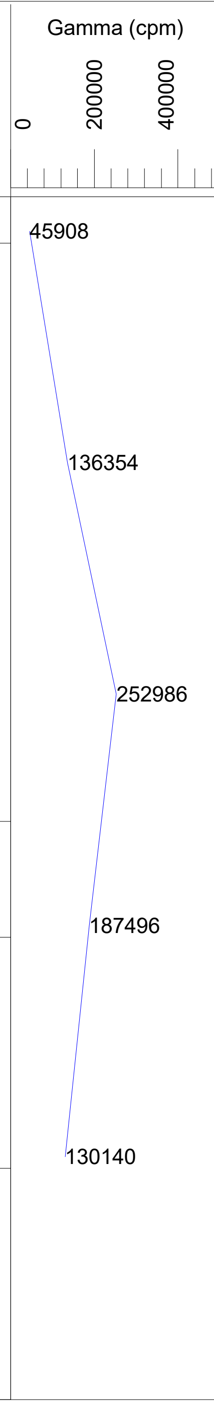
BOREHOLE ID:	**S1011-SCX-018**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling
DRILLING METHOD:	Rotary Sonic
DRILLING EQUIPMENT:	Geoprobe 8140LC
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter

COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
EASTING:	785608.82	NORTHING:	3914315.71
DATE STARTED:	6/10/2017	DATE STARTED:	6/10/2017
TOTAL DEPTH (ft.):	4	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–2.5	POORLY GRADED GRAVEL WITH SAND (GP): white and gray, gravels are angular to subangular, dry.
2.5–3	WELL GRADED GRAVELS AND SAND (GW): gray.
3–4	LIMESTONE: gray.
4	Terminated borehole at 4 ft. below ground surface in competent limestone.

Gamma (cpm)



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-018-001	0-0.5	grab	19.80
S1011-SCX-018-002	1-3.5	comp	80.20

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

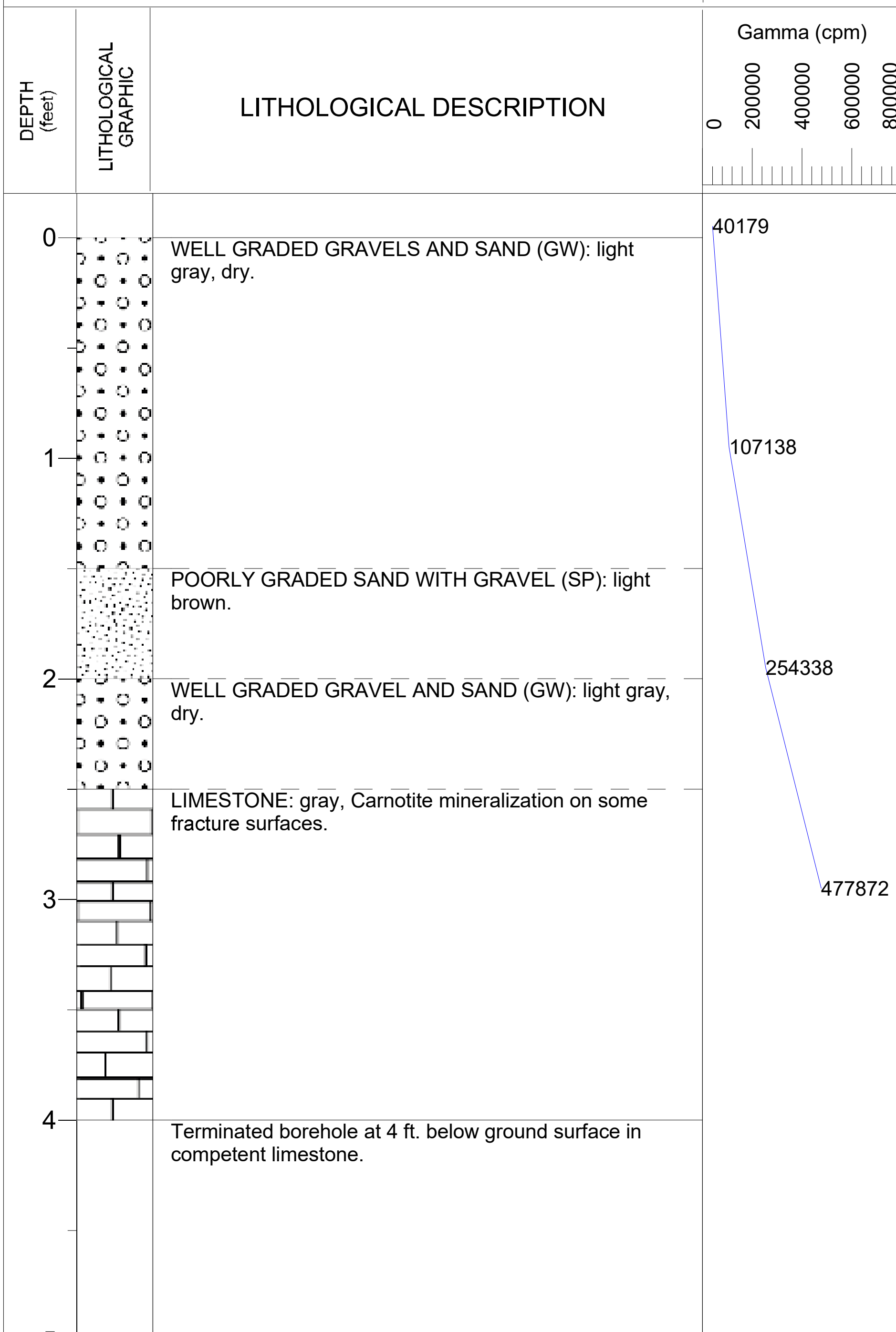
- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-019**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling
DRILLING METHOD:	Rotary Sonic
DRILLING EQUIPMENT:	Geoprobe 8140LC
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
EASTING:	785584.19	NORTHING:	3914327.37
DATE STARTED:	6/10/2017	DATE STARTED:	6/10/2017
TOTAL DEPTH (ft.):	4	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–1.5	WELL GRADED GRAVELS AND SAND (GW): light gray, dry.
1.5–2	POORLY GRADED SAND WITH GRAVEL (SP): light brown.
2–2.5	WELL GRADED GRAVEL AND SAND (GW): light gray, dry.
2.5–4	LIMESTONE: gray, Carnotite mineralization on some fracture surfaces.
4	Terminated borehole at 4 ft. below ground surface in competent limestone.



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-019-001	0-0.5	grab	13.60
S1011-SCX-019-002	0.5-2.5	comp	37.20

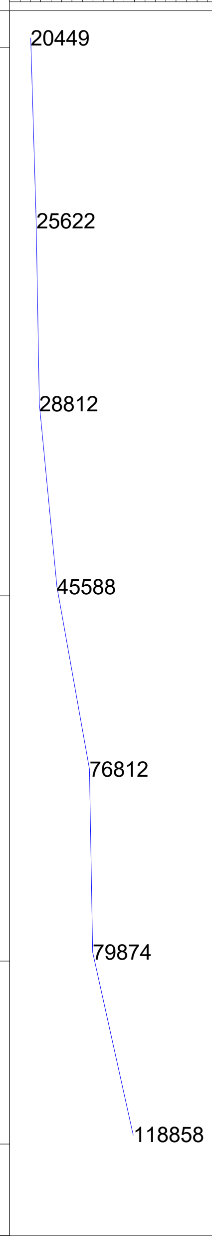
Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-020**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785611.49	NORTHING: 3914344.48
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/10/2017	DATE STARTED: 6/10/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 6	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	



DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	POORLY GRADED FINE SAND WITH GRAVEL (SP): red (5YR 5/6).	20449	S1011-SCX-020-001	0-0.5	grab	6.24
1		25622				
2		28812	S1011-SCX-020-002	0.5-4	comp	6.23
3	with lenses of medium sand grains and inorganic stiff clays.	45588				
4		76812				
5	LIMESTONE: gray	79874				
6	Terminated borehole at 6 ft. below ground surface in competent limestone.	118858				

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-021**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785627.17	NORTHING: 3914465.38
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/10/2017	DATE STARTED: 6/10/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 20	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED FINE SAND WITH GRAVEL (SP): red (5YR 5/6), gravels are angular to subangular, loose dry, sand 85%, gravel 15%, minor roots.	11964
1		14878
2		16610
3	becoming moderately dense.	16712
4		17798
5		17462
6		17212
7		16554
8		14260
9		13470
10		14074
11		16628
12	WELL GRADED SAND AND GRAVEL (SW): red, gray, dry.	25502
13		30366
14	WELL GRADED GRAVEL AND SAND (GW): red, dry.	26570
15	WELL GRADED SAND AND GRAVEL (SW): dry, loose, red, gray.	22026
16		15886
17	WELL GRADED GRAVEL AND SAND (GW): red, dry, gravels are subangular.	17180
18	SHALE: assorted color.	29628
19		37786
19.5	LIMESTONE: black, dark gray.	
20	Terminated borehole at 20 ft. below ground surface in competent limestone.	29272
21		

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-021-001	0-0.5	grab	3.02
S1011-SCX-021-005	12-13	grab	5.59
S1011-SCX-021-002 S1011-SCX-021-202	14-15	grab	3.99 4.15
S1011-SCX-021-003	17-18	grab	5.76
S1011-SCX-021-004	19-20	grab	6.75

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-022**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785626.97	NORTHING: 3914511.23
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/10/2017	DATE STARTED: 6/10/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 22	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

LITHOLOGICAL DESCRIPTION

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	WELL GRADED SAND AND GRAVEL (SW): light red, with subrounded to subangular gravels.
0.5	POORLY GRADED GRAVEL WITH SAND (GP): gray, limestone cobbles and boulders. Poor sample recovery.
5	POORLY GRADED SAND (SP): red, fine sand 100%.
5.75	grey, fine sands.
6.5	red.
6.75	grey, fine sands.
7	red, fine sand.
10	POORLY GRADED SAND WITH GRAVEL (SP): red (5YR 3/6), dry.
12	WELL GRADED GRAVEL AND SAND (GW): light red, dry.
12.5	WELL GRADED SAND AND GRAVEL (SW): red (5YR 5/6).
18	increase in cobbles, white, light brown.
20	LIMESTONE: gray, brown, limonite staining.
22	Terminated borehole at 22 ft. below ground surface in competent limestone.

Gamma (cpm)

Depth (feet)	Gamma (cpm)
0	11584
1	10014
2	10162
3	10390
4	10572
5	10538
6	10160
7	10124
8	11216
9	14474
10	16838
11	19754
12	21062
13	22684
14	21010
15	23160
16	23892
17	23822
18	26782
19	29084
20	33188

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-022-001	0-0.5	grab	3.64
S1011-SCX-022-002	5-7	comp	0.78

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-023**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785649.39	NORTHING: 3914554.88
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/10/2017	DATE STARTED: 6/10/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 17.5	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED SAND WITH GRAVEL (SP): red (5YR 5/6), loose, dry.	11194
1		12954
2		13554
3		13538
4		13460
5		12650
6		11678
7		12514
8		13054
9		13532
10		13714
11		14780
12		14028
13		13874
14	WELL GRADED GRAVEL AND SAND (GW): gravels are 0.25 inch to 4 inch in diameter, angular to subangular, gravels are composed of limestone.	18286
15	SHALE: assorted color, thin discontinuous lamination, green, pink.	26014
16		
17		
18	Terminated borehole at 17.5 ft. below ground surface in bedrock.	
19		
20		

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-023-001	0-0.5	grab	1.44
S1011-SCX-023-002	0.5-5	comp	0.84
S1011-SCX-023-003	13.5-14.5	grab	1.22

Notes: cpm = counts per minute
pCi/g = picocuries per gram

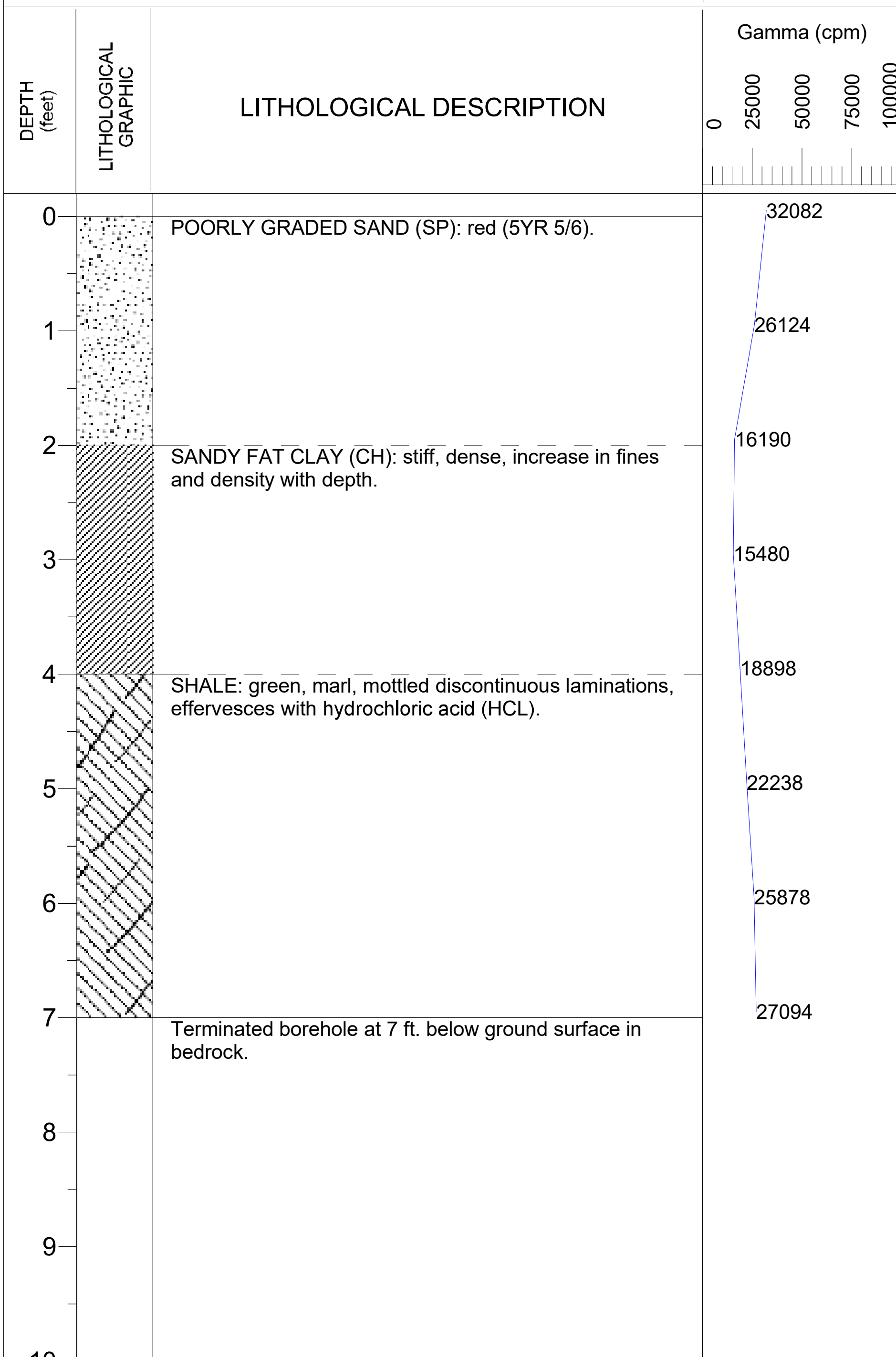
grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-024**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling
DRILLING METHOD:	Rotary Sonic
DRILLING EQUIPMENT:	Geoprobe 8140LC
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter

COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
EASTING:	785657.63	NORTHING:	3914569.55
DATE STARTED:	6/11/2017	DATE STARTED:	6/11/2017
TOTAL DEPTH (ft.):	7	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Tom Osborn		



Depth (feet)	LITHOLOGICAL DESCRIPTION
0–2	POORLY GRADED SAND (SP): red (5YR 5/6).
2–4	SANDY FAT CLAY (CH): stiff, dense, increase in fines and density with depth.
4–7	SHALE: green, marl, mottled discontinuous laminations, effervesces with hydrochloric acid (HCL).
7	Terminated borehole at 7 ft. below ground surface in bedrock.

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-024-001 S1011-SCX-024-201	0-0.5	grab	9.00 6.67
S1011-SCX-024-002	3-4	grab	10.20

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: S1011-SCX-025

CLIENT: NNAUMERT

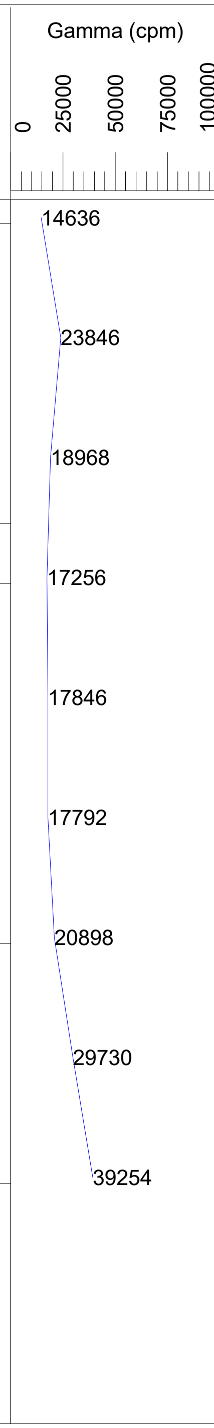
PROJECT: Removal Site Evaluation

SITE LOCATION: Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785580.09	NORTHING: 3914579.83
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/11/2017	DATE STARTED: 6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 8	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–2.5	POORLY GRADED SAND WITH GRAVEL (SP): red (5YR 5/6).
2.5–3	SILT WITH FINE SAND (ML): green, gray (10Y 7/1), with red (5YR 5/6).
3–6	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM): gravels are subangular dark gray limestone.
6–8	SHALE: green, marl with discontinuous laminations.
8	Terminated borehole at 8 ft. below ground surface in bedrock.

Gamma (cpm)



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-025-001	0-0.5	grab	6.08
S1011-SCX-025-002	0.5-3	comp	3.32

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-026**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785534.46	NORTHING: 3914533.87
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/11/2017	DATE STARTED: 6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 9	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–6	POORLY GRADED SAND (SP): red (5YR 5/6), dry, loose, trace gravel.
6–9	LIMESTONE: gray, planar bedding.
9	Terminated borehole at 9 ft. below ground surface in bedrock.

Gamma (cpm) (scale 0, 25000, 50000, 75000, 100000)

DEPTH (feet)	Gamma (cpm)
0	11826
1	16592
2	18044
3	16534
4	16388
5	15326
6	15000
7	12426
8	12886
8.5	13314

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-026-001	0-0.5	grab	1.26
S1011-SCX-026-002	0.5-5	comp	1.48
S1011-SCX-026-003	5-6	grab	1.12

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-027**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
DRILLING METHOD:	Rotary Sonic	EASTING:	785581.12	NORTHING:	3914553.94
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED:	6/11/2017	DATE STARTED:	6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.):	9	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED SAND (SP): red, loose, with trace gravels.	14552
1		13266
2	SILTY SAND (SM): red, brown, dense, trace gravels.	13404
3		10856
4		9462
5	WELL GRADED GRAVEL WITH SAND (GW): red, gray, subangular to subrounded.	8428
6		8884
7	SILTY SAND (SM): brown, red, dense to very dense sands, trace gravels.	9148
8	LIMESTONE: gray.	8580
9	Terminated borehole at 9 ft. below ground surface in bedrock.	8958
10		

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-027-001	0-0.5	grab	1.74
S1011-SCX-027-002	0.5-3	comp	1.15
S1011-SCX-027-003	6-8.5	comp	1.20

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

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NAVAJO NATION
AUM Environmental Response Trust–First Phase

BOREHOLE ID:	**S1011-SCX-028**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785561.15	NORTHING: 3914509.67
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/11/2017	DATE STARTED: 6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 19	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED SAND (SP): with trace gravels, angular, gravels are limestone.
2.5	increase in angular gravels.
6.5	LIMESTONE: cobble or small boulder.
7.25	POORLY GRADED SAND (SP): with trace gravels, angular, gravels are limestone.
8.25	LIMESTONE: grey, cobble or small boulder.
8.5	POORLY GRADED SAND (SP): red (5yr 5/6), dry, loose, with trace gravels, angular, gravels are limestone.
14	SHALE: green and pink, mottled, marl with discontinuous laminations.
18	SANDSTONE: fine grained, calcium carbonate cement.
19	Terminated borehole at 19 ft. below ground surface in bedrock.

Gamma (cpm)

DEPTH (feet)	Gamma (cpm)
0	13424
1	47276
2	208490
3	352526
4	103780
5	85838
6	123720
7	174166
8	223904
9	72022
10	34166
11	27028
12	24992
13	24632
14	21364
15	17048
16	16304
17	17316
18	24485
18.5	39182

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-028-001	0-0.5	grab	1.91
S1011-SCX-028-002 S1011-SCX-028-202	0.5-5	comp	47.10 45.80
S1011-SCX-028-003	5-8	comp	10.60
S1011-SCX-028-004	8-10	comp	13.80
S1011-SCX-028-005	10-12	comp	0.63
S1011-SCX-028-006	12-14	comp	1.36

Notes: cpm = counts per minute
pCi/g = picocuries per gram

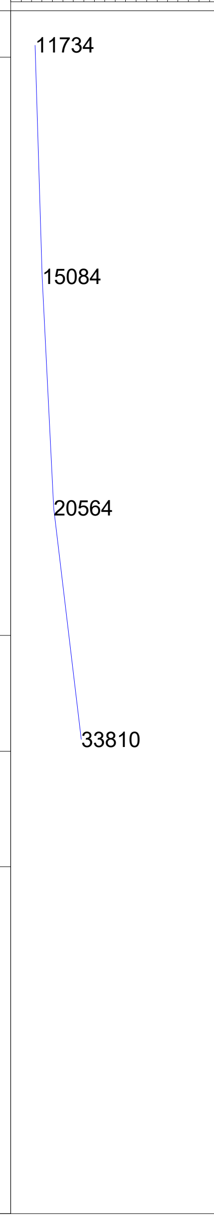
grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-029**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785628.21	NORTHING: 3914490.56
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/11/2017	DATE STARTED: 6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 3.5	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED SAND WITH GRAVEL (SP): red (5YR 5/6), sand 75%, gravel 25%, angular, gravels are limestone.	11734
1		15084
2		20564
2.5	POORLY GRADED GRAVEL WITH SAND (GP): light red, dense, gravel 60%, sand 40%.	
3	LIMESTONE: gray.	33810
3.5	Terminated borehole at 3.5 ft. below ground surface in bedrock.	



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-029-001	0-0.5	grab	1.73
S1011-SCX-029-002	0.5-3	comp	2.87

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

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BOREHOLE ID:	**S1011-SCX-030**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
DRILLING METHOD:	Rotary Sonic	EASTING:	785580.14	NORTHING:	3914467.81
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED:	6/11/2017	DATE STARTED:	6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.):	14	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm) (0, 25000, 50000, 75000, 100000)
0	POORLY GRADED SAND (SP): red (5YR 5/6), trace gravel, rounded, gravel are 0.25 inch diameter.	10412
1		11078
2		10834
3		11048
4		11634
5		12246
6	with few subrounded limestone gravel, 0.5 inch to 2.0 inch diameter.	13378
7		14020
8		14542
9		16164
10	MUDSTONE: green, light red, assorted colors, with discontinuous laminations.	14666
11		14218
12		16740
13		17184
		18014
14	Terminated borehole at 14 ft. below ground surface in bedrock.	
15		

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-030-001	0-0.5	grab	1.16
S1011-SCX-030-002	0.5-5	comp	0.79

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

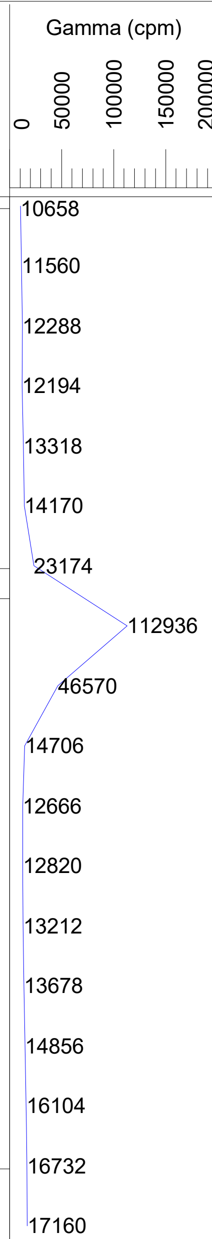
BOREHOLE ID:	**S1011-SCX-031**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling
DRILLING METHOD:	Rotary Sonic
DRILLING EQUIPMENT:	Geoprobe 8140LC
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
EASTING:	785554.61	NORTHING:	3914489.46
DATE STARTED:	6/11/2017	DATE STARTED:	6/11/2017
TOTAL DEPTH (ft.):	19	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Tom Osborn		

LITHOLOGICAL DESCRIPTION

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–6	POORLY GRADED SAND (SP): red (5YR 5/6), trace gravel, gravels are rounded to subrounded.
6–6.5	Refuse including cans, paper, bottle caps.
6.5–16	POORLY GRADED SAND (SP): red (5YR 5/6), dry, loose, trace gravel.
16–18	POORLY GRADED GRAVEL WITH SAND (GP): subrounded, gravel are limestone.
18–19	LIMESTONE: with sand, grey.
19	Terminated borehole at 19 ft. below ground surface in bedrock.



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-031-001	0-0.5	grab	0.98
S1011-SCX-031-002	0.5-5	comp	0.92
S1011-SCX-031-003	5-7	comp	0.69
S1011-SCX-031-004	7-10	comp	0.67
S1011-SCX-031-005 S1011-SCX-031-205	10-12	comp	0.57 0.61

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-032**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785532.4	NORTHING: 3914481.94
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/11/2017	DATE STARTED: 6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 12	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–1	POORLY GRADED SAND (SP): red (5YR 5/6), dry, loose, trace gravel.
1–2	WELL GRADED SAND WITH GRAVEL (SW): red (5YR 5/6), dry, loose, sand is fine to medium grained, gravels are rounded.
2–9	POORLY GRADED SAND WITH GRAVEL (SP): red (5YR 5/6), gravels are rounded to subrounded.
9–12	MUDSTONE: green, pink, with interfingering sandstone.
12	Terminated borehole at 12 ft. below ground surface in bedrock.

Gamma (cpm), scale 0, 25000, 50000, 75000, 100000

DEPTH (feet)	Gamma (cpm)
0	10570
1	14382
2	16332
3	14894
4	13608
5	13554
6	14296
7	14250
8	14892
9	17310
10	21916
11	23336

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-032-001	0-0.5	grab	1.44
S1011-SCX-032-002	0.5-5	comp	0.81
S1011-SCX-032-003	5-9	comp	1.01

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S1011-SCX-033**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Section 26

DRILLING CONTRACTOR: Cascade Drilling
DRILLING METHOD: Rotary Sonic
DRILLING EQUIPMENT: Geoprobe 8140LC
SAMPLING METHOD: Sonic Core Barrel, 4 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 785618.17 NORTHING: 3914451.68
DATE STARTED: 6/11/2017 DATE STARTED: 6/11/2017
TOTAL DEPTH (ft.): 11 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0–5	POORLY GRADED SAND (SP): red (5YR 5/6), dry, loose, with a few gravel.
5–5.5	LIMESTONE: cobble or small boulder.
5.5–7	WELL GRADED SAND WITH GRAVEL (SP): fine sand, angular gravel 0.25 inch to 0.5 inch.
7–9	becoming dense, fines increase with depth, minor coarse sands and trace gravel.
9–11	LIMESTONE: with wavy laminations, red mineralization.
11	Terminated borehole at 11 ft. below ground surface in bedrock.

Gamma (cpm) — scale 0, 25000, 50000, 75000, 100000

Depth (ft)	Gamma (cpm)
0	12994
1	18482
2	18922
3	18392
4	20686
5	23166
6	24122
7	22206
8	22044
9	23926
10	31118

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-033-001 S1011-SCX-033-201	0-0.5	grab	1.75 1.54
S1011-SCX-033-002	0.5-5	comp	1.59
S1011-SCX-033-003	5-9	comp	3.31

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

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BOREHOLE ID:	**S1011-SCX-034**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
DRILLING METHOD:	Rotary Sonic	EASTING:	785596.46	NORTHING:	3914489.25
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED:	6/11/2017	DATE STARTED:	6/11/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.):	15	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Tom Osborn		

LITHOLOGICAL DESCRIPTION

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED SAND WITH GRAVEL (SP): thin shale gravel, cuttings less than 0.5 inches, 90% sand, 10% gravel. Minor organics including roots and grass.
2	POORLY GRADED SAND (SP): red (5YR 5/6),100% sand.
8	fine gray sand.
8.3	red (5YR 5/6),100% sand.
9	POORLY GRADED SAND WITH GRAVEL (SP): light brown (10R 6/3), gravels are rounded.
10	CLAYEY SAND (SC): with some silt and gravel, dense, weathered bedrock gravels.
12	CLAYSTONE: green, marl, weathered.
13.25	MUDSTONE: green, with minor sandstone.
15	Terminated borehole at 15 ft. below ground surface in bedrock.

Gamma (cpm)

Scale: 0, 25000, 50000, 75000, 100000

DEPTH (feet)	Gamma (cpm)
0	10216
1	12334
2	10874
3	10392
4	10602
5	11044
6	11470
7	11290
8	12642
9	13500
10	13430
11	14888
13	18172
14	19656
14.5	21210

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-034-001	0-0.5	grab	1.26
S1011-SCX-034-002	0.5-5	comp	0.66
S1011-SCX-034-003	5-10	comp	0.65

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-035**		
CLIENT:	NNAUMERT		
PROJECT:	Removal Site Evaluation		
SITE LOCATION:	Section 26		

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
DRILLING METHOD:	Rotary Sonic	EASTING:	785584.73	NORTHING:	3914514.82
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED:	6/12/2017	DATE STARTED:	6/12/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.):	20	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Tom Osborn		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	SILTY SAND (SM): with roots.	11674
1	with calcium carbonate in thin discontinuous lenses.	14782
2	increase in density.	16220
3	POORLY GRADED SAND (SP): red (5YR 5/6), dry, loose, trace subrounded gravel.	16496
4		14548
5		13084
6		13386
7		13298
8		13728
9		13652
10	POORLY GRADED SAND WITH GRAVEL (SP): red (5YR 5/6).	14074
11		13990
12		15622
13		15690
14		15844
15		17532
16		18100
17	LIMESTONE: gray and tan, sandy limestone.	17820
18		17452
19		29954
20	Terminated borehole at 20 ft. below ground surface in bedrock.	31690
21		

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-035-001	0-0.5	grab	1.51
S1011-SCX-035-002	0.5-5	comp	0.94
S1011-SCX-035-003	5-8	comp	1.33

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

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BOREHOLE ID:	**S1011-SCX-036**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785631.74	NORTHING: 3914563.54
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/12/2017	DATE STARTED: 6/12/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 7.5	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm) (scale 0, 25000, 50000, 75000, 100000)
0	POORLY GRADED SAND (SP): red (5YR 5/6), sands are fine.	13564
1	dense, with few angular gravel, dry.	15048
2		14742
3	SILTY SAND (SM): with few angular gravel.	12738
4	MUDSTONE: marl, green, purple, light pink, with calcium carbonate.	11068
5		13984
6		21554
7		25802
7.5	Terminated borehole at 7.5 ft. below ground surface in bedrock.	22384
8		
9		
10		

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-036-001 S1011-SCX-036-201	0-0.5	grab	3.79 3.74
S1011-SCX-036-002	0.5-3	comp	2.11

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

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BOREHOLE ID:	**S1011-SCX-037**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785568.09	NORTHING: 3914568.95
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/12/2017	DATE STARTED: 6/12/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 5	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Tom Osborn

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED SAND WITH GRAVEL (SP): red (5YR 5/6), dry, subangular, gravel are 0.5 inch diameter.	14226
1		18620
2		13508
3	MUDSTONE: green, pink, mottled, calcium carbonate.	13690
4		12558
5	Terminated borehole at 5 ft. below ground surface in bedrock.	13066

Gamma (cpm) scale: 0, 25000, 50000, 75000, 100000

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-037-001	0-0.5	grab	7.80
S1011-SCX-037-002	0.5-3	comp	1.28

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

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AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S1011-SCX-038**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Cascade Drilling	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Rotary Sonic	EASTING: 785559.08	NORTHING: 3914524.77
DRILLING EQUIPMENT:	Geoprobe 8140LC	DATE STARTED: 6/12/2017	DATE STARTED: 6/12/2017
SAMPLING METHOD:	Sonic Core Barrel, 4 inch diameter	TOTAL DEPTH (ft.): 19.5	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Tom Osborn	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED SAND (SP): red (5YR 5/6), loose, minor roots and grass.
2	POORLY GRADED SAND WITH GRAVEL (SP): brown, red (7.5YR 4/4), dense, dry.
3	POORLY GRADED SAND (SP): red (5YR 5/6), loose, fine sand.
8	trace gravel, subangular, dry, limestone gravel.
16	LIMESTONE: gray, sandy.
19.5	Terminated borehole at 19.5 ft. below ground surface in bedrock.

