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Occurrence B (#296)
Removal Site Evaluation Report

Final | October 8, 2018

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

Stantec

Occurrence B (#296) Removal Site Evaluation Report - Final

October 8, 2018

Prepared for:

Navajo Nation AUM Environmental Response Trust – First Phase

Prepared by:

Stantec Consulting Services Inc.

Title and Approval Sheet

Title: Occurrence B Removal Site Evaluation Report - Final

Approvals

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

10/10/18

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Revision Log

Revision No.	Date	Description
0	October 11, 2017	Submission of Draft RSE report to Agencies for review
1	October 8, 2018	Submission of Final RSE report to Agencies

Sign-off Sheet

This document entitled *Occurrence B 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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Reviewed by Kelly Johnson

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- 2017 Cooper aerial survey orthophotographs and data files
- Historical documents referenced in this RSE Report (refer to Section 7 for complete citation)
  - Chenoweth, 1990 – Uranium Occurrences on the Zhealy Tso Mining Permit near Chinle, Apache County, Arizona
  - Hendricks, 2001 – An Aerial Radiological Survey of Abandoned Uranium Mines in the Navajo Nation
  - Scarborough, 1981 – Radioactive Occurrences and Uranium Production in Arizona, Final Report
  - USEPA, 2007a – Abandoned Uranium Mines and the Navajo Nation. Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data
  - USGS, 1955 – USGS 1:24000-scale Quadrangle for Sonsala Butte 3 NW, AZ 1955: U.S. Geological Survey
  - Weston Solutions, 2011 - Navajo Abandoned Uranium Mine Site Screen Report for Occurrence B

Executive Summary

Introduction

The Occurrence B site (the Site) is located within the Navajo Nation, Chinle Bureau of Indian Affairs (BIA) Agency, Chinle Chapter in northeastern Arizona. The Site is one of 46 "priority" abandoned uranium mines (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, 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 November 2016 at the Site. The primary objectives of the RSEs are to provide data required to evaluate relevant site conditions and to support future removal action evaluations at the Sites. It is not intended to establish cleanup levels or determine cleanup options or potential remedies. The purpose of the RSE data (e.g., the review of relevant information and the collection of data related to historical mining activities) is 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

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

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

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. Bedrock outcrops on the Site consist of sandstone and siltstone with lesser amounts of conglomerate and shale of the Shinarump Member of the Triassic Chinle Formation. The Site is also located within the San Juan River watershed, an area of approximately 24,600 square miles spanning Utah, Colorado, New Mexico, and Arizona. Topographically the Site is located on gently sloping ground and the elevation on-site is approximately 6,430 ft above mean sea level. The main drainage closest to the Site is located 100 ft to the south, flows from the northeast to the southwest, and intersects the Chinle Wash located approximately five miles southwest of the Site. On-site overland surface water flow, when present, flows to the south-southwest in drainages that either intersect the main drainage or terminate within the unconsolidated deposits.

Based on the historical documentation review, the following is known (1) the Occurrence B RSE Site was not included on Mr. Zhealy Tso's mining permit(Chenoweth, 1990); (2) exploration activities that included digging prospect pits, rim stripping, and drilling boreholes occurred on Parcel 1 of Mr. Tso's mining permit, which was located approximately 2 miles west of the Occurrence B RSE Site(Chenoweth, 1990); (3) the location of the Occurrence B RSE Site is the same location as a historical borrow pit(USGS, 1982); and (4) there is no historical information to establish that the Occurrence B RSE Site was associated with uranium mining. Of note, even though there is no historical information that the Occurrence B RSE Site was mined for uranium, there were activities associated with excavation related to the historical borrow pit. **Based on the historical information, it appears that the Site was not a uranium mine.**

In 2011, Weston Solutions (Weston) performed site screening on behalf of the USEPA. The screening included: (1) recording site observations (i.e., number of homes, water sources, and sensitive environments[2] around the Site); (2) recording the type, number, and reclamation status of mine features; and (3) performing a surface gamma survey.

Summary of Removal Site Evaluation Activities

The Trust's RSE was performed in accordance with the *Site Clearance Work Plan* (MWH, 2016a) and 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). The Trust conducted Site Clearance activities as the initial task for the RSE work to obtain information necessary to develop the *Removal Site Evaluation Work Plan* ([*RSE Work Plan*] MWH, 2016b). Following Site Clearance activities, the Trust

[2] Weston defined sensitive environments as "all sensitive environments located within visible range of the mine site, including: wetlands, endangered species, habitats and approximate locations of sites that may be under protection of the government of the Navajo Nation"

conducted two sequential tasks to complete the RSE: 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 (soil sampling, laboratory analyses, surface gamma surveying, and subsurface static gamma measurements) were used, along with sampling, to evaluate potential mining-related impacts in areas containing 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 use as screening tools for site assessments.
- **Site Characterization Activities and Assessment** included surface and subsurface soil sampling, and surface water sampling. The results of the surface and subsurface soil sampling analyses were used to evaluate mining impacts and define the lateral and vertical extent of TENORM at the Site. The results of the surface water analyses were used to evaluate mining impacts to surface water.

Findings and Discussion

Surface and subsurface soil sampling results. One background reference area was selected to develop surface gamma, subsurface static gamma, Ra-226, and metals ILs for the Site. Arsenic, molybdenum, uranium, vanadium, and Ra-226 concentrations and gamma radiation measurements in soil exceeded their respective ILs and are confirmed constituents of potential concern (COPCs) for the Site. An IL for selenium was not identified because selenium sample results were non-detect in the background area. However, because selenium was detected in soil samples from the Survey Area (i.e., the full areal extent of the Site surface gamma survey), it is also confirmed as a COPC for the Site. Based on the data analyses performed for this report along with the multiple lines of evidence, approximately 6.2 acres, out of the 22.5 acres of the Survey Area (i.e., the full areal of the Site surface gamma survey), were estimated to contain TENORM. Given that there is no evidence of historical uranium mining, TENORM that meets the USEPA definition (refer to Glossary) is the result of the impacts from excavation of the historical borrow pit that may have dispersed uranium contaminated rock and soils. Of the 6.2 acres that contain TENORM, 5.3 acres contain TENORM exceeding ILs. The volume of TENORM in excess of ILs was estimated to be 8,504 cubic yards (yd^3) (6,502 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, where sampling or gamma surveys are not available. The model was made of the correlation results predicting the concentrations of Ra-226 in surface soils from the mean of the gamma measurements in five correlation location. Additional correlation studies may be needed to refine the relationship between gamma and Ra-226.

Water sampling results. Water samples were collected from one surface water pond located approximately 565 ft south of the Site. Analytical results indicated that the sample from the pond did not exceed any analytical ILs, which indicates that the surface water was not impacted by the historical borrow pit or surface modifications made after the excavation of the borrow pit. Based on these results, there are no confirmed COPCs for the pond and further characterization may not be needed at the pond.

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

°F	degrees Fahrenheit
e.g.	exempli gratia
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
AUM	abandoned uranium mine
bgs	below ground surface
BIA	Bureau of Indian Affairs
CCV	continuing calibration verification
C.F.R	Code of Federal Regulations
COPC	constituent of potential concern
cpm	counts per minute
Dinétahdóó	Dinétahdóó Cultural Resource Management
DMP	Data Management Plan
DQO	Data Quality Objective
ERG	Environmental Restoration Group, Inc.
ESA	Endangered Species Act
FSP	Field Sampling Plan
GIS	geographic information system
GPS	global positioning system
HASP	Health and Safety Plan
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
MBTA	Migratory Bird Treaty Act
MCL	maximum contaminant level
MLR	Multivariate Linear Regression
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
NNPDWR	Navajo National Primary Drinking Water Regulation
NORM	Naturally Occurring Radioactive Material
NRCS	Natural Resources Conservation Service
NSDWR	National Secondary Drinking Water Regulation
NURE	National Uranium Resource Evaluation
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
R^2	Pearson's Correlation Coefficient
Ra-226	Radium-226
Ra-228	Radium-228
Redente	Redente Ecological Consultants
RSE	Removal Site Evaluation
SOP	standard operating procedure
Stantec	Stantec Consulting Services Inc.
T&E	threatened and endangered
Th-230	thorium-230
Th-232	thorium-232
TDS	total dissolved solids
TENORM	Technologically Enhanced Naturally Occurring Radioactive Materials
U-235	uranium-235
U-238	uranium-238
U_3O_8	uranium oxide
UCL	upper confidence limit
US	United States
U.S.C.	United States Code

UTL	upper tolerance limit
USAEC	US Atomic Energy Commission
USEPA	US Environmental Protection Agency
USFWS	US Fish and Wildlife Service
USGS	U.S. Geological Survey
V_2O_5	vanadium oxide
Weston	Weston Solutions

Glossary

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, 2002).

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, 2002).

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, 2002).

Earthworks - human-caused disturbance of the land surface.

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.

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).

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).

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).

Pan Evaporation – evaporative water losses from a standardized pan.

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

Radium-228 (Ra-228) – 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, 1992).

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, 1992).

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

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 November 2016 at the Occurrence B site (the Site) located in northeastern Arizona, as shown in Figure 1-1. The Site is also identified by the United States Environmental Protection Agency (USEPA) as abandoned uranium mine (AUM) identification #296 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 claim boundary polygon (refer to Figure 2-1) used for the RSE encompassed an area of approximately 4.7 acres (204,732 square feet [ft^2]) and was provided as part of the *2007 AUM Atlas*. Per the *2007 AUM Atlas* this polygon and other factors represent the location and surface extent of the AUM.

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[3]: (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 RSEs are to provide data required to evaluate relevant site conditions and to support future removal action evaluations at the Sites. It is not intended to establish cleanup levels or determine cleanup options or potential remedies. The purpose of the RSE data (e.g., the review of relevant information and the collection of data related to historical mining activities) is 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 Federal Regulations (CFR) Section 300.5 of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP; USEPA, 1992).

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

The Trust conducted Site Clearance activities 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)(2011) 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, two sequential tasks were conducted to complete the RSE: 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 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 – surface soil sampling and laboratory analyses.
- Characterization of subsurface soils – static gamma measurements (at surface and subsurface hand auger borehole locations), and subsurface sampling and laboratory analyses. Hand auger borehole locations are referred to hereafter as boreholes.
- Characterization of perennial surface water – surface water sampling and laboratory analyses.

Details regarding the Site Clearance activities are provided in the *Occurrence B 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 *Occurrence B 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 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

The Site is located on the Navajo Nation, in northeastern Arizona and approximately 5.5 miles east of Chinle, Arizona, as shown in Figure 1-1 inset. The Site is also located east of Indian Route 64, as shown in Figure 2-1.

A note to the reader: The Historical documentation for the RSE Occurrence B Site is confusing because of the proximity of multiple historic mine and exploration sites in the area, the lack of clarity in some historic documents, and the use of similar sounding names or area descriptions. Therefore, the Occurrence B site investigated by the Trust for this RSE, for the purposes of this section of the RSE report, will be called "the RSE Site".

Uranium exploration in the Chinle region began in 1952 when the US Geological Survey (USGS) conducted aerial radiometric surveys of the region and identified two radioactive anomalies located northeast of Chinle (Chenoweth, 1990). The first anomaly was located approximately 5.25 miles southwest of the junction of Slim Canyon and Cottonwood Canyon. The second anomaly was located 4 miles south-southwest of the first anomaly and on the west rim of Canyon del Muerto. The locations of Slim Canyon, Cottonwood Canyon, and Canyon del Muerto are shown in Figure 2-2. The USGS did not conduct ground investigations as part of the surveys.

In 1955, the Arizona Giant Mining Company (Arizona Giant) discovered areas of uranium containing (mineralized) outcrops located adjacent to Canyon de Chelly National Monument along the east rim of Slim Canyon and north of the junction with Cottonwood Canyon (northeast of Chinle, Arizona) (Chenoweth, 1990). The location of Canyon de Chelly National Monument is shown in Figure 2-2. Of note, the area Arizona Giant identified as locating uranium containing outcrops does not correspond with the area of the RSE Site but was instead approximately 2 miles west of the RSE Site.

In June 1955, the Navajo Tribal Minerals Department issued Arizona Giant a 120-day exploration and drilling permit (Chenoweth, 1990) for the area it had identified (which did not overlap with the RSE Site). Mr. Zhealy Tso, former Vice Chairman of the Navajo Tribe, was retained as Arizona Giant's local representative. Exploration activities in the Arizona Giant-identified area occurred in the areas of mineralized outcrops, and included digging prospect pits, stripping rims, and drilling boreholes to further determine viable mineralized zones (Scarborough, 1981 and Chenoweth, 1990). Arizona Giant drilled 75 boreholes behind the mineralized outcrops in the area it identified; boreholes ranged in depth from 25 to 30 ft below ground surface (bgs) (Chenoweth, 1990). Of the 75 boreholes, no radioactivity was detected in 18, some radioactivity was detected in 54, and measurable amounts of uranium-containing material were detected in the three remaining boreholes.

In September 1955, Mr. Tso reported to the US Atomic Energy Commission (USAEC) that Arizona Giant had shipped 40 tons of ore. The shipped ore averaged 0.25 percent uranium oxide (U_3O_8), mined from the property where Arizona Giant was performing exploration activities. However, according to USAEC ore-purchasing records, this reported shipment was never delivered to any of the USAEC ore-buying stations (Scarborough, 1981 and Chenoweth, 1990).

In the fall of 1955, in an effort to locate the missing ore shipment, the USAEC sent Mr. Irving B. Gray, a USAEC geologist, to examine the Arizona Giant exploration/mined property (Chenoweth, 1990). While trying to locate the exploration/mined property, Mr. Gray ended up also locating and then describing three other uranium occurrences he observed that were located near the Arizona Giant exploration/mined property. Mr. Gray referred to the three occurrences as “Occurrence A”, “Occurrence B”, and “Occurrence C”. Of note, the “Occurrence B” area identified by Mr. Gray does not correspond with the RSE Site but was instead located 2 miles west-southwest of the Site and on the southwest side of Far Spiral Canyon. The location of Far Spiral Canyon is shown in Figure 2-2. Therefore, to avoid confusion, “Occurrence B” described by Mr. Gray will be referred to hereafter as “Occurrence B-Gray”. The locations of “Occurrence A”, “Occurrence B-Gray”, and “Occurrence C” are shown on Figure 1 of Chenoweth (1990).

Mr. Gray located the Arizona Giant exploration/mined property (which did not overlap with the RSE Site) and noted there was a stockpile of 40 tons of material on the property. Mr. Gray estimated that the material in the stockpile averaged 0.30 percent U_3O_8. Chenoweth (1990). Mr Gray speculated that this stockpile could have been the 40 tons of material that Mr. Tso thought had been shipped but not recorded by USAEC. Late in 1955, Arizona Giant applied to the Defense Minerals Exploration Administration, US Department of the Interior, for a financial loan to continue exploration and development of the areas it was exploring and mining. The application was denied, and in 1956, Arizona Giant abandoned its exploration/mined property. Chenoweth (1990) speculated that the loan was denied because of the unfavorable results of the earlier borehole drilling, but the actual reason in unknown.

In January 1956, the Navajo Tribal Minerals Department approved Mining Permit No. 395 to Mr. Tso (Chenoweth, 1990). The mining permit covered 456 acres located along the east rim of Slim Canyon and north of the junction with Cottonwood Canyon. Mr.Tso’s mining permit was divided into three parcels. The location of the three parcels do not overlap at all with the RSE Site, but instead are approximately 2 miles west of the RSE Site. The location of the three parcels is shown on Figure 1 of Chenoweth (1990). Parcel 1 was the location where Arizona Giant had previously conducted exploration/mining activities in 1955. Parcel 1 was also the location where Mr. Gray had located the 40-ton stockpile of material believed to be the missing ore shipment Refer to Figure 2-3 for the location of Parcel 1(also the location of “Occurrence B-Gray”) versus the location of the RSE Site. Of note, per the *2007 AUM Atlas* three claims are associated with Parcel 1, as shown in Figure 2-3, as follows: claim 297 is also referred to as Zhealy Tso South Prospect Pit, claim 298 is also referred to as Zhealy Tso Pits, and claim 300 is also referred to as Zhealy Tso North Prospect Pit.

In 1958, Mr. William Chenoweth, a geologist with the Arizona office of the USAEC, contacted Mr. Tso (Chenoweth, 1990). Mr. Tso informed Mr. Chenoweth that he was still trying to get mining companies interested in his three parcels that were covered by his mining permit[4]. In 1959, Mr. Chenoweth examined the three parcels and noted the following abandoned exploration/mining features on Parcel 1. These features were remnants of the exploration/mining activities conducted in 1955 by Arizona Giant:

- Rim strips of approximately 100 ft and two prospect pits measuring 25 ft by 50 ft and 15 ft deep in the western part of Parcel 1
- Scattered bulldozer cuts and prospects pits over an area of 150 ft by 30 ft along the south rim of Slim Canyon in the northern part of Parcel 1
- A 40-ton stockpile of material located at the prospect pit in the northern part of Parcel 1 (Parcel 1 is also the same location as "Occurrence B-Gray", where Mr. Gray had located the 40-ton stockpile of material believed to be the missing ore shipment)
- Rim strips of an area approximately 150 ft by 20 ft along the north rim of Cottonwood Canyon in the southern part of Parcel 1

In January 1960, Mining Permit No. 395 expired. During the four years it was held by Mr. Tso he was unable to generate any interest in mining the property (Chenoweth, 1990). Chenoweth (1990) also stated that the results of the exploration on Mr. Tso's three parcels indicated the uranium mineralization was very sporadic and too low grade to be mined economically.

In 1978, the Department of Energy's National Uranium Resource Evaluation (NURE) program sent Mr. Robert E. Thaden with the USGS to examine four areas near Chinle, Arizona where uranium occurrences had previously been noted (Chenoweth, 1990). The four areas that Mr. Thaden attempted to examine were the 456 acre area previously included in Mr. Tso's mining permit and the three uranium occurrences described by Mr. Gray: "Occurrence A", "Occurrence B-Gray", and "Occurrence C". Mr. Thaden was unable to locate "Occurrence B-Gray" based on the 1955 description provided by Mr. Gray. During his visit in 1959, Mr. Chenoweth also attempted to locate "Occurrence B-Gray"[5] but was also unable to locate this mine area. The location of "Occurrence B-Gray", based on the 1955 description provided by Mr. Gray, is shown on Figure 1 of Chenoweth (1990).

While attempting to locate "Occurrence B-Gray", Mr. Thaden discovered radioactive rocks located in a stripped area that measured 500 ft by 470 ft by 10 ft deep. Mr. Thaden collected one grab sample of the radioactive rocks for analyses (e.g., uranium, thorium, chromium,

[4] Mr. Tso also stated to Mr. Chenoweth that he regretted doing business with Arizona Giant because he felt they stole his ore and he did not receive any royalties.

[5] As a reminder to the reader, Occurrence B-Gray does not correspond with the RSE Site, but was instead located 2 miles west-southwest of the Site and on the southwest side of Far Spiral Canyon.

strontium, vanadium, and zirconium). The results of the sample are provided in Table 4 of Chenoweth (1990). Mr. Thaden described the location of the radioactive rocks as being in a borrow pit located on the northwest side of Far Spiral Canyon, whereas "Occurrence B-Gray" was located on the southwest side of Far Spiral Canyon. The location where Mr. Thaden observed the radioactive rocks was labeled on Figure 1 in Chenoweth (1990) as "Occurrence B-Thaden". Figure 1 in Chenoweth (1990) also shows the locations of "Occurrence B-Gray" and "Occurrence B-Thaden" in relation to: Mr. Tso's three parcels, Far Spiral Canyon, Slim Canyon, and Cottonwood Canyon. Neither of these "Occurrence B" areas are co-located with the RSE Site but instead were approximately 2 miles west of the RSE Site.

Chenoweth (1990) also reported that the location of the borrow pit referred to by Mr. Thaden (i.e. "Occurrence B-Thaden") was also shown as a borrow pit on a 1982 USGS topographic quadrangle map of the area (USGS, 1982). Of note, on a 1955 USGS topographic quadrangle map of the area (USGS, 1955) a home-site is mapped on what is now the borrow pit location and the borrow pit is not present on the 1955 map. Therefore, it can be assumed that the borrow pit was developed after 1955. A portion of the 1982 USGS topographic map is presented in Figure 2-2 and shows the mapped borrow pit and the claim boundary for the RSE Site. As is shown in Figure 2-2, the RSE Site is coincident with the mapped borrow pit location, which in turn is also coincident with the "Occurrence B-Thaden" location. Therefore, it can be assumed that the RSE Site is the same location as the historical "Occurrence B-Thaden" site as presented by Chenoweth (1990). Based on this conclusion, the stripped area observed by Thaden that measured 500 ft by 470 ft by 10 ft deep can be assumed to be the historical borrow pit. The reason the borrow pit was excavated is unknown. Even though there is no historical information that the RSE Site was mined for uranium, there was some form of excavation, possibly for gravel or other reasons.

Based on the historical documentation review, the following is known (1) the RSE Site was not included on Mr. Tso's mining permit; (2) exploration activities that included digging prospect pits, rim stripping, and drilling boreholes occurred on Parcel 1 of Mr. Tso's mining permit, which was located approximately 2 miles west of the RSE Site; (3) the location of the RSE Site is the same location as a historical borrow pit; and (4) there is no historical information to establish that the RSE Site was associated with uranium mining. Of note, even though there is no historical information that the RSE Site was mined for uranium, the excavation related to the historical borrow pit could be considered a type of "mining" by definition. **Based on this historical information, it appears that the Site was not a uranium mine.**

2.1.2 Ownership and Surrounding Land Use

The Site is located within the Navajo Nation, Chinle Bureau of Indian Affairs (BIA) Agency in Section 15 of Township 32 North, Range 27 East, Gila and Salt River Principal Meridian. Land ownership where the Site is located falls under Navajo Trust lands. The Site is located within the Chinle Chapter of the Navajo Nation, as shown in Figure 1-1, and is in Grazing Unit 10, as designated by the Navajo Nation Division of Natural Resources (NNDNR, 2006). The Site is currently uninhabited. However, four home-sites are located within 0.25 miles of the Site, 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 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 home-site leases and grazing rights, as applicable. In addition, the Trustee consulted with the Chinle Chapter officials and nearby residents and notified them of the work.

2.1.4 Previous Work at the Site

2.1.4.1 1994 through 1999 Aerial Radiological Surveys

Between 1994 and 1999, aerial radiological surveys were conducted at 41 geographical areas within the Navajo Nation, including the Chinle area, which included the location of the Site (Hendricks, 2001). The surveys were done at the request of the USEPA Region 9 and were performed by the Remote Sensing laboratory, a US Department of Energy facility, National Nuclear Security Administration Nevada Operations Office. The intent of the surveys was to characterize the overall radioactivity levels and excess bismuth-214 activity (i.e., a radioisotope that is an indicator of uranium ore deposits and/or uranium mines) within the surveyed areas. Data collected from the surveys was used to assess the risks (i.e., average gross exposure rate) in mined areas and to determine what action, if any, was needed.

The aerial radiological survey for the Chinle area covered approximately 15.0 square miles and included the location of the Site. The aerial radiological survey results for the area within a 0.25 mile radius of the Site indicated a gross exposure rate range of 0 μR/hr to 6 μR/hr and no excess bismuth (i.e., bismuth activity greater than approximately 3.5 μR/hr) within 0.25 miles of the Site (*2007 AUM Atlas*). The aerial radiological survey results for the Chinle area indicated a gross exposure rate range of 3.49 μR/hr to 16.37 μR/hr and excess bismuth (i.e., bismuth activity greater than approximately 3.5 μR/hr) present in approximately 0.07 square miles of the 15.0 square miles of the Chinle flight area (Hendricks, 2001).

2.1.4.2 2011 Site Screening

In 2011, Weston performed site screening on behalf of the USEPA (Weston, 2011). The screening included: (1) recording site observations (i.e., number of homes, water sources, and sensitive environments[6] around the Site); (2) recording the type, number, and reclamation status of mine features; and (3) performing a surface gamma survey. Weston reported it observed an oval-shaped pit-like depression on-site that appeared to be reclaimed and measured

[6] Weston defined sensitive environments as "all sensitive environments located within visible range of the mine site, including: wetlands, endangered species, habitats and approximate locations of sites that may be under protection of the government of the Navajo Nation"

approximately 375 ft by 100 ft. Weston also reported three home-sites within 0.25 miles of the Site and one water feature within a one-mile radius of the Site. Weston noted that the Site was located within the Canyon De Chelly National Monument, which is a sensitive environment. Based on Weston's performance of a surface gamma survey, Weston determined that the highest gamma measurements were greater than 2 times the site-specific background level used for its gamma screening.

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 (NAIP, 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 2-2 presents the regional USGS topographic map in the vicinity of the Site and shows site topography within a portion of the Colorado Plateau. The Site is located on gently sloping ground. The elevation on-site is approximately 6,430 ft above mean sea level (amsl) (refer to Figure 2-2).

2.2.2 Geologic Conditions

2.2.2.1 Regional Geology

Regionally the Site is located within the Colorado Plateau, which is a massive outcrop of generally flat-lying sedimentary rocks ranging in age from the Paleozoic Era to the Cenozoic Era (USGS, 2017a). 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 one 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 Site is located within the Triassic Chinle Formation, which is composed of various rocks of lacustrine and fluvial continental origin, including claystone, sandstone, limestone, siltstone, and conglomerate (USAEC, 1972). Figure 2-4 depicts a regional geology map showing the Site in relation to the regional extent of the Chinle Formation. The Chinle Formation extends over the majority of the Colorado Plateau. In the southern portion of the Colorado Plateau, where the Site is located, the Chinle Formation ranges in thickness from a thin wedge to greater than 1,700 ft thick, but is generally greater than 1,000 ft thick (USAEC, 1972). In the Cenozoic Era, uplift and tilting of the plateau caused rapid down cutting of streams, forming many dramatic outcrops and incised streams characteristic of the region today.

2.2.2.2 Site Geology

Bedrock outcrops on the Site consist of sandstone and siltstone with lesser amounts of conglomerate and shale of the Shinarump Member of the Triassic Chinle Formation, as shown in Figure 2-5. Unconsolidated deposits on-site (i.e., Quaternary deposits) are alluvium and colluvium consisting of silt, sand, and gravel, as shown on the borehole logs in Appendix C.2. Colluvium sporadically overlays bedrock across the Site and alluvium is present in the main drainage (refer to Section 2.2.4). During the Site Characterization field activities, boreholes were advanced through the unconsolidated deposits using a hand auger (refer to Section 3.3.2.2 and the borehole logs in Appendix C.2). The unconsolidated deposits ranged in depth from 0.25 ft to 2.7 ft bgs at borehole locations.

According to the US Department of Agriculture (USDA) Soil Survey for the Chinle area, Arizona, soils on-site that have not been disturbed are classified as Aquima-Ustic Haplocambids Complex consisting of soils formed in eolian sands that were derived from sandstone and are well drained. (USDA, 2011).

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 021634, Canyon De Chelly in Chinle, Arizona (Western Regional Climate Center, 2017) located approximately 6.8 miles southwest of the Site, ranges between 42.7 degrees Fahrenheit (°F) in January to 91.2°F in July. Daily temperature extremes reach as high as 104°F in summer and as low as -32°F in winter. Chinle receives an average annual precipitation of 9.2 inches, with August being the wettest month, averaging 1.6 inches, and June being the driest month, averaging 0.33 inches.

Potential evaporation in the area is greater than the area's average annual precipitation. The potential evaporation noted at the Many Farms School weather station, located approximately 16 miles northwest of the Site, averages 90 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 Window Rock, Arizona airport, located approximately 40 miles to the southeast of the Site, had the most complete record of wind conditions. A wind rose for Windrow Rock 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 southwest (refer to the wind rose on Figure 1-1).

2.2.4 Surface Water Hydrology

The Site is located within the San Juan River watershed, an area of approximately 24,600 square miles spanning Utah, Colorado, New Mexico, and Arizona, as shown in Figure 1-1. The main drainage closest to the Site is located 100 ft to the south, flows from the northeast to the southwest, and intersects the Chinle Wash located approximately five miles southwest of the Site. The main drainage has a parallel drainage pattern and precipitation runoff on-site, shown as the approximate overland water flow directions on Figure 2-6, flows to the south-southwest in drainages that either intersect the main drainage or terminate within the unconsolidated deposits. An ephemeral pond is located approximately 565 ft south of the Site within the main drainage and fills during seasonal rain events. Figure 2-6 shows the Site drainages, pond, and flow direction of the drainages.

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 that would be attractive to wildlife (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 April and May 2016, Adkins conducted a wildlife survey and 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. The vegetation communities on-site included sparsely vegetated grassland with sporadic shrubs and scattered pinyon pine and juniper on the eastern and southern boundaries (refer to Appendix E). During the surveys, Stantec and/or its subcontractors observed on-site wildlife including common raven, cottontail rabbit, and mule deer (refer to Appendix E).

2.2.6 Cultural Resources

In April 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). Dinétahdóó reported that in 1998 a waterline project took place within the area of the Site and an archaeological inventory for the project was performed by Navajo Nation Archaeological Department archaeologists. The 1998 inventory identified three features: a Hogan depression, a collapsed oven made of sandstone slabs, and a wood chopping area. The three features were located approximately 0.4 miles northeast of the Site.

However, during the 2016 Dinétahdóó survey, archaeologists determined these three features had been completely destroyed. The Dinétahdóó archaeologists were informed by a local resident that the area that included the three features had been bulldozed and that the features were removed by the bulldozing. The coordinates of the destroyed features were collected during the 1998 waterline survey and are provided in Dinétahdóó (2016).

During the 2016 cultural resource survey Dinétahdóó did identify one archaeological site and one isolated occurrence. 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

During RSE activities, Stantec field personnel (field personnel) observed the following features indicative of the borrow pit excavation: a potential haul road located near the southwestern side of the Site, a topographic depression located in the southeast corner of the Site, and a potentially disturbed area. 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, potentially caused by the excavation, was present (refer to Section 4.6).

3.0 SUMMARY OF SITE INVESTIGATION ACTIVITIES

3.1 INTRODUCTION

This section summarizes Site Clearance and other RSE activities conducted between August 2015 and November 2016. Site Clearance activities were conducted initially to obtain information necessary to develop the *RSE Work Plan*. Site Clearance activities were performed in accordance with the approved *Site Clearance Work Plan.* Resulting RSE activities were performed in accordance with the approved *RSE Work Plan.*

The primary objectives of the RSEs are to provide data required to evaluate relevant site conditions and to support future removal action evaluations at the Sites. It 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[7] 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).

[7] (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 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 soil sampling, 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 preparation, field investigation methods, and procedures for data collection during the Site Clearance activities and other RSE activities. Activities subsequent to the Site Clearance are described in detail in the *RSE Work Plan,* Section 4. Appendix A 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 soil sample field forms, Appendix C.2 includes borehole logs, and Appendix C.3 includes water sample field forms.

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, 2016); 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, 1953, 1954, 1976, 1997, and 2005 for comparison against a current 2017 image (NAIP, 2018). The selected historical photographs are shown in Figure 3-1a. Comparison of the historical photographs to the current photograph showed the Site was cleared of vegetation sometime after 1954. The 1997 photograph shows a cleared area north of the claim boundary that was cleared for a home-site. This is a different home-site location than the home-site that was identified on the 1955 USGS topographic map; refer to Section 2.1.1. Figure 3-1b compares the aerial photograph from 1976 and the current 2017 image. The 1976 photograph is presented because it provides the best resolution of what the RSE Site looked like after ground disturbances occurred. It is unclear if the ground disturbances were associated with remnants of a historical borrow pit or surface modifications made after the excavation of the borrow pit. However, as presented in Section 2.1.1 the Site was visited by Mr. Thaden in 1978 and he observed a stripped area that measured 500 ft by 470 ft by 10 ft deep that he associated with a borrow pit (Chenoweth, 1990). For comparison, the cleared area shown in the 1976 photograph is approximately 500 ft by 375 ft.

- The 2017 aerial photograph review confirmed four home-sites located within 0.25 miles of the Site, as shown in Figure 2-1. The 2017 aerial also identified numerous dirt roads within 0.25 miles of the RSE 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).

- No water features were identified based on the review of information provided by the NNDWR and the *2007 AUM Atlas*.

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

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 2-6, were marked in the field with stakes and/or flagging and mapped with a global positioning system (GPS).
- Topographic features – The mapped area was gently sloping ground, as shown Appendix B photograph numbers 1 and 2.
- Topographic depression – A topographic depression was mapped, as shown in Figure 2-6 and Appendix B photograph number 5. The topographic depression was located near, and approximately the same size as, the oval-shaped pit described by Weston (2011). However, the topographic depression observed by field personnel did not have the appearance of a reclaimed or backfilled pit, as described by Weston (2011), but rather had a cut wall on one side that did not surround the entire depression. Field personnel observed between the top of the cut wall and the drainage east of the Site, the geology and ground cover were topographically continuous with the surrounding area, indicating that the top of the cut wall was a natural feature and not a man-made berm. Field personnel also observed excavation cuts (refer to Appendix B photograph number 7) and noted that vegetation on-site is younger than vegetation off-site. The topographic depression is also shown as earthworks in Figure 2-5.
- Potentially disturbed area – The majority of the Site was mapped by field personnel as a potentially disturbed area, as shown in Figure 2-6. This was based on observed excavation cuts and vegetation on-site appearing younger than vegetation off-site, indicating the Site was historically excavated and then naturally re-vegetated. Field personnel could not determine if the potentially disturbed area was associated with remnants of a historical borrow pit or surface modifications made after the excavation of the borrow pit. The potentially disturbed area is also shown as earthworks in Figure 2-5.
- Drainages – Drainages were mapped on-site, as shown in Figure 2-6. The main ephemeral drainage was located 100 ft south of the Site and drained from the northeast to the southwest. Precipitation runs off the Site draining southeast and then flows south-southwest in drainages that either intersect the main drainage or terminate within the unconsolidated deposits.
- Roads – Roads were mapped, as shown in Figure 2-6. A well-maintained dirt road was mapped on the northeast of the Site that ran north-south from Indian Route 64 to the closest home-site. This road was not mapped as a potential haul road because in the historical

photographs, shown in Figure 3-1a, it appeared to be a trail before 1976 and a road after 1976. A potential haul road was mapped that entered/exited the Site from the southwest and intersected Antelope House Overlook Road approximately 1,800 ft west of the Site, as shown in Figure 2-6. The potential haul road also appeared to be the main egress to and from the Site as shown in the historical photographs in Figure 3-1a.

- Utilities – A water line and a power line were mapped, as shown in Figure 2-6. The water line ran across the east side of the Site to one of the home-sites and the power line was present near the same home-site. The power line did not run across the Site but ran from the home-site and continued northeast to where it connected to the main power line located along road Indian Route 64.

- Crops – Three residential crop fields were mapped, as shown in Figure 2-6 and Appendix B photograph number 3. The crop fields were located 810 ft to the north of the Site and 185 ft to the east of the Site.

- Water feature – During site mapping activities field personnel mapped one ephemeral pond, as shown in Figure 2-1 (S296-Pond-1) and described in Table 3-1. The pond was located 565 ft south of the Site within the main drainage and measured approximately 20 ft across. The pond is shown in Appendix B photograph number 4.

- Structures – Four home-sites and one uninhabited building were mapped within 0.25 miles of the Site, as shown in Figure 2-6. The uninhabited building was a shed used by a local resident.

- Ground cover – Ground cover and vegetation observed on-site are discussed in Sections 2.2.2.2 and 2.2.5, respectively.

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. This information 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.

3.2.2.2 Potential Background Reference Area Evaluation

The desktop study findings and field investigation observations were used to identify four potential background reference areas (BG-1 through BG-4) for the Site, as shown in Figure 3-2 and described in Appendix D.1. BG-1 was selected as a suitable background reference area for the Site for the following reasons:

- BG-1 encompassed an area of 1,111 ft^2 (approximately 0.03 acres), was located 700 ft southwest of the Site, and was upwind and hydrologically cross-gradient from the Site. Geologically, BG-1 represented the areas of the Site where colluvium and bedrock outcrops of the Chinle Formation were present, as discussed in Section 2.2.2 and shown in Figure 2-5. The vegetation and ground cover at BG-1 were similar to the Site.

BG-2 through BG-4 were not selected as background reference areas for the Site for the reasons described in Appendix D.1.

A background reference area was not identified to represent Quaternary deposits in the drainage southeast of the Site. Because there is potential for runoff of potentially mining-impacted materials from the northeast corner of the Site into the drainage, further background investigation of the drainage may be warranted as part of future work at the Site. This is included as a data gap in Section 4.9.

The potential background reference area was selected based on *MARSSIM* guidance (i.e., similar geology and ground conditions, upwind of the Site, 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 the area. Stantec does not view the size of the selected background reference area 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 area was 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 area. The ILs derived from the background reference area 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 U.S.C. §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 16 U.S.C. §1536(a)(4). 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 C.F.R §402.2.

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 (now Stantec) 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[8]. 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 required a spring survey.

The NNDFW listed five T&E plant species that may occur on-site; alcove death camas (G3), alcove bog-orchid (G3), Rydberg's thistle (G4), Utah bladder fern (G4), and Gooding's onion (G3). The USFWS listed one T&E plant species that may occur on-site: Navajo sedge. Alcove death camas is a native perennial forb that grows in hanging gardens, seeps, and alcoves mostly on the Navajo Sandstone formation. This species is endemic to the Colorado Plateau in southern Utah and northern Arizona at elevations from 3,698 ft to 6,999 ft amsl. Alcove bog-orchid is a native perennial forb that grows in seeps, hanging gardens, and moist stream areas from the desert shrub to the pinyon juniper communities. This species is found in New Mexico, Utah, and Arizona at elevations from 4,003 ft to 7,201 ft amsl. Rydberg's thistle is a native perennial forb that occurs in hanging gardens, seeps, and stream banks below hanging gardens at elevations from 3,297 ft to 6,946 ft amsl. Its distribution includes southern San Juan County along with Coconino and Apache Counties in Arizona. Utah bladder fern is a native perennial vascular plant that grows in seeps, cracks, and cliff ledges on calcareous substrates. The only known occurrence on the Navajo Nation is in Canyon de Chelly. Populations are known to occur at elevations from 4,200 ft to 8,800 ft amsl. Gooding's onion is a native perennial herb that grows in spruce-fir and mixed-conifer forests at elevations from 6,400 ft to 9,400 ft amsl. Potential distribution on the Navajo Nation include the Chuska Mountains and the Defiance Plateau. Navajo sedge is a native perennial grass-like plant that grows in seeps and hanging gardens primarily on sandstone cliffs and alcoves. Known populations occur at elevations from 4,600 ft to 7,201 ft amsl in San Juan County and northern Arizona.

Before beginning the Site vegetation survey, 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 the T&E species, specifically seeps, hanging gardens, and/or spruce fir/mixed conifer forests.

The Redente botanist did not identify any of the six T&E species at the Site, based on observations he made during the on-site survey. The botanist concluded he 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.

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[8] 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).

Observed vegetation communities on-site were sparsely vegetated grassland with sporadic shrubs and scattered pinyon pine and juniper on the eastern and southern boundaries.

Wildlife Survey - In April-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 boundary. 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 seven ESA-species with the potential to occur in the area of the Site; two birds (Mexican spotted owl and western yellow-billed cuckoo), two fish (roundtail chub and Zuni bluehead sucker), two mammals (black-footed ferret and gray wolf), and one reptile (northern Mexican gartersnake). The NNDFW included: four birds (golden eagle [G3], American peregrine falcon [G4], southwestern willow flycatcher [G2], and American dipper [G3]) and one amphibian (northern leopard frog [G2]). All species on the USFWS list and all the species from the NNDFW list, with the exception 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 (golden eagle and American peregrine falcon) remained as species of concern warranting further analysis during the Site survey.

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 18 bird species in addition to those listed above, known as "Priority Birds of Conservation Concern with the Potential to Occur"[9] 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, ferruginous hawk, mountain plover, and western burrowing owl. These 18 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 have 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

[9] USFWS, 2008. Birds of Conservation Concern 2008. United States Department of Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia. 85 pp.

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 April 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 on behalf of the Trust 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[10]).

The survey included the areas within the claim boundary and the 100-ft claim boundary buffer, as shown in Figure 2-6. The survey identified one archaeological site and one isolated occurrence. However, Dinétahdóó determined that the archaeological site had been previously destroyed (refer to Section 2.2.6) and determined no marking or avoidance was needed. For confidentiality reasons, details regarding the archaeological site and isolated occurrence 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 it surveyed with the stipulation that RSE activities be halted at any time if cultural resources were encountered. Stantec complied with Dinétahdóó's recommendations while conducting RSE activities on–site.

Dinétahdóó also escorted field personnel during the collection of subsurface soil samples at the background reference area (refer to Section 3.3.1.1). 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 additional tasks following the Site Clearance Activities: 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 sampling, and surface water sampling. Results of the

[10] Call with Sadie Hoskie, Tamara Billie of NNHPD, and Linda Reeves, June 8, 2018.

RSE activities are presented in Section 4.0. 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 area selected for the Site. Refer to Section 3.2.2.2 for an explanation of the selection of the background reference area for the Site. The Background Reference Area Study included a surface gamma survey, static surface and subsurface gamma measurements, surface soil sampling, and subsurface soil sampling. The soil sample locations in the background reference area 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 area was selected based on a variety of factors, including *MARSSIM* criteria, which indicated whether the area was 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 sampling locations at the background reference area are presented in Figure 3-3. Field personnel performed the Background Reference Area Study in accordance with the *RSE Work Plan,* Sections 4.2, 4.4, and 4.5.

The surface gamma survey at BG-1 was completed in November 2016. ERG performed the surface gamma survey using Ludlum Model 44-10 2-inch by 2-inch sodium iodide (NaI) high-energy gamma detectors (the detectors). 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 survey by walking the background reference area 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 1 ft 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 survey they went around the obstruction.

Subsequent to each workday, ERG downloaded the gamma measurements to a computer and secure server.

The same equipment used for the surface gamma survey was also used to collect static one-minute gamma measurements at the ground surface and down-hole (subsurface) at borehole locations S296-BG1-011, -BG1-012, and –BG-013. Refer to Appendix C.2 for borehole logs. 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 samples collected as part of the background study are detailed in Table 3-2 and sample locations are shown in Figure 3-3. Soil 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. Field personnel collected the following samples, in November 2016, from the background reference area:

- BG-1 – Ten surface soil grab samples were collected from 10 locations and two subsurface soil grab samples from borehole location S296-BG1-011. Two additional borehole locations were attempted (S296-BG1-012 and S296-BG1-013), but no subsurface soil samples were collected from those locations due to shallow bedrock encountered at 0.7 ft and 0.83 ft bgs, respectively.

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 sample analytical results provided background reference data to guide the Site Characterization surface and subsurface soil 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 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. The approximate centerlines of the historical roads were not surveyed, but the shoulders were, due to miscommunication with the field personnel. This is identified as a potential data gap in Section 4. 9.

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

In November 2016, the surface gamma survey was performed using the methods and equipment described in Section 3.3.1.1. The surface gamma survey included the claim area, a 100-ft buffer around the claim area, 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 area to determine if additional surface gamma surveying was needed.

The full areal extent of the surface gamma survey was 22.5 acres and is referred to as the Survey Area, as shown in Figure 3-4. The surface gamma survey results are presented in Section 4.2. The ERG survey report in Appendix A 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 use as screening tools for site assessments:

- Gamma measurements (in cpm) and concentrations of Ra-226 in surface soils (in picocuries per gram [pCi/g])
- Gamma measurements (in cpm) and exposure rates (in microRoentgens per hour [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 soils 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, 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 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 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 provides a discussion of the correlations and the regression equations for both correlations.

In November 2016, 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 three 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 to gamma measurements 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). 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 Sampling

Site Characterization activities included surface soil sampling and associated laboratory analyses. The surface soil 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 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.

In November 2016, samples were collected from the locations shown in Figure 3-6 and are summarized in Table 3-2. The numbers of surface samples collected within specific mine features are listed in Table 3-3. Fourteen surface soil grab samples were collected from each of the 14 locations in the Survey 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. 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 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 Sampling

Site Characterization activities included subsurface soil sampling and associated laboratory analyses. Similar to the surface soil 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). Additionally, surface and subsurface static gamma measurements were collected in the borehole using the same equipment 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.

Seven boreholes in the Survey Area were advanced through the unconsolidated deposits (from 0.25 ft to 2.7 ft bgs; refer to Table 3-2 and Appendix C.2) until refusal on bedrock. Field personnel manually advanced the subsurface boreholes to a desired sample depth by using a 3-inch diameter hand auger. The boreholes were advanced through silt, sand, and gravel (refer to Appendix C.2 for borehole information). A drill rig was not employed at the Site because soil depths were estimated to be shallow.

Of the seven boreholes advanced in the Survey Area, only two boreholes (S296-SCX-002 and –SCX-007) could be advanced deeper than 0.5 ft bgs to collect subsurface soil samples, due to refusal on bedrock. In November 2016, three subsurface soil grab samples were collected from the two borehole locations (two samples were collected from borehole S296-SCX-007). Samples were collected from the locations shown in Figure 3-6 and are summarized in Table 3-2. The numbers of subsurface samples collected within specific mine features are listed in Table 3-3. Soil samples were not collected from every borehole location, per the *RSE Work Plan*, where samples were not required or intended to be collected at every subsurface borehole location. Ground disturbance within the area of the Site was uniform and some borehole locations were placed to confirm the depth to bedrock. The depths to bedrock at the three locations where samples were not collected (S296-SCX-001, -SCX-003, and -SCX-006) were less than 0.5 ft bgs. Field observations (e.g., depth to bedrock, etc.) from boreholes where samples were not collected, were used in Section 4.0 to evaluate the physical conditions of the subsurface. Subsurface samples were not collected from the area of the topographic depression due to oversight. This is identified as a data gap in Section 4.9. Additionally, samples were not collected from the area of the potential haul road, further investigation of the potential haul road may be warranted as part of future work.

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

One water feature was identified during site mapping, refer to Section 3.2.2.1 and Table 3-1, and was sampled as detailed below.

On November 9, 2016 a surface water sample (S296-WS-001) was collected from the pond identified by Stantec as S296-Pond-1. The pond was located approximately 565 ft south of the Site within the main drainage and measured approximately 20 ft across. The location of the pond is shown in Figure 2-1.

The water sample collected for dissolved metals analyses was sampled and field filtered using a peristaltic pump, Teflon® tubing, and 0.45-micron inline filter in the field at the time of sample collection per the *RSE Work Plan*, Section 4.6.1. All other analyses did not require in-field filtering. The sample was collected, packaged, and shipped in accordance with the *RSE Work Plan,* Sections 4.6, 4.9, 4.11, and Appendix E. ACZ Laboratories, Inc. in Steamboat Springs, Colorado conducted the mercury analysis and ALS Environmental Laboratories in Fort Collins, Colorado conducted all other analyses including Ra-226 and Radium-228 (Ra-228), adjusted gross alpha, and the following total and dissolved metals: antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, thallium, uranium, vanadium, and zinc.

Additional general water quality analyses or field measurements included: total dissolved solids (TDS), anions (carbonate, bicarbonate, chloride, and sulfate), cations (sodium and calcium), and field measurements (pH, conductivity, turbidity, temperature, salinity, and oxidation reduction potential). Table 3-3 provides a summary of the water analyses. Surface water analytical results are presented in Section 4.8. Field forms are provided in Appendix C.3 and the laboratory analytical data and Data Usability Report for the analyses are provided in Appendix F.

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 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 explored for mining 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, 2002) 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, 2002) 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 reported.

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

- **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 qualified.

- **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 sample locations in BG-1 and results of the background reference area surface gamma survey are shown in Figure 4-1. Analytical results of the samples collected from BG-1 are summarized in Table 4-1. The gamma measurements and surface soil sample analytical results collected from BG-1 were evaluated statistically to calculate ILs (refer to Appendix D.2).

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 area and the Survey Area data, and calculating descriptive statistics for the background reference area. 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, 2016c).

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, prior to the change. 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 from the derivation of the surface gamma IL 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 the Site were established using statistical analysis of background data from BG-1(refer to Figures 3-2 and 3-3) and are as follows:

- Arsenic 3.15 milligrams per kilogram (mg/kg)
- Molybdenum 0.47 mg/kg
- Selenium – an IL for selenium was not identified because the selenium sample results in BG-1 were all non-detect
- Uranium 0.39 mg/kg
- Vanadium 13.7 mg/kg
- Ra-226 1.26 pCi/g
- Surface gamma measurements – 11,649 cpm

It is important to note that comparisons to the IL (i.e., 1.5 times the IL) are provided for context, and evaluations of: (1) areas of the Site; (2) samples or; (3) TENORM that exceed the ILs, which are based on the statistically derived IL values.

In addition to the surface gamma survey performed in the background reference area, subsurface static gamma measurements were collected in the borehole completed at BG-1. These measurements were used to establish a subsurface static gamma screening level for the Survey Area. Where possible, the selected subsurface static gamma screening level value met the following criteria: (1) it was the lowest value measured at or below 1 ft bgs and (2) it was not directly measured on bedrock. The subsurface static gamma screening level from BG-1 provides a comparison and assessment tool for the Survey Area and is included as an IL for the Site.

However, it is important to consider that the subsurface static gamma IL is based on a single measurement, and it is 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.

Three boreholes were completed in BG-1 (S296-BG1-011, -BG1-012, and -BG1-013) and subsurface static gamma measurements measured from the boreholes are summarized in Table 4-2 and in Appendix C.2. Subsurface static gamma measurements collected at boreholes S296-BG1-012 and BG1-013 were all collected at less than 1.0 ft bgs. Because sample depths of at least 1.0 ft bgs are preferable, the subsurface static gamma measurements collected at borehole S296-BG1-011 were evaluated to identify the Survey Area subsurface static gamma IL. Three subsurface static gamma measurements of 14,707, 15,722, and 15,630 cpm were collected from BG-1 borehole S296-BG1-011, at down-hole depths of 0.67, 1.0, 1.5, and 1.17 ft bgs, respectively. The lowest measured value at a depth of at least 1.0 ft (15,722 cpm) was selected as the subsurface static gamma IL for the Survey Area.

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 1 ft 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 and may be indicative of the presence of TENORM at the surface, but additional lines of evidence are generally needed to support that conclusion.

The Site gamma measurements, and soil sample analytical results were compared to their respective ILs to confirm 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 to support 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 4-1 where the calculated surface gamma IL for the background reference area is 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 bins ranges were based on the minimum site gamma measurement, the BG-1 IL, and the maximum site gamma measurement. The maximum survey measurement was

48,436 cpm, which was greater than four times the BG-1 IL of 11,649 cpm, and was measured at a bedrock outcrop northwest of the claim boundary (refer to Figure 4-1).

The spatial distribution of surface gamma measurements and IL exceedances are shown in Figure 4-1. Surface gamma measurements were generally less than two times the IL and were uniformly distributed across the Survey Area, with some higher readings located to the northwest of the claim boundary. The higher measurements outside the claim boundary were in an undisturbed area and appeared to be associated with shallow bedrock and bedrock outcrops of the Chinle Formation.

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

1. The extent of greater-than-IL gamma survey measurements are not bound by lower-than-IL gamma survey measurements along the north, east, and west edges of the Site. However, because these areas are undisturbed and, therefore, are not TENORM, it is not necessary to bound these areas with lower-than-IL gamma survey measurements. In addition, gamma results within these areas are relatively low (less than 20,000 cpm) and generally uniformly distributed; therefore, a substantial amount of additional gamma survey data (extending over large areas) could be required to bound these areas with lower-than-IL gamma measurements.

2. The approximate centerlines of the historical roads were not surveyed, but the shoulders were, due to miscommunication with the field personnel.

4.2.1.2 Subsurface Gamma Survey

Surface and subsurface static gamma measurements were collected at all seven borehole locations. Only two of the seven boreholes (S296-SCX-002 and –SCX-007) could be advanced deeper than 0.5 ft bgs (due to refusal on bedrock) to collect multiple subsurface static gamma measurements in unconsolidated material. Surface and subsurface static gamma measurement locations are shown in Figure 4-1. Measurements and corresponding measurement depths are provided in Table 4-2 and are shown on the borehole logs in Appendix C.2.

The Survey Area subsurface static gamma measurements exceeded the BG-1 subsurface static gamma measurement IL of 15,722 cpm in six out of seven boreholes. The six boreholes were located within the potentially disturbed area or just outside the claim boundary. Borehole S296-SCX-006 was the only borehole where the static gamma measurement IL was not exceeded. The highest subsurface static gamma measurement from unconsolidated material was 20,064 cpm at borehole S296-SCX-007 (1.5 ft bgs) located southeast of the claim boundary. At four borehole locations only one subsurface static gamma measurement could be collected at each borehole because of the shallow nature of the boreholes (refer to Section 3.3.2.2 and Appendix C.2) The single measurement in each of the four boreholes was collected at the interface between the unconsolidated material and bedrock. The highest subsurface static gamma measurement at the interface between unconsolidated material and bedrock was 18,777 cpm at borehole S296-SCX-007 (2.7 ft bgs). Borehole S296-SCX-007 was located southeast of the claim boundary. Borehole S296-006 was the only borehole having subsurface static gamma measurements at the interface between unconsolidated material and bedrock that did not exceed the subsurface IL. Subsurface static gamma measurements increased with depth at six boreholes and were variable with depth at one borehole.

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.

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 0.82 which is within the DQO 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 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:

$$\text{Gamma (cpm)} = 2{,}917 \times \text{Surface Soil Ra-226 (pCi/g)} + 8{,}994$$

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 (11,090 cpm) and greater than the maximum (18,497 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 0.7 pCi/g and the concentration associated with the maximum mean gamma measurement is 3.3 pCi/g. Therefore, predicted Ra-226 concentrations less than 0.7 pCi/g and greater than 3.3 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 8,994 cpm. The predicted concentrations are shown in Figure 4-2a and the values less than zero are very limited and occur on the road northeast of the Site and in the area of the southern corner 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). This is because the predicted Ra-226 concentrations are based on a correlation with the gamma measurements. Predicted Ra-226 concentrations in the Survey Area range from -0.4 to 13.5 pCi/g, with a mean of 1.2 pCi/g, and a standard deviation of 0.8 pCi/g. Bin ranges in Figure 4-2a are based on these mean and standard deviation values. Negative values for Ra-226 are a function of the linear regression equation and are not physically possible.

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, 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, 2017).

When comparing the predicted Ra-226 concentrations to the Ra-226 laboratory concentrations, soil/sediment sample locations are generally co-located with specific gamma measurement locations (refer to Figure 4-2b. Twelve out of 14 sample locations had Ra-226 laboratory concentrations that were within the applicable predicted Ra-226 bin ranges. In one out of two 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 lower than the reported laboratory concentration detected in the soil/sediment sample. The two locations where the predicted Ra-226 concentration differed from the laboratory concentrations (S296-SCX-002 predicted value was lower and S296-SCX-005 predicted value was higher) were located in the central part of the claim area. 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 IL, 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. Predicted Ra-226 concentrations exceeded the Ra-226 IL across the majority of the Site. In addition, Ra-226 laboratory concentrations exceeded the Ra-226 IL for all surface soil samples and these samples were located in areas that were also predicted to exceed the Ra-226 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 14 surface soil grab samples from 14 locations and three subsurface soil grab samples from two borehole locations were collected at the Site (refer to Table 3-2). The unconsolidated deposits on and near the Site are shallow because of the historical excavation. Therefore, only three subsurface soil samples could be collected from two of the seven borehole locations where the hand auger could be advanced deeper than 0.5 ft bgs (S296-SCX-002 and S296-SCX-007). The other five borehole locations met refusal at bedrock from 0.25 to 0.5 ft bgs. The metals and Ra-226 analytical results for the Survey Area are compared to their respective ILs and are presented in Table 4-4. Figure 4-3 presents the spatial patterns, both laterally and vertically, of metals and Ra-226 detections and IL exceedances in the soil samples.

Ra-226 and/or metals concentrations exceeded their respective ILs in all surface and subsurface soil samples. The maximum Ra-226 and metals concentrations were detected in samples collected from the area along the northern claim boundary. Surface and subsurface soil IL exceedances for each analyte are described below. Presented sample counts include normal samples and do not include duplicate samples.