Gamma (cpm) (scale 0, 25000, 50000, 75000, 100000)

Depth (ft)	Gamma (cpm)
0	24372
1	17094
2	12736
3	16092
4	13244
5	11722
6	12444
7	13204
8	14028
9	14446
10	15148
11	14630
12	15030
13	15232
14	14684
15	13868
16	13826
17	14336
18	13668
19	12206
19.5	14560

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-038-001	0-0.5	grab	8.20
S1011-SCX-038-002	0.5-3	comp	0.73
S1011-SCX-038-003	3-10	comp	0.68

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

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BOREHOLE ID: **S1011-SCX-039**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Section 26

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 13N
EASTING: 785065.71 NORTHING: 3914559.84
DATE STARTED: 9/19/2017 DATE STARTED: 9/19/2017
TOTAL DEPTH (ft.): 0.2 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Michael Ward

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 50000 100000 150000 200000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL (SP): reddish gray (10YR 6/1), loose, dry, angular gravels, small to large.	25341 72575	S1011-SCX-039-1	0-0.2	grab	6.90
		Terminated hand auger borehole at 0.2 ft. below ground surface. Refusal on rock.					
1							
2							
3							
4							
5							

SUBSURFACE SAMPLE INFORMATION

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

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BOREHOLE ID:	**S1011-SCX-040**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:		NAD 1983 UTM Zone 13N	
DRILLING METHOD:	Hand auger	EASTING:	785071.9	NORTHING:	3914571.15
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	9/19/2017	DATE STARTED:	9/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.2	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0–0.2		POORLY GRADED SAND WITH GRAVEL (SP): yellowish red (5YR 5/6), loose, dry, fine to medium grained sand.	16404 24374	S1011-SCX-040-1	0-0.2	grab	2.91
		Terminated hand auger borehole at 0.2 ft. below ground surface. Refusal on rock.					

Depth scale: 0, 1, 2, 3, 4, 5

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

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BOREHOLE ID:	**S1011-SCX-041**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N
DRILLING METHOD:	Hand auger	EASTING: 785167.65	NORTHING: 3914012.35
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 9/19/2017	DATE STARTED: 9/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 2.5	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Michael Ward

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED SAND WITH GRAVEL (SP): strong brown (7.5YR 5/8), fine to medium grained sand, loose, dry.	8725
0.5		11463
1		14067
1.5		14704
2		16358
2.5	Terminated hand auger borehole at 2.5 ft. below ground surface in undisturbed native material.	17072
3		
4		
5		

Gamma (cpm) scale: 0, 25000, 50000, 75000, 100000

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-041-1	0-0.2	grab	0.72
S1011-SCX-041-2	0.2-2.5	comp	1.66

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-042**		
CLIENT:	NNAUMERT		
PROJECT:	Removal Site Evaluation		
SITE LOCATION:	Section 26		

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N		
DRILLING METHOD:	Hand auger	EASTING:	785341.87	NORTHING:	3914013.37
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	9/19/2017	DATE STARTED:	9/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	2	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL (SP): strong brown (7.5YR 5/8), fine to medium grained sand, loose, dry.	8158	S1011-SCX-042-1	0-0.2	grab	1.11
			9653				
1			10000	S1011-SCX-042-2	0.2-2	comp	0.56
			9725				
2		Terminated hand auger borehole at 2.0 ft. below ground surface in undisturbed native material.	9365				
3							
4							
5							

Gamma (cpm) scale: 0, 25000, 50000, 75000, 100000

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

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BOREHOLE ID:	**S1011-SCX-043**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N
DRILLING METHOD:	Hand auger	EASTING: 785626.96	NORTHING: 3914061.41
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 9/19/2017	DATE STARTED: 9/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 0.2	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Michael Ward

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL (SP): strong brown (7.5YR 5/8), fine to medium grained sand, dense to medium dense. Sampled in compacted unsealed road.	10128 12081	S1011-SCX-043-1 S1011-SCX-243-1	0-0.2	grab	1.77 1.99
		Terminated hand auger borehole at 0.2 ft. below ground surface. Refusal on rock.					
1							
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

BOREHOLE ID:	**S1011-SCX-044**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Section 26

DRILLING CONTRACTOR:	Stantec
DRILLING METHOD:	Hand auger
DRILLING EQUIPMENT:	Hand auger
SAMPLING METHOD:	Regular hand auger, 3 inch diameter

COORDINATE SYSTEM:	NAD 1983 UTM Zone 13N		
EASTING:	785065.4598	NORTHING:	3914556.9391
DATE STARTED:	9/19/2017	DATE STARTED:	9/19/2017
TOTAL DEPTH (ft.):	0.7	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm) (0, 25000, 50000, 75000, 100000)
0	POORLY GRADED SAND WITH GRAVEL (SP): light reddish brown (5YR 6/3), fine to coarse grained sand, mostly medium grained sand, gravels are subangular to angular, gravels are gray, loose, dry.	18638 32807
0.7	Terminated hand auger borehole at 0.7 ft. below ground surface. Refusal on rock.	37173
1		
2		
3		
4		
5		

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S1011-SCX-044-1	0-0.2	grab	7.80
S1011-SCX-044-2	0.2-0.7	grab	7.01

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Appendix D Evaluation of RSE Data

D.1 Background Reference Area Selection

D.2 Statistical Evaluation

BACKGROUND REFERENCE AREA SELECTION

1.0 INTRODUCTION

This appendix presents the rationale for selection of the background reference areas for the Section 26 Site (Site). To select the background reference areas for the Site, personnel considered geology, predominant wind direction, hydrologic influence, similarities of vegetation and ground cover, distance from the Site, and visual evidence of impacts due to mining (or other anthropogenic sources) in accordance with the *Multi-Agency Radiation Survey and Site Investigation Manual – Appendix A* ([MARSSIM] USEPA, 2000).

2.0 POTENTIAL BACKGROUND REFERENCE AREAS

The potential background reference area study was initiated during the Site Clearance desktop study and field investigations. In November 2016, two potential background reference areas were identified to represent the geologic formations at the Site where mining-impacted material was assumed to be present: BG-1 represents areas of the Site within the Luciano Mesa Member of the Todilto Formation (Todilto Limestone) and BG-2 represents areas of the Site within the Quaternary deposits. BG-1 and BG-2 were initially gamma surveyed using a Ludlum Model 44-20 2-inch by 2-inch sodium iodide (NaI) high-energy gamma detector in May 2016. Soil samples were collected at BG-1 and BG-2 in November 2016. Following discussions with the Agencies, it was identified that the Site would be characterized using a 3-inch by 3-inch NaI detector; BG-1 and BG-2 were surveyed using a 3-inch by 3-inch NaI detector in March 2017. The initial (3-inch by 3-inch NaI detector) gamma survey at BG-1 did not cover the areal extent of the surface soil samples collected in BG-1, so BG-1 was surveyed again in September 2017 and those survey data were used for the Removal Site Evaluation (RSE).

BG-1 and BG-2 are shown in Figure D.1-1. It should be considered that BG-1 is located along the inferred geologic contact between the Todilto Limestone and the Quaternary deposits. The geologic contact was adapted from a regional geologic map (shown in Figure 2-5 of the RSE Report) based on aerial imagery. While there are Quaternary soils present in BG-1, they are assumed to limited in depth across the potential background reference area.

Following review of the data collected during Baseline Studies and Site Characterization, Stantec observed that mining-related impacts extended down the mesa sidewall and into the plains area south of the Site. Additional potential background reference areas were required to represent the additional geological conditions. Potential mining-related impacts were observed in the following geologic units (refer to Figure D.1-1):

- Todilto Limestone (BG-1)
- Quaternary deposits (BG-2, BG-4, BG-7 and BG-8))
- Entrada Sandstone (BG-3)
- Wingate Sandstone (BG-6)

Section 3.3.1.2 in the RSE report discusses the extent of the surface gamma survey at the Site, the geologic conditions present within the Survey Area, and how the Survey Area is broken up into individual Survey Areas (Survey Area A, Survey Area B, etc.) based on MARSSIM criteria, including geologic conditions. Figure 3-4 in the RSE Report shows the separate Survey Areas. Six additional potential background reference areas were identified to represent the geologic conditions, as described below, where potential mining-related impacts were observed. Gamma surveys were conducted in June 2017 (BG-3 and BG-6) and in September 2017 (BG-4, BG-5, BG-7, and BG-8). Following review of Site Characterization data, it was determined that BG-6, BG-7, and BG-8 would not be used to represent the Site, as described in Section 3.0 below. Soil/sediment samples were collected from BG-3, BG-4, and BG-5 in September 2017. It was later determined that BG-6 should have been sampled to provide a background reference area to represent the Wingate Sandstone. The need to collect soil samples in BG-6 is identified as a data gap in the RSE Report.

The locations of the eight potential background reference areas (BG-1 through BG-8), geology, and predominant wind direction are shown in Figure D.1-2. The potential background reference areas are described below:

- BG-1 encompasses an area of 1,708 ft^2 (approximately 0.04 acres), is located 521 ft west of claim #1011, and is upwind and hydrologically cross-gradient from the Site. The thin soils and bedrock outcrops represent the portions of the survey areas within the Todilto Limestone on the mesa top. The vegetation and ground cover at BG-1 are similar to the portions of the Site on the mesa edge.
- BG-2 encompasses an area of 2,362 ft^2 (approximately 0.05 acres), is located 557 ft northwest of claim #1011, and is upwind and hydrologically cross-gradient from the Site. The thicker soils represent the portions of the survey areas that consist of undifferentiated Quaternary deposits on the mesa top including residual soils, alluvium, and eolian deposits. The vegetation and ground cover at BG-2 are similar to the portions of the Site on the mesa top.
- BG-3 encompasses an area of 683 ft^2 (approximately 0.02 acres), is located 618 ft west of claim #1011, and is upwind and hydrologically cross-gradient from the Site. The thin soils, colluvium-covered slopes, and bedrock outcrops represent the portions of the survey areas within the Entrada Sandstone on the mesa sidewall. The vegetation and ground cover at BG-3 are similar to the portions of the Site on the mesa sidewall.
- BG-4 encompasses an area of 5,623 ft^2 (approximately 0.13 acres), is located 1,387 ft west of claim #1012, and is upwind and hydrologically cross-gradient from the Site. The soils

represent the portions of the survey areas that consist of undifferentiated Quaternary deposits on the plains below the claim boundaries. The vegetation and ground cover at BG-4 are similar to the areas of the Site on the plains.

- BG-5 encompasses an area of 1,151 ft^2 (approximately 0.03 acres), is located 1,447 ft southwest of claim #1012, and is upwind and hydrologically cross-gradient from the Site. The sediments represent the portions of the survey areas that consist of Quaternary alluvium in the drainages. The vegetation and ground cover at BG-5 are similar to the alluvial drainages on the plains.

- BG-6 encompasses an area of 2,957 ft^2 (approximately 0.07 acres), is located 1,017 ft west of claim #1012, is upwind and hydrologically cross-gradient from the Site, and across multiple drainage divides. The thin soils, colluvium-covered slopes, and bedrock outcrops represent the portions of the survey areas within the Wingate Sandstone on the plains. The vegetation and ground cover at BG-6 are similar to the portions of the Site where mesa sidewall transitions to the plains.

- BG-7 encompasses an area of 5,273 ft^2 (approximately 0.12 acres), is located 1,173 ft west of claim #1012, is upwind and hydrologically cross-gradient from the Site, and is across multiple drainage divides. The soils represent the portions of the survey areas that consist of Quaternary deposits on the plains. The vegetation and ground cover at BG-7 are similar to the areas of the Site that are on the plains.

- BG-8 encompasses an area of 2,338 ft^2 (approximately 0.05 acres), is located 1,873 ft southwest of claim #1012 on the plains, is upwind and cross-gradient from the Site, and across multiple drainage divides. The sediments represent the portions of the survey areas that consist of Quaternary alluvium in the drainages. The vegetation and ground cover at BG-8 are similar to the alluvial drainages on the plains.

The potential background reference area evaluation included surface gamma surveys, surface and subsurface static gamma measurements, and collection of surface and subsurface soil/sediment samples as described below:

- BG-1– 11 surface soil grab samples were collected from 11 locations; one subsurface soil grab sample, and surface and subsurface static gamma measurements, were collected from borehole location S1011-BG1-011

- BG-2 –11 surface soil grab samples were collected from 11 locations; one subsurface soil grab sample, and surface and subsurface static gamma measurements, were collected from borehole location S1011-BG2-011

- BG-3 –11 surface soil grab samples were collected from 11 locations; a borehole could not be advanced beyond 0.25 feet below ground surface (ft bgs) at S1011-BG3-011, so no subsurface samples were collected at BG-3; surface and subsurface static gamma measurements were collected at S1011-BG3-011

- BG-4 –11 surface soil grab samples were collected from 11 locations; one subsurface soil composite sample, and surface and subsurface static gamma measurements, were collected from borehole location S1011-BG4-011

- BG-5 –11 surface sediment grab samples were collected from 11 locations; one subsurface sediment composite sample, and surface and subsurface static gamma measurements, were collected from borehole location S1011-BG5-011
- BG-6 – surface gamma survey only
- BG-7 – surface gamma survey only
- BG-8 – surface gamma survey only

The sample locations and surface gamma survey data for BG-1, BG-2, BG-3 and BG-4 are shown in Figure D.1-2. The sample locations for BG-5, and the surface gamma survey data for BG-6, BG-7, and BG-8, are shown in Figure D.1-3. Samples were categorized as surface soil/sediment samples where sample depths were up to 0.5 ft bgs, and as subsurface samples where sample depths were greater than 0.5 ft bgs. Static gamma measurements were categorized as surface where static gamma was measured at the ground surface, and as subsurface where static gamma was measured at or greater than 0.1 ft bgs. Tables D.1-1 and D.1-2 provide descriptive statistics for the metals/Ra-226 concentrations and the surface gamma measurements, respectively. Field forms, including borehole logs, are provided in Appendix C of the RSE Report.

The equipment used for the surface gamma survey (with the exception that a 2-inch by 2-inch NaI detector was used due to borehole diameter) were also used for static one-minute gamma measurements at the ground surface, and for subsurface gamma measurements at the borehole locations. Soil/sediment samples and gamma measurements were collected according to the methods described in the *Removal Site Evaluation Work Plan* (MWH, 2016).

3.0 SELECTION OF BACKGROUND REFERENCE AREA

Background reference areas were selected to represent the areas of the Site where mining-related disturbances may have occurred or otherwise come to be located including downgradient drainages. BG-1, BG-2, BG-3, BG-4 and BG-5 were selected to represent their respective geologic formations described above. BG-4 and BG-5 were selected to represent the Quaternary deposits (e.g., Quaternary alluvium, respectively, on the plains area of the Site because the gamma measurements in the plains area were generally lower than those within the Quaternary deposits on the mesa top.

The need to collect soil samples from BG-6 to represent the Wingate Sandstone is identified as a data gap in the RSE report. Gamma measurements from BG-6 were considered for the estimation of the location and volume of mining-impacted material for the RSE.

BG-7 was not selected as a background reference area, because it was redundant with BG-4. BG-4 was selected over BG-7 because it was located across a drainage from the area of the plains downgradient from the Site.

BG-8 was not selected as a background reference area, because it was redundant with BG-5. BG-8 also appeared to extend outside of the center of the drainage and the Quaternary alluvium.

Surface gamma survey measurements, soil and sediment sample results, and subsurface static gamma measurements collected from BG-1, BG-2, BG-3, BG-4, BG-5 and the gamma survey measurements collected from BG-6 were used for the remainder of the RSE of the Site.

4.0 REFERENCES

MWH, 2016. *Navajo Nation AUM Environmental Response Trust – First Phase Removal Site Evaluation Work Plan*. October.

USEPA, 2000. *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM), EPA 402-R-97-016, Rev. 1.

Table D.1-1
Soil and Sediment Sampling Summary
Section 26
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Reference Area Study - Background Area 1 - Todilto Limestone						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	18%	100%	--	--	--
Minimum[1]	2	--	--	1.60	5.50	1.05
Minimum Detect[2]	--	0.320	--	--	--	--
Mean[1]	4.32	--	--	2.17	11.5	1.47
Mean Detects[2]	--	0.567	--	--	--	--
Median[1]	3.40	--	--	2.10	11.0	1.43
Median Detects[2]	--	0.490	--	--	--	--
Maximum[1]	11	--	--	2.80	26.0	1.86
Maximum Detect[2]	--	1.40	--	--	--	--
Distribution	Normal	Gamma	Not Calculated	Normal	Normal	Normal
Coefficient of Variation[1]	0.621	--	--	0.172	0.488	0.160
CV Detects[2]	--	0.587	--	--	--	--
UCL Type	95% Student's-t UCL	95% KM Adjusted Gamma UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	5.78	0.824	Not Calculated	2.38	14.6	1.60
UTL Type	UTL Normal	UTL KM Gamma WH	Not Calculated	UTL Normal	UTL Normal	UTL Normal
UTL Result	11.9	2.26	Not Calculated	3.23	27.3	2.13
Background Reference Area Study - Background Area 2 - Quaternary Deposits (Mesa Top)						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	82%	100%	--	--	--
Minimum[1]	1.30	--	--	1.30	6.70	1.73
Minimum Detect[2]	--	0.220	--	--	--	--
Mean[1]	1.69	--	--	1.69	8.52	2.07
Mean Detects[2]	--	0.275	--	--	--	--
Median[1]	1.70	--	--	1.50	8.60	2.02
Median Detects[2]	--	0.275	--	--	--	--
Maximum[1]	2.00	--	--	3.40	10.0	2.70
Maximum Detect[2]	--	0.330	--	--	--	--
Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
Coefficient of Variation[1]	0.136	--	--	0.347	0.114	0.152
CV Detects[2]	--	0.283	--	--	--	--
UCL Type	95% Student's-t UCL	95% KM (t) UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	1.82	0.156	Not Calculated	2.01	9.05	2.25
UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
UTL Result	2.34	0.346	Not Calculated	3.34	11.2	2.96

Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Study Reference Area 3 - Entrada Sandstone						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	64%	100%	--	--	--
Minimum[1]	1	--	--	0.600	9.20	0.710
Minimum Detect[2]	--	0.200	--	--	--	--
Mean[1]	1.57	--	--	1.05	11.3	0.985
Mean Detects[2]	--	0.260	--	--	--	--
Median[1]	1.20	--	--	1.00	10.0	0.990
Median Detects[2]	--	0.235	--	--	--	--
Maximum[1]	5.20	--	--	1.60	15.0	1.23
Maximum Detect[2]	--	0.370	--	--	--	--
Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
Coefficient of Variation[1]	0.772	--	--	0.293	0.191	0.181
CV Detects[2]	--	0.300	--	--	--	--
UCL Type	95% Student's-t UCL	95% KM (t) UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	2.24	0.245	Not Calculated	1.21	12.5	1.08
UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
UTL Result	4.99	0.367	Not Calculated	1.91	17.4	1.49
Background Study Reference Area 4 - Quaternary Deposits (Plains)						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	82%	100%	--	--	--
Minimum[1]	1.20	--	--	0.360	7.7	0.710
Minimum Detect[2]	--	0.200	--	--	--	--
Mean[1]	1.43	--	--	0.444	9.01	0.985
Mean Detects[2]	--	0.205	--	--	--	--
Median[1]	1.50	--	--	0.460	9.20	1.04
Median Detects[2]	--	0.205	--	--	--	--
Maximum[1]	1.60	--	--	0.490	9.80	1.27
Maximum Detect[2]	--	0.210	--	--	--	--
Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
Coefficient of Variation[1]	0.083	--	--	0.088	0.077	0.18
CV Detects[2]	--	0.035	--	--	--	--
UCL Type	95% Student's-t UCL	95% KM (t) UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	1.49	0.197	Not Calculated	0.465	9.39	1.08
UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
UTL Result	1.76	0.210	Not Calculated	0.554	11.0	1.49

Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Study Reference Area 5 - Quaternary Alluvium (Plains)						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	100%	100%	--	--	--
Minimum[1]	1.10	--	--	0.290	5.10	0.500
Minimum Detect[2]	--	--	--	--	--	--
Mean[1]	1.27	--	--	0.415	7.32	0.610
Mean Detects[2]	--	--	--	--	--	--
Median[1]	1.30	--	--	0.410	7.50	0.630
Maximum[1]	1.60	--	--	0.680	9.40	0.790
Maximum Detect[2]	--	--	--	--	--	--
Distribution	Normal	Not Calculated	Not Calculated	Normal	Normal	Normal
Coefficient of Variation[1]	0.127	--	--	0.237	0.165	0.134
UCL Type	95% Student's-t UCL	Not Calculated	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	1.36	Not Calculated	Not Calculated	0.468	7.98	0.655
UTL Type	UTL Normal	Not Calculated	Not Calculated	UTL Normal	UTL Normal	UTL Normal
UTL Result	1.73	Not Calculated	Not Calculated	0.691	10.7	0.839

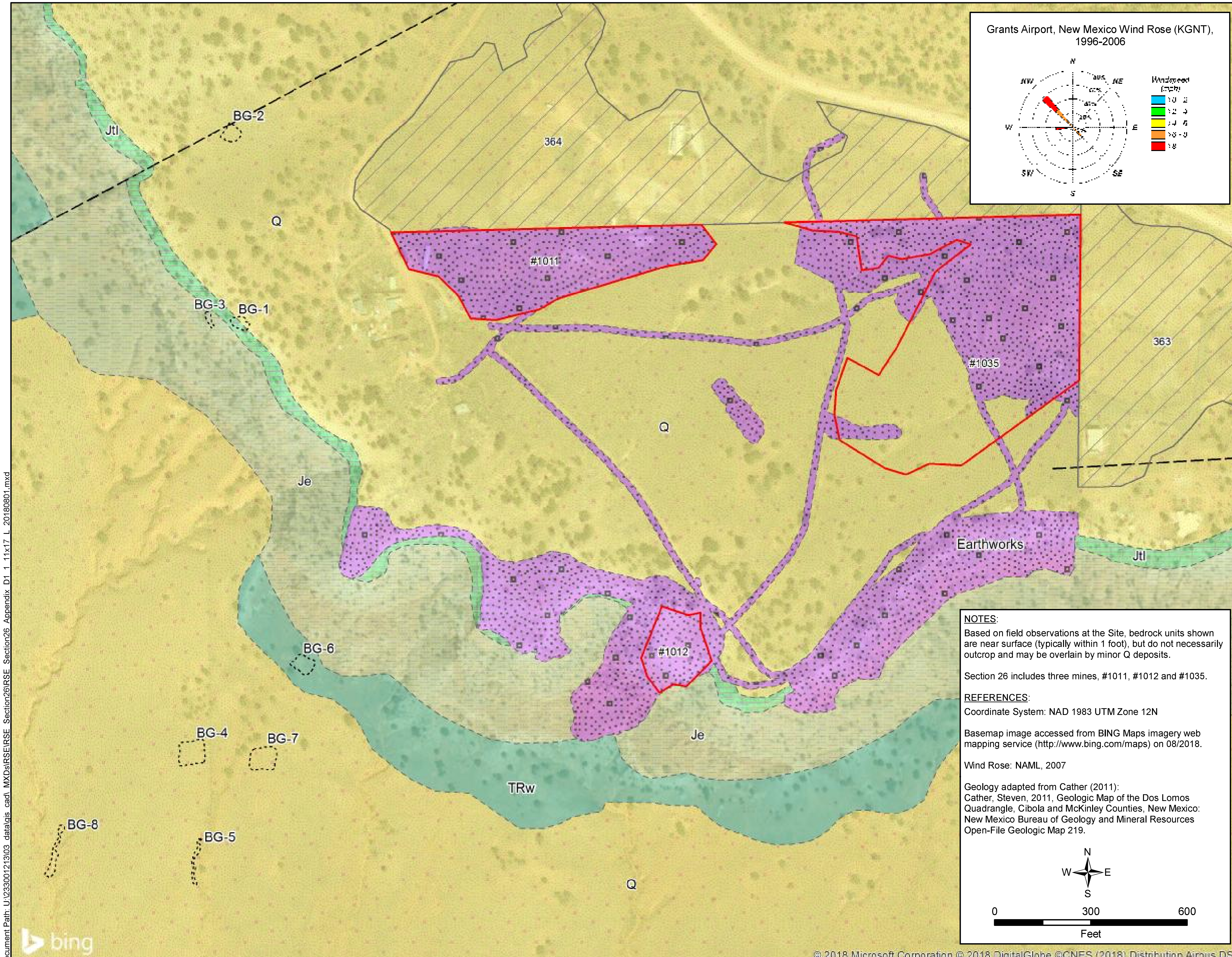
Notes
[1] This statistic is reported by ProUCL when the dataset contains 100 percent detections.
[2] This statistic is reported by ProUCL when non-detect values exist in the dataset. The value reported is calculated using detections only.

CV	Coefficient of variation
KM	Kaplan Meier
mg/kg	Milligrams per kilogram
--	Not applicable
pCi/g	Picocuries per gram
WH	Wilson Hilferty

Table D.1-2
Surface Gamma Survey Summary
Section 26
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

	Background Reference Area 1 (BG-1)	Background Reference Area 2 (BG-2)	Background Reference Area 3 (BG-3)	Background Reference Area 4 (BG-4)	Background Reference Area 5 (BG-5)	Background Reference Area 6 (BG-6)	Background Reference Area 7 (BG-7)	Background Reference Area 8 (BG-8)
Geologic Formation	Todilto Limestone	Quaternary Deposits (Mesa Top)	Entrada Sandstone	Quaternary Deposits (Plains)	Quaternary Alluvium (Plains)	Wingate Sandstone	Quaternary Deposits (Plains)	Quaternary Alluvium (Plains)
Statistic								
Total Number of Observations	171	288	80	442	138	127	370	205
Minimum	11,464	18,508	13,202	15,868	16,299	14,221	15,313	16,424
Mean	14,082	21,269	29,080	18,804	19,213	23,377	18,694	18,824
Median	14,041	21,227	26,603	18,780	19,101	21,966	18,696	18,808
Maximum	20,015	25,542	57,059	22,772	22,914	37,524	21,537	21,532
Distribution	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Coefficient of Variation	0.105	0.0540	0.341	0.0550	0.0740	0.250	0.0577	0.0594
UCL Type	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	14,269	21,379	30,927	18,886	19,412	24,238	18,786	18,953
UTL Type	UTL Normal	UTL Normal	UTL Normal	UTL Normal	UTL Normal	UTL Normal	UTL Normal	UTL Normal
UTL Result	16,829	23,320	48,542	20,637	21,864	34,429	20,615	20,875

Notes
cpm Counts per minute
UCL Upper confidence limit
UTL Upper tolerance limit
WH Wilson Hilferty



NOTES:
Based on field observations at the Site, bedrock units shown are near surface (typically within 1 foot), but do not necessarily outcrop and may be overlain by minor Q deposits.

Section 26 includes three mines, #1011, #1012 and #1035.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 08/2018.

Wind Rose: NAML, 2007

Geology adapted from Cather (2011):
Cather, Steven, 2011, Geologic Map of the Dos Lomos Quadrangle, Cibola and McKinley Counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-File Geologic Map 219.

N W E S

0 300 600
Feet

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Potential Background Reference Area (BG-1)
- Claim Boundary
- Other Claim Boundary
- Geology Contact (Inferred)
- Fault

Site Geology

HOLOCENE

Earthworks: Human-caused disturbance of the land surface potentially related to mining or reclamation.

Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly colluvial and alluvial deposits, and eolian sand deposits.

JURASSIC

Jtl: Luciano Mesa Member of the Todilto Formation (Upper Jurassic) – Olive-gray to pale-yellow, thin- to thick-bedded limestone deposited in a lacustrine or saline environment.

Je: Entrada Sandstone – (Upper and Middle Jurassic) – Reddish-orange to reddish-brown fine- to medium-grained eolian crossbedded sandstone and dark-reddish-brown clayey siltstone and very fine grained silty sandstone.

TRIASSIC

TRw: Wingate Sandstone (Upper Triassic) – Reddish-brown, fine- to medium-grained, cross-bedded eolian sandstone.

TITLE:
Geologic Map and Potential Background Reference Areas

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 8/1/2018	DOCUMENT NAME: Removal Site Evaluation Report
AUTHOR: EDZ	REVIEWER: CBB
Stantec	FIGURE: D.1-1

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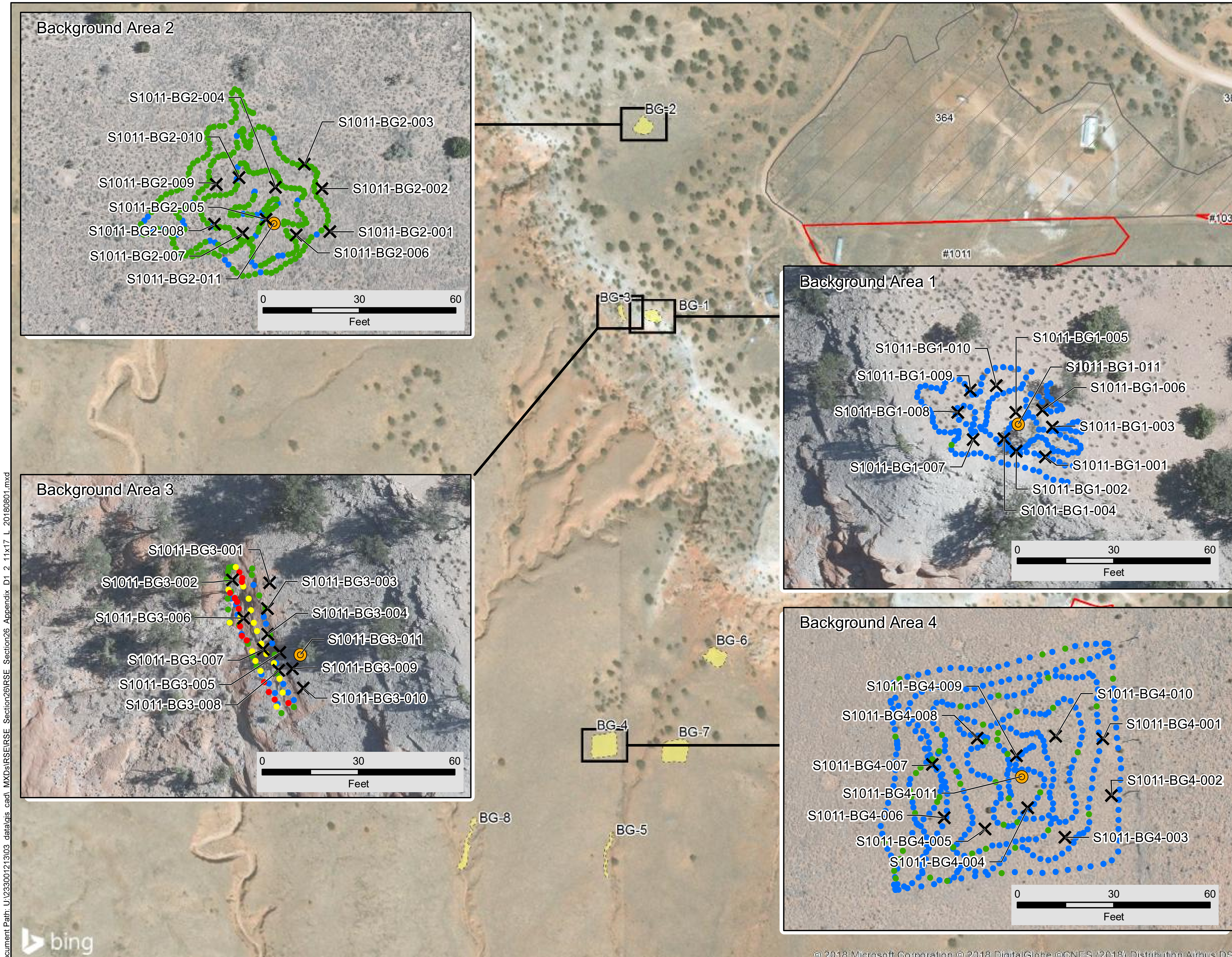


NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Subsurface Borehole Location for Background Reference
- Potential Background Reference Area
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 11,464 - 20,000
- 20,001 - 30,000
- 30,001 - 40,000
- 40,001 - 57,059

NOTES:

Surface gamma measurements were collected using a 3 x 3 inch detector.

Section 26 includes three mines, #1011, #1012 and #1035.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Main display basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

Inset basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 300 600
Feet

TITLE:
Gamma Radiation Survey Results and Soil Sample Locations for Potential Background Reference Areas 1 through 4

PROJECT:
Removal Site Evaluation
Section 26 Mine Site

DATE: 9/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

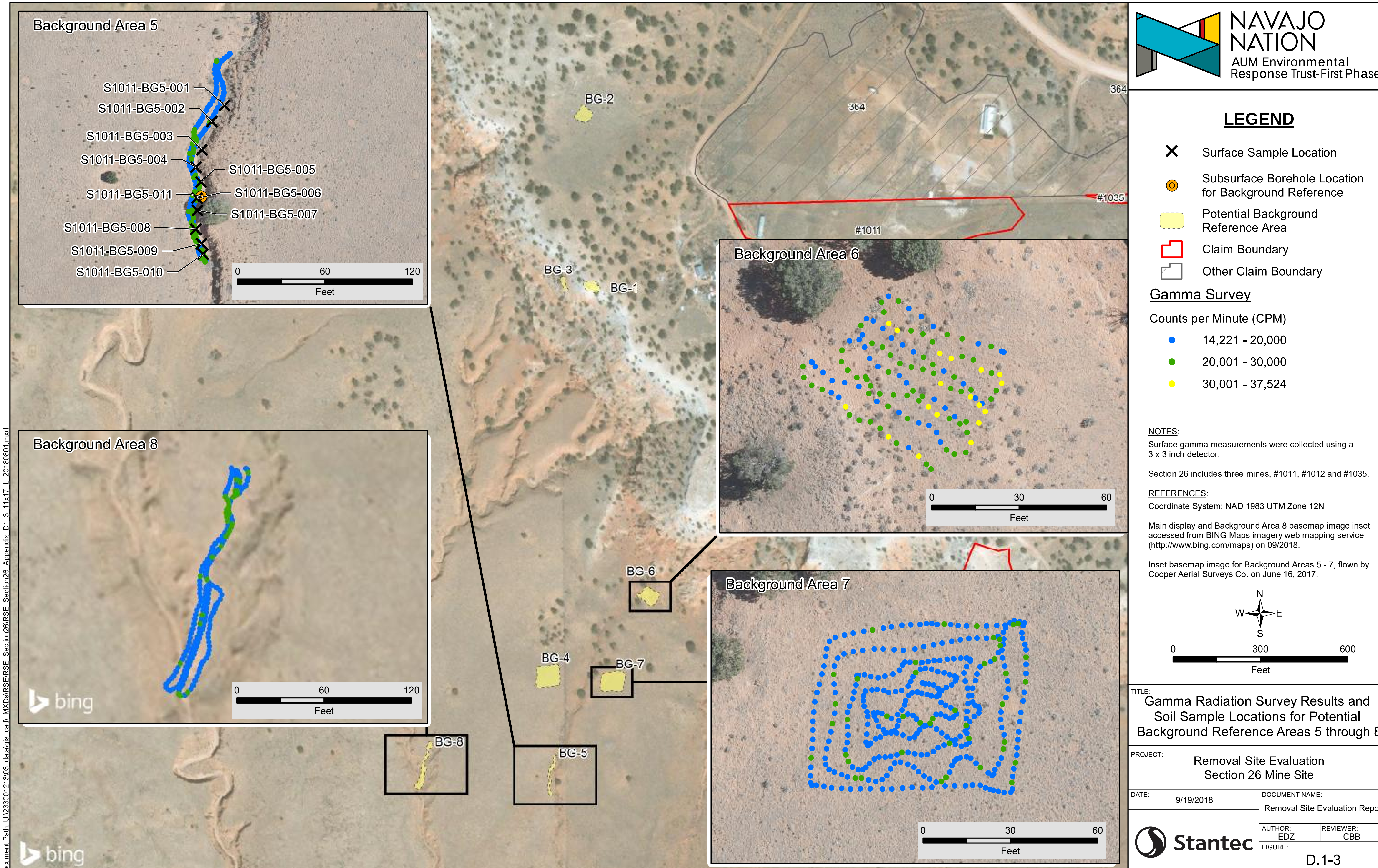
AUTHOR: EDZ

REVIEWER: CBB

Stantec

FIGURE: D.1-2

Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_Section26\RSE_Section26_Appendix_D1_2_11x17_L_20180801.mxd



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STATISTICAL EVALUATION

1.0 INTRODUCTION

This statistical evaluation presents the methods used in, and results of, statistical analyses performed on gamma radiation survey results and soil sample analytical results collected from the Section 26 Site (Site). The evaluation includes comparing background reference area and Survey Area data distributions, and documents the decision process followed to select site-specific investigation levels (ILs). The ILs are used to confirm contaminants of potential concern (COPCs) listed in the *RSE Work Plan*, and to support identification of technologically enhanced naturally occurring radioactive materials (TENORM) at the Site.

2.0 EVALUATIONS

The evaluation process included compiling the results for gamma radiation surveys and soil sample analytical results from five background reference areas and five Survey Areas. These areas are designated Background Reference Area 1 (BG-1) through Background Reference Area 5 (BG-5), Survey Area A, Survey Area B, Survey Area C, Survey Area D, and Survey Area E. The Background Reference Areas BG-1 through BG-5 were selected to represent the Site's natural conditions as described in Appendix D.1. The gamma radiation survey data and soil sample analytical results for the background reference areas and Survey Areas were evaluated to determine the appropriate ILs for the Site as follows:

1. Identify and examine potential outlier values. Potential outlier values were identified statistically and, if justified upon further examination, removed from a dataset prior to further evaluation and calculations. No data were removed from the dataset for the calculations presented in this appendix.

2. Compare data populations between BG-1 and Survey Area A, BG-2 and Survey Area B, BG-3 and Survey Area C, BG-4 and Survey Area D, and BG-5 and Survey Area E (box plots, probability plots, hypothesis testing with Wilcoxon Mann-Whitney test). Soil sample and gamma radiation survey results were compared between background reference areas and Survey Areas qualitatively and quantitatively to evaluate similarity or difference in data distributions between the areas, and as a component of evaluating background area adequacy and representativeness.

3. Develop descriptive statistics. Descriptive statistics for gamma survey results and soil sample analytical results (e.g., number of observations, mean, maximum, median, etc.) were generated to facilitate qualitative comparisons of soil sample and gamma radiation survey results from one area to another.

4. Select ILs for the Site based on the results of the statistical evaluations.

3.0 RESULTS

The following sections present the evaluation of potential outlier values in the dataset, calculated descriptive statistics, and comparison of data populations between groups in support of determining ILs for use at the Site.

3.1 POTENTIAL OUTLIER VALUES

A potential outlier is a data point within a random sample of a population that is different enough from the majority of other values in the sample as to be considered potentially unrepresentative of the population, and therefore requires further inspection and evaluation. Unrepresentative values in a dataset have potential to yield distorted estimates of population parameters of interest (e.g., means, upper confidence limits, upper percentiles). Therefore, potential outliers in the Site data were evaluated further prior to performing data comparisons (Section 3.2) and developing the descriptive statistics (Section 3.3). In the context of this statistical evaluation, extreme values and statistical outliers are referred to as potential outliers.

A potential outlier value in a sample may be a true representative value in the test population (not a "discrepant" value), simply representing a degree of inherent variation present in the population. Furthermore, a statistical determination of one or more potential outliers does not indicate that the measurements are actually discrepant from the rest of the data set. Therefore, general statistical guidance does not recommend that extreme values (potential outliers) be removed from an analysis solely on a statistical basis. Statistical outlier tests can provide supportive information, but a reasonable scientific rationale needs to be identified for the removal of any potential outlier values (e.g., sampling error, records error, or the potential outlier is determined to violate underlying assumptions of the sampling design, such as the targeted geology).

In the background reference areas, soil samples were collected randomly. Potential outliers in the background reference area datasets were examined using box plots, probability plots and statistical testing. Descriptive statistics were then calculated with and without the potential outliers, as applicable. Finally, the potential outlier values were evaluated to determine if a reason could be found to remove the data points before calculating final statistics. The results of these evaluations are described in the following sections.

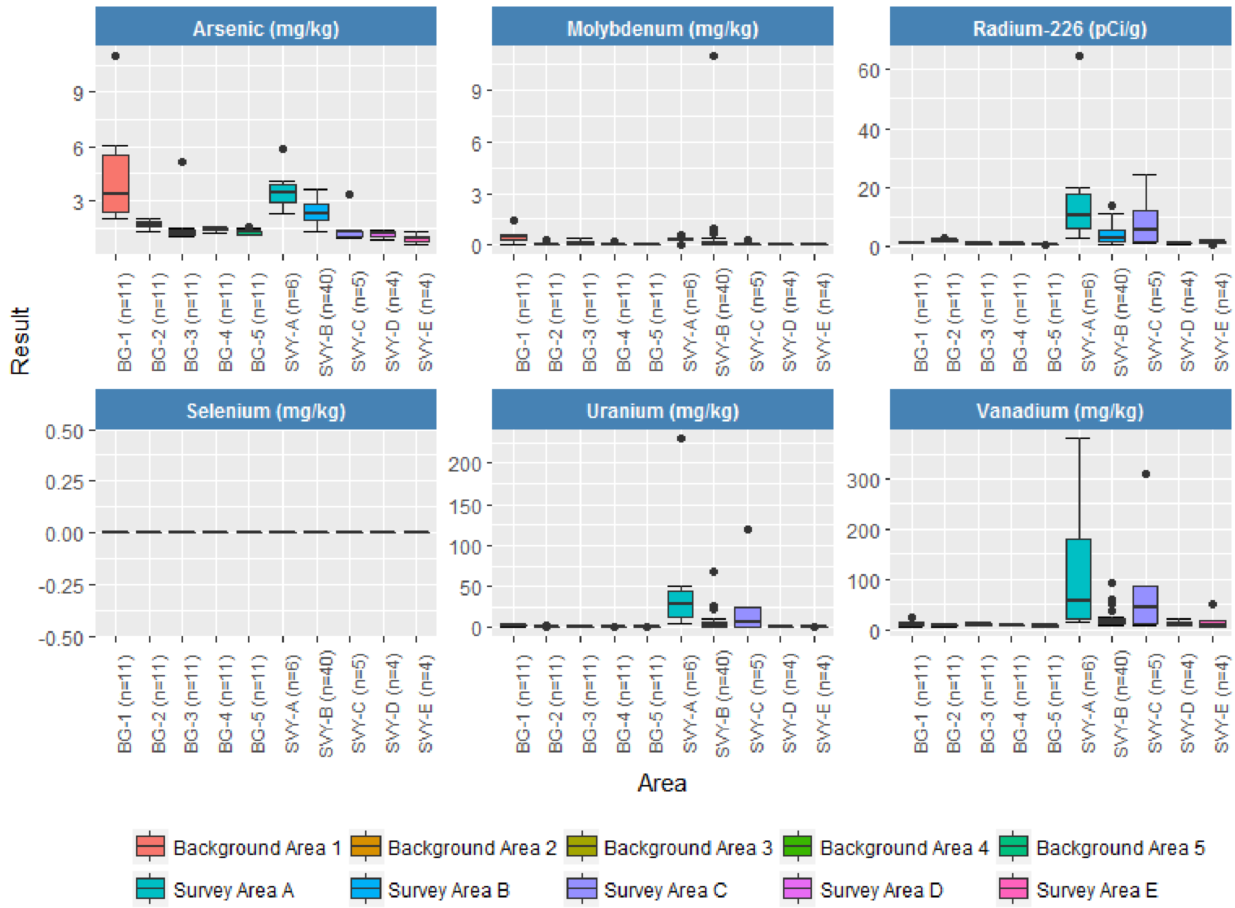
In the Survey Areas at Section 26, soil samples were collected using a judgmental sampling approach. Specifically, some sample locations were selected to characterize areas of higher gamma radiation and, as a result, potential outlier values are not unexpected in the Survey Area sample statistics. Potential outliers in this context mean values that are well-separated from the majority of the data set coming from the far/extreme tails of the data distribution (USEPA, 2016a). Descriptive statistics for the survey areas and some comparisons to background reference areas are still presented for qualitative assessment. However, potential outlier values in the Survey Areas are not evaluated further nor removed from the dataset.

3.1.1 Box Plots

Box plots depict descriptive statistics from a group of data (Figure 1A). The interquartile range is represented by the bounds of the box, the minimum and maximum values, not including potential outlier values (extreme values), are depicted by the whiskers (vertical lines), and any potential outliers are identified as singular dots. Potential outliers in this context are defined as values outside 1.5 times the interquartile range above or below the box.

3.1.1.1 Soil Sample Results Box Plots

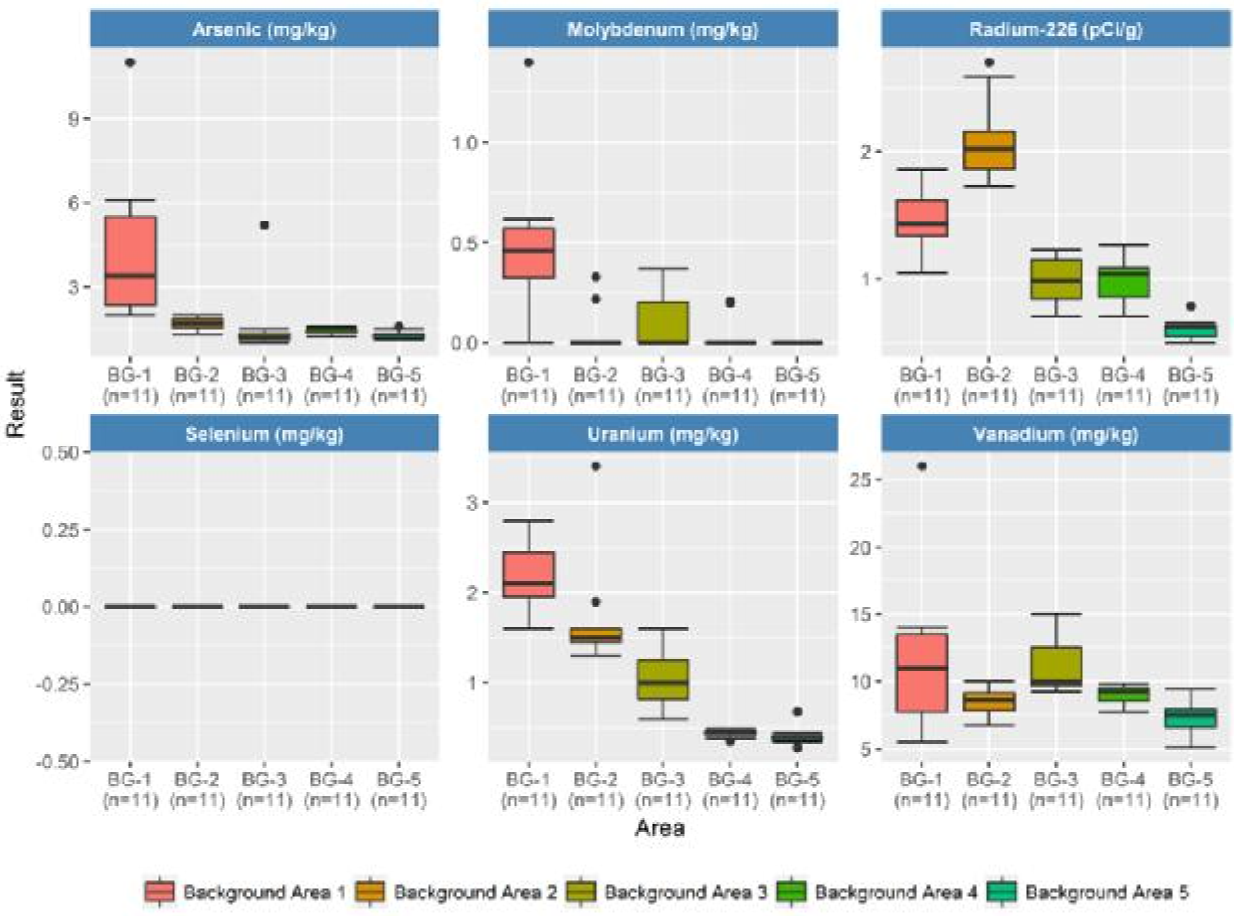
Figure 1A. Survey Areas A, B, C, D and E and Background Reference Areas 1 (BG-1), 2 (BG-2), 3 (BG-3), 4 (BG-4) and 5 (BG-5) Soil Sample Box Plots



The soil sample box plots shown on Figure 1A depict differences in the data distributions for analytical constituent concentrations between background reference areas and Survey Areas. One or more potential outlier values are present in the datasets for each background reference area and all Survey Areas except Survey Area D.

Potential outlier values are of greatest concern in the background reference area datasets as these data are to be used to determine the ILs. Background reference area data are presented alone in Figure 1B.

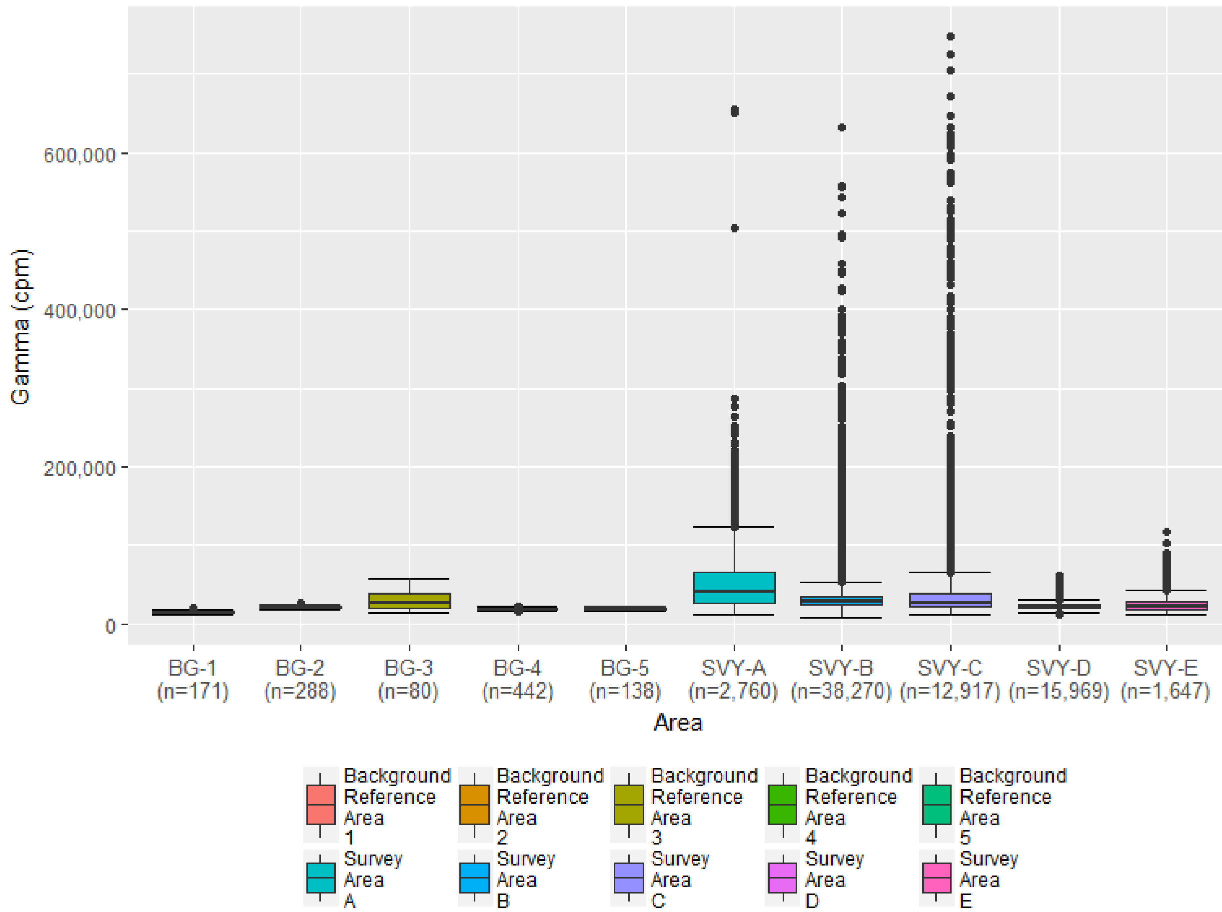
Figure 1B. Background Reference Areas 1 (BG-1), 2 (BG-2), 3 (BG-3), 4 (BG-4) and 5 (BG-5) Soil Sample Box Plots



As shown in Figure 1B, in the boxplots for BG-1, one high value each for arsenic (As), molybdenum (Mo), and vanadium (V) are identified as potential outliers (i.e., above 1.5 times the interquartile range); in the boxplots for BG-2, three high values each for molybdenum, uranium (U), and radium-226 (Ra-226) are identified as potential outliers; in the boxplots for BG-3, one high value for arsenic is identified as a potential outlier; in the boxplots for BG-4, two high values for molybdenum and one low value for uranium are identified as potential outliers; and in the boxplots for BG-5, one high value each for arsenic and Ra-226 and one high and one low value for uranium are identified as potential outliers. These potential outlier values are further evaluated with the use of probability plots in Section 3.1.2 and statistical outlier testing in Section 3.1.3.

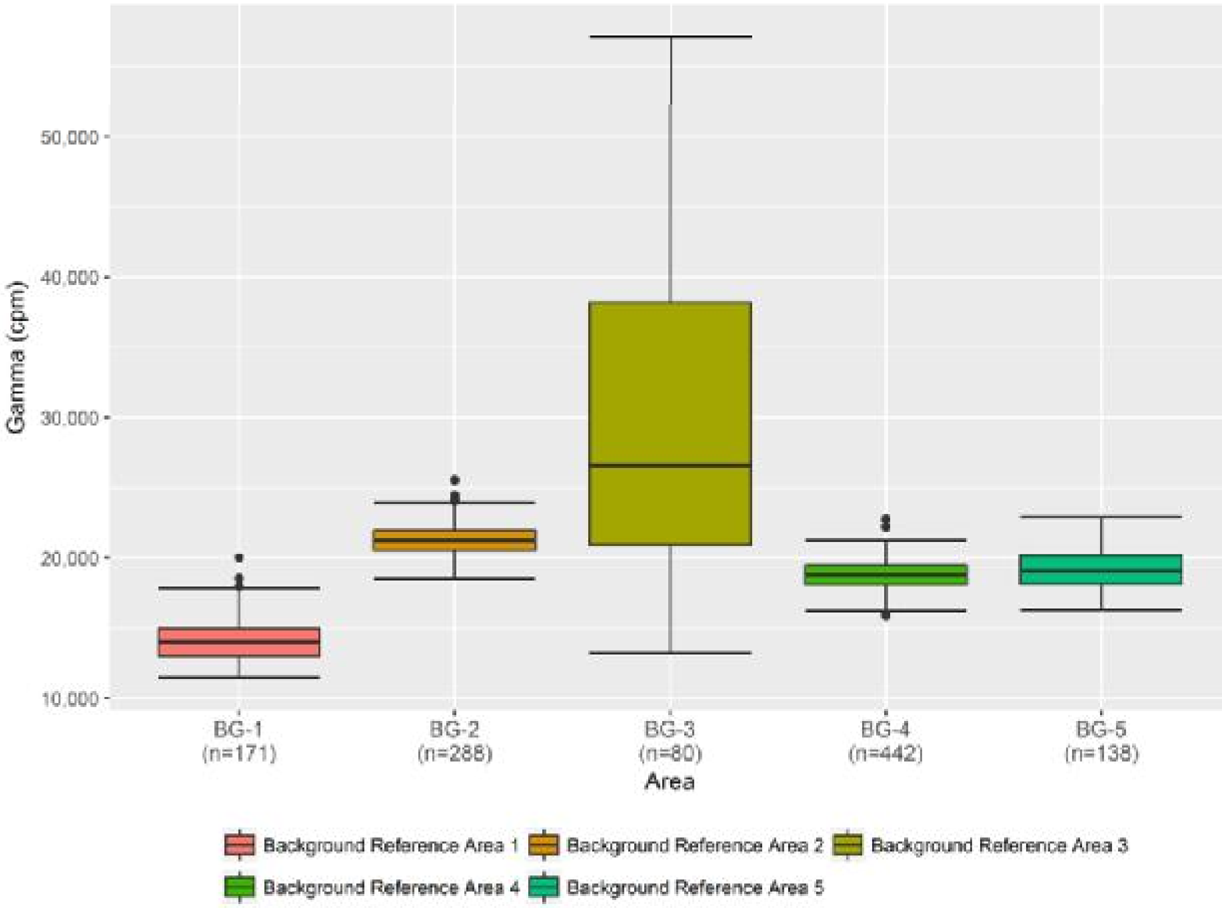
3.1.1.2 Gamma Radiation Results Box Plots

Figure 2A. Survey Areas and Background Reference Area Gamma Radiation Box Plots



The gamma radiation survey results box plots shown on Figure 2A depict differences in the data distribution for gamma measurements between background reference areas and Survey Areas. The large number of potential outlier values in the Survey Area box plots indicate high skewness or possibly non-normally distributed data, instead of outlier values. Based on Site geology, the potential gamma radiation outlier values observed for the Survey Area data on Figure 2A represent localized areas of higher gamma radiation with respect to other parts of each of the Survey Areas, as would be expected in areas with varying levels of mineralization, naturally occurring radioactive material (NORM) and potential TENORM.

Figure 2B. Background Reference Areas Gamma Radiation Box Plots



As shown in Figure 2B, there are five, six, and four high potential outlier values shown for gamma data in the BG-1, BG-2, and BG-4 datasets, respectively. These potential outlier values do not represent skewed data as do the Survey Area results, and the gamma data are shown to be more normally distributed in the background reference areas than in the Survey Areas. The potential outlier values shown in the background reference areas are most likely representative of natural variation of gamma in these areas. These observations are further evaluated with the use of probability plots in Section 3.1.2 and statistical outlier testing in Section 3.1.4.

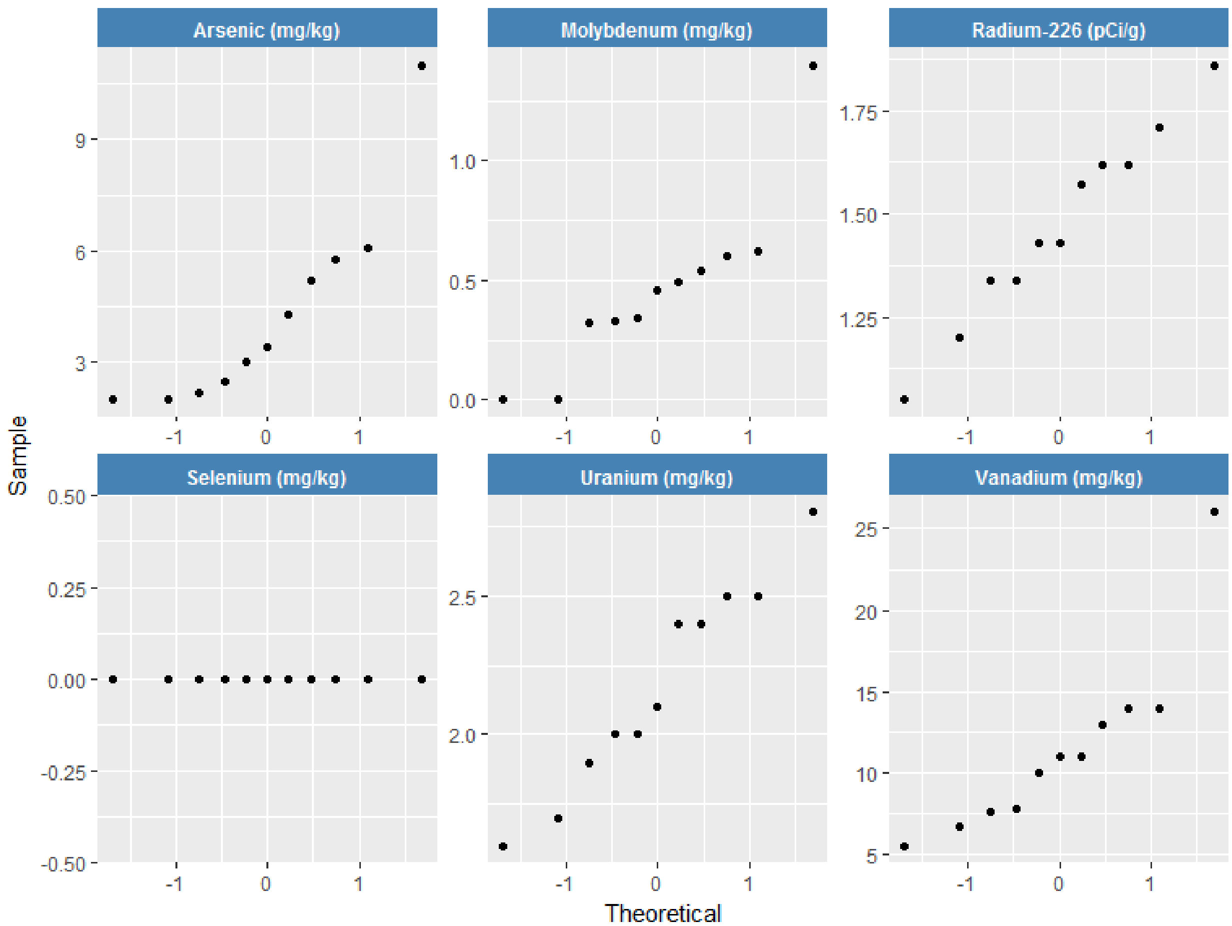
3.1.2 Probability Plots

The normal probability plot is a graphical technique for assessing whether or not a data set is approximately normally distributed and where there may be potential outlier values. The data are plotted against a theoretical normal distribution in such a way that the points, if normally distributed, should form an approximate straight line. Curved lines may indicate non-normally or log-normally distributed data, and "S"-shaped lines may indicate two distinct groups within the dataset.