- Ra-226
    - The Ra-226 IL (1.26 pCi/g) was exceeded in 14 of 14 surface soil samples and two of three subsurface soil samples. Ra-226 concentrations ranged from 1.23 to 4.22 pCi/g. The maximum concentration was in a subsurface soil sample collected from surface sample

S296-CX-008. The highest concentrations occurred in surface soil (S296-SCX-005 and S296-SCX-008) collected from the area to the northwest of the claim boundary.

- Uranium
  - The uranium IL (0.39 mg/kg) was exceeded in all surface and subsurface soil samples (14 surface and three subsurface). Uranium concentrations ranged from 0.6 to 5.7 mg/kg. The maximum concentration was in a surface soil sample collected from S296-CX-007. The highest concentrations occurred in surface and subsurface soil (S296-CX-004 through -CX-010 and S296-SCX-005) collected from the area along the northern claim boundary.

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 in the Survey Area soil samples.

- Arsenic
  - The arsenic IL (3.15 mg/kg) was exceeded in 10 of 14 surface soil samples and no subsurface soil samples. Arsenic concentrations ranged from 2 to 42 mg/kg. The maximum concentration was in a surface soil sample collected from S296-CX-007. The highest concentrations occurred in surface soil (S296-CX-007 and -CX-008) collected from the area along the northern claim boundary and the area to the northwest of the claim boundary.

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 Survey Area soil samples.

- Molybdenum
  - The molybdenum IL (0.47 mg/kg) was exceeded in two of 14 surface soil samples and no subsurface soil samples. Molybdenum concentrations ranged from 0 to 0.96 mg/kg. The maximum concentration was in a surface soil sample collected from S296-CX-003. The highest concentrations occurred in surface soil (S296-CX-003 and -CX-008) collected from the area along the northern claim boundary.

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). All molybdenum concentrations were within the typical range of regional values in the Survey Area soil samples.

  - Selenium – an IL for selenium was not identified because selenium sample results in BG-1 were all non-detect. Selenium was detected in three surface soil samples (S296-CX-004, -CX-007, -CX-008, and -SCX-005) collected from the area along the northern claim boundary and the area to the northwest of the claim boundary. Selenium concentrations ranged from 0 to 2.4 mg/kg. The maximum concentration was in a surface soil sample collected from S296-CX-007.

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 the Survey Area soil samples.

- Vanadium
  - The vanadium IL (13.7 mg/kg) was exceeded in 10 of 14 surface soil samples and no subsurface soil samples. Vanadium concentrations ranged from 9.5 to 54 mg/kg. The maximum concentration was in a surface soil sample collected from S296-CX-004. The highest concentrations occurred in surface soil (S296-CX-004, -CX-008, and -SCX-005) collected from the area along the northern claim boundary and the area to the northwest of the claim boundary.

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 were within the typical range of regional values in the Survey Area soil samples.

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, arsenic, molybdenum, uranium, vanadium in soil exceeded their respective ILs in the Survey Area and are confirmed as COPCs for the Site. An IL for selenium was not identified because selenium sample results were non-detect in BG-1. However, because selenium was detected in soil samples from the Survey Area, it is also confirmed as a COPC for the Site.

4.5 AREAS THAT EXCEED THE INVESTIGATION LEVELS

The approximate lateral extent of surface gamma IL exceedances in soil is 17.9 acres, as shown in Figure 4-4. 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. IL exceedances occurred at a majority of the surface and subsurface soil sample locations, and all sample locations were within the 17.9 acre area.

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 also shows the surface gamma IL exceedances for reference.

IL exceedances in metals and Ra-226 concentrations at surface and subsurface sample locations were co-located with surface gamma survey measurements and/or subsurface static gamma measurements that also exceeded their ILs. 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 4-4 were compared to the predicted Ra-226 concentrations that exceeded ILs in Figure 4-2c. Predicted Ra-226 concentrations exceeded the Ra-226 IL in a smaller area of the Site than the surface gamma IL exceedances. Surface gamma IL exceedances covered approximately 90 percent of the Survey Area while predicted Ra-226 exceedances covered approximately 75 percent of the Survey Area. The most noticeable differences were in the area of the southern corner of the claim boundary central and along the potential haul road where there were fewer predicted Ra-226 exceedances.

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. While the Trust has not identified any indications of uranium mining at this Site, TENORM is likely from the excavation of the borrow pit that disturbed naturally occurring uranium. **Therefore, the disturbance is identified herein as TENORM according to the USEPA definition.**

Based on this evaluation, 6.2 acres, out of the 22.5 acres of the Survey Area, were estimated to contain TENORM at the Site. This estimate is inclusive of the potential haul road and the area inclusive of the claim boundary. 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
  - Historical documentation review indicated the RSE Site was not included on the mining permit owned by Mr. Zhealy Tso. Exploration activities that included digging prospect pits, rim stripping, and drilling boreholes occurred on Parcel 1 of Mr. Tso's mining permit, which was located approximately 2 miles west of this RSE Site.
  - Historical documentation review of a 1982 USGS topographic map indicated the location of the Site is coincident with a historical borrow pit. Of note, on a 1955 USGS topographic quadrangle map of the area inclusive of the Site a home-site is mapped in the location of the borrow pit, and the borrow pit is not present on the 1955 map. Therefore, it can be assumed that the borrow pit was developed after 1955.
  - Historical photograph review shows the Site was cleared of vegetation and excavated sometime between 1954 and 1976.
  - Historical documentation review indicated the RSE Site was probably not associated with uranium mining.

- Geology/geomorphology
  - Bedrock at the Site consisted of sandstone and siltstone with lesser amounts of conglomerate and shale of the Shinarump Member of the Triassic Chinle Formation. Portions of the Site consisted of shallow or outcropping bedrock. Therefore, the geology and geomorphology of the Site was conducive to the presence of NORM at or near the ground surface (refer to Appendix B photograph number 6).
  - The main ephemeral drainage was located 100 ft south of the Site and drained from the northeast to the southwest. This drainage could have transported NORM/TENORM to the southwest.
  - A topographic depression is present along the southeast claim boundary of the Site. Runoff from the majority of the potentially disturbed area drains into the topographic depression and typically seeps into the ground within the topographic depression.
- Disturbance Mapping – Stantec field personnel observed the following features:
  - The majority of the Site was mapped as a potentially disturbed area. This was based on observed excavation cuts and vegetation on-site appearing younger than vegetation off-site, indicating the Site was historically excavated and then naturally re-vegetated. Field personnel could not determine if the potentially disturbed area was associated with remnants of a historical borrow pit or surface modifications made after the excavation of the borrow pit.
  - A well-maintained dirt road was mapped on the northeast of the Site that ran north-south from Indian Route 64 to the closest home-site. This road was not mapped as a potential haul road because in the historical photographs it appeared to be a trail before 1976 and a road after 1976.
  - A potential haul road was mapped that entered/exited the Site from the southwest and intersected Antelope House Overlook Road approximately 1,800 ft west of the Site. The potential haul road also appeared to be the main egress to and from the Site.
- Site Characterization
  - Surface gamma measurements within the disturbed areas are similar to or lower than the gamma measurements in the undisturbed areas adjacent to the Site that are considered NORM.
  - Metals concentrations in samples collected outside the area of TENORM (four locations) were less than or within the regional concentration values.
  - Surface gamma measurements collected along the potential haul road generally were less than the surface gamma IL.
  - Surface gamma measurements collected along the main ephemeral drainage generally exceeded the surface gamma IL. However, the drainage is considered NORM because gamma measurements collected in the stream channels are not elevated compared to

the other non-disturbed areas adjacent to the Site. Additionally, elevated gamma measurements were collected in an area of NORM in the drainage as shown in Appendix B photograph number 6.

- No mine waste was observed at the RSE Site. TENORM present at the RSE Site is from historical borrow pit operations or surface modifications made after the excavation of the borrow pit.
- The subsurface static gamma IL was used as the only evidence to evaluate the vertical extent of TENORM at two borehole locations where samples were not collected (S296-SCX-001 and -SCX-003). However, as described in Section 4.7 below, a uniform depth of TENORM (1.0 ft bgs) was applied to the Site.

The area of the Site considered to contain TENORM (i.e., multiple lines of evidence indicated the presence of mining-related impacts) was 6.2 acres, as shown on Figure 4-8. Portions of the TENORM exceeded one or more IL, where approximately 5.3 acres contained TENORM that exceeded the surface gamma IL and all sample locations where TENORM exceeded the ILs. TENORM that exceeded the ILs in the Survey Area is shown on Figure 4-8, and is also compared to mining-related features in Figure 4-8.

4.7 TENORM VOLUME ESTIMATE

The volume estimate of TENORM that exceeded one or more ILs is approximately 8,504 yd^3, as shown in Figure 4-8. 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) utilizing the USGS (2017b) 10 m National Elevation Dataset coupled with hand-derived contours based on field personnel observations, depth to bedrock in boreholes, gamma measurements, sample analytical data, and historical 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 material and/or soil deposits. The assumptions that were used to calculate the volume of TENORM with IL exceedances were as follows:

General Assumptions

- The volume of TENORM exceeding ILs was based on field observations and borehole data and was assumed to be 1.0 ft thick over the area of the TENORM that exceeds ILs polygon.
- It was assumed that subsurface bedrock encountered in boreholes was not previously modified by human activity and is therefore NORM.

4.8 WATER ANALYTICAL RESULTS

The surface water sample collected as part of the Site Characterization activities was analyzed for the constituents listed in Section 3.3.2.3 to evaluate potential mining-related impacts. The location of the water feature is shown in Figure 2-1 and included the following:

- Pond S296-Pond-1 (sample S296-WS-001) located approximately 565 ft south of the Site within the main drainage

The analytical results from the sample were compared to the water ILs, which are defined as the lowest value from the following regulations/standards: the National Secondary Drinking Water Regulations (NSDWR), the Navajo Nation Surface Water Quality Standards, the Navajo Drinking Water maximum contaminant levels (MCLs), and/or the National Primary Drinking Water Regulations. The water ILs are shown in Table 4-6a and the analytical results compared to the water ILs are shown in Table 4-6b.

Analytical results indicated that the sample from S296-Pond-1 (S296-WS-001) did not exceed any analytical ILs, which indicates that the surface water was not impacted by the historical borrow pit or surface modifications made after the excavation of the borrow pit. Based on these results, there are no confirmed COPCs for the pond. The laboratory analytical data and Data Usability Report are provided in Appendix F.

4.9 POTENTIAL DATA GAPS AND SUPPLEMENTAL STUDIES

4.9.1 Data Gaps

Four potential data gaps were identified based on the Site Clearance and RSE data collection and analyses for the Site. These data gaps can be considered for subsequent evaluations in support of future Removal or Remedial Action evaluations at the Site.

1. A background reference area was not identified to represent Quaternary deposits in the drainage southeast of the Site. Because there is potential for runoff of potentially mining-impacted materials from the northeast corner of the Site into the drainage, further background investigation of the drainage may be warranted as part of future work at the Site.

2. Samples were not collected from the area of the topographic depression due to an oversight.

3. The extent of greater-than-IL gamma survey measurements are not bound by lower-than-IL gamma survey measurements along the north, east, and west edges of the Site. However, because these areas are undisturbed and, therefore, are not TENORM, it is not necessary to bound these areas with lower-than-IL gamma survey measurements. In addition, gamma results within these areas are relatively low (less than 20,000 cpm) and generally uniformly distributed; therefore, a substantial amount of additional gamma survey data (extending over large areas) could be required to bound these areas with lower-than-IL gamma measurements.

4. The approximate centerlines of the historical roads were not surveyed, but the shoulders were, due to miscommunication with the field personnel.

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. Additional correlation studies may be needed to refine the relationship between gamma and Ra-226.
2. Further evaluation of the potential haul road may be warranted as part of future work at the Site.
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. It is recommended that the two databases be compared (with additional field work, if necessary) to confirm the locations of water features.

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 November 2016. The Site is known as the Occurrence B site and is also identified by the USEPA as AUM identification #296 in the *2007 AUM Atlas*.

The primary objectives of the RSEs are to provide data required to evaluate relevant site conditions and to support future removal action evaluations at the Sites. It is not intended to establish cleanup levels or determine cleanup options or potential remedies. The purpose of the RSE data (e.g., the review of relevant information and the collection of data related to historical mining activities) is 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. The RSE included historical data review, visual observations, surface gamma surveys, surface and subsurface static gamma measurements, and soil 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. Given that there is no evidence of historical uranium mining, TENORM that meets the USEPA definition (refer to Glossary) is the result of impacts from excavation of the historical borrow pit that may have dispersed uranium contaminated rock and soils.

A surface water sample was also collected as part of the RSE to evaluate potential mining-related impacts. 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 analytical results. However, predicted Ra-226 concentrations were compared to the actual Ra-226 laboratory results and ILs from the surface soil samples at the Agencies' request.

Based on the historical documentation review, the following is known (1) the RSE Site was not included on Mr. Zhealy Tso's mining permit; (2) exploration activities that included digging prospect pits, rim stripping, and drilling boreholes occurred on Parcel 1 of Mr. Tso's mining permit, which was located approximately 2 miles west of the RSE Site; (3) the location of the RSE Site is the same location as a historical borrow pit; and (4) there is no historical information to establish that the RSE Site was associated with uranium mining. Of note, even though there is no historical information that the Occurrence B RSE Site was mined for uranium, there were activities associated with excavation related to the historical borrow pit. **Based on this historical information, it appears that the Site was not a uranium mine.**

Four potential background reference areas were considered. One of the four potential background reference areas (BG-1) was selected to develop surface gamma, Ra-226, and metals ILs for the Survey Area at the Site. A subsurface static gamma IL was also identified for the Survey Area.

Arsenic, molybdenum, uranium, vanadium, and Ra-226 concentrations and gamma radiation measurements in soil exceeded their respective ILs and are confirmed COPCs for the Site. An IL for selenium was not identified because selenium sample results were non-detect in the background area. However, because selenium was detected in soil samples from the Survey Area, it is also confirmed as a COPC for the Site.

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 refine the relationship between gamma and Ra-226.

Surface gamma measurements were uniformly distributed across the Survey Area, with some higher readings located to the northwest of the claim boundary. The higher measurements outside the claim boundary were in an undisturbed area and appeared to be associated with shallow bedrock and bedrock outcrops of the Chinle Formation. Ra-226 and metals concentrations were generally highest in the area along the northern claim boundary and the area to the northwest of the claim boundary. The maximum survey measurement was 48,436 cpm, which was greater than four times the BG-1 IL and was measured at an undisturbed bedrock outcrop northwest of the claim boundary (refer to Figure 4-1). The highest subsurface static gamma measurements in unconsolidated material was detected at borehole S296-SCX-007 (1.5 ft bgs) located southeast of the claim boundary.

Based on the data analysis performed for this RSE report along with the multiple lines of evidence, approximately 6.2 acres, out of the 22.5 acres of the Survey Area were estimated to contain TENORM. **The TENORM is the result of the borrow pit excavation and not uranium mining.** This estimate is inclusive of the potential historical haul road area (southwest) and the area where historical earthwork activities presumably occurred (associated with the borrow pit) within and just beyond the claim boundary. 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 6.2 acres that contain TENORM, 5.3 acres contain TENORM exceeding the surface gamma IL and TENORM that exceeded the ILs at soil sample locations. The volume of TENORM in excess of ILs was estimated to be 8,504 yd^3 (6,502 cubic meters). It should be noted that the COPC measurements and concentrations in the area that contains TENORM that exceeded the ILs are generally similar to the COPC measurements and concentrations in the area of NORM located outside the TENORM boundary.

Surface water samples were collected from one surface water pond (S296-Pond-1). Analytical results indicated that the sample from S296-Pond-1 (S296-WS-001) did not exceed any analytical ILs, which indicates that the surface water was not impacted by the historical borrow pit or surface modifications made after the excavation of the borrow pit. Based on these results, there are no confirmed COPCs for the pond and further characterization may not be needed at the pond.

Four 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 Occurrence B 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 Occurrence B RSE were $422,700. Stantec's costs associated with interim actions (sign installation) were $4,000. In addition, Administrative costs provided by the Trust were estimated currently at $191,500[11,12]. Administrative costs will change due to continued community outreach and close out activities.

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

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TABLES

Table 3-1
Identified Water Features
Occurrence B
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Identified Water Feature	Source of Identified Water Feature	Water Feature Identification	Field Sample Identification	Field Personnel Observations
Pond	Stantec/Trust	S296-Pond-1	S852-WS-001	Pond identified by Stantec field personnel during site mapping. Pond was located approximately 565 ft south of the Site within the main drainage. This location was sampled as part of the RSE on November 9, 2016, sample location ID S296-WS-001.

Notes
ID - identification

Table 3-2
Soil Sampling Summary
Occurrence B
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											
S296-BG1-001	0 - 0.5	soil	SF	grab	NA	11/11/2016	640369.60	4005073.14	N	N	--
S296-BG1-002	0 - 0.5	soil	SF	grab	NA	11/11/2016	640372.67	4005076.97	N	N	--
S296-BG1-003	0 - 0.5	soil	SF	grab	NA	11/11/2016	640372.38	4005072.90	N	N	--
S296-BG1-004	0 - 0.5	soil	SF	grab	NA	11/11/2016	640374.26	4005073.53	N	N	--
S296-BG1-005	0 - 0.5	soil	SF	grab	NA	11/11/2016	640376.29	4005072.75	N	N	--
S296-BG1-006	0 - 0.5	soil	SF	grab	NA	11/11/2016	640378.65	4005074.15	N;FD	N;FD	--
S296-BG1-007	0 - 0.5	soil	SF	grab	NA	11/11/2016	640376.61	4005077.19	N	N	--
S296-BG1-008	0 - 0.5	soil	SF	grab	NA	11/11/2016	640380.64	4005077.53	N	N	--
S296-BG1-009	0 - 0.5	soil	SF	grab	NA	11/11/2016	640378.57	4005076.17	N	N	--
S296-BG1-010	0 - 0.5	soil	SF	grab	NA	11/11/2016	640376.48	4005079.53	N;MS;MSD	N	--
S296-BG1-011	0 - 0.7	soil	SB	grab	NA	11/11/2016	640377.17	4005076.01	N;MS;MSD	N	--
S296-BG1-011	0.7 - 1.2	soil	SB	grab	NA	11/11/2016	640377.17	4005076.01	N	N	--
Correlation											
S296-C01-001	0 - 0.5	soil	SF	5-point composite	NA	11/9/2016	640649.84	4005239.32	--	N	N
S296-C02-001	0 - 0.5	soil	SF	5-point composite	NA	11/9/2016	640591.56	4005171.82	--	N	N
S296-C03-001	0 - 0.5	soil	SF	5-point composite	NA	11/9/2016	640625.45	4005155.47	--	N	N
S296-C04-001	0 - 0.5	soil	SF	5-point composite	NA	11/9/2016	640678.47	4005089.06	--	N	N
S296-C05-001	0 - 0.5	soil	SF	5-point composite	NA	11/9/2016	640727.94	4005214.93	--	N	N
Characterization											
S296-CX-001	0 - 0.5	soil	SF	grab	Site Survey Area	11/9/2016	640728.75	4005271.79	N;MS;MSD	N	--
S296-CX-002	0 - 0.5	soil	SF	grab	Site Survey Area	11/9/2016	640723.11	4005223.43	N	N	--
S296-CX-003	0 - 0.5	soil	SF	grab	Site Survey Area	11/9/2016	640698.18	4005266.38	N	N	--
S296-CX-004	0 - 0.5	soil	SF	grab	Site Survey Area	11/9/2016	640685.44	4005237.91	N	N	--
S296-CX-005	0 - 0.5	soil	SF	grab	Site Survey Area	11/9/2016	640655.00	4005247.71	N;FD	N;FD	--
S296-CX-006	0 - 0.5	soil	SF	grab	Site Survey Area	11/9/2016	640657.27	4005216.92	N	N	--
S296-CX-007	0 - 0.5	soil	SF	grab	Site Survey Area	11/9/2016	640636.34	4005198.60	N	N	--
S296-CX-008	0 - 0.5	soil	SF	grab	Site Survey Area	11/9/2016	640584.92	4005180.70	N	N	--
S296-CX-009	0 - 0.5	soil	SF	grab	Site Survey Area	11/9/2016	640622.73	4005127.05	N	N	--
S296-CX-010	0 - 0.5	soil	SF	grab	Site Survey Area	11/9/2016	640686.80	4005175.88	N	N	--
S296-SCX-002	0 - 0.5	soil	SF	grab	Site Survey Area	11/9/2016	640711.18	4005244.55	N	N	--
S296-SCX-002	0.5 - 0.93	soil	SB	grab	Site Survey Area	11/9/2016	640711.18	4005244.55	N	N	--
S296-SCX-004	0 - 0.42	soil	SF	grab	Site Survey Area	11/9/2016	640648.68	4005150.84	N	N	--
S296-SCX-005	0 - 0.5	soil	SF	grab	Site Survey Area	11/9/2016	640566.92	4005182.06	N	N	--
S296-SCX-007	0 - 0.5	soil	SF	grab	Site Survey Area	11/9/2016	640793.52	4005219.20	N	N	--
S296-SCX-007	1 - 1.5	soil	SB	grab	Site Survey Area	11/9/2016	640793.52	4005219.20	N	N	--
S296-SCX-007	2.5 - 2.7	soil	SB	grab	Site Survey Area	11/9/2016	640793.52	4005219.20	N	N	--

Notes

--	Not Sampled
N	Normal
FD	Field Duplicate
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NA	Not Applicable
Ra-226	Radium 226
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
Occurrence B
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Mine Feature	Surface Samples	Subsurface Samples	Area (sq. ft)	Volume of TENORM exceeding ILs (yd^3)
Potential Disturbed Area	10	1	213,476	7,907
Topographic Depression	0	0	24,776	918
Potential Haul Road	0	0	--	400

Notes

sq.ft - square feet

yd^3 - cubic yards

ILs - investigation levels

TENORM - technologically enhanced naturally occurring radioactive material

-- Area not determined because the width of the potential haul road varies throughout the Site

Table 3-4
Water Sampling Summary
Occurrence B
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Sample Location	Water Feature Identification	Sample Date	Easting[1]	Northing[1]	Sample Types							
					Ra-226	Ra-228	Gross Alpha	Metals, Dissolved	Metals, Total	TDS	Anions	Cations
Surface Water												
S296-WS-001	S296-Pond-1	11/9/2016	640564.98	4004943.09	N	N	N;MS	N;MS;MSD	N;MS;MSD	N	N;MS;MSD	N;MS;MSD

Notes

N	Normal
MS	Matrix Spike
MSD	Matrix Spike Duplicate
Ra-226	Radium 226
Ra-228	Radium 228
TDS	Total Dissolved Solids

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

Table 4-1
Background Reference Area Soil Sample Analytical Results
Occurrence B
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification	S296-BG1-001	S296-BG1-002	S296-BG1-003	S296-BG1-004	S296-BG1-005	S296-BG1-006	S296-BG1-006 Dup	S296-BG1-007	S296-BG1-008	S296-BG1-009	S296-BG1-010	S296-BG1-011	S296-BG1-011
Date Collected	11/11/2016	11/11/2016	11/11/2016	11/11/2016	11/11/2016	11/11/2016	11/11/2016	11/11/2016	11/11/2016	11/11/2016	11/11/2016	11/11/2016	11/11/2016
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.7	0.7 - 1.2
Analyte (Units)													
Metals[1] (mg/kg)													
Arsenic	2.1	1.8	2.9	2.5	2	2.1	2	1.7	1.8	1.9	1.8	1.8	2.5
Molybdenum	0.31	0.22	0.26	0.26	<0.2	<0.2	<0.2	<0.19	<0.2	0.22	<0.2	<0.2	0.31
Selenium	<0.98	<1	<1	<0.95	<1	<1	<1	<0.94	<1	<1	<1	<0.99	<1
Uranium	0.34	0.37	0.32	0.34	0.36	0.36	0.34	0.35	0.35	0.33	0.36	0.33 J	0.42
Vanadium	10	11	13	12	11	12	11	11	11	11	11	11 J	13
Radionuclides (pCi/g)													
Radium-226	1.09 ± 0.26	0.92 ± 0.26	0.84 ± 0.25	0.99 ± 0.25	1 ± 0.25	0.98 ± 0.23	1.17 ± 0.28	0.9 ± 0.23	1.01 ± 0.26	0.94 ± 0.26	1.17 ± 0.27	0.97 ± 0.26	1.13 ± 0.27

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

Table 4-2
Static Gamma Measurement Summary
Occurrence B
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S296-BG1-011	Background Area 1	*	0.00	soil	11,402
S296-BG1-011	Background Area 1	*	0.67	soil	14,707
S296-BG1-011	Background Area 1	*	1.00	soil	15,722
S296-BG1-011	Background Area 1	*	1.17	soil	15,630
S296-BG1-012	Background Area 1	*	0.00	soil	11,207
S296-BG1-012	Background Area 1	*	0.75	soil	15,232
S296-BG1-013	Background Area 1	*	0.00	soil	11,537
S296-BG1-013	Background Area 1	*	0.58	soil	14,286
S296-BG1-013	Background Area 1	*	0.83	soil	14,686
S296-SCX-001	Site Survey Area	--	0.00	soil	14,808
S296-SCX-001	Site Survey Area	15,722	0.40	soil	16,969**
S296-SCX-002	Site Survey Area	--	0.00	soil	14,662
S296-SCX-002	Site Survey Area	15,722	0.50	soil	16,289
S296-SCX-002	Site Survey Area	15,722	0.93	soil	17,803**
S296-SCX-003	Site Survey Area	--	0.00	soil	14,853
S296-SCX-003	Site Survey Area	15,722	0.25	soil	16,797**
S296-SCX-004	Site Survey Area	--	0.00	soil	13,933
S296-SCX-004	Site Survey Area	15,722	0.42	soil	18,017**
S296-SCX-005	Site Survey Area	--	0.00	soil	15,061
S296-SCX-005	Site Survey Area	15,722	0.50	soil	16,608**
S296-SCX-006	Site Survey Area	--	0.00	soil	12,815
S296-SCX-006	Site Survey Area	15,722	0.33	soil	15,402**
S296-SCX-007	Site Survey Area	--	0.00	soil	14,963
S296-SCX-007	Site Survey Area	15,722	0.50	soil	16,354
S296-SCX-007	Site Survey Area	15,722	1.00	soil	19,232
S296-SCX-007	Site Survey Area	15,722	1.50	soil	20,064
S296-SCX-007	Site Survey Area	15,722	2.00	soil	18,984
S296-SCX-007	Site Survey Area	15,722	2.70	soil	18,777**

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
Occurrence B
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification	S296-C01-001	S296-C02-001	S296-C03-001	S296-C04-001	S296-C05-001
Date Collected	11/9/2016	11/9/2016	11/9/2016	11/9/2016	11/9/2016
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Analyte (Units)					
Radionuclides (pCi/g)					
Radium-226	2.75 ± 0.46	2.88 ± 0.47	1.07 ± 0.27	0.85 ± 0.23	1.45 ± 0.34
Thorium-228	1.11 ± 0.19	1.31 ± 0.23	0.79 ± 0.15	0.77 ± 0.14	1.27 ± 0.22
Thorium-230	2.52 ± 0.41	2.52 ± 0.41	0.82 ± 0.16	0.74 ± 0.14	1.05 ± 0.19
Thorium-232	1.09 ± 0.19	1.24 ± 0.21	0.73 ± 0.14	0.72 ± 0.13	1.25 ± 0.22

Notes

Bold   Bolded result indicates positively identified compound

pCi/g   picocuries per gram

Table 4-4
Site Characterization Soil Sample Analytical Results
Occurrence B
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification		S296-CX-001	S296-CX-002	S296-CX-003	S296-CX-004	S296-CX-005	S296-CX-005 Dup	S296-CX-006	S296-CX-007	S296-CX-008	S296-CX-009	S296-CX-010	S296-SCX-002	S296-SCX-002	S296-SCX-004	S296-SCX-005	S296-SCX-007	S296-SCX-007	S296-SCX-007
Date Collected		11/9/2016	11/9/2016	11/9/2016	11/9/2016	11/9/2016	11/9/2016	11/9/2016	11/9/2016	11/9/2016	11/9/2016	11/9/2016	11/9/2016	11/9/2016	11/9/2016	11/9/2016	11/9/2016	11/9/2016	11/9/2016
Depth (feet)		0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 0.93	0 - 0.42	0 - 0.5	0 - 0.5	1 - 1.5	2.5 - 2.7
Sample Category		surface	surface	surface	surface	surface	surface	surface	surface	surface	surface	surface	surface	subsurface	surface	surface	surface	subsurface	subsurface
Sample Collection Method		grab	grab	grab	grab	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	soil	soil	soil	soil
Analyte (Units)	Investigation Level																		
Metals¹ (mg/kg)																			
Arsenic	3.15	4.1	2.9	5.2	3.6	3	3.2	4.6	42	7.4	3.8	2.2	4.6	2.2	4.3	4.8	2.3	2	2.6
Molybdenum	0.47	0.36	0.32	0.96	0.28	0.36	0.34	0.28	0.38	0.5	0.28	0.27	0.36	<0.21	0.23	<0.21	<0.2	<0.21	<0.21
Selenium	NA	<0.99	<0.96	<0.95	1.7	<1	<1	<1	2.4	1.8	<1	1.1	<1	<1.1	<1	1.1	<0.99	<1	<1
Uranium	0.39	1.1	1.1	1.6	2.2	5.4	4.7	2.1	5.7	3.6	2.4	2.1	1.7	1.7	1.6	2	0.89	0.82	0.6
Vanadium	13.7	16	16	13	54	17	18	15	21	32	16	16	9.5	11	11	22	10	9.6	12
Radionuclides (pCi/g)																			
Radium-226	1.26	1.67 ± 0.31	1.38 ± 0.32	1.71 ± 0.37 J-	2.13 ± 0.42	3.98 ± 0.57	3.81 ± 0.58	1.74 ± 0.32	1.83 ± 0.35	4.22 ± 0.64	2.55 ± 0.41	2.53 ± 0.46	2.3 ± 0.47 J+	1.64 ± 0.35	1.87 ± 0.38	1.81 ± 0.33	1.56 ± 0.35	1.72 ± 0.33	1.23 ± 0.26

Notes
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 for selenium is not identified because selenium sample results in BG-1 were all non-detect
¹ Analysis required 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
J+ Data are estimated and are potentially biased high due to associated quality control data

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

Sample Location	Investigation Level Exceedances
S296-SCX-001[1]	Static Gamma
S296-SCX-002	As, Se, U, Ra-226, Static Gamma
S296-SCX-003[1]	Static Gamma
S296-SCX-004	As, U, Ra-226, Static Gamma
S296-SCX-005[2]	As, Se, U, V, Ra-226, Static Gamma
S296-SCX-007	U, Ra-226, Static Gamma

Notes
[1] Samples were not collected at borehole location
[2] Detection of Se included for reference, no IL was established for Se
IL - investigation level
As - Arsenic
Mo - Molybdenum
Ra-226 - Radium 226
Se- Selenium
U - Uranium
V - Vanadium

Table 4-6a
Water Sampling Investigation Level Derivation
Occurrence B
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Analyte (Units)	USEPA MCL [a]	USEPA Secondary Standard [b]	Navajo Nation Surface Water Quality Standards [c]	Navajo Nation Primary Drinking Water MCL[d]	Investigation Level
Radionuclides (pCi/L)					
Ra-226 [e]	5	*	5	5	5
Ra-228 [e]	5	*	5	5	5
Gross Alpha	15	*	15	15	15
Metals (ng/L)					
Mercury	2000	*	2000	2000	2000
Metals (µg/L)					
Antimony	6	*	5.6	6	5.6
Arsenic	10	*	10	10	10
Barium	2000	*	2000	2000	2000
Beryllium	4	*	4	4	4
Cadmium	5	*	5	5	5
Chromium, Total	100	*	100	100	100
Cobalt	*	*	*	*	*
Copper	1300	*	1300	*	1300
Lead	15	*	15	15	15
Molybdenum	*	*	*	*	*
Nickel	*	*	610	*	610
Selenium	50	*	50	50	50
Silver	*	100	35	*	35
Thallium	2	*	2	2	2
Uranium	30	*	30	30	30
Vanadium	*	*	*	*	*
Zinc	*	5000	2100	*	2100
General Chemistry Parameters (mg/L) [f]					
Bicarbonate	*	*	*	*	*
Calcium	*	*	*	*	*
Carbonate	*	*	*	*	*
Chloride	*	250	*	*	250
Sodium	*	*	*	*	*
Sulfate	*	250	*	*	250
TDS	*	500	*	*	500

Notes
Bold – indicates the most conservative value to be used for comparison.
[a] "Table of Regulated Drinking Water Contaminants", Groundwater and Drinking Water (USEPA, 2016a).
[b] "Table of Secondary Drinking Water Standards", Secondary Drinking Water Standards: Guidance for Nuisance Chemicals (USEPA, 2016b).
[c] Navajo Nation Surface Water Quality Standards (NNEPA, 2015)
[d] Maximum Contaminant Levels Navajo Nation Primary Drinking Water Regulations (NNPDWR, 2015)
[e] The MCL for Ra-226 and Ra-228 have a combined limit of 5 pCi/L, and are not individually 5pCi/L
[f] Collected data will be used for water quality analysis purposes

* USEPA primary (MCL), secondary standard, Navajo Nation Surface Water Quality Standards, or Navajo Drinking Water MCLs are not established for these analytes.

MCL - maximum contaminant level
µg/L - micrograms per liter
mg/L - milligrams per liter
ng/L - nanograms per liter
pCi/L - picocuries per liter
TDS - Total Dissolved Solids
Ra-226 - Radium 226
Ra-228 - Radium 228
USEPA - Unites States Environmental Protection Agency

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

Table 4-6b
Water Sampling Analytical Results
Occurrence B
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

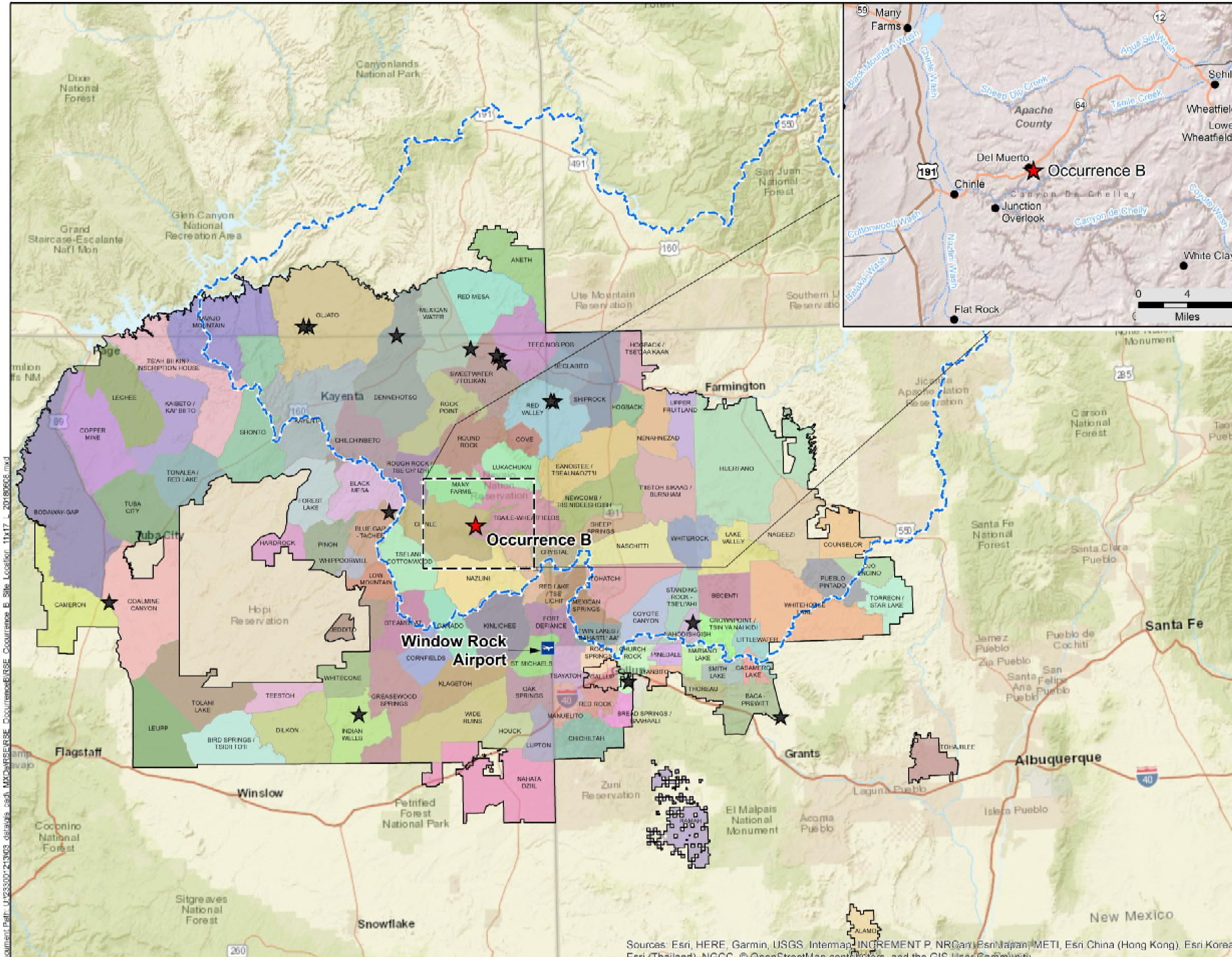
Analyte (Units)	Water Feature Identification Field Sample Identification Date Collected Matrix Preparation	S296-Pond-1 S296-WS-001 11/9/2016 Surface Water Dissolved	S296-Pond-1 S296-WS-001 11/9/2016 Surface Water Total
	Investigation Level		
Radionuclides (pCi/L)			
Ra-226	5 [1]	NS	0 ± 0.1
Ra-228	5 [1]	NS	1.19 ± 0.47
Gross Alpha	--	NS	0 ± 1.1
Adjusted Gross Alpha [2]	15	NS	NA
Gross Beta	--	NS	7.9 ± 2
Metals (ng/L)			
Mercury	2000	1.9	4.7
Metals [3] (µg/L)			
Antimony	5.6	0.37	<0.3
Arsenic	10	3.6	4.4
Barium	2000	300	310
Beryllium	4	<0.5	<0.5
Cadmium	5	<0.3	<0.3
Chromium, Total	100	<10	<10
Cobalt	--	1.4	1.5
Copper	1300	<10	<10
Lead	15	0.67	1.5
Molybdenum	--	2.4	2
Nickel	610	5.3	<5
Selenium	50	<1	<1
Silver	35	<0.1	<0.1
Thallium	2	<0.2	<0.2
Uranium	30	0.72	0.79
Vanadium	--	1.4	3.6
Zinc	2100	<20	<20
General Chemistry Parameters (mg/L)			
TDS	500	NS	280 J
Carbonate	--	NS	<20
Bicarbonate	--	NS	160
Chloride	250	NS	3.4
Sulfate	250	NS	3.3
Calcium	--	48 D	50 D
Sodium	--	1.7 D	1.9 D
Field Parameters			
Oxidation Reduction Potential(millivolts)	--	NS	129.8
pH(pH units)	--	NS	7.64
Salinity(pptv)	--	NS	0.33
Specific Conductivity(µS/cm)	--	NS	543
Temperature(°C)	--	NS	14.6
Turbidity(NTU)	--	NS	37.6

Notes
Bold Bold result indicates positively identified compound
B Analyte detected in an associated blank
D 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
°C Degrees Celsius
µg/L micrograms per liter
µS/cm microSiemens per centimeter
mg/L milligrams per liter
ng/L nanograms per liter
NTU nephelometric turbidity unit
pptv parts per thousand by volume
pCi/L picocuries per liter
-- Not established
NA Adjusted Gross Alpha result is not applicable because it was negative, refer to note [2]
NS Not scheduled
Ra-226 Radium 226
Ra-228 Radium 228
TDS Total Dissolved Solids
1 The Investigation Level for Ra-226 and Ra-228 have a combined limit of 5 pCi/L, and are not individually 5pCi/L
2 Adjusted Gross Alpha = Gross alpha concentration - uranium concentration, using the conversion factor of 0.6757 to convert uranium µg/L to pCi/L (U.S. Department of Energy, 2011)
3 Analysis required sample dilution of 10 times; reported values have been converted to non-diluted value

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
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

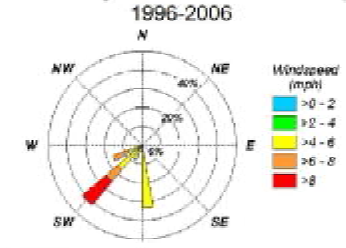


NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Occurrence B Mine Site
- Priority Abandoned Uranium Mine (AUM) Site
- Populated Place
- US Highway
- State Highway
- Major Road
- Intermittent Stream
- San Juan River Watershed
- Navajo Nation Boundary
- Navajo Nation Chapter

Window Rock Airport, Arizona Wind Rose (KRQE), 1996-2006



REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap: ESRI World Street Map and World Shaded Relief accessed 06/2018.

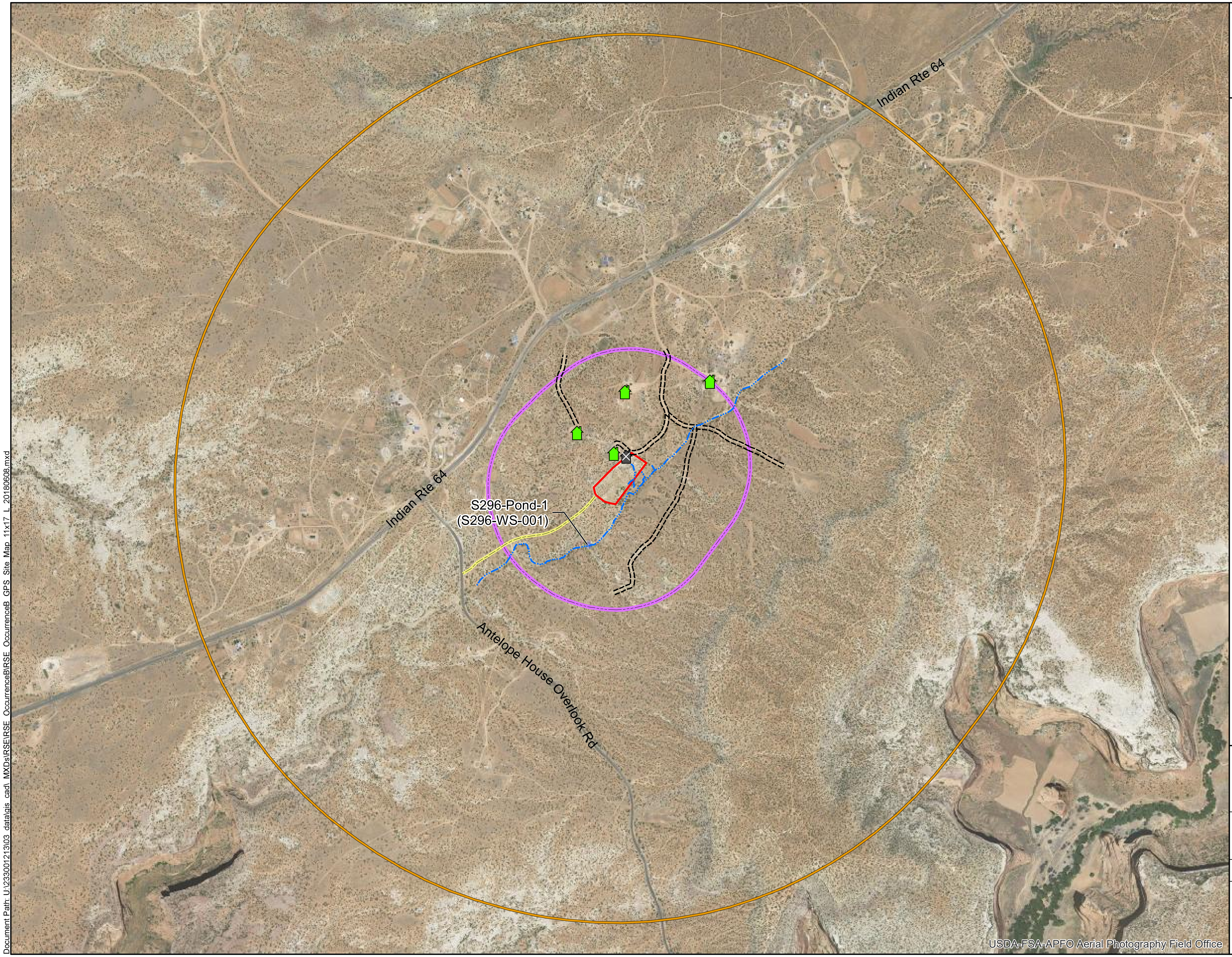
Wind Rose: USEPA, 2007a

0 25 50
Miles

TITLE:
Site Location

PROJECT:
Removal Site Evaluation
Occurrence B Mine Site

DATE: 6/12/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EDZ
	FIGURE: 1-1	



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Habitable Building
- Uninhabitable Building
- Drainage
- Potential Haul Road
- Road
- Pond
- Claim Boundary
- 1/4-Mile Claim Boundary Buffer
- 1-Mile Claim Boundary Buffer

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 6/11/2018

N W E S

0 1,200 2,400
Feet

TITLE:
Site Features

PROJECT:
Removal Site Evaluation
Occurrence B Mine Site

DATE: 6/11/2018

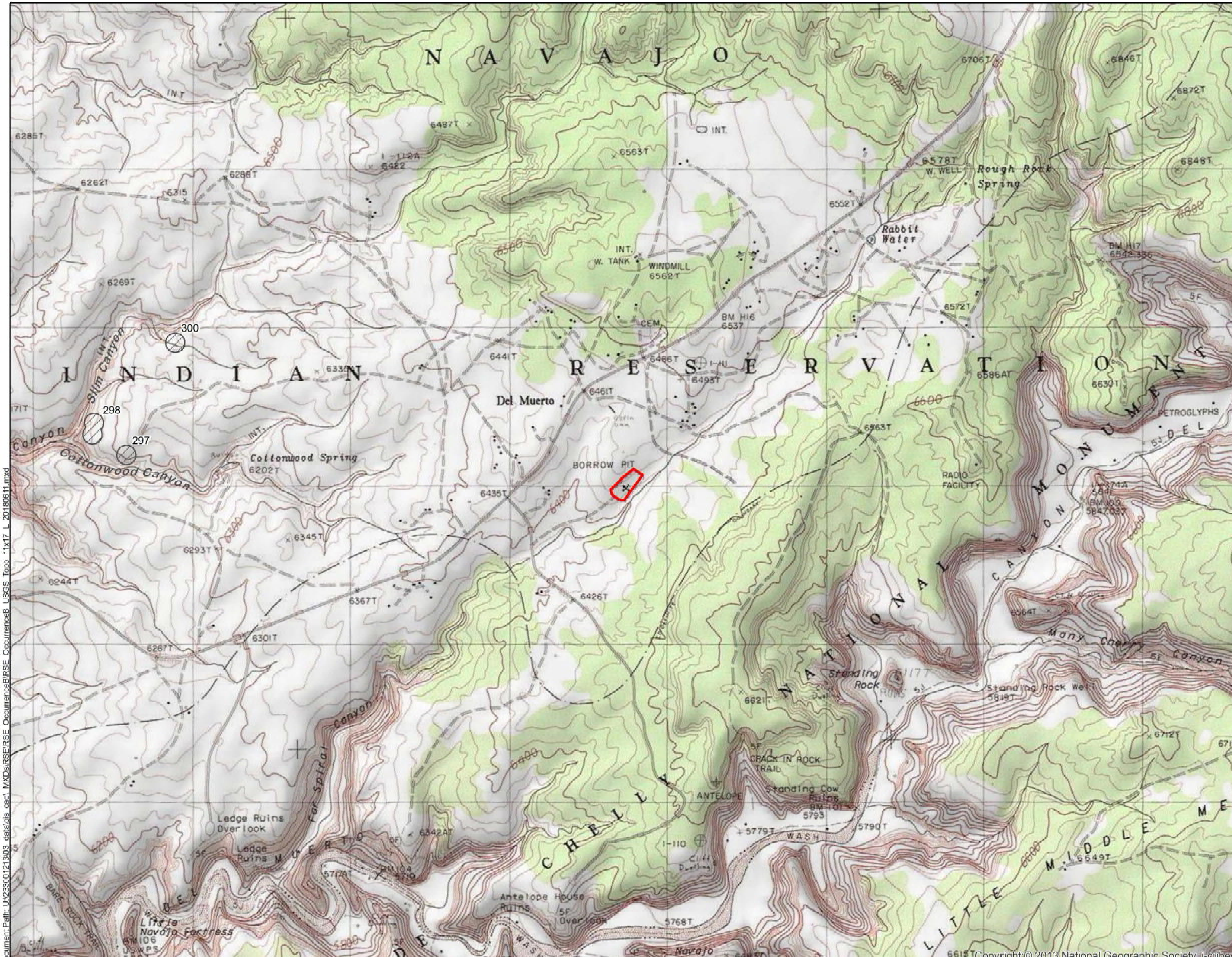
DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB
REVIEWER: EDZ

Stantec

FIGURE: 2-1

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\RSE_OccurrenceB_GPS_Site_Map_11x17_L_20180608.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Borrow Pit
- Claim Boundary
- Other Claim Boundary

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap: ESRI USA Topo Maps service accessed 06/2018.

0 2,000 4,000
Feet

TITLE: Regional Topographic Map

PROJECT: Removal Site Evaluation
Occurrence B Mine Site

DATE: 6/11/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 2-2

Stantec

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\RSE_OccurrenceB_USGS_Topo_11x17_L_20180611.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Claim Boundary

Other Claim Boundary

Notes:
1. Per the *2007 AUM Atlas* (USEPA, 2007a) claim 297 is also referred to as Zhealy Tso South Prospect Pit, claim 298 is also referred to as Zhealy Tso Pits, and claim 300 is also referred to as Zhealy Tso North Prospect Pit.
2. Parcel 1 is also the location of "Occurrence B-Gray" refer to Section 2.1.1 of the RSE report).

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 6/11/2018.

N
W E
S

0 2,000 4,000
Feet

TITLE:
Regional Aerial Photograph

PROJECT:
Removal Site Evaluation
Occurrence B Mine Site

DATE: 6/11/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

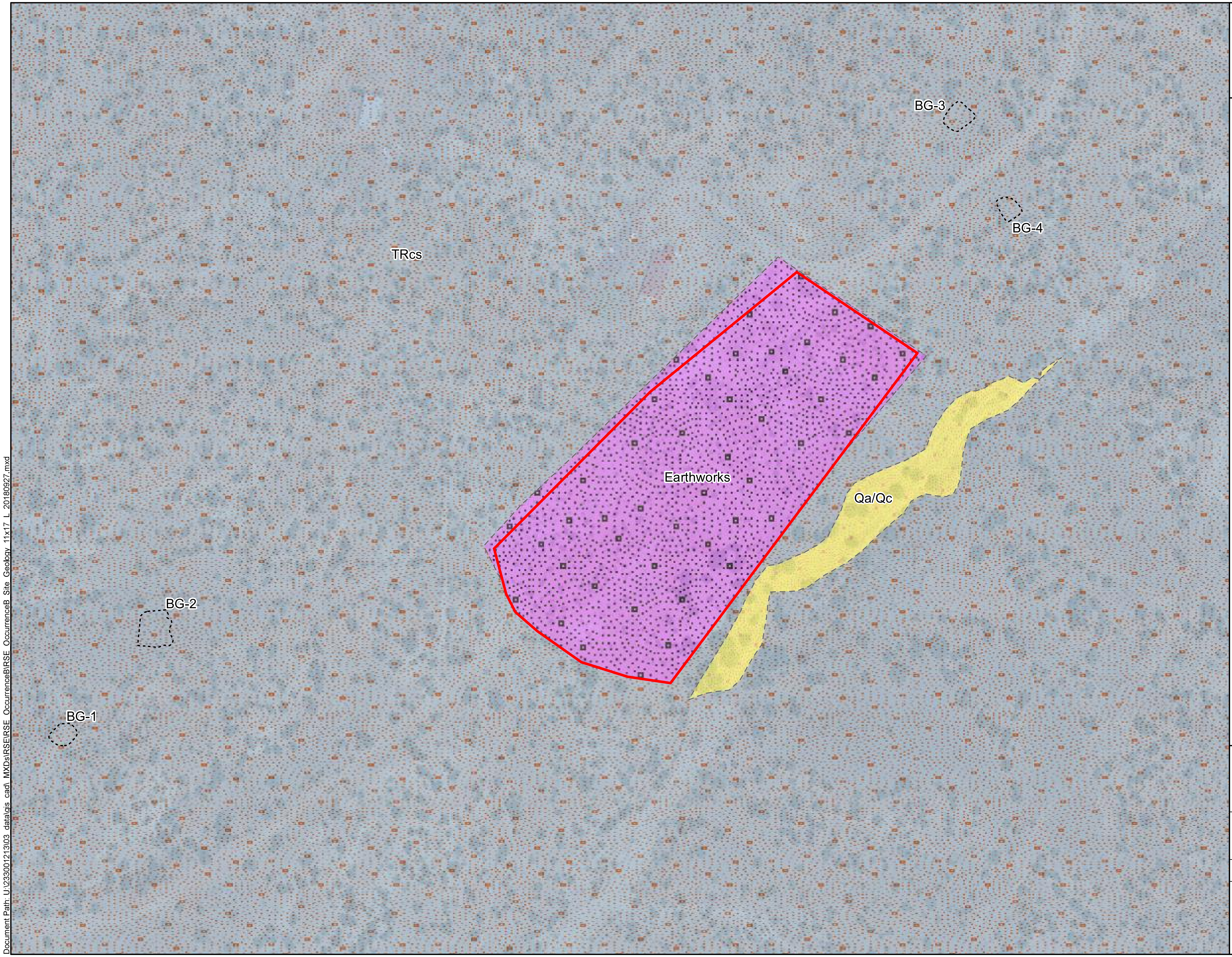
FIGURE: 2-3

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\RSE_OccurrenceB_Aerial_11x17_L_20180608.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

TITLE:	Regional Geology
PROJECT:	Removal Site Evaluation Occurrence B Mine Site
DATE: 6/11/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: CBB · REVIEWER: EDZ
	FIGURE: 2-4

NAVAJO NATION
AUM Environmental Response Trust-First Phase



LEGEND

- Potential Background Reference Area
- Claim Boundary
- Geologic Contact (Inferred)

Site Geology

QUATERNARY

- Earthworks: Surficial earthworks of TRcs outcrops and decomposed or highly weathered rock derived from TRcs.
- Qa/Qc: Surficial deposits of alluvium and/or colluvium.

TRIASSIC

- TRcs: Shinarump Member of the Chinle Formation (Upper Triassic), - moderate-orange and yellowish-gray sandstone, siltstone, conglomerate and sandy shale.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 9/28/2018.