3.1.2.1 Soil Sample Results Probability Plots

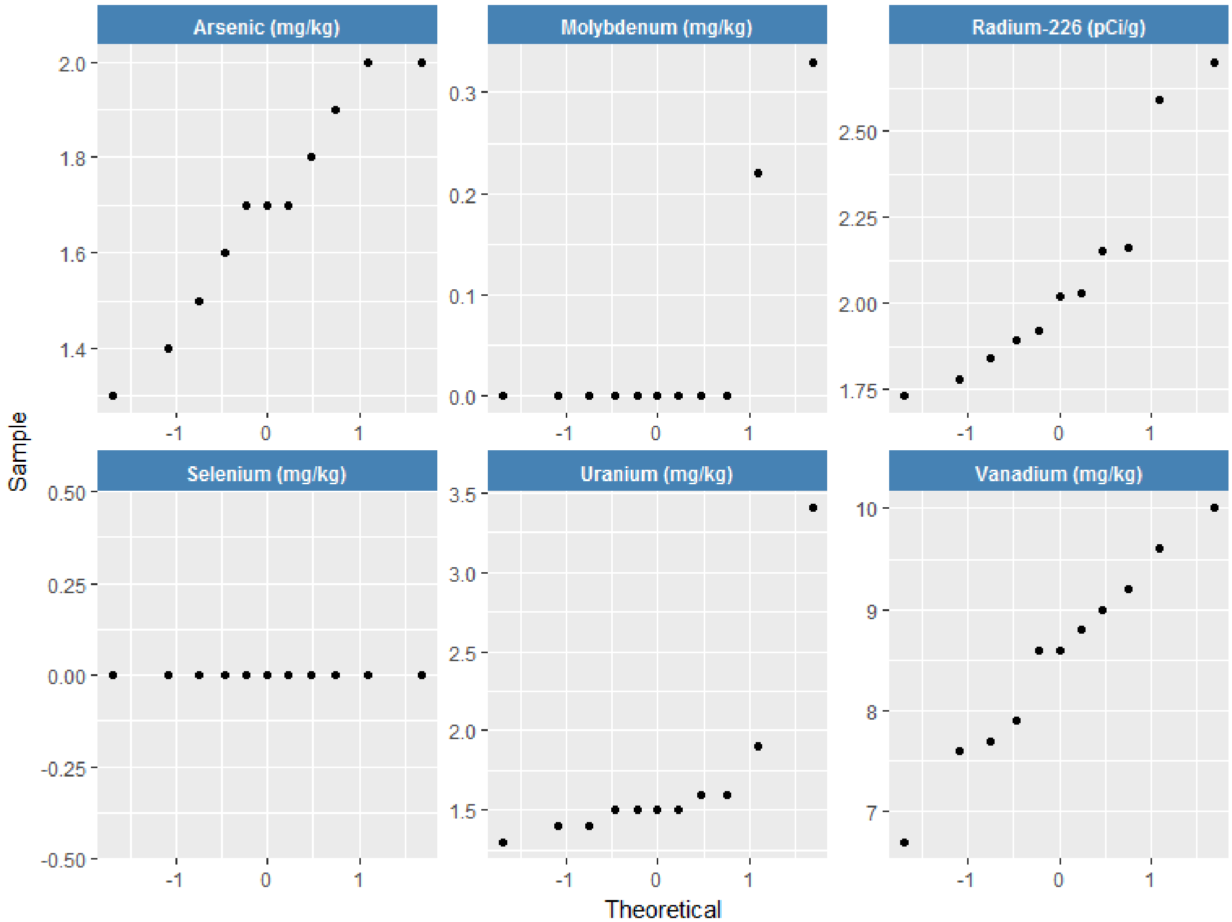
Figure 3 through 7 depict the probability plots for metals and Ra-226 results at background reference areas.

Figure 3. Background Reference Area 1 (BG-1) Soil Sample Probability Plots



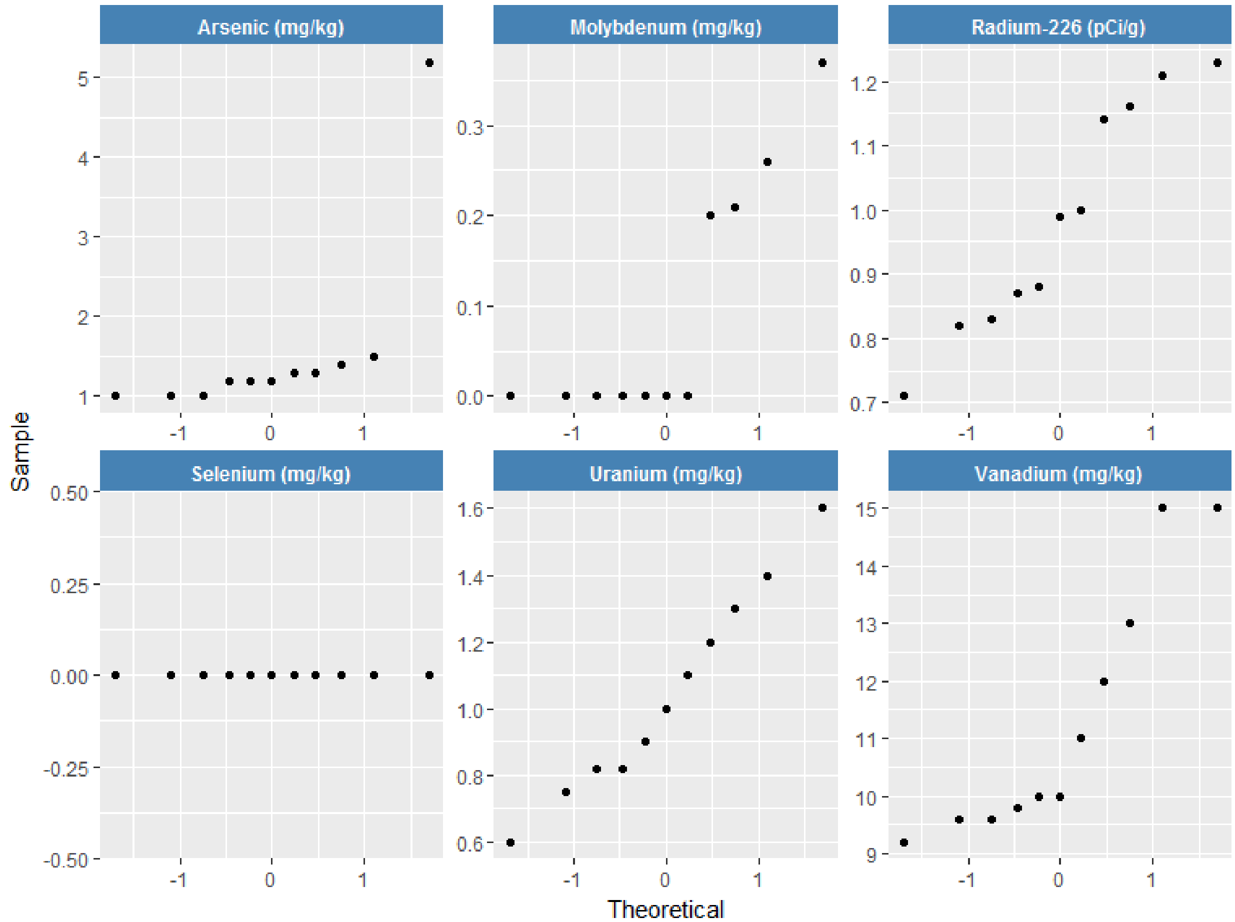
One high value each for arsenic, molybdenum and vanadium were identified as potential outliers (i.e., above 1.5 times the interquartile range) in the BG-1 box plots in Figure 1B. When viewed in the probability plots in Figure 3, these values do appear to be substantially higher than the rest of their respective datasets. The values for Ra-226 and uranium are approximately linear in Figure 3, indicating a normally distributed dataset. These three values are tested further for statistical significance as potential outliers in Section 3.1.3.

Figure 4. Background Reference Area 2 (BG-2) Soil Sample Probability Plots



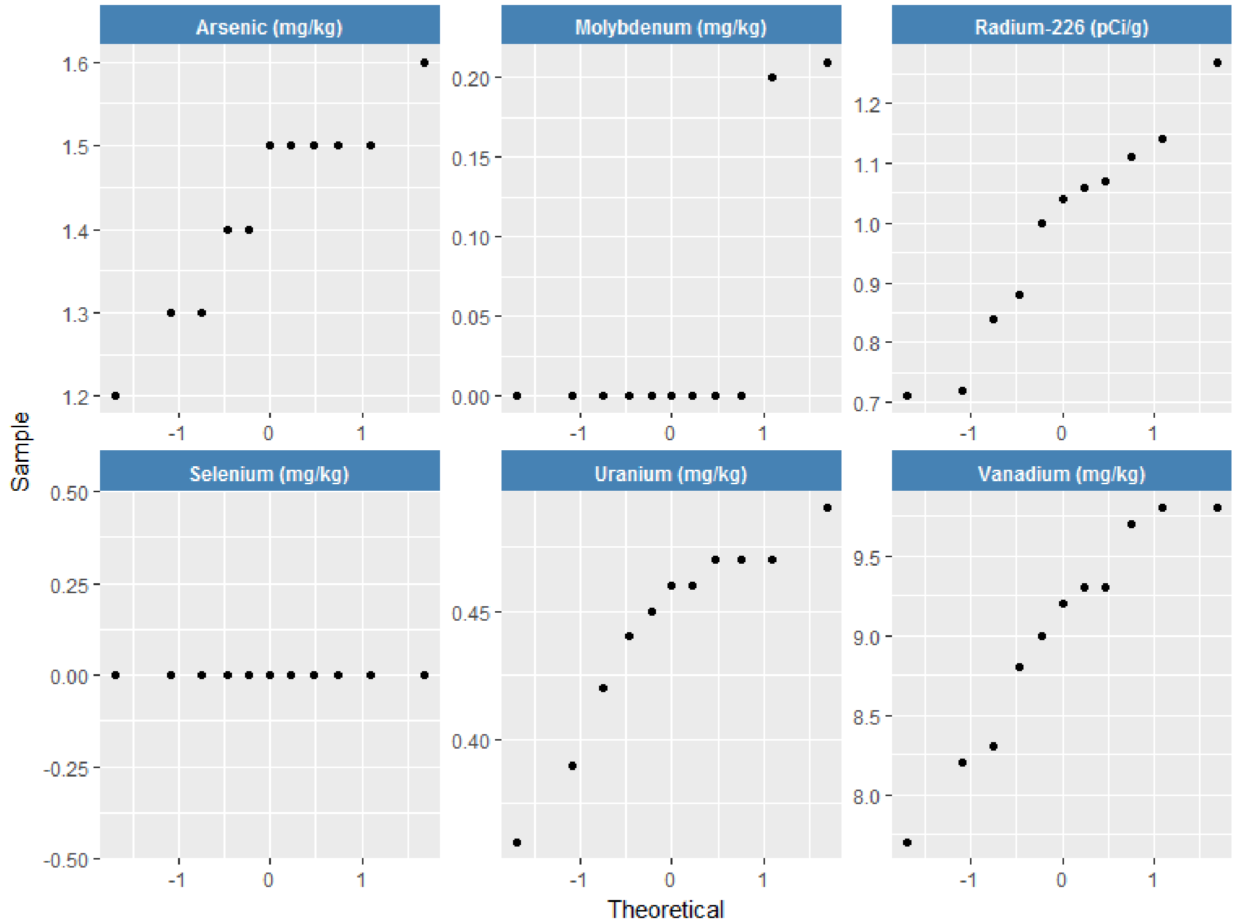
Two high values for molybdenum and uranium and one high value for Ra-226 were identified as potential outliers (i.e., above 1.5 times the interquartile range) in the BG-2 box plots in Figure 1B. When viewed in the probability plots in Figure 4, the highest value for uranium does appear to be substantially higher than the rest of the dataset, while the second potential outlier is only slightly out of line with the rest of the data. The high values for molybdenum are the only detected values in the BG-2 dataset. The one high value for Ra-226 does appear to be substantially higher than the rest of the dataset; although there appears to be a second potential outlier in the Ra-226 dataset, this high value is equal to, but not greater than, 1.5 times the interquartile range. The values for arsenic, Ra-226 and vanadium are approximately linear in Figure 4, indicating a normally distributed dataset. These five potential outlier values are tested further for statistical significance in Section 3.1.3.

Figure 5. Background Reference Area 3 (BG-3) Soil Sample Probability Plots



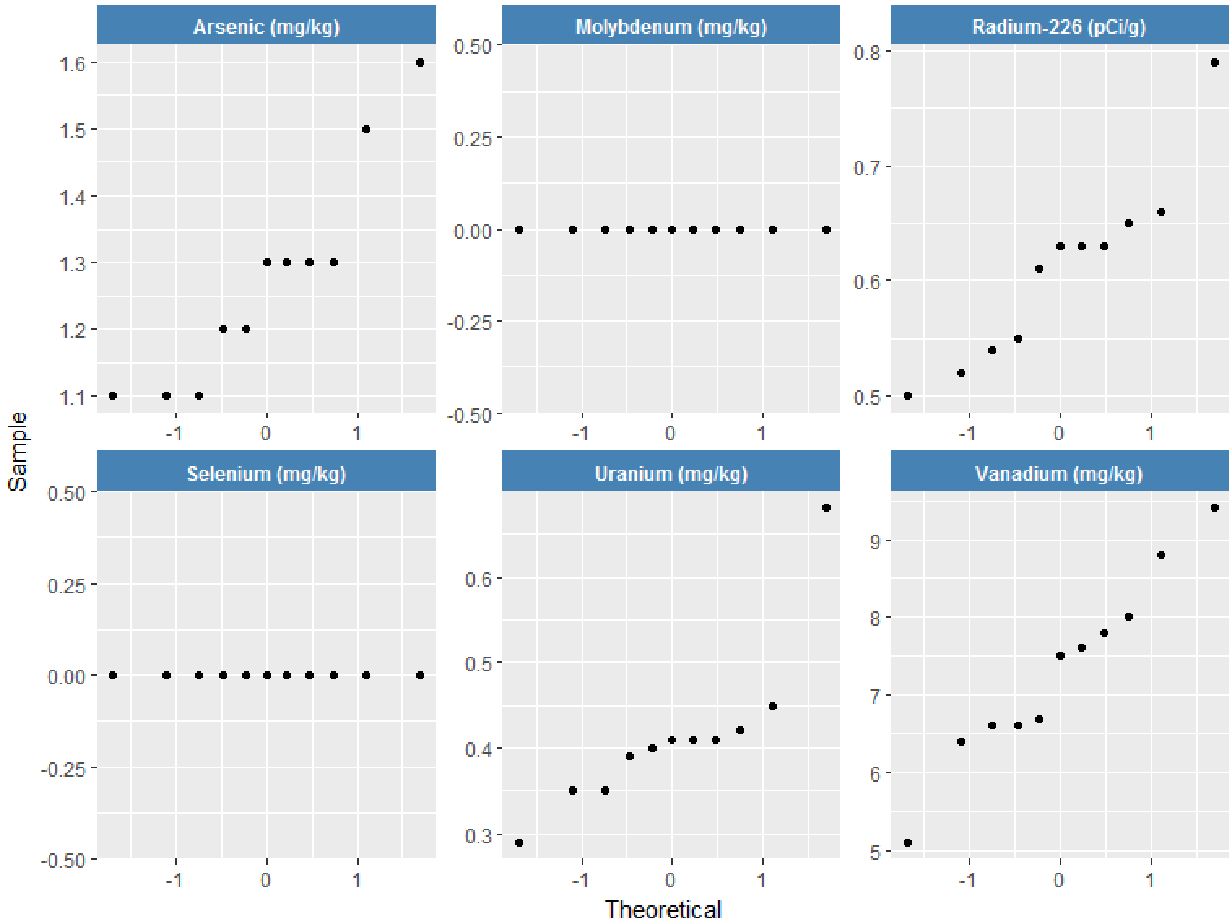
One high value for arsenic was identified as a potential outlier (i.e., above 1.5 times the interquartile range) in the BG-3 box plots in Figure 1B. When viewed in the probability plot in Figure 1B, the value does appear to be substantially higher than the rest of the dataset. The values for Ra-226, uranium and vanadium, and the detected values for molybdenum are approximately linear in Figure 5, indicating a normally distributed dataset. The one potential arsenic outlier value is tested further for statistical significance in Section 3.1.3.

Figure 6. Background Reference Area 4 (BG-4) Soil Sample Probability Plots



Two high values for molybdenum and one low value for uranium were identified as potential outliers (i.e., 1.5 times the interquartile range) in the BG-4 box plots in Figure 1B. When viewed in the probability plot in Figure 6, it is apparent that the high values for molybdenum are the only detected values in the BG-4 dataset. The low uranium value appears to be only slightly lower than the rest of the dataset. The values for arsenic, Ra-226, and vanadium are approximately linear in Figure 6, indicating a normally distributed dataset. These three potential outlier values are tested further for statistical significance as potential outliers in Section 3.1.3.

Figure 7. Background Reference Area 5 (BG-5) Soil Sample Probability Plots

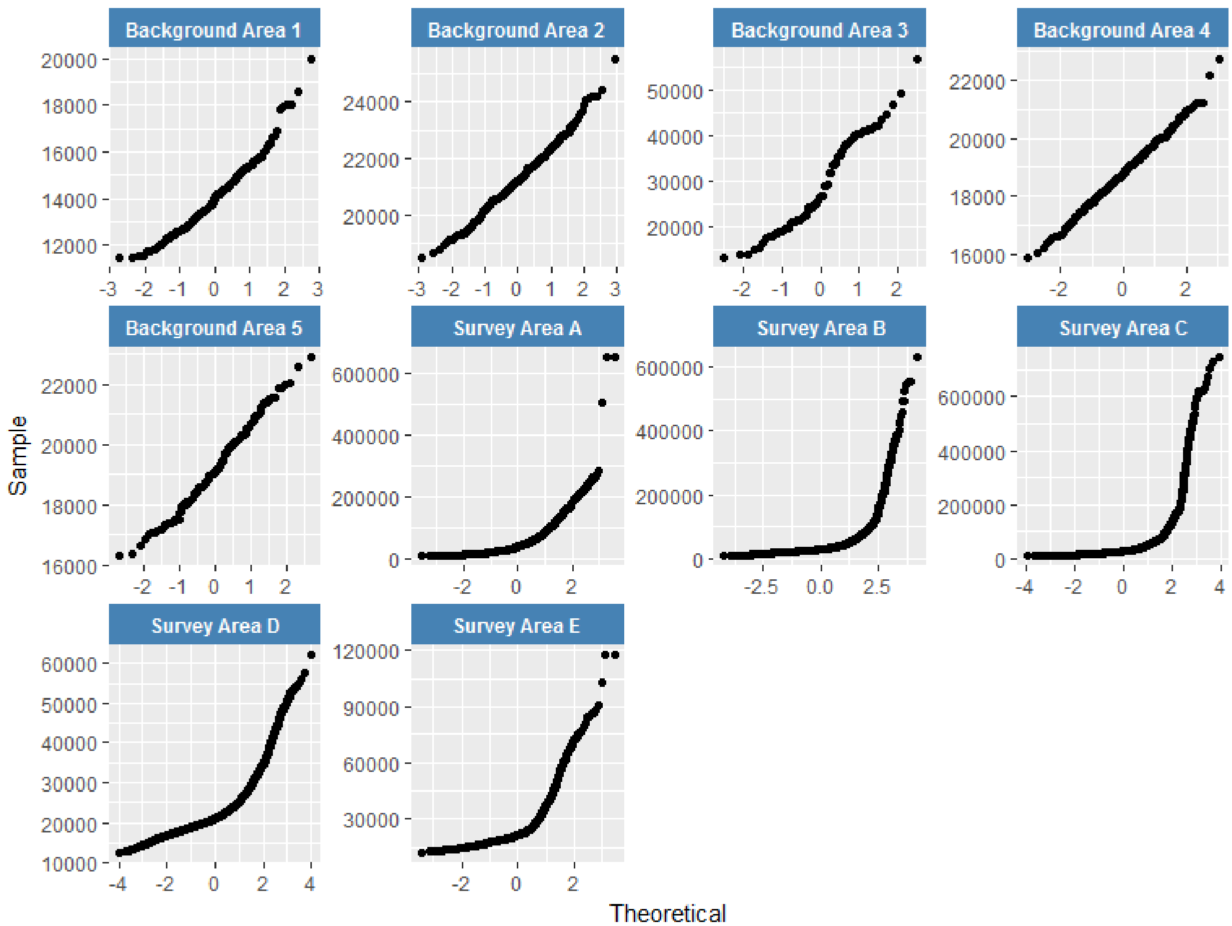


One high value each for arsenic and Ra-226, and one high value and one low value for uranium, were identified as potential outliers (i.e., 1.5 times the interquartile range) in the BG-5 box plots in Figure 1B. When viewed in the probability plots in Figure 7, the high values for Ra-226 and uranium, and the low value for uranium, do appear to be substantially higher or lower than the rest of their respective datasets. The high value for arsenic does not appear to be out of line with the rest of the dataset, suggesting that it represents natural variability within the dataset rather than an aberrant measurement. The values for arsenic and vanadium are approximately linear in Figure 7, indicating a normally distributed dataset. Although the highest arsenic value does not appear substantially different than the rest of the arsenic dataset, all four potential outlier values are tested further for statistical significance as potential outliers in Section 3.1.3.

3.1.2.2 Gamma Survey Results Probability Plots

Figure 8 depicts the probability plots for gamma radiation results at background reference areas and the Survey Areas.

Figure 8. Survey Area and Background Reference Area Gamma Probability Plots



The gamma probability plots for background reference areas in Figure 8 are approximately linear; these plots indicate that gamma data at background reference areas are approximately normally distributed. The five highest values in BG-1, identified as potential outliers in the box plot in Figure 2B, appear to be higher than, and out of line with, the distribution of the rest of the dataset indicating that they are potential outliers. High values at BG-2 and BG-4 also appear to be significantly elevated compared with the rest of the gamma datasets for these background reference areas. The 15 potential outliers in BG-1, BG-2 and BG-4 are further evaluated for statistical significance in Section 3.1.4. The highest values in the BG-3 and BG-5 datasets also appear slightly elevated relative to the rest of the data, however, these values are not outside 1.5 times the interquartile range for their respective datasets, and were not identified as potential outliers.

The gamma probability plots in Figure 8 for Survey Areas A, B, C, D and E are non-linear or S-shaped, indicating that gamma data from these Survey Areas are not normally distributed. The shape of the Survey Area A, B, C, D and E gamma probability plots indicates that the data may represent two or three distinct sub-groups of gamma radiation values within these Survey Areas. The smoothness of the probability plots for the survey areas at Section 26 suggests that high values shown in Figure 2B are not potential outliers, but rather are representative of the spatial variability of gamma radiation in these areas.

3.1.3 Potential Soil Sample Data Outliers

Fourteen high results and two low results were identified as potential outlier values in the box plots in Figure 1B and probability plots in Figures 3 through 7. These values are:

Background Reference Area 1 (BG-1)

- Arsenic: 11.0 mg/kg
- Molybdenum: 1.40 mg/kg
- Vanadium: 26.0 mg/kg

Background Reference Area 2 (BG-2)

- Molybdenum: 0.220 mg/kg, 0.330 mg/kg
- Radium-226: 2.70 mg/kg
- Uranium: 1.90 mg/kg, 3.40 mg/kg

Background Reference Area 3 (BG-3)

- Arsenic: 5.20 mg/kg

Background Reference Area 4 (BG-4)

- Molybdenum: 0.200 mg/kg, 0.210 mg/kg
- Uranium: 0.360 mg/kg (low)

Background Reference Area 5 (BG-5)

- Arsenic: 1.60 mg/kg
- Ra-226: 0.790 pCi/g
- Uranium: 0.290 mg/kg (low), 0.680 mg/kg

Dixon's Test (Dixon, 1953) is designed to be used for datasets containing a small number potential outlier values. Therefore, Dixon's Test was performed to the 95% confidence level on each of the potential outlier values identified in the BG-1, BG-2, BG-3, BG-4, and BG-5 datasets. The results of Dixon's Test are summarized in Table 1.

Table 1. Summary of Dixon's Test on Maximum Values

Area	Constituent	Location ID	Method	Hypothesis	p_Value	Conclusion
Background Reference Area 1 (BG-1)	As	S1011-BG1-005	Dixon test for potential outliers	High value 11.0 is a potential outlier	> 0.05	Hypothesis rejected
	Mo	S1011-BG1-005	Dixon test for potential outliers	High value 1.40 is a potential outlier	> 0.05	Hypothesis rejected
	V	S1011-BG1-005	Dixon test for potential outliers	High value 26.0 is a potential outlier	> 0.05	Hypothesis rejected
Background Reference Area 2 (BG-2)	Mo	S1011-BG2-009	Dixon test for potential outliers	High value 0.220 is a potential outlier	< 0.05	Hypothesis accepted
	Mo	S1011-BG2-010	Dixon test for potential outliers	High value 0.330 is a potential outlier	< 0.05	Hypothesis accepted
	Ra-226	S1011-BG2-002	Dixon test for potential outliers	High value 2.70 is a potential outlier	> 0.05	Hypothesis rejected
	U	S1011-BG2-003	Dixon test for potential outliers	High value 1.90 is a potential outlier	< 0.05	Hypothesis accepted
	U	S1011-BG2-010	Dixon test for potential outliers	High value 3.40 is a potential outlier	< 0.05	Hypothesis accepted
Background Reference Area 3 (BG-3)	As	S1011-BG3-010	Dixon test for potential outliers	High value 5.20 is a potential outlier	< 0.05	Hypothesis accepted
Background Reference Area 4 (BG-4)	Mo	S1011-BG4-004	Dixon test for potential outliers	High value 0.210 is a potential outlier	< 0.05	Hypothesis accepted
	Mo	S1011-BG4-009	Dixon test for potential outliers	High value 0.200 is a potential outlier	< 0.05	Hypothesis accepted
	U	S1011-BG4-001	Dixon test for potential outliers	Low value 0.360 is a potential outlier	> 0.05	Hypothesis rejected
Background Reference Area 5 (BG-5)	As	S1011-BG5-011	Dixon test for potential outliers	High value 1.60 is a potential outlier	> 0.05	Hypothesis rejected
	Ra-226	S1011-BG5-008	Dixon test for potential outliers	High value 0.790 is a potential outlier	> 0.05	Hypothesis rejected
	U	S1011-BG5-004	Dixon test for potential outliers	Low value 0.290 is a potential outlier	> 0.05	Hypothesis rejected
	U	S1011-BG5-007	Dixon test for potential outliers	High value 0.680 is a potential outlier	< 0.05	Hypothesis accepted

As = Arsenic Mo = Molybdenum U = Uranium V = Vanadium Ra-226 = Radium 226

The test confirms that eight of the 16 potential outliers tested are statistically significant (p value <0.05). These potential outlier values were further investigated by reviewing sample forms, notes and laboratory reports. Field staff and field notes indicated nothing abnormal about the locations where these samples were collected, and the laboratory datasets show no data quality flags were applied that would call the accuracy of the results in to question. Therefore, while these values: 1) are outside the interquartile range of their respective datasets (Figure 1B), 2) do not conform with their dataset distributions in the probability plots (Figures 3 through 7), and 3) are deemed potential outliers by Dixon's Test, they were not removed from the background reference area datasets because no scientific reason was found to justify removing them, and they are considered representative of the natural variation of the background reference areas. However, Section 3.3 presents statistics calculated both with and without these potential outlier values.

3.1.4 Potential Gamma Data Outliers

A total of 15 potential outliers were identified from the background reference area gamma survey datasets. These values were initially identified in the box plots in Figure 2B.

High gamma values were identified for the BG-1, BG-2, and BG-4 gamma datasets shown in the boxplots in Figure 2B. When viewed in the probability plots in Figure 8, gamma probability plots for all the background reference areas are largely linear, indicating normal distribution. Because the number of values in the background reference areas gamma datasets are each >30, Dixon’s Test was not appropriate for testing potential outliers. Instead, because the values appear to be generally normally distributed, it was appropriate to identify potential outliers using Z, t and chi squared scoring methods at the 95% confidence level. These tests were performed in the 'Outliers' package in R (Lukasz Komsta, 2011), and the results are summarized in Table 2. The R programming language complements ProUCL in its ability to provide more meaningful and useful graphics and summarizes the results equivalent to ProUCL. Because ProUCL and R packages follow similar statistical procedures, the results are comparable. The interquartile range evaluation (values outside 1.5 times the interquartile range) results are also provided in Table 2.

The results presented in Table 2 are deemed potential outliers and represent 15 of 901 data points (1.7 percent) in BG-1, BG-2 and BG-4. One possible reason for the small number/percentage of potential outliers in the gamma radiation dataset, may be the presence of a localized source of radiation within a background reference area. Nothing in the field notes or the gamma data records indicates a scientific reason for these values to be excluded (e.g., data handling error, equipment malfunction), and there is no record of anomalous soil or other material in the background reference areas. Therefore, the values are considered representative of the natural variation present, and there is no basis to remove them from the gamma dataset. However, descriptive statistics were calculated with and without these values for comparison (Section 3.3.2).

Table 2. Potential Gamma Outlier Interquartile Range, Z Score, t Score and Chi Squared Score Results

Area	Value (cpm)	Interquartile Range Result	Z Score Result	t Score Result	Chi Sq Score Result
Background Reference Area 1 (BG-1)	20,015	High	Potential Outlier	Potential Outlier	Potential Outlier
	18,564	High	Potential Outlier	Potential Outlier	Potential Outlier
	18,022	High	Potential Outlier	Potential Outlier	Potential Outlier
	18,021	High	Potential Outlier	Potential Outlier	Potential Outlier
	17,971	High	Potential Outlier	Potential Outlier	Potential Outlier
Background Reference Area 2 (BG-2)	25,542	High	Potential Outlier	Potential Outlier	Potential Outlier
	24,440	High	Potential Outlier	Potential Outlier	Potential Outlier
	24,202	High	Potential Outlier	Potential Outlier	Potential Outlier
	24,192	High	Potential Outlier	Potential Outlier	Potential Outlier
	24,160	High	Potential Outlier	Potential Outlier	Potential Outlier
	24,080	High	Potential Outlier	Potential Outlier	Potential Outlier
Background Reference Area 4 (BG-4)	22,772	High	Potential Outlier	Potential Outlier	Potential Outlier
	22,206	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,008	Low	Potential Outlier	Potential Outlier	Potential Outlier
	15,868	Low	Potential Outlier	Potential Outlier	Potential Outlier

cpm Counts per minute

Potential outlier values in the gamma dataset for the Survey Areas appear in the Figure 2A boxplots. Because of the non-linear shape and continuous distribution of gamma results shown in the probability plot in Figure 8, the values are thought to be representative of the heterogeneous nature of radioactive materials within the Survey Areas and are not outlier values. Figure 4-1 of the RSE Report shows that while gamma results for the majority of each of the Survey Areas are within the range of background, localized areas of elevated gamma results associated with mineralized areas are also present.

3.2 COMPARE DATA POPULATIONS

Group comparison analyses provide insight into the relative concentrations of constituents between background reference areas and the Survey Areas. Observations made during these analyses may indicate the need for further evaluation or discussion regarding the influence of potential outlier values, and the use of background data. For instance, if two or more background areas were determined to be statistically similar to each other, these data could be combined to calculate more robust statistics (not a factor in this evaluation, as one background area each was selected to represent the five Survey Areas). Alternatively, testing of this kind may reveal background concentrations statistically higher than corresponding Survey Area concentrations, requiring additional interpretation or modifications in the use of background area datasets. Finally, results of these evaluations are a component of determining background area representativeness, though statistical comparisons are not the only factors to be considered in judging representativeness. Factors such as geologic materials, topographic gradient, distance from the site being represented, wind direction and non-impacted condition are all important to the selection of background reference areas.

Group comparisons, therefore, are considered instructive as a component of the overall evaluation of soil sample and gamma radiation survey results collected from the background reference areas and the Survey Areas. Relative data distributions were investigated by evaluating the box plots and probability plots in Figures 1A through 8, and by hypothesis testing with the non-parametric Mann-Whitney test, as applicable.

3.2.1 Evaluation of Box Plots

3.2.1.1 Soil Sample Box Plots

When interpreting the soil sample boxplots in Figures 1A and 1B, it is important to note that samples at background reference areas were collected randomly, while samples in the Survey Areas were collected judgmentally from areas of suspected contamination. Analytic constituent results from background reference areas tend to be lower than, or similar to, analytical results from their respective Survey Areas. Analytical constituent-specific observations from the boxplots in Figures 1A and 1B indicate:

- Arsenic. Arsenic results appear highest at BG-1 and its corresponding Survey Area A. Arsenic results at Survey Area B appear higher than in BG-2. Arsenic results from the BG-3, BG-4 and BG-5 are similar to those measured in their corresponding Survey Areas.
- Molybdenum. Molybdenum results appear highest at BG-1 and at Survey Area B. Molybdenum results from BG-3 are similar to Survey Area C. Molybdenum results from BG-1 appear higher than in Survey Area A. Molybdenum was not detected in BG-5, Survey Area D and Survey Area E.
- Ra-226. Ra-226 results appear highest in Survey Areas A and C. Ra-226 results appear higher in all Survey Areas when compared to their respective background reference areas.
- Selenium. Selenium was not detected in any background reference area or Survey Area.
- Uranium. Uranium results appear highest in Survey Area A. Uranium results appear similar between BG-2, BG-3, BG-4, BG-5, Survey Area D and Survey Area E, and slightly elevated at BG-1. Uranium results in Survey Areas A, B and C are higher than in the background reference areas.
- Vanadium. Vanadium results appear highest in Survey Area A. Vanadium results appear similar between BG-1, BG-2, BG-3, BG-4, BG-5 and Survey Area D, and elevated at Survey Areas A, B, C, and E.