N W E S

0 150 300
Feet

TITLE:
Site Geology

PROJECT:
Removal Site Evaluation
Occurrence B Mine Site

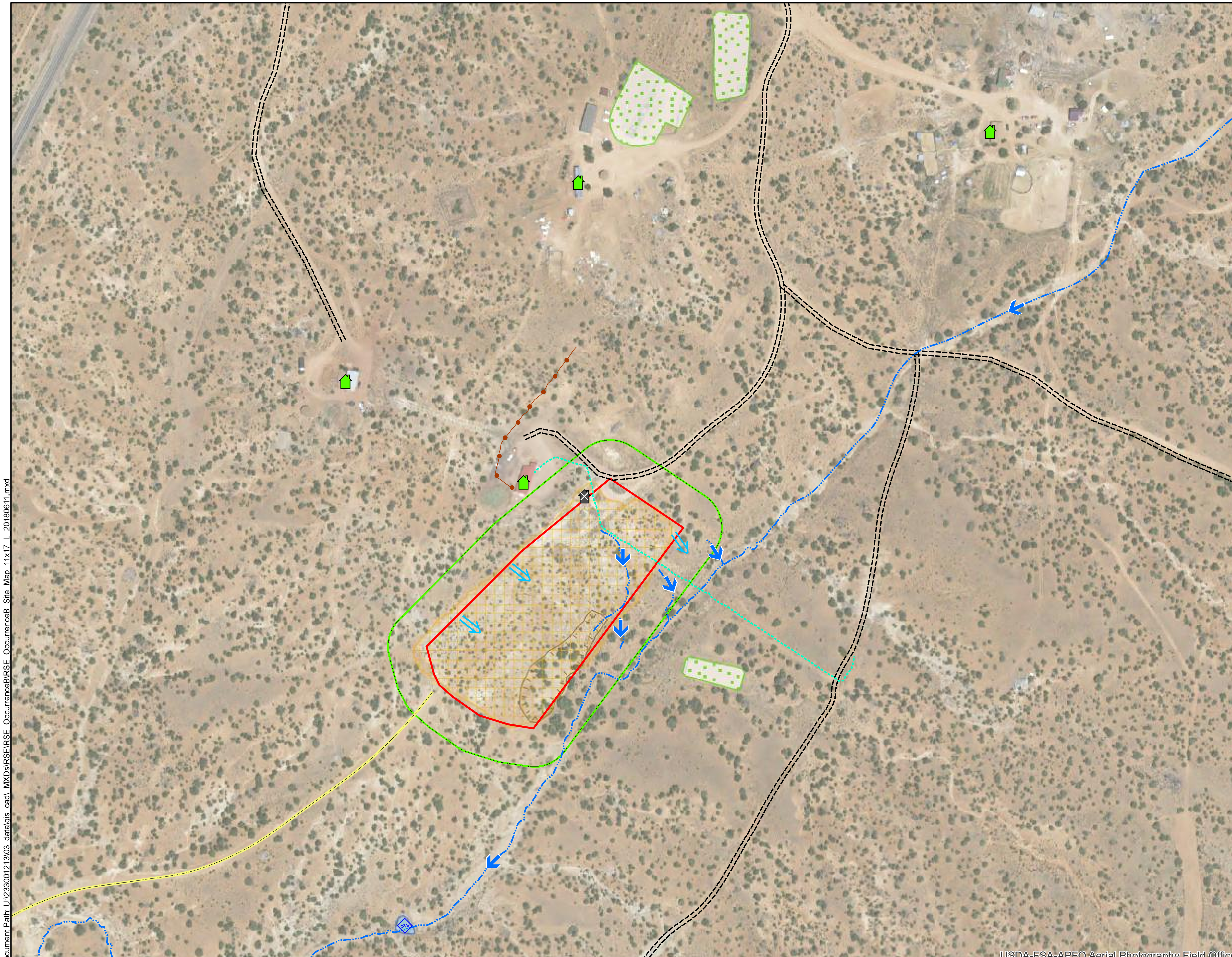
DATE:	DOCUMENT NAME:
9/28/2018	Removal Site Evaluation Report

AUTHOR:	REVIEWER:
CBB	EDZ

Stantec

FIGURE: 2-5

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\RSE_OccurrenceB_Site_Geology_11x17_L_20180927.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Habitable Building
- Uninhabitable Building
- Surface Water Sample
- Flow Direction
- Approximate Overland Water Flow Direction
- Drainage
- Potential Haul Road
- Power Line
- Road
- Water Line
- Topographic Depression
- Crops
- Pond
- Potentially Disturbed Area
- Claim Boundary
- 100-Foot Claim Buffer

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 6/11/2018.

N W E S

0 250 500
Feet

TITLE:
Site Map

PROJECT:
Removal Site Evaluation
Occurrence B Mine Site

DATE: 6/11/2018

DOCUMENT NAME: Removal Site Evaluation Report

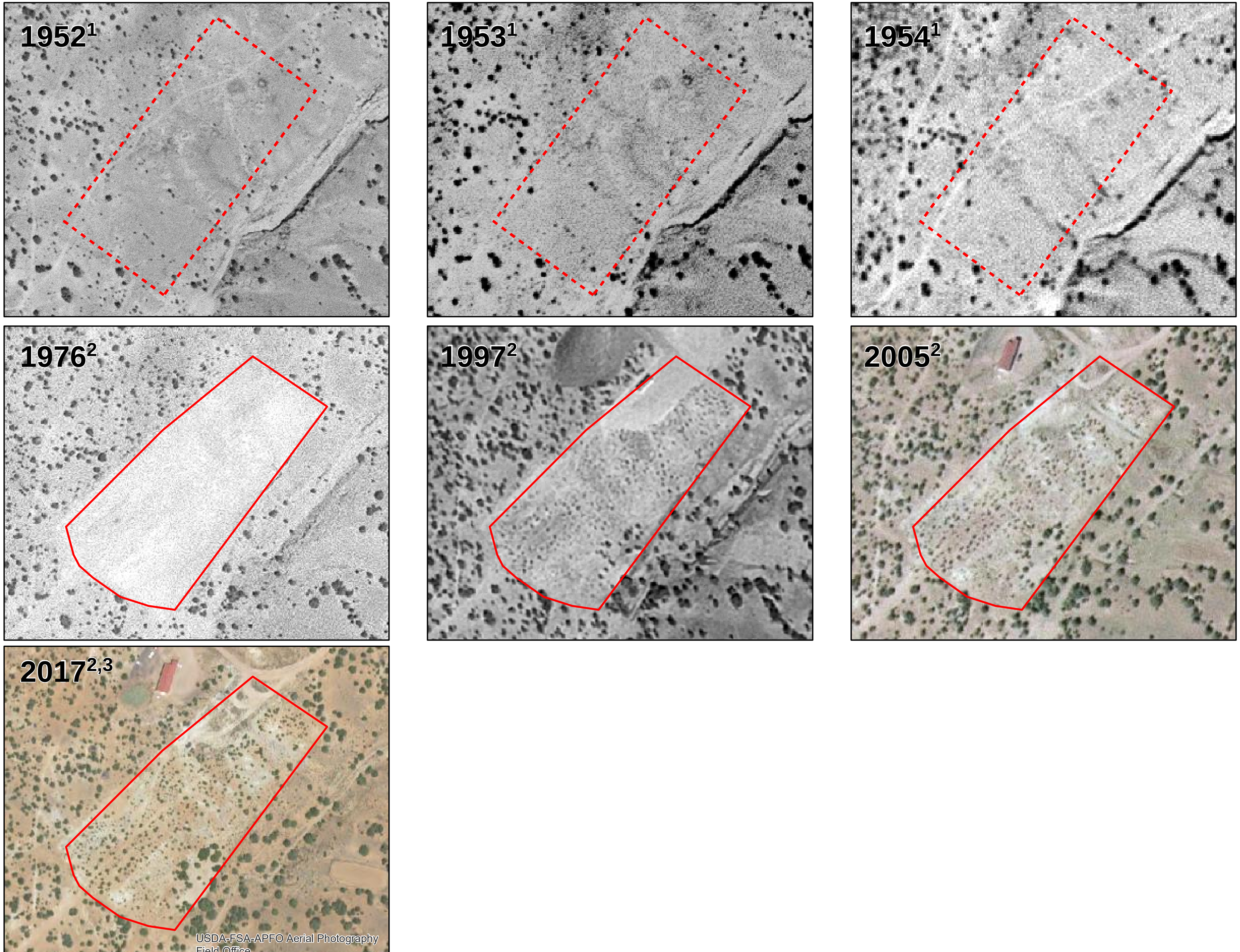
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 2-6

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\RSE_OccurrenceB_Site Map_11x17_L_20180611.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Occurrence B 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. 2017 image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 6/11/2018.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

N W E S

0 500 1,000
Feet

TITLE:

Historical Aerial Photograph Comparison

PROJECT:

Removal Site Evaluation
Occurence B Mine Site

DATE: 6/11/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 3-1a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\RSE_OccurenceB_Historical_Aerial_Compilation_V2_11x17_L_20170926.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Claim Boundary

REFERENCES:

1. Coordinate System: NAD 1983 UTM Zone 12N
2. 1976 aerial image downloaded from https://earthexplorer.usgs.gov/ (01/2016) and georeferenced using current image from BING (03/2016).
3. 2017 image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 6/11/2018.

N W E S

0 200 400
Feet

TITLE: 1976 Historical Aerial Photograph Comparison

PROJECT: Removal Site Evaluation Occurrence B Mine Site

DATE: 6/11/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 3-1b

Stantec

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE OccurrenceB\RSE OccurrenceB Historical Aerial 1976 11x17 L 20180608.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Potential Background Reference Area
- Claim Boundary

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 9/27/2018.

N
W E
S

0 200 400
Feet

TITLE:
Potential Background Reference Areas

PROJECT:
Removal Site Evaluation
Occurrence B Mine Site

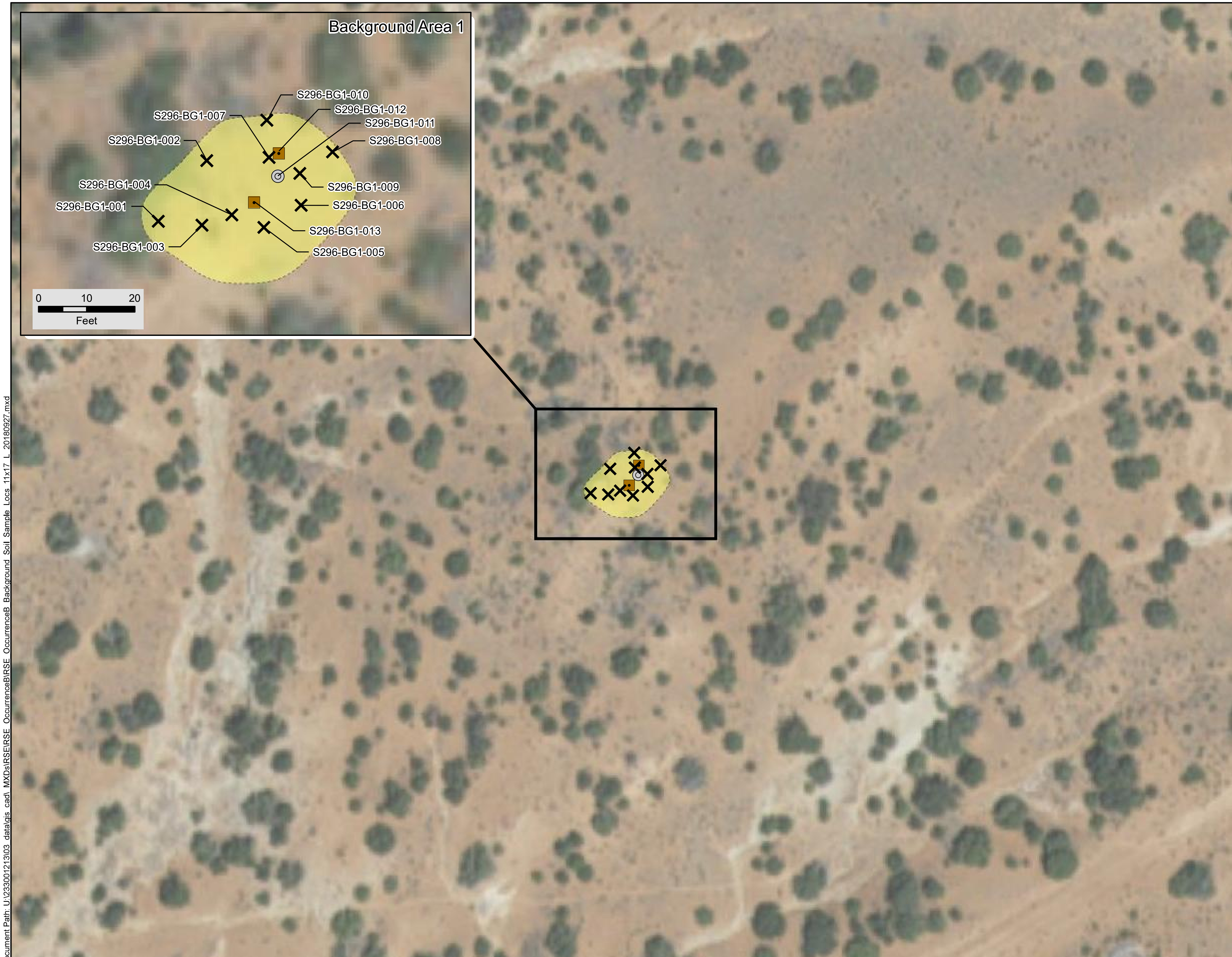
DATE:	DOCUMENT NAME:
9/27/2018	Removal Site Evaluation Report

Stantec

AUTHOR:	REVIEWER:
CBB	EDZ

FIGURE: 3-2

Document Path: U:\123300121\03_data\gis_cad_MXDs\RSE\RSE_Occurrence\B\RSE_OccurrenceB_Background_Areas_11x17_L_20180927.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Soil Sample Location
- Borehole Location - Surface and Subsurface Samples
- Subsurface Sample Attempted but no Samples were Collected because the Hand Auger met Refusal at Bedrock
- Background Reference Area

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 9/27/2018.

N W E S

0 50 100
Feet

TITLE: Background Reference Area - Sample Locations

PROJECT: Removal Site Evaluation Occurrence B Mine Site

DATE: 9/27/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 3-3

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\RSE_OccurrenceB_Background_Soil_Sample_Locs_11x17_L_20180927.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Background Reference Area
- Survey Area
- Claim Boundary

NOTE:
Gamma survey area is approximately 22.5 acres.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 9/27/2018.

N E S W

0 300 600
Feet

TITLE:
Gamma Radiation Survey Area

PROJECT:
Removal Site Evaluation
Occurrence B Mine Site

DATE: 9/27/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 3-4

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Occurrence\B\RSE_OccurrenceB_Gamma_Survey_Areas_11x17_L_20180927.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

S296-C01-001 Correlation Location (30' x 30')

Claim Boundary

100-Foot Claim Buffer

Gamma Survey
Counts per Minute (CPM)

- 10,037 - 11,649 (Minimum to BG-1 UTL)
- 11,650 - 23,298 (>BG-1 UTL to 2x BG-1 UTL)
- 23,299 - 31,285 (>2x BG-1 UTL to Maximum)

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

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 6/12/2018.

N W E S

0 100 200
Feet

TITLE:
Gamma Correlation Study Locations

PROJECT:
Removal Site Evaluation Occurrence B Mine Site

DATE: 6/12/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 3-5

Stantec

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\RSE_OccurrenceB_Correlation_11x17_L_20180608.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Borehole Location - Static Gamma Data Only
- Flow Direction
- Drainage
- Topographic Depression
- Survey Area
- Claim Boundary

NOTES:

Surface and subsurface static gamma measurements were collected at all borehole locations.

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

Subsurface soil samples range from 0.5 - 2.7 ft bgs

Static gamma measurements range from 0.0 - 2.7 ft bgs

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 9/28/2018.

N W E S

0 100 200
Feet

TITLE: Site Characterization Surface and Subsurface Soil Sample Locations

PROJECT: Removal Site Evaluation Occurrence B Mine Site

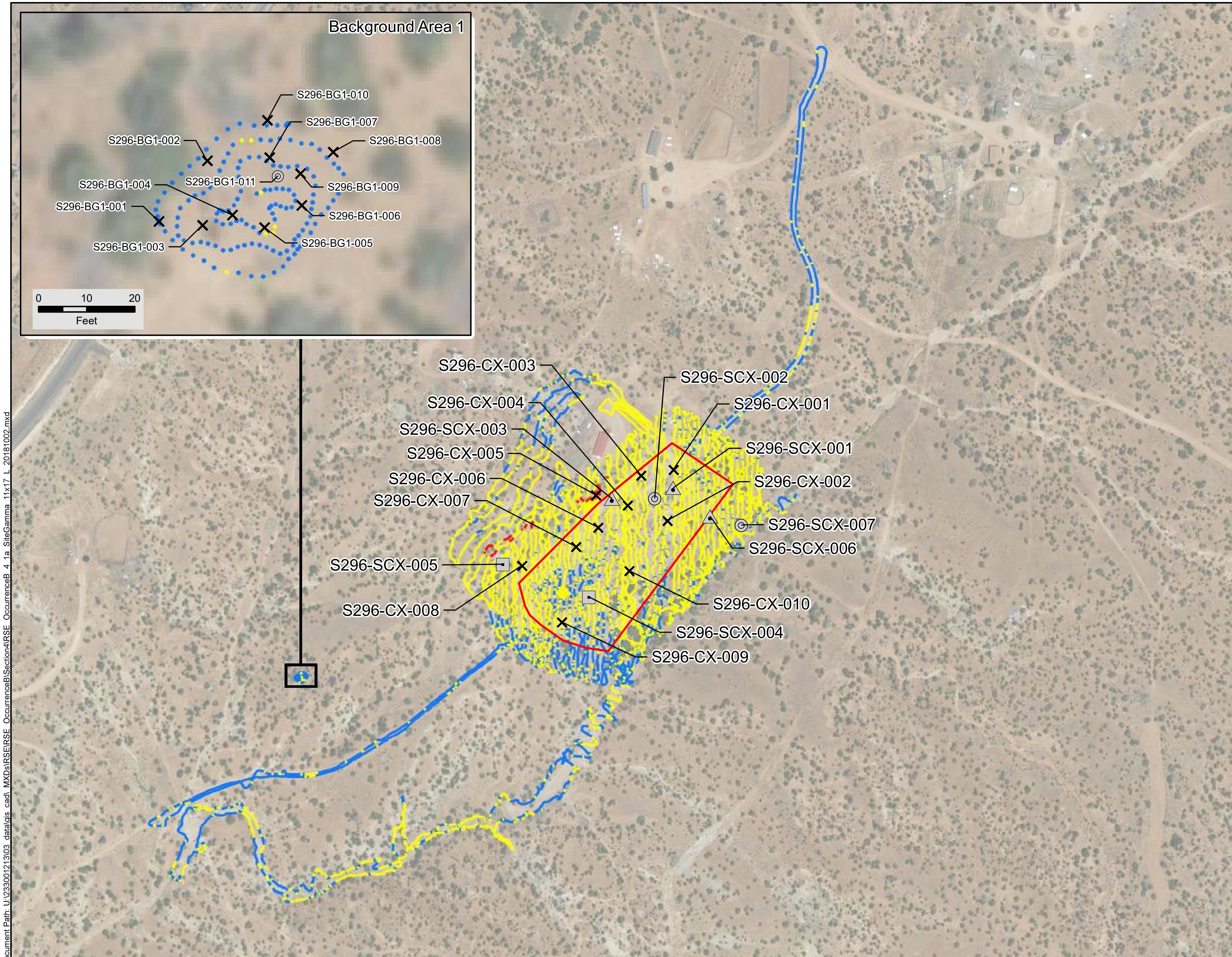
DATE:	DOCUMENT NAME:
9/28/2018	Removal Site Evaluation Report

AUTHOR:	REVIEWER:
CBB	EDZ

Stantec

FIGURE: 3-6

Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_Occurrence\B\RSE_OccurrenceB_Soil_Sample_Locs_11x17_L_20180928.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Borehole Location - Static Gamma Data Only
- Claim Boundary

Gamma Survey
Counts per Minute (CPM)
- 7,910 - 11,649 (Minimum to BG-1 IL)
- 11,650 - 23,298 (>BG-1 IL to 2x BG-1 IL)
- 23,299 - 48,436 (>2x BG-1 IL to Maximum)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 10/2/2018.

N
W E
S

0 300 600
Feet

TITLE:
Gamma Radiation Survey Results

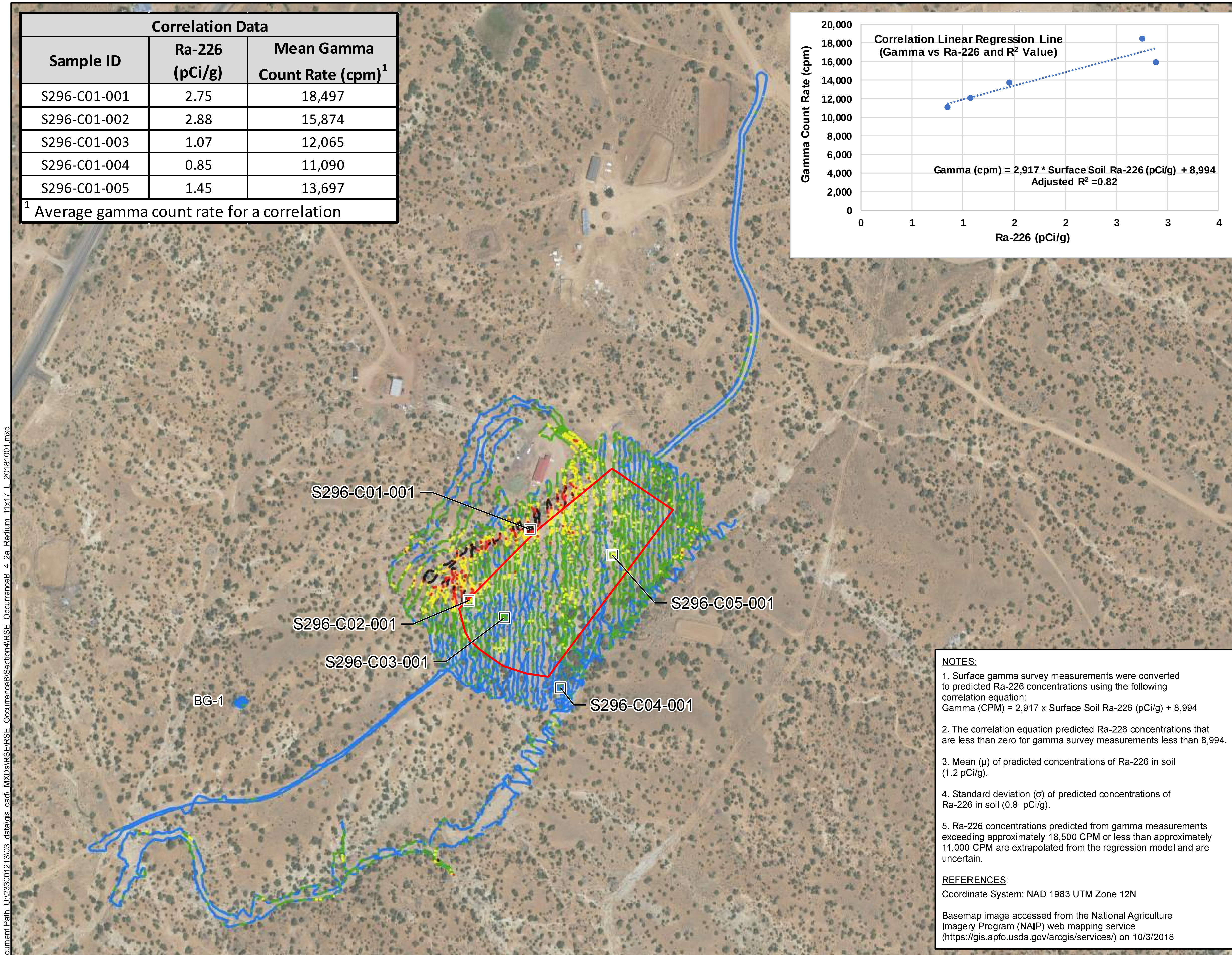
PROJECT:
Removal Site Evaluation Occurrence B Mine Site

DATE:	DOCUMENT NAME:	
10/2/2018	Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EDZ
	FIGURE: 4-1	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\Section4\RSE_OccurrenceB_4_1a_SiteGamma_11x17_L_20181002.mxd

Correlation Data		
Sample ID	Ra-226 (pCi/g)	Mean Gamma Count Rate (cpm)[1]
S296-C01-001	2.75	18,497
S296-C01-002	2.88	15,874
S296-C01-003	1.07	12,065
S296-C01-004	0.85	11,090
S296-C01-005	1.45	13,697

[1] Average gamma count rate for a correlation



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

S852-C01-001 Correlation Location (30' x 30')

Claim Boundary

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

- Less than 0[2]
- 0 - 1.2 (μ)[3]
- 1.3 - 2.0 (μ + 1σ[4])
- 2.1 - 2.8 (μ + 2σ)
- 2.9 - 3.6 (μ + 3σ)
- 3.7 - 13.5

N W E S

0 300 600
Feet

NOTES:

1. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
Gamma (CPM) = 2,917 x Surface Soil Ra-226 (pCi/g) + 8,994

2. The correlation equation predicted Ra-226 concentrations that are less than zero for gamma survey measurements less than 8,994.

3. Mean (μ) of predicted concentrations of Ra-226 in soil (1.2 pCi/g).

4. Standard deviation (σ) of predicted concentrations of Ra-226 in soil (0.8 pCi/g).

5. Ra-226 concentrations predicted from gamma measurements exceeding approximately 18,500 CPM or less than approximately 11,000 CPM are extrapolated from the regression model and are uncertain.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 10/3/2018

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

PROJECT:
Removal Site Evaluation Occurrence B Mine Site

DATE: 10/3/2018

DOCUMENT NAME: Removal Site Evaluation Report

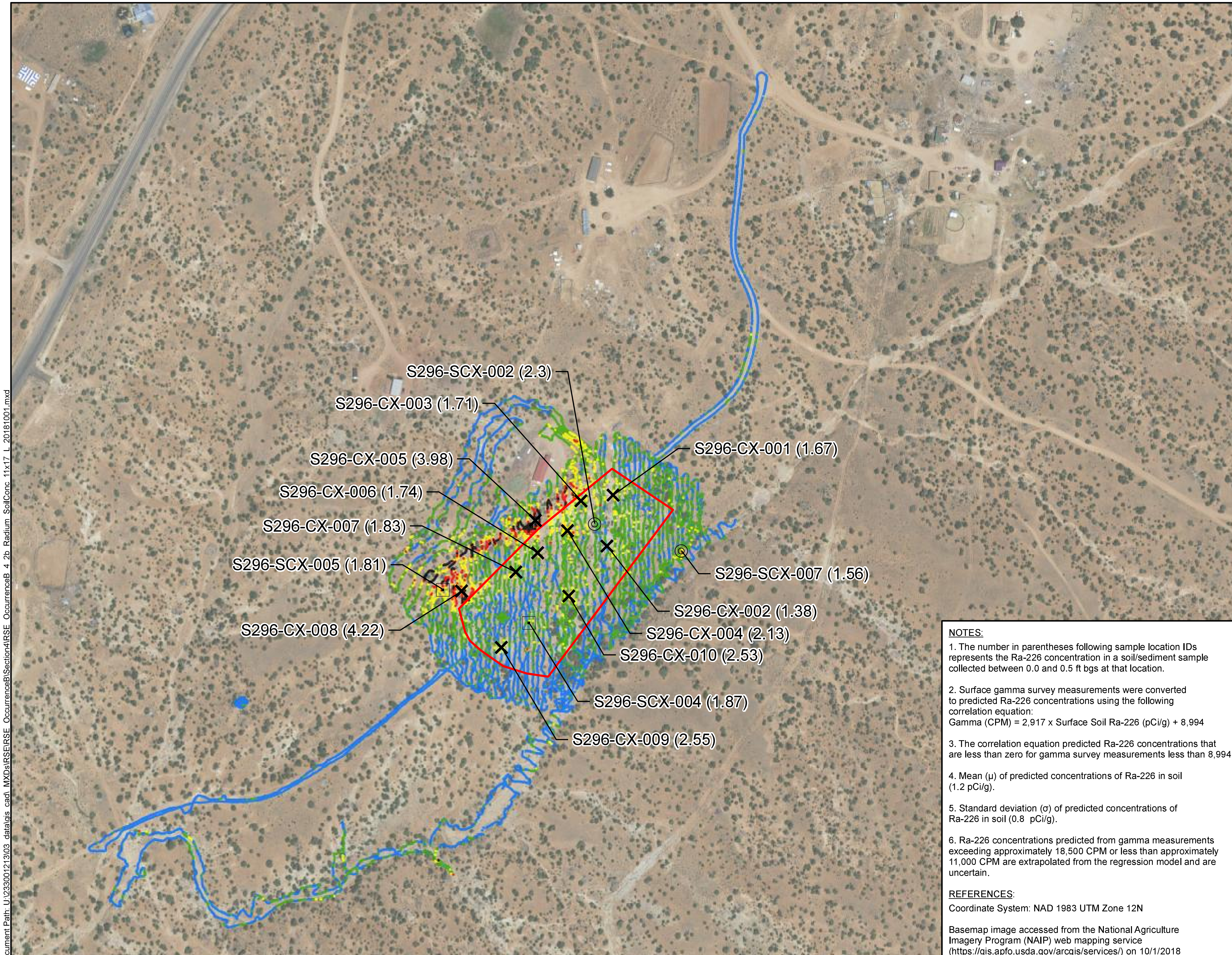
AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: 4-2a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\Section4\RSE_OccurrenceB_4_2a_Radium_11x17_L_20181001.mxd



NOTES:

1. The number in parentheses following sample location IDs represents the Ra-226 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) = 2,917 x Surface Soil Ra-226 (pCi/g) + 8,994

3. The correlation equation predicted Ra-226 concentrations that are less than zero for gamma survey measurements less than 8,994.

4. Mean (μ) of predicted concentrations of Ra-226 in soil (1.2 pCi/g).

5. Standard deviation (σ) of predicted concentrations of Ra-226 in soil (0.8 pCi/g).

6. Ra-226 concentrations predicted from gamma measurements exceeding approximately 18,500 CPM or less than approximately 11,000 CPM are extrapolated from the regression model and are uncertain.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 10/1/2018

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

Predicted Ra-226 Concentration[2] (pCi/g)

- Less than 0[3]
- 0 - 1.2 (μ)[4]
- 1.3 - 2.0 (μ + 1σ[5])
- 2.1 - 2.8 (μ + 2σ)
- 2.9 - 3.6 (μ + 3σ)
- 3.7 - 13.5

N
W E
S

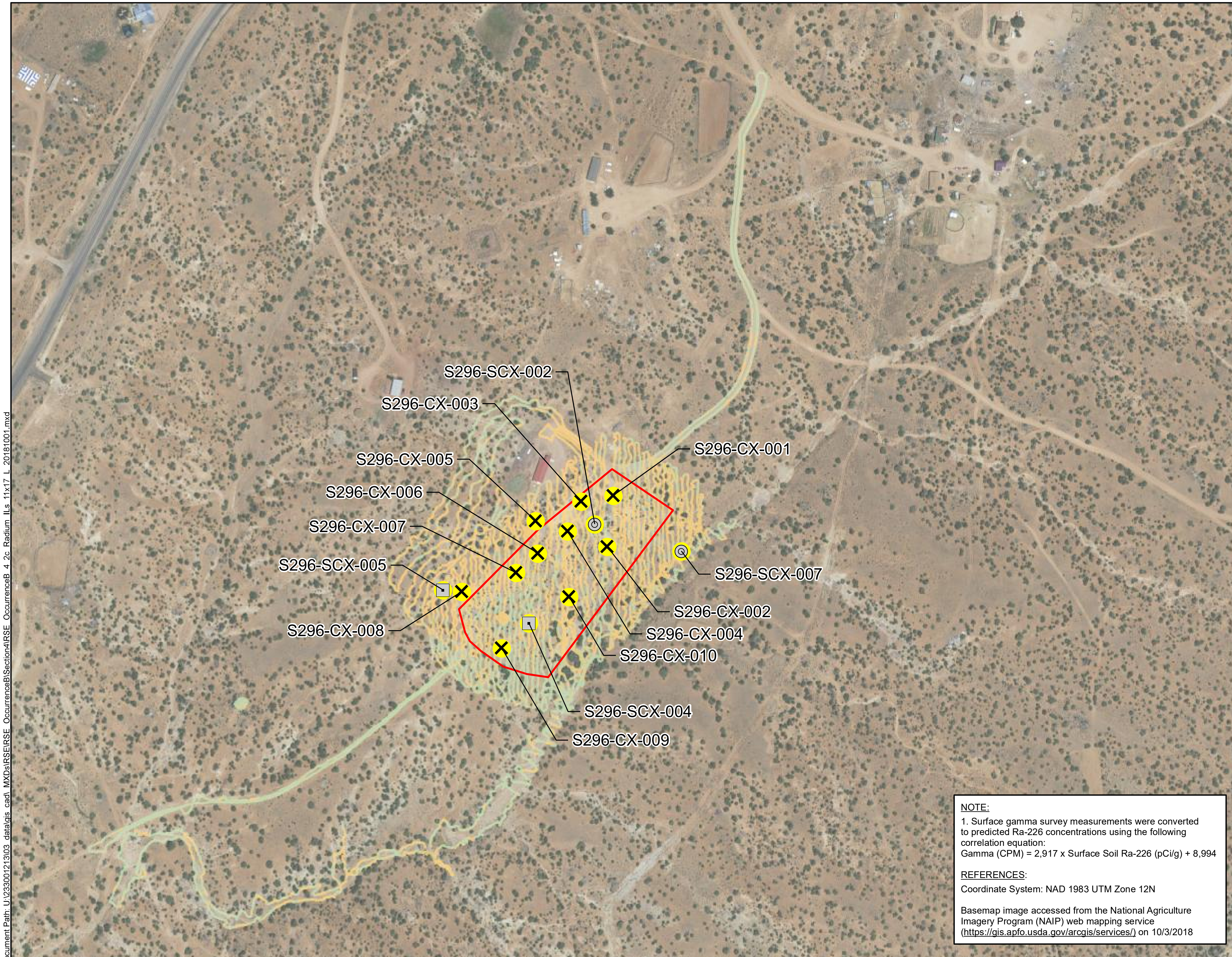
0 300 600
Feet

TITLE:
Predicted Ra-226 Concentrations in Soil Compared to Ra-226 Concentrations in Soil/Sediment

PROJECT:
Removal Site Evaluation Occurrence B Mine Site

DATE: 10/1/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EDZ
	FIGURE: 4-2b	

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE\RSE OccurrenceB\Section4\RSE OccurrenceB 4 2b Radium SoilConc 11x17 L 20181001.mxd



NOTE:
1. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
Gamma (CPM) = 2,917 x Surface Soil Ra-226 (pCi/g) + 8,994

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 10/3/2018

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

Predicted Ra-226 Concentration (pCi/g)

- IL Not Exceeded Survey Area: -0.4 - 1.1
- IL Exceeded Survey Area: 1.2 - 13.5

N W E S

0 300 600
Feet

TITLE:
Predicted Ra-226 Concentrations in Soil Compared to Ra-226 ILs

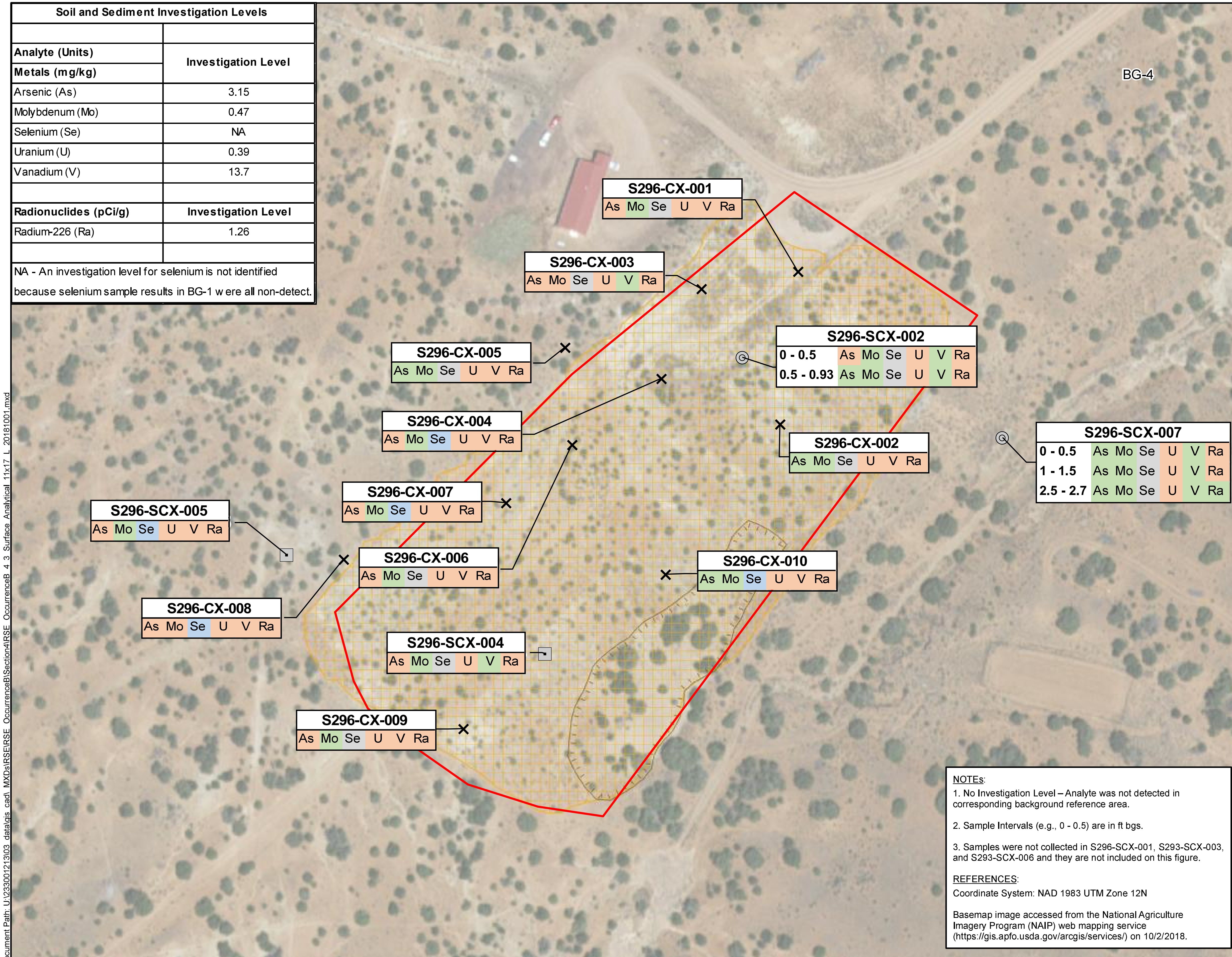
PROJECT:
Removal Site Evaluation
Occurrence B Mine Site

DATE: 10/3/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EDZ
	FIGURE: 4-2c	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\Section4\RSE_OccurrenceB_4_2c_Radium_ILs_11x17_L_20181001.mxd

Soil and Sediment Investigation Levels	
Analyte (Units)	Investigation Level
Metals (mg/kg)	
Arsenic (As)	3.15
Molybdenum (Mo)	0.47
Selenium (Se)	NA
Uranium (U)	0.39
Vanadium (V)	13.7
Radionuclides (pCi/g)	Investigation Level
Radium-226 (Ra)	1.26

NA - An investigation level for selenium is not identified because selenium sample results in BG-1 were all non-detect.



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Potenially Impacted Area
- Topographic Depression
- Claim Boundary
- Investigation Level Not Exceeded
- Investigation Level Exceeded
- Analyte Detected - No Investigation Level
- Non-detect - No Investigation Level

N W E S

0 100 200
Feet

NOTEs:

1. No Investigation Level – Analyte was not detected in corresponding background reference area.
2. Sample Intervals (e.g., 0 - 0.5) are in ft bgs.
3. Samples were not collected in S296-SCX-001, S293-SCX-003, and S293-SCX-006 and they are not included on this figure.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

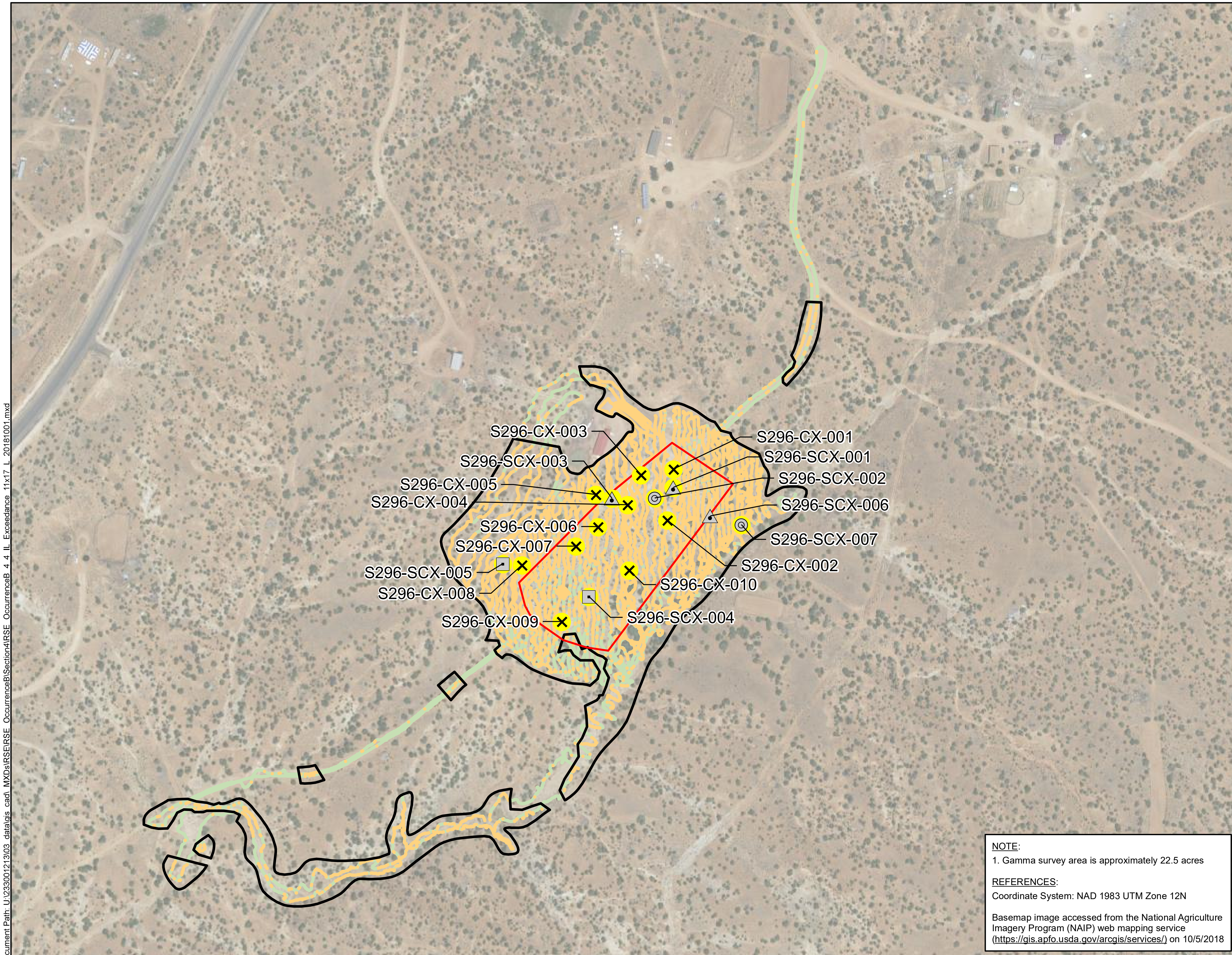
Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 10/2/2018.

TITLE: Surface and Subsurface Metals and Ra-226 Analytical Results

PROJECT: Removal Site Evaluation Occurrence B Mine Site

DATE:	DOCUMENT NAME:	
10/2/2018	Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EDZ
	FIGURE: 4-3	

Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_OccurrenceB\Section4\RSE_OccurrenceB_4_3_Surface_Analytical_11x17_L_20181001.mxd



NOTE:
1. Gamma survey area is approximately 22.5 acres

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 10/5/2018

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Borehole Location - Static Gamma Data Only
- IL Exceedance in Unconsolidated Material at Location
- Claim Boundary
- Approximate Area where Surface Gamma IL is Exceeded (17.9 acres)

Gamma Survey[1]
Counts per Minute (CPM)
- 7,910 - 11,649 (IL Not Exceeded; 4.6 acres)
- 11,650 - 48,436 (IL Exceeded; 17.9 acres)

N W E S

0 300 600
Feet

TITLE:
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation
Occurrence B Mine Site

DATE: 10/5/2018

DOCUMENT NAME: Removal Site Evaluation Report

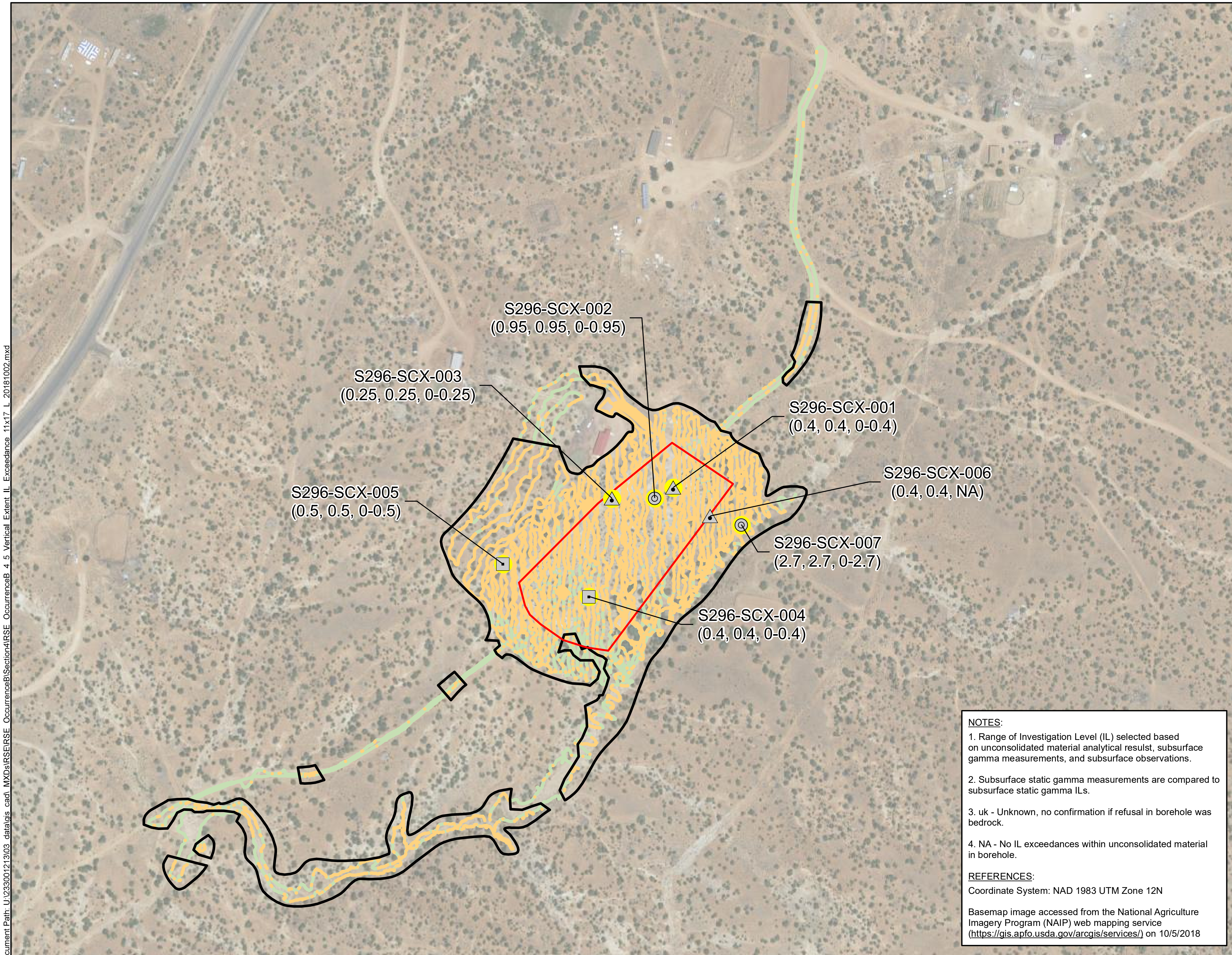
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-4

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\Section4\RSE_OccurrenceB_4_4_IL_Exceedance_11x17_L_20181001.mxd



NOTES:

1. Range of Investigation Level (IL) selected based on unconsolidated material analytical resulst, subsurface gamma measurements, and subsurface observations.

2. Subsurface static gamma measurements are compared to subsurface static gamma ILs.

3. uk - Unknown, no confirmation if refusal in borehole was bedrock.

4. NA - No IL exceedances within unconsolidated material in borehole.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 10/5/2018

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Borehole Location - Surface and Subsurface Samples (Depth of Bedrock, Borehole Depth, Depth Range of IL Exceedance in Unconsolidated Material)[1]
- Borehole Location - Surface Samples Only (Depth of Bedrock, Borehole Depth, Depth Range of IL Exceedance in Unconsolidated Material)[1]
- Borehole Location - Static Gamma Data Only (Depth of Bedrock, Borehole Depth, Depth Range of IL Exceedance in Unconsolidated Material)[1]
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma IL is Exceeded (17.9 acres)
- Claim Boundary

Gamma Survey[1]

Counts per Minute (CPM)

- 7,910 - 11,649 (IL Not Exceeded; 4.6 acres)
- 11,650 - 48,436 (IL Exceeded; 17.9 acres)

N
W E
S

0 300 600
Feet

TITLE:

Vertical Extent of IL Exceedances in Unconsolidated Material

PROJECT:

Removal Site Evaluation
Occurrence B Mine Site

DATE: 10/5/2018

DOCUMENT NAME: Removal Site Evaluation Report

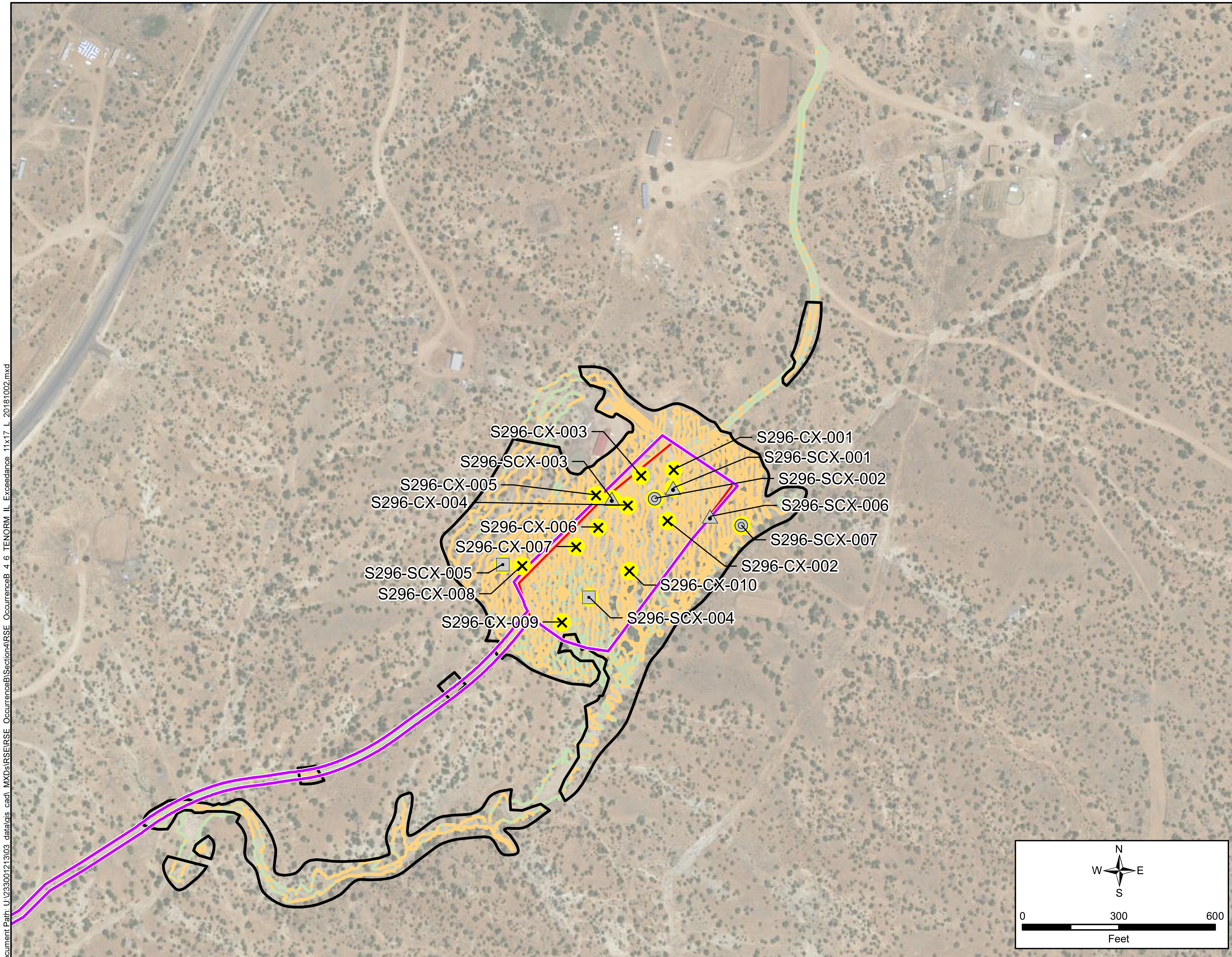
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-5

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\Section4\RSE_OccurrenceB_4_5_Vertical_Extent_IL_Exceedance_11x17_L_20181002.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Borehole Location - Static Gamma Data Only
- IL Exceedance in Unconsolidated Material at Location
- TENORM (6.2 acres)
- Approximate Area where Surface Gamma IL is Exceeded (17.9 acres)
- Claim Boundary

Gamma Survey[1]

Counts per Minute (CPM)

- 7,910 - 11,649 (IL Not Exceeded; 4.6 acres)
- 11,650 - 48,436 (IL Exceeded; 17.9 acres)

NOTE:
1. Gamma survey area is approximately 22.5 acres

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

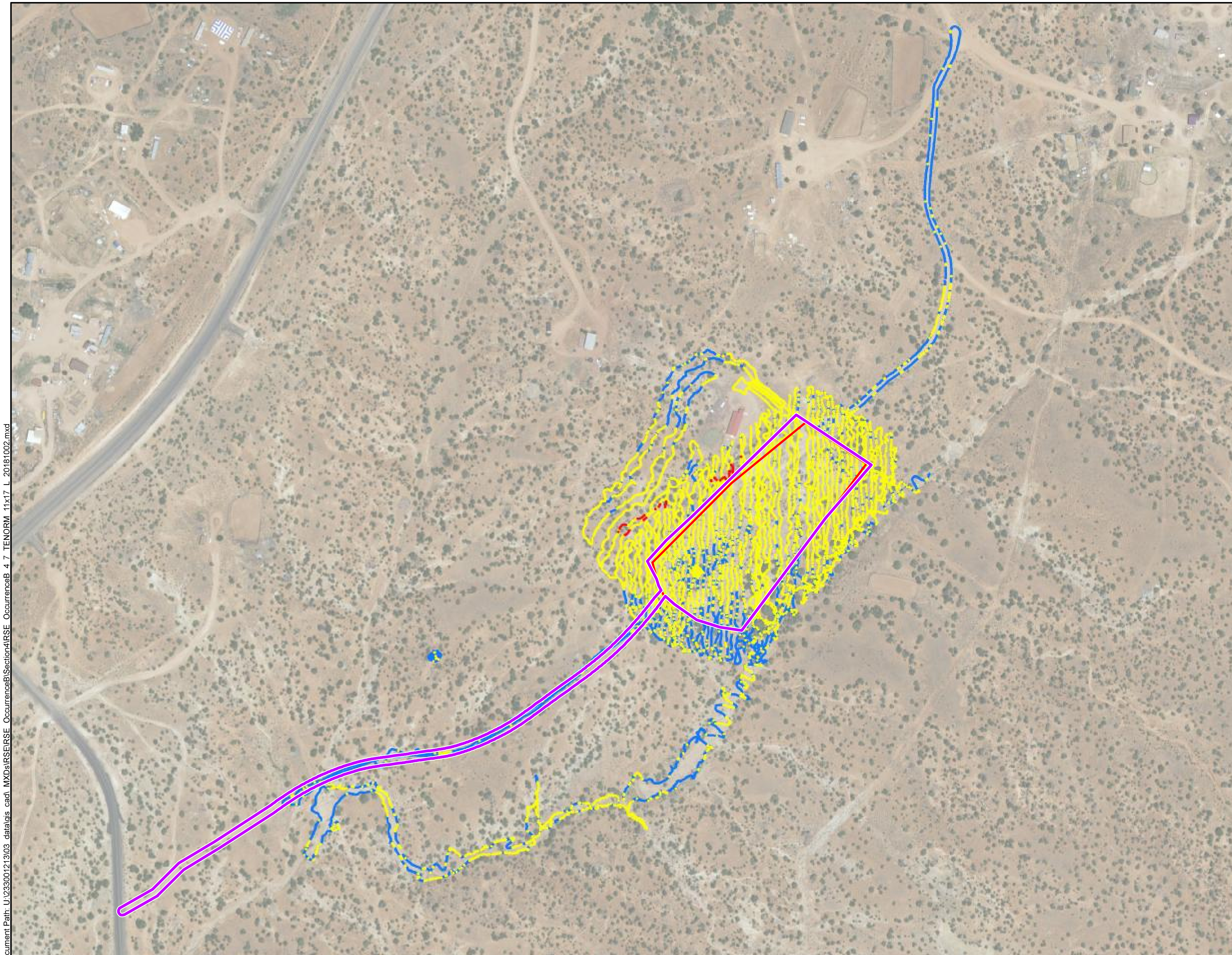
Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 10/5/2018.