3.2.1.2 Gamma Radiation Box Plots and Probability Plots

The box plot comparison in Figures 2A and 2B suggests that mean, median and interquartile range gamma values are similar between BG-1, BG-2, BG-4 and BG-5, while those in BG-3 are higher. Gamma values in the Survey Areas appear higher, and more skewed, than the background reference areas, with this being most pronounced in the Survey Area A, Survey Area B and Survey Area C datasets. These observations of relative similarities and differences between the gamma datasets are further evaluated in Section 3.2.2 using the non-parametric Mann-Whitney test.

3.2.2 Mann-Whitney Testing

The Mann-Whitney test (Bain and Engelhardt, 1992) is a nonparametric test used to determine whether a difference exists between two or more population distributions. This test is also known as the Wilcoxon Rank Sum (WRS) test. This test evaluates whether measurements from one population consistently tend to be larger (or smaller) than those from another population. This test was selected over other comparative tests such as the Student's t test and analysis of variance (ANOVA) because it remains robust in the absence of required assumptions that these two tests require, such as normally distributed data and equality of variances.

Soil samples at background reference areas were collected randomly, while soil samples in the Survey Areas were collected judgmentally (see Section 3.1). Mann-Whitney testing is not appropriate for comparative analysis if one or both groups contain data collected using a judgmental approach. Therefore, the Mann-Whitney test was not performed for soil sample data between background reference areas and Survey Areas. Gamma radiation data, however, do represent non-judgmental sampling, and so the Mann-Whitney test was appropriate for comparison between background reference areas and Survey Areas (Table 3). Therefore, the test was performed 2-sided on the background reference area and Survey Area gamma radiation data. The two-sided test accounts for results from one group being lower or higher than any other group (i.e., the hypothesis tested whether the two groups differ, independent of which group is higher). A test result p-value of 0.05 or smaller indicates that a significant difference exists between any two groups that are compared. Results of Mann-Whitney testing are presented in Table 3.

Table 3. Summary of Gamma Survey Mann-Whitney Test Results

Comparison	p_Value	Description
Background Reference Area 1 (BG-1) vs Survey Area A	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 1 (BG-1) Potential Outliers Excluded	0.643	No Significant Difference
Background Reference Area 1 (BG-1) Potential Outliers Excluded vs Survey Area A	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Survey Area B	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Background Reference Area 2 (BG-2) Potential Outliers Excluded	0.667	No Significant Difference
Background Reference Area 2 (BG-2) Potential Outliers Excluded vs Survey Area B	<0.05	Significant Difference
Background Reference Area 3 (BG-3) vs Survey Area C	0.303	No Significant Difference
Background Reference Area 4 (BG-4) vs Survey Area D	<0.05	Significant Difference
Background Reference Area 4 (BG-4) vs Background Reference Area 4 (BG-4) Potential Outliers Excluded	1.00	No Significant Difference
Background Reference Area 4 (BG-4) Potential Outliers Excluded vs Survey Area D	<0.05	Significant Difference
Background Reference Area 5 (BG-5) vs Survey Area E	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 2 (BG-2)	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 3 (BG-3)	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 4 (BG-4)	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 5 (BG-5)	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Background Reference Area 3 (BG-3)	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Background Reference Area 4 (BG-4)	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Background Reference Area 5 (BG-5)	<0.05	Significant Difference
Background Reference Area 3 (BG-3) vs Background Reference Area 4 (BG-4)	<0.05	Significant Difference
Background Reference Area 3 (BG-3) vs Background Reference Area 5 (BG-5)	<0.05	Significant Difference
Background Reference Area 4 (BG-4) vs Background Reference Area 5 (BG-5)	<0.05	Significant Difference
Survey Area A vs Survey Area B	<0.05	Significant Difference
Survey Area A vs Survey Area C	<0.05	Significant Difference
Survey Area A vs Survey Area D	<0.05	Significant Difference
Survey Area A vs Survey Area E	<0.05	Significant Difference
Survey Area B vs Survey Area C	<0.05	Significant Difference
Survey Area B vs Survey Area D	<0.05	Significant Difference
Survey Area B vs Survey Area E	<0.05	Significant Difference
Survey Area C vs Survey Area D	<0.05	Significant Difference
Survey Area C vs Survey Area E	<0.05	Significant Difference
Survey Area D vs Survey Area E	<0.05	Significant Difference

The results of the Mann-Whitney testing on gamma radiation survey results in Table 3 indicate the following:

- Gamma results are statistically elevated in Survey Area A with respect to BG-1.
- Gamma results are statistically elevated in Survey Area B with respect to BG-2. The inclusion or removal of potential outlier values from BG-2 has no effect on this result.
- Gamma results are not statistically different between BG-3 and Survey Area C. While there are much higher values in the Survey Area C dataset compared to BG-3, the Mann-Whitney test compares group means and concludes that mean gamma results are not statistically different between BG-3 and Survey Area C.
- Gamma results are statistically elevated in Survey Area D with respect to BG-4. The inclusion or removal of potential outlier values from BG-4 has no effect on this result.
- Gamma results are statistically elevated in Survey Area E with respect to BG-5.
- Gamma datasets from all five background reference areas differ significantly from each other.
- Gamma datasets from all five Survey Areas differ significantly from each other.
- The observation that gamma results at four Survey Areas are elevated relative to their respective background reference areas is likely attributable to the fact that background reference areas may not fully represent the degree of natural mineralization present at Survey Areas (see RSE Report Section 3.2.2.2). This latter point does not prohibit use of the gamma ILs calculated from these background reference areas, but this observation should be considered, as Site conditions are further evaluated for remediation.

3.3 DESCRIPTIVE STATISTICS

Descriptive statistics, including the upper confidence limit (UCL) of the mean and the 95-95 upper tolerance limit (UTL), were calculated from gamma survey data and soil sample results. Descriptive statistics are important for any data evaluation to present the basic statistics of a data set with regards to its limits (maximum and minimum), central tendencies (mean and median) as well as data dispersion (coefficient of variance). The ILs for the Site also are taken from the descriptive statistics, namely the 95-95 UTL. The parameters and constituents evaluated include gamma radiation, arsenic, molybdenum, selenium, uranium, vanadium, and Ra-226. Selenium results for all background reference areas and molybdenum results for BG-5 were 100 percent non-detect; therefore, no statistics were calculated for selenium and molybdenum at these respective background reference areas.

Statistics were calculated using Environmental Protection Agency (EPA) ProUCL version 5.1 software. Statistical methodology employed by the software is documented in the *ProUCL Version 5.1 Technical Guide Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations* (EPA, 2015). In the case of non-detect results, ProUCL does not recommend detection limit substitution methods (e.g., 1/2 the detection limit), considering these methods to be imprecise and out of date (EPA, 2015). The software instead calculates descriptive statistics for the detected results only, and follows various methods accordingly to calculate UCL and UTL values based on the percentage of non-detect results present in the dataset and on the distribution of the data (i.e., normal, lognormal, gamma, or unknown distribution).

Descriptive statistics for soil samples and gamma radiation survey results have been calculated with and without the potential outlier values previously identified, as applicable. Select descriptive statistics for these constituents are presented in Tables 4 and 5.

3.3.1 Soil Sample Analytical Results Summary

Table 4 presents the descriptive statistics output from the ProUCL software for the soil sample results.

The relative levels of arsenic, molybdenum, selenium, uranium, vanadium, and Ra-226 results measured between the background reference areas and Survey Areas are shown in the box plots in Figures 1A and 1B and are described in Section 3.2.1.1. An important consideration when comparing concentrations of metals and Ra-226 between background reference areas and the Survey Areas is that the background reference areas were selected to be representative of the geology present in the region around the Site, whereas the Site was selected as a mine claim because it is in an area of mineralized bedrock likely to have localized, naturally elevated uranium concentrations (see RSE Report Section 3.2.2.2). In addition, soil sampling for metals and Ra-226 in the background reference areas was conducted in a random manner, whereas soil sampling for metals and Ra-226 in the Survey Areas was judgmental. As a result, it's not surprising that metals and Ra-226 concentrations in the Survey Areas appear to be elevated relative to the background reference areas. It should be noted, however, that concentrations of several of the metals measured in the Survey Areas are within the range of metals concentrations typically observed in Western U.S. soils (United States Geological Survey [USGS], 1984):

- Arsenic (mean = 5.5 mg/kg; range <0.10 – 97 mg/kg)
- Molybdenum (mean = 0.85 mg/kg; range <3 – 7 mg/kg)
- Selenium (mean = 0.23 mg/kg; range <0.1 – 4.3 mg/kg)
- Uranium (mean = 2.5 mg/kg; range 0.68 – 7.9 mg/kg)
- Vanadium (mean = 70 mg/kg; range 7 – 500 mg/kg)

As shown in Table 4, maximum detected concentrations of arsenic and vanadium in the Survey Areas are within typical ranges reported for Western U.S soils, and may not be related to the uranium mineralization. Exceptions to the above are molybdenum, uranium, and Ra-226; elevated concentrations of these constituents in the Survey Area are present in soils associated with mining-related disturbances at the Site.

Table 4. Summary of Soil Sampling Results

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Reference Area 1 (BG-1) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	18%	100%	--	--	--
	Minimum¹	2.00	--	--	1.60	5.50	1.05
	Minimum Detect²	--	0.320	--	--	--	--
	Mean¹	4.32	--	--	2.17	11.5	1.47
	Mean Detects²	--	0.567	--	--	--	--
	Median¹	3.40	--	--	2.10	11.0	1.43
	Median Detects²	--	0.490	--	--	--	--
	Maximum¹	11.0	--	--	2.80	26.0	1.86
	Maximum Detect²	--	1.40	--	--	--	--
	Distribution	Normal	Gamma	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation¹	0.621	--	--	0.172	0.488	0.160
	CV Detects²	--	0.587	--	--	--	--
	UCL Type	95% Student's-t UCL	95% KM Adjusted Gamma UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	5.78	0.824	Not Calculated	2.38	14.6	1.60
	UTL Type	UTL Normal	UTL KM Gamma WH	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	11.9	2.26	Not Calculated	3.23	27.3	2.13
Background Reference Area 2 (BG-2) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	82%	100%	--	--	--
	Minimum¹	1.30	--	--	1.30	6.70	1.73
	Minimum Detect²	--	0.220	--	--	--	--
	Mean¹	1.69	--	--	1.69	8.52	2.07
	Mean Detects²	--	0.275	--	--	--	--
	Median¹	1.70	--	--	1.50	8.60	2.02
	Median Detects²	--	0.275	--	--	--	--
	Maximum¹	2.00	--	--	3.40	10.0	2.70
	Maximum Detect²	--	0.330	--	--	--	--
	Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation¹	0.136	--	--	0.347	0.114	0.152
	CV Detects²	--	0.283	--	--	--	--
	UCL Type	95% Student's-t UCL	95% KM (t) UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	1.82	0.156	Not Calculated	2.01	9.05	2.25
	UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	2.34	0.346	Not Calculated	3.34	11.2	2.96
Background Reference Area 2 (BG-2) Excluding Potential Outliers ³	Total Number of Observations	--	9	--	9	--	--
	Percent Non-Detects	--	100%	--	--	--	--
	Minimum¹	--	--	--	1.30	--	--
	Minimum Detect²	--	--	--	--	--	--
	Mean¹	--	--	--	1.48	--	--
	Mean Detects²	--	--	--	--	--	--
	Median¹	--	--	--	1.50	--	--
	Maximum¹	--	--	--	1.60	--	--
	Maximum Detect²	--	--	--	--	--	--
	Distribution	--	Not Calculated	--	Normal	--	--
	Coefficient of Variation¹	--	--	--	0.066	--	--
	UCL Type	--	Not Calculated	--	95% Student's-t UCL	--	--
	UCL Result	--	Not Calculated	--	1.54	--	--
	UTL Type	--	Not Calculated	--	UTL Normal	--	--
	UTL Result	--	Not Calculated	--	1.77	--	--

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Reference Area 3 (BG-3) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	64%	100%	--	--	--
	Minimum¹	1.00	--	--	0.600	9.20	0.710
	Minimum Detect²	--	0.200	--	--	--	--
	Mean¹	1.57	--	--	1.05	11.3	0.985
	Mean Detects²	--	0.260	--	--	--	--
	Median¹	1.20	--	--	1.00	10.0	0.990
	Median Detects²	--	0.235	--	--	--	--
	Maximum¹	5.20	--	--	1.60	15.0	1.23
	Maximum Detect²	--	0.370	--	--	--	--
	Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation¹	0.772	--	--	0.293	0.191	0.181
	CV Detects²	--	0.300	--	--	--	--
	UCL Type	95% Student's-t UCL	95% KM (t) UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	2.24	0.245	Not Calculated	1.21	12.5	1.08
	UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	4.99	0.367	Not Calculated	1.91	17.4	1.49
Background Reference Area 3 (BG-3) Excluding Potential Outliers ³	Total Number of Observations	10	--	--	--	--	--
	Minimum¹	1.00	--	--	--	--	--
	Mean¹	1.21	--	--	--	--	--
	Median¹	1.20	--	--	--	--	--
	Maximum¹	1.50	--	--	--	--	--
	Distribution	Normal	--	--	--	--	--
	Coefficient of Variation¹	0.143	--	--	--	--	--
	UCL Type	95% Student's-t UCL	--	--	--	--	--
	UCL Result	1.31	--	--	--	--	--
	UTL Type	UTL Normal	--	--	--	--	--
	UTL Result	1.71	--	--	--	--	--
Background Reference Area 4 (BG-4) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	82%	100%	--	--	--
	Minimum¹	1.20	--	--	0.360	7.70	0.710
	Minimum Detect²	--	0.200	--	--	--	--
	Mean¹	1.43	--	--	0.444	9.01	0.985
	Mean Detects²	--	0.205	--	--	--	--
	Median¹	1.50	--	--	0.460	9.20	1.04
	Median Detects²	--	0.205	--	--	--	--
	Maximum¹	1.60	--	--	0.490	9.80	1.27
	Maximum Detect²	--	0.210	--	--	--	--
	Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation¹	0.083	--	--	0.088	0.077	0.180
	CV Detects²	--	0.035	--	--	--	--
	UCL Type	95% Student's-t UCL	95% KM (t) UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	1.49	0.197	Not Calculated	0.465	9.39	1.08
	UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	1.76	0.210	Not Calculated	0.554	11.0	1.49
Background Reference Area 4 (BG-4) Excluding Potential Outliers	Total Number of Observations	--	9	--	--	--	--
	Percent Non-Detects	--	100%	--	--	--	--
	Distribution	--	Not Calculated	--	--	--	--
	UCL Type	--	Not Calculated	--	--	--	--
	UCL Result	--	Not Calculated	--	--	--	--
	UTL Type	--	Not Calculated	--	--	--	--
	UTL Result	--	Not Calculated	--	--	--	--

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Reference Area 5 (BG-5) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	100%	100%	--	--	--
	Minimum¹	1.10	--	--	0.290	5.10	0.500
	Minimum Detect²	--	--	--	--	--	--
	Mean¹	1.27	--	--	0.415	7.32	0.610
	Mean Detects²	--	--	--	--	--	--
	Median¹	1.30	--	--	0.410	7.50	0.630
	Maximum¹	1.60	--	--	0.680	9.40	0.790
	Maximum Detect²	--	--	--	--	--	--
	Distribution	Normal	Not Calculated	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation¹	0.127	--	--	0.237	0.165	0.134
	UCL Type	95% Student's-t UCL	Not Calculated	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	1.36	Not Calculated	Not Calculated	0.468	7.98	0.655
	UTL Type	UTL Normal	Not Calculated	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	1.73	Not Calculated	Not Calculated	0.691	10.7	0.839
Background Reference Area 5 (BG-5) Excluding Potential Outliers	Total Number of Observations	--	--	--	10	--	--
	Minimum¹	--	--	--	0.290	--	--
	Mean¹	--	--	--	0.388	--	--
	Median¹	--	--	--	0.405	--	--
	Maximum¹	--	--	--	0.450	--	--
	Distribution	--	--	--	Normal	--	--
	Coefficient of Variation¹	--	--	--	0.118	--	--
	UCL Type	--	--	--	95% Student's-t UCL	--	--
	UCL Result	--	--	--	0.415	--	--
	UTL Type	--	--	--	UTL Normal	--	--
	UTL Result	--	--	--	0.522	--	--
Survey Area A	Total Number of Observations	6	6	6	6	6	6
	Percent Non-Detects	--	17%	100%	--	--	--
	Minimum¹	2.30	--	--	5.30	16.0	2.93
	Minimum Detect²	--	0.270	--	--	--	--
	Mean¹	3.67	--	--	58.2	123	18.9
	Mean Detects²	--	0.384	--	--	--	--
	Median¹	3.45	--	--	28.5	57.0	10.3
	Median Detects²	--	0.350	--	--	--	--
	Maximum¹	5.90	--	--	230	380	64.4
	Maximum Detect²	--	0.580	--	--	--	--
	Distribution	Normal	Normal	Not Calculated	Gamma	Normal	Normal
	Coefficient of Variation¹	0.343	--	--	1.47	1.18	1.22
	CV Detects²	--	0.311	--	--	--	--
	UCL Type	95% Student's-t UCL	95% KM (t) UCL	Not Calculated	95% Adjusted Gamma UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	4.70	0.463	Not Calculated	376	243	37.8
	UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Gamma WH	UTL Normal	UTL Normal
	UTL Result	8.33	0.801	Not Calculated	766	664	104

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Survey Area B	Total Number of Observations	40	40	40	40	40	40
	Percent Non-Detects	--	55%	100%	--	--	--
	Minimum[1]	1.30	--	--	0.560	7.20	0.880
	Minimum Detect[2]	--	0.200	--	--	--	--
	Mean[1]	2.34	--	--	6.55	21.4	4.06
	Mean Detects[2]	--	0.927	--	--	--	--
	Median[1]	2.25	--	--	2.45	14.5	2.76
	Median Detects[2]	--	0.240	--	--	--	--
	Maximum[1]	3.60	--	--	68.0	92.0	13.6
	Maximum Detect[2]	--	11.0	--	--	--	--
	Distribution	Normal	Unknown	Not Calculated	Lognormal	Unknown	Gamma
	Coefficient of Variation[1]	0.238	--	--	1.79	0.805	0.785
	CV Detects[2]	--	2.72	--	--	--	--
	UCL Type	95% Student's-t UCL	95% KM (Chebyshev) UCL	Not Calculated	95% H-UCL	95% Chebyshev (Mean, Sd) UCL	95% Adjusted Gamma UCL
	UCL Result	2.48	1.65	Not Calculated	9.49	33.2	5.01
	UTL Type	UTL Normal	Non-Parametric -Max	Not Calculated	UTL Lognormal	UTL Non-Parametric	UTL Gamma WH
	UTL Result	3.51	11.0	Not Calculated	34.6	92.0	12.4
Survey Area C	Total Number of Observations	5	5	5	5	5	5
	Percent Non-Detects	--	80%	100%	--	--	--
	Minimum[1]	0.940	--	--	0.480	8.30	0.950
	Minimum Detect[2]	--	0.270	--	--	--	--
	Mean[1]	1.59	--	--	30.5	91.7	8.98
	Mean Detects[2]	--	0.270	--	--	--	--
	Median[1]	1.30	--	--	7.10	43.0	5.64
	Maximum[1]	3.40	--	--	120	310	24.3
	Maximum Detect[2]	--	0.270	--	--	--	--
	Distribution	Lognormal	Not Calculated	Not Calculated	Gamma	Normal	Normal
	Coefficient of Variation[1]	0.646	--	--	1.67	1.37	1.07
	UCL Type	95% H-UCL	Not Calculated	Not Calculated	95% Adjusted Gamma UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	3.48	Not Calculated	Not Calculated	656	212	18.2
	UTL Type	UTL Lognormal	Not Calculated	Not Calculated	UTL Gamma WH	UTL Normal	UTL Normal
	UTL Result	12.3	Not Calculated	Not Calculated	826	621	49.4
Survey Area D	Total Number of Observations	4	4	4	4	4	4
	Percent Non-Detects	--	100%	100%	--	--	--
	Minimum[1]	0.840	--	--	0.570	8.40	0.720
	Minimum Detect[2]	--	--	--	--	--	--
	Mean[1]	1.16	--	--	1.11	13.3	1.20
	Mean Detects[2]	--	--	--	--	--	--
	Median[1]	1.20	--	--	0.940	12.5	1.15
	Maximum[1]	1.40	--	--	2.00	20.0	1.77
	Maximum Detect[2]	--	--	--	--	--	--
	Distribution	Normal	Not Calculated	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation[1]	0.213	--	--	0.614	0.396	0.363
	UCL Type	95% Student's-t UCL	Not Calculated	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	1.45	Not Calculated	Not Calculated	1.92	19.5	1.71
	UTL Type	UTL Normal	Not Calculated	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	2.43	Not Calculated	Not Calculated	4.63	40.4	3.43

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Survey Area E	Total Number of Observations	4	4	4	4	4	4
	Percent Non-Detects	--	100%	100%	--	--	--
	Minimum[1]	0.560	--	--	0.680	4.10	0.720
	Minimum Detect[2]	--	--	--	--	--	--
	Mean[1]	0.913	--	--	1.03	17.9	1.37
	Mean Detects[2]	--	--	--	--	--	--
	Median[1]	0.895	--	--	0.765	7.75	1.56
	Maximum[1]	1.30	--	--	1.90	52.0	1.64
	Maximum Detect[2]	--	--	--	--	--	--
	Distribution	Normal	Not Calculated	Not Calculated	Normal	Gamma	Normal
	Coefficient of Variation[1]	0.340	--	--	0.569	1.27	0.318
	UCL Type	95% Student's-t UCL	Not Calculated	Not Calculated	95% Student's-t UCL	95% Adjusted Gamma UCL	95% Student's-t UCL
	UCL Result	1.28	Not Calculated	Not Calculated	1.72	--	1.88
	UTL Type	UTL Normal	Not Calculated	Not Calculated	UTL Normal	UTL Gamma WH	UTL Normal
	UTL Result	2.51	Not Calculated	Not Calculated	4.03	382	3.61

1	This statistic is reported by ProUCL when the dataset contains 100 percent detections.
2	This statistic is reported by ProUCL when non-detect values exist in the dataset. The value reported is calculated using detections only.
3	Statistics shown are for the constituents where statistical potential outliers were identified, calculated with the potential outliers removed.
CV	Coefficient of variation
KM	Kaplan Meier
mg/kg	Milligrams per kilogram
--	Not applicable
pCi/g	Picocuries per gram
WH	Wilson Hilferty
Note	The UTL result that is shown on the table is based on the output from ProUCL. ProUCL evaluates the data and provides all possible UCLs from its UCL module for three possible data distributions, then identifies a recommended UCL value. ProUCL does not identify a recommended UTL value. The UTLs are therefore based on the distribution of the recommended UCL. Please refer to *ProUCL Version 5.1 Technical Guide Statistical Software for Environmental Applications for Data Sets with and without Non-detect Observations* (EPA, 2015) for further information

3.3.2 Gamma Radiation Results Summary

As noted for metals and Ra-226 in Section 3.3.1, gamma results measured within the Survey Areas are elevated relative to gamma results measured in background reference areas because background reference areas were selected to represent the geology present in the region around the Site, whereas the Site was selected as a mine claim because it is in an area of mineralized bedrock likely to have localized naturally elevated uranium concentrations. Therefore, it's not surprising that gamma results within the Survey Areas are somewhat higher than gamma results at the background reference areas. Elevated gamma results in portions of the Survey Areas are likely attributable to historic waste piles, as well as a higher degree of natural mineralization within the Survey Areas relative to the background reference areas.

Table 5 presents the descriptive statistics output from the ProUCL software for the gamma radiation survey results.

Table 5. Summary of Walk-over Gamma Results

Area	Statistic	Gamma (cpm)
Background Reference Area 1 (BG-1) All Data	Total Number of Observations	171
	Minimum	11,464
	Mean	14,082
	Median	14,041
	Maximum	20,015
	Distribution	Normal
	Coefficient of Variation	0.105
	UCL Type	95% Student's-t UCL
	UCL Result	14,269
	UTL Type	UTL Normal
	UTL Result	16,829
Background Reference Area 1 (BG-1) Excluding Potential Outliers	Total Number of Observations	166
	Minimum	11,464
	Mean	13,948
	Median	13,944
	Maximum	17,840
	Distribution	Normal
	Coefficient of Variation	0.092
	UCL Type	95% Student's-t UCL
	UCL Result	14,112
	UTL Type	UTL Normal
	UTL Result	16,319
Background Reference Area 2 (BG-2) All Data	Total Number of Observations	288
	Minimum	18,508
	Mean	21,269
	Median	21,227
	Maximum	25,542
	Distribution	Normal
	Coefficient of Variation	0.054
	UCL Type	95% Student's-t UCL
	UCL Result	21,379
	UTL Type	UTL Normal
	UTL Result	23,320
Background Reference Area 2 (BG-2) Excluding Potential Outliers	Total Number of Observations	282
	Minimum	18,508
	Mean	21,201
	Median	21,207
	Maximum	23,932
	Distribution	Normal
	Coefficient of Variation	0.050
	UCL Type	95% Student's-t UCL
	UCL Result	21,304
	UTL Type	UTL Normal
	UTL Result	23,093
Background Reference Area 3 (BG-3) All Data	Total Number of Observations	80
	Minimum	13,202
	Mean	29,080
	Median	26,603
	Maximum	57,059
	Distribution	Normal
	Coefficient of Variation	0.341
	UCL Type	95% Student's-t UCL
	UCL Result	30,927
	UTL Type	UTL Normal
	UTL Result	48,542
Background Reference Area 4 (BG-4) All Data	Total Number of Observations	442
	Minimum	15,868
	Mean	18,804
	Median	18,780
	Maximum	22,772
	Distribution	Normal
	Coefficient of Variation	0.055
	UCL Type	95% Student's-t UCL
	UCL Result	18,886
	UTL Type	UTL Normal
	UTL Result	20,637
Background Reference Area 4 (BG-4) Excluding Potential Outliers	Total Number of Observations	438
	Minimum	16,230
	Mean	18,801
	Median	18,780
	Maximum	21,239
	Distribution	Normal
	Coefficient of Variation	0.053
	UCL Type	95% Student's-t UCL
	UCL Result	18,879
	UTL Type	UTL Normal
	UTL Result	20,555
Background Reference Area 5 (BG-5) All Data	Total Number of Observations	138
	Minimum	16,299
	Mean	19,213
	Median	19,101
	Maximum	22,914
	Distribution	Normal
	Coefficient of Variation	0.074
	UCL Type	95% Student's-t UCL
	UCL Result	19,412
	UTL Type	UTL Normal
	UTL Result	21,864

Area	Statistic	Gamma (cpm)
Survey Area A	Total Number of Observations	2,760
	Minimum	11,058
	Mean	54,008
	Median	40,409
	Maximum	654,837
	Distribution	Unknown
	Coefficient of Variation	0.842
	UCL Type	95% Chebyshev (Mean, Sd) UCL
	UCL Result	57,781
	UTL Type	UTL Non-Parametric
	UTL Result	154,167
Survey Area B	Total Number of Observations	38,270
	Minimum	8,652
	Mean	33,786
	Median	28,107
	Maximum	633,057
	Distribution	Normal
	Coefficient of Variation	0.694
	UCL Type	95% Student's-t UCL
	UCL Result	33,983
	UTL Type	UTL Normal
	UTL Result	72,663
Survey Area C	Total Number of Observations	12,917
	Minimum	11,527
	Mean	28,427
	Median	27,310
	Maximum	749,127
	Distribution	Unknown
	Coefficient of Variation	1.17
	UCL Type	95% Chebyshev (Mean, Sd) UCL
	UCL Result	40,149
	UTL Type	UTL Non-Parametric
	UTL Result	91,235
Survey Area D	Total Number of Observations	15,969
	Minimum	12,476
	Mean	22,219
	Median	21,069
	Maximum	62,220
	Distribution	Normal
	Coefficient of Variation	0.203
	UCL Type	95% Student's-t UCL
	UCL Result	22,277
	UTL Type	UTL Normal
	UTL Result	29,722
Survey Area E	Total Number of Observations	1,647
	Minimum	12,054
	Mean	26,892
	Median	21,675
	Maximum	117,875
	Distribution	Normal
	Coefficient of Variation	0.528
	UCL Type	95% Student's-t UCL
	UCL Result	27,468
	UTL Type	UTL Normal
	UTL Result	51,153

cpm Counts per minute

4.0 INVESTIGATION LEVELS

The calculated 95-95 UTL values described in Section 3.3 are used as the ILs for gamma measurement results and soil sampling results because they reflect the natural variability in the background data, and provide an upper limit from background data to be used for single-point comparisons to Survey Area data. The ILs for analytical results of soil samples and gamma radiation results in Survey Areas A, B, C, D and E are based on Background Reference Areas BG-1, BG-2, BG-3, BG-3, BG-4 and BG-5, respectively.

4.1 SURVEY AREA A INVESTIGATION LEVELS

- Arsenic (mg/kg): 11.9
- Molybdenum (mg/kg): 2.26
- Selenium (mg/kg): None (All results non-detect)
- Uranium (mg/kg): 3.23
- Vanadium (mg/kg): 27.3
- Ra-226 (pCi/g): 2.13
- Gamma radiation measurements (cpm): 16,829

4.2 SURVEY AREA B INVESTIGATION LEVELS

- Arsenic (mg/kg): 2.34
- Molybdenum (mg/kg): 0.346
- Selenium (mg/kg): None (All results non-detect)
- Uranium (mg/kg): 3.34
- Vanadium (mg/kg): 11.2
- Ra-226 (pCi/g): 2.96
- Gamma radiation measurements (cpm): 23,320

4.3 SURVEY AREA C INVESTIGATION LEVELS

- Arsenic (mg/kg): 4.99
- Molybdenum (mg/kg): 0.367
- Selenium (mg/kg): None (All results non-detect)
- Uranium (mg/kg): 1.91
- Vanadium (mg/kg): 17.4
- Ra-226 (pCi/g): 1.49
- Gamma radiation measurements (cpm): 48,542

4.4 SURVEY AREA D INVESTIGATION LEVELS

- Arsenic (mg/kg): 1.76
- Molybdenum (mg/kg): 0.210
- Selenium (mg/kg): None (All results non-detect)
- Uranium (mg/kg): 0.554
- Vanadium (mg/kg): 11.0
- Ra-226 (pCi/g): 1.49
- Gamma radiation measurements (cpm): 20,637

4.5 SURVEY AREA E INVESTIGATION LEVELS

- Arsenic (mg/kg): 1.73
- Molybdenum (mg/kg): None (All results non-detect)
- Selenium (mg/kg): None (All results non-detect)
- Uranium (mg/kg): 0.691
- Vanadium (mg/kg): 10.7
- Ra-226 (pCi/g): 0.839
- Gamma radiation measurements (cpm): 21,864

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Appendix E Cultural and Biological Resource Clearance Documents

BIOLOGICAL EVALUATION

For the Proposed:

Section 26 (Desidero Group)
Abandon Uranium Mine - Environmental Response Trust Project

Sponsored by:

MWH Global / Stantec

Prepared by:

Adkins Consulting, Inc.
180 East 12th Street, Unit 5
Durango, Colorado 81301

Revised August 2016
June 2016

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1. INTRODUCTION AND PROJECT BACKGROUND

The federal Endangered Species Act (ESA) of 1973, 16 U.S.C. §1531 et seq., requires all federal departments and agencies to conserve threatened, endangered, and critical and sensitive species and the habitats on which they depend, and to consult with the U.S. Fish and Wildlife Service (USFWS) on all actions authorized, funded, or carried out by each agency to ensure that the action will not likely jeopardize the continued existence of any threatened and endangered species or adversely modify critical habitat [USFWS 1998]. This report describes the potential for federal ESA-listed species and Navajo Nation Endangered Species List (NESL) endangered, threatened, candidate, or otherwise designated sensitive flora and fauna to occur in the proposed action area. The action area with regard to the ESA is defined as any area that may be directly or indirectly impacted by the proposed action [50 CFR §402.02]. This report is intended to provide the responsible official with information to make determinations of effect on species with special conservation status.