TITLE:
TENORM Compared to Lateral Extent of IL Exceedances

PROJECT:
Removal Site Evaluation
Occurrence B Mine Site

DATE: 10/5/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EDZ
	FIGURE: 4-6	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\Section4\RSE_OccurrenceB_4_6_TENORM_IL_Exceedance_11x17_L_20181002.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- TENORM (6.2 acres)
- Claim Boundary

Gamma Survey
Counts per Minute (CPM)
- 7,910 - 11,649 (Minimum to BG-1 IL)
- 11,650 - 23,298 (>BG-1 IL to 2x BG-1 IL)
- 23,299 - 48,436 (>2x BG-1 IL to Maximum)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 10/2/2018.

N W E S

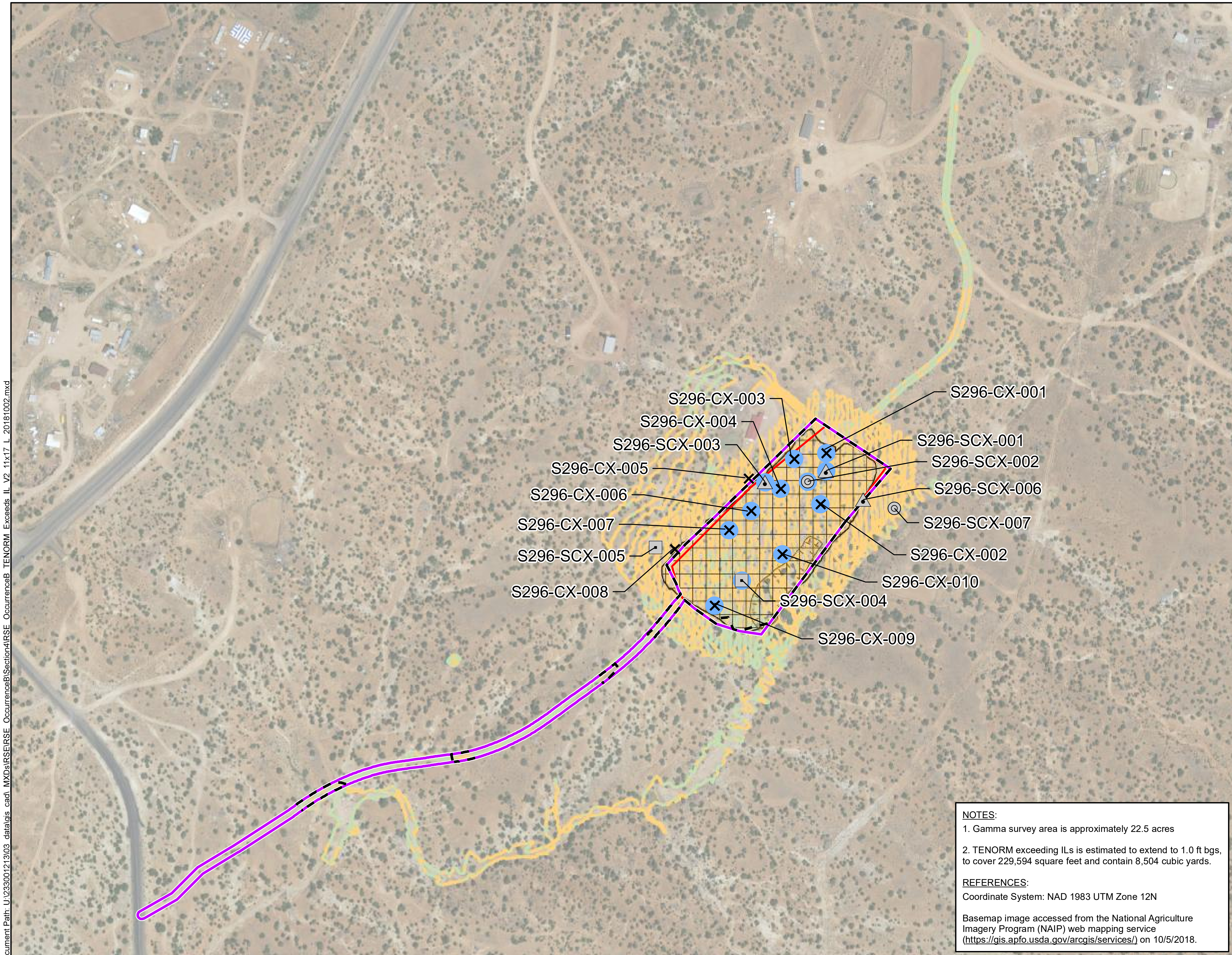
0 300 600
Feet

TITLE:
Area that Contains TENORM Compared to Gamma Radiation Survey Results

PROJECT:
Removal Site Evaluation
Occurrence B Mine Site

DATE: 10/2/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: CBB / REVIEWER: EDZ
	FIGURE: 4-7

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\Section4\RSE_OccurrenceB_4_7_TENORM_11x17_L_20181002.mxd



NOTES:
1. Gamma survey area is approximately 22.5 acres

2. TENORM exceeding ILs is estimated to extend to 1.0 ft bgs, to cover 229,594 square feet and contain 8,504 cubic yards.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 10/5/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Borehole Location - Static Gamma Data Only
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding ILs (5.3 acres)
- TENORM (6.2 acres)
- Potenially Impacted
- Topographic Depression
- Claim Boundary

Gamma Survey[1]
Counts per Minute (CPM)
- 7,910 - 11,649 (IL Not Exceeded; 4.6 acres)
- 11,650 - 48,436 (IL Exceeded; 17.9 acres)

N W E S

0 300 600
Feet

TITLE: TENORM that Exceeds ILs

PROJECT: Removal Site Evaluation Occurrence B Mine Site

DATE: 10/5/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-8

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\Section4\RSE_OccurrenceB_TENORM_Exceeds_IL_V2_11x17_L_20181002.mxd

APPENDICES

October 8, 2018

Appendix A Radiological Characterization of the Occurrence B Abandoned Uranium Mine

Radiological Characterization of the Occurrence B Abandoned Uranium Mine

September 18, 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

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Acronyms

AUM	abandoned uranium mine
BG1	Background Reference Area 1
bgs	below ground surface
cpm	counts per minute
DQOs	data quality objectives
ERG	Environmental Restoration Group, Inc.
ft	foot
GPS	global positioning system
MDC	minimum detectable concentration
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 Occurrence B abandoned uranium mine (AUM) located in the Chinle Chapter of the Navajo Nation near Chinle, Arizona. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, as described in the 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) in accordance with 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 November 4 and 9, 2016. 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; and roads and drainages within a 0.25-mile radius of the 100-ft buffer; and correlation studies. The Survey Area was extended beyond the 100-ft buffer where elevated gamma count rates were observed.

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 "Occurrence B 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 observed along a ridge of bedrock off to the north end of the mine claim.
- One potential Background Reference Area was 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) = 2917 x [radium-226 (pCi/g)] + 8994

- The distribution of concentrations of radium-226 in surface soils predicted using this model is rightward tailed. The values in the Survey Area range from –0.4 to 13.5 pCi/g, with a central tendency (median) of 1.1 pCi/g.

- The thorium series radionuclides do not appear to affect predicted of concentrations of radium-226 from gamma count rates.

- There is evidence of equilibrium, but not secular equilibrium, among the uranium decay series radionuclides.

- The relationship between gamma count rates and exposure rates is described by a linear regression model:

$$\text{Exposure Rate } (\mu R/h) = \text{Gamma Count Rate (cpm)} \times 6 \times 10^{-4} + 6.8623$$

- The distribution of exposure rates predicted using this model is rightward tailed. The values in the Survey Area range from 11.6 to 35.9, with a central tendency (median) of 14.2 μR/h.

1.0 Introduction

This report addresses the radiological characterization of the Occurrence B abandoned uranium mine (AUM) located in the Chinle Chapter of the Navajo Nation near Chinle, Arizona. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, as described in the 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) in accordance with the Navajo Nation AUM Environmental Response Trust – First Phase.

The activities described here focus on the characterization of uranium series radionuclides in surface soils at the AUM. This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of gamma count rates to exposure rates and concentrations of radium-226 in surface soils, and 3) an assessment of equilibrium in the uranium decay series.

The objective of the correlation between field gamma count rate and surface soil concentrations of radium-226 was to use field instrumentation to predict surface soil concentrations of radium-226. The objective of the correlation between field gamma count rate and exposure rate was to use field instrumentation to predict exposure rates.

The field activities were conducted on November 4 and 9, 2016 in accordance with the methods described in the RSE Work Plan. The GPS-based radiological survey of land surfaces covered an approximately 22.5-acre Survey Area that included the mine claim area out to a 100-foot buffer; and roads and drainages within a 0.25-mile radius of the buffer; gamma count rate and exposure rate measurements at fixed points; and gamma count rate measurements and soil sampling for radionuclides (radium-226 and isotopic thorium) and metals in areas centered on these fixed points. The Survey Area was extended beyond the 100-ft buffer where elevated gamma count rates were observed. Section 3.0 of the RSE Work Plan provides the data quality objectives (DQOs) for the project.

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 “Occurrence B Removal Site Evaluation Report” (Stantec, 2018). Figure 1 shows the location of the AUM. Background information that is pertinent to the characterization of this AUM is presented in the “Occurrence B Removal Site Evaluation Report” (Stantec, 2018).

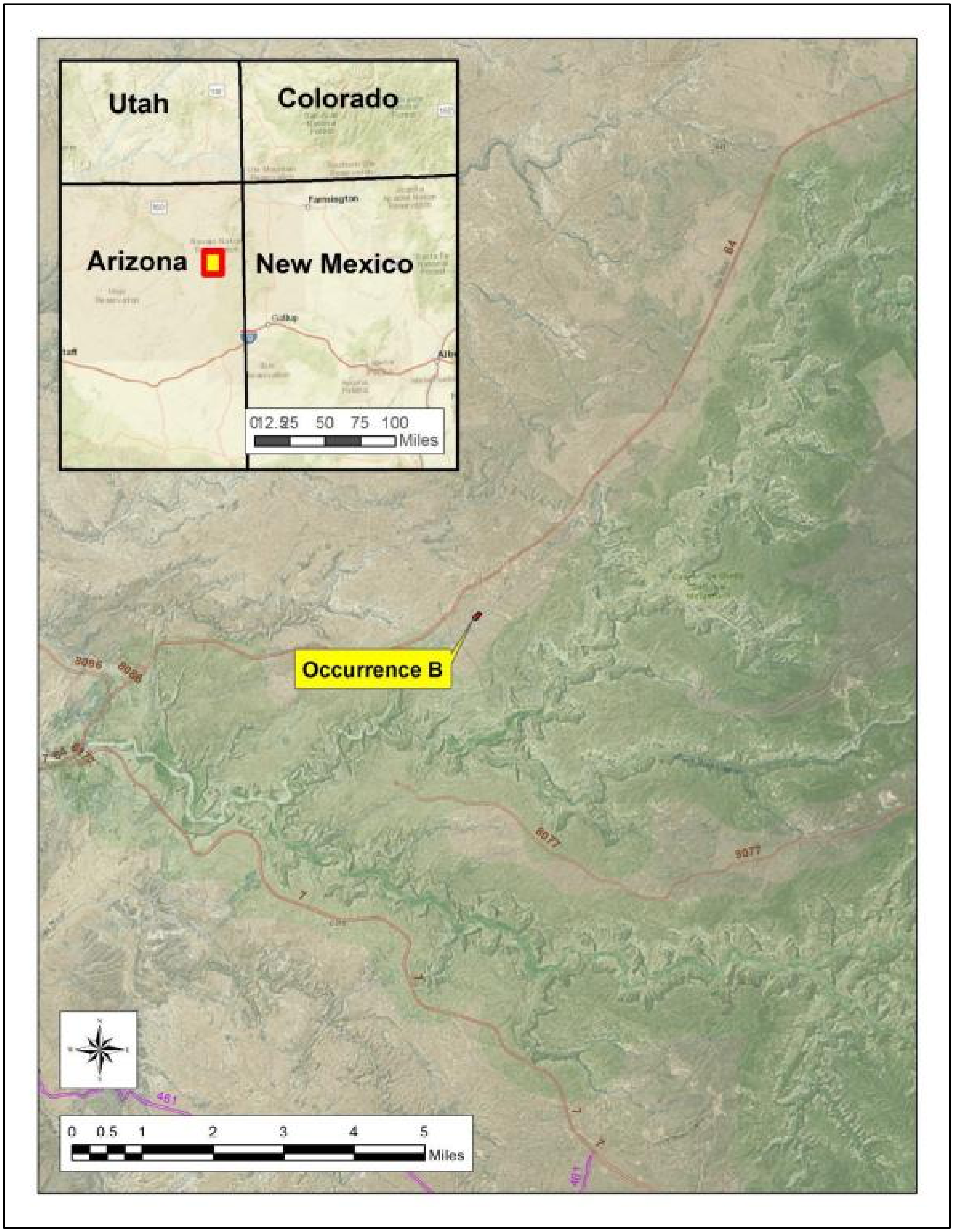


Figure 1. Location of the Occurrence B Abandoned Uranium Mine.

2.0 GPS-Based Gamma Surveys

This section addresses the GPS-based surveys conducted in one potential Background Reference Area 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 Work Plan, detectors were function checked each day to ensure the instruments were stable to the limits prescribed by the Work Plan. Detector normalization was not performed as it was not addressed by the RSE Work Plan. 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 Work Plan and are provided in Appendix E therein. ERG followed the quality assurance and control requirements stipulated in the approved Work Plan.

The 2x2 sodium iodide (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. 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 44-10	Ludlum Model 2221 Ratemeter/Scaler
Potential Background Reference Area	PR303727[a]	254772[a]
Survey Area	PR303727	254772
	PR295014	196086
	PR154615	138368
	PR150507	282966

Notes:
a. Detection system used in the correlation studies described in Section 3.0.

2.1 Potential Background Reference Area

A potential Background Reference Area was surveyed, the location and results of which are depicted on Figure 2. BG1 in the figure is Background Reference Area 1.

Table 2 lists a summary of the gamma count rates in BG1, which range from 9,405 to 13,860 counts per minute (cpm), with a mean and median of 10,436 and 10,298 cpm, respectively.

Figure 3 depicts a histogram of the gamma count rates. 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 Area.

	Gamma Count Rate (cpm)				
n	Min	Max	Mean	Median	Standard Deviation
156	9,405	13,860	10,436	10,298	651

Notes:
cpm = counts per minute

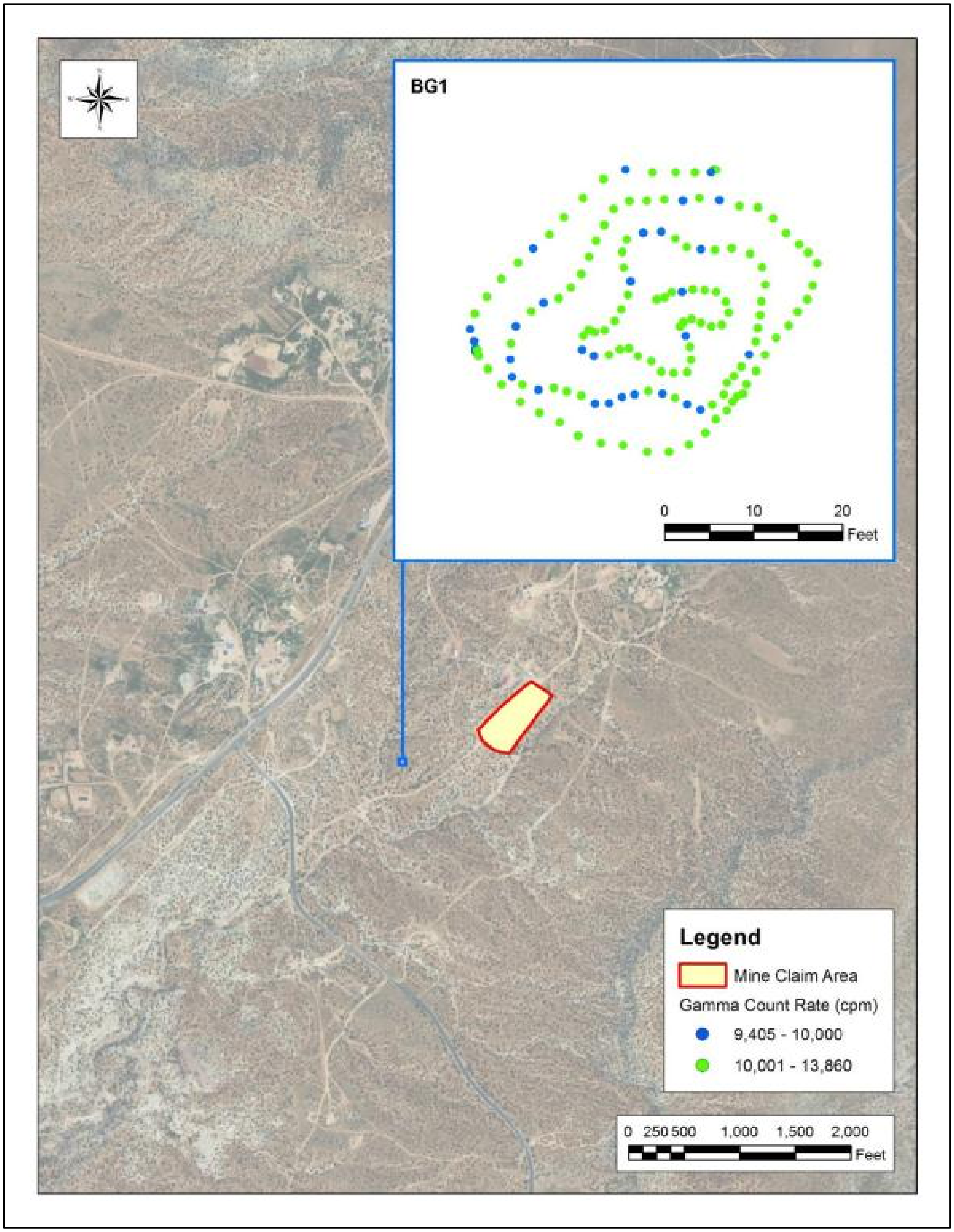


Figure 2. Gamma count rates in the potential Background Reference Area.

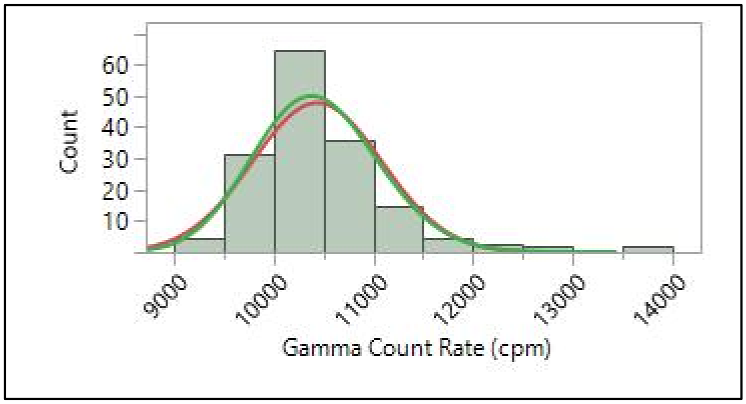


Figure 3. Histogram of gamma count rates in the potential Background Reference Area.

2.2 Survey Area

The gamma count rates observed in the Survey Area are depicted in Figure 4. The highest count rates were observed along a ridge of bedrock off to the north end of the mine claim.

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, 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 11,254, 12,238, and 13,399 cpm, respectively.

Table 3 is a statistical summary of the measurements, which range from 7,910 to 48,436 cpm and have a central tendency (median) of 12,238 cpm.

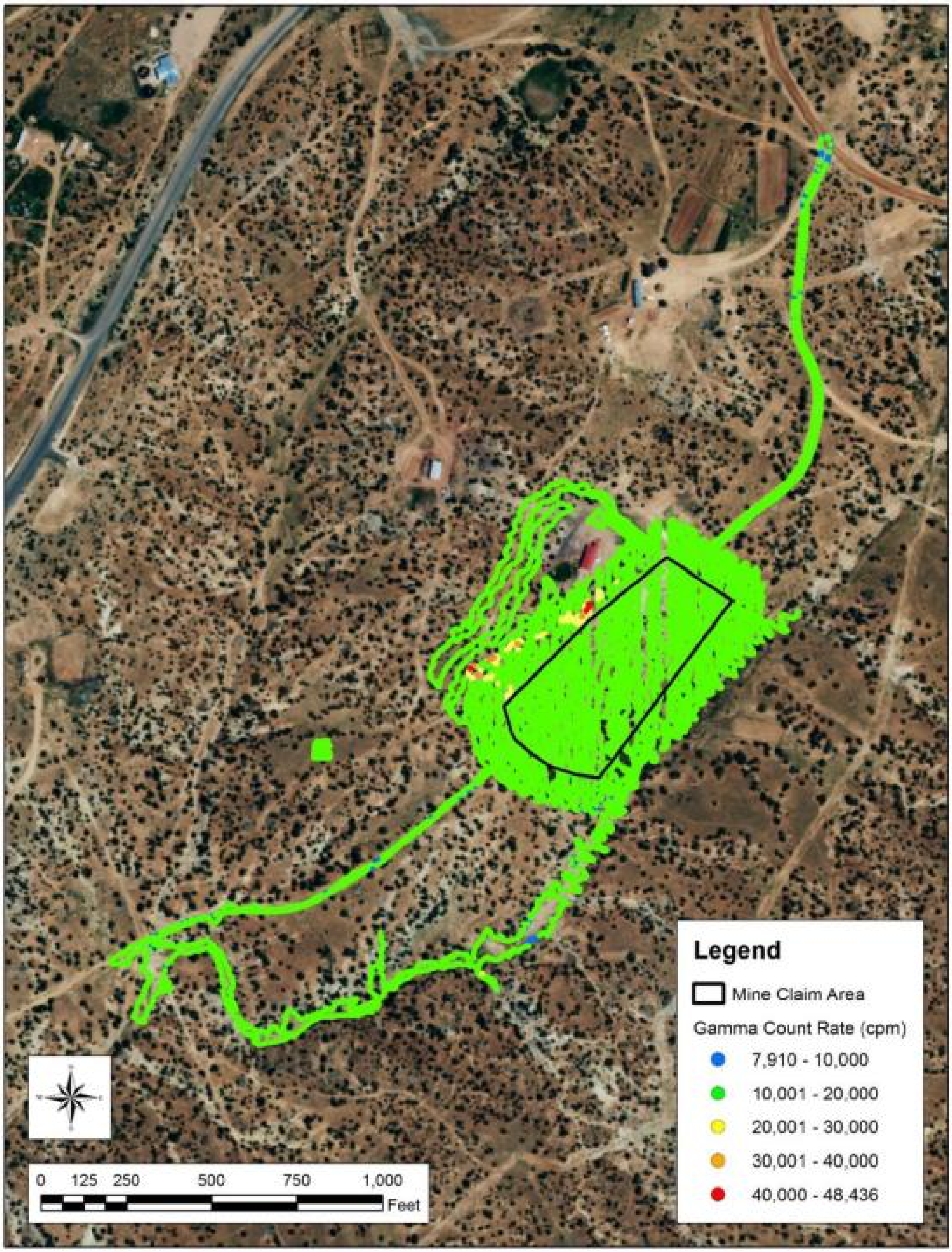


Figure 4. Gamma count rates in the Survey Area.

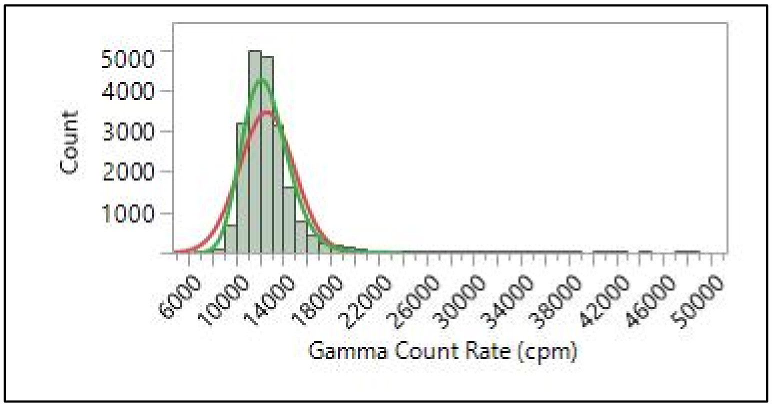


Figure 5. Histogram of gamma count rates in the Survey Area.

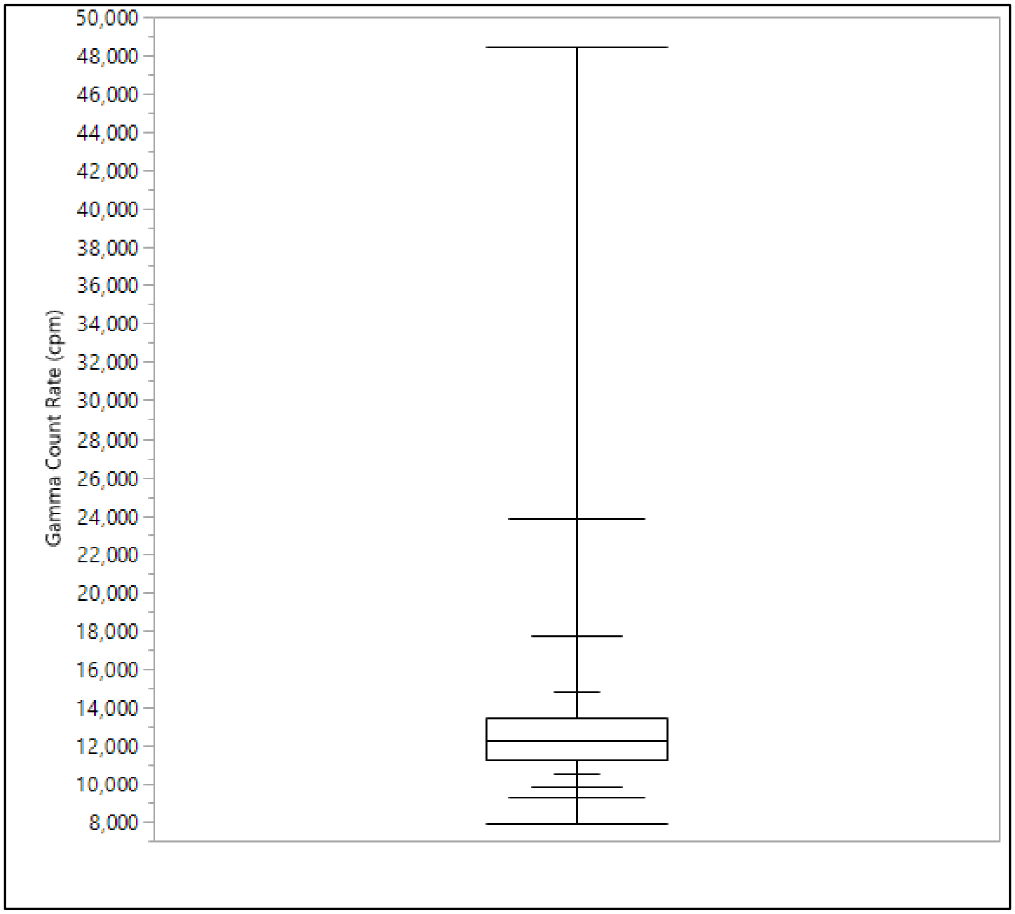


Figure 6. Box plot of gamma count rates in the Survey Area.

Table 3. Summary statistics for gamma count rates in the Survey Area.

Parameter	Gamma Count Rate (cpm)
n	20,123
Minimum	7,910
Maximum	48,436
Mean	12,611
Median	12,238
Standard Deviation	2,314

Notes:
cpm = counts per minute

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 and thorium concentrations in surface soils and gamma count rates

On November 9, 2016 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 AUM. These areas were selected using criteria established in the RSE Work Plan. No DQO was established for homogeneity of the correlation plots and as described in Section 4.3 and Appendix E of the RSE Work Plan, homogeneity of the correlation plots was evaluated qualitatively. Sub-samples were collected from the correlation plot centroid and at each corner of the plot. The activities were performed contemporaneously, by area and all on the same day, such that the two could be compared. 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 Fort 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. Table 4 lists the results of the measurements and radium-226 concentrations in the soil samples. The means of the gamma count rate measurements range from 11,090 to 18,497 cpm. The concentrations of radium-226 range from 0.85 to 2.88 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 “Occurrence B Removal Site Evaluation Report” (Stantec, 2018).

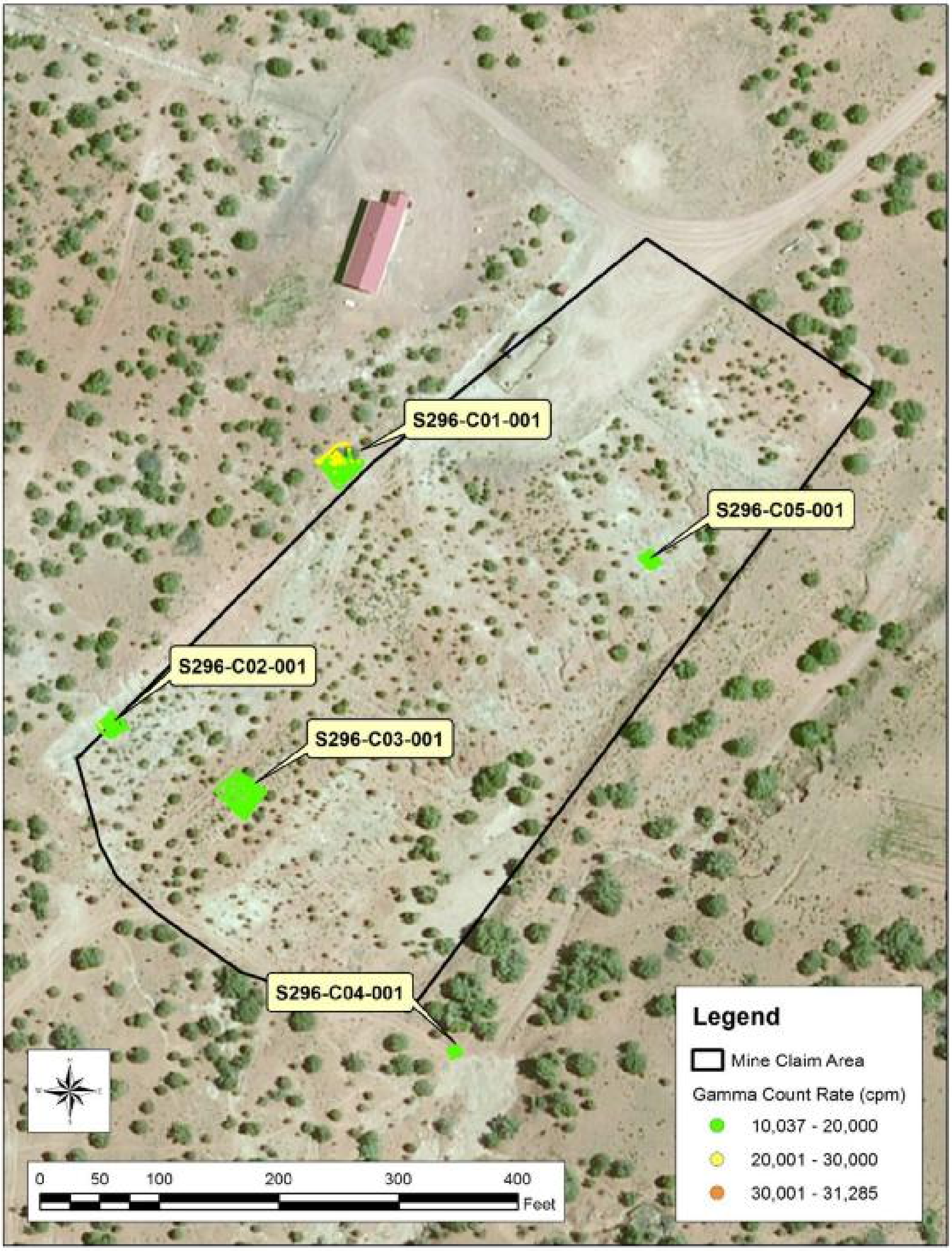


Figure 7. GPS-based gamma count rate measurements made for the correlation study.

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	Area (m^2)	Mean	Minimum	Maximum	σ	Result	Error ±2σ	MDC
S296-C01-001	93.9	18,497	15,289	31,285	2,262	2.75	0.46	0.5
S296-C02-001	41.2	15,874	13,564	20,113	1,402	2.88	0.47	0.45
S296-C03-001	101.5	12,065	10,433	14,149	704	1.07	0.27	0.41
S296-C04-001	9.5	11,090	10,037	13,204	557	0.85	0.23	0.4
S296-C05-001	23.8	13,697	12,021	16,101	836	1.45	0.34	0.48

Notes:
cpm = counts per minute
MDC = minimum detectable concentration
m^2 =square meters
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			Thorium-230			Thorium-232		
Sample ID	Result	Error ± 2 σ	MDC	Result	Error ± 2 σ	MDC	Result	Error ± 2 σ	MDC
S296-C01-001	1.11	0.19	0.04	2.52	0.41	0.07	1.09	0.19	0.02
S296-C02-001	1.31	0.23	0.04	2.52	0.41	0.07	1.24	0.21	0.02
S296-C03-001	0.79	0.15	0.05	0.82	0.16	0.08	0.73	0.14	0.02
S296-C04-001	0.77	0.14	0.03	0.74	0.14	0.07	0.72	0.13	0.0
S296-C05-001	1.27	0.22	0.05	1.05	0.19	0.07	1.25	0.22	0.02

Notes:
MDC = minimum detectable concentration
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 mean relationship between the measurements, shown in Figure 8, is a linear function with an adjusted Pearson's Correlation Coefficient (adjusted R^2) of 0.82, as expressed in the equation:

Gamma Count Rate (cpm) = 2917 x [radium-226 (pCi/g)] + 8994

The root mean square error and p-value for the model are 1.3×10^3 and 0.023, respectively; these parameters are not data quality objectives (DQOs) and are included only as information. The R^2 value for this model exceeds the project DQO of 0.8.

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 -0.4 to 13.5 pCi/g, with a mean and median of 1.2 and 1.1 pCi/g, respectively. While the gamma correlation equation can be used to convert gamma count rates to concentrations of Ra-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.

Figure 9 shows the predicted concentrations of radium-226, the spatial and numerical distribution of which mirror those depicted in Figure 4.

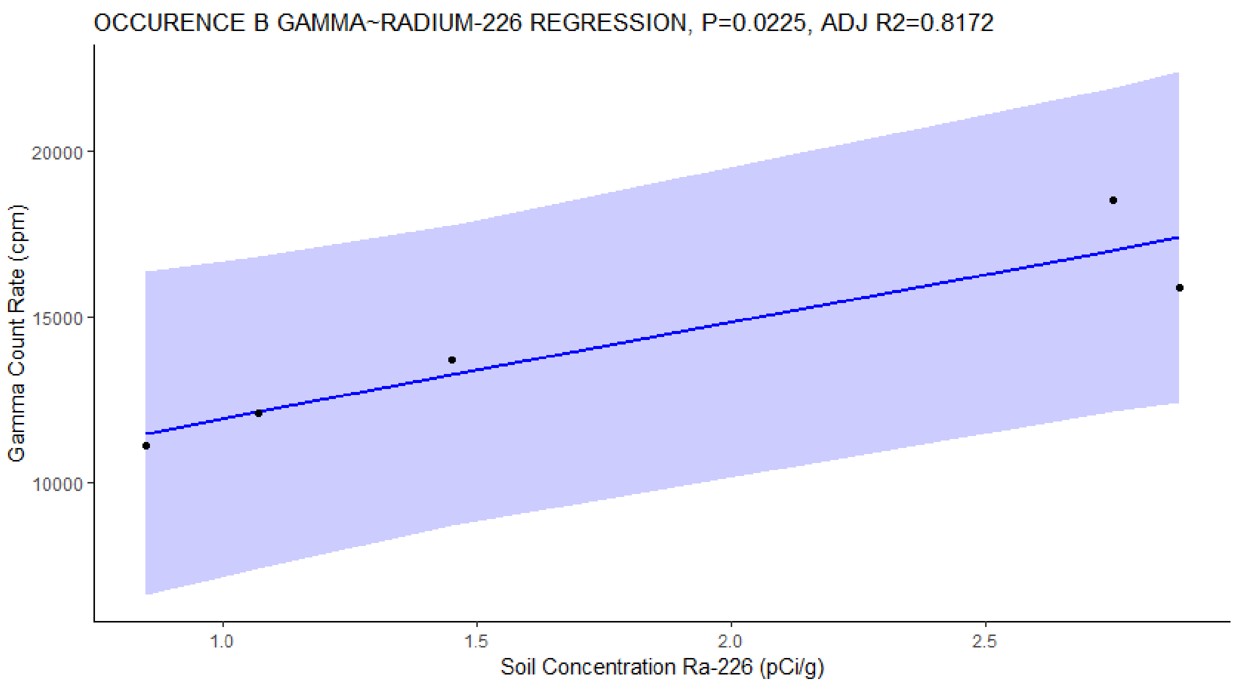


Figure 8. Correlation of gamma count rates and concentrations of radium-226 in surface soils (blue line) and 95% prediction intervals plotted (shaded band).

Table 6. Predicted concentrations of radium-226 in the Survey Area.

Parameter	Radium-226 (pCi/g)
n	20,123
Minimum	-0.4
Maximum	13.5
Mean	1.2
Median	1.1
Standard Deviation	0.8

Notes:
pCi/g = picocuries per gram

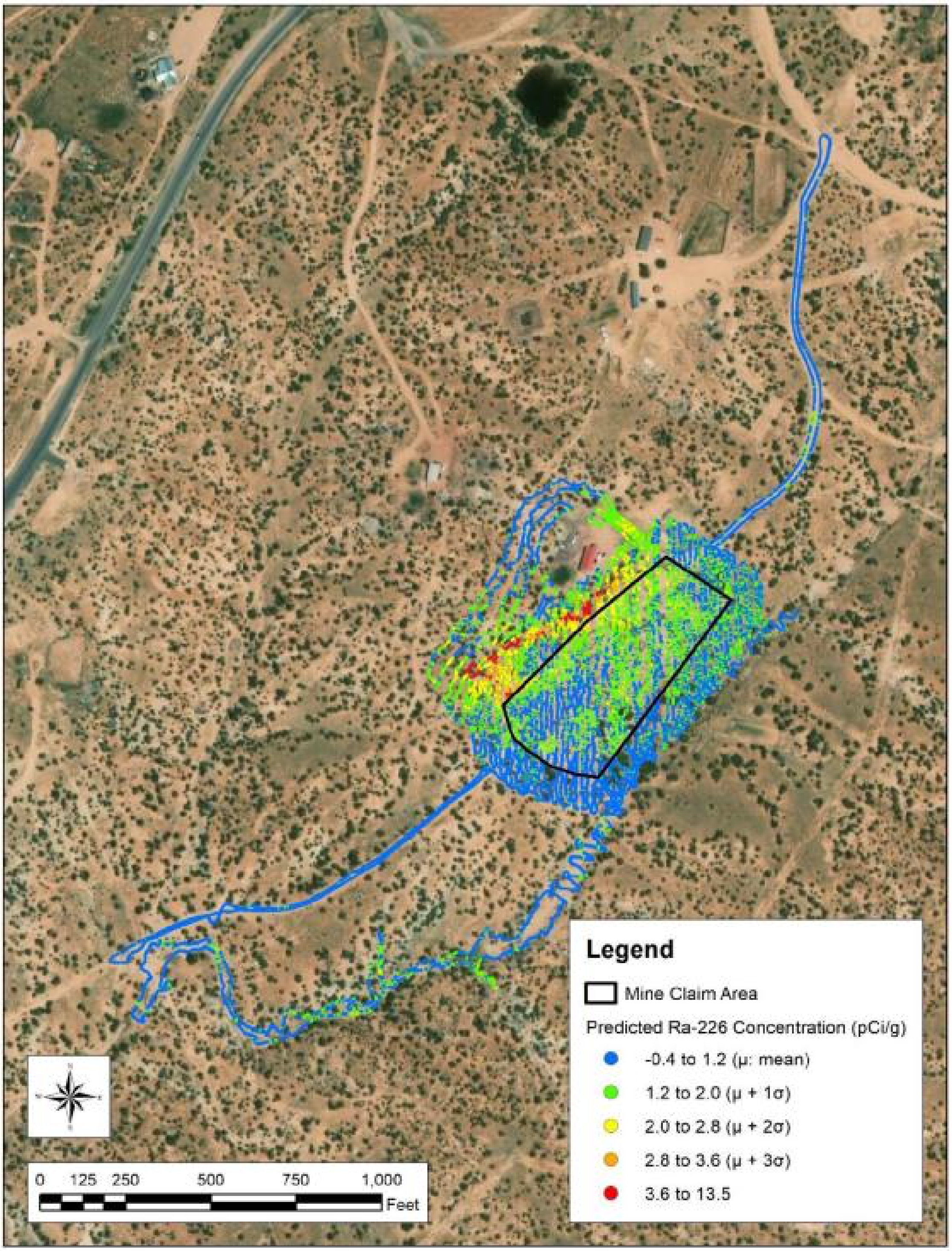


Figure 9. Predicted concentrations of radium-226 in the Survey Area.

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 Work Plan. 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 (0.13 and 0.99 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 0.22 with an adjusted R^2 of 0.26. The thorium-232 coefficient is not significant ($p > 0.05$) and the R^2 value does not meet the project DQO. Subsequently we conclude that thorium-232 and thorium-228 concentrations in soil are not significant predictors of gamma count rate. Finally, the p-value for radium-226 as a predictor of gamma count rate was significant ($p = 0.023$), as described above, and the adjusted R^2 value (0.82) met the applicable project DQO ($R^2 > 0.8$).

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.

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 Work Plan 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 thorium-230 and radium-226 was conducted. The RSE Work Plan did not require an evaluation of equilibrium condition of uranium-238 and uranium-234 because the natural activity abundance for these isotopes is expected and therefore assumed. Likewise, thorium-234 and protactinium-234m were not evaluated since their half-lives are sufficiently short that secular equilibrium can be assumed. Uranium-235 is not in the uranium-238 decay series therefore it wasn't evaluated. The ratio of thorium-230 to radium-226 can be evaluated even though different analytical 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 results

The 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 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).

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.

   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.

Based on this method, ERG concludes that there is evidence of equilibrium, but not secular equilibrium, among the uranium decay series radionuclides (Figure 10).

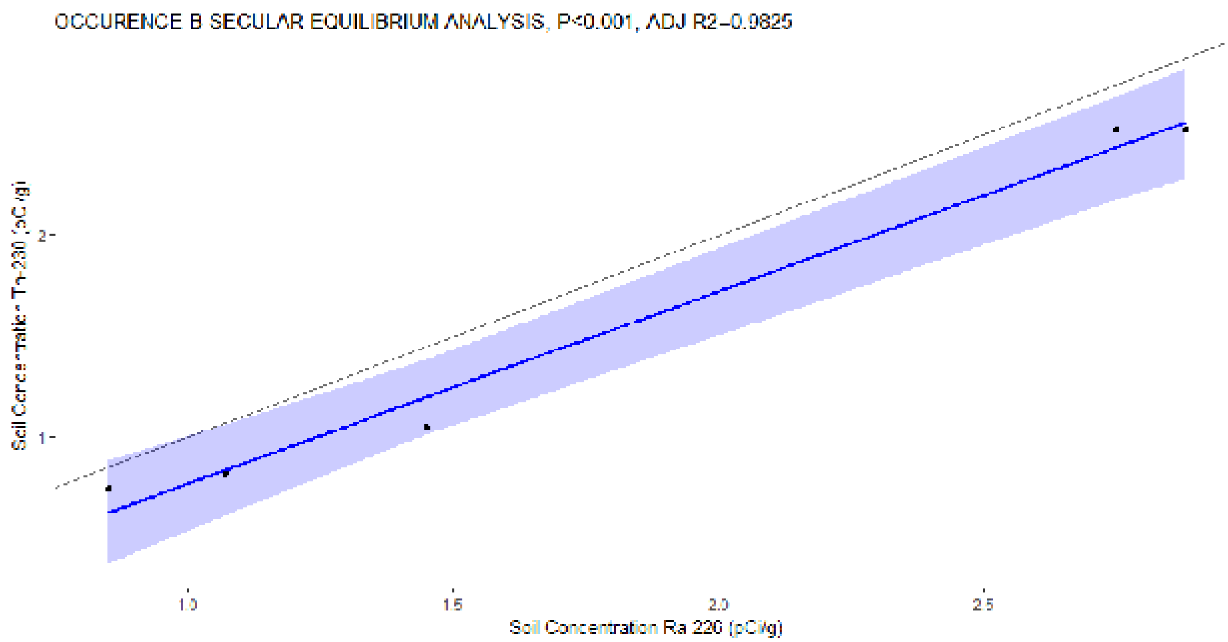


Figure 10. Evaluation of secular equilibrium in the uranium decay series.

3.3 Exposure rates and gamma count rates

Field personnel made co-located one-minute static count rate and exposure rate measurements at the 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 on November 9, 2016 at 0.5 m and 1 m above the ground surface, respectively. The gamma count rate measurements were made using one of the four sodium iodide detection systems used in the GPS-based gamma survey of the Survey Area

(Serial Number PR303727/254772). The exposure rate measurements were made using a Reuter Stokes Model RSS-131 high pressure ionization chamber (HPIC) at six-second intervals for about 10 minutes. The exposure rate used in the comparison was the mean of these measurements, less those occurring in initial instrument spikes. The HPIC was in current calibration and function checked before and after use. A correction factor of 1.02 was applied to the measured value per the manufacturer's recommendation by the software of the unit. 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 individual (one second) exposure rate measurements.

The best predictive relationship between the measurements is linear with a R^2 of 0.9504, strongly indicating a correlation. The root mean square error and p-value for the correlation are 0.439 and 0.0048, respectively; these parameters are not DQOs and are included only as information.

The following equation is the linear regression (shown in **Figure 11**) between the mean exposure rate and gamma count rate results in Table 7 that was generated using MS Excel:

$$\text{Exposure Rate } (\mu R/h) = 6 \times 10^{-4} \times \text{Gamma Count Rate (cpm)} + 6.8623$$

Figure 12 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 potential Background Reference Area and Survey Area, respectively. The range of predicted exposure rates at BG1 is 12.5 to 15.2 µR/h, with a mean and median of 13.1 and 13.0 µR/h, respectively. The range of predicted exposure rates in the Survey Area is 11.6 to 35.9 µR/h, with a mean and median of 14.4 and 14.2 µR/h, respectively.

Table 7. Co-located gamma count rate and exposure rate measurements.

Location	Gamma Count Rate[a] (cpm)	Exposure Rate (µR/h)
S296-C01-001	18,413	16.8
S296-C02-001	15,966	16.4
S296-C03-001	11,973	13.3
S296-C04-001	11,134	13.1
S296-C05-001	13,974	14.8

Notes:
[a]The gamma count rate is a one-minute, static measurement made at the center of the plot
cpm = counts per minute
µR/h = microRoentgens per hour

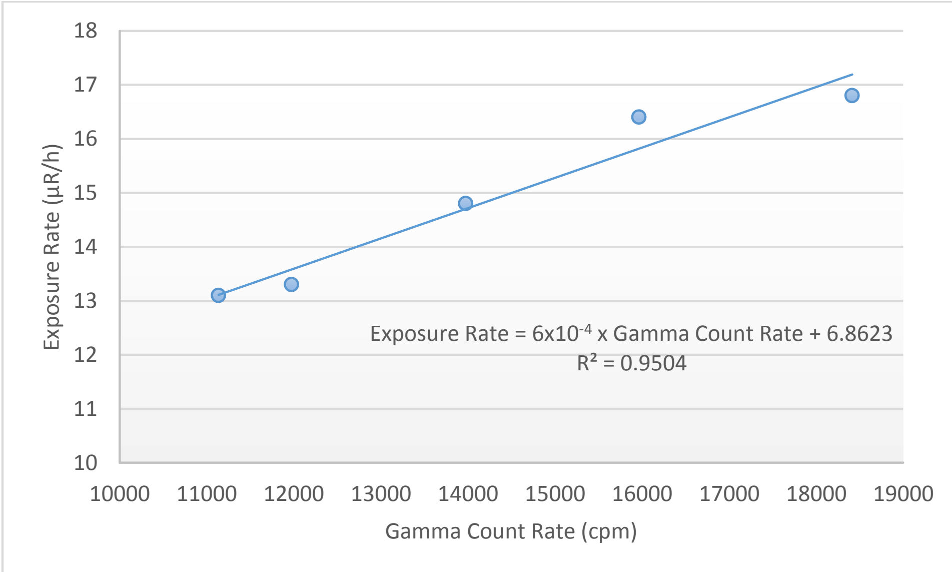


Figure 11. Correlation of gamma count rates and exposure rates.

Table 8. Predicted exposure rates in the potential Background Reference Area.

Parameter	Exposure Rate (µR/h)
n	156
Minimum	12.5
Maximum	15.2
Mean	13.1
Median	13.0
Standard Deviation	0.4

Notes:
µR/h = microRoentgens per hour

Table 9. Predicted exposure rates in the Survey Area.

Parameter	Exposure Rate (µR/h)
n	20,123
Minimum	11.6
Maximum	35.9
Mean	14.4
Median	14.2
Standard Deviation	1.4

Notes:
µR/h = microRoentgens per hour

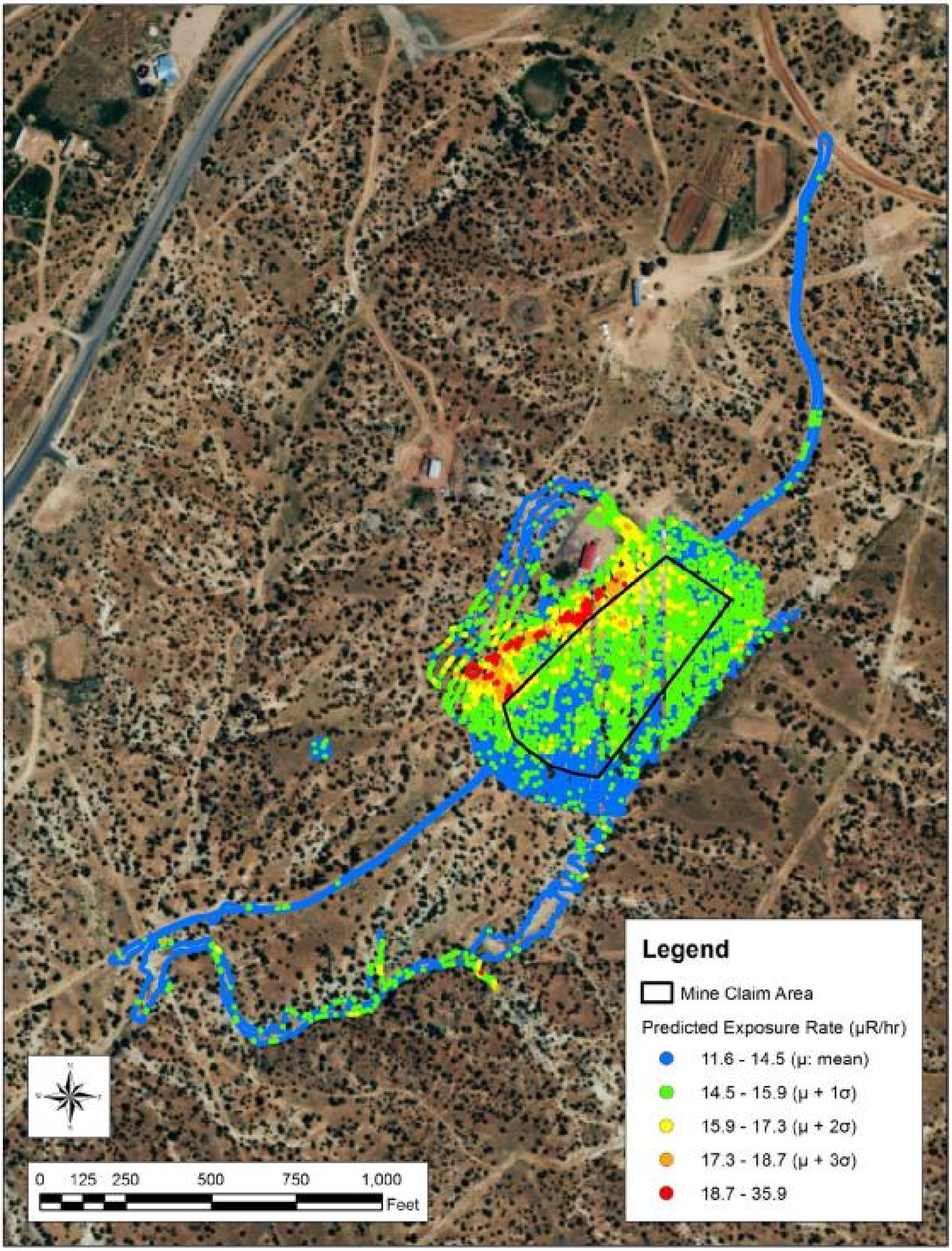


Figure 12. Predicted exposure rates in the Survey Area.

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.

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 observed along a ridge of bedrock off to the north end of the mine claim.
- One potential Background Reference Area was 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) = 2917 x [radium-226 (pCi/g)] + 8994

- The distribution of concentrations of radium-226 in surface soils predicted using this model is rightward tailed. The values in the Survey Area range from –0.4 to 13.5 pCi/g, with a central tendency (median) of 1.1 pCi/g.
- The thorium series radionuclides do not appear to affect predicted concentrations of radium-226 from gamma count rates.
- There is evidence of equilibrium, but not secular equilibrium, among the uranium decay series radionuclides.
- 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 6×10^{-4} + 6.8623

- The distribution of exposure rates predicted using this model is rightward tailed. The values in the Survey Area range from 11.6 to 35.9, with a central tendency (median) of 14.2 μR/h.
- Further work is recommended to support a robust gamma correlation.

6.0 References

MWH, 2016. Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan, October 24, 2016.

Stantec, 2018. Occurrence B Removal Site Evaluation Report, October 2018.

Appendix A Instrument calibration and completed function check forms

ERG

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Certificate of Calibration

Calibration and Voltage Plateau

	Manufacturer:		Model Number:		Serial Number:	
Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	254772
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR303727

- [x] Mechanical Check
- [x] F/S Response Check
- [x] Geotropism
- [x] Meter Zeroed
- [x] THR/WIN Operation
- [x] Reset Check
- [x] Audio Check
- [x] Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): [x] 500 V [x] 1000 V [x] 1500 V

Cable Length: [ ] 39-inch [x] 72-inch [ ] Other:

Source Distance: [ ] Contact [x] 6 inches [ ] Other:

Source Geometry [x] Side [ ] Below [ ] Other:

Threshold: 10 mV

Window:

Barometric Pressure: 24.6 inches Hg

Temperature: 73 °F

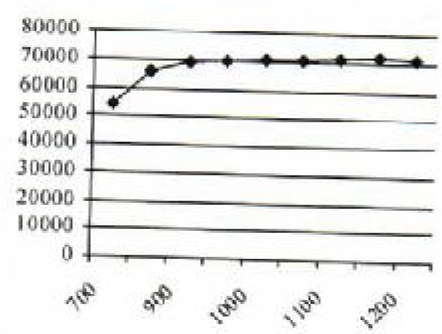
Relative Humidity: 20 %

Instrument found within tolerance: [x] Yes [ ] No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Cour
x 1000	400	400	400	398773	400
x 1000	100	100	100		100
x 100	400	400	400	39887	400
x 100	100	100	100		100
x 10	400	400	400	3988	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	53957	
800	65946	
900	69049	
950	69687	
1000	70240	9925
1050	70288	
1100	71224	
1150	71563	
1200	71161	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1000

Reference Instruments and/or Sources:

Ludlum pulser serial number: [ ] 97743 [x] 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: [ ] 8749012

[x] Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

[ ] Other Source:

Calibrated By: [signature]

Calibration Date: 1-20-16

Calibration Due 1-20-17

Reviewed By: [signature]

Date: 1/20/16

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration

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:	196086
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR295014

✔ 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: 24.78 inches Hg

Source Distance: ☐ Contact ✔ 6 inches ☐ Other: Threshold: 10 mV Temperature: 74 °F

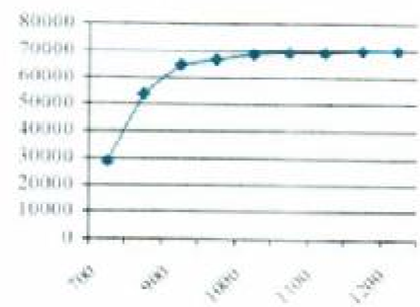
Source Geometry: ✔ Side ☐ Below ☐ Other: Window: Relative Humidity: 20 %

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	399802	400
x 1000	100	100	100		100
x 100	400	400	400	39989	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
700	28456	
800	53330	
900	64430	
950	66209	
1000	68333	
1050	69077	
1100	69121	8924
1150	69973	
1200	70155	

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: [signature] Calibration Date: 7-1-16 Calibration Due: 7-1-17

Reviewed By: [signature] Date: 7/20/16

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: 282966

Detector: Manufacturer: Ludlum Model Number: 44-10 Serial Number: PR150507

☑ 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: 60"

☑ Geotropism ☑ Audio Check

☑ Meter Zeroed ☑ Battery Check (Min 4.4 VDC)

Source Distance: ☐ Contact ☑ 6 inches ☐ Other: Threshold: 10 mV

Source Geometry: ☑ Side ☐ Below ☐ Other: Window:

Barometric Pressure: 24.89 inches Hg

Temperature: 73 °F

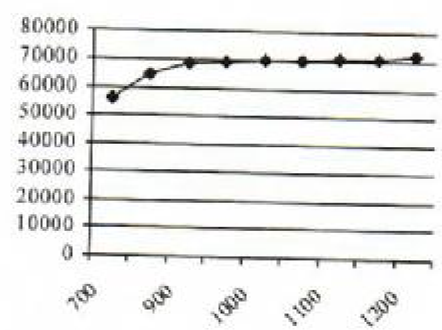
Relative Humidity: 20 %

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	398753	400
x 1000	100	100	100		100
x 100	400	400	400	39879	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	56463	
800	64304	
900	68534	
950	69331	
1000	69868	9696
1050	70054	
1100	70609	
1150	70681	
1200	71955	

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:

alibrated By: Calibration Date: 10-31-16 Calibration Due: 10-31-17

eviewed By: Date: 10/31/16

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:	138368
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR154615

✔ 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:

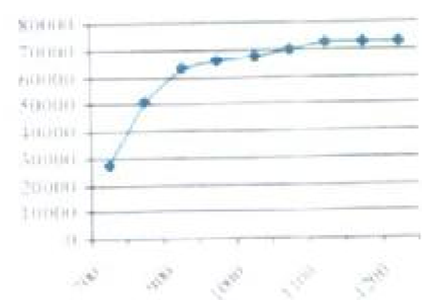
Barometric Pressure: 24.78 inches Hg
Temperature: 74 °F
Relative Humidity: 20 %

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	398436	400
x 1000	100	100	100		100
x 100	400	400	400	39845	400
x 100	100	100	100		100
x 10	400	400	400	3984	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	26998	
800	51037	
900	63340	
950	65550	
1000	67410	
1050	70113	
1100	72217	
1150	72561	9216
1200	72337	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1150

Reference Instruments and/or Sources:

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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: [illegible]
Calibration Due: [illegible]

Reviewed By: [signature]
Date: 7/20/16

K&S Associates, Inc.
1926 Elm Tree Drive
Nashville, Tennessee 37210-3718
Phone 800-522-2325 Fax 615-871-0656

ACCREDITED
CALIBRATION CERT #1866.01

CALIBRATION REPORT

SUBMITTED BY: ERG
8809 Washington Street Northeast
Suite 150
Albuquerque, NM 87113

INSTRUMENT: Reuter Stokes RSS-131, #07J00KM1

REPORT NUMBER: 161866
TEST NUMBER(S) M161588
REPORT DATE: June 29, 2016

The CALIBRATION COEFFICIENTS contained in this report were obtained by intercomparison with instruments calibrated by, or directly traceable to, the National Institute of Standards and Technology (NIST). K• S Associates, Inc. is licensed by the State of Tennessee (R-19075-G97, R-19136-B00) to perform calibrations, and is recognized by the Health Physics Society (HPS) as an ACCREDITED INSTRUMENT CALIBRATION LABORATORY. As part of the accreditation K • S participates in a measurement assurance program conducted by the HPS and NIST. K • S also certifies that the calibration was performed using quality policies, methods and procedures that meet or exceed the requirements of ISO/IEC 17025:2005.

This laboratory is accredited by the American Association for Laboratory Accreditation (A2LA) and the results shown in this report have been determined in accordance with the laboratory's terms of accreditation unless stated otherwise in this report

The CALIBRATION COEFFICIENTS stated herein are valid under the conditions specified. It is the instrument user's responsibility to perform the appropriate constancy tests prior to shipment and after return from calibration. It is also the responsibility of the user to assure that the interpretation of the information in this report is consistent with that intended by K • S Associates, Inc.

K&S Associates, Inc
Nashville, Tennessee 37210-3718

ACCREDITED

CALIBRATION CERTIFICATE

Calibration Date: 6/27/2016 Report Number: 161866 Test Number: M161588

K&S certifies that the environmental radiation monitor identified below has been calibrated for radiation measurement using collimated radiation sources whose output has been calibrated with instruments calibrated by or directly traceable to the National Institute of Standards and Technology. K&S is accredited by the American Association for Laboratory Accreditation to perform environmental level calibrations and further certifies that the calibration was performed using accredited policies and procedures (SI 25) that meet or exceed the requirements of ISO/IEC 17025:2005.

Sensor Type: 100 mR/h

Serial Number: 07J00KM1

Average Calibration Coefficient for the range of 0.012 mR/h – 0.220 mR/h*:
1.02 mR/"mR" reading
(Measured at 4 points)

Calibration Coefficient for the 50.0 mR/h point*:
1.12 mR/"mR" reading

Calibration Coefficient for the 80.0 mR/h point*:
1.10 mR/"mR" reading

Found RAC: 2.169e-8

*Multiply the reading in **mR/h** by the Calibration Coefficient to obtain true **mR/h**.

Calibrated By: Richard Hardison Reviewed By: Angela Roper
Richard Hardison
Title: Calibration Technician Title: Calibration Physicist

Log: M-53 Page: 73

K&S Associates, Inc
Nashville, Tennessee 37210-3718

ACCREDITED

AS FOUND DATA
Reuter-Stokes Chamber Calibration

June 27, 2016 *Test Number M161588*

CHAMBER:

Mfgr: Reuter Stokes
Model: RSS-131
Serial: 07J00KM1

SUBMITTED BY:
ERG

Albuquerque, NM

ORIENTATION/CONDITIONS:

Serial number away from source

"True" background exposure rate of 6.7 uR/h, instrument reading was 0.0076 mR/h

ATMOSPHERIC COMMUNICATION: SEALED

POLARIZING POTENTIAL 401V

LEAKAGE: negligible

BEAM QUALITY BEAM		EXPOSURE RATE		CALIBRATION COEFFICIENT	UNCERT	LOG
CsEn220	(11mCi)	0.22mR/h	N_x=	1.00 mR/h/rdg	11%	M-53 73
CsEn80	(11mCi)	0.08mR/h	N_x=	1.03 mR/h/rdg	11%	
CsEnv12	(1mCi)	0.012mR/h	N_x=	1.01 mR/h/rdg	11%	
CsEnv15	(1mCi)	0.015mR/h	N_x=	1.02 mR/h/rdg	11%	
Cs199m	(20 Ci)	50mR/h	N_x=	1.12 mR/h/rdg	8%	
Cs252m	(20 Ci)	80mR/h	N_x=	1.10 mR/h/rdg	8%	

Comments Batt: 6.1V, Temp: 24.6 deg C, K&S Environment: Temp:21 deg C , RH 59%, Press: 752 mmHg;
Report Number: 161866
Refer to Appendix I of this report for details on PIC ionization chamber calibrations. Procedure: SI 25
RAC Found: 2.169e-8

Calibrated By Richard Hardison **Reviewed By:**
Title: Calibration Technician **Title:** Calibration Physicist
Checked By: **Prepared By:** REH

Form RSS

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	GE
Model:	853-131
Serial No.:	07J0UKM1
Cal. Due Date:	6-29-17

DETECTOR	
Manufacturer:	SAME AS METER
Model:	
Serial No.:	
Cal. Due Date:	

Comments:
NNERT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-6-94 Distance to Source: Contact - housing

Serial No.: 333-44 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts µR/h	BKG Counts µR/h	Net Counts	Initials	Note(s): Project reference points
10-26-16	0525	~6.4	~400	NA	~27.8	~10.5	~17.3	NW	Best Western room - Flagstaff
10-26-16	2010	~6.3	~400	NA	~26	~9.5	~16.5	NW	Gouldings room ~~Best Western room - Flagstaff~~ NW
10-27-16	0720	~6.2	~400	NA	~26.7	~10.0	~16.7	NW	Gouldings room
10-27-16	1710	~6.2	~400	NA	~27.0	~10.8	~16.2	NW	Gouldings room
10-31-16	0609	~6.3	~400	NA	~27.0	~10	~16	NW	Gouldings room
10-31-16	1520	~6.3	~400	NA	~26	~10	~16	NW	Gouldings room
11-3-16	0700	~6.2	~400	NA	~26.5	~10.5	~16	NW	Gouldings room
11-3-16	1924	~6.1	~400	NA	~28.8	~12.5	~16.3	NW	Holiday Inn Chinle-room
11-9-16	0615	~6.3	~400	NA	~30	~12.8	~17.2	NW	Holiday Inn-Chinle room
11-9-16	1430	~6.2	~400	NA	~29.5	~12.5	~17	NW	Holiday Inn Chinle - room
11-11-16	0610	~6.4	~400	NA	~31.5	~13.5	~18	NW	Holiday Inn Chinle - room
11-11-16	1825	~6.2	~400	NA	~28	~11	~17	NW	Holiday Inn Chinle - room

Reviewed by: [signature] Review Date: 11-29-16

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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.:	196086
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR295014
Cal. Due Date:	7-9-17

Comments:
NNERT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-6-94 Distance to Source: 6 Inches

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference points
11-1-16	0744	5.3	1107	100	43406	4729	38677	NW	Charles Keith
11-1-16	1718	5.2	1102	99	44319	5332	38987	NW	Goulding's in SUV
11-2-16	0818	5.2	1108	100	43456	5555	37901	NW	Charles Keith
11-2-16	1703	5.1	1101	100	43874	5111	38763	NW	Gouldings in SUV
a 11-3-16	1050	6.2	1107	100	45017	5399	39618	NW	Charles Keith
11-3-16	1845	6.2	1104	99	47896	7562	40334	NW	Chinle Holiday Inn SUV
11-4-16	0856	6.2	1109	100	47119	8387	38732	NW	Occurrence B
11-4-16	1147	6.1	1105	100	46025	7972	38053	NW	Occurrence B
11-5-16	1112	6.1	1107	100	47483	8555	38928	NW	Claim 28
11-5-16	1824	6.1	1107	99	46828	7017	39811	NW	Chinle lot in SUV
11-7-16	0822	6.1	1108	100	46784	8794	37990	NW	Claim 28
11-7-16	1829	5.9	1104	99	46382	6448	39934	NW	Chinle lot

a. Charged batteries

Reviewed by: [signature] Review Date: 11/29/16

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:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR295014
Cal. Due Date:	7-9-17

Comments:
NNERT

Source: Cs-137 Activity: 5.12 µCi Source Date: 6-6-94 Distance to Source: 6 inches

Serial No.: 339-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference points
11-8-16	0805	6.0	1109	100	49571	9246	40325	NW	Claim 28
11-8-16	1641	5.8	1104	100	45893	6864	39029	NW	Chinle lot
11-9-16	0724	5.8	1110	101	46451	8453	37998	NW	occurrence 13
11-9-16	1925	5.8	1104	100	47096	6903	40193	NW	Chinle lot
11-10-16	0826	5.8	1109	100	47011	9425	37586	NW	Claim 28
11-10-16	1628	5.7	1103	100	48672	8509	40163	NW	Claim 28 (2nd location)
11-12-16	0834	5.7	1109	101	47463	9188	38275	NW	Hoskie Tso
11-12-16	1347	5.6	1101	101	48929	8265	40664	NW	Hoskie Tso
11-14-16	1218	5.7	1105	100	48870	8074	40796	NW	Hoskie Tso
11-14-16	1639	5.7	1105	100	47696	9068	38628	NW	Hoskie Tso (2nd location)
11-15-16	0834	5.7	1110	101	50555	~~9145~~ 9150 NW	41405	NW	Hoskie Tso
11-15-16	1142	5.5	1101	100	48004	8598	39406	NW	Hoskie Tso

Reviewed by: MR Review Date: 11/29/16

(1)

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:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	7-9-17

Comments:
NNERT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-6-94 Distance to Source: 6 inches

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference points
11-9-16	0729	5.6	1009	100	47673	8821	38852	NW	Occurrence B
11-9-16	1415	5.4	1002	99	46465	7541	38924	NW	Church Lol
11-10-16	0820	5.6	1011	100	47628	9750	37878	NW	Claim 28
11-10-16	1632	5.4	1002	99	50634	8930	41704	NW	Claim 28 (2nd location)
11-11-16	0816	5.5	1010	100	49034	9824	39210	NW	Claim 28
11-11-16	1555	5.4	1002	99	48985	8643	40342	NW	Occurrence B
11-12-16	0819	5.5	1009	100	49296	9054	40242	NW	Hoskie Tso
11-12-16	1340	5.3	1002	99	49800	8556	41244	NW	Hoskie Tso
11-14-16	0818	5.5	1012	100	47737	9609	38128	NW	Hoskie Tso
11-14-16	1637	5.3	1002	99	47714	9150	38564	NW	Hoskie Tso (2nd location)
11-16-16	0809	5.4	1011	100	49413	12340	37073	NW	Standing Rock
11-16-16	1510	5.3	1003	99	49649	11268	38381	NW	Gallup Lol

Reviewed by: MP Review Date: 11/29/16

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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.:	138368
Cal. Due Date:	7-19-16

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR154615
Cal. Due Date:	7-19-16

Comments:
NNERT

Source: Cs-137 Activity: 5.17 uCi Source Date: 6-16-94 Distance to Source: 6 in.

Serial No: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
10-28-16	0813	5.6	1162	144	50583	9051	41532	NW	Harvey Blackwater
10-29-16	0815	5.6	1222	199	44566	5053	39513	NW	Mitten No. 3
10-29-16	1338	5.5	1141	125	44503	4794	39709	NW	Mitten No 3
10-31-16	0846	5.5	1133	111	44824	4753	40071	NW	Mitten No. 3
10-31-16	1502	5.5	1132	114	44994	4883	40111	NW	Goulding's in SUV
11-1-16	0758	5.5	1133	110	45344	4771	40573	NW	Charles Keith
11-1-16	1712	5.3	1120	100	44220	4928	39292	NW	Goulding's in SUV
11-2-16	0826	5.3	1127	103	44389	5834	38555	NW	Charles Keith
11-2-16	1715	5.3	1125	106	43737	5179	38558	NW	Goulding's in SUV
11-3-16	1055	5.3	1125	105	44443	5368	39075	NW	Charles Keith
11-3-16	1842	5.3	1123	104	47047	7583	39464	NW	Chinle Holiday Inn SUV
11-4-16	0900	5.4	1128	104	46230	8402	37828	NW	Occurrence B

Reviewed by: MN

Review Date: 11/29/16

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

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ERG

Single-Channel Function Check Log

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	138638
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR 154615
Cal. Due Date:	7-4-17

Comments:
NNEAT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-6-94 Distance to Source: 6 Inches

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference points
11-4-16	1143	5.2	1131	110	46332	8240	38092	NW	Occurrence B
11-5-16	1113	5.4	1135	112	46611	8815	37796	NW	Claim 28
11-5-16	1519	5.2	1127	104	46761	7064	39697	NW	Chinle lot
11-7-16	0815	5.3	1130	107	49792	8843	40949	NW	Claim 28
11-7-16	1821	5.2	1120	100	47318	6436	40882	NW	Chinle lot
11-16-16	0821	5.4	1158	132	50609	11976	38633	NW	Standing Rock
11-16-16	1507	5.2	1125	106	49562	10942	38620	NW	Gallup lot

NW
12-6-16

Reviewed by: MM Review Date: 11/29/16

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.:	282966
Cal. Due Date:	10-31-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR150507
Cal. Due Date:	10-31-17

Comments:
NNEAT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-6-94 Distance to Source: 6 inches

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference point,
11-2-16	0832	6.0	1007	100	43939	6161	37778	NW	Charles Keith
11-2-16	1711	6.0	1003	101	44857	5744	39113	NW	Goulding's in SUV
11-4-16	0904	6.0	1008	101	47156	8938	38218	NW	Occurrence B
11-4-16	1152	5.9	1007	101	46787	8341	38446	NW	Occurrence B
11-5-16	1121	6.0	1007	101	47567	9195	38372	NW	Claim 28
11-5-16	1531	5.9	1007	101	46740	7360	39380	NW	Chinle lot in SUV
11-7-16	0810	6.0	1010	104	49757	9136	40621	NW	Claim 28
11-7-16	1832	5.8	1003	100	45791	6809	38982	NW	Chinle lot
11-8-16	0810	5.8	1009	100	49552	9855	39697	NW	Claim 28
11-8-16	1634	5.7	1003	100	48686	7133	41553	NW	Chinle lot
11-10-16	0812	5.8	1012	101	48023	9818	38205	NW	Claim 28
11-10-16	1635	5.7	1003	101	46906	9042	37864	NW	Claim 28 (2nd location)

Reviewed by: NM Review Date: 11/29/16

Appendix B Exposure Rate Measurements

Date and Time	Exposure Rate (mR/h)	Location	Date and Time	Exposure Rate (mR/h)	Location
11/09/2016 10:00	0.0548	Correlation Location 1	11/09/2016 10:05	0.0169	Correlation Location 1
11/09/2016 10:00	0.0965	Correlation Location 1	11/09/2016 10:06	0.017	Correlation Location 1
11/09/2016 10:00	0.0856	Correlation Location 1	11/09/2016 10:06	0.0168	Correlation Location 1
11/09/2016 10:00	0.0603	Correlation Location 1	11/09/2016 10:06	0.0166	Correlation Location 1
11/09/2016 10:00	0.0411	Correlation Location 1	11/09/2016 10:06	0.0165	Correlation Location 1
11/09/2016 10:00	0.029	Correlation Location 1	11/09/2016 10:06	0.0165	Correlation Location 1
11/09/2016 10:00	0.0227	Correlation Location 1	11/09/2016 10:06	0.0165	Correlation Location 1
11/09/2016 10:01	0.0198	Correlation Location 1	11/09/2016 10:06	0.0166	Correlation Location 1
11/09/2016 10:01	0.018	Correlation Location 1	11/09/2016 10:06	0.0166	Correlation Location 1
11/09/2016 10:01	0.0177	Correlation Location 1	11/09/2016 10:06	0.0166	Correlation Location 1
11/09/2016 10:01	0.0168	Correlation Location 1	11/09/2016 10:06	0.0165	Correlation Location 1
11/09/2016 10:01	0.0164	Correlation Location 1	11/09/2016 10:07	0.0165	Correlation Location 1
11/09/2016 10:01	0.0162	Correlation Location 1	11/09/2016 10:07	0.0165	Correlation Location 1
11/09/2016 10:01	0.0166	Correlation Location 1	11/09/2016 10:07	0.0168	Correlation Location 1
11/09/2016 10:01	0.017	Correlation Location 1	11/09/2016 10:07	0.017	Correlation Location 1
11/09/2016 10:01	0.017	Correlation Location 1	11/09/2016 10:07	0.017	Correlation Location 1
11/09/2016 10:01	0.017	Correlation Location 1	11/09/2016 10:07	0.017	Correlation Location 1
11/09/2016 10:02	0.017	Correlation Location 1	11/09/2016 10:07	0.0173	Correlation Location 1
11/09/2016 10:02	0.017	Correlation Location 1	11/09/2016 10:07	0.0172	Correlation Location 1
11/09/2016 10:02	0.0172	Correlation Location 1	11/09/2016 10:07	0.017	Correlation Location 1
11/09/2016 10:02	0.0172	Correlation Location 1	11/09/2016 10:07	0.0173	Correlation Location 1
11/09/2016 10:02	0.0172	Correlation Location 1	11/09/2016 10:08	0.0176	Correlation Location 1
11/09/2016 10:02	0.0174	Correlation Location 1	11/09/2016 10:08	0.0176	Correlation Location 1
11/09/2016 10:02	0.0173	Correlation Location 1	11/09/2016 10:08	0.0175	Correlation Location 1
11/09/2016 10:02	0.0173	Correlation Location 1	11/09/2016 10:08	0.0173	Correlation Location 1
11/09/2016 10:02	0.017	Correlation Location 1	11/09/2016 10:08	0.0172	Correlation Location 1
11/09/2016 10:02	0.0166	Correlation Location 1	11/09/2016 10:08	0.017	Correlation Location 1
11/09/2016 10:03	0.0166	Correlation Location 1	11/09/2016 10:08	0.0169	Correlation Location 1
11/09/2016 10:03	0.0165	Correlation Location 1	11/09/2016 10:08	0.017	Correlation Location 1
11/09/2016 10:03	0.0165	Correlation Location 1	11/09/2016 10:08	0.017	Correlation Location 1
11/09/2016 10:03	0.0168	Correlation Location 1	11/09/2016 10:08	0.0172	Correlation Location 1
11/09/2016 10:03	0.017	Correlation Location 1	11/09/2016 10:09	0.0169	Correlation Location 1
11/09/2016 10:03	0.0168	Correlation Location 1	11/09/2016 10:09	0.0168	Correlation Location 1
11/09/2016 10:03	0.0169	Correlation Location 1	11/09/2016 10:09	0.0164	Correlation Location 1
11/09/2016 10:03	0.017	Correlation Location 1	11/09/2016 10:09	0.0163	Correlation Location 1
11/09/2016 10:03	0.0174	Correlation Location 1	11/09/2016 10:09	0.0163	Correlation Location 1
11/09/2016 10:03	0.0174	Correlation Location 1	11/09/2016 10:09	0.0162	Correlation Location 1
11/09/2016 10:04	0.017	Correlation Location 1	11/09/2016 10:09	0.0161	Correlation Location 1
11/09/2016 10:04	0.0169	Correlation Location 1	11/09/2016 10:09	0.0158	Correlation Location 1
11/09/2016 10:04	0.0168	Correlation Location 1	11/09/2016 10:09	0.0155	Correlation Location 1
11/09/2016 10:04	0.017	Correlation Location 1	11/09/2016 10:09	0.0158	Correlation Location 1
11/09/2016 10:04	0.0173	Correlation Location 1	11/09/2016 10:10	0.0167	Correlation Location 1
11/09/2016 10:04	0.017	Correlation Location 1	11/09/2016 10:10	0.0172	Correlation Location 1
11/09/2016 10:04	0.017	Correlation Location 1	11/09/2016 10:10	0.0169	Correlation Location 1
11/09/2016 10:04	0.0166	Correlation Location 1	11/09/2016 10:10	0.0168	Correlation Location 1
11/09/2016 10:04	0.0167	Correlation Location 1	11/09/2016 10:10	0.0168	Correlation Location 1
11/09/2016 10:04	0.017	Correlation Location 1	11/09/2016 10:10	0.0167	Correlation Location 1
11/09/2016 10:05	0.0169	Correlation Location 1	11/09/2016 10:10	0.0163	Correlation Location 1
11/09/2016 10:05	0.0164	Correlation Location 1	11/09/2016 10:10	0.0163	Correlation Location 1
11/09/2016 10:05	0.0164	Correlation Location 1	11/09/2016 10:10	0.0166	Correlation Location 1
11/09/2016 10:05	0.0169	Correlation Location 1	11/09/2016 10:10	0.0165	Correlation Location 1
11/09/2016 10:05	0.017	Correlation Location 1	11/09/2016 10:11	0.0166	Correlation Location 1
11/09/2016 10:05	0.0164	Correlation Location 1	11/09/2016 10:11	0.0167	Correlation Location 1
11/09/2016 10:05	0.0163	Correlation Location 1	11/09/2016 10:11	0.0169	Correlation Location 1
11/09/2016 10:05	0.0162	Correlation Location 1	11/09/2016 10:40	0.0544	Correlation Location 2
11/09/2016 10:05	0.0166	Correlation Location 1	11/09/2016 10:40	0.0955	Correlation Location 2

Occurrence B Exposure Rate Measurements for Correlation

Date and Time	Exposure Rate (mR/h)	Location
11/09/2016 10:40	0.084	Correlation Location 2
11/09/2016 10:40	0.0589	Correlation Location 2
11/09/2016 10:40	0.04	Correlation Location 2
11/09/2016 10:41	0.0283	Correlation Location 2
11/09/2016 10:41	0.0217	Correlation Location 2
11/09/2016 10:41	0.019	Correlation Location 2
11/09/2016 10:41	0.0178	Correlation Location 2
11/09/2016 10:41	0.0175	Correlation Location 2
11/09/2016 10:41	0.017	Correlation Location 2
11/09/2016 10:41	0.0168	Correlation Location 2
11/09/2016 10:41	0.0165	Correlation Location 2
11/09/2016 10:41	0.0163	Correlation Location 2
11/09/2016 10:41	0.0162	Correlation Location 2
11/09/2016 10:42	0.0161	Correlation Location 2
11/09/2016 10:42	0.0156	Correlation Location 2
11/09/2016 10:42	0.0155	Correlation Location 2
11/09/2016 10:42	0.016	Correlation Location 2
11/09/2016 10:42	0.0162	Correlation Location 2
11/09/2016 10:42	0.0162	Correlation Location 2
11/09/2016 10:42	0.0166	Correlation Location 2
11/09/2016 10:42	0.0166	Correlation Location 2
11/09/2016 10:42	0.0166	Correlation Location 2
11/09/2016 10:42	0.0166	Correlation Location 2
11/09/2016 10:43	0.0167	Correlation Location 2
11/09/2016 10:43	0.0163	Correlation Location 2
11/09/2016 10:43	0.0162	Correlation Location 2
11/09/2016 10:43	0.0166	Correlation Location 2
11/09/2016 10:43	0.0169	Correlation Location 2
11/09/2016 10:43	0.0168	Correlation Location 2
11/09/2016 10:43	0.0167	Correlation Location 2
11/09/2016 10:43	0.0167	Correlation Location 2
11/09/2016 10:43	0.0166	Correlation Location 2
11/09/2016 10:43	0.0165	Correlation Location 2
11/09/2016 10:44	0.0165	Correlation Location 2
11/09/2016 10:44	0.0167	Correlation Location 2
11/09/2016 10:44	0.0168	Correlation Location 2
11/09/2016 10:44	0.0169	Correlation Location 2
11/09/2016 10:44	0.0166	Correlation Location 2
11/09/2016 10:44	0.0161	Correlation Location 2
11/09/2016 10:44	0.0158	Correlation Location 2
11/09/2016 10:44	0.0162	Correlation Location 2
11/09/2016 10:44	0.0164	Correlation Location 2
11/09/2016 10:44	0.0166	Correlation Location 2
11/09/2016 10:45	0.0161	Correlation Location 2
11/09/2016 10:45	0.016	Correlation Location 2
11/09/2016 10:45	0.0163	Correlation Location 2
11/09/2016 10:45	0.0163	Correlation Location 2
11/09/2016 10:45	0.0163	Correlation Location 2
11/09/2016 10:45	0.0163	Correlation Location 2
11/09/2016 10:45	0.0162	Correlation Location 2
11/09/2016 10:45	0.0158	Correlation Location 2
11/09/2016 10:45	0.016	Correlation Location 2
11/09/2016 10:45	0.0164	Correlation Location 2
11/09/2016 10:46	0.0169	Correlation Location 2
11/09/2016 10:46	0.0168	Correlation Location 2
11/09/2016 10:46	0.0165	Correlation Location 2
11/09/2016 10:46	0.0162	Correlation Location 2
11/09/2016 10:46	0.0165	Correlation Location 2
11/09/2016 10:46	0.0166	Correlation Location 2
11/09/2016 10:46	0.0168	Correlation Location 2
11/09/2016 10:46	0.0168	Correlation Location 2
11/09/2016 10:46	0.0169	Correlation Location 2
11/09/2016 10:46	0.0167	Correlation Location 2
11/09/2016 10:47	0.0163	Correlation Location 2
11/09/2016 10:47	0.016	Correlation Location 2
11/09/2016 10:47	0.0158	Correlation Location 2
11/09/2016 10:47	0.0163	Correlation Location 2
11/09/2016 10:47	0.0163	Correlation Location 2
11/09/2016 10:47	0.0162	Correlation Location 2
11/09/2016 10:47	0.0165	Correlation Location 2
11/09/2016 10:47	0.0165	Correlation Location 2
11/09/2016 10:47	0.0163	Correlation Location 2
11/09/2016 10:47	0.0162	Correlation Location 2
11/09/2016 10:48	0.0164	Correlation Location 2
11/09/2016 10:48	0.0163	Correlation Location 2
11/09/2016 10:48	0.0163	Correlation Location 2
11/09/2016 10:48	0.0161	Correlation Location 2
11/09/2016 10:48	0.0164	Correlation Location 2
11/09/2016 10:48	0.017	Correlation Location 2
11/09/2016 10:48	0.017	Correlation Location 2
11/09/2016 10:48	0.0165	Correlation Location 2
11/09/2016 10:48	0.0164	Correlation Location 2
11/09/2016 10:48	0.0163	Correlation Location 2
11/09/2016 10:49	0.0158	Correlation Location 2
11/09/2016 10:49	0.0158	Correlation Location 2
11/09/2016 10:49	0.0162	Correlation Location 2
11/09/2016 10:49	0.0164	Correlation Location 2
11/09/2016 10:49	0.0166	Correlation Location 2
11/09/2016 10:49	0.017	Correlation Location 2
11/09/2016 10:49	0.017	Correlation Location 2
11/09/2016 10:49	0.0165	Correlation Location 2
11/09/2016 10:49	0.0163	Correlation Location 2
11/09/2016 10:49	0.0163	Correlation Location 2
11/09/2016 10:50	0.0164	Correlation Location 2
11/09/2016 10:50	0.0164	Correlation Location 2
11/09/2016 10:50	0.0166	Correlation Location 2
11/09/2016 10:50	0.0166	Correlation Location 2
11/09/2016 10:50	0.0168	Correlation Location 2
11/09/2016 10:50	0.0167	Correlation Location 2
11/09/2016 10:50	0.0166	Correlation Location 2
11/09/2016 10:50	0.0167	Correlation Location 2
11/09/2016 10:50	0.0168	Correlation Location 2
11/09/2016 10:50	0.0165	Correlation Location 2
11/09/2016 10:51	0.0166	Correlation Location 2
11/09/2016 10:51	0.0167	Correlation Location 2
11/09/2016 10:51	0.0167	Correlation Location 2
11/09/2016 10:51	0.016	Correlation Location 2
11/09/2016 10:51	0.0161	Correlation Location 2
11/09/2016 10:51	0.0165	Correlation Location 2
11/09/2016 11:16	0.054	Correlation Location 3
11/09/2016 11:16	0.0942	Correlation Location 3
11/09/2016 11:17	0.0828	Correlation Location 3
11/09/2016 11:17	0.0573	Correlation Location 3
11/09/2016 11:17	0.0378	Correlation Location 3

Occurrence B Exposure Rate Measurements for Correlation

Date and Time	Exposure Rate (mR/h)	Location	Date and Time	Exposure Rate (mR/h)	Location
11/09/2016 11:17	0.0265	Correlation Location 3	11/09/2016 11:23	0.0137	Correlation Location 3
11/09/2016 11:17	0.0199	Correlation Location 3	11/09/2016 11:23	0.0136	Correlation Location 3
11/09/2016 11:17	0.0161	Correlation Location 3	11/09/2016 11:23	0.0133	Correlation Location 3
11/09/2016 11:17	0.0145	Correlation Location 3	11/09/2016 11:23	0.0128	Correlation Location 3
11/09/2016 11:17	0.0138	Correlation Location 3	11/09/2016 11:23	0.0127	Correlation Location 3
11/09/2016 11:17	0.0136	Correlation Location 3	11/09/2016 11:23	0.0131	Correlation Location 3
11/09/2016 11:17	0.0133	Correlation Location 3	11/09/2016 11:23	0.0132	Correlation Location 3
11/09/2016 11:18	0.0131	Correlation Location 3	11/09/2016 11:23	0.013	Correlation Location 3
11/09/2016 11:18	0.0128	Correlation Location 3	11/09/2016 11:23	0.0129	Correlation Location 3
11/09/2016 11:18	0.0131	Correlation Location 3	11/09/2016 11:23	0.0132	Correlation Location 3
11/09/2016 11:18	0.0134	Correlation Location 3	11/09/2016 11:24	0.0134	Correlation Location 3
11/09/2016 11:18	0.0135	Correlation Location 3	11/09/2016 11:24	0.0136	Correlation Location 3
11/09/2016 11:18	0.0134	Correlation Location 3	11/09/2016 11:24	0.0137	Correlation Location 3
11/09/2016 11:18	0.0132	Correlation Location 3	11/09/2016 11:24	0.014	Correlation Location 3
11/09/2016 11:18	0.0134	Correlation Location 3	11/09/2016 11:24	0.014	Correlation Location 3
11/09/2016 11:18	0.0136	Correlation Location 3	11/09/2016 11:24	0.0138	Correlation Location 3
11/09/2016 11:18	0.0133	Correlation Location 3	11/09/2016 11:24	0.0136	Correlation Location 3
11/09/2016 11:19	0.0129	Correlation Location 3	11/09/2016 11:24	0.0139	Correlation Location 3
11/09/2016 11:19	0.0122	Correlation Location 3	11/09/2016 11:24	0.014	Correlation Location 3
11/09/2016 11:19	0.0122	Correlation Location 3	11/09/2016 11:24	0.0134	Correlation Location 3
11/09/2016 11:19	0.0127	Correlation Location 3	11/09/2016 11:25	0.0129	Correlation Location 3
11/09/2016 11:19	0.0132	Correlation Location 3	11/09/2016 11:25	0.0129	Correlation Location 3
11/09/2016 11:19	0.0135	Correlation Location 3	11/09/2016 11:25	0.0131	Correlation Location 3
11/09/2016 11:19	0.0137	Correlation Location 3	11/09/2016 11:25	0.0129	Correlation Location 3
11/09/2016 11:19	0.0138	Correlation Location 3	11/09/2016 11:25	0.0131	Correlation Location 3
11/09/2016 11:19	0.014	Correlation Location 3	11/09/2016 11:25	0.0133	Correlation Location 3
11/09/2016 11:19	0.014	Correlation Location 3	11/09/2016 11:25	0.0132	Correlation Location 3
11/09/2016 11:20	0.0138	Correlation Location 3	11/09/2016 11:25	0.0131	Correlation Location 3
11/09/2016 11:20	0.0138	Correlation Location 3	11/09/2016 11:25	0.013	Correlation Location 3
11/09/2016 11:20	0.0138	Correlation Location 3	11/09/2016 11:25	0.0133	Correlation Location 3
11/09/2016 11:20	0.0137	Correlation Location 3	11/09/2016 11:26	0.0136	Correlation Location 3
11/09/2016 11:20	0.0139	Correlation Location 3	11/09/2016 11:26	0.0135	Correlation Location 3
11/09/2016 11:20	0.014	Correlation Location 3	11/09/2016 11:26	0.0136	Correlation Location 3
11/09/2016 11:20	0.0138	Correlation Location 3	11/09/2016 11:26	0.0135	Correlation Location 3
11/09/2016 11:20	0.0138	Correlation Location 3	11/09/2016 11:26	0.013	Correlation Location 3
11/09/2016 11:20	0.0136	Correlation Location 3	11/09/2016 11:26	0.0127	Correlation Location 3
11/09/2016 11:20	0.0136	Correlation Location 3	11/09/2016 11:26	0.0129	Correlation Location 3
11/09/2016 11:21	0.0137	Correlation Location 3	11/09/2016 11:26	0.0135	Correlation Location 3
11/09/2016 11:21	0.0136	Correlation Location 3	11/09/2016 11:26	0.0134	Correlation Location 3
11/09/2016 11:21	0.0133	Correlation Location 3	11/09/2016 11:26	0.0133	Correlation Location 3
11/09/2016 11:21	0.0135	Correlation Location 3	11/09/2016 11:27	0.0134	Correlation Location 3
11/09/2016 11:21	0.0137	Correlation Location 3	11/09/2016 11:27	0.0133	Correlation Location 3
11/09/2016 11:21	0.0136	Correlation Location 3	11/09/2016 11:27	0.0135	Correlation Location 3
11/09/2016 11:21	0.0136	Correlation Location 3	11/09/2016 11:27	0.0135	Correlation Location 3
11/09/2016 11:21	0.0135	Correlation Location 3	11/09/2016 11:27	0.0132	Correlation Location 3
11/09/2016 11:21	0.0133	Correlation Location 3	11/09/2016 11:27	0.0129	Correlation Location 3
11/09/2016 11:21	0.0134	Correlation Location 3	11/09/2016 11:27	0.0127	Correlation Location 3
11/09/2016 11:22	0.0136	Correlation Location 3	11/09/2016 11:27	0.0129	Correlation Location 3
11/09/2016 11:22	0.0136	Correlation Location 3	11/09/2016 11:52	0.054	Correlation Location 4
11/09/2016 11:22	0.0131	Correlation Location 3	11/09/2016 11:52	0.0944	Correlation Location 4
11/09/2016 11:22	0.0128	Correlation Location 3	11/09/2016 11:52	0.0823	Correlation Location 4
11/09/2016 11:22	0.0128	Correlation Location 3	11/09/2016 11:53	0.0566	Correlation Location 4
11/09/2016 11:22	0.013	Correlation Location 3	11/09/2016 11:53	0.037	Correlation Location 4
11/09/2016 11:22	0.0132	Correlation Location 3	11/09/2016 11:53	0.0253	Correlation Location 4
11/09/2016 11:22	0.0132	Correlation Location 3	11/09/2016 11:53	0.0189	Correlation Location 4
11/09/2016 11:22	0.0128	Correlation Location 3	11/09/2016 11:53	0.0158	Correlation Location 4
11/09/2016 11:22	0.0133	Correlation Location 3	11/09/2016 11:53	0.0141	Correlation Location 4

Occurrence B Exposure Rate Measurements for Correlation

Date and Time	Exposure Rate (mR/h)	Location
11/09/2016 11:53	0.0134	Correlation Location 4
11/09/2016 11:53	0.0136	Correlation Location 4
11/09/2016 11:53	0.0133	Correlation Location 4
11/09/2016 11:53	0.0132	Correlation Location 4
11/09/2016 11:54	0.0131	Correlation Location 4
11/09/2016 11:54	0.0132	Correlation Location 4
11/09/2016 11:54	0.0137	Correlation Location 4
11/09/2016 11:54	0.0136	Correlation Location 4
11/09/2016 11:54	0.0132	Correlation Location 4
11/09/2016 11:54	0.013	Correlation Location 4
11/09/2016 11:54	0.0127	Correlation Location 4
11/09/2016 11:54	0.0127	Correlation Location 4
11/09/2016 11:54	0.0124	Correlation Location 4
11/09/2016 11:54	0.0122	Correlation Location 4
11/09/2016 11:55	0.012	Correlation Location 4
11/09/2016 11:55	0.012	Correlation Location 4
11/09/2016 11:55	0.0121	Correlation Location 4
11/09/2016 11:55	0.0121	Correlation Location 4
11/09/2016 11:55	0.0122	Correlation Location 4
11/09/2016 11:55	0.0126	Correlation Location 4
11/09/2016 11:55	0.0128	Correlation Location 4
11/09/2016 11:55	0.013	Correlation Location 4
11/09/2016 11:55	0.0132	Correlation Location 4
11/09/2016 11:55	0.0131	Correlation Location 4
11/09/2016 11:56	0.013	Correlation Location 4
11/09/2016 11:56	0.013	Correlation Location 4
11/09/2016 11:56	0.0132	Correlation Location 4
11/09/2016 11:56	0.0134	Correlation Location 4
11/09/2016 11:56	0.0134	Correlation Location 4
11/09/2016 11:56	0.0135	Correlation Location 4
11/09/2016 11:56	0.0138	Correlation Location 4
11/09/2016 11:56	0.0135	Correlation Location 4
11/09/2016 11:56	0.0133	Correlation Location 4
11/09/2016 11:56	0.0134	Correlation Location 4
11/09/2016 11:57	0.0135	Correlation Location 4
11/09/2016 11:57	0.0132	Correlation Location 4
11/09/2016 11:57	0.0129	Correlation Location 4
11/09/2016 11:57	0.0126	Correlation Location 4
11/09/2016 11:57	0.0126	Correlation Location 4
11/09/2016 11:57	0.0127	Correlation Location 4
11/09/2016 11:57	0.0131	Correlation Location 4
11/09/2016 11:57	0.0135	Correlation Location 4
11/09/2016 11:57	0.0133	Correlation Location 4
11/09/2016 11:57	0.0132	Correlation Location 4
11/09/2016 11:58	0.0131	Correlation Location 4
11/09/2016 11:58	0.013	Correlation Location 4
11/09/2016 11:58	0.0132	Correlation Location 4
11/09/2016 11:58	0.0135	Correlation Location 4
11/09/2016 11:58	0.0132	Correlation Location 4
11/09/2016 11:58	0.0133	Correlation Location 4
11/09/2016 11:58	0.0134	Correlation Location 4
11/09/2016 11:58	0.0133	Correlation Location 4
11/09/2016 11:58	0.0129	Correlation Location 4
11/09/2016 11:58	0.013	Correlation Location 4
11/09/2016 11:59	0.0132	Correlation Location 4
11/09/2016 11:59	0.0133	Correlation Location 4
11/09/2016 11:59	0.0138	Correlation Location 4

Date and Time	Exposure Rate (mR/h)	Location
11/09/2016 11:59	0.0138	Correlation Location 4
11/09/2016 11:59	0.0135	Correlation Location 4
11/09/2016 11:59	0.013	Correlation Location 4
11/09/2016 11:59	0.0122	Correlation Location 4
11/09/2016 11:59	0.012	Correlation Location 4
11/09/2016 11:59	0.0126	Correlation Location 4
11/09/2016 11:59	0.0127	Correlation Location 4
11/09/2016 12:00	0.0127	Correlation Location 4
11/09/2016 12:00	0.0128	Correlation Location 4
11/09/2016 12:00	0.0133	Correlation Location 4
11/09/2016 12:00	0.0136	Correlation Location 4
11/09/2016 12:00	0.0136	Correlation Location 4
11/09/2016 12:00	0.0136	Correlation Location 4
11/09/2016 12:00	0.0137	Correlation Location 4
11/09/2016 12:00	0.0138	Correlation Location 4
11/09/2016 12:00	0.0135	Correlation Location 4
11/09/2016 12:00	0.0136	Correlation Location 4
11/09/2016 12:01	0.0141	Correlation Location 4
11/09/2016 12:01	0.0141	Correlation Location 4
11/09/2016 12:01	0.014	Correlation Location 4
11/09/2016 12:01	0.0137	Correlation Location 4
11/09/2016 12:01	0.0132	Correlation Location 4
11/09/2016 12:01	0.0127	Correlation Location 4
11/09/2016 12:01	0.0123	Correlation Location 4
11/09/2016 12:01	0.0126	Correlation Location 4
11/09/2016 12:01	0.0131	Correlation Location 4
11/09/2016 12:01	0.0132	Correlation Location 4
11/09/2016 12:02	0.0131	Correlation Location 4
11/09/2016 12:02	0.013	Correlation Location 4
11/09/2016 12:02	0.0129	Correlation Location 4
11/09/2016 12:02	0.0127	Correlation Location 4
11/09/2016 12:02	0.0126	Correlation Location 4
11/09/2016 12:02	0.0123	Correlation Location 4
11/09/2016 12:02	0.0124	Correlation Location 4
11/09/2016 12:02	0.0124	Correlation Location 4
11/09/2016 12:02	0.0129	Correlation Location 4
11/09/2016 12:02	0.0129	Correlation Location 4
11/09/2016 12:03	0.0126	Correlation Location 4
11/09/2016 12:03	0.0128	Correlation Location 4
11/09/2016 12:03	0.0129	Correlation Location 4
11/09/2016 12:03	0.013	Correlation Location 4
11/09/2016 12:03	0.0129	Correlation Location 4
11/09/2016 12:03	0.0132	Correlation Location 4
11/09/2016 12:41	0.054	Correlation Location 5
11/09/2016 12:41	0.0945	Correlation Location 5
11/09/2016 12:41	0.0827	Correlation Location 5
11/09/2016 12:41	0.0573	Correlation Location 5
11/09/2016 12:41	0.0385	Correlation Location 5
11/09/2016 12:41	0.0274	Correlation Location 5
11/09/2016 12:41	0.0213	Correlation Location 5
11/09/2016 12:41	0.0178	Correlation Location 5
11/09/2016 12:41	0.0158	Correlation Location 5
11/09/2016 12:42	0.0151	Correlation Location 5
11/09/2016 12:42	0.0147	Correlation Location 5
11/09/2016 12:42	0.0148	Correlation Location 5
11/09/2016 12:42	0.0147	Correlation Location 5
11/09/2016 12:42	0.0151	Correlation Location 5

Date and Time	Exposure Rate (mR/h)	Location
11/09/2016 12:42	0.0153	Correlation Location 5
11/09/2016 12:42	0.0152	Correlation Location 5
11/09/2016 12:42	0.0147	Correlation Location 5
11/09/2016 12:42	0.0146	Correlation Location 5
11/09/2016 12:42	0.0146	Correlation Location 5
11/09/2016 12:43	0.0148	Correlation Location 5
11/09/2016 12:43	0.0148	Correlation Location 5
11/09/2016 12:43	0.0143	Correlation Location 5
11/09/2016 12:43	0.0143	Correlation Location 5
11/09/2016 12:43	0.0148	Correlation Location 5
11/09/2016 12:43	0.0153	Correlation Location 5
11/09/2016 12:43	0.0154	Correlation Location 5
11/09/2016 12:43	0.0154	Correlation Location 5
11/09/2016 12:43	0.0156	Correlation Location 5
11/09/2016 12:43	0.0154	Correlation Location 5
11/09/2016 12:44	0.0152	Correlation Location 5
11/09/2016 12:44	0.015	Correlation Location 5
11/09/2016 12:44	0.0147	Correlation Location 5
11/09/2016 12:44	0.0144	Correlation Location 5
11/09/2016 12:44	0.0147	Correlation Location 5
11/09/2016 12:44	0.0151	Correlation Location 5
11/09/2016 12:44	0.0152	Correlation Location 5
11/09/2016 12:44	0.015	Correlation Location 5
11/09/2016 12:44	0.0147	Correlation Location 5
11/09/2016 12:44	0.0145	Correlation Location 5
11/09/2016 12:45	0.0146	Correlation Location 5
11/09/2016 12:45	0.0144	Correlation Location 5
11/09/2016 12:45	0.0145	Correlation Location 5
11/09/2016 12:45	0.0147	Correlation Location 5
11/09/2016 12:45	0.0148	Correlation Location 5
11/09/2016 12:45	0.0148	Correlation Location 5
11/09/2016 12:45	0.0145	Correlation Location 5
11/09/2016 12:45	0.0146	Correlation Location 5
11/09/2016 12:45	0.0148	Correlation Location 5
11/09/2016 12:45	0.0145	Correlation Location 5
11/09/2016 12:46	0.0147	Correlation Location 5
11/09/2016 12:46	0.0148	Correlation Location 5
11/09/2016 12:46	0.0149	Correlation Location 5
11/09/2016 12:46	0.0154	Correlation Location 5
11/09/2016 12:46	0.0153	Correlation Location 5
11/09/2016 12:46	0.0153	Correlation Location 5
11/09/2016 12:46	0.0151	Correlation Location 5
11/09/2016 12:46	0.0152	Correlation Location 5
11/09/2016 12:46	0.0153	Correlation Location 5
11/09/2016 12:46	0.0152	Correlation Location 5
11/09/2016 12:47	0.0153	Correlation Location 5
11/09/2016 12:47	0.0148	Correlation Location 5
11/09/2016 12:47	0.0144	Correlation Location 5
11/09/2016 12:47	0.0142	Correlation Location 5
11/09/2016 12:47	0.0141	Correlation Location 5
11/09/2016 12:47	0.0138	Correlation Location 5
11/09/2016 12:47	0.0138	Correlation Location 5
11/09/2016 12:47	0.0138	Correlation Location 5
11/09/2016 12:47	0.0143	Correlation Location 5
11/09/2016 12:47	0.0144	Correlation Location 5
11/09/2016 12:48	0.0143	Correlation Location 5
11/09/2016 12:48	0.0143	Correlation Location 5
11/09/2016 12:48	0.0143	Correlation Location 5
11/09/2016 12:48	0.0144	Correlation Location 5
11/09/2016 12:48	0.0148	Correlation Location 5
11/09/2016 12:48	0.0155	Correlation Location 5
11/09/2016 12:48	0.0156	Correlation Location 5
11/09/2016 12:48	0.0153	Correlation Location 5
11/09/2016 12:48	0.0149	Correlation Location 5
11/09/2016 12:48	0.0145	Correlation Location 5
11/09/2016 12:49	0.0141	Correlation Location 5
11/09/2016 12:49	0.0138	Correlation Location 5
11/09/2016 12:49	0.0142	Correlation Location 5
11/09/2016 12:49	0.0145	Correlation Location 5
11/09/2016 12:49	0.0145	Correlation Location 5
11/09/2016 12:49	0.0144	Correlation Location 5
11/09/2016 12:49	0.0143	Correlation Location 5
11/09/2016 12:49	0.0147	Correlation Location 5
11/09/2016 12:49	0.0151	Correlation Location 5
11/09/2016 12:49	0.0149	Correlation Location 5
11/09/2016 12:50	0.0146	Correlation Location 5
11/09/2016 12:50	0.0145	Correlation Location 5
11/09/2016 12:50	0.0147	Correlation Location 5
11/09/2016 12:50	0.0143	Correlation Location 5
11/09/2016 12:50	0.014	Correlation Location 5
11/09/2016 12:50	0.0145	Correlation Location 5
11/09/2016 12:50	0.0148	Correlation Location 5
11/09/2016 12:50	0.0147	Correlation Location 5
11/09/2016 12:50	0.0148	Correlation Location 5
11/09/2016 12:50	0.0152	Correlation Location 5
11/09/2016 12:51	0.0152	Correlation Location 5
11/09/2016 12:51	0.0151	Correlation Location 5
11/09/2016 12:51	0.015	Correlation Location 5
11/09/2016 12:51	0.0149	Correlation Location 5
11/09/2016 12:51	0.015	Correlation Location 5
11/09/2016 12:51	0.0147	Correlation Location 5
11/09/2016 12:51	0.0146	Correlation Location 5
11/09/2016 12:51	0.0146	Correlation Location 5
11/09/2016 12:51	0.0149	Correlation Location 5
11/09/2016 12:51	0.0148	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.

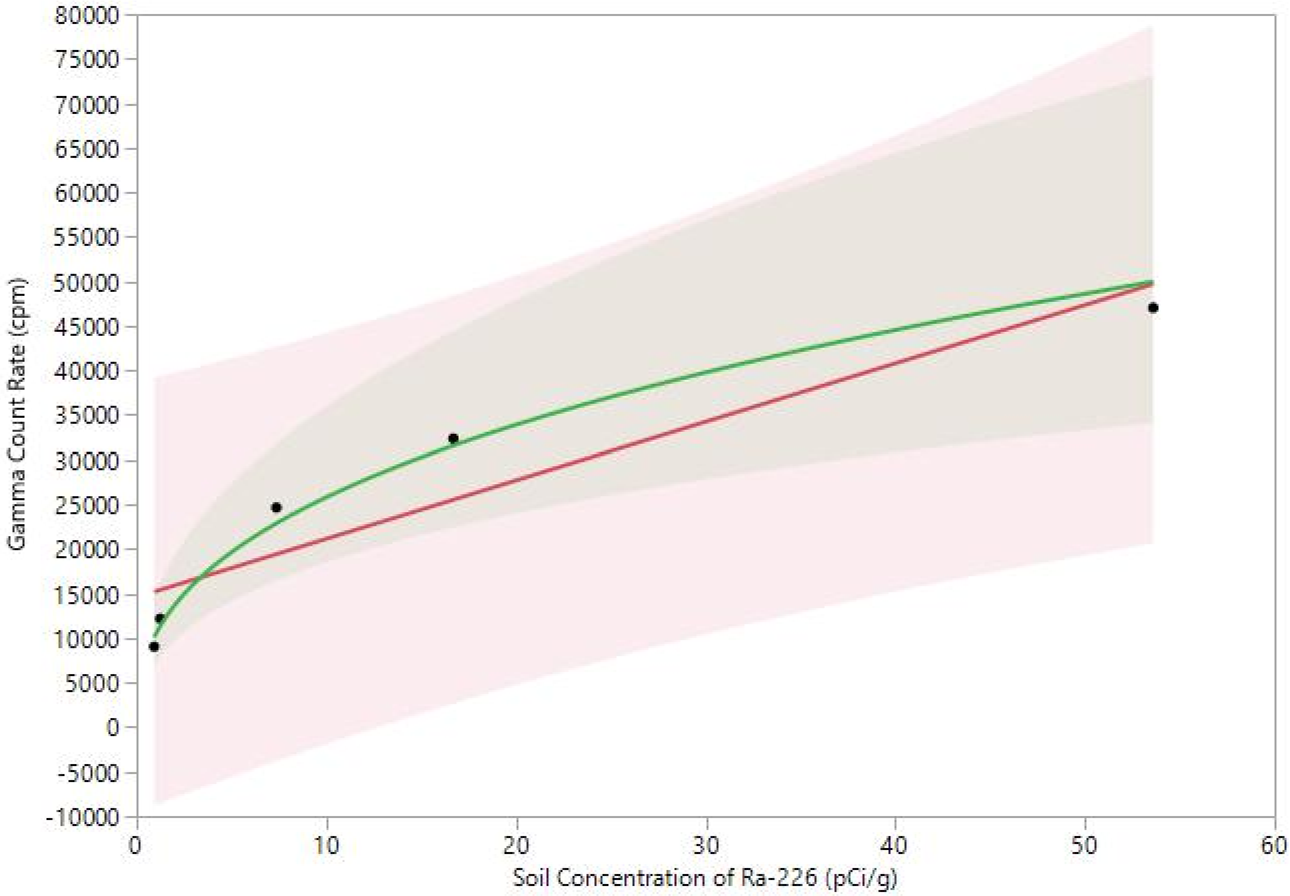

Figure 1. Regression models (linear versus power curve) for gamma count rate regressed on radium-226 showing 95% UPLs (upper prediction limits). Both models meet the study DQO for adjusted R^2 (greater than 0.8). Gamma count rate is not an especially strong predictor of soil concentration of radium-226 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.,

$$\varphi = \frac{\left[{}^{226}Ra\right]}{\left[{}^{230}Th\right]}$$

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.