As the result of settlement by the United States, the Navajo Nation AUM Environmental Response Trust—First Phase was established to evaluate certain abandoned uranium mines located across the Navajo Nation. The project requires investigation of these sites prior to potential remediation activities in the future. MWH Global, a division of Stantec (MWH), will conduct exploratory activities at the Section 26 (Desidero Group) abandoned uranium mine (AUM) such as pedestrian gamma surveys, mapping, well sampling, and surface soil sampling within the mine claim boundaries and surrounding buffer zone. Subsequent earthwork and long term monitoring may be involved after final approval by the Navajo Nation Environmental Protection Agency (NNEPA) in conjunction with the U. S. Environmental Protection Agency (USEPA).

In support of this project, MWH contracted Adkins Consulting, Inc. (ACI) to conduct surveys for ESA-listed fauna and Navajo Nation Endangered Species List (NESL) endangered, threatened, candidate, or otherwise designated sensitive fauna. MWH contracted Redente Ecological Consultants (Redente) to conduct surveys for NESL and ESA-listed plant species. The results of the 2016 Redente biological investigations will be incorporated in Sections 4.2 and 4.3 of this report and can be found in entirety attached as Appendix C.

The objectives of the biological surveys were as follows:

- To compile a list of ESA-listed or NESL species potentially occurring in the proposed action area.
- To provide a physical and biological description of the proposed action area.
- To determine the presence of ESA-listed or NESL species in the proposed action area.
- To assess potential impacts the proposed action may have on any ESA-listed or NESL species present in the area.
- To assess potential impacts to species protected under the Migratory Bird Treaty Act (MBTA).

2. PROJECT DESCRIPTION

2.1. Location

Section 26 (Desidero Group) is comprised of three separate areas within close proximity to one another within Township 13 North, Range 10 West, New Mexico Principal Meridian (NMPM). Two of the areas are located on the northern end of Section 26 and the northern extent of their site buffers extend into the southern end of Section 23 while the easternmost buffer extends into Section 25. The third area is located to the south in the middle of Section 26. The Section 26 (Desidero Group) is located in McKinley County, New Mexico approximately 12.8 miles north of Grants, New Mexico at an elevation of approximately 7,117 feet. Global Positioning System coordinates are 35° 20' N by 107° 51.57' W NAD 83. Project area maps are provided in Appendix A.

2.2. Estimated Disturbance

MWH proposes a phased approach to scientific investigations at the Section 26 (Desidero Group) AUM. The study area is comprised of three separate areas within close proximity to one another. The three areas together including the buffer zones surrounding the perimeter of the boundaries encompass approximately 32.8 acres. Please refer to Appendix A for maps delineating the mine claim boundaries and buffer zones.

The project will also include a walkover survey for gamma radiation across a small area known as the "background area". Please refer to Appendix A for a map of the background sample areas. A few soil samples approximately 3 inches in diameter and up to 6 inches deep will be collected by hand in these areas.

- Phase I: Spring of 2016, activity would entail pedestrian biological surveys and land surveying. Fall of 2016 work would entail pedestrian activity including gamma surveys, mapping, well sampling, and surface soil sampling. In 2016 there will be a maximum of 5 people onsite for no more than 5 to 7 days. Surface disturbance would be minimal and noise would be light.

- Phase II: Beginning in 2017, equipment including an excavator or small mobile drilling unit may be used to collect one or more soil samples. Up to 8 people may be onsite all day for a period of one week. Equipment travel would be confined to a temporary travel corridor approximately 20 feet in width. Within the travel corridor, vegetation and surface soil would sustain some disturbance but would not be bladed or bulldozed. During Phase II, noise may be moderate for a short duration, and surface disturbance will be light to moderate but confined to a minimal footprint within the study area. No permanent structures will be left on site.

3. AFFECTED ENVIRONMENT

3.1. Proposed Project Area (PPA)

The proposed project area (PPA) includes the mine boundaries with 100-foot buffers surrounding the perimeter of the boundaries. The affected environment or action area includes any area that may be directly or indirectly impacted by the proposed activities. Project area maps are provided in Appendix A.

3.1.1. Environmental Setting

Project activities would occur in northwestern New Mexico located within the USEPA designated Arizona/New Mexico Plateau Level III Ecoregion. The Arizona/New Mexico Plateau occurs primarily in Arizona, Colorado, and New Mexico, with a small portion in Nevada. This ecoregion is approximately 45,870,500 acres, and the elevation ranges from 2,165 to 11,949 feet. The ecoregion's landscapes include low mountains, hills, mesas, foothills, irregular plains, alkaline basins, some sand dunes, and wetlands. This ecoregion is a large transitional region between the semiarid grasslands to the east, the drier shrublands and woodlands to the north, and the lower, hotter, less vegetated areas to the west and south.

Section 26 (Desidero Group) is comprised of three separate areas within close proximity to one another. The areas are situated on a low cuesta rim with crumbling sandstone cliffs off the south side of the area and previous disturbance from residences and driveways throughout.

Flora

Vegetation communities found within the Arizona/New Mexico Plateau ecoregion include shrublands with big sagebrush, rabbitbrush, winterfat, shadscale saltbush, and greasewood; and grasslands of blue grama, Western wheatgrass, green needlegrass, and needle-and-thread grass. Higher elevations may support piñon pine and juniper woodlands. The Section 26 (Desidero Group) is sparsely vegetated grassland with sporadic shrubs and scattered piñon/juniper on the eastern and southernmost boundaries. Vegetative cover is estimated to be approximately 25 percent in areas undisturbed by residences or unmaintained road.

Fauna

Wildlife or evidence of wildlife observed within the PPA included common raven (*Corvus corax*), common nighthawk (*Chordeiles minor*), cottontail rabbit (*Sylvilagus* sp.), and mule deer (*Odocoileus hemionus*). No signs of consistent raptor use such as whitewash or nests were observed. No prairie dog (*Cynomys* sp.) burrows were recorded within the PPA or immediate vicinity. Further analysis of sensitive species can be found in Section 4 of this document.

Hydrology/Wetlands

Under Executive Orders 11988 and 11990, Federal agencies are required to minimize the destruction, loss, or degradation of wetlands and floodplains, and preserve and enhance their natural and beneficial values. These habitats should be conserved through avoidance, or mitigated to ensure that there would be no net loss of wetlands function and value.

Run-off from precipitation in the project area generally drains southeast across the top of the cuesta and then connects with a larger ephemeral / intermittent, north-south trending ravine to the east. The larger ravine eventually ends at a fresh water pond approximately 1.2 miles south of the project area. The Rio San Jose is the nearest perennial water source, approximately 7 miles south of the PPA. There are no wetlands, seeps, springs, or riparian areas within the proposed project area. The proposed project activities would contribute to a negligible increase in sedimentation down gradient of the project area. This increase is not anticipated to be a factor due to the distance from perennial waters. ESA-listed fish species are not known to occur in Rio San Jose, nor is it considered critical habitat of any ESA-listed species.

Cumulative impacts to surface waters would be negligible. Surface-disturbing activities other than the proposed action that may cause accelerated erosion include, but are not limited to, construction of roads, other facilities, and installation of trenches for utilities; road maintenance such as grading or ditch-cleaning; public recreational activities; vegetation manipulation and management activities; natural and prescribed fires; and livestock grazing. Because the proposed action would have a negligible impact to downstream surface water quality, the cumulative impact also would be negligible when added to other past, present, and reasonably foreseeable activities.

4. THREATENED, ENDANGERED, AND SENSITIVE SPECIES EVALUATION

The Endangered Species Act (ESA) of 1973 requires all federal departments and agencies to conserve threatened, endangered, and critical and sensitive species and the habitats on which they depend, and to consult with the U.S. Fish and Wildlife Service (USFWS) on all actions authorized, funded, or carried out by the agency to ensure that the action will not likely jeopardize the continued existence of any threatened and endangered species or adversely modify critical habitat.

4.1. Methods

4.1.1. Off-site Methods

Prior to conducting fieldwork, ACI compiled data on animal species listed under the ESA. Informal consultation was initiated by requesting an Official Species List from the USFWS Information, Planning, and Conservation System (IPaC) website (http://ecos.fws.gov/ipac/). ACI received the Official Species

List (02ENNM00-2016-SLI-0447) on April 8, 2016. See Table 1 for USFWS-listed threatened, endangered, or candidate species with potential to occur in the PPA.

The Navajo Nation Department of Fish and Wildlife (NNDFW), Navajo Natural Heritage Program (File # 15mwh101) sent MWH a NESL information letter dated 29 December, 2015. The letter suggests biologists determine habitat suitability within the project area for the provided list of species of concern with potential to occur on the 7.5-minute quadrangles containing the project boundaries. The Navajo species of concern listed in the NESL information letter are included in Table 2.a below.

In addition to the above listed species, ACI reviewed species protected under the MBTA with potential to occur in the proposed project and action area (Table 3).

4.1.2. On-site Survey Methods

An on-site pedestrian survey was conducted in April 2016 by ACI personnel under a permit issued by NNDFW. The purpose of the survey was to assess habitat potential for ESA-listed or NESL animal species. Field biologists with considerable experience identifying local wildlife species lead survey crews. The survey consisted of walking transects ten feet apart throughout the PPA including a survey buffer of approximately 50 feet beyond the PPA edge of disturbance. The surrounding areas were visually inspected with binoculars for nests, raptors, or past signs of raptor use. Weather conditions were clear with a slight breeze. All plant and wildlife species observed in the action area were recorded, and digital photos were taken (Appendix B).

Redente conducted surveys for plant species of concern. The results of the 2016 Redente biological investigations will be incorporated in Sections 4.2 and 4.3 of this report and can be found in entirety attached as Appendix C.

4.2. ESA-Listed Species Analysis and Results

4.2.1. Species from the USFWS IPaC Official Species List

Table 1 includes ESA-listed plant and animal species that have the potential to occur in the project area based on the USFWS IPaC Official Species List. Biologists evaluated habitat suitability within and surrounding the PPA for the species in Table 1.

Table 1: USFWS Species List for the Section 26 Project

Species	Status	Occurrence Within Region	Habitat	Potential to Occur within Action Area
BIRDS				
Southwestern Willow Flycatcher (*Empidonax traillii extimus*)	Endangered with Designated Critical Habitat	Summer/breeding range.[2]	Breeds in dense riparian habitat.[2]	No potential. Action area does not provide suitable habitat for species to occur.
Mexican spotted owl (*Strix occidentalis lucida*)	Threatened with Designated Critical Habitat	Year-round range.[1]	Mixed conifer forests. Typically where unlogged, uneven-aged, closed-canopy forests occur in steep canyons.[1]	No potential. Action area does not provide suitable habitat for species to occur.
Western Yellow-Billed Cuckoo (*Coccyzus americanus*)	Threatened	Possible rare summer/breeding occurrences.[2]	In the southwestern U.S., associated with riparian woodlands dominated by cottonwood or willow trees. In New Mexico, native or exotic species may be used.[2]	No potential. Action area does not provide suitable habitat for species to occur.

Table 1: USFWS Species List for the Section 26 Project

Species	Status	Occurrence Within Region	Habitat	Potential to Occur within Action Area
FISHES				
Zuni Bluehead Sucker (*Catostomus discobolus yarrowi*)	Endangered	Native to headwater streams of the Little Colorado River in east-central AZ and west-central NM; current range in NM is limited to the upper Río Nutria drainage.[2]	Low-velocity pools and pool-runs with seasonally dense perilithic and periphytic algae, particularly shady, cobble/boulder/bedrock substrates in streams with frequent runs and pools.[2]	No potential. Action area does not provide suitable habitat for species to occur.
PLANTS				
Zuni fleabane (*Erigeron rhizomatus*)	Threatened	Zuni and Chuska Mountains, and Datil and Sawtooth ranges in New Mexico.[3]	Found on fine textured clay hillsides of mid to high elevation between 7000 and 8300ft. It is known from clays derived from the Chinle Formation in the Zuni and Chuska Mountains, and to similar clays of the Baca Formation in the Datil and Sawtooth ranges in New Mexico.[3]	No potential. Action area does not provide suitable habitat for species to occur. No individuals found during Redente site surveys.[5]

[1]USFWS; [2]NatureServe Explorer; [3]Navajo Endangered Species List, Species Accounts 2008, [4] IUCN Red List, [5]Redente 2016

4.2.2. ESA-Listed Species Eliminated From Further Consideration

Table 1 includes five (5) ESA-listed species that have the potential to occur in the project area based on the USFWS IPaC Official Species List. All of the species in Table 1 have been eliminated from further discussion in this report. There would be no direct, indirect or cumulative impacts to the species in Table 1.

4.3. NESL Species Analysis and Results

4.3.1. Navajo Endangered Species List (NESL) and Species of Concern

Table 2.a lists species of concern with potential to occur on the 7.5-minute quadrangle(s) containing the project boundaries. According to the NESL information letter received from the NFWD found in Appendix D, there is no record of species of concern occurring on or near the project site. Biologists evaluated the potential for species of concern listed in the table below to occur within the project area.

Additionally, the NESL information letter requested that the potential for black-footed ferret (*Mustela nigripes*) be evaluated if prairie dog towns of sufficient size (per NFWD guidelines) occur in the project area, and that potential for Parish's alkali grass (*Puccinellia parishii*) be evaluated if wetland conditions exist that contain white alkaline crusts. Species listed by the USFWS in Table 1 are not reiterated here.

Table 2.a: Navajo Endangered Species List (NESL) and Species of Concern

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area
ANIMALS			
Black-Footed ferret (*Mustela nigripes*)	Endangered	Open habitat, including grasslands, steppe, and shrub steppe. Closely associated with prairie dog colonies. At least 40 hectares of prairie dog colony required to support one ferret.[2]	No potential. Action area does not provide suitable habitat for species to occur. Action area does not provide prairie dog colonies of sufficient size
Mountain plover *(Charadrius montanus)*	NESL G4	Typically nests in flat (<2% slope) to slightly rolling expanses of grassland, semi-desert, or badland, in an area with short, sparse vegetation, large bare areas (often >1/3 of total area), and that is typically disturbed (e.g. grazed); may also nest in plowed or fallow cultivation fields. Nest is a scrape in dirt often next to a grass clump or old cow manure pile. Migration habitat is similar to breeding habitat.[2,3]	No potential. Action area does not provide suitable habitat for species to occur.
Western burrowing owl (*Athene cunicularia hypugaea*)	NESL G4	Open grasslands and sometimes other open areas (such as vacant lots). Nests in abandoned burrows, such as those dug by prairie dogs.[2,3]	No potential. Action area does not provide suitable habitat for species to occur.
Golden eagle (*Aquila chrysaetos*)	NESL G3	In the west, mostly open habitats in mountainous, canyon terrain. Nests primarily on cliffs.[1,3]	Action area provides potential foraging habitat for species to occur.
American peregrine falcon (*Falco peregrinus*)	NESL G4 NM-T	Nests on steep cliffs >30 m tall (typically >45 m) in a scrape on sheltered ledges or potholes. Foraging habitat quality is an important factor; often, but not always, extensive wetland and/or forest habitat is within the falcon's hunting range of <=12 km. Nest in ledges or potholes on cliffs in wooded/forested habitats; Forage over riparian woodlands, coniferous & deciduous forests, shrublands, prairies. [3]	Action area provides potential foraging habitat for species to occur.
PLANTS			
Parish's alkali grass (*Puccinellia parishii*)	NESL G4 NM-E	Alkaline springs, seeps, and seasonally wet areas that occur at the heads of drainages or on gentle slopes. Elevation: 2600-7200 feet.[2,3]	No potential. Action area does not provide suitable habitat for species to occur.

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area

Species are listed by the NESL as; Group 2: Endangered (survival or recruitment in jeopardy); Group 3: Endangered (survival or recruitment in jeopardy in foreseeable future); and Group 4: Species of Consideration. NESL Species with New Mexico State Endangered or Threatened status are labeled as NM-T or NM-E.

Sources: [1]New Mexico Natural Heritage Program 2010, [2]NatureServe Explorer; [3]Navajo Endangered Species List, Species Accounts 2008, [4] IUCN Red List, [5]Redente 2016, [6] Hammerson et al 2004.

4.3.2. NESL Species Eliminated From Further Consideration

Table 2.a includes six (6) NESL and Navajo Species of Concern that have the potential to occur in the project area based on general geographical association. The following species have been eliminated from further discussion in this report because the action area does not provide suitable habitat for them to occur: Mountain plover *(Charadrius montanus),* Western burrowing owl (*Athene cunicularia hypugaea*), Black-footed ferret (*Mustela nigripes*), and Parish's alkali grass (*Puccinellia parishii*). None of these species were observed during surveys of the proposed project area or immediate surroundings. Critical habitats of these species do not exist within or adjacent to the proposed project area. There would be no direct, indirect or cumulative impacts to these species.

4.3.3. NESL Species Warranting Further Analysis

Table 2.b lists NESL and Navajo Species of Concern with potential to occur within the proposed project area based on habitat suitability or actual record of observation.

Table 2.b: NESL and Navajo Species of Concern Warranting Further Analysis

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area
ANIMALS			
Golden eagle (*Aquila chrysaetos*)	NESL G3	In the west, mostly open habitats in mountainous, canyon terrain. Nests primarily on cliffs.[1,4]	Action area provides potential foraging habitat for species to occur.
American peregrine falcon (*Falco peregrinus*)	NESL G4 NM-T	Nest in ledges or potholes on cliffs in wooded/forested habitats; Forage over riparian woodlands, coniferous & deciduous forests, shrublands, prairies.	Action area provides potential foraging habitat for species to occur.

Species are listed by the NESL as; Group 2: Endangered (survival or recruitment in jeopardy); Group 3: Endangered (survival or recruitment in jeopardy in foreseeable future); and Group 4: Species of Consideration. NESL Species with New Mexico State Endangered or Threatened status are labeled as NM-T or NM-E.

Sources: [1]New Mexico Natural Heritage Program 2010, [2]NatureServe Explorer; [3]Navajo Endangered Species List, Species Accounts 2008, [4] IUCN Red List, [5]Redente 2016, [6] Hammerson et al 2004.

4.4. Migratory Bird Species

The Migratory Bird Treaty Act (MBTA) implements various treaties and conventions between the U.S. and Canada, Japan, Mexico and the former Soviet Union for the protection of migratory birds. Under the Act, taking, killing or possessing migratory birds is unlawful.

The bald eagle (*Haliaeetus leucocephalus*) was delisted under the ESA on August 9, 2007. Both the bald eagle and golden eagle (*Aquila chrysaetos*) are still protected under the MBTA and Bald and Golden Eagle Protection Act (BGEPA). The BGEPA affords both eagles protection in addition to that provided by the MBTA, in particular, by making it unlawful to "disturb" eagles.

In preparation for conducting the migratory bird survey, information from the New Mexico Partners In Flight website (http://www.hawksaloft.org/pif.shtml), the New Mexico PIF highest priority list of species of concern by vegetation type, the USFWS's Division of Migratory Bird Management website (http://www.fws.gov/migratorybirds/), and the 2002 Birds of Conservation Concern Report for the Southern Rockies/Colorado Plateau Bird Conservation Region (BCR) No. 16, were used to develop a list of high priority migratory bird species with potential to occur in the area of the proposed action. Species addressed previously will not be reiterated here.

Table 3: Priority Birds of Conservation Concern with Potential to Occur in the Project Area

Species Name	Habitat Associations	Potential to Occur in the Project Area
Black-throated sparrow (*Amphispiza bilineata*)	Xeric habitats dominated by open shrubs with areas of bare ground.	Suitable habitat is present within the action area for species to occur.
Brewer's sparrow (*Spizella breweri*)	Closely associated with sagebrush, preferring dense stands broken up with grassy areas.	No suitable habitat is present within the action area for species to occur.
Gray vireo (*Vireo vicinior*)	Open stands of piñon pine and Utah juniper (5,800 – 7,200 ft) with a shrub component and mostly bare ground; antelope bitterbrush, mountain mahogany, Utah serviceberry and big sagebrush often present. Broad, flat or gently sloped canyons, in areas with rock outcroppings, or near ridge-tops.	No suitable habitat is present within the action area for species to occur.
Loggerhead shrike (*Lanius ludovicianus*)	Open country interspersed with improved pastures, grasslands, and hayfields. Nests in sagebrush areas, desert scrub, and woodland edges.	Suitable habitat is present within the action area for species to occur.
Mountain bluebird (*Sialia currucoides*)	Open piñon-juniper woodlands, mountain meadows, and sagebrush shrublands; requires larger trees and snags for cavity nesting.	No suitable habitat is present within the action area for species to occur.
Mourning dove (*Zenaida macroura*)	Open country, scattered trees, and woodland edges. Feeds on ground in grasslands and agricultural fields. Roost in woodlands in the winter. Nests in trees or on ground.	Suitable habitat is present within the action area for species to occur.
Sage sparrow (*Amphispiza belli*)	Large and contiguous areas of tall and dense sagebrush. Negatively associated with seral mosaics and patchy shrublands and abundance of greasewood.	No suitable habitat is present within the action area for species to occur.
Sage thrasher (*Oreoscoptes montanus*)	Shrub-steppe dominated by big sagebrush.	Marginal habitat is present within the action area for species to occur. Lack of significant sagebrush shrubland likely a limiting factor.
Scaled quail (*Callipepla squamata*)	Brushy arroyos, cactus flats, sagebrush or mesquite plains, desert grasslands, Plains grasslands, and agricultural areas. Good breeding habitat has a diverse grass composition, with varied forbs and scattered shrubs.	No suitable habitat present within the action area for species to occur. Lack of diverse grass composition with varied forbs likely a limiting factor.
Swainson's hawk (*Buteo swainsoni*)	A mixture of grassland, cropland, and shrub vegetation; nests on utility poles and in isolated trees in rangeland. Nest densities higher in agricultural areas.	No suitable habitat is present within the action area for species to occur.

Vesper sparrow (*Pooecetes gramineus*)	Dry montane meadows, grasslands, prairie, and sagebrush steppe with grass component; nests on ground at base of grass clumps.	No suitable habitat present within the action area for species to occur. Lack of significant grassland/prairie component a limiting factor.
Bald eagle (*Haliaeetus leucocephalus*)	Near lakes, rivers and cottonwood galleries. Nests near surface water in large trees. May forage terrestrially in winter	No suitable habitat present within the action area for species to occur.
Bendire's thrasher (*Toxostoma bendirei*)	Typically inhabits sparse desert shrubland & open woodland with scattered shrubs; breeds in scattered locations in central & western portions of NM; most common in southwest NM.	Suitable habitat is present within the action area for species to occur. However likely out of species typical range.
Piñon jay (*Gymnorhinus cyanocephalus*)	Foothills throughout CO and NM wherever large blocks of piñon-juniper woodland habitat occurs.	No suitable habitat present within the action area for species to occur.
Prairie falcon (*Falco mexicanus*)	Arid, open country, grasslands or desert scrub, rangeland; nests on cliff ledges, trees, power structures.	Action area provides potential foraging habitat for species to occur.
Ferruginous hawk (*Buteo regalis*)	Breed in open country, usually prairies, plains and badlands; semi- desert grass-shrub, sagebrush-grass & piñon-juniper plant associations.	No suitable habitat present within the action area for species to occur.

5. EFFECTS ANALYSIS

Effects or impacts can be either long term (permanent or residual) or short term (incidental or temporary). Short-term impacts affect the environment for only a limited period and then the environment reverts rapidly back to pre-action conditions. Long-term impacts are substantial and permanent alterations to the pre-existing environmental condition. Direct effects are those effects that are caused by the action and occur in the same time and place as the action. Indirect effects are those effects that are caused by or will result from the proposed action and are later in time but still reasonably certain to occur (USFWS 1998).

5.1. Direct and Indirect Effects

The PPA includes the claim boundary and a 100-foot perimeter buffer for a total of approximately 32.8 acres. The project will also include a walkover survey for gamma radiation across a small area known as the "background area" (see Appendix A for map). A few soil samples approximately 3 inches in diameter and up to 6 inches deep will be collected by hand in these areas. The proposed action would result in a short term increase in human activity within the PPA at varying degrees depending on the project phase:

- Phase I: Spring of 2016 activity would entail pedestrian biological surveys and land surveying. During 2016, work would entail pedestrian activity including gamma surveys, mapping, well sampling, and surface soil sampling. For this phase, there will be a maximum of 5 people onsite for no more than 5 to 7 days. Surface disturbance would be minimal and noise would be light.

- Phase II: Beginning in 2017, equipment including an excavator or small mobile drilling unit may be used to collect soil samples. Up to 8 people may be onsite all day for a period of one week. Equipment travel would be confined to a temporary travel corridor approximately 20 feet in width. Within the travel corridor, vegetation and surface soil would sustain some disturbance but would not be bladed or bulldozed. One or more soil samples may be taken using an excavator or small mobile drilling unit. During Phase II, noise may be moderate for a short duration, and surface disturbance will be light to moderate but confined to a minimal footprint within the study area. No permanent structures will be left on site.

Best Management Practices (BMPs) incorporated into project design will reduce potential impacts including: confining equipment travel to PPA boundary, minimizing travel corridors as much as practicable, limiting truck and equipment travel within the PPA when surfaces are wet and soil may become deeply rutted, and using previously disturbed areas for travel when possible.

5.1.1. Golden eagle, American peregrine falcon

Due to the mobility of adult raptors and the lack of appropriate nesting sites in the vicinity of the proposed project area, it is unlikely that the proposed project would result in 1) injury to a raptor, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior. Short term audial and visual disturbances associated with the Phase II activity could cause minor indirect habitat loss by temporarily deterring raptors from using available habitat adjacent to the proposed project area.

5.1.2. Migratory Birds

The PPA encompasses approximately 32.8 acres of potential migratory bird habitat in the form of Great Basin Desert scrub. Approximately 50-60 trees are within the PPA boundary.

Phase I:
Noise and surface disturbance will be low during pedestrian survey activity. Adult migratory birds would not be directly impacted by Phase I because of their mobility and ability to avoid areas of human activity. Minor human presence during project activities within the breeding season may indirectly disturb or displace adults from nests and foraging habitats for a short period of time. Direct and indirect effects are expected to be short term and negligible.

Phase II:
Adult migratory birds would not be directly harmed by the activities because of their mobility and ability to avoid areas of human activity. During Phase II, noise may be moderate but for a short duration, and surface disturbance will be light to moderate but confined to a minimal footprint within the study area. Equipment travel may require the removal of no more than five trees. No permanent structures will be left on site. Direct impacts are more likely if surface disturbing activities occur during the breeding season (April 1 through August 15); however, surface disturbance will be confined to a minimal footprint (likely less than one acre) within the study area. The increased human presence during project activities within the breeding season may indirectly disturb or displace adults from nests and foraging habitats for a short period of time.

5.2. Cumulative Effects

Cumulative impacts of an action include the total effects on a resource or ecosystem. Cumulative effects in the context of the Endangered Species Act pertain to non-Federal actions, and are reasonably certain to occur in the action area (USFWS 1998).

5.2.1. Golden eagle, American peregrine falcon

Additional existing surface disturbances within the action area include unimproved access roads to the residences nearby, all-terrain vehicle use and active wildlife and livestock grazing. Local plant and animal pest control are also activities that may occur in the vicinity. These foreseeable actions would cumulatively impact raptors through habitat loss or contamination. Human activity may also increase available prey base if the activity leads to an increase in rodent population numbers. The intensity of indirect effects would be dependent upon the species, its life history, time of year and/or day and the type and level of human and vehicular activity is occurring.

5.2.2. Migratory Birds

With the implementation of BMPs discussed in Section 5.1, the cumulative impact of the proposed action on migratory birds would be low based on the minimal surface disturbance involved and the availability of adjacent similar habitats.

6. CONCLUSIONS

U.S. Fish and Wildlife Service Listed Species (USFWS)

ACI conducted informal consultation with the USFWS and received an Official Species List for the proposed project area. Qualified ACI biologists evaluated habitat suitability within and surrounding the PPA for these species and concluded the potential does not exist for USFWS-listed species to occur within the proposed project area. No further consultation with the USFWS is required.

Migratory Birds

The proposed action phases would result in short term activity within approximately 32.8 acres of potential migratory bird habitat in the form of Great Basin Desert scrub/grassland and approximately 50-60 piñon-juniper trees. During Phase I, noise and surface disturbance will be low during pedestrian survey activity. Direct and indirect effects are expected to be short term and negligible. For Phase II, the total surface disturbance is unknown at this point; however equipment movement would be confined to only a few temporary travel corridors. Within the travel corridors, vegetation and surface soil would sustain some disturbance but would not be bladed or bulldozed. Equipment travel may require the removal of no more than five trees. Possible direct impacts would be short term and are more likely if surface disturbing activities occur during the breeding season (April 1 through August 15). Effects to potential habitat for migratory birds is anticipated to be minor and short term due to the limited degree of vegetation and soil disruption and the abundance of adjacent habitat for these species.

Wetlands

Under Executive Orders 11988 and 11990, Federal agencies are required to minimize the destruction, loss, or degradation of wetlands and floodplains, and preserve and enhance their natural and beneficial values. These habitats should be conserved through avoidance, or mitigated to ensure that there would be no net loss of wetlands function and value. No impacts to wetlands are anticipated. The proposed project activities would contribute to a negligible increase in sedimentation down gradient of the project area. This increase is not anticipated to be a factor due to the distance from perennial waters. There is no suitable habitat for ESA-listed fish in Chaco Wash, nor is it considered critical habitat of any ESA-listed species.

Navajo Endangered Species List (NESL) and Species of Concern

Two (2) NESL and Navajo species of concern have potential to occur within the PPA based on habitat suitability or actual record of observation. Based on site surveys, ACI determined the PPA contains potential foraging habitat for the following: golden eagle and American peregrine falcon. Due to the mobility of adult raptors and the lack of appropriate nesting sites in the vicinity of the proposed project area, it is unlikely that the proposed project would result in detriment to the raptors.

7. RECOMMENDATIONS FOR AVOIDANCE

ACI recommends that the proponent implement standard Best Management Practices (BMPs) designed to protect sensitive wildlife species during project activity including: confining equipment travel to PPA boundary, minimizing travel corridors as much as practicable, limiting truck and equipment travel within the PPA when surfaces are wet and soil may become deeply rutted, and using previously disturbed areas for travel when possible.

8. SUPPORTING INFORMATION

8.1. Consultation and Coordination

John Nystedt, Fish and Wildlife Biologist/AESO Tribal Coordinator
USFWS AZ Ecological Services Office - Flagstaff Suboffice
Southwest Forest Science Complex, 2500 S Pine Knoll Dr, Rm 232
Flagstaff, AZ 86001

Pam Kyselka, Project Reviewer and
Chad Smith, Zoologist
Navajo Nation Department of Fish and Wildlife
Natural Heritage Program
PO Box 1480
Window Rock, AZ 86515

8.2. Report Preparers and Certification

Adkins Consulting, Inc.
180 E. 12th Street, Unit 5
Durango, Colorado 81301
Lori Gregory, Biologist; Sarah McCloskey, Field Biologist; Arnold Clifford, Lead Field Biologist

It is believed by Adkins Consulting that the proposed action would not violate any of the provisions of the Endangered Species Act of 1973, as amended. Conclusions are based on actual field examination and are correct to the best of my knowledge.