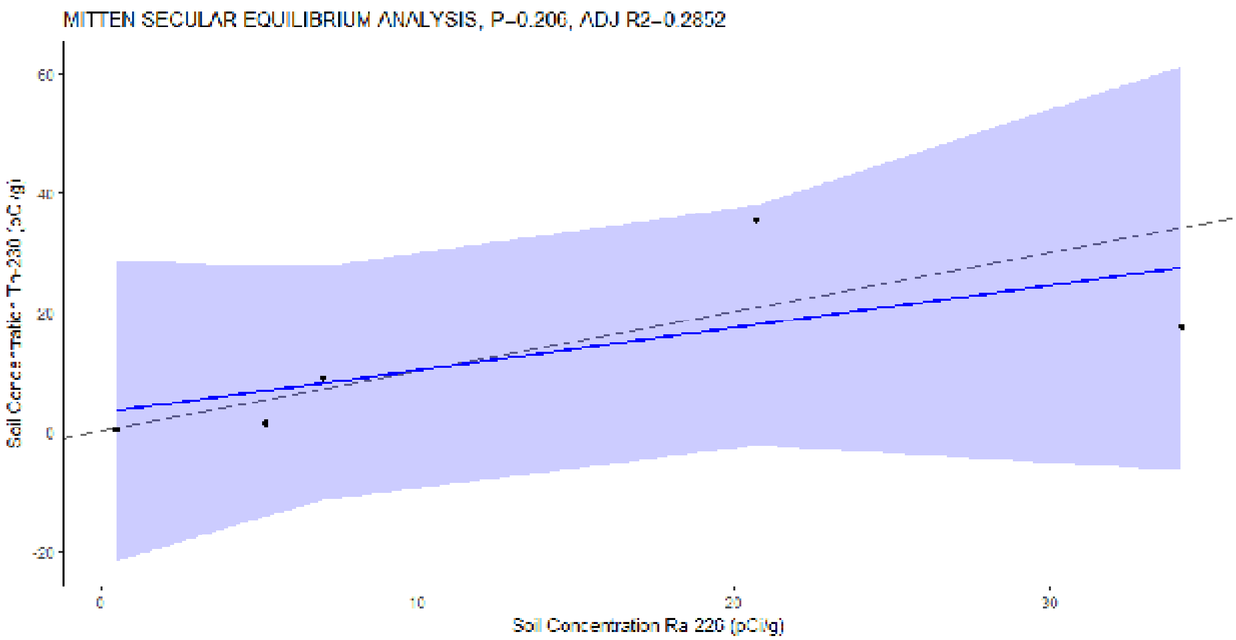

Figure 2. Result for Mitten secular equilibrium analysis, showing failure to meet p-value and adjusted R^2 criteria, i.e., the data are poorly correlated.

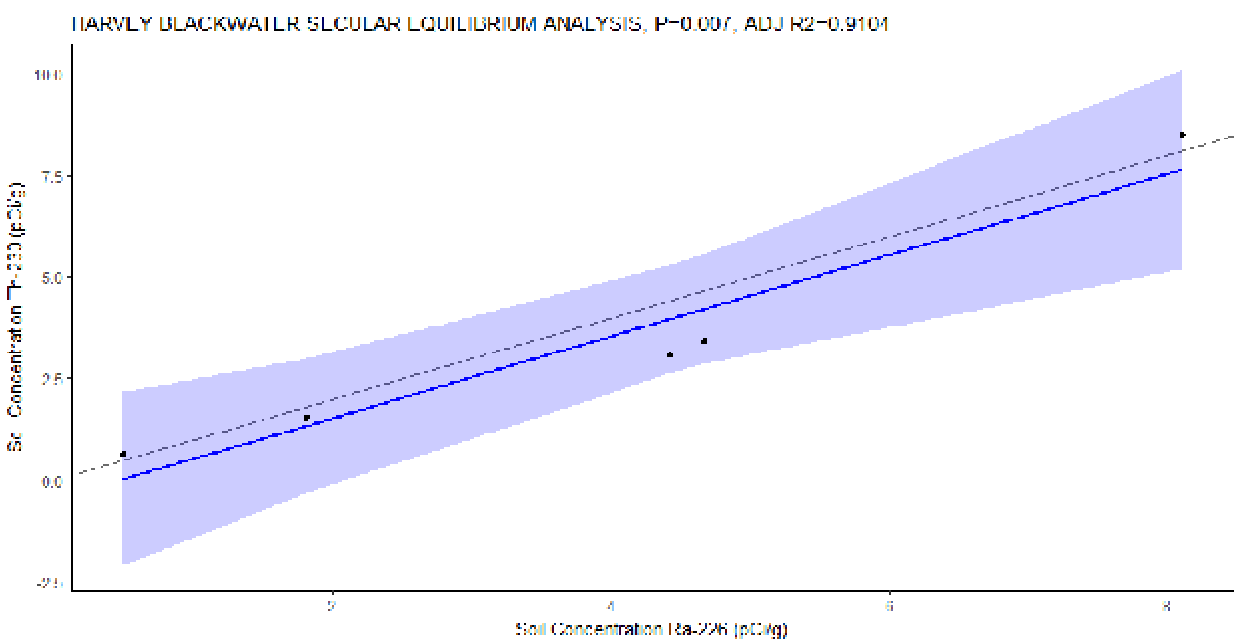

Figure 3. Result for Harvey Blackwater secular equilibrium analysis, showing excellent correlation between the data and the y=x line, i.e., Th-230 and Ra-226 are in secular equilibrium.

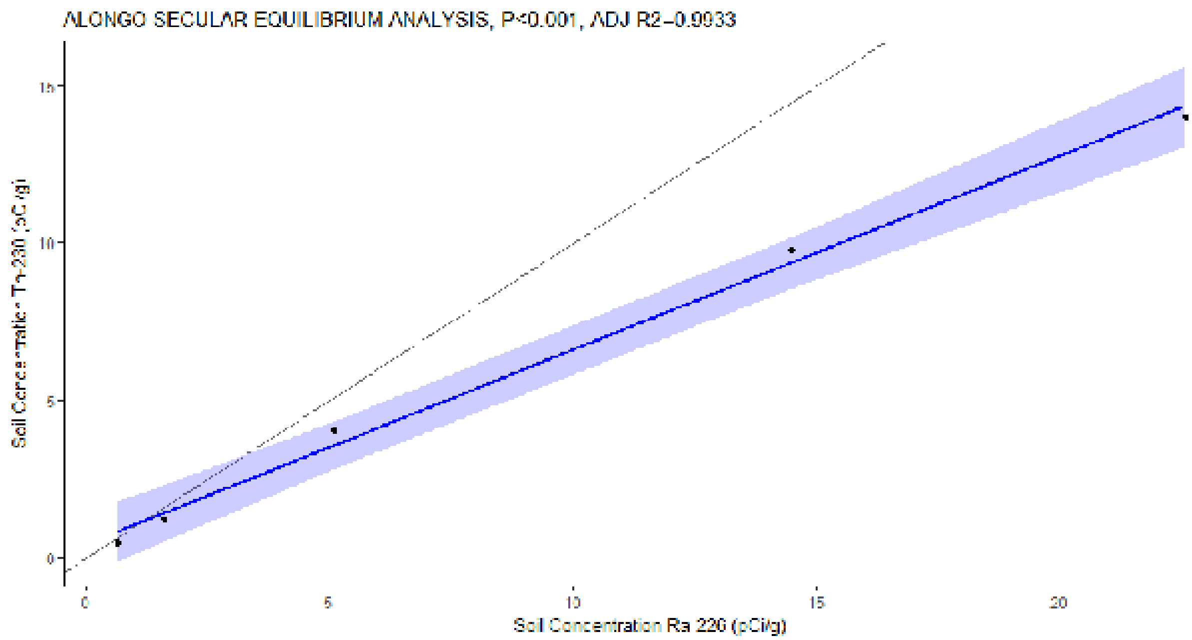

Figure 4. Result for Alongo Mines secular equilibrium analysis, showing excellent correlation between the data, but poor agreement with the y=x line, i.e., Th-230 and Ra-226 are in equilibrium, but not secular equilibrium.

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 "Occurrence B Abandoned Uranium Mine"

Disclaimer: Data and analytical methods used in this Preliminary Report are superseded by the Final Report.

Radiological Characterization of the Occurrence B Abandoned Uranium Mine

Preliminary

October 6, 2017

prepared for:

Stantec Consulting Services Inc.

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Acronyms

ANSI	American National Standards Institute
AUM	abandoned uranium mine
BG1	Background Reference Area 1
bgs	below ground surface
cpm	counts per minute
DQOs	data quality objectives
ERG	Environmental Restoration Group, Inc.
ft	foot
GPS	global positioning system
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 Occurrence B abandoned uranium mine (AUM) located in the Chinle Chapter of the Navajo Nation near Chinle, Arizona. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, as described in the 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) in accordance with 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 November 4 and 9, 2016. 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; and roads and drainages within a 0.25-mile radius of the 100-ft buffer; and correlation studies. The Survey Area was extended beyond the 100-ft buffer where elevated gamma count rates were observed.

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 continuing RSE are addressed in "Occurrence B Removal Site Evaluation Report" (Stantec, 2017).

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 observed along a ridge of bedrock off the north end of the mine claim.
- One potential Background Reference Area was established.
- The relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface [bgs]) is described by a power regression model:

  Radium-226 Concentration (pCi/g) = 4×10^{-11} (Gamma Count Rate, in cpm)$^{2.5463}$

- 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 0.3 to 34, with a central tendency (median) of 1.0 picocuries per gram.

- 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 6×10^{-4} + 6.8623

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 11.6 to 35.9, with a central tendency (median) of 14.2 µR/h.

1.0 Introduction

This report addresses the radiological characterization of the Occurrence B abandoned uranium mine (AUM) located in the Chinle Chapter of the Navajo Nation near Chinle, Arizona. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, as described in the 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) in accordance with the Navajo Nation AUM Environmental Response Trust – First Phase.

The activities described here focus on the characterization of uranium series radionuclides in surface soils at the AUM. This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of gamma count rates to exposure rates and concentrations of radium-226 in surface soils, and 3) an assessment of equilibrium in the uranium decay series.

The field activities were conducted on November 4 and 9, 2016 in accordance with the methods described in the RSE Work Plan. The GPS-based radiological survey of land surfaces covered an approximately 7-acre Survey Area that included the mine claim area out to a 100-foot buffer; and roads and drainages within a 0.25-mile radius of the buffer; gamma count rate and exposure rate measurements at fixed points; and gamma count rate measurements and soil sampling for radionuclides (radium-226 and isotopic thorium) and metals in areas centered on these fixed points. The Survey Area was extended beyond the 100-ft buffer where elevated gamma count rates were observed.

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 continuing RSE are addressed in "Occurrence B Removal Site Evaluation Report" (Stantec, 2017).

Figure 1 shows the location of the AUM. Background information that is pertinent to the characterization of this AUM is presented in the "Occurrence B Removal Site Evaluation Report" (Stantec, 2017).

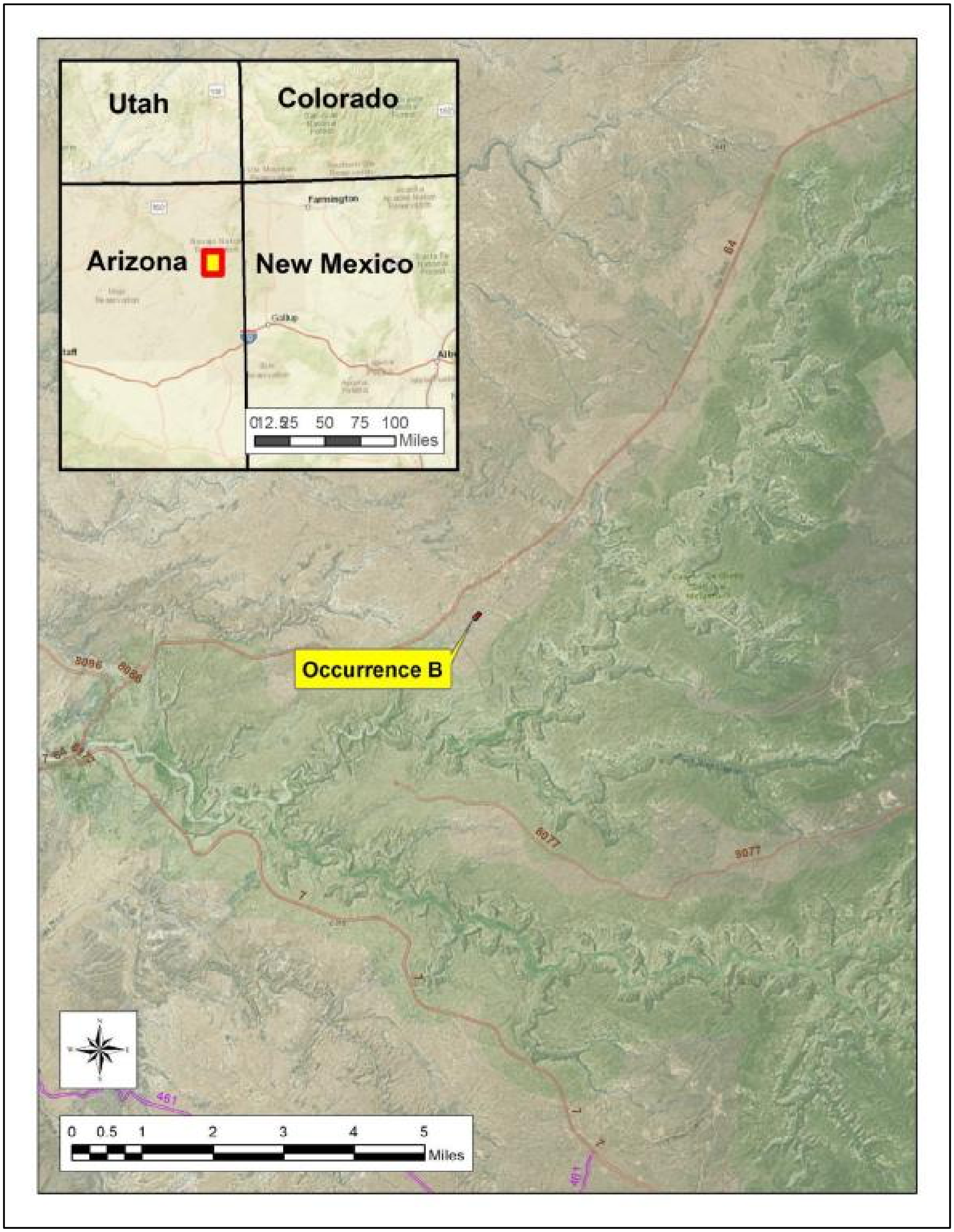


Figure 1. Location of the Occurrence B Abandoned Uranium Mine.

2.0 GPS-Based Gamma Surveys

This section addresses the GPS-based surveys conducted in one potential Background Reference Area and the Survey Area. 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 44-10	Ludlum Model 2221 Ratemeter/Scaler
Potential Background Reference Area	PR303727[a]	254772[a]
Survey Area	PR303727	254772
	PR295014	196086
	PR154615	138368
	PR150507	282966

Notes:
a. Detection system used in the correlation studies described in Section 3.0.

2.1 Potential Background Reference Area

A potential Background Reference Area was surveyed, the location and results of which are depicted on Figure 2. BG1 in the figure is Background Reference Area 1.

Table 2 lists a summary of the gamma count rates in BG1, which range from 9,405 to 13,860 counts per minute (cpm), with a mean and median of 10,436 and 10,298 cpm, respectively.

Figure 3 depicts a histogram of the gamma count rates. 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 Area.

	Gamma Count Rate (cpm)				
n	Min	Max	Mean	Median	Standard Deviation
156	9,405	13,860	10,436	10,298	651

Notes:
cpm = counts per minute

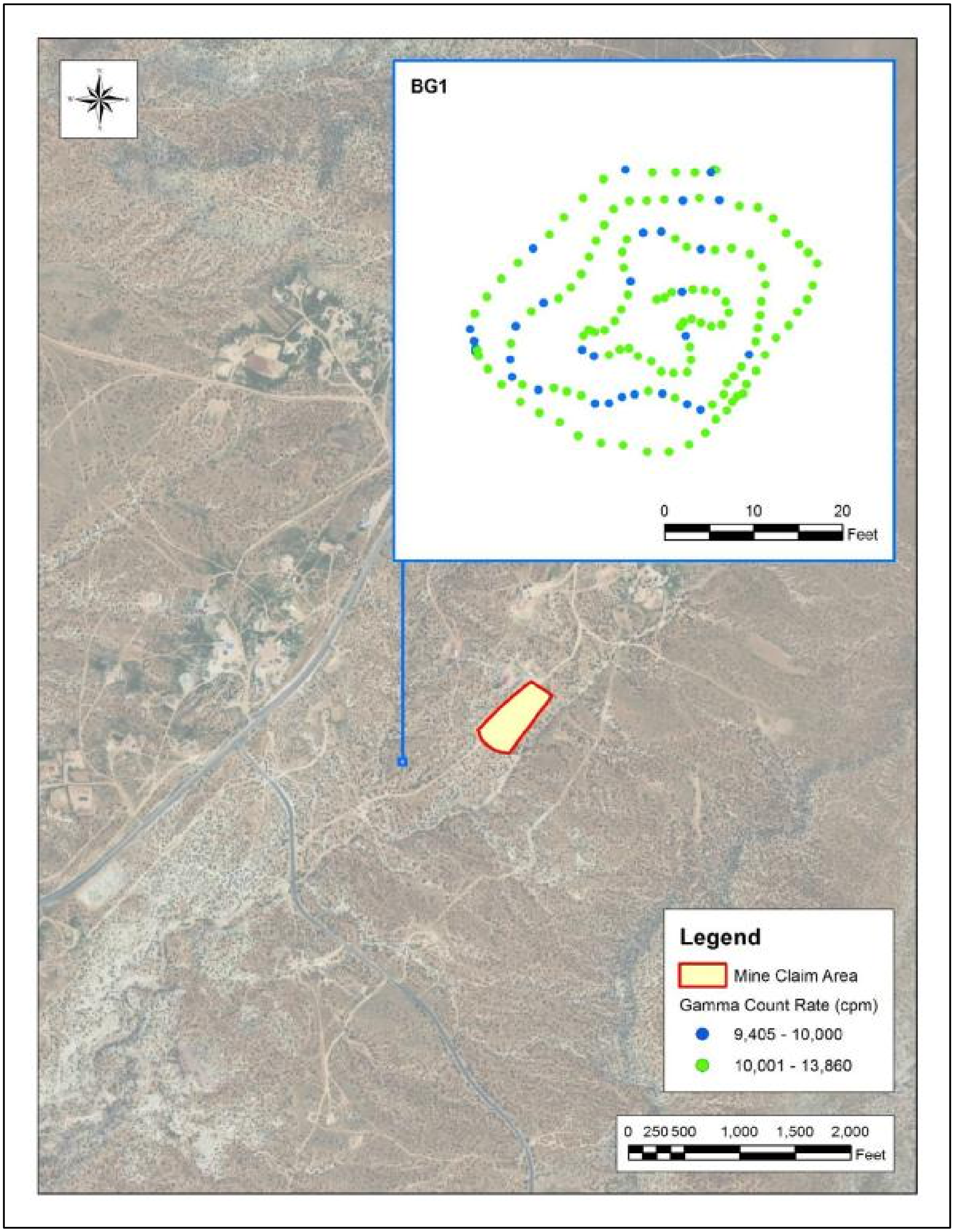


Figure 2. Gamma count rates in the potential Background Reference Area.

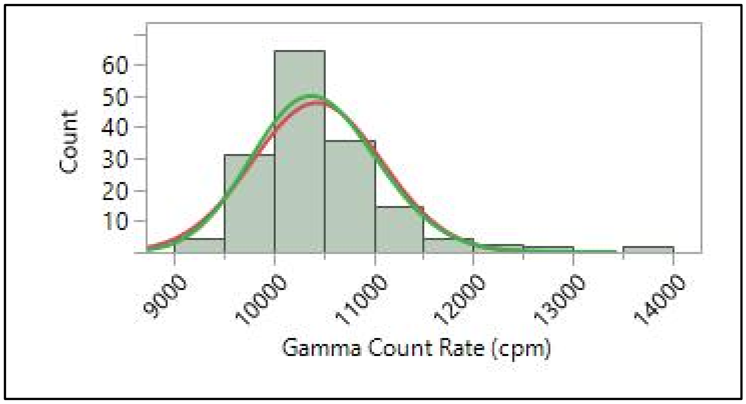


Figure 3. Histogram of gamma count rates in the potential Background Reference Area.

2.2 Survey Area

The gamma count rates observed in the Survey Area are depicted in Figure 4. The highest count rates were observed along a ridge of bedrock off the north end of the mine claim.

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, 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 11,254, 12,238, and 13,399 cpm, respectively.

Table 3 is a statistical summary of the measurements, which range from 7,910 to 48,436 cpm and have a central tendency (median) of 12,238 cpm.

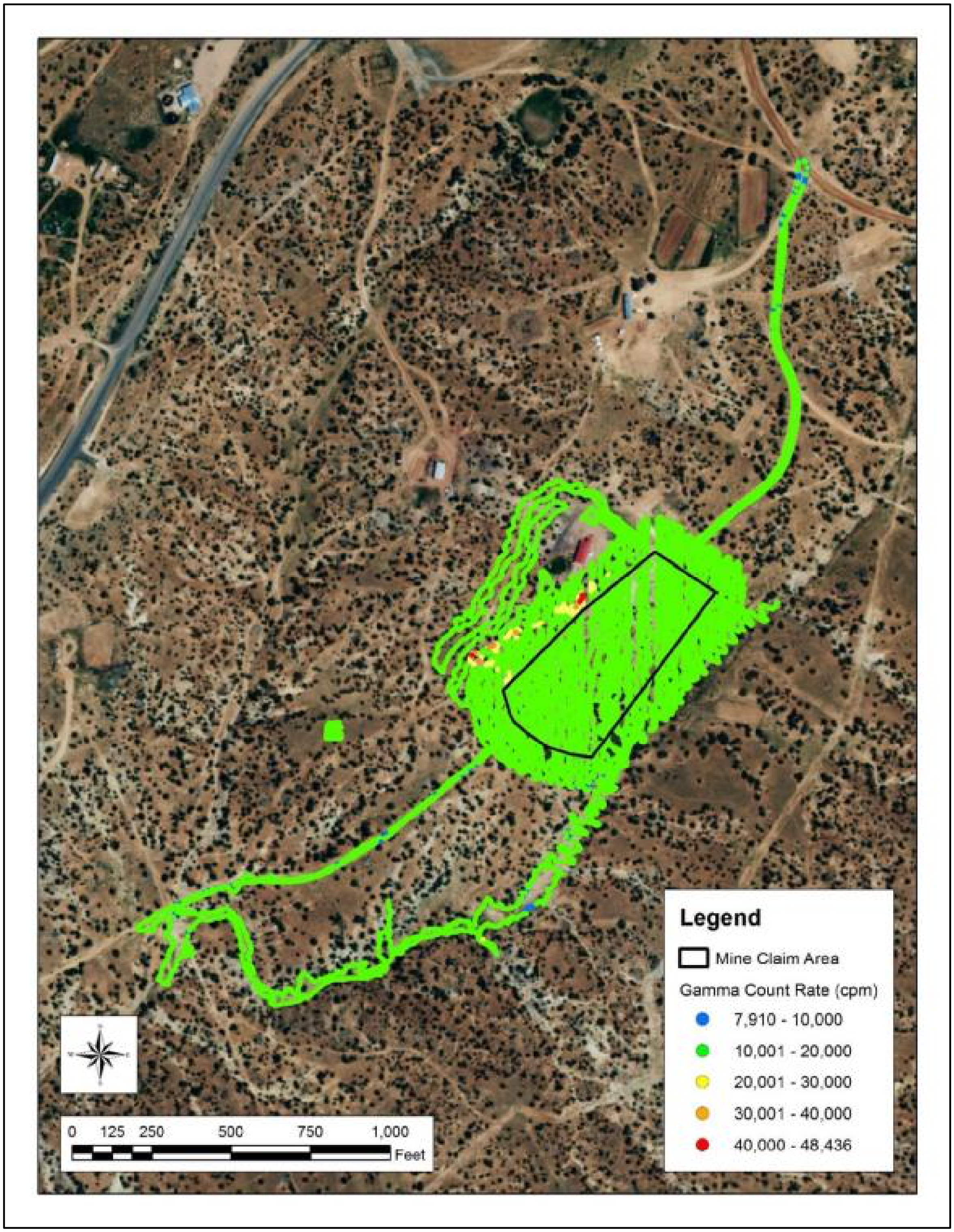


Figure 4. Gamma count rates in the Survey Area.

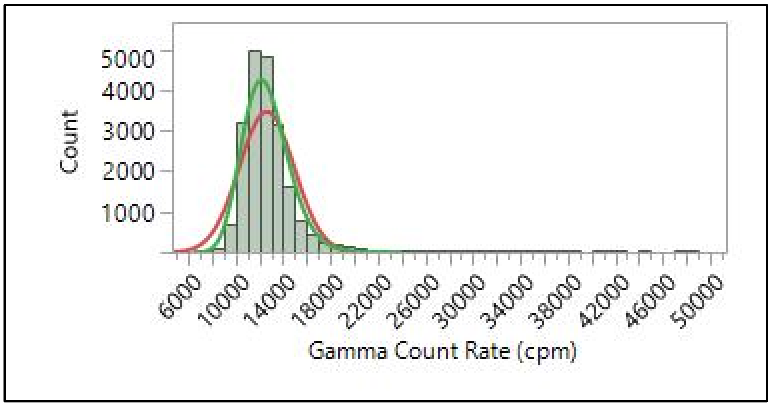


Figure 5. Histogram of gamma count rates in the Survey Area.

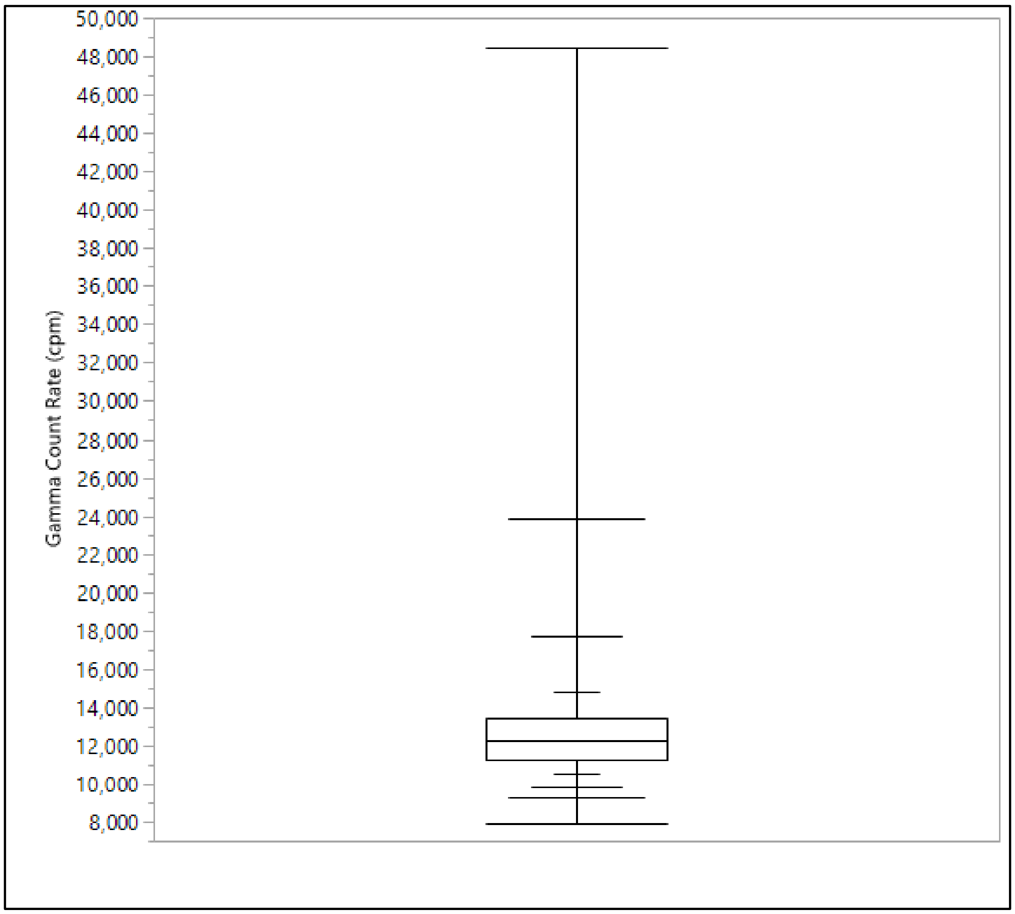


Figure 6. Box plot of gamma count rates in the Survey Area.

Table 3. Summary statistics for gamma count rates in the Survey Area.

Parameter	Gamma Count Rate (cpm)
n	20,123
Minimum	7,910
Maximum	48,436
Mean	12,611
Median	12,238
Standard Deviation	2,314

Notes:
cpm = counts per minute

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 and thorium concentrations in surface soils and gamma count rates

On November 9, 2016 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 AUM. The activities were performed contemporaneously, by area and all on the same day, such that the two could be compared. 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 Fort 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. Table 4 lists the results of the measurements and radium-226 concentrations in the soil samples. The means of the gamma count rate measurements range from 11,090 to 18,508 cpm. The concentrations of radium-226 range from 0.85 to 2.88 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, Laboratory Analytical Data and Data Usability Report, in “Occurrence B Removal Site Evaluation Report” (Stantec, 2017).

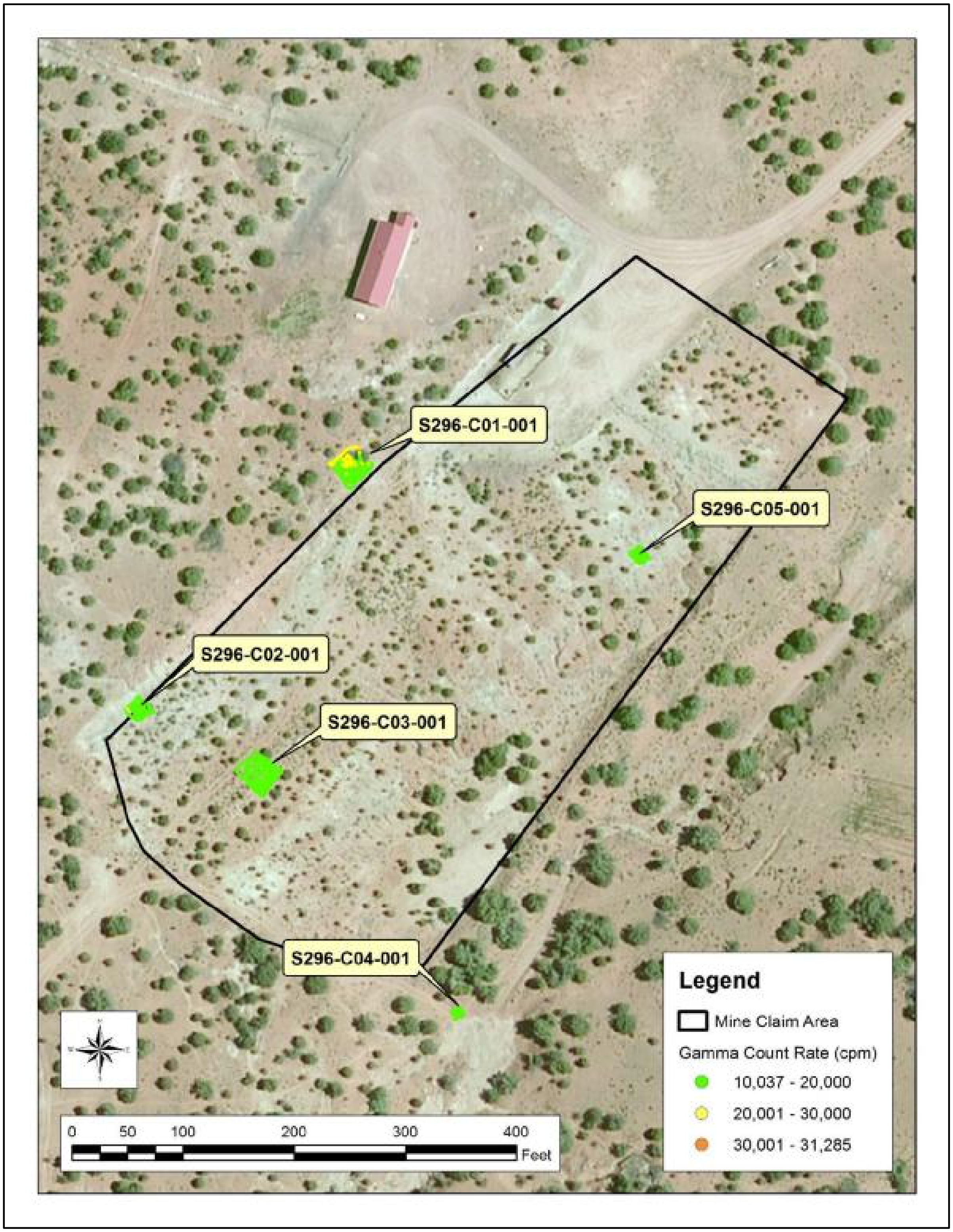


Figure 7. GPS-based gamma count rate measurements made for the correlation study.

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
S296-C01-001	18,508	15,289	31,285	2,252	2.75	0.46	0.5
S296-C02-001	15,874	13,564	20,113	1,397	2.88	0.47	0.45
S296-C03-001	12,065	10,433	14,149	702	1.07	0.27	0.41
S296-C04-001	11,090	10,037	13,204	554	0.85	0.23	0.4
S296-C05-001	13,697	12,021	16,101	831	1.45	0.34	0.48

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
S296-C01-001	1.11	0.19	0.04	2.52	0.41	0.07	1.09	0.19	0.02
S296-C02-001	1.31	0.23	0.04	2.52	0.41	0.07	1.24	0.21	0.02
S296-C03-001	0.79	0.15	0.05	0.82	0.16	0.08	0.73	0.14	0.02
S296-C04-001	0.77	0.14	0.03	0.74	0.14	0.07	0.72	0.13	0.0
S296-C05-001	1.27	0.22	0.05	1.05	0.19	0.07	1.25	0.22	0.02

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, power function with a Pearson's Correlation Coefficient (R^2) of 0.9138, as expressed in the equation:

$$\text{Radium-226 concentration (pCi/g)} = 4 \times 10^{-11} \times \text{Gamma Count Rate (cpm)}^{2.5463}$$

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 correlation are 0.186 and 0.0110, 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 1.31 pCi/g. Given these low concentrations and the high R^2 of the power 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 0.3 to 34 pCi/g, with a mean and median of 1.2 and 1.0 pCi/g, respectively.

Figure 9 shows the predicted concentrations of radium-226, the spatial and numerical distribution of which mirror those depicted in Figure 4.

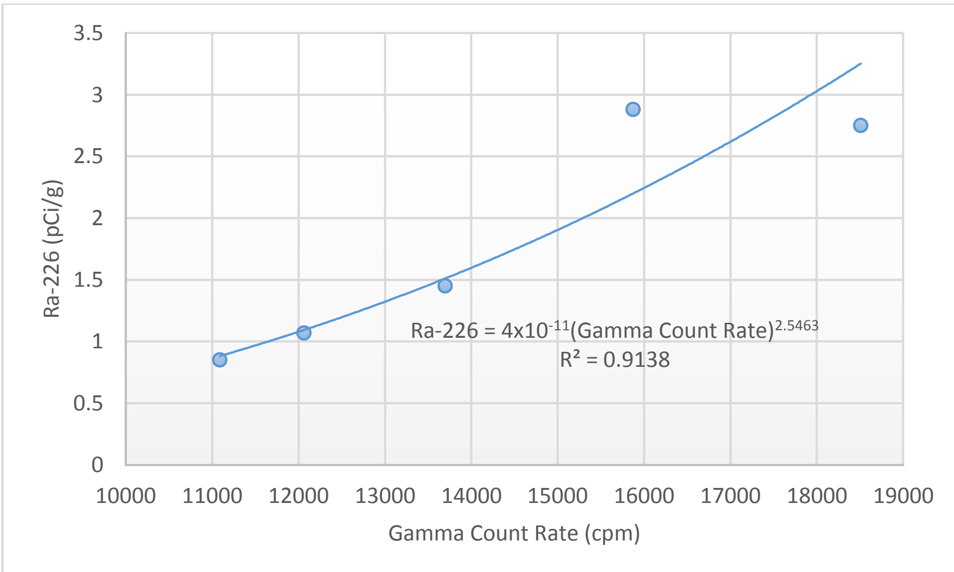


Figure 8. Correlation of gamma count rates and concentrations of radium-226 in surface soils.

Table 6. Predicted concentrations of radium-226 in the Survey Area.

Parameter	Radium-226 (pCi/g)
n	20,203
Minimum	0.3
Maximum	34
Mean	1.2
Median	1.0
Standard Deviation	1.0

Notes:
pCi/g = picocuries per gram

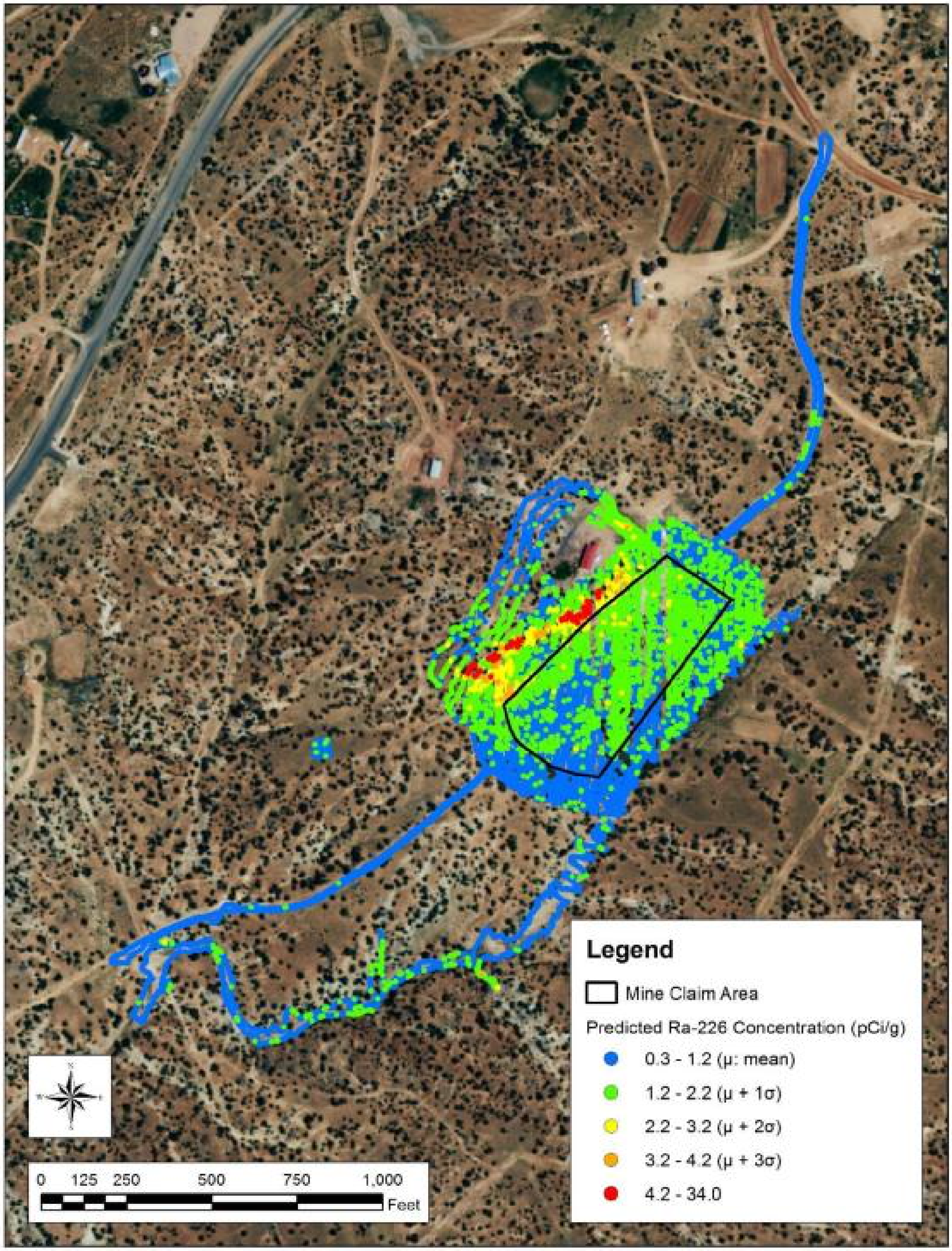


Figure 9. Predicted concentrations of radium-226 in the Survey Area.

3.2 Equilibrium in the uranium series

Secular equilibrium 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 1.1 (Sample S852-C01-001), 1.1 (Sample S852-C02-001), 1.3 (Sample S852-C03-001), 1.1 (Sample S852-C04-001), and 1.4 (Sample S852-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.

3.3 Exposure rates and gamma count rates

Field personnel made co-located one-minute static count rate and exposure rate measurements at the 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 on November 9, 2016 at 0.5 m and 1 m above the ground surface, respectively. The gamma count rate measurements were made using one of the four sodium iodide detection systems used in the GPS-based gamma survey of the Survey Area (Serial Number PR303727/254772). The exposure rate measurements were made using a Reuter Stokes Model RSS-131 high pressure ionization chamber (HPIC) at six-second intervals for about 10 minutes. The exposure rate used in the comparison was the mean of these measurements, less those occurring in initial instrument spikes. 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 individual (one second) exposure rate measurements.

The Pearson's Correlation Coefficient (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 best predictive relationship between the measurements is linear with a R^2 of 0.9504, strongly indicating a positive correlation. The root mean square error and p-value for the correlation are 0.439 and 0.0048, 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:

$$\text{Exposure Rate } (\mu R/h) = 6 \times 10^{-4} \times \text{Gamma Count Rate (cpm)} + 6.8623$$

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 potential Background Reference Area and Survey Area, respectively. The range of predicted exposure rates at BG1 is 12.5 to 15.2 µR/h, with a mean and median of 13.1 and 13.0 µR/h, respectively. The range of predicted exposure rates in the Survey Area is 11.6 to 35.9 µR/h, with a mean and median of 14.4 and 14.2 µR/h, respectively.

Table 7. Co-located gamma count rate and exposure rate measurements.

Location	Gamma Count Rate[a] (cpm)	Exposure Rate (µR/h)
S296-C01-001	18,413	16.8
S296-C02-001	15,966	16.4
S296-C03-001	11,973	13.3
S296-C04-001	11,134	13.1
S296-C05-001	13,974	14.8

Notes:
[a]The gamma count rate is a one-minute, static measurement made at the center of the plot
cpm = counts per minute
µR/h = microRoentgens per hour

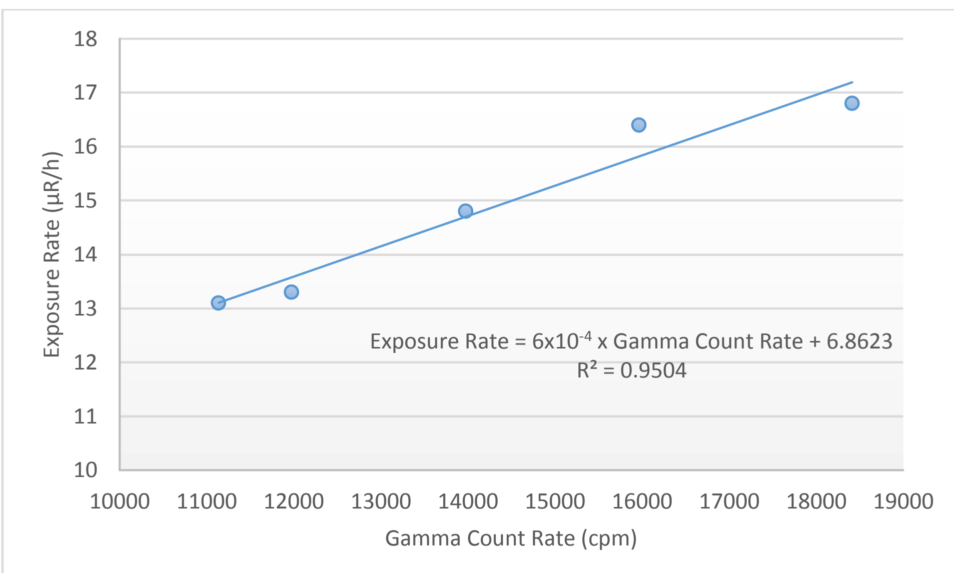


Figure 10. Correlation of gamma count rates and exposure rates.

Table 8. Predicted exposure rates in the potential Background Reference Area.

Parameter	Exposure Rate (µR/h)
n	156
Minimum	12.5
Maximum	15.2
Mean	13.1
Median	13.0
Standard Deviation	0.4

Notes:
µR/h = microRoentgens per hour

Table 9. Predicted exposure rates in the Survey Area.

Parameter	Exposure Rate (µR/h)
n	20,123
Minimum	11.6
Maximum	35.9
Mean	14.4
Median	14.2
Standard Deviation	1.4

Notes:
µR/h = microRoentgens per hour

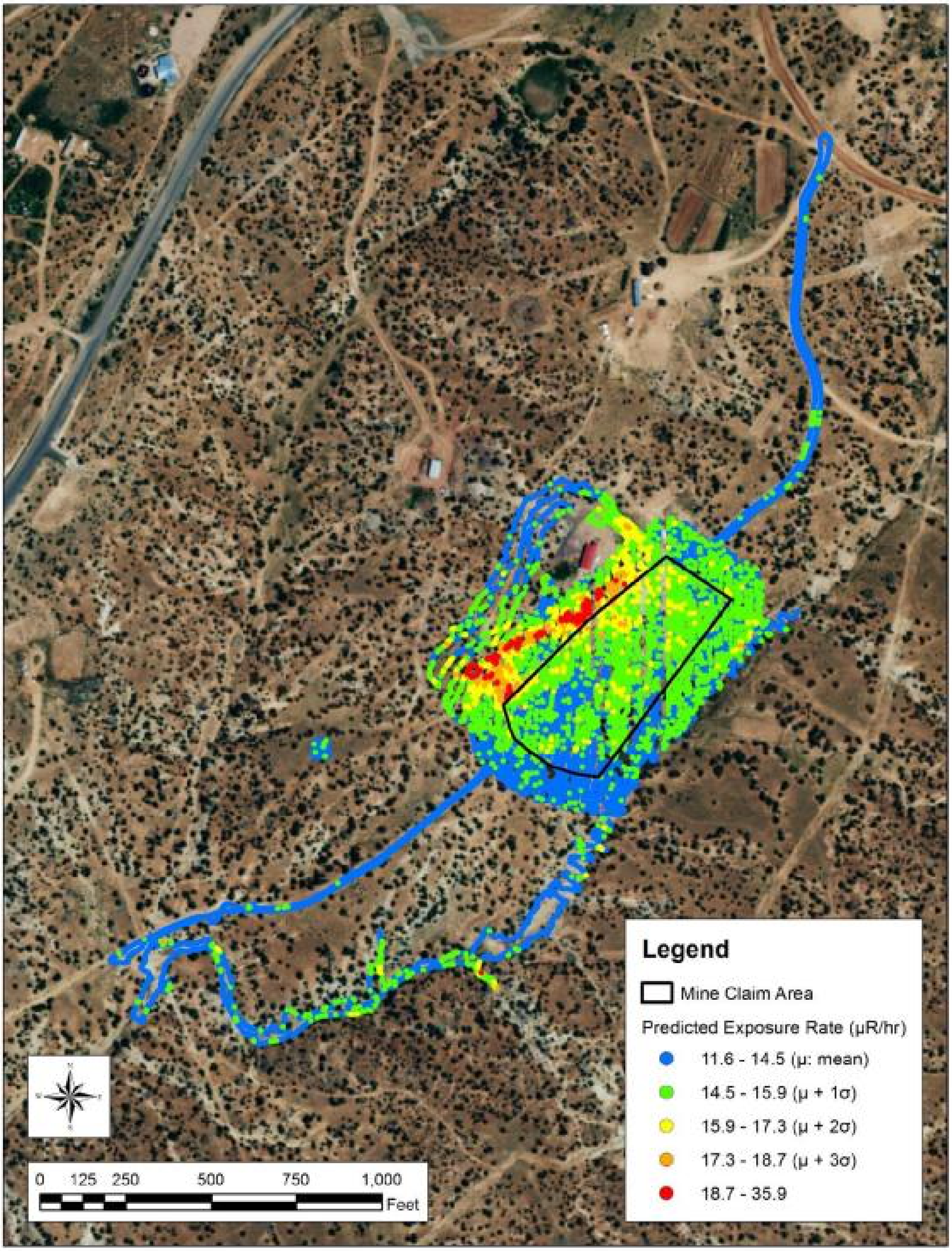


Figure 11. Predicted exposure rates in the Survey Area.

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.

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 observed along a ridge of bedrock off the north end of the mine claim.

- One potential Background Reference Area was established.

- The relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft bgs) is described by a power regression model:

  Radium-226 concentration (pCi/g) = 4×10^{-11} x Gamma Count Rate $(\text{cpm})^{2.5463}$

- 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 0.3 to 34, with a central tendency (median) of 1.0 pCi/g.

- 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 6×10^{-4} + 6.8623

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 11.6 to 35.9, with a central tendency (median) of 14.2 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.

MWH, 2016. Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan, October 24, 2016.

Stantec, 2017. Occurrence B Removal Site Evaluation Report, October 2017.

Appendix A Instrument calibration and completed function check forms

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:	44-10	Serial Number:	PR303727

☑ 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:

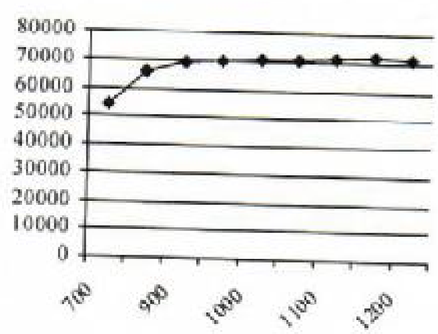
Barometric Pressure: 24.6 inches Hg
Temperature: 73 °F
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Cour
x 1000	400	400	400	398773	400
x 1000	100	100	100		100
x 100	400	400	400	39887	400
x 100	100	100	100		100
x 10	400	400	400	3988	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	53957	
800	65946	
900	69049	
950	69687	
1000	70240	9925
1050	70288	
1100	71224	
1150	71563	
1200	71161	

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: ☐ 8749012
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By:
Calibration Date: 1-20-16
Calibration Due 1-20-17

Reviewed By:
Date: 1/20/16

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration ...

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:	196086
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR295014

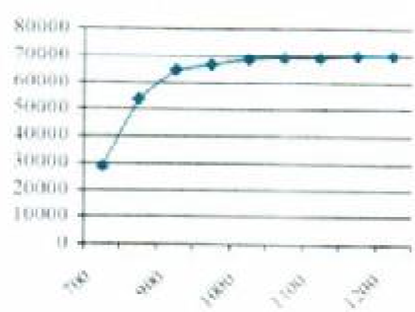
✔ Mechanical Check ✔ THR WIN Operation HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
✔ F/S Response Check ✔ Reset Check Cable Length: ☐ 39-inch ✔ 72-inch Other:
✔ Geotropism ✔ Audio Check
✔ Meter Zeroed ✔ Battery Check (Min 4.4 VDC) Barometric Pressure: 24.78 inches Hg
Source Distance: ☐ Contact ✔ 6 inches ☐ Other: Threshold: 10 mV Temperature: 74 °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	399802	400
x 1000	100	100	100		100
x 100	400	400	400	39989	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
700	28456	
800	53330	
900	64430	
950	66209	
1000	68333	
1050	69077	
1100	69121	8924
1150	69973	
1200	70155	

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: [signature] Calibration Date: 7 [illegible] 16 Calibration Due: 7-[illegible]-17

Reviewed By: [signature] Date: 7/20/16

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:	282966
Detector:	Manufacturer: Ludlum	Model Number:	44-10	Serial Number:	PR150507

☑ 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: 60"
☑ Geotropism ☑ Audio Check
☑ Meter Zeroed ☑ Battery Check (Min 4.4 VDC)

Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Source Geometry: ☑ Side ☐ Below ☐ Other:

Threshold: 10 mV
Window:

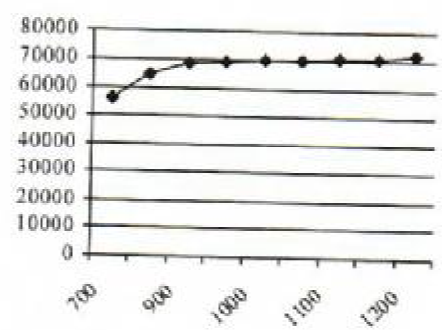
Barometric Pressure: 24.89 inches Hg
Temperature: 73 °F
Relative Humidity: 20 %

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	398753	400
x 1000	100	100	100		100
x 100	400	400	400	39879	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	56463	
800	64304	
900	68534	
950	69331	
1000	69868	9696
1050	70054	
1100	70609	
1150	70681	
1200	71955	

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:

alibrated By: [signature] Calibration Date: 10-31-16 Calibration Due: 10-31-17

eviewed By: [signature] Date: 10/31/16

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:	138368
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR154615

✔ 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:

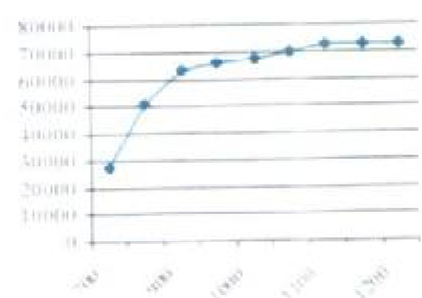
Barometric Pressure: 24.78 inches Hg
Temperature: 74 °F
Relative Humidity: 20 %

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	398436	400
x 1000	100	100	100		100
x 100	400	400	400	39845	400
x 100	100	100	100		100
x 10	400	400	400	3984	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	26998	
800	51037	
900	63340	
950	65550	
1000	67410	
1050	70113	
1100	72217	
1150	72561	9216
1200	72337	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1150

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: 7-6-16
Calibration Due: 7-6-17

Reviewed By:
Date: 7/20/16

K&S Associates, Inc.
1926 Elm Tree Drive
Nashville, Tennessee 37210-3718
Phone 800-522-2325 Fax 615-871-0656

ACCREDITED
CALIBRATION CERT #1866.01

CALIBRATION REPORT

SUBMITTED BY: ERG
8809 Washington Street Northeast
Suite 150
Albuquerque, NM 87113

INSTRUMENT: Reuter Stokes RSS-131, #07J00KM1

REPORT NUMBER: 161866
TEST NUMBER(S) M161588
REPORT DATE: June 29, 2016

The CALIBRATION COEFFICIENTS contained in this report were obtained by intercomparison with instruments calibrated by, or directly traceable to, the National Institute of Standards and Technology (NIST). K• S Associates, Inc. is licensed by the State of Tennessee (R-19075-G97, R-19136-B00) to perform calibrations, and is recognized by the Health Physics Society (HPS) as an ACCREDITED INSTRUMENT CALIBRATION LABORATORY. As part of the accreditation K • S participates in a measurement assurance program conducted by the HPS and NIST. K • S also certifies that the calibration was performed using quality policies, methods and procedures that meet or exceed the requirements of ISO/IEC 17025:2005.

This laboratory is accredited by the American Association for Laboratory Accreditation (A2LA) and the results shown in this report have been determined in accordance with the laboratory's terms of accreditation unless stated otherwise in this report

The CALIBRATION COEFFICIENTS stated herein are valid under the conditions specified. It is the instrument user's responsibility to perform the appropriate constancy tests prior to shipment and after return from calibration. It is also the responsibility of the user to assure that the interpretation of the information in this report is consistent with that intended by K • S Associates, Inc.

K&S Associates, Inc
Nashville, Tennessee 37210-3718

ACCREDITED

CALIBRATION CERTIFICATE

Calibration Date: 6/27/2016 Report Number: 161866 Test Number: M161588

K&S certifies that the environmental radiation monitor identified below has been calibrated for radiation measurement using collimated radiation sources whose output has been calibrated with instruments calibrated by or directly traceable to the National Institute of Standards and Technology. K&S is accredited by the American Association for Laboratory Accreditation to perform environmental level calibrations and further certifies that the calibration was performed using accredited policies and procedures (SI 25) that meet or exceed the requirements of ISO/IEC 17025:2005.

Sensor Type: 100 mR/h

Serial Number: 07J00KM1

Average Calibration Coefficient for the range of 0.012 mR/h – 0.220 mR/h*:
1.02 mR/"mR" reading
(Measured at 4 points)

Calibration Coefficient for the 50.0 mR/h point*:
1.12 mR/"mR" reading

Calibration Coefficient for the 80.0 mR/h point*:
1.10 mR/"mR" reading

Found RAC: 2.169e-8

*Multiply the reading in **mR/h** by the Calibration Coefficient to obtain true **mR/h**.

Calibrated By: Richard Hardison
Title: Calibration Technician

Reviewed By: Angela Roper
Title: Calibration Physicist

Log: M-53 Page: 73

K&S Associates, Inc
Nashville, Tennessee 37210-3718

ACCREDITED

AS FOUND DATA
Reuter-Stokes Chamber Calibration

June 27, 2016 *Test Number M161588*

CHAMBER: **SUBMITTED BY:**

Mfgr: Reuter Stokes ERG

Model: RSS-131

Serial: 07J00KM1 Albuquerque, NM

ORIENTATION/CONDITIONS: **ATMOSPHERIC COMMUNICATION:** SEALED

Serial number away from source

"True" background exposure rate of 6.7 uR/h, instrument reading was 0.0076 mR/h

POLARIZING POTENTIAL 401V **LEAKAGE:** negligible

BEAM QUALITY BEAM		EXPOSURE RATE		CALIBRATION COEFFICIENT	UNCERT	LOG
CsEn220	(11mCi)	0.22mR/h	$N_x=$	1.00 mR/h/rdg	11%	M-53 73
CsEn80	(11mCi)	0.08mR/h	$N_x=$	1.03 mR/h/rdg	11%	
CsEnv12	(1mCi)	0.012mR/h	$N_x=$	1.01 mR/h/rdg	11%	
CsEnv15	(1mCi)	0.015mR/h	$N_x=$	1.02 mR/h/rdg	11%	
Cs199m	(20 Ci)	50mR/h	$N_x=$	1.12 mR/h/rdg	8%	
Cs252m	(20 Ci)	80mR/h	$N_x=$	1.10 mR/h/rdg	8%	

Comments Batt: 6.1V, Temp: 24.6 deg C, K&S Environment: Temp:21 deg C , RH 59%, Press: 752 mmHg;
Report Number: 161866
Refer to Appendix I of this report for details on PIC ionization chamber calibrations. Procedure: SI 25
RAC Found: 2.169e-8

Calibrated By Richard Hardison **Reviewed By:**

Title: Calibration Technician **Title:** Calibration Physicist

Checked By: **Prepared By:** REH

Form RSS

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	GE
Model:	2S3-131
Serial No.:	07JOUKM1
Cal. Due Date:	6-29-17

DETECTOR	
Manufacturer:	SAME AS METER
Model:	
Serial No.:	
Cal. Due Date:	

Comments:
NNERT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-6-94 Distance to Source: Contact - housing

Serial No.: 333-54 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts µR/h	BKG Counts µR/h	Net Counts	Initials	Note(s): Project reference points
10-26-16	0525	~6.4	~400	NA	~27.8	~10.5	~17.3	NW	Best Western room - Flagstaff
10-26-16	2010	~6.3	~400	NA	~26	~9.5	~16.5	NW	Gouldings room ~~Best Western room - Flagstaff~~ NW
10-27-16	0720	~6.2	~400	NA	~26.7	~10.0	~16.7	NW	Gouldings room
10-27-16	1710	~6.2	~400	NA	~27.0	~10.8	~16.2	NW	Gouldings room
10-31-16	0609	~6.3	~400	NA	~27.0	~10	~16	NW	Gouldings room
10-31-16	1520	~6.3	~400	NA	~26	~10	~16	NW	Gouldings room
11-3-16	0700	~6.2	~400	NA	~26.5	~10.5	~16	NW	Gouldings room
11-3-16	1924	~6.1	~400	NA	~28.8	~12.5	~16.3	NW	Holiday Inn Chinle-room
11-9-16	0615	~6.3	~400	NA	~30	~12.8	~17.2	NW	Holiday Inn-Chinle room
11-9-16	1430	~6.2	~400	NA	~29.5	~12.5	~17	NW	Holiday Inn Chinle-room
11-11-16	0610	~6.4	~400	NA	~31.5	~13.5	~18	NW	Holiday Inn Chinle-room
11-11-16	1825	~6.2	~400	NA	~28	~11	~17	NW	Holiday Inn Chinle-room

Reviewed by: [signature] Review Date: 11-29-16

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.:	196086
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR295014
Cal. Due Date:	7-9-17

Comments:
NNERT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-6-94 Distance to Source: 6 Inches

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference points
11-1-16	0744	5.3	1107	100	43406	4729	38677	NW	Charles Keith
11-1-16	1718	5.2	1102	99	44319	5332	38987	NW	Goulding's in SUV
11-2-16	0818	5.2	1108	100	43456	5555	37901	NW	Charles Keith
11-2-16	1703	5.1	1101	100	43874	5111	38763	NW	Gouldings in SUV
a 11-3-16	1050	6.2	1107	100	45017	5399	39618	NW	Charles Keith
11-3-16	1845	6.2	1104	99	47896	7562	40334	NW	Chinle Holiday Inn SUV
11-4-16	0856	6.2	1109	100	47119	8387	38732	NW	Occurrence B
11-4-16	1147	6.1	1105	100	46025	7972	38053	NW	Occurrence B
11-5-16	1112	6.1	1107	100	47483	8555	38928	NW	Claim 28
11-5-16	1824	6.1	1107	99	46828	7017	39811	NW	Chinle lot in SUV
11-7-16	0822	6.1	1108	100	46734	8744	37990	NW	Claim 28
11-7-16	1829	5.9	1104	99	46382	6448	39934	NW	Chinle lot

a. Charged batteries

Reviewed by: [signature] Review Date: 11/29/16

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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.:	196086
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR295014
Cal. Due Date:	7-9-17

Comments:
NNEST

Source: Cs-137 Activity: 5.12 µCi Source Date: 6-6-94 Distance to Source: 6 inches

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference points
11-8-16	0805	6.0	1109	100	49571	9246	40325	NW	Claim 28
11-8-16	1641	5.8	1104	100	45893	6864	39029	NW	Childe lot
11-9-16	0724	5.8	1110	101	46451	8453	37998	NW	occurrence B
11-9-16	1925	5.8	1104	100	47096	6903	40193	NW	Childe lot
11-10-16	0826	5.8	1107	100	47011	9425	37586	NW	Claim 28
11-10-16	1628	5.7	1103	100	48672	8509	40163	NW	Claim 28 (2nd location)
11-12-16	0834	5.7	1109	101	47463	9188	38275	NW	Hoskie Tso
11-12-16	1347	5.6	1101	101	48929	8265	40664	NW	Hoskie Tso
11-14-16	1218	5.7	1105	100	48870	8074	40796	NW	Hoskie Tso
11-14-16	1639	5.7	1105	100	47696	9068	38628	NW	Hoskie Tso (2nd location)
11-15-16	0834	5.7	1110	101	50555	~~9145~~ 9150 NW	41405	NW	Hoskie Tso
11-15-16	1142	5.5	1101	100	48004	8598	39406	NW	Hoskie Tso

Reviewed by: MM Review Date: 11/29/16

(1)

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:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	7-9-17

Comments:
NNERT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-6-94 Distance to Source: 6 inches

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference points
11-9-16	0729	5.6	1009	100	47673	8821	38852	NW	Occurrence B
11-9-16	1415	5.4	1002	99	46465	7541	38924	NW	Christle lol
11-10-16	0820	5.6	1011	100	47628	9750	37878	NW	Claim 28
11-10-16	1632	5.4	1002	99	50634	8930	41704	NW	Claim 28 (2nd location)
11-11-16	0816	5.5	1010	100	49034	9824	39210	NW	Claim 28
11-11-16	1555	5.4	1002	99	48985	8643	40342	NW	Occurrence B
11-12-16	0819	5.5	1009	100	49296	9054	40242	NW	Hoskie Tso
11-12-16	1340	5.3	1002	99	49800	8556	41244	NW	Hoskie Tso
11-14-16	0818	5.5	1012	100	47737	9609	38128	NW	Hoskie Tso
11-14-16	1637	5.3	1002	99	47714	9150	38564	NW	Hoskie Tso (2nd location)
11-16-16	0809	5.4	1011	100	49413	12340	37073	NW	Standing Rock
11-16-16	1510	5.3	1003	99	49649	11268	38381	NW	Gallup lol

Reviewed by: MM Review Date: 11/29/16

ERG Form ITC.201.A

(3)

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.:	138368
Cal. Due Date:	7-19-16

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR154615
Cal. Due Date:	7-19-16

Comments:
NNERT

Source: Cs-137　Activity: 5.17 uCi　Source Date: 6-16-94　Distance to Source: 6 in.

Serial No.: 333-94　Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
10-28-16	0813	5.6	1162	144	50583	9051	41532	NW	Harvey Blackwater
10-29-16	0815	5.6	1222	199	44566	5053	39513	NW	Mitten No. 3
10-29-16	1338	5.5	1141	125	44503	4794	39709	NW	Mitten No. 3
10-31-16	0846	5.5	1133	111	44824	4753	40071	NW	Mitten No. 3
10-31-16	1502	5.5	1132	114	44994	4883	40111	NW	Goulding's in SUV
11-1-16	0758	5.5	1133	110	45344	4771	40573	NW	Charles Keith
11-1-16	1712	5.3	1120	100	44220	4928	39292	NW	Goulding's in SUV
11-2-16	0826	5.3	1127	103	44389	5834	38555	NW	Charles Keith
11-2-16	1715	5.3	1125	106	43737	5179	38558	NW	Goulding's in SUV
11-3-16	1055	5.3	1125	105	44443	5368	39075	NW	Charles Keith
11-3-16	1842	5.3	1123	104	47047	7583	39464	NW	Chinle Holiday Inn SUV
11-4-16	0900	5.4	1128	134	46230	8402	37828	NW	Occurrence B

Reviewed by: MA　　Review Date: 11/29/16

(3)

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.:	138638
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR 154615
Cal. Due Date:	7-9-17

Comments:
NNERT

Source: Cs-137 Activity: 5.R uCi Source Date: 6-6-94 Distance to Source: 6 Inches

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference points
11-4-16	1143	5.2	1131	110	46332	8240	38092	NW	Occurrence B
11-5-16	1117	5.4	1135	112	46611	8815	37796	NW	Claim 28
11-5-16	1519	5.2	1127	104	46761	7064	39697	NW	Chinle lot
11-7-16	0815	5.3	1130	107	49792	8843	40949	NW	Claim 28
11-7-16	1821	5.2	1120	100	47318	6436	40882	NW	Chinle lot
11-16-16	0821	5.4	1158	132	50609	11976	38633	NW	Standing Rock
11-16-16	1507	5.2	1125	106	49562	10942	38620	NW	Gallup lot
				NW 12-6-16					

Reviewed by: MM Review Date: 11/29/16

(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.:	282966
Cal. Due Date:	10-31-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR150507
Cal. Due Date:	10-31-17

Comments: NNERT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-6-94 Distance to Source: 6 inches

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference point,
11-2-16	0832	6.0	1007	100	43939	6161	37778	NW	Charles keith
11-2-16	1711	6.0	1003	101	44857	5744	39113	NW	Goulding's in SUV
11-4-16	0904	6.0	1008	101	47156	8938	38218	NW	Occurrence B
11-4-16	1152	5.9	1007	101	46787	8341	38446	NW	Occurrence B
11-5-16	1121	6.0	1007	101	47567	9195	38372	NW	Claim 28
11-5-16	1531	5.9	1007	101	46740	7360	39380	NW	Chinle lot in SUV
11-7-16	0810	6.0	1010	104	49757	9136	40621	NW	Claim 28
11-7-16	1832	5.8	1003	100	45791	6809	38982	NW	Chinle lot
11-8-16	0810	5.8	1009	100	49552	9855	39697	NW	Claim 28
11-8-16	1634	5.7	1003	100	48686	7133	41553	NW	Chinle lot
11-10-16	0812	5.8	1012	101	48023	9818	38205	NW	Claim 28
11-10-16	1635	5.7	1003	101	46906	9042	37864	NW	Claim 28 (2nd location)

Reviewed by: MJ Review Date: 11/29/16

Appendix B Exposure Rate Measurements

Date and Time	Exposure Rate (mR/h)	Location
11/09/2016 10:00	0.0548	Correlation Location 1
11/09/2016 10:00	0.0965	Correlation Location 1
11/09/2016 10:00	0.0856	Correlation Location 1
11/09/2016 10:00	0.0603	Correlation Location 1
11/09/2016 10:00	0.0411	Correlation Location 1
11/09/2016 10:00	0.029	Correlation Location 1
11/09/2016 10:00	0.0227	Correlation Location 1
11/09/2016 10:01	0.0198	Correlation Location 1
11/09/2016 10:01	0.018	Correlation Location 1
11/09/2016 10:01	0.0177	Correlation Location 1
11/09/2016 10:01	0.0168	Correlation Location 1
11/09/2016 10:01	0.0164	Correlation Location 1
11/09/2016 10:01	0.0162	Correlation Location 1
11/09/2016 10:01	0.0166	Correlation Location 1
11/09/2016 10:01	0.017	Correlation Location 1
11/09/2016 10:01	0.017	Correlation Location 1
11/09/2016 10:01	0.017	Correlation Location 1
11/09/2016 10:02	0.017	Correlation Location 1
11/09/2016 10:02	0.017	Correlation Location 1
11/09/2016 10:02	0.0172	Correlation Location 1
11/09/2016 10:02	0.0172	Correlation Location 1
11/09/2016 10:02	0.0172	Correlation Location 1
11/09/2016 10:02	0.0174	Correlation Location 1
11/09/2016 10:02	0.0173	Correlation Location 1
11/09/2016 10:02	0.0173	Correlation Location 1
11/09/2016 10:02	0.017	Correlation Location 1
11/09/2016 10:02	0.0166	Correlation Location 1
11/09/2016 10:03	0.0166	Correlation Location 1
11/09/2016 10:03	0.0165	Correlation Location 1
11/09/2016 10:03	0.0165	Correlation Location 1
11/09/2016 10:03	0.0168	Correlation Location 1
11/09/2016 10:03	0.017	Correlation Location 1
11/09/2016 10:03	0.0168	Correlation Location 1
11/09/2016 10:03	0.0169	Correlation Location 1
11/09/2016 10:03	0.017	Correlation Location 1
11/09/2016 10:03	0.0174	Correlation Location 1
11/09/2016 10:03	0.0174	Correlation Location 1
11/09/2016 10:04	0.017	Correlation Location 1
11/09/2016 10:04	0.0169	Correlation Location 1
11/09/2016 10:04	0.0168	Correlation Location 1
11/09/2016 10:04	0.017	Correlation Location 1
11/09/2016 10:04	0.0173	Correlation Location 1
11/09/2016 10:04	0.017	Correlation Location 1
11/09/2016 10:04	0.017	Correlation Location 1
11/09/2016 10:04	0.0166	Correlation Location 1
11/09/2016 10:04	0.0167	Correlation Location 1
11/09/2016 10:04	0.017	Correlation Location 1
11/09/2016 10:05	0.0169	Correlation Location 1
11/09/2016 10:05	0.0164	Correlation Location 1
11/09/2016 10:05	0.0164	Correlation Location 1
11/09/2016 10:05	0.0169	Correlation Location 1
11/09/2016 10:05	0.017	Correlation Location 1
11/09/2016 10:05	0.0164	Correlation Location 1
11/09/2016 10:05	0.0163	Correlation Location 1
11/09/2016 10:05	0.0162	Correlation Location 1
11/09/2016 10:05	0.0166	Correlation Location 1
11/09/2016 10:05	0.0169	Correlation Location 1
11/09/2016 10:06	0.017	Correlation Location 1
11/09/2016 10:06	0.0168	Correlation Location 1
11/09/2016 10:06	0.0166	Correlation Location 1
11/09/2016 10:06	0.0165	Correlation Location 1
11/09/2016 10:06	0.0165	Correlation Location 1
11/09/2016 10:06	0.0165	Correlation Location 1
11/09/2016 10:06	0.0166	Correlation Location 1
11/09/2016 10:06	0.0166	Correlation Location 1
11/09/2016 10:06	0.0166	Correlation Location 1
11/09/2016 10:06	0.0165	Correlation Location 1
11/09/2016 10:07	0.0165	Correlation Location 1
11/09/2016 10:07	0.0165	Correlation Location 1
11/09/2016 10:07	0.0168	Correlation Location 1
11/09/2016 10:07	0.017	Correlation Location 1
11/09/2016 10:07	0.017	Correlation Location 1
11/09/2016 10:07	0.017	Correlation Location 1
11/09/2016 10:07	0.0173	Correlation Location 1
11/09/2016 10:07	0.0172	Correlation Location 1
11/09/2016 10:07	0.017	Correlation Location 1
11/09/2016 10:07	0.0173	Correlation Location 1
11/09/2016 10:08	0.0176	Correlation Location 1
11/09/2016 10:08	0.0176	Correlation Location 1
11/09/2016 10:08	0.0175	Correlation Location 1
11/09/2016 10:08	0.0173	Correlation Location 1
11/09/2016 10:08	0.0172	Correlation Location 1
11/09/2016 10:08	0.017	Correlation Location 1
11/09/2016 10:08	0.0169	Correlation Location 1
11/09/2016 10:08	0.017	Correlation Location 1
11/09/2016 10:08	0.017	Correlation Location 1
11/09/2016 10:08	0.0172	Correlation Location 1
11/09/2016 10:09	0.0169	Correlation Location 1
11/09/2016 10:09	0.0168	Correlation Location 1
11/09/2016 10:09	0.0164	Correlation Location 1
11/09/2016 10:09	0.0163	Correlation Location 1
11/09/2016 10:09	0.0163	Correlation Location 1
11/09/2016 10:09	0.0162	Correlation Location 1
11/09/2016 10:09	0.0161	Correlation Location 1
11/09/2016 10:09	0.0158	Correlation Location 1
11/09/2016 10:09	0.0155	Correlation Location 1
11/09/2016 10:09	0.0158	Correlation Location 1
11/09/2016 10:10	0.0167	Correlation Location 1
11/09/2016 10:10	0.0172	Correlation Location 1
11/09/2016 10:10	0.0169	Correlation Location 1
11/09/2016 10:10	0.0168	Correlation Location 1
11/09/2016 10:10	0.0168	Correlation Location 1
11/09/2016 10:10	0.0167	Correlation Location 1
11/09/2016 10:10	0.0163	Correlation Location 1
11/09/2016 10:10	0.0163	Correlation Location 1
11/09/2016 10:10	0.0166	Correlation Location 1
11/09/2016 10:10	0.0165	Correlation Location 1
11/09/2016 10:11	0.0166	Correlation Location 1
11/09/2016 10:11	0.0167	Correlation Location 1
11/09/2016 10:11	0.0169	Correlation Location 1
11/09/2016 10:40	0.0544	Correlation Location 2
11/09/2016 10:40	0.0955	Correlation Location 2

Occurrence B Exposure Rate Measurements for Correlation

Date and Time	Exposure Rate (mR/h)	Location	Date and Time	Exposure Rate (mR/h)	Location
11/09/2016 10:40	0.084	Correlation Location 2	11/09/2016 10:46	0.0165	Correlation Location 2
11/09/2016 10:40	0.0589	Correlation Location 2	11/09/2016 10:46	0.0166	Correlation Location 2
11/09/2016 10:40	0.04	Correlation Location 2	11/09/2016 10:46	0.0168	Correlation Location 2
11/09/2016 10:41	0.0283	Correlation Location 2	11/09/2016 10:46	0.0168	Correlation Location 2
11/09/2016 10:41	0.0217	Correlation Location 2	11/09/2016 10:46	0.0169	Correlation Location 2
11/09/2016 10:41	0.019	Correlation Location 2	11/09/2016 10:46	0.0167	Correlation Location 2
11/09/2016 10:41	0.0178	Correlation Location 2	11/09/2016 10:47	0.0163	Correlation Location 2
11/09/2016 10:41	0.0175	Correlation Location 2	11/09/2016 10:47	0.016	Correlation Location 2
11/09/2016 10:41	0.017	Correlation Location 2	11/09/2016 10:47	0.0158	Correlation Location 2
11/09/2016 10:41	0.0168	Correlation Location 2	11/09/2016 10:47	0.0163	Correlation Location 2
11/09/2016 10:41	0.0165	Correlation Location 2	11/09/2016 10:47	0.0163	Correlation Location 2
11/09/2016 10:41	0.0163	Correlation Location 2	11/09/2016 10:47	0.0162	Correlation Location 2
11/09/2016 10:41	0.0162	Correlation Location 2	11/09/2016 10:47	0.0165	Correlation Location 2
11/09/2016 10:42	0.0161	Correlation Location 2	11/09/2016 10:47	0.0165	Correlation Location 2
11/09/2016 10:42	0.0156	Correlation Location 2	11/09/2016 10:47	0.0163	Correlation Location 2
11/09/2016 10:42	0.0155	Correlation Location 2	11/09/2016 10:47	0.0162	Correlation Location 2
11/09/2016 10:42	0.016	Correlation Location 2	11/09/2016 10:48	0.0164	Correlation Location 2
11/09/2016 10:42	0.0162	Correlation Location 2	11/09/2016 10:48	0.0163	Correlation Location 2
11/09/2016 10:42	0.0162	Correlation Location 2	11/09/2016 10:48	0.0163	Correlation Location 2
11/09/2016 10:42	0.0166	Correlation Location 2	11/09/2016 10:48	0.0161	Correlation Location 2
11/09/2016 10:42	0.0166	Correlation Location 2	11/09/2016 10:48	0.0164	Correlation Location 2
11/09/2016 10:42	0.0166	Correlation Location 2	11/09/2016 10:48	0.017	Correlation Location 2
11/09/2016 10:42	0.0166	Correlation Location 2	11/09/2016 10:48	0.017	Correlation Location 2
11/09/2016 10:43	0.0167	Correlation Location 2	11/09/2016 10:48	0.0165	Correlation Location 2
11/09/2016 10:43	0.0163	Correlation Location 2	11/09/2016 10:48	0.0164	Correlation Location 2
11/09/2016 10:43	0.0162	Correlation Location 2	11/09/2016 10:48	0.0163	Correlation Location 2
11/09/2016 10:43	0.0166	Correlation Location 2	11/09/2016 10:49	0.0158	Correlation Location 2
11/09/2016 10:43	0.0169	Correlation Location 2	11/09/2016 10:49	0.0158	Correlation Location 2
11/09/2016 10:43	0.0168	Correlation Location 2	11/09/2016 10:49	0.0162	Correlation Location 2
11/09/2016 10:43	0.0167	Correlation Location 2	11/09/2016 10:49	0.0164	Correlation Location 2
11/09/2016 10:43	0.0167	Correlation Location 2	11/09/2016 10:49	0.0166	Correlation Location 2
11/09/2016 10:43	0.0166	Correlation Location 2	11/09/2016 10:49	0.017	Correlation Location 2
11/09/2016 10:43	0.0165	Correlation Location 2	11/09/2016 10:49	0.017	Correlation Location 2
11/09/2016 10:44	0.0165	Correlation Location 2	11/09/2016 10:49	0.0165	Correlation Location 2
11/09/2016 10:44	0.0167	Correlation Location 2	11/09/2016 10:49	0.0163	Correlation Location 2
11/09/2016 10:44	0.0168	Correlation Location 2	11/09/2016 10:49	0.0163	Correlation Location 2
11/09/2016 10:44	0.0169	Correlation Location 2	11/09/2016 10:50	0.0164	Correlation Location 2
11/09/2016 10:44	0.0166	Correlation Location 2	11/09/2016 10:50	0.0164	Correlation Location 2
11/09/2016 10:44	0.0161	Correlation Location 2	11/09/2016 10:50	0.0166	Correlation Location 2
11/09/2016 10:44	0.0158	Correlation Location 2	11/09/2016 10:50	0.0166	Correlation Location 2
11/09/2016 10:44	0.0162	Correlation Location 2	11/09/2016 10:50	0.0168	Correlation Location 2
11/09/2016 10:44	0.0164	Correlation Location 2	11/09/2016 10:50	0.0167	Correlation Location 2
11/09/2016 10:44	0.0166	Correlation Location 2	11/09/2016 10:50	0.0166	Correlation Location 2
11/09/2016 10:45	0.0161	Correlation Location 2	11/09/2016 10:50	0.0167	Correlation Location 2
11/09/2016 10:45	0.016	Correlation Location 2	11/09/2016 10:50	0.0168	Correlation Location 2
11/09/2016 10:45	0.0163	Correlation Location 2	11/09/2016 10:50	0.0165	Correlation Location 2
11/09/2016 10:45	0.0163	Correlation Location 2	11/09/2016 10:51	0.0166	Correlation Location 2
11/09/2016 10:45	0.0163	Correlation Location 2	11/09/2016 10:51	0.0167	Correlation Location 2
11/09/2016 10:45	0.0163	Correlation Location 2	11/09/2016 10:51	0.0167	Correlation Location 2
11/09/2016 10:45	0.0162	Correlation Location 2	11/09/2016 10:51	0.016	Correlation Location 2
11/09/2016 10:45	0.0158	Correlation Location 2	11/09/2016 10:51	0.0161	Correlation Location 2
11/09/2016 10:45	0.016	Correlation Location 2	11/09/2016 10:51	0.0165	Correlation Location 2
11/09/2016 10:45	0.0164	Correlation Location 2	11/09/2016 11:16	0.054	Correlation Location 3
11/09/2016 10:46	0.0169	Correlation Location 2	11/09/2016 11:16	0.0942	Correlation Location 3
11/09/2016 10:46	0.0168	Correlation Location 2	11/09/2016 11:17	0.0828	Correlation Location 3
11/09/2016 10:46	0.0165	Correlation Location 2	11/09/2016 11:17	0.0573	Correlation Location 3
11/09/2016 10:46	0.0162	Correlation Location 2	11/09/2016 11:17	0.0378	Correlation Location 3

Occurrence B Exposure Rate Measurements for Correlation

Date and Time	Exposure Rate (mR/h)	Location
11/09/2016 11:17	0.0265	Correlation Location 3
11/09/2016 11:17	0.0199	Correlation Location 3
11/09/2016 11:17	0.0161	Correlation Location 3
11/09/2016 11:17	0.0145	Correlation Location 3
11/09/2016 11:17	0.0138	Correlation Location 3
11/09/2016 11:17	0.0136	Correlation Location 3
11/09/2016 11:17	0.0133	Correlation Location 3
11/09/2016 11:18	0.0131	Correlation Location 3
11/09/2016 11:18	0.0128	Correlation Location 3
11/09/2016 11:18	0.0131	Correlation Location 3
11/09/2016 11:18	0.0134	Correlation Location 3
11/09/2016 11:18	0.0135	Correlation Location 3
11/09/2016 11:18	0.0134	Correlation Location 3
11/09/2016 11:18	0.0132	Correlation Location 3
11/09/2016 11:18	0.0134	Correlation Location 3
11/09/2016 11:18	0.0136	Correlation Location 3
11/09/2016 11:18	0.0133	Correlation Location 3
11/09/2016 11:19	0.0129	Correlation Location 3
11/09/2016 11:19	0.0122	Correlation Location 3
11/09/2016 11:19	0.0122	Correlation Location 3
11/09/2016 11:19	0.0127	Correlation Location 3
11/09/2016 11:19	0.0132	Correlation Location 3
11/09/2016 11:19	0.0135	Correlation Location 3
11/09/2016 11:19	0.0137	Correlation Location 3
11/09/2016 11:19	0.0138	Correlation Location 3
11/09/2016 11:19	0.014	Correlation Location 3
11/09/2016 11:19	0.014	Correlation Location 3
11/09/2016 11:20	0.0138	Correlation Location 3
11/09/2016 11:20	0.0138	Correlation Location 3
11/09/2016 11:20	0.0138	Correlation Location 3
11/09/2016 11:20	0.0137	Correlation Location 3
11/09/2016 11:20	0.0139	Correlation Location 3
11/09/2016 11:20	0.014	Correlation Location 3
11/09/2016 11:20	0.0138	Correlation Location 3
11/09/2016 11:20	0.0138	Correlation Location 3
11/09/2016 11:20	0.0136	Correlation Location 3
11/09/2016 11:20	0.0136	Correlation Location 3
11/09/2016 11:21	0.0137	Correlation Location 3
11/09/2016 11:21	0.0136	Correlation Location 3
11/09/2016 11:21	0.0133	Correlation Location 3
11/09/2016 11:21	0.0135	Correlation Location 3
11/09/2016 11:21	0.0137	Correlation Location 3
11/09/2016 11:21	0.0136	Correlation Location 3
11/09/2016 11:21	0.0136	Correlation Location 3
11/09/2016 11:21	0.0135	Correlation Location 3
11/09/2016 11:21	0.0133	Correlation Location 3
11/09/2016 11:21	0.0134	Correlation Location 3
11/09/2016 11:22	0.0136	Correlation Location 3
11/09/2016 11:22	0.0136	Correlation Location 3
11/09/2016 11:22	0.0131	Correlation Location 3
11/09/2016 11:22	0.0128	Correlation Location 3
11/09/2016 11:22	0.0128	Correlation Location 3
11/09/2016 11:22	0.013	Correlation Location 3
11/09/2016 11:22	0.0132	Correlation Location 3
11/09/2016 11:22	0.0132	Correlation Location 3
11/09/2016 11:22	0.0128	Correlation Location 3
11/09/2016 11:22	0.0133	Correlation Location 3

Date and Time	Exposure Rate (mR/h)	Location
11/09/2016 11:23	0.0137	Correlation Location 3
11/09/2016 11:23	0.0136	Correlation Location 3
11/09/2016 11:23	0.0133	Correlation Location 3
11/09/2016 11:23	0.0128	Correlation Location 3
11/09/2016 11:23	0.0127	Correlation Location 3
11/09/2016 11:23	0.0131	Correlation Location 3
11/09/2016 11:23	0.0132	Correlation Location 3
11/09/2016 11:23	0.013	Correlation Location 3
11/09/2016 11:23	0.0129	Correlation Location 3
11/09/2016 11:23	0.0132	Correlation Location 3
11/09/2016 11:24	0.0134	Correlation Location 3
11/09/2016 11:24	0.0136	Correlation Location 3
11/09/2016 11:24	0.0137	Correlation Location 3
11/09/2016 11:24	0.014	Correlation Location 3
11/09/2016 11:24	0.014	Correlation Location 3
11/09/2016 11:24	0.0138	Correlation Location 3
11/09/2016 11:24	0.0136	Correlation Location 3
11/09/2016 11:24	0.0139	Correlation Location 3
11/09/2016 11:24	0.014	Correlation Location 3
11/09/2016 11:24	0.0134	Correlation Location 3
11/09/2016 11:25	0.0129	Correlation Location 3
11/09/2016 11:25	0.0129	Correlation Location 3
11/09/2016 11:25	0.0131	Correlation Location 3
11/09/2016 11:25	0.0129	Correlation Location 3
11/09/2016 11:25	0.0131	Correlation Location 3
11/09/2016 11:25	0.0133	Correlation Location 3
11/09/2016 11:25	0.0132	Correlation Location 3
11/09/2016 11:25	0.0131	Correlation Location 3
11/09/2016 11:25	0.013	Correlation Location 3
11/09/2016 11:25	0.0133	Correlation Location 3
11/09/2016 11:26	0.0136	Correlation Location 3
11/09/2016 11:26	0.0135	Correlation Location 3
11/09/2016 11:26	0.0136	Correlation Location 3
11/09/2016 11:26	0.0135	Correlation Location 3
11/09/2016 11:26	0.013	Correlation Location 3
11/09/2016 11:26	0.0127	Correlation Location 3
11/09/2016 11:26	0.0129	Correlation Location 3
11/09/2016 11:26	0.0135	Correlation Location 3
11/09/2016 11:26	0.0134	Correlation Location 3
11/09/2016 11:26	0.0133	Correlation Location 3
11/09/2016 11:27	0.0134	Correlation Location 3
11/09/2016 11:27	0.0133	Correlation Location 3
11/09/2016 11:27	0.0135	Correlation Location 3
11/09/2016 11:27	0.0135	Correlation Location 3
11/09/2016 11:27	0.0132	Correlation Location 3
11/09/2016 11:27	0.0129	Correlation Location 3
11/09/2016 11:27	0.0127	Correlation Location 3
11/09/2016 11:27	0.0129	Correlation Location 3
11/09/2016 11:52	0.054	Correlation Location 4
11/09/2016 11:52	0.0944	Correlation Location 4
11/09/2016 11:52	0.0823	Correlation Location 4
11/09/2016 11:53	0.0566	Correlation Location 4
11/09/2016 11:53	0.037	Correlation Location 4
11/09/2016 11:53	0.0253	Correlation Location 4
11/09/2016 11:53	0.0189	Correlation Location 4
11/09/2016 11:53	0.0158	Correlation Location 4
11/09/2016 11:53	0.0141	Correlation Location 4

Date and Time	Exposure Rate (mR/h)	Location
11/09/2016 11:53	0.0134	Correlation Location 4
11/09/2016 11:53	0.0136	Correlation Location 4
11/09/2016 11:53	0.0133	Correlation Location 4
11/09/2016 11:53	0.0132	Correlation Location 4
11/09/2016 11:54	0.0131	Correlation Location 4
11/09/2016 11:54	0.0132	Correlation Location 4
11/09/2016 11:54	0.0137	Correlation Location 4
11/09/2016 11:54	0.0136	Correlation Location 4
11/09/2016 11:54	0.0132	Correlation Location 4
11/09/2016 11:54	0.013	Correlation Location 4
11/09/2016 11:54	0.0127	Correlation Location 4
11/09/2016 11:54	0.0127	Correlation Location 4
11/09/2016 11:54	0.0124	Correlation Location 4
11/09/2016 11:54	0.0122	Correlation Location 4
11/09/2016 11:55	0.012	Correlation Location 4
11/09/2016 11:55	0.012	Correlation Location 4
11/09/2016 11:55	0.0121	Correlation Location 4
11/09/2016 11:55	0.0121	Correlation Location 4
11/09/2016 11:55	0.0122	Correlation Location 4
11/09/2016 11:55	0.0126	Correlation Location 4
11/09/2016 11:55	0.0128	Correlation Location 4
11/09/2016 11:55	0.013	Correlation Location 4
11/09/2016 11:55	0.0132	Correlation Location 4
11/09/2016 11:55	0.0131	Correlation Location 4
11/09/2016 11:56	0.013	Correlation Location 4
11/09/2016 11:56	0.013	Correlation Location 4
11/09/2016 11:56	0.0132	Correlation Location 4
11/09/2016 11:56	0.0134	Correlation Location 4
11/09/2016 11:56	0.0134	Correlation Location 4
11/09/2016 11:56	0.0135	Correlation Location 4
11/09/2016 11:56	0.0138	Correlation Location 4
11/09/2016 11:56	0.0135	Correlation Location 4
11/09/2016 11:56	0.0133	Correlation Location 4
11/09/2016 11:56	0.0134	Correlation Location 4
11/09/2016 11:57	0.0135	Correlation Location 4
11/09/2016 11:57	0.0132	Correlation Location 4
11/09/2016 11:57	0.0129	Correlation Location 4
11/09/2016 11:57	0.0126	Correlation Location 4
11/09/2016 11:57	0.0126	Correlation Location 4
11/09/2016 11:57	0.0127	Correlation Location 4
11/09/2016 11:57	0.0131	Correlation Location 4
11/09/2016 11:57	0.0135	Correlation Location 4
11/09/2016 11:57	0.0133	Correlation Location 4
11/09/2016 11:57	0.0132	Correlation Location 4
11/09/2016 11:58	0.0131	Correlation Location 4
11/09/2016 11:58	0.013	Correlation Location 4
11/09/2016 11:58	0.0132	Correlation Location 4
11/09/2016 11:58	0.0135	Correlation Location 4
11/09/2016 11:58	0.0132	Correlation Location 4
11/09/2016 11:58	0.0133	Correlation Location 4
11/09/2016 11:58	0.0134	Correlation Location 4
11/09/2016 11:58	0.0133	Correlation Location 4
11/09/2016 11:58	0.0129	Correlation Location 4
11/09/2016 11:58	0.013	Correlation Location 4
11/09/2016 11:59	0.0132	Correlation Location 4
11/09/2016 11:59	0.0133	Correlation Location 4
11/09/2016 11:59	0.0138	Correlation Location 4

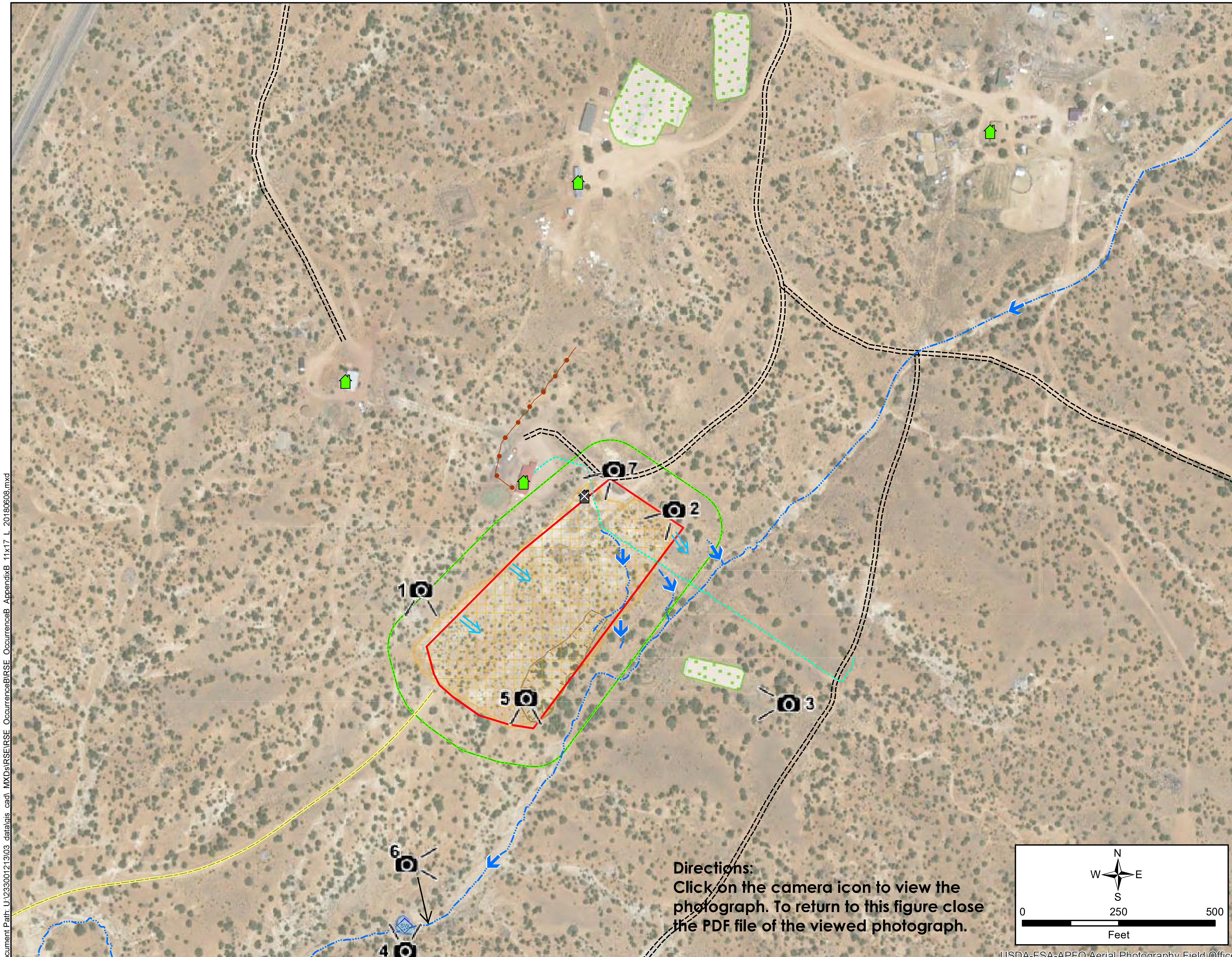
Date and Time	Exposure Rate (mR/h)	Location
11/09/2016 11:59	0.0138	Correlation Location 4
11/09/2016 11:59	0.0135	Correlation Location 4
11/09/2016 11:59	0.013	Correlation Location 4
11/09/2016 11:59	0.0122	Correlation Location 4
11/09/2016 11:59	0.012	Correlation Location 4
11/09/2016 11:59	0.0126	Correlation Location 4
11/09/2016 11:59	0.0127	Correlation Location 4
11/09/2016 12:00	0.0127	Correlation Location 4
11/09/2016 12:00	0.0128	Correlation Location 4
11/09/2016 12:00	0.0133	Correlation Location 4
11/09/2016 12:00	0.0136	Correlation Location 4
11/09/2016 12:00	0.0136	Correlation Location 4
11/09/2016 12:00	0.0136	Correlation Location 4
11/09/2016 12:00	0.0137	Correlation Location 4
11/09/2016 12:00	0.0138	Correlation Location 4
11/09/2016 12:00	0.0135	Correlation Location 4
11/09/2016 12:00	0.0136	Correlation Location 4
11/09/2016 12:01	0.0141	Correlation Location 4
11/09/2016 12:01	0.0141	Correlation Location 4
11/09/2016 12:01	0.014	Correlation Location 4
11/09/2016 12:01	0.0137	Correlation Location 4
11/09/2016 12:01	0.0132	Correlation Location 4
11/09/2016 12:01	0.0127	Correlation Location 4
11/09/2016 12:01	0.0123	Correlation Location 4
11/09/2016 12:01	0.0126	Correlation Location 4
11/09/2016 12:01	0.0131	Correlation Location 4
11/09/2016 12:01	0.0132	Correlation Location 4
11/09/2016 12:02	0.0131	Correlation Location 4
11/09/2016 12:02	0.013	Correlation Location 4
11/09/2016 12:02	0.0129	Correlation Location 4
11/09/2016 12:02	0.0127	Correlation Location 4
11/09/2016 12:02	0.0126	Correlation Location 4
11/09/2016 12:02	0.0123	Correlation Location 4
11/09/2016 12:02	0.0124	Correlation Location 4
11/09/2016 12:02	0.0124	Correlation Location 4
11/09/2016 12:02	0.0129	Correlation Location 4
11/09/2016 12:02	0.0129	Correlation Location 4
11/09/2016 12:03	0.0126	Correlation Location 4
11/09/2016 12:03	0.0128	Correlation Location 4
11/09/2016 12:03	0.0129	Correlation Location 4
11/09/2016 12:03	0.013	Correlation Location 4
11/09/2016 12:03	0.0129	Correlation Location 4
11/09/2016 12:03	0.0132	Correlation Location 4
11/09/2016 12:41	0.054	Correlation Location 5
11/09/2016 12:41	0.0945	Correlation Location 5
11/09/2016 12:41	0.0827	Correlation Location 5
11/09/2016 12:41	0.0573	Correlation Location 5
11/09/2016 12:41	0.0385	Correlation Location 5
11/09/2016 12:41	0.0274	Correlation Location 5
11/09/2016 12:41	0.0213	Correlation Location 5
11/09/2016 12:41	0.0178	Correlation Location 5
11/09/2016 12:41	0.0158	Correlation Location 5
11/09/2016 12:42	0.0151	Correlation Location 5
11/09/2016 12:42	0.0147	Correlation Location 5
11/09/2016 12:42	0.0148	Correlation Location 5
11/09/2016 12:42	0.0147	Correlation Location 5
11/09/2016 12:42	0.0151	Correlation Location 5

Date and Time	Exposure Rate (mR/h)	Location
11/09/2016 12:42	0.0153	Correlation Location 5
11/09/2016 12:42	0.0152	Correlation Location 5
11/09/2016 12:42	0.0147	Correlation Location 5
11/09/2016 12:42	0.0146	Correlation Location 5
11/09/2016 12:42	0.0146	Correlation Location 5
11/09/2016 12:43	0.0148	Correlation Location 5
11/09/2016 12:43	0.0148	Correlation Location 5
11/09/2016 12:43	0.0143	Correlation Location 5
11/09/2016 12:43	0.0143	Correlation Location 5
11/09/2016 12:43	0.0148	Correlation Location 5
11/09/2016 12:43	0.0153	Correlation Location 5
11/09/2016 12:43	0.0154	Correlation Location 5
11/09/2016 12:43	0.0154	Correlation Location 5
11/09/2016 12:43	0.0156	Correlation Location 5
11/09/2016 12:43	0.0154	Correlation Location 5
11/09/2016 12:44	0.0152	Correlation Location 5
11/09/2016 12:44	0.015	Correlation Location 5
11/09/2016 12:44	0.0147	Correlation Location 5
11/09/2016 12:44	0.0144	Correlation Location 5
11/09/2016 12:44	0.0147	Correlation Location 5
11/09/2016 12:44	0.0151	Correlation Location 5
11/09/2016 12:44	0.0152	Correlation Location 5
11/09/2016 12:44	0.015	Correlation Location 5
11/09/2016 12:44	0.0147	Correlation Location 5
11/09/2016 12:44	0.0145	Correlation Location 5
11/09/2016 12:45	0.0146	Correlation Location 5
11/09/2016 12:45	0.0144	Correlation Location 5
11/09/2016 12:45	0.0145	Correlation Location 5
11/09/2016 12:45	0.0147	Correlation Location 5
11/09/2016 12:45	0.0148	Correlation Location 5
11/09/2016 12:45	0.0148	Correlation Location 5
11/09/2016 12:45	0.0145	Correlation Location 5
11/09/2016 12:45	0.0146	Correlation Location 5
11/09/2016 12:45	0.0148	Correlation Location 5
11/09/2016 12:45	0.0145	Correlation Location 5
11/09/2016 12:46	0.0147	Correlation Location 5
11/09/2016 12:46	0.0148	Correlation Location 5
11/09/2016 12:46	0.0149	Correlation Location 5
11/09/2016 12:46	0.0154	Correlation Location 5
11/09/2016 12:46	0.0153	Correlation Location 5
11/09/2016 12:46	0.0153	Correlation Location 5
11/09/2016 12:46	0.0151	Correlation Location 5
11/09/2016 12:46	0.0152	Correlation Location 5
11/09/2016 12:46	0.0153	Correlation Location 5
11/09/2016 12:46	0.0152	Correlation Location 5
11/09/2016 12:47	0.0153	Correlation Location 5
11/09/2016 12:47	0.0148	Correlation Location 5
11/09/2016 12:47	0.0144	Correlation Location 5
11/09/2016 12:47	0.0142	Correlation Location 5
11/09/2016 12:47	0.0141	Correlation Location 5
11/09/2016 12:47	0.0138	Correlation Location 5
11/09/2016 12:47	0.0138	Correlation Location 5
11/09/2016 12:47	0.0138	Correlation Location 5
11/09/2016 12:47	0.0143	Correlation Location 5
11/09/2016 12:47	0.0144	Correlation Location 5
11/09/2016 12:48	0.0143	Correlation Location 5
11/09/2016 12:48	0.0143	Correlation Location 5

Date and Time	Exposure Rate (mR/h)	Location
11/09/2016 12:48	0.0143	Correlation Location 5
11/09/2016 12:48	0.0144	Correlation Location 5
11/09/2016 12:48	0.0148	Correlation Location 5
11/09/2016 12:48	0.0155	Correlation Location 5
11/09/2016 12:48	0.0156	Correlation Location 5
11/09/2016 12:48	0.0153	Correlation Location 5
11/09/2016 12:48	0.0149	Correlation Location 5
11/09/2016 12:48	0.0145	Correlation Location 5
11/09/2016 12:49	0.0141	Correlation Location 5
11/09/2016 12:49	0.0138	Correlation Location 5
11/09/2016 12:49	0.0142	Correlation Location 5
11/09/2016 12:49	0.0145	Correlation Location 5
11/09/2016 12:49	0.0145	Correlation Location 5
11/09/2016 12:49	0.0144	Correlation Location 5
11/09/2016 12:49	0.0143	Correlation Location 5
11/09/2016 12:49	0.0147	Correlation Location 5
11/09/2016 12:49	0.0151	Correlation Location 5
11/09/2016 12:49	0.0149	Correlation Location 5
11/09/2016 12:50	0.0146	Correlation Location 5
11/09/2016 12:50	0.0145	Correlation Location 5
11/09/2016 12:50	0.0147	Correlation Location 5
11/09/2016 12:50	0.0143	Correlation Location 5
11/09/2016 12:50	0.014	Correlation Location 5
11/09/2016 12:50	0.0145	Correlation Location 5
11/09/2016 12:50	0.0148	Correlation Location 5
11/09/2016 12:50	0.0147	Correlation Location 5
11/09/2016 12:50	0.0148	Correlation Location 5
11/09/2016 12:50	0.0152	Correlation Location 5
11/09/2016 12:51	0.0152	Correlation Location 5
11/09/2016 12:51	0.0151	Correlation Location 5
11/09/2016 12:51	0.015	Correlation Location 5
11/09/2016 12:51	0.0149	Correlation Location 5
11/09/2016 12:51	0.015	Correlation Location 5
11/09/2016 12:51	0.0147	Correlation Location 5
11/09/2016 12:51	0.0146	Correlation Location 5
11/09/2016 12:51	0.0146	Correlation Location 5
11/09/2016 12:51	0.0149	Correlation Location 5
11/09/2016 12:51	0.0148	Correlation Location 5

Occurrence B Exposure Rate Measurements for Correlation

Appendix B Site Photographs



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Photograph Indicating Direction Taken
- Habitable Building
- Uninhabitable Building
- Surface Water Sample
- Flow Direction
- Approximate Overland Water Flow Direction
- Drainage
- Potential Haul Road
- Power Line
- Road
- Water Line
- Topographic Depression
- Crops
- Pond
- Potentially Disturbed Area
- Claim Boundary
- 100-Foot Claim Buffer

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 6/11/2018.