1 August 2016

Lori Gregory
Wildlife Biologist
Adkins Consulting
505.787.4088

Date

8.3. References

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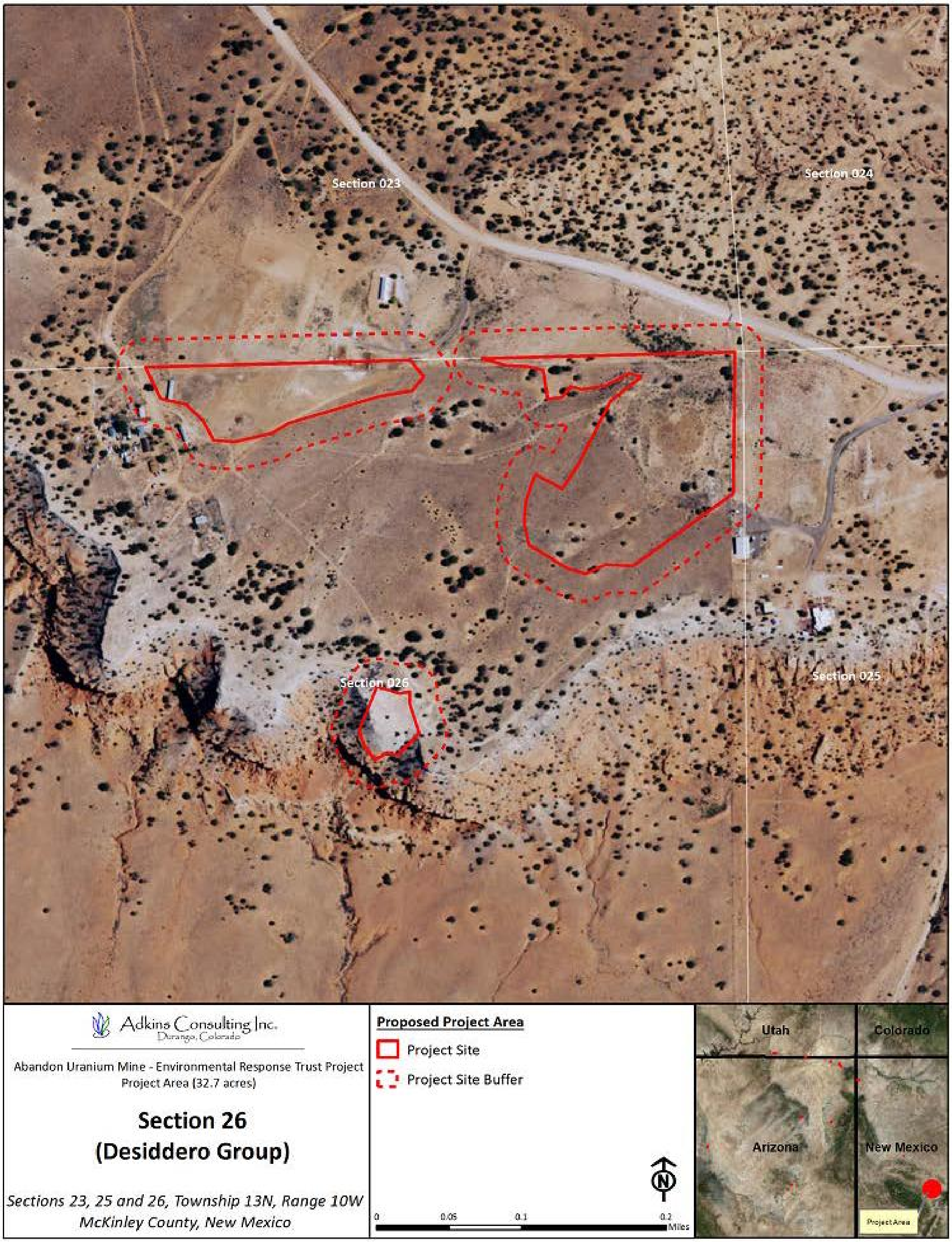
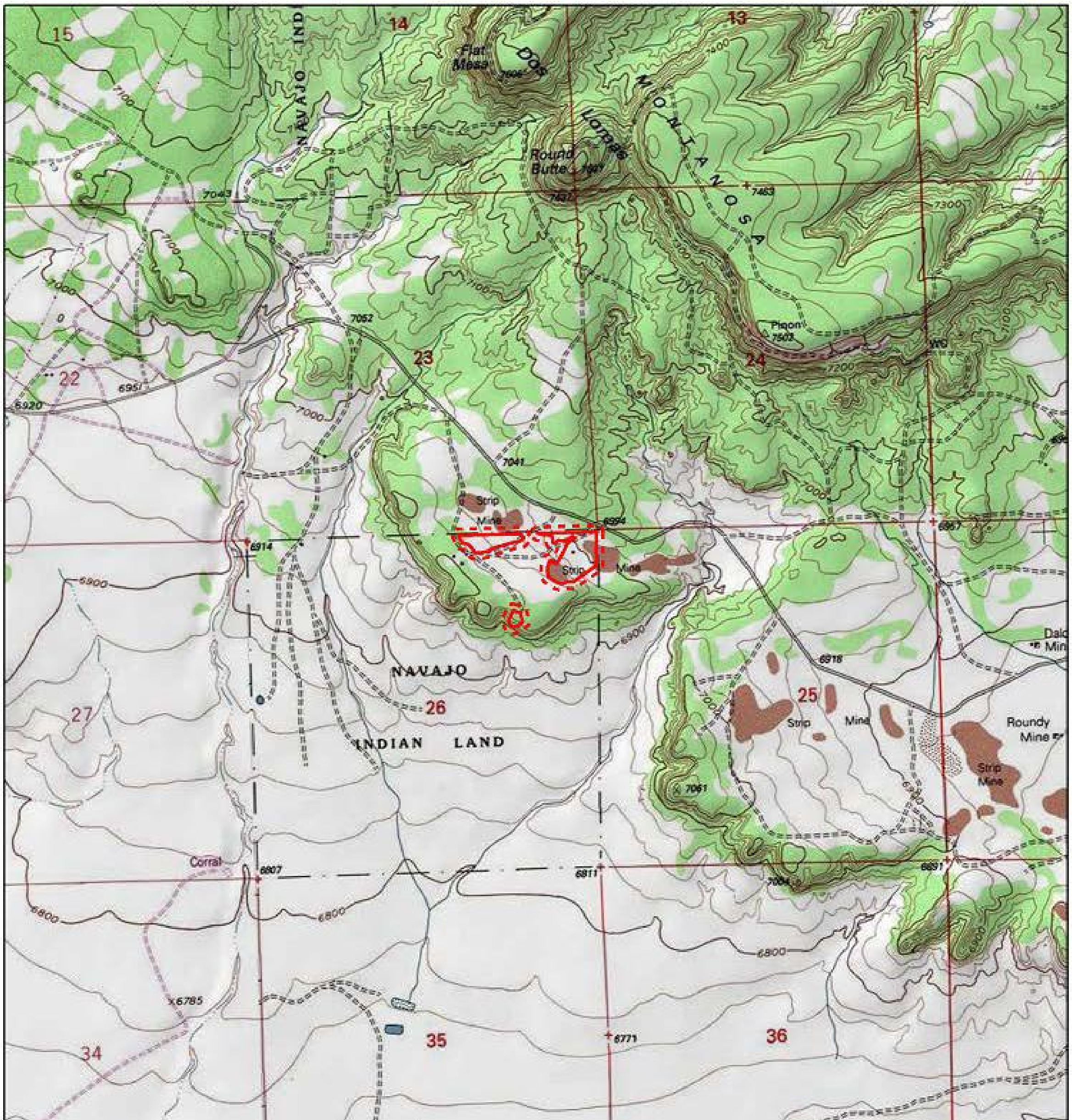
APPENDIX A. MAPS





Adkins Consulting Inc.
Durango, Colorado

Abandon Uranium Mine - Environmental Response Trust Project
Project Area (32.7 acres)

Section 26
(Desiddero Group)

Sections 23, 25 and 26, Township 13N, Range 10W
McKinley County, New Mexico

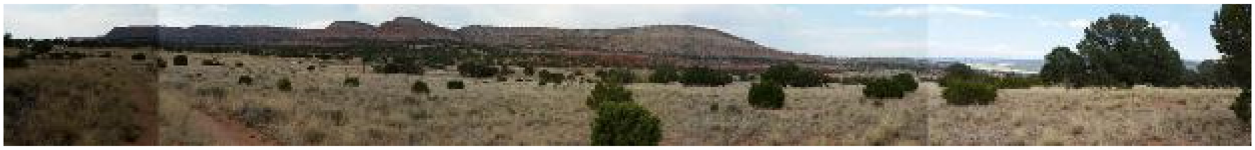
Proposed Project Area

Project Site

Project Site Buffer

0 0.25 0.5 1 Miles

APPENDIX B. PHOTOGRAPHS



Site overview looking north from southern end of site boundary

View north from southern end of northern area boundary

View south from northern end of southern area boundary

APPENDIX C. REDENTE PLANT SURVEY REPORT

Navajo Nation AUM Environmental Response Trust

Plant Survey Report for Species of Concern At Section 26 (Desidero Group) Project Site McKinley County, New Mexico August 2016

Prepared by:
Redente Ecological Consultants
1322 Alene Circle
Fort Collins, CO 80525

TABLE OF CONTENTS

INTRODUCTION

Purpose of Report

A biological survey was conducted at the Section 26 (Desidero Group) site as part of the Navajo Nation AUM Environmental Response Trust. The purpose of the survey is to determine if plant species of concern are present within the claim boundary and extending 100 feet around the site. Biological clearance is required at each site prior to any site investigation to determine if the project may affect potential species-of-concern or potential federal threatened and endangered (T&Es) species and/or critical habitat.

Site Location

Section 26 (Desidero Group) is located in McKinley County New Mexico, approximately 35 km (22 miles) east of Thoreau, New Mexico at an elevation of approximately 2,134 m (7,000 ft). Global Positioning System coordinates are 35° 19' 59" N by 107° 51' 38" W (North American Datum of 1983). The site is located on an allotment.

Environmental Setting

Climate

The climate of the Section 26 (Desidero Group) site is classified as semi-arid. The average annual precipitation at the closest official weather station in Thoreau, New Mexico is 287 mm (11.3 in), with the greatest precipitation months occurring in July and August. Average annual temperature is 10.7° C (51.3° F).

Soils

The U.S. Department of Agriculture (USDA) Soil Survey for McKinley County was published in 1993 and covers the area just to the south of Section 26 (Desidero Group) . The soil mapping unit for this site is the Penistaja-San Mateo Series and consists of fan terraces, flood plains and alluvial fans with slopes ranging from 1 to 10%. The soil are primarily fine sandy loams that are deep and well drained.

Plant Community Type

The vegetation on the Section 26 site is classified as an open canopy Pinyon-Juniper woodland. The most common species on the site include pinyon pine (*Pinus edulis*), oneseeded juniper (*Juniperus monosperma*), blue grama (*Bouteloua gracilis*), sand dropseed (*Sporobolus cryptandrus*), Indian ricegrass (*Achnatherum hymenoides*), fourwing saltbush (*Atriplex canescens*), rubber rabbitbrush (*Ericameria nauseosa*), broom snakeweed (*Gutierrizia sarathrae*) and winterfat (*Krascheninnikovia lanata*).

Land Use

The land type on the Section 26 site is rangeland and the principal land use is domestic grazing.

REGULATORY SETTING

The survey for vegetation species-of-concern was conducted according to the Navajo Natural Heritage Program (NNHP) guidelines and the Endangered Species Act (ESA), including the procedures set forth in the *Biological Resource Land Use Clearance Policies and Procedures* (RCP), RCS-44-08 (NNDFW 2008), the Species Accounts document (NNHP 2008), and the USFWS survey protocols and recommendations. Data requests for species of concern were submitted to the NNHP and for federal T&E species to the USFWS. NNHP responded to the request for species of concern with a letter to MWH dated 19 November 2015. The letter provided a list of species of concern known to occur within the proximity of the project area. The list of species included their status as either NESL (Navajo Endangered Species List), Federally Endangered, Federally Threatened, or Federal Candidate. Species were further classified as G2, G3 or G4. G2 includes endangered species or subspecies whose prospects of survival or recruitment are in jeopardy. G3 includes endangered species or subspecies whose prospects of survival or recruitment are likely to be in jeopardy in the foreseeable future. G4 are "candidates" and includes those species or subspecies which may be endangered but for which we lack sufficient information to support being listed.

The Navajo Natural Heritage Program and the USFWS listed one endangered plant species that may occur in the project area—Zuni fleabane (*Erigeron rhizomatus*).

METHODS

Study Area

The area evaluated for plant species of concern was defined by the claim boundary, with an additional 100 foot buffer around all sides.

Database Queries and Literature Review

Prior to initiating field surveys, a target list of all potentially occurring species of concern identified by NNHP and the USFWS was compiled. Ecologic and taxonomic information was reviewed for each species prior to initiating field work to better understand ecological characteristics of the species, habitat requirements and key taxonomic indicators for proper identification (ANPS 2000).

Rare Plant Survey Protocols

The plant survey followed currently accepted resource agency protocols and guidelines, for conducting and reporting botanical inventories for special status plant species (USFWS 1996). According to these protocols, rare plant surveys were conducted by botanists with considerable experience with the local flora. All species observed during the surveys were identified to the degree necessary to correctly identify the species and determine if the plant had special status. The survey was conducted in the summer (July) of 2016 during the appropriate season to observe the phenological characteristics of the special status plant species that were necessary for identification.

The botanical survey team was assisted during the survey by GIS trained staff from MWH with training specifically in the use of the Garmin Montana 600. The GPS operator was also instructed in sight identification of species of concern to help delineate points or polygons and other data collection and data management tasks. GPS units were preloaded for the plant team with background and data files that showed the aerial photographic base map, the site boundaries, and the study area, so team members could clearly identify their exact location in the field at all times.

2016 Field Survey

The project site was surveyed by a field botanist. The botanist walked "transect" lines through each area and looked for suitable habitat for *Erigeron rhizomatus*, specifically fine-textured clay hillsides. The most emphasis was placed in areas with suitable habitat for the species of concern. If a species of concern was identified, the location would be recorded using the point or polygon feature in the GPS units. Further, the population size was planned to be obtained either by direct counts, estimations, or by sampling the population.

Field botanists documented every field visit on field forms, by area, and took photographs of field conditions and species of concern, if found on site. The botanist also recorded all plant communities and plant species observed during each field visit. Plant community types were also photographed to document site conditions (Photos #1 and #2).

RESULTS

One plant species of concern, *Erigeron rhizomatus,* was identified as potentially occurring within the proximity of the project area. *Erigeron rhizomatus* is native perennial forb found in McKinley, San Juan and Catron Counties. It is found growing on fine textured clay hillsides primarily in Pinyon-Juniper type. It occurs at elevation ranges between 2,135 and 2,530 m (7,005 and 8,301 ft).

The survey at Section 26 (Desidero Group) on July 19, 2016 did not identify *Erigeron rhizomatus* on the Section 26 site. The habitat at Section 26 may not be appropriate for the occurrence of this species because fine-textured clay hillsides were not present on site.

Photo #1—Overview of general landscape and plant community at Section 26 (Desidero Group).

Photo #2—Overview of general landscape and plant community at Section 26 (Desidero Group).

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LIST OF PREPARERS

Redente, Edward F. Plant Ecologist. B.A., M.S. and Ph.D. Over 40 years of experience in plant ecology and plant survey studies throughout the semi-arid and arid western U.S. Author or Co-author of over 200 publications.

APPENDIX D. NESL LETTER

Navajo Natural Heritage Program

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86515

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http://nnhp.nndfw.org

15mwh101

19-November-2015

Eileen Dornfest - Project Manager
MWH Americas
3665 John F Kennedy Parkway
Bldg 1, Suite 206
Ft. Collins, CO 80525

SUBJECT: Navajo Nation AUM Environmental Response Trust (ERT) Project - 16 Abandoned Uranium Mine (AUM) Sites

Eileen Dornfest,

NNHP has performed an analysis of your project in comparison to known biological resources of the Navajo Nation and has included the findings in this letter. The letter is composed of seven parts. The sections as they appear in the letter are:

1. **Known Species** – a list of all species within relative proximity to the project
2. **Potential Species** – a list of potential species based on project proximity to respective suitable habitat
3. **Quadrangles** – an exhaustive list of quads containing the project
4. **Project Summary** – a categorized list of biological resources within relative proximity to the project grouped by individual project site(s) or quads
5. **Conditional Criteria Notes** – additional details concerning various species, habitat, etc.
6. **Personnel Contacts** – a list of employee contacts
7. **Resources** – identifies sources for further information

Known Species lists "species of concern" known to occur within proximity to the project area. Planning for avoidance of these species is expected. If no species are displayed then based upon the records of the Navajo Nation Department of Fish and Wildlife (NNDFW) there are no "species of concern" within proximity to the project. Refer to the Navajo Endangered Species List (NESL) Species Accounts for recommended avoidance measures, biology, and distribution of NESL species on the Navajo Nation (http://nnhp.nndfw.org/sp_account.htm).

Potential Species lists species that are potentially within proximity to the project area and need to be evaluated for presence/absence. If no species are found within the Known or Potential Species lists, the project is not expected to affect any federally listed species, nor significantly impact any tribally listed species or other species of concern. Potential for species has been determined primarily on habitat characteristics and species range information. A thorough habitat analysis, and if necessary, species specific surveys, are required to determine the potential for each species.

Species of concern include protected, candidate, and other rare or otherwise sensitive species, including certain native species and species of economic or cultural significance. For legally protected species, the following tribal and federal statuses are indicated: NESL, federal Endangered Species Act (ESA), Migratory

Bird Treaty Act (MBTA), and Eagle Protection Act (EPA). No legal protection is afforded species with only ESA candidate, NESL group 4 status, and species listed on the Sensitive Species List. Please be aware of these species during surveys and inform the NNDFW of observations. Reported observations of these species and documenting them in project planning and management is important for conservation and may contribute to ensuring they will not be up listed in the future.

In any and all correspondence with NNDFW or NNHP concerning this project please cite the Data Request Code associated with this document. It can be found in this report on the top right corner of the every page. Additionally please cite this code in any biological evaluation documents returned to our office.

1. Known Species *(NESL=Navajo Endangered Species List, FE=Federally Endangered, FT=Federally Threatened, FC=Federal Candidate)*

Species

AMPE = Amsonia peeblesii / Peebles' Blue-star NESL G4
AQCH = Aquila chrysaetos / Golden Eagle NESL G3
CASP = Carex specuicola / Navajo Sedge NESL G3 FT
LIPI = Lithobates pipiens / Northern Leopard Frog NESL G2
PEAMCI = Perognathus amplus cineris / Wupatki Pocket Mouse NESL G4
PUPA = Puccinellia parishii / Parish's Alkali Grass NESL G4
**All or parts of this project currently are within areas protected by the Golden and Bald Eagle Nest Protection Regulations; consult with NNDFW zoologist or EA Reviewer for more information and recommendations.

2. Potential Species

Species

ALGO = Allium gooddingii / Gooding's Onion NESL G3
AMPE = Amsonia peeblesii / Peebles' Blue-star NESL G4
AQCH = Aquila chrysaetos / Golden Eagle NESL G3
ASBE = Astragalus beathii / Beath Milk-vetch NESL G4
ASNA = Astragalus naturitensis / Naturita Milk-vetch NESL G3
ASWE = Asclepias welshii / Welsh's Milkweed NESL G3 FT
ATCU = Athene cunicularia / Burrowing Owl NESL G4
BURE = Buteo regalis / Ferruginous Hawk NESL G3
CASP = Carex specuicola / Navajo Sedge NESL G3 FT
CHMO = Charadrius montanus / Mountain Plover NESL G4
CIME = Cinclus mexicanus / American Dipper NESL G3
CIRY = Cirsium rydbergii / Rydberg's Thistle NESL G4
CYUT = Cystopteris utahensis / Utah Bladder-fern NESL G4
EMTREX = Empidonax traillii extimus / Southwestern Willow Flycatcher NESL G2 FE
ERAC = Erigeron acomanus / Acoma Fleabane NESL G3
ERRH = Erigeron rhizomatus / Rhizome Fleabane/zuni Fleabane NESL G2 FT
ERRO = Errazurizia rotundata / Round Dunebroom NESL G3
ERSI = Erigeron sivinskii / Sivinski's Fleabane NESL G4
FAPE = Falco peregrinus / Peregrine Falcon NESL G4
GIRO = Gila robusta / Roundtail Chub NESL G2
LENA = Lesquerella navajoensis / Navajo Bladderpod NESL G3
LIPI = Lithobates pipiens / Northern Leopard Frog NESL G2
MUNI = Mustela nigripes / Black-footed Ferret NESL G2 FE

PEAMCI = Perognathus amplus cineris / Wupatki Pocket Mouse NESL G4
PLZO = Platanthera zothecina / Alcove Bog-orchid NESL G3
PRSP = Primula specuicola / Cave Primrose NESL G4
PTLU = Ptchocheilus lucius / Colorado Pikeminnow NESL G2
PUPA = Puccinellia parishii / Parish's Alkali Grass NESL G4
SAPAER = Salvia pachyphylla ssp eremopictus / Arizona Rose Sage NESL G4
STOCLU = Strix occidentalis lucida / Mexican Spotted Owl NESL G3 FT
VUMA = Vulpes macrotis / Kit Fox NESL G4
ZIVA = Zigadenus vaginatus / Alcove Death Camass NESL G3

3. Quadrangles (7.5 Minute)

Quadrangles

Cameron SE (35111-G3) / AZ
Dalton Pass (35108-F3) / NM
Del Muerto (36109-B4) / AZ
Dos Lomas (35107-C7) / NM
Gallup East (35108-E6) / NM
Garnet Ridge (36109-H7) / AZ, UT
Horse Mesa (36109-F1) / AZ, NM
Indian Wells (35110-D1) / AZ
Mexican Hat SE (37109-A7) / UT, AZ
Oljeto (37110-A3) / UT, AZ
Toh Atin Mesa East (36109-H3) / AZ, UT
Toh Atin Mesa West (36109-H4) / AZ, UT

4. Project Summary *(EO1 Mile/EO 3 Miles=elements occuring within 1 & 3 miles., MSO=mexican spotted owl PACs, POTS=potential species, RCP=Biological Areas)*

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
Alongo Mines	None	AQCH	Horse Mesa (36109-F1) / AZ, NM	None	LIPI, FAPE, EMTREX, CHMO, BURE, ATCU, AQCH, ZIVA, PUPA, PLZO, CIRY, CASP	Area 3
Barton 3	None	None	Toh Atin Mesa West (36109-H4) / AZ, UT	None	PTLU, GIRO, EMTREX, CHMO, BURE, ATCU, AQCH, ZIVA, PLZO, CIRY, CASP	Area 3
Boyd Tisi No. 2 Western	None	AMPE, PEAMCI, LIPI	Cameron SE (35111-G3) / AZ	None	LIPI, PEAMCI, FAPE, EMTREX, BURE, AQCH, ERRO, ASBE, AMPE	Area 3
Charles Keith	None	None	Oljeto (37110-A3) / UT, AZ	None	LIPI, FAPE, EMTREX, CHMO, BURE, AQCH	Area 1, Area 3

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
Eunice Becenti	None	None	Gallup East (35108-E6) / NM	None	FAPE, EMTREX, ATCU, AQCH, LENA, ERSI, ERRH, ERAC	Area 3
Harvey Blackwater No. 3	AQCH	AQCH, PUPA	Garnet Ridge (36109-H7) / AZ, UT	None	VUMA, LIPI, FAPE, EMTREX, CIME, BURE, ATCU, AQCH, ZIVA, PUPA, PRSP, PLZO, CIRY, CASP, ASWE	Area 3
Harvey Blackwater No. 3	AQCH	AQCH, PUPA	Mexican Hat SE (37109-A7) / UT, AZ	None	VUMA, FAPE, EMTREX, ATCU, AQCH, ZIVA, PLZO, CIRY, CASP, ASWE	Area 1
Hoskie Tso No. 1	AQCH	AQCH	Indian Wells (35110-D1) / AZ	None	FAPE, CHMO, BURE, ATCU, AQCH, SAPAER	Area 3
Mitten No. 3	None	AQCH	Oljeto (37110-A3) / UT, AZ	None	LIPI, FAPE, EMTREX, CHMO, BURE, AQCH	Area 3
NA-0904	None	AQCH	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, ATCU, AQCH, PUPA	Area 3
NA-0928	None	None	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, ATCU, AQCH, PUPA	Area 3
Oak124, Oak125	AQCH	AQCH	Horse Mesa (36109-F1) / AZ, NM	None	LIPI, FAPE, EMTREX, CHMO, BURE, AQCH, ZIVA, PUPA, PLZO, CIRY, CASP	Area 3
Occurrence B	None	AQCH, CASP	Del Muerto (36109-B4) / AZ	None	LIPI, FAPE, EMTREX, CIME, AQCH, ZIVA, PLZO, CYUT, CIRY, CASP, ALGO	Area 3
Section 26 (Desiddero Group)	None	None	Dos Lomas (35107-C7) / NM	None	FAPE, CHMO, ATCU, AQCH	Area 3
Standing Rock	None	None	Dalton Pass (35108-F3) / NM	None	VUMA, MUNI, FAPE, CHMO, BURE, ATCU, AQCH, ERSI, ASNA	Area 3

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
Tsosie 1	AQCH	AQCH	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, AQCH, PUPA	Area 1, Area 3

5. Conditional Criteria Notes *(Recent revisions made please read thoroughly. For certain species, and/or circumstances, please read and comply)*

A. **Biological Resource Land Use Clearance Policies and Procedures (RCP)** - The purpose of the RCP is to assist the Navajo Nation government and chapters ensure compliance with federal and Navajo laws which protect, wildlife resources, including plants, and their habitat resulting in an expedited land use clearance process. After years of research and study, the NNDFW has identified and mapped wildlife habitat and sensitive areas that cover the entire Navajo Nation.
The following is a brief summary of six (6) wildlife areas:
1.***Highly Sensitive Area*** – recommended no development with few exceptions.
2.***Moderately Sensitive Area*** – moderate restrictions on development to avoid sensitive species/habitats.
3.***Less Sensitive Area*** – fewest restrictions on development.
4.***Community Development Area*** – areas in and around towns with few or no restrictions on development.
5.***Biological Preserve*** – no development unless compatible with the purpose of this area.
6.***Recreation Area*** – no development unless compatible with the purpose of this area.
None - outside the boundaries of the Navajo Nation
This is not intended to be a full description of the RCP please refer to the our website for additional information at http://www.nndfw.org/clup.htm.

B. **Raptors** – If raptors are known to occur within 1 mile of project location: Contact Chad Smith at 871-7070 regarding your evaluation of potential impacts and mitigation.
o **Golden and Bald Eagles**- If Golden or Bald Eagle are known to occur within 1 mile of the project, decision makers need to ensure that they are not in violation of the Golden and Bald Eagle Nest Protection Regulations found at http://nnhp.nndfw.org/docs_reps/gben.pdf.
o **Ferruginous Hawks** – Refer to "Navajo Nation Department of Fish and Wildlife's Ferruginous Hawk Management Guidelines for Nest Protection" http://nnhp.nndfw.org/docs_reps.htm for relevant information on avoiding impacts to Ferruginous Hawks within 1 mile of project location.
o **Mexican Spotted Owl** - Please refer to the Navajo Nation Mexican Spotted Owl Management Plan http://nnhp.nndfw.org/docs_reps.htm for relevant information on proper project planning near/within spotted owl protected activity centers and habitat.

C. **Surveys** – Biological surveys need to be conducted during the appropriate season to ensure they are complete and accurate please refer to NN Species Accounts http://nnhp.nndfw.org/sp_account.htm. Surveyors on the Navajo Nation must be permitted by the Director, NNDFW. Contact Jeff Cole at (928) 871-7068 for permitting procedures. Questions pertaining to surveys should be directed to the NNDFW Zoologist (Chad Smith) for animals at 871-7070, and Botanist (Andrea Hazelton) for plants at (928)523-3221. Questions regarding biological evaluation should be directed to Jeff Cole at 871-7068.

D. **Oil/Gas Lease Sales** – Any settling or evaporation pits that could hold contaminants should be lined and covered. Covering pits, with a net or other material, will deter waterfowl and other migratory bird use. Lining pits will protect ground water quality.

E. **Power line Projects** – These projects need to ensure that they do not violate the regulations set forth in the Navajo Nation Raptor Electrocution Prevention Regulations found at http://nnhp.nndfw.org/docs_reps/repr.pdf.

F. **Guy Wires** – Does the project design include guy wires for structural support? If so, and if bird species may occur in relatively high concentrations in the project area, then guy wires should be equipped with highly visual markers to reduce the potential mortality due to bird-guy wire collisions. Examples of visual markers include aviation balls and bird flight diverters. Birds can be expected to occur in relatively high concentrations along migration routes (e.g., rivers, ridges or other distinctive linear topographic features) or where important habitat for breeding, feeding, roosting, etc. occurs. The U.S. Fish and Wildlife Service recommends marking guy wires with at least one marker per 100 meters of wire.

G. **San Juan River** – On 21 March 1994 (Federal Register, Vol. 59, No. 54), the U.S. Fish and Wildlife Service designated portions of the San Juan River (SJR) as critical habitat for Ptychocheilus lucius (Colorado pikeminnow) and Xyrauchen texanus (Razorback sucker). Colorado pikeminnow critical habitat includes the SJR and its 100-year floodplain from the State Route 371 Bridge in T29N, R13W, sec. 17 (New Mexico Meridian) to Neskahai Canyon in the San Juan arm of Lake Powell in T41S, R11E, sec. 26 (Salt Lake Meridian) up to the full pool elevation. Razorback sucker critical habitat includes the SJR and its 100-year floodplain from the Hogback Diversion in T29N, R16W, sec. 9 (New Mexico Meridian) to the full pool elevation at the mouth of Neskahai Canyon on the San Juan arm of Lake Powell in T41S, R11E, sec. 26 (Salt Lake Meridian). All actions carried out, funded or authorized by a federal agency which may alter the constituent elements of critical habitat must undergo section 7 consultation under the Endangered Species Act of 1973, as amended. Constituent elements are those physical and biological attributes essential to a species conservation and include, but are not limited to, water, physical habitat, and biological environment as required for each particular life stage of a species.

H. **Little Colorado River** - On 21 March 1994 (Federal Register, Vol. 59, No. 54) the U.S. Fish and Wildlife Service designated Critical Habitat along portions of the Colorado and Little Colorado Rivers (LCR) for Gila cypha (humpback chub). Within or adjacent to the Navajo Nation this critical habitat includes the LCR and its 100-year floodplain from river mile 8 in T32N R6E, sec. 12 (Salt and Gila River Meridian) to its confluence with the Colorado River in T32N R5E sec. 1 (S&GRM) and the Colorado River and 100-year floodplain from Nautuloid Canyon (River Mile 34) T36N R5E sec. 35 (S&GRM) to its confluence with the LCR. All actions carried out, funded or authorized by a federal agency which may alter the constituent elements of Critical Habitat must undergo section 7 consultation under the Endangered Species Act of 1973, as amended. Constituent elements are those physical and biological attributes essential to a species conservation and include, but are not limited to, water, physical habitat, and biological environment as required for each particular life stage of a species.

I. **Wetlands –** In Arizona and New Mexico, potential impacts to wetlands should also be evaluated. The U.S. Fish & Wildlife Service's National Wetlands Inventory (NWI) maps should be examined to determine whether areas classified as wetlands are located close enough to the project site(s) to be impacted. In cases where the maps are inconclusive (e.g., due to their small scale), field surveys must be completed. For field surveys, wetlands identification and delineation methodology contained in the "Corps of Engineers Wetlands Delineation Manual" (Technical Report Y-87-1) should be used. When wetlands are present, potential impacts must be addressed in an environmental assessment and the Army Corps of Engineers, Phoenix office, must be contacted. NWI maps are available for examination at the Navajo Natural Heritage Program (NNHP) office, or may be purchased through the U.S. Geological Survey (order forms are available through the NNHP). The NNHP has complete coverage of the Navajo Nation, excluding Utah, at 1:100,000 scale; and coverage at 1:24,000 scale in the southwestern portion of the Navajo Nation. In Utah, the U.S. Fish & Wildlife Service's National Wetlands Inventory maps are not yet available for the Utah portion of the Navajo Nation, therefore, field surveys should be completed to determine whether wetlands are located close enough to the project site(s) to be impacted. For field surveys, wetlands identification and delineation methodology contained in the "Corps of Engineers Wetlands Delineation Manual" (Technical Report Y-87-1) should be used. When wetlands are present, potential impacts must be addressed in an environmental assessment and the Army Corps of Engineers, Phoenix office, must be contacted. For more information contact the Navajo Environmental Protection Agency's Water Quality Program.

J. **Life Length of Data Request –** The information in this report was identified by the NNHP and NNDFW's biologists and computerized database, and is based on data available at the time of this response. If project planning takes more than two (02) years from the date of this response, verification of the information provided herein is necessary. It should not be regarded as the final statement on the occurrence of any species, nor should it substitute for on-site surveys. Also, because the NNDFW information is continually updated, any given information response is only wholly appropriate for its respective request.

K. **Ground Water Pumping** - Projects involving the ground water pumping for mining operations, agricultural projects or commercial wells (including municipal wells) will have to provide an analysis on the effects to surface water and address potential impacts on all aquatic and/or wetlands species listed below. NESL Species potentially impacted by ground water pumping: Carex specuicola (Navajo Sedge), Cirsium rydbergii (Rydberg's Thistle), Primula specuicola (Cave Primrose), Platanthera zothecina (Alcove Bog Orchid), Puccinellia parishii (Parish Alkali Grass), Zigadenus vaginatus (Alcove Death Camas), Perityle specuicola (Alcove Rock Daisy), Symphyotrichum welshii (Welsh's American-aster), Coccyzus americanus (Yellow-billed Cuckoo), Empidonax traillii extimus (Southwestern Willow Flycatcher), Rana pipiens (Northern Leopard Frog), Gila cypha (Humpback Chub), Gila robusta (Roundtail Chub), Ptychocheilus lucius (Colorado Pikeminnow), Xyrauchen texanus (Razorback Sucker), Cinclus mexicanus (American Dipper), Speyeria nokomis (Western Seep Fritillary), Aechmophorus clarkia (Clark's Grebe), Ceryle alcyon (Belted Kingfisher), Dendroica petechia (Yellow Warbler), Porzana carolina (Sora), Catostomus discobolus (Bluehead Sucker), Cottus bairdi (Mottled Sculpin), Oxyloma kanabense (Kanab Ambersnail)

6. Personnel Contacts

Wildlife Manager
Sam Diswood
928.871.7062
sdiswood@nndfw.org

Zoologist
Chad Smith
928.871.7070
csmith@nndfw.org

Botanist
Vacant

Biological Reviewer
Pamela Kyselka
928.871.7065
pkyselka@nndfw.org

GIS Supervisor
Dexter D Prall
928.645.2898
prall@nndfw.org

Wildlife Tech
Sonja Detsoi
928.871.6472
sdetsoi@nndfw.org

7. Resources

National Environmental Policy Act

Navajo Endangered Species List:
http://nnhp.nndfw.org/endangered.htm

Species Accounts:
http://nnhp.nndfw.org/sp_account.htm

Biological Investigation Permit Application
http://nnhp.nndfw.org/study_permit.htm

Navajo Nation Sensitive Species List
http://nnhp.nndfw.org/study_permit.htm

Various Species Management and/or Document and Reports
http://nnhp.nndfw.org/docs_reps.htm

Consultant List
(Coming Soon)

Dexter D Prall

Digitally signed by Dexter D Prall
DN: cn=Dexter D Prall, o=Navajo Nation Department of Fish and Wildlife, ou=Navajo Natural Heritage Program, email=prall@nndfw.org, c=US
Date: 2015.11.19 15:56:30 -07'00'

Dexter D Prall, GIS Supervisor - Natural Heritage Program
Navajo Nation Department of Fish and Wildlife

MWH

BUILDING A BETTER WORLD

November 18, 2015

TO: Navajo Natural Heritage Program
Navajo Nation Dept. of Fish and Wildlife
ATTN: Sonja Detsoi and Dexter Prall
P.O. Box 1480
Window Rock, AZ 86515

FROM: MWH Americas
ATTN: Eileen Dornfest, Project Manager
3665 John F Kennedy Parkway
Bldg 1, Suite 206
Ft. Collins, CO 80525
Phone: (970) 377-9410
Fax: (970) 377-9406
E-mail: Eileen.Dornfest@mwhglobal.com

SUBJECT: Request for T and E Information for 16 Abandoned Uranium Mine (AUM) Sites

PROJECT NAME:
Navajo Nation AUM Environmental Response Trust (ERT) Project

LOCATION:
16 AUM Sites (attached in GIS shape files and USGS topographic maps)

SUMMARY DESCRIPTION OF PROJECT:
The work is to be conducted at 16 Abandoned Uranium Mines (AUMs) and includes Removal Site Evaluations (RSEs) according to CERCLA at each of the Sites. The RSEs are site investigations that include the following activities:

- conducting background soil studies
- conducting gamma radiation scans of surface soils
- sampling surface and subsurface soils and sediments related to historic mining operations
- assessing radiation exposure inside mine operations buildings, homes, or other nearby structures (if present at the Sites)
- sampling existing and accessible groundwater wells
- mitigating physical hazards and other interim response actions
- preparing a final written report documenting the work performed and information obtained for each of the Sites

MWH

BUILDING A BETTER WORLD

TOPOGRAPHIC MAPS ATTACHED:

- Blue Gap Quadrangle, Arizona-Apache Co.
- Cameron SE Quadrangle, Arizona-Coconino Co.
- Cameron South Quadrangle, Arizona-Coconino Co.
- Del Muerto Quadrangel, Arizona-Apache Co.
- Five Buttes Quadrangle, Arizona-Navajo Co.
- Garnet Ridge Quadrangle, Arizona-Utah
- Horse Mesa Quadrangle, Arizona-New Mexico
- Indian Wells Quadrangle, Arizona-Navajo Co.
- Tah Chee Wash Quadrangle, Arizona-Apache Co.
- Toh Atin Mesa East Quadrangle, Arizona-Utah
- Toh Atin Mesa West Quadrangle, Arizona-Utah
- Bluewater Quadrangle, New Mexico
- Bread Springs Quadrangle, New Mexico-McKinley Co.
- Dalton Pass Quadrangle, New Mexico-McKinley Co.
- Dos Lomas Quadrangle, New Mexico
- Gallup East Quadrangle, New Mexico-McKinley Co.
- Sand Spring Quadrangle, New Mexico-San Juan Co.
- Standing Rock Quadrangle, New Mexico-McKinley Co.
- Mexican Hat SE Quadrangle, Utah-San Juan Co.
- Oljato Quadrangle, Utah-San Juan Co.

THE NAVAJO NATION
HISTORIC PRESERVATION DEPARTMENT
PO Box 4950, Window Rock, Arizona 86515
TEL: (928) 871-7198 FAX: (928) 871-7886

CULTURAL RESOURCES COMPLIANCE FORM

ROUTE COPIES TO:	NNHPD NO.: HPD-16-565 - *REVISED*
☑ DCRM	OTHER PROJECT NO.: DCRM 2016-09

PROJECT TITLE: A Cultural Resource Inventory of Three Abandoned Uranium Mines for MWH Global, Inc.: (Eunice Becenti, Standing Rock, and Section 26 Desidero Group) in Church Rock, Nahodishgish, and Baca/Prewitt Chapters, Navajo Nation

LEAD AGENCY: BIA/NR

SPONSOR: Sadie Hoskie, Trustee, Navajo Nation AUM, Environmental Response Trust, PO Box 3330, Window Rock, Arizona 86515

PROJECT DESCRIPTION: The proposed undertaking will involve the removal site evaluations to define the horizontal extent of contamination in surface soil and sediments a three former uranium mine areas. The area of potential effect is 51.8-acres. Ground disturbing activities will be intensive and extensive with the use of heavy equipment.

LAND STATUS:	Navajo Tribal Trust													
CHAPTER:	Church Rock, Nahodishgish, Baca/Prewitt													
LOCATION:	*T.*	15	*N.,*	*R.*	17	*W*	*Sec.*	28;	Gallup East	Quadrangle,	McKinley	County	New Mexico	NMPM
	T.	18	*N.,*	*R.*	14	*W-*	*Sec.*	34/35;	Dalton Pass	Quadrangle,	McKinley	County	New Mexico	NMPM
	T.	13	*N.,*	*R.*	10	*W-*	*Sec.*	26;	Don Lomas	Quadrangle,	McKinley	County	New Mexico	NMPM

PROJECT ARCHAEOLOGIST:	Clifford Werito, Tristin Moone, Rena Martin, Arlo Werito with Klara Kelley and Harris Francis
NAVAJO ANTIQUITIES PERMIT NO.:	B16161
DATE INSPECTED:	5/2/2016 - 5/16/2016
DATE OF REPORT:	7/5/2016
TOTAL ACREAGE INSPECTED:	87.6 – ac
METHOD OF INVESTIGATION:	Class III pedestrian inventory with transects spaced 15 m apart.
LIST OF CULTURAL RESOURCES FOUND:	**(1) Site (NM-R-47-01); (4) Isolated Occurrences (IO), (2) In-Use Sites (IUS); (1) Traditional Cultural Property (TCP)**
LIST OF ELIGIBLE PROPERTIES:	**(1) TCP**
LIST OF NON-ELIGIBLE PROPERTIES:	**(1) Site (NM-R-47-01); (4) IO; (2) IUS**
LIST OF ARCHAEOLOGICAL RESOURCES:	**None**

EFFECT/CONDITIONS OF COMPLIANCE: No adverse effect with the following conditions:

Site NM-R-47-01:
No further work is warranted.

TCP:

1. TCP boundary will be marked/flagged by qualified archaeologist prior to remediation activities.
2. TCP will be avoided by all mining activities & a qualified archaeologist will monitor all activities within 100-at of the TCP.

If TCP cannot be avoided:

Mitigation measures will be initiated by the sponsor in consultation with NNHPD and with the Chee Bob Thompson family.

In the event of a discovery [*"discovery"* means any previously unidentified or incorrectly identified cultural resources including but not limited to archaeological deposits, human remains, or locations reportedly associated with Native American religious/traditional beliefs or practices], all operations in the immediate vicinity of the discovery must cease, and the Navajo Nation Historic Preservation Department must be notified at (928) 871-7198.

FORM PREPARED BY: **Tamara Billie**
FINALIZED: September 9, 2016

Notification to Proceed	☑ Yes	☐ No	Tamara Billie ·	9/9/16
Recommended Conditions:	☑ Yes	☐ No	The Navajo Nation Historic Preservation Office	Date
Navajo Region Approval	☒ Yes	☐ No	Acting BIA – Navajo Regional Office	SEP 2 8 2016 Date

7/11/16

BIOLOGICAL RESOURCES COMPLIANCE FORM
NAVAJO NATION DEPARTMENT OF FISH AND WILDLIFE
P.O. BOX 1480, WINDOW ROCK, ARIZONA 86515-1480

It is the Department's opinion the project described below, with applicable conditions, is in compliance with Tribal and Federal laws protecting biological resources including the Navajo Endangered Species and Environmental Policy Codes, U.S. Endangered Species, Migratory Bird Treaty, Eagle Protection and National Environmental Policy Acts. This form does not preclude or replace consultation with the U.S. Fish and Wildlife Service if a Federally-listed species is affected.

PROJECT NAME & NO.: Section 26 (Desidero Group) - Abandoned Uranium Mine Project

DESCRIPTION: Proposed Phase I & II scientific investigations at an abandoned mine site. Phase I would entail biological and land surveying with a maximum of 5 people onsite for no more than 5-7 days. Disturbance would be light. Phase II would require the use of an excavator or a small mobile drilling unit to collect one or more soil samples with up to 8 people onsite for a period of one week. A temporary travel corridor 20 ft. in width would be necessary to move equipment to the site. Disturbance would be light to moderate. No permanent structures would be left onsite. The proposed project area (mine boundary and buffer) would be approximately 32.8 acres.

LOCATION: 35°20'N 107°51.57'W, Baca/Prewitt Chapter, McKinley County, New Mexico

REPRESENTATIVE: Lori Gregory, Adkins Consulting, Inc. for MWH Global/Stantec

ACTION AGENCY: U.S. Environmental Protection Agency and Navajo Nation

B.R. REPORT TITLE / DATE / PREPARER: BE-Section 26 (Desidero Group) Abandoned Uranium Mine Project/AUG 2016/Lori Gregory, Plant Survey Report for Species of Concern At Section 26 (Desidero Group) Project Site/AUG 2016/Redente Ecological Consultants

SIGNIFICANT BIOLOGICAL RESOURCES FOUND: Area 3. Suitable nesting habitat is present in the project area for Migratory Birds not listed under the NESL or ESA. Migratory Birds and their habitats are protected under the Migratory Bird Treaty Act (16 USC §703-712) and Executive Order 13186. Under the EO, all federal agencies are required to consider management impacts to protect migratory non-game birds.

<u>POTENTIAL IMPACTS</u>

NESL SPECIES POTENTIALLY IMPACTED: NA

FEDERALLY-LISTED SPECIES AFFECTED: NA

OTHER SIGNIFICANT IMPACTS TO BIOLOGICAL RESOURCES: NA

AVOIDANCE / MITIGATION MEASURES: Mitigation measures will be implemented to ensure that there are no impacts to migratory birds that could potentially nest in the project area.

CONDITIONS OF COMPLIANCE*: NA

FORM PREPARED BY / DATE: Pamela A. Kyselka/10 NOV 2016

COPIES TO: (add categories as necessary)

☐ ______________________ ☐ ______________________

2 NTC § 164 Recommendation: Signature Date

☒Approval

☐Conditional Approval (with memo)

☐Disapproval (with memo)

☐Categorical Exclusion (with request letter)

☐None (with memo)

11/16/16

Gloria M. Tom, Director, Navajo Nation Department of Fish and Wildlife

*I understand and accept the conditions of compliance, and acknowledge that lack of signature may be grounds for the Department not recommending the above described project for approval to the Tribal Decision-maker.

Representative's signature Date

From:	Nystedt, John
To:	Justin Peterson
Cc:	Lori Gregory; Pam Kyselka; tbillie@navajo-nsn.gov; Harrilene Yazzie; Melissa Mata
Subject:	Navajo Nation AUM Environmental Response Trust - -First Phase
Date:	Monday, November 07, 2016 4:08:30 PM
Attachments:	image001.png

Justin,

Thank you for your November 6, 2016, email. This email documents our response regarding the subject project, in compliance with section 7 of the Endangered Species Act of 1973 (ESA) as amended (16 U.S.C. 1531 et seq.). Based on the information you provided, we believe no endangered or threatened species or critical habitat will be affected by this project; nor is this project likely to jeopardize the continued existence of any proposed species or adversely modify any proposed critical habitat. No further review is required for this project at this time. Should project plans change or if new information on the distribution of listed or proposed species becomes available, this determination may need to be reconsidered. In all future communication on this project, please refer to consultation numbers given below.

In keeping with our trust responsibilities to American Indian Tribes, by copy of this email, we will notify the Navajo Nation, which may be affected by the proposed action and encourage you to invite the Bureau of Indian Affairs to participate in the review of your proposed action.

Should you require further assistance or if you have any questions, please contact me as indicated below, or my supervisor, Brenda Smith, at 556-2157. Thank you for your continued efforts to conserve endangered species.

Claim 28	02EAAZ00-2016-SLI-0358
Section 26 (Desiddero Group)	02ENNM00-2016-SLI-0447
Mitten #3	06E23000-2016-SLI-0210
NA-0904	02EAAZ00-2016-SLI-0363
Occurrence B	02EAAZ00-2016-SLI-0361
Standing Rock	02ENNM00-2016-SLI-0448
Alongo Mines	02ENNM00-2016-SLI-0465
Tsosie 1*	02EAAZ00-2016-SLI-0364
Boyd Tisi No. 2 Western	02EAAZ00-2016-SLI-0355
Harvey Blackwater #3	02EAAZ00-2016-SLI-0356 / 06E23000-2016-SLI-0207
Oak 124/125	02ENNM00-2016-SLI-0466
NA-0928	02EAAZ00-2016-SLI-0360
Hoskie Tso #1	02EAAZ00-2016-SLI-0362
Charles Keith	06E23000-2016-SLI-0208
Barton 3	02EAAZ00-2016-SLI-0354
Eunice Becenti	02ENNM00-2016-SLI-0444

* It is our understanding that the Tsosie No. 1 site has been put on hold indefinitely due to access issues. However, provided the results of the survey were negative (i.e., no potential for

any ESA-listed species) then we would come to the same conclusion, above, as for the other 15 projects.

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Fish and Wildlife Biologist/AESO Tribal Coordinator
USFWS AZ Ecological Services Office - Flagstaff Suboffice
Southwest Forest Science Complex, 2500 S Pine Knoll Dr, Rm 232
Flagstaff, AZ 86001-6381 (928) 556-2160 Fax-2121 Cell:(602) 478-3797
http://www.fws.gov/southwest/es/arizona/

Appendix F Data Usability Report, Laboratory Analytical Data, and Data Validation Reports

F.1 Data Usability Report

F.2 Laboratory Analytical Data and Data Validation Reports

(provided in a separate electronic file due to its file size and length)

F.1 Data Usability Report

DATA USABILITY REPORT

1.0 INTRODUCTION

This data usability report presents a summary of the validation results for the sample data collected from the Section 26 Site (the Site) as part of the Removal Site Evaluation (RSE) performed for the Navajo Nation AUM Environmental Response Trust—First Phase. The purpose of the validation was to ascertain the data usability measured against the data quality objectives (DQOs) and confirm that results obtained are scientifically defensible.

Samples were collected between November 30, 2016 and September 19, 2017 and were analyzed by ALS Environmental of Ft. Collins, Colorado, for all methods. Samples were analyzed for one or more of the following:

- Radium-226 in soil by United States Environmental Protection Agency (USEPA) Method 901.1
- Metals in soil by USEPA Method SW6020
- Isotopic thorium in soil by USDOEAS-06/EMSL/LV

Samples were collected and analyzed according to the procedures and specific criteria presented in the *Quality Assurance Project Plan, Navajo Nation AUM Environmental Response Trust (QAPP)* (MWH, 2016).

Project data were validated as follows:

- Laboratory Data Consultants, Inc. (LDC) of Carlsbad, California, performed validation of all radiological soil data, plus ten percent of the non-radiological data (Level IV only)
- All non-radiological soil data were validated by the Stantec Consulting Services Inc. (Stantec; formerly MWH) Project Chemist (Level III only)
- All samples received Level III data validation
- Ten percent of the sample results for all methods received a more detailed Level IV validation

The analytical data were validated based on the results of the following data evaluation parameters or quality control (QC) samples:

- Compliance with the QAPP
- Sample preservation
- Sample extraction and analytical holding times

- Initial calibration (ICAL), initial calibration verification (ICV), and continuing calibration verification (CCV) results
- Method and initial/continuing calibration blank (ICB/CCB) sample results
- Matrix spike/matrix spike duplicate (MS/MSD) sample results
- Laboratory duplicate results
- Serial dilution (metals analysis only)
- Interference check samples (ICS) (metals analysis only)
- Laboratory control sample (LCS) and laboratory control sample duplicate (LCSD) results
- Field duplicate sample results
- Minimum detectable concentration (radiological analyses only)
- Reporting limits
- Sample result verification
- Completeness evaluation
- Comparability evaluation

Sample results that were qualified due to quality control parameters outside of acceptance criteria are listed on Table F.1-1.

2.0 DATA VALIDATION RESULTS

Stantec reviewed the data validation reports and assessed the qualified data against the DQOs for the project. The following summarizes the data validation findings for each of the data evaluation parameters.

2.1 QUALITY ASSURANCE PROJECT PLAN COMPLIANCE EVALUATION

Based on the data validation, all samples were analyzed following the quality control criteria specified in the QAPP, with the following exception: ALS routinely dilutes all metals samples by a factor of 10 times in order to protect their ICP-MS instrument from the adverse effects of running samples with high total dissolved solids. This also includes running a long series of samples (as is common in a production laboratory) with intermediate dissolved solids. The vulnerable parts of the instrument are the nebulizer, which produces an aerosol, and the cones, which disperse the aerosol. These areas form scaly deposits from the samples in the sample solution, despite the nitric acid and other acids present in the digestate. These parts of the instrument periodically need to be taken apart and cleaned, but in a production setting the laboratory wants to avoid any downtime as much as possible. As an ameliorating factor, the laboratory also takes account of this dilution factor up front in the project planning stages. The laboratory will not quote a reporting limit for this instrument that cannot be achieved after the 10 times dilution required for the instrument. Not all of the requested reporting limits can be met using the laboratory's routine protocol. The dilution is narrated by the laboratory merely as a matter of transparency, as well as for the validator's information. The dilution should have no impact on the project's sensitivity goals.

Sample Preservation Evaluation. All samples were preserved as specified in the QAPP.

Holding Time Evaluation. All analytical holding times were met.

Initial Calibration, Initial Calibration Verification, and Continuing Calibration Verification Evaluation. All ICAL, ICV, and CCV results were within acceptance criteria.

Method Blank Evaluation. No sample data were qualified due to method blank results.

Initial and Continuing Calibration Blank Evaluation. No sample data were qualified due to ICB/CCB data.

Matrix Spike/Matrix Spike Duplicate Samples Evaluation. All MS/MSD recoveries were within acceptance criteria with the exception of several metals. Table F.1-1 lists the analytes where an MS and/or MSD percent recovery was outside the acceptance criteria. Sample results were qualified with a "J+" flag for results that are estimated and potentially biased high; sample results were qualified with a "J-"flag for results that are estimated and potentially biased low. All MS/MSD RPDs were within acceptance criteria with the exception of one RPD for the analysis of uranium. The sample result was already qualified with a "J+" flag.

Laboratory Duplicate Sample Evaluation. For some analyses, the laboratory prepared and analyzed a duplicate sample. RPD results were evaluated between the parent and laboratory duplicate samples. Several RPDs were outside the acceptance criteria for the analysis of metals. Sample results were qualified with a "J" flag if not otherwise qualified.

Serial Dilution Evaluation. All serial dilution percent differences were within acceptance criteria, except for two samples analyzed for arsenic. The sample results were qualified as estimated with a "J" flag.

Interference Check Sample Evaluation. All interference check samples were within acceptance criteria.

Laboratory Control Sample/Laboratory Control Sample Duplicate Evaluation. All LCS and LCSD recoveries were within acceptance criteria. All LCS/LCSD RPDs were within acceptance criteria.

Field Duplicate Evaluation. The RPDs were less than the guidance RPD of 30 percent established in the QAPP for all field duplicate pairs, with the exception of results for nine metals and one radium-226. The primary cause for RPDs exceeding 30 percent for some duplicate pairs is assumed to be the heterogeneity/variability of soil samples. The sample IDs, sample results, and RPDs for those results that did not meet the guidance RPD are listed in Table F.1-2. Sample results were not qualified due to RPDs exceeding the guidance criteria, as described in the QAPP.

Minimum Detectable Concentration Evaluation. All minimum detectable concentrations met reporting limits with the exception of one sample for the analysis of radium-226. However, the reported activity for this sample was greater than the achieved minimum detectable concentration and no qualification was needed.

Reporting Limit Evaluation. All sample data were reported to the reporting limit established in the QAPP, with the exception of the metals, as discussed at the beginning of this section related to dilution.

Sample Result Verification. All sample result verifications were acceptable with the exception of sixteen samples analyzed for radium-226. Cases that exceed the limit of +/- 15% of the density of the calibration standard were qualified with a "J+" flag for those results that may be biased high and a "J-" flag for those results that may be biased low (see Table F.1-1).

Completeness Evaluation. All samples and QC samples were collected as scheduled, resulting in 100 percent sampling completeness for this project. Based on the results of the data validation described in the previous sections, all data are considered valid as qualified. No data were rejected; consequently, analytical completeness was 100 percent, which met the 95 percent analytical completeness goal established in the QAPP.

Comparability Evaluation. Comparability is a qualitative parameter that expresses the confidence that one data set may be compared to another. For this project, sample collection and analysis followed standard methods and the data were reported using standard units of measure as specified in the QAPP. In addition, QC data for this project indicate the data are comparable. As a result, the data from this project should be comparable to other data collected at this Site using similar sample collection and analytical methodology.

3.0 DATA VALIDATION SUMMARY

Precision. Based on the MS/MSD sample, LCS/LCSD sample, laboratory duplicate sample, and field duplicate results, the data are precise as qualified.

Accuracy. Based on the ICAL, ICV, CCV, MS/MSD, and LCS, the data are accurate as qualified.

Representativeness. Based on the results of the sample preservation and holding time evaluation; the method and ICB/CCB blank sample results; the field duplicate sample evaluation; and the RL evaluation the data are considered representative of the Site as reported.

Completeness. All media and QC sample results were valid and collected as scheduled; therefore, completeness for this RSE is 100 percent.

Comparability. Standard methods of sample collection and standard units of measure were used during this project. The analysis performed by the laboratory was in accordance with current USEPA methodology and the QAPP.

Based on the results of the data validation, all data are considered valid as qualified.

Table F.1-1
Summary of Qualified Data
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Field Sample Identification	Sample Date	Analysis Code	Analyte	Sample Result	Units	QC Type	QC Result	QC Limit	Added Flag	Comment
S1011-BG1-005	11/30/16	SW6020	Arsenic	11	mg/kg	MS MSD LR	32% 34% 65%	75% - 125% 75% - 125% 20%	J-	Result is estimated, potentially biased low. MS and MSD recoveries below acceptance criteria. LR RPD outside acceptance criteria.
S1011-BG1-005	11/30/16	SW6020	Molybdenum	1.4	mg/kg	LR	97%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S1011-BG1-005	11/30/16	SW6020	Vanadium	26	mg/kg	MS MSD LR	-20% -20% 58%	75% - 125% 75% - 125% 20%	J-	Result is estimated, potentially biased low. MS and MSD recoveries below acceptance criteria. LR RPD outside acceptance criteria.
S1011-BG2-009	11/30/16	SW6020	Uranium	1.5	mg/kg	MS MSD MS/MSD RPD	135% 197% 21%	75% - 125% 75% - 125% 20%	J+	Result is estimated, potentially biased high. MS and MSD recoveries above acceptance criteria. MS/MSD RPD outside acceptance criteria.
S1011-CX-005	12/1/16	E901.1	Radium-226	11.3	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-CX-204	12/1/16	E901.1	Radium-226	4.81	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-CX-004	12/1/16	E901.1	Radium-226	4.24	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-BG1-011-1	3/25/17	E901.1	Radium-226	1.62	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S1011-SCX-007-1	5/13/17	SW6020	Uranium	24	mg/kg	LR	34%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S1011-SCX-007-1	5/13/17	SW6020	Vanadium	26	mg/kg	MS	64%	75% - 125%	J-	Result is estimated, potentially biased low. Ms recovery below acceptance criteria.

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
LCS laboratory control sample
LR laboratory replicate (duplicate)
MS matrix spike
MSD matrix spike duplicate
RPD relative percent difference

Field Sample Identification	Sample Date	Analysis Code	Analyte	Sample Result	Units	QC Type	QC Result	QC Limit	Added Flag	Comment
S1011-CX-002	5/13/17	E901.1	Radium-226	12.1	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S1011-CX-004	5/13/17	E901.1	Radium-226	5.54	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S1011-CX-005	5/13/17	SW6020	Uranium	1.6	mg/kg	LR	37%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S1011-SCX-009-001	6/9/17	SW6020	Arsenic	2.3	mg/kg	Serial Dilution	21%	10%	J	Result is estimated, bias unknown. Serial dilution %D greater than control limit.
S1011-SCX-009-002	6/9/17	E901.1	Radium-226	0.92	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-SCX-011-002	6/9/17	E901.1	Radium-226	0.78	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-SCX-017-001	6/10/17	E901.1	Radium-226	64.4	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S1011-SCX-019-001	6/10/17	SW6020	Arsenic	3	mg/kg	LR	121%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S1011-SCX-019-001	6/10/17	SW6020	Vanadium	92	mg/kg	LR	33%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S1011-SCX-018-001	6/10/17	E901.1	Radium-226	19.8	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S1011-SCX-020-002	6/10/17	E901.1	Radium-226	6.23	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
LCS laboratory control sample
LR laboratory replicate (duplicate)
MS matrix spike
MSD matrix spike duplicate
RPD relative percent difference

Field Sample Identification	Sample Date	Analysis Code	Analyte	Sample Result	Units	QC Type	QC Result	QC Limit	Added Flag	Comment
S1011-SCX-023-001	6/10/17	SW6020	Vanadium	21	mg/kg	MS MSD LR	25% 68% 30%	75% - 125% 75% - 125% 20%	J-	Result is estimated, potentially biased low. MS and MSD recoveries below acceptance criteria. LR RPD outside acceptance criteria.
S1011-SCX-028-001	6/11/17	SW6020	Arsenic	2.9	mg/kg	Serial Dilution	11%	10%	J	Result is estimated, bias unknown. Serial dilution %D greater than control limit.
S1011-SCX-028-001	6/11/17	SW6020	Uranium	2.1	mg/kg	MS MSD LR	21% 26% 41%	75% - 125% 75% - 125% 20%	J-	Result is estimated, potentially biased low. MS and MSD recoveries below acceptance criteria. LR RPD outside acceptance criteria.
S1011-SCX-027-002	6/11/17	E901.1	Radium-226	1.15	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-SCX-029-002	6/11/17	E901.1	Radium-226	2.87	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-SCX-024-001	6/11/17	E901.1	Radium-226	9	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-SCX-024-201	6/11/17	E901.1	Radium-226	6.67	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S1011-SCX-035-001	6/12/17	SW6020	Uranium	0.99	mg/kg	LR	48%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S1011-SCX-042-02	9/19/17	SW6020	Vanadium	11	mg/kg	MSD	306%	75% - 125%	J+	Result is estimated, potentially biased high. MSD recovery above acceptance criteria.
S1011-BG3-002	9/18/17	SW6020	Vanadium	10	mg/kg	MS MSD	146% 181%	75% - 125% 75% - 125%	J+	Result is estimated, potentially biased high. MS and MSD recoveries above acceptance criteria.
S1011-BG3-003	9/18/17	E901.1	Radium-226	0.82	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S1011-BG5-001	9/19/17	SW6020	Uranium	0.42	mg/kg	LR	24%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
LCS laboratory control sample
LR laboratory replicate (duplicate)
MS matrix spike
MSD matrix spike duplicate
RPD relative percent difference

Table F.1-2
Results that did not Meet the Relative Percent Difference Guidance
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Primary Sample / Duplicate Indentification	Sample Date	Parameter	Primary Result	Duplicate Result	Units	RPD (%)
S1011-BG1-006/S1011-BG1-206	11/30/2016	Arsenic	3.4	12	mg/kg	112%
S1011-BG1-006/S1011-BG1-206	11/30/2016	Molybdenum	0.62	1.7	mg/kg	93%
S1011-BG1-006/S1011-BG1-206	11/30/2016	Vanadium	10	18	mg/kg	57%
S1011-SCX-003-1/S1011-SCX-203-1	5/12/2017	Uranium	0.72	1.5	mg/kg	70%
S1011-SCX-003-1/S1011-SCX-203-1	5/12/2017	Vanadium	8.7	28	mg/kg	105%
S1011-SCX-015-001/S1011-SCX-015-201	6/10/2017	Molybdenum	0.73	0.39	mg/kg	61%
S1011-SCX-028-002/S1011-SCX-028-202	6/11/2017	Uranium	28	11	mg/kg	87%
S1011-SCX-043-01/S1011-SCX-243-01	9/19/2017	Uranium	2	0.71	mg/kg	95%
S1011-SCX-043-01/S1011-SCX-243-01	9/19/2017	Vanadium	20	13	mg/kg	42%
S1011-BG4-003/S1011-BG4-203	9/19/2017	Radium-226	0.72	1.24	pCi/g	53%

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
RPD relative percent difference