TITLE:
Site Photographs

PROJECT:
Removal Site Evaluation
Occurrence B Mine Site

DATE: 6/11/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: Appendix B

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\RSE_OccurrenceB_AppendixB_11x17_L_20180608.mxd

Appendix C Field Activity Forms

C.1 Soil Sample Field Forms

C.2 Hand Auger Borehole Logs

C.3 Water Sample Field Forms

C.1 Soil Sample Field Forms

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S296-BG1-ØØ1 [Occurrence B]

SAMPLE I.D. S296-BG1-ØØ1

SAMPLE COLLECTION DATE 11/11/16

SAMPLE COLLECTION TIME 16:03

SAMPLE COLLECTED BY N. Randle

WEATHER CONDITIONS ~65°F & Sunny

FIELD USCS DESCRIPTIONS Soft, Dry, Red/Brown,

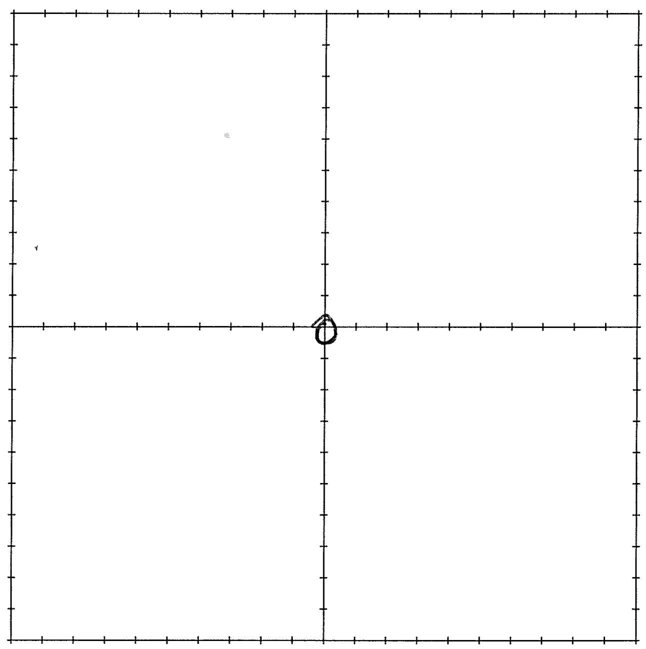
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☒ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 S296-BG1-ØØ2 [Occurrence B]

SAMPLE I.D. S296-BG1-ØØ2

SAMPLE COLLECTION DATE 11/11/16

SAMPLE COLLECTION TIME 16:10

SAMPLE COLLECTED BY N. Ravelle

WEATHER CONDITIONS ~65°F, Sunny

FIELD USCS DESCRIPTIONS Soft, Dry, Red/brown

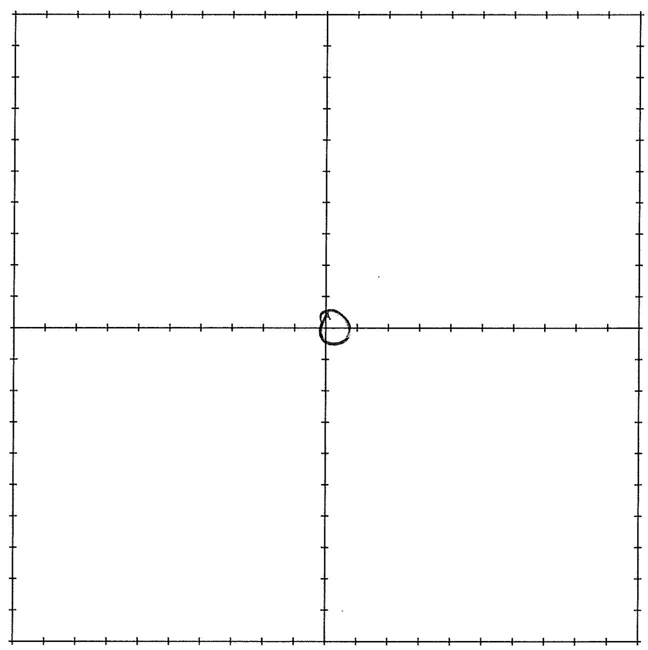
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☒ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 S296-BG1-ØØ3 [Occurrence B]

SAMPLE I.D. S296-BG1-ØØ3

SAMPLE COLLECTION DATE 11/11/16

SAMPLE COLLECTION TIME 16:20

SAMPLE COLLECTED BY N. Rundle

WEATHER CONDITIONS ~65°F, Sunny

FIELD USCS DESCRIPTIONS Soft, Dry, Red/Brown

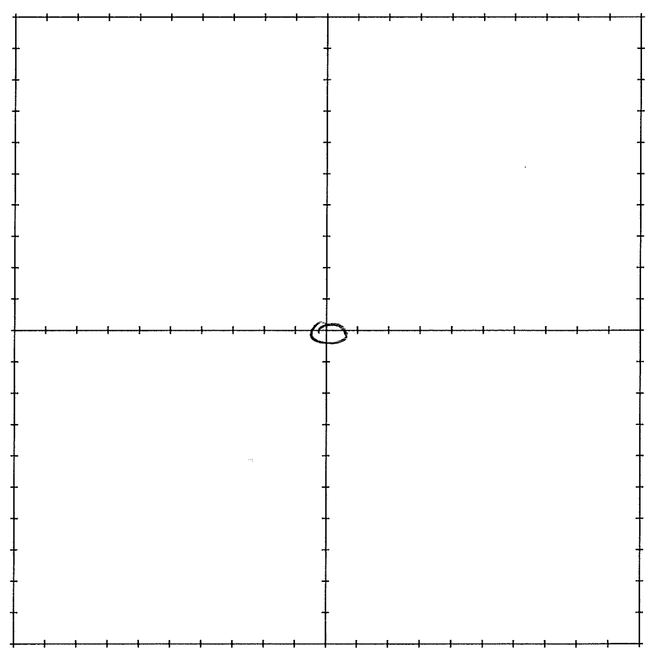
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☒ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☒ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 Ziplock

ANALYSES:



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S296-BG1-ØØ4 [Occurrence B]

SAMPLE I.D. S296-BG1-ØØ4

SAMPLE COLLECTION DATE 11/11/16

SAMPLE COLLECTION TIME 16:27

SAMPLE COLLECTED BY N. Randle

WEATHER CONDITIONS ~65°F, Sunny

FIELD USCS DESCRIPTIONS Soft, Dry, Red/Brown

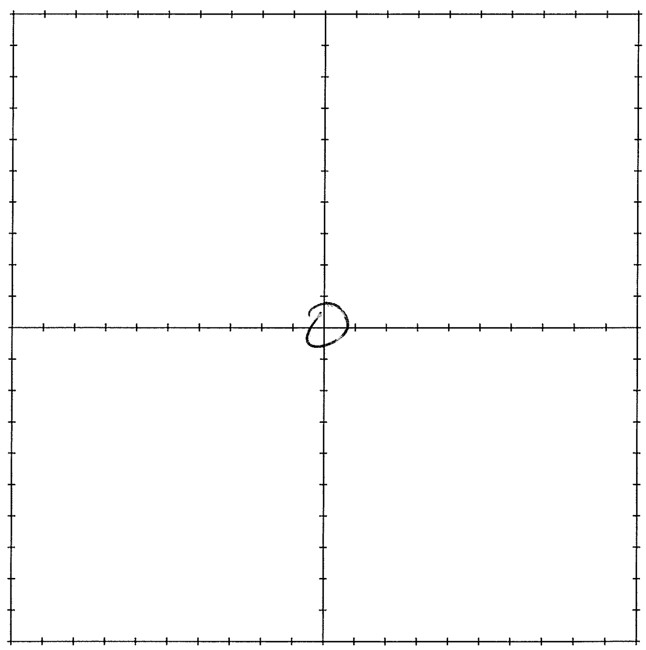
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☒ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 S296-BG1-005 [Occurrence B]

SAMPLE I.D. S296-BG1-005

SAMPLE COLLECTION DATE 11/11/16

SAMPLE COLLECTION TIME 16:37

SAMPLE COLLECTED BY N. Randle

WEATHER CONDITIONS ~65°F, Sunny

FIELD USCS DESCRIPTIONS Soft, Dry, Red/Brown

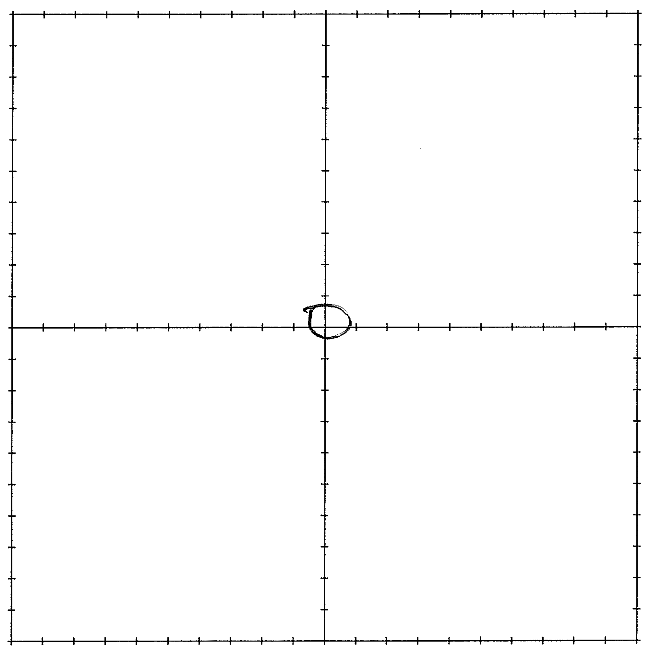
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☒ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 S296-BG1-ØØ6 [Occurrence B]

SAMPLE I.D. S296-BG1-ØØ6

SAMPLE COLLECTION DATE 11/11/16

SAMPLE COLLECTION TIME 16:40

SAMPLE COLLECTED BY N. Ranelle

WEATHER CONDITIONS ~65°F, Sunny

FIELD USCS DESCRIPTIONS Soft, Dry, Red/Brown

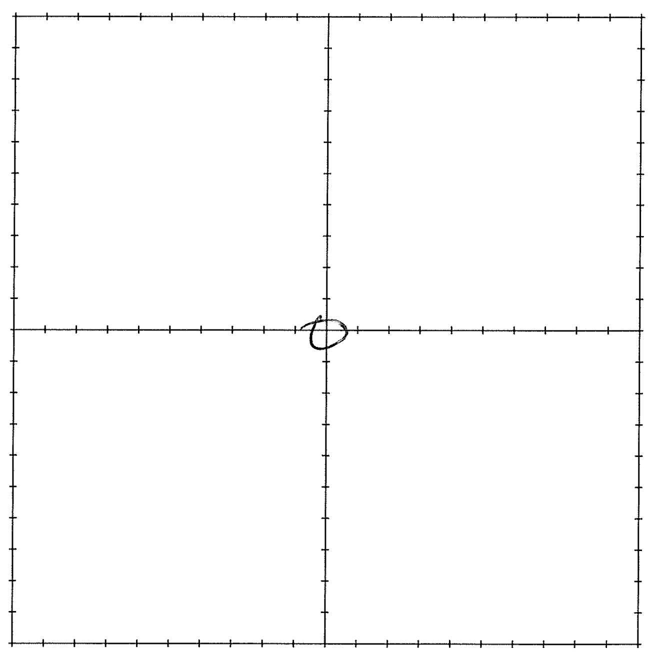
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☒ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 S296-BG1-007 [Occurrence B]

SAMPLE I.D. S296-BG1-007

SAMPLE COLLECTION DATE 11/11/16

SAMPLE COLLECTION TIME 16:45

SAMPLE COLLECTED BY N. Randle

WEATHER CONDITIONS ~65°F, Sunny

FIELD USCS DESCRIPTIONS Soft, Dry, Red/Brown

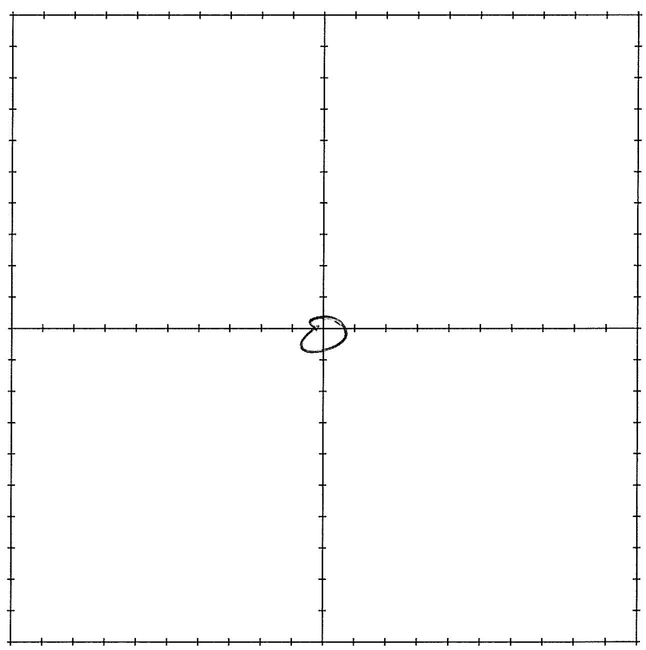
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☒ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 S296-BG1-ØØ8 [Occurrence B]

SAMPLE I.D. S296-BG1-ØØ8

SAMPLE COLLECTION DATE 11/11/16

SAMPLE COLLECTION TIME 16:50

SAMPLE COLLECTED BY N. Randle

WEATHER CONDITIONS ~65°F, Sunny

FIELD USCS DESCRIPTIONS Soft, Dry, Red/Brown

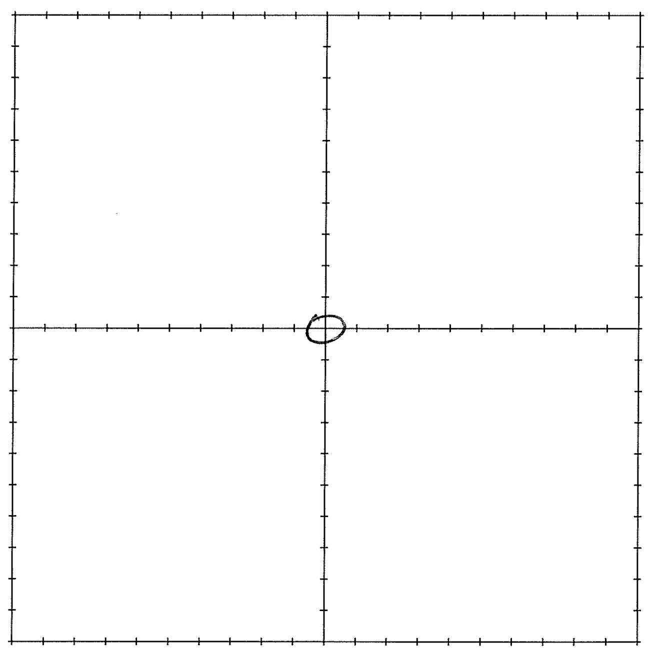
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☒ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 S246-BG1-ØØ9 [Occurrence B]

SAMPLE I.D. S246-BG1-ØØ9

SAMPLE COLLECTION DATE 11/11/16

SAMPLE COLLECTION TIME 16:55

SAMPLE COLLECTED BY N. Randle

WEATHER CONDITIONS ~65°F, Sunny

FIELD USCS DESCRIPTIONS Soft, Dry, Red/Brown

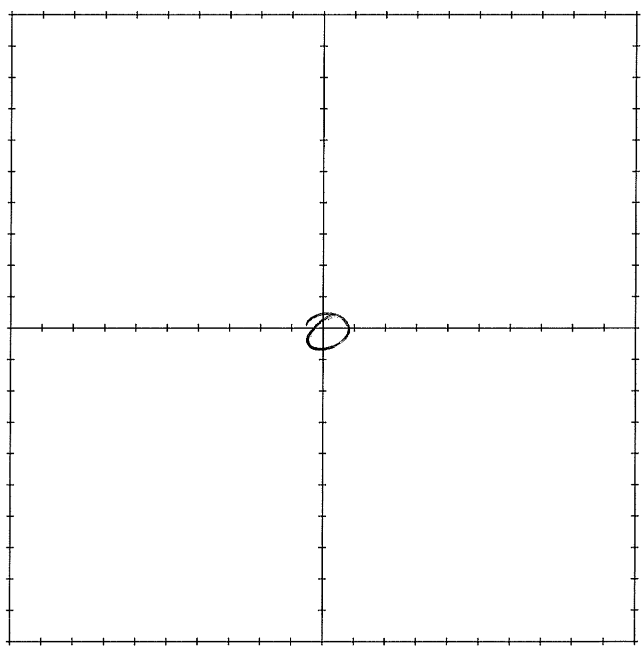
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☒ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 S296-BG1-Ø1Ø [Occurrence B]

SAMPLE I.D. S296-BG1-Ø1Ø

SAMPLE COLLECTION DATE 11/11/16

SAMPLE COLLECTION TIME 17:00

SAMPLE COLLECTED BY N. Ravelle

WEATHER CONDITIONS ~65°F, Sunny

FIELD USCS DESCRIPTIONS Soft, Dry, Red/Brown

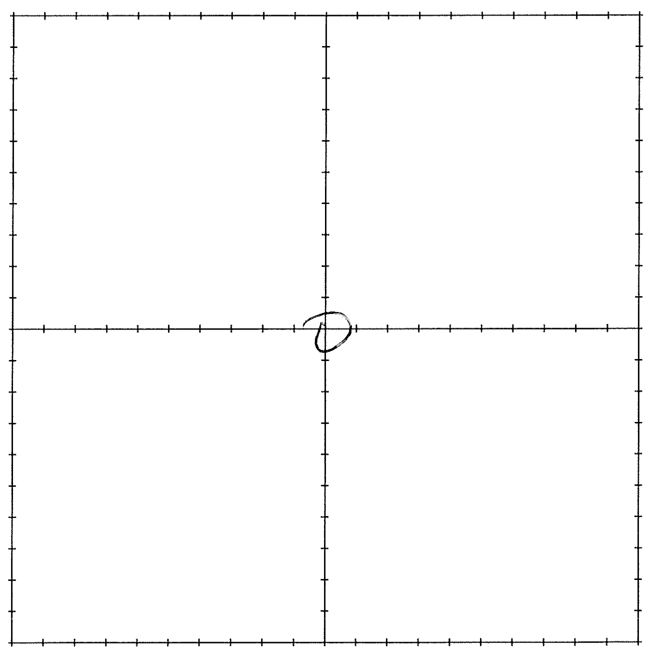
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☒ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 S296-C07-001 [Occurrence B]

SAMPLE I.D. S296-C07-001

SAMPLE COLLECTION DATE ~~[illegible]~~ 11/09/16

SAMPLE COLLECTION TIME 08:10

SAMPLE COLLECTED BY N. Randle

WEATHER CONDITIONS ~60° F, Sunny

FIELD USCS DESCRIPTIONS

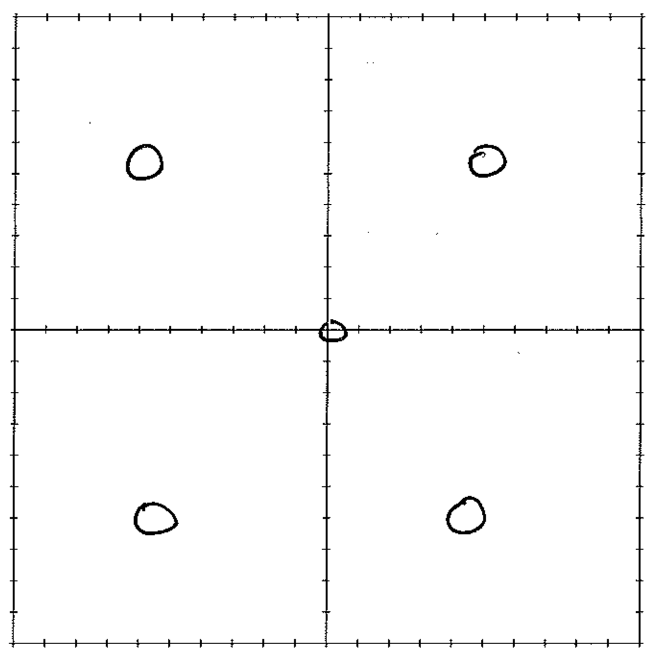
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 S296-C02-001 [Occurrence B]

SAMPLE I.D. S296-C02-001

SAMPLE COLLECTION DATE 11/09/2016

SAMPLE COLLECTION TIME 09:25

SAMPLE COLLECTED BY N. Randle

WEATHER CONDITIONS ~60°F, Sunny

FIELD USCS DESCRIPTIONS

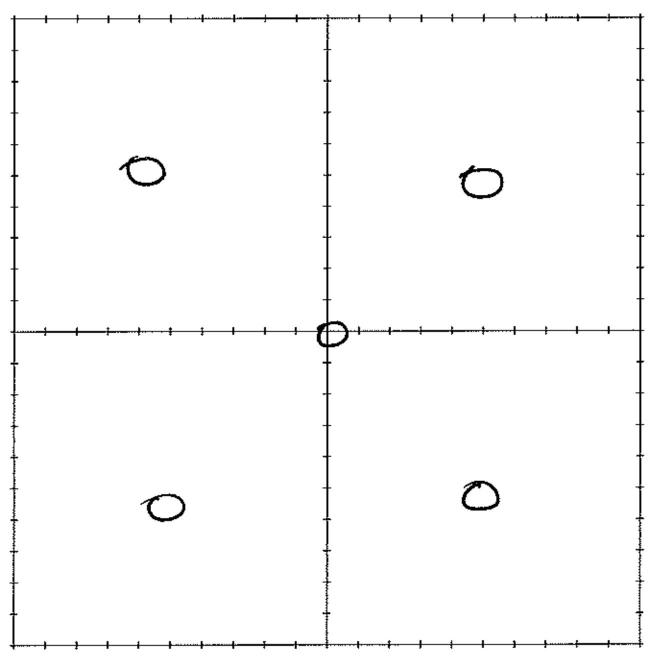
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 S246-C03-001 [Occurrence B]

SAMPLE I.D. S246-C03-001

SAMPLE COLLECTION DATE 11/09/2016

SAMPLE COLLECTION TIME 10:10

SAMPLE COLLECTED BY N. Randle

WEATHER CONDITIONS ~60°F, Sunny

FIELD USCS DESCRIPTIONS

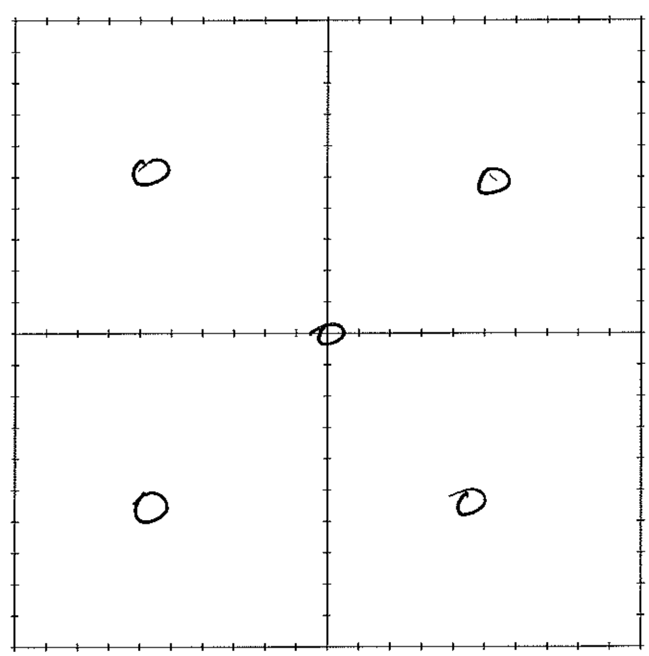
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 S296-C04-001 [Occurrence B]

SAMPLE I.D. S296-C04-001

SAMPLE COLLECTION DATE 11/09/2016

SAMPLE COLLECTION TIME 10:37

SAMPLE COLLECTED BY N. Randle

WEATHER CONDITIONS ~60°F, Sunny

FIELD USCS DESCRIPTIONS

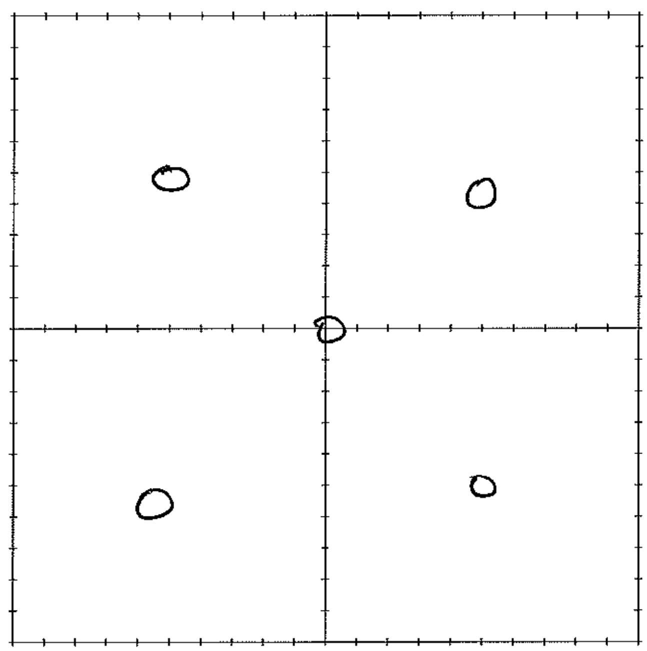
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 S296-CØ5-ØØ1 [Occurrence B]

SAMPLE I.D. S296-CØ5-ØØ1

SAMPLE COLLECTION DATE 11/09/2016

SAMPLE COLLECTION TIME ~~[illegible]~~ 11:19

SAMPLE COLLECTED BY N. ~~[illegible]~~ Randle

WEATHER CONDITIONS ~60°F, Sunny

FIELD USCS DESCRIPTIONS

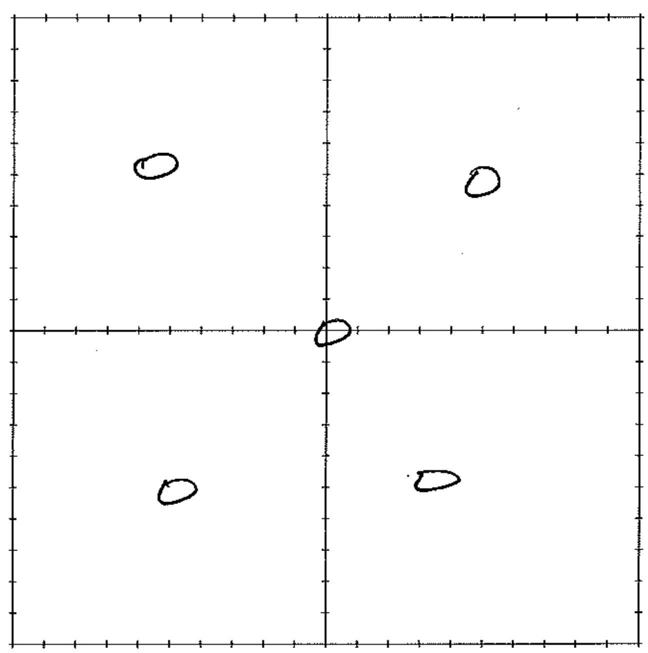
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 Occurrence B

SAMPLE I.D. S296-CX-001

SAMPLE COLLECTION DATE 11/09/16

SAMPLE COLLECTION TIME 1006

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS Sunny, 50°

FIELD USCS DESCRIPTIONS Dry silt with finesands (10% fine, 5% clay) Hard gray clay layer 2" bgs

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC

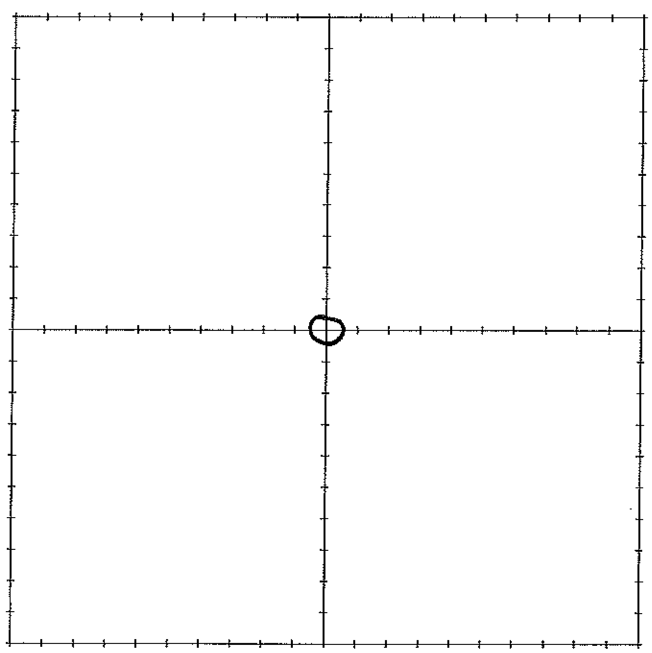
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☒ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplocs

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: Occurrence B

SAMPLE I.D.: S296-CX-002

SAMPLE COLLECTION DATE: 11/09/16

SAMPLE COLLECTION TIME: 1025

SAMPLE COLLECTED BY: KJJ

WEATHER CONDITIONS: Sunny, 50's

FIELD USCS DESCRIPTIONS: Dry decomposed/weathered shale, medium grained sand w/ clay & minor cobbles to gravels

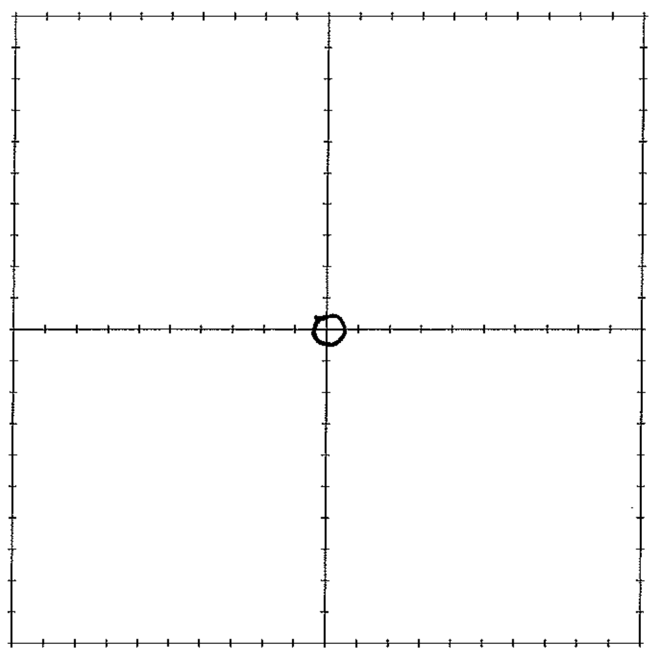
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☒ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ~~☐ FINE~~ ☒ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE): 2 ziplocs

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Occurrence B

SAMPLE I.D. S296- CX - 003

SAMPLE COLLECTION DATE 11/09/16

SAMPLE COLLECTION TIME 1038

SAMPLE COLLECTED BY KSJ

WEATHER CONDITIONS Sunny 50's

FIELD USCS DESCRIPTIONS Dry sandy/clayey silt, popcorn texture, some organics

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC

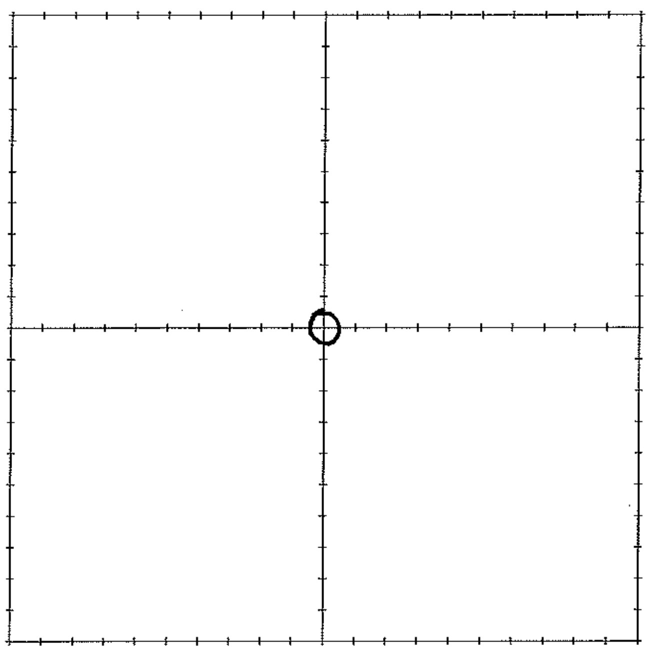
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☒ SOME; SAND SIZE ☒ FINE ☒ MEDIUM ☒ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplocs

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Occurrence B

SAMPLE I.D. S296-CX-004

SAMPLE COLLECTION DATE 11/09/16

SAMPLE COLLECTION TIME 1046

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS Sunny, 50's

FIELD USCS DESCRIPTIONS Dry silty sand w/ 10% cobbles & clay, cobbles are sandstone

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC

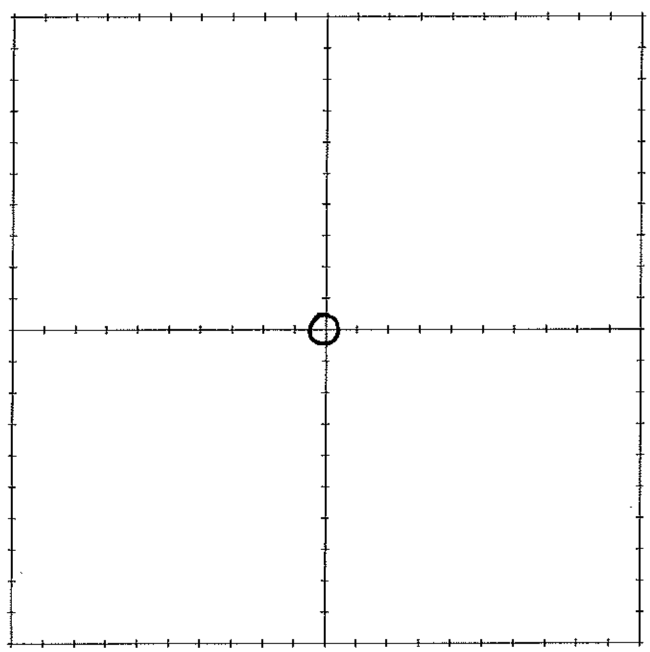
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☒ FINE ☒ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplocs

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Occurrence B

SAMPLE I.D. S296-CX-005, S296-CX-205

SAMPLE COLLECTION DATE 11/09/16

SAMPLE COLLECTION TIME 1055

SAMPLE COLLECTED BY KSS

WEATHER CONDITIONS Sunny, 50's

FIELD USCS DESCRIPTIONS Slightly moist silt w/ slick clay & trace sandstone cobbles

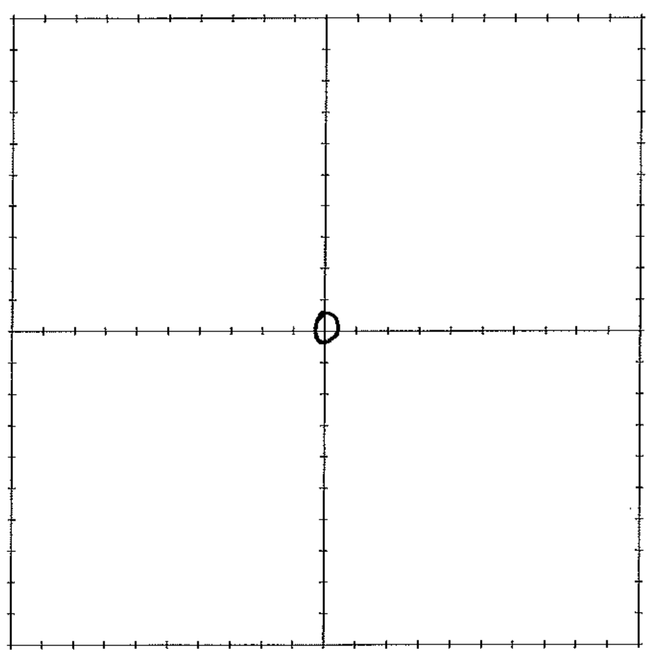
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☒ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 4 ziplocs

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Occurrence B

SAMPLE I.D. S296-CX-006

SAMPLE COLLECTION DATE 11/09/16

SAMPLE COLLECTION TIME 1107

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS sunny 50's

FIELD USCS DESCRIPTIONS Dry clayey silt w/fine sand & trace gravels

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☒ ML ☐ SC

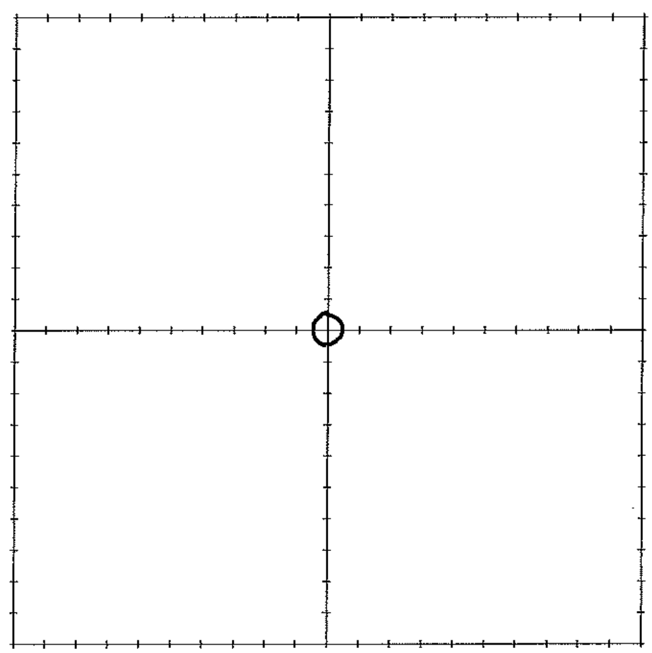
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☒ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplocs

ANALYSES: Ra-226- metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Occurrence B

SAMPLE I.D. S296-CX-007

SAMPLE COLLECTION DATE 11/09/17

SAMPLE COLLECTION TIME 1116

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS sunny, 50's

FIELD USCS DESCRIPTIONS Sand with minor silt & clay, in drainage w/ trace cobble gravels

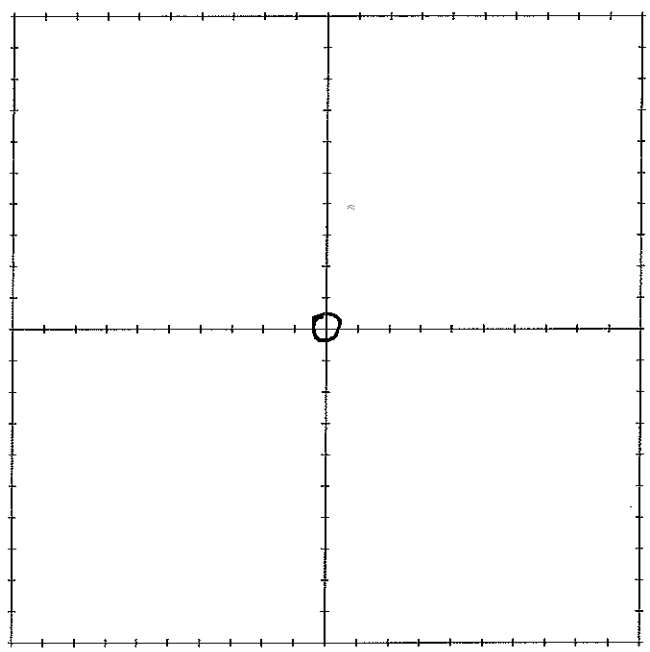
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☑ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☑ MINOR ☐ SOME; SAND SIZE ☒ FINE ☑ MEDIUM ☑ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplocs

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Occurrence B

SAMPLE I.D. S296 - CX - 008

SAMPLE COLLECTION DATE 11/09/16

SAMPLE COLLECTION TIME 11:24

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS Sunny 50's

FIELD USCS DESCRIPTIONS Dry clayey silt w/ minor gravels near toe of drainage

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☒ ML ☐ SC

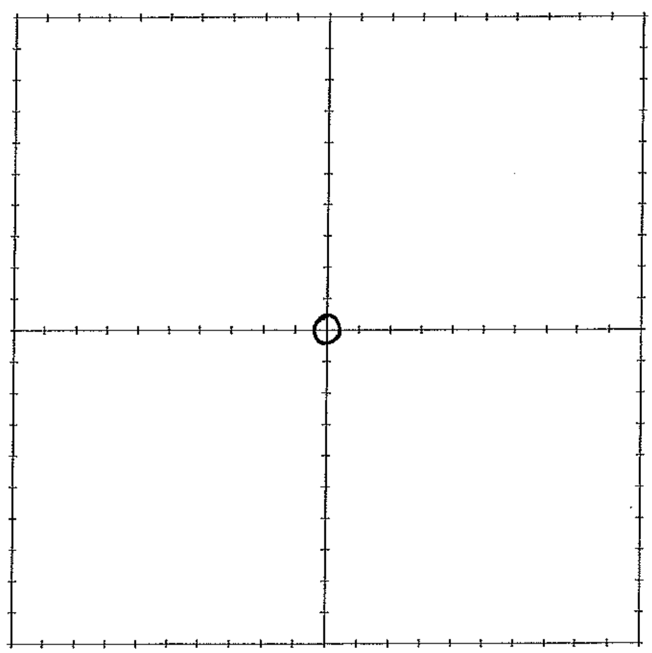
☐ SM ~~☒ SP~~ ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplocs

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Occurrence B

SAMPLE I.D. S296-EX-009

SAMPLE COLLECTION DATE 11/09/16

SAMPLE COLLECTION TIME 11:34

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS Sunny, 50's

FIELD USCS DESCRIPTIONS Dry sand with silt & clay & trace gravels

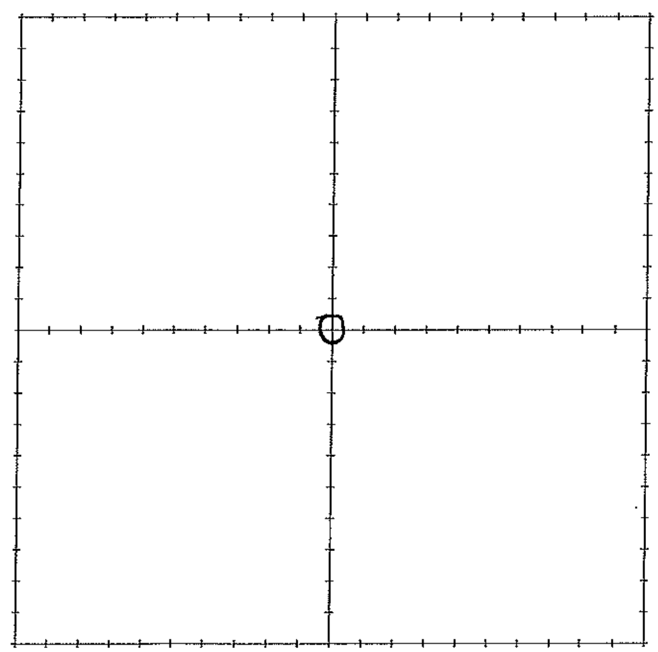
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☒ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplocs

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Occurrence B

SAMPLE I.D. S296-CX-010

SAMPLE COLLECTION DATE 11/09/16

SAMPLE COLLECTION TIME 11:47

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS Sunny, 50's

FIELD USCS DESCRIPTIONS Dry clayey sand with some silt & trace gravels weathered sandst popcorn texture

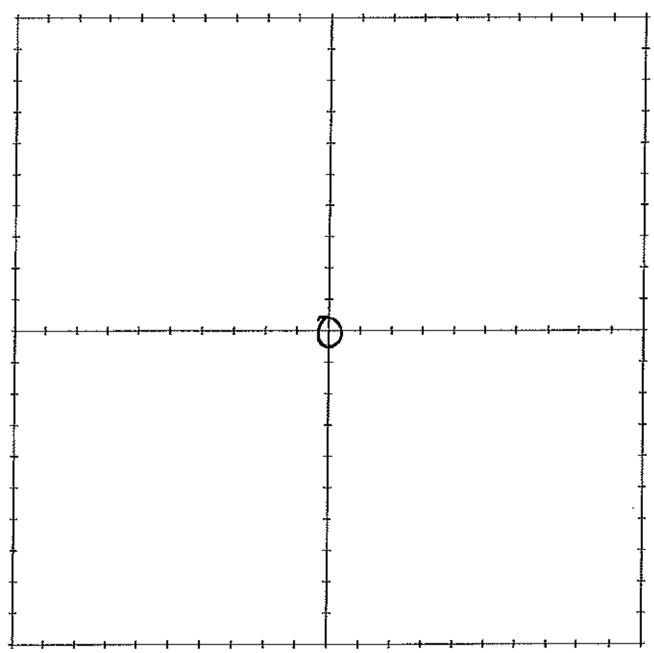
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☒ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☒ FINE ☒ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplocs

ANALYSES: R2-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

C.2 Hand Auger Borehole Logs

BOREHOLE ID:	**S296-BG1-011**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Occurrence B

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
DRILLING METHOD:	Hand auger	EASTING:	640377.17	NORTHING:	4005076.01
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	11/11/2016	DATE STARTED:	11/11/2016
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	1.2	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Nicholas Randle		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 10000 20000 30000 40000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): fine sand, dry.	11402	S296-BG1-011-1	0-0.7	grab	0.97
			14707				
1			15722	S296-BG1-011-2	0.7-1.2	grab	1.13
			15630				
		Termination of hand auger borehole at 1.2 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: **S296-BG1-012** CLIENT: NNAUMERT PROJECT: Removal Site Evaluation SITE LOCATION: Occurrence B

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
DRILLING METHOD:	Hand auger	EASTING:	640377.22	NORTHING:	4005077.47
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	11/11/2016	DATE STARTED:	11/11/2016
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.7	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Nicholas Randle		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 10000 20000 30000 40000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0 – 0.7		POORLY GRADED SAND (SP): fine sand, dry.	11207 15232	No Sample	0-0.7		No Sample Collected
0.7		Termination of hand auger borehole at 0.7 ft. below ground surface. Refusal on bedrock.					

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

BOREHOLE ID:	**S296-BG1-013**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Occurrence B

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 640375.67	NORTHING: 4005074.36
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 11/11/2016	DATE STARTED: 11/11/2016
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 0.83	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Nicholas Randle

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): fine sand, dry.	11537 14286 14686	No Sample	0-0.83		No Sample Collected
1		Termination of hand auger borehole at 0.83 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

BOREHOLE ID:	**S296-SCX-001**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Occurrence B

Stantec | NAVAJO NATION AUM Environmental Response Trust - First Phase

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 640728.81	NORTHING: 4005254.62
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 11/9/2016	DATE STARTED: 11/9/2016
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 0.4	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Nicholas Randle

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 10000 20000 30000 40000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		SILT (ML): light brown, non plastic, low density, dry, few gravel and trace sand.	14808 16969	No Sample	0-0.4		No Sample Collected
		Terminated borehole at 0.4 ft. below ground surface. Refusal on bedrock					
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:	**S296-SCX-002**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Occurrence B

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
DRILLING METHOD:	Hand auger	EASTING:	640711.18	NORTHING:	4005244.54
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	11/9/2016	DATE STARTED:	11/9/2016
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.95	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Nicholas Randle		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	GRAVELY SILT (ML): light brown, dry	14662	S296-SCX-002-1	0-0.5	grab	2.3
	light brown to gray, dry, some fine sand.	16289	S296-SCX-002-2	0.5-0.95	grab	1.64
1	Terminated borehole at 0.95 ft. below ground surface. Refusal on bedrock.	17803				
2						
3						
4						
5						

Gamma (cpm) scale: 0, 10000, 20000, 30000, 40000

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

BOREHOLE ID:	**S296-SCX-003**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Occurrence B

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 640670.79	NORTHING: 4005244.13
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 11/9/2016	DATE STARTED: 11/9/2016
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 0.25	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Nicholas Randle

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 10000 20000 30000 40000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		SILTY SAND / SANDY SILT (SM/ML): light brown to white, dry	14853 16797	No Sample	0-0.25		No Sample Collected
		Terminated borehole at 0.25 ft. below ground surface. Refusal on bedrock.					
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:	**S296-SCX-004**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Occurrence B

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
DRILLING METHOD:	Hand auger	EASTING:	640648.68	NORTHING:	4005150.84
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	11/9/2016	DATE STARTED:	11/9/2016
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.4	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Nicholas Randle		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	SANDY SILT (ML): light gray, dry.	13933	S296-SCX-004-1	0-0.42	grab	1.87
0.4	Terminated borehole at 0.4 ft. below ground surface. Refusal on sandstone bedrock.	18017				

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S296-SCX-005**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Occurrence B

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
DRILLING METHOD:	Hand auger	EASTING:	640566.91	NORTHING:	4005182.06
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	11/9/2016	DATE STARTED:	11/9/2016
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.5	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Nicholas Randle		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 10000 20000 30000 40000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		GRAVELLY SILT (ML): light brown, dry to slightly moist	15061 16608	S296-SCX-005-1	0-0.5	grab	1.81
		Terminated borehole at 0.5 ft. below ground surface. Refusal on sandstone bedrock.					
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:	**S296-SCX-006**		
CLIENT:	NNAUMERT		
PROJECT:	Removal Site Evaluation		
SITE LOCATION:	Occurrence B		
DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 640763.98	NORTHING: 4005227.26
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 11/9/2016	DATE STARTED: 11/9/2016
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 0.4	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Nicholas Randle

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 10000 20000 30000 40000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		SANDY SILT WITH GRAVEL (ML), light gray, dry, very fine sand	12815 15402	No Sample	0-0.4		No Sample Collected
		Terminated borehole at 0.4 ft. below ground surface. Refusal on bedrock .					
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: **S296-SCX-007**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Occurrence B

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 12N
EASTING: 640793.51 NORTHING: 4005219.2
DATE STARTED: 11/9/2016 DATE STARTED: 11/9/2016
TOTAL DEPTH (ft.): 2.7 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Nicholas Randle

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	GRAVELLY SILT (ML): gray to red, dry.	14963
0.5		16354
1	red, rounded gravel.	19232
1.5	grades to dry to slightly moist.	20064
2	SILT (ML): dry to slightly moist, trace intermittent gravels.	18984
2.5		18777
2.7	Terminated borehole at 2.7 ft. below ground surface. Refusal on sandstone bedrock.	

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S296-SCX-007-1	0-0.5	grab	1.56
S296-SCX-007-2	1-1.5	grab	1.72
S296-SCX-007-3	2.5-2.7	grab	1.23

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

C.3 Water Sample Field Forms

WATER SAMPLE COLLECTION FORM

Project: Removal Site Evaluation Navajo Nation AUM Environmental Response Trust – First Phase

Date 11 / 09 / 2016 **Arrival Time** 1450

Field Personnel

K. Johnson, Linda Reeves (USEPA)

SITE DESCRIPTION

Entered 12/20/2016

Surface Water ☒ **Well Water** ☐

Station Name Occurrence B POND **Station Number** 10A

Site Description Pond in drainage downstream from Occurrence B ~20 ft across, surface water collection, Ran pump tubing 10' out pole

Water Characteristics (color, odor, appearance): Murky, no odor

SAMPLE COLLECTION

Collection Method: 1L bottle, Horizontal-bottle, Swing-sampler, Other(pump). Up-stream / Across-stream

Sample ID: S296-WS-001, S296-WS-001MS, S296-WS-001MSD **Sample Time:** 1510/1530/1541

Field Measurements			
Parameter	**Sample 1 (normal sample)**	**Sample 2 (field dup or MS)**	**Sample 3 (MSD)**
Time	1552		
pH	7.64		
Conductivity (µS/cm)	543		
Turbidity (NTU)	37.6		
Water Temperature (°C)	14.6		
Salinity	0.33		
Oxidation Reduction Potential (mV)	129.8		

SURFACE WATER FLOW MEASUREMENT FORM

Project: Removal Site Evaluation Navajo Nation AUM Environmental Response Trust – First Phase

Date 11/09/2016 **Time** 1450 **Station Number** Occurrence B POND

Field Personnel: K. Johnson Linda Reeves USEPA

Flow by Capture Method

Measurement Number	Time (sec)	Volume (L)
N/A	POND	

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 area for the Occurrence B site (Site). To select the background reference area 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 April 2016, two potential background reference areas (hereafter referred to as BG-3 and BG-4[1]) were identified for the Site, and gamma surveys of the two areas were completed. Following data review during generation of the *Occurrence B Site Clearance Data Report*, it was determined that the two initial potential background reference areas may not be representative of the Site (see Section 3.0). Consequently, two additional potential background reference areas were evaluated (hereafter referred to as BG-1 and BG-2) and gamma surveys of the areas were completed in November 2016. All four of these areas were identified to represent the geologic conditions of the Site, which consists of the Chinle Formation overlain by shallow Quaternary deposits.

The locations of the four potential background reference areas (BG-1, BG-2, BG-3, and BG-4) are shown along with the Site geology in Figure D.1-1. The potential background reference areas are described below.

- BG-1 encompasses an area of 1,112 square feet (ft^2) (approximately 0.03 acres), is located approximately 900 feet (ft) west-southwest of the claim boundary, is upwind and hydrologically cross-gradient from the Site. Geologically, BG-1 represents the Chinle Formation overlain by shallow Quaternary deposits. The area contains similar ground conditions as observed at the Site, although a portion of the Site was excavated and contains less soil thickness than other nearby areas near the Site.

- BG-2 encompasses an area of 2684 ft^2 (approximately 0.06 acres), is located approximately 600 feet (ft) west-southwest of the claim boundary, is upwind and hydrologically cross-gradient from the Site. Geologically, the BG-2 represents the Chinle Formation overlain by

[1] The background reference area designations used in this RSE Report have been revised from the Removal Site Evaluation Work Plan (MWH, 2016a) and the *Occurrence B Site Clearance Data Report* (MWH, 2016b).

shallow Quaternary deposits. The area contains similar ground conditions as observed at the Site, although a portion of the Site was excavated and contains less soil thickness than other nearby areas near the Site.

- BG-3 encompasses an area of 1,476 ft^2 (approximately 0.03 acres), is located approximately 300 feet (ft) northeast of the claim boundary, is downwind and hydrologically cross-gradient from the Site. Geologically, the BG-3 represents the Chinle Formation overlain by shallow Quaternary deposits. The area contains similar ground conditions as observed at the Site, although a portion of the Site was excavated and contains less soil thickness than other nearby areas near the Site.
- BG-4 encompasses an area of 1,003 ft^2 (approximately 0.02 acres), is located approximately 375 feet (ft) northeast of the claim boundary, is downwind and hydrologically cross-gradient from the Site. Geologically, the BG-4 represents the Chinle Formation overlain by shallow Quaternary deposits. The area contains similar ground conditions as observed at the Site, although a portion of the Site was excavated and contains less soil thickness than other nearby areas near the Site.

The potential background reference area evaluation included surface gamma surveys at BG-1 through BG-4. Surface static gamma measurements, subsurface static gamma measurements, and collection of surface and subsurface soil samples were completed in BG-1. Samples were collected at BG-1 as follows: 10 surface soil grab samples were collected from 10 locations and two subsurface soil samples were collected from borehole location S296-BG1-011. Two additional borehole locations were attempted (S296-BG1-012 and S296-BG1-013), but no subsurface soil samples were collected from those locations due to shallow bedrock encountered at 0.7 ft and 0.83 ft bgs, respectively.

The sample locations and surface gamma survey data for BG-1 are shown in Figure D.1-2. Samples were categorized as surface soil samples where sample depths were up to 0.5 ft below ground surface (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 ground surface and as subsurface where static gamma was measured at or greater than 0.1 ft bgs due to the different geometric effects for subsurface static gamma measurements. Table 4-1 in the RSE Report provides the results of the sample analyses, and 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 were also used for static one-minute gamma measurements at the ground surface and for subsurface gamma measurements at the borehole location. 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

Subsequent to performing the gamma surveys at BG-3 and BG-4, it was determined that these two areas are downwind of the Site, and therefore, are not good candidate locations to represent background conditions for the Site. Additionally, BG-3 and BG-4 are near a dirt road that accesses residential dwellings in the area and there was concern that dust from traffic on the road may be deposited in those areas.

BG-1 and BG-2 are both located upwind of the Site and have similar geology, vegetation, and ground cover to undisturbed portions of the Site. Geologically, both BG-1 and BG-2 represent undisturbed areas of the Site where Quaternary deposits and bedrock outcrops of the Chinle Formation are present. Due to the relatively uniform Site conditions, only one background reference area was required. As a result, BG-1 was selected and BG-2 was considered redundant. Soil samples from BG-1 were collected in November 2016, and the BG-1 gamma survey measurements and soil sample results were used for the remainder of the RSE for the Site.

4.0 REFERENCES

MWH, 2016a. Navajo Nation AUM Environmental Response Trust – First Phase Removal Site Evaluation Work Plan. October.

MWH, 2016b. Occurrence B Site Clearance Data Report – Revision 1, Navajo Nation Abandoned Uranium Mines Environmental Response Trust. December.

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
Occurrence B
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 - Chinle Formation						
Total Number of Observations	10	10	10	10	10	10
Percent Non-Detects	--	0.5	1	--	--	--
Minimum[1]	1.7	--	--	0.32	10	0.84
Minimum Detect[2]	--	0.22	--	--	--	--
Mean[1]	2.06	--	--	0.348	11.3	0.984
Mean Detects[2]	--	0.254	--	--	--	--
Median[1]	1.95	--	--	0.35	11	0.985
Maximum[1]	2.9	--	--	0.37	13	1.17
Maximum Detect[2]	--	0.31	--	--	--	--
Distribution	Normal	Normal	No Calculation	Normal	Normal	Normal
Coefficient of Variation[1]	0.182	--	--	0.0445	0.0729	0.0962
UCL Type	95% Student's-t UCL	95% KM (t) UCL	No Calculation	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	2.277	0.218	No Calculation	0.357	11.78	1.039
UTL Type	UTL Normal	UTL KM Normal	--	UTL Normal	UTL Normal	UTL Normal
UTL Result	3.151	0.467	--	0.393	13.7	1.26

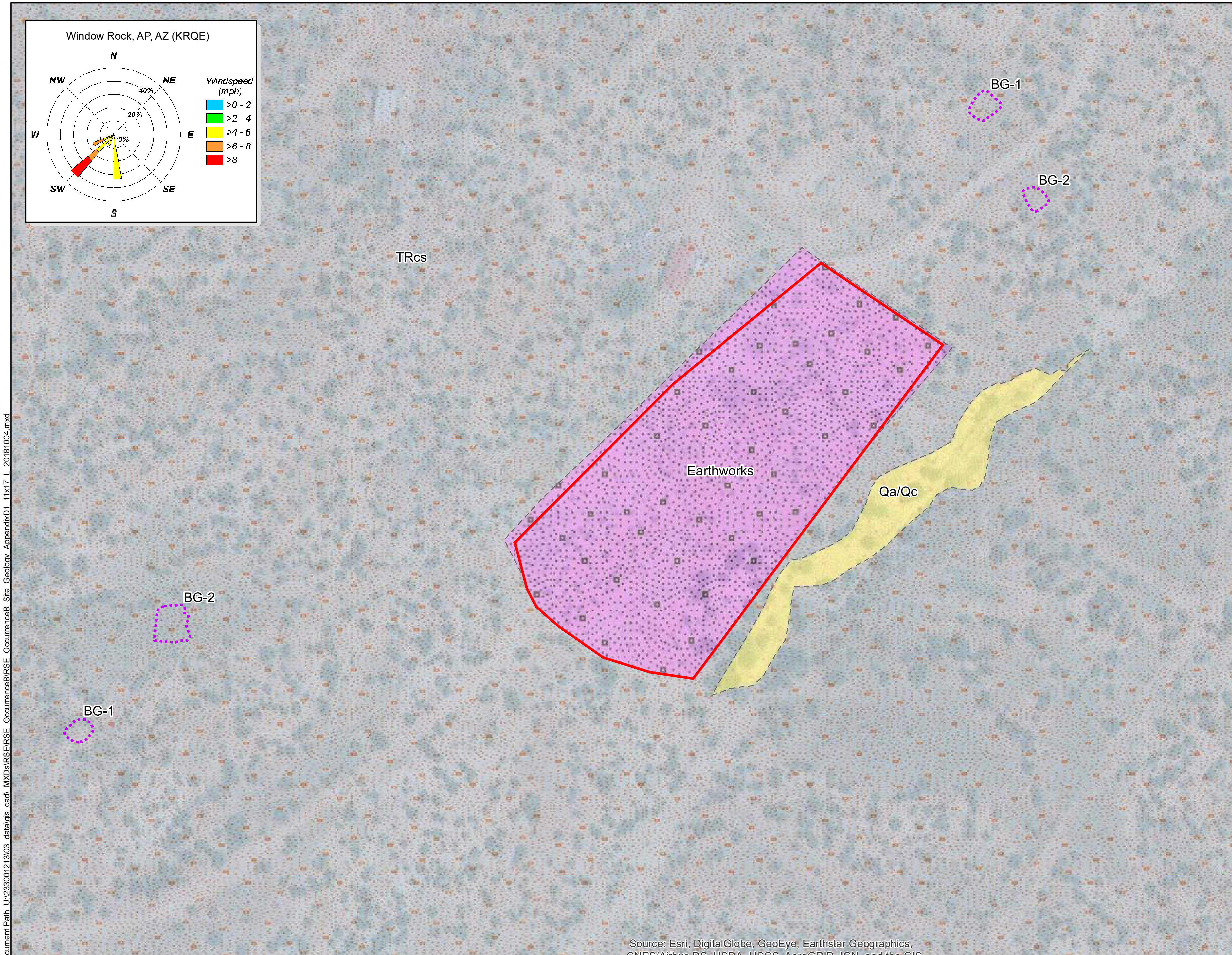
Notes
[1] This statistic is reported by ProUCL when the dataset contains 100 percent detections.
[2] This statistic is reported by ProUCL when non-detect values exist in the dataset. The value reported is calculated using detections only.

KM	Kaplan Meier
mg/kg	Milligrams per kilogram
--	Not applicable
pCi/g	Picocuries per gram

Table D.1-2
Surface Gamma Survey Summary
Occurrence B
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)
Geologic Formation	Chinle Formation	Chinle Formation	Chinle Formation	Chinle Formation
Statistic				
Total Number of Observations	156	400	164	144
Minimum	9405	9679	9351	9446
Mean	10436	11039	11170	11107
Median	10298	10911	11129	11099
Maximum	13860	13678	13222	13127
Distribution	Normal	Normal	Normal	Normal
Coefficient of Variation	0.0624	0.0682	0.0706	0.0671
UCL Type	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	10,522	11101	11,272	11,209
UTL Type	UTL Normal	UTL Normal	UTL Normal	UTL Normal
UTL Result	11,649	12,378	12,634	12,502

Notes
cpm Counts per minute
UCL Upper confidence limit
UTL Upper tolerance limit



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Potential Background Reference Area

Claim Boundary

Geologic Contact (Inferred)

Site Geology

QUATERNARY

Earthworks: Surficial earthworks of TRcs outcrops and decomposed or highly weathered rock derived from TRcs.

Qa/Qc: Surficial deposits of alluvium and/or colluvium.

TRIASSIC

TRcs: Shinarump Member of the Chinle Formation (Upper Triassic), - moderate-orange and yellowish-gray sandstone, siltstone, conglomerate and sandy shale.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 10/4/2018.

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Feet

TITLE:
Geologic Map and Potential Background Reference Areas

PROJECT:
Removal Site Evaluation
Occurrence B Mine Site

DATE: 10/4/2018

DOCUMENT NAME: Removal Site Evaluation Report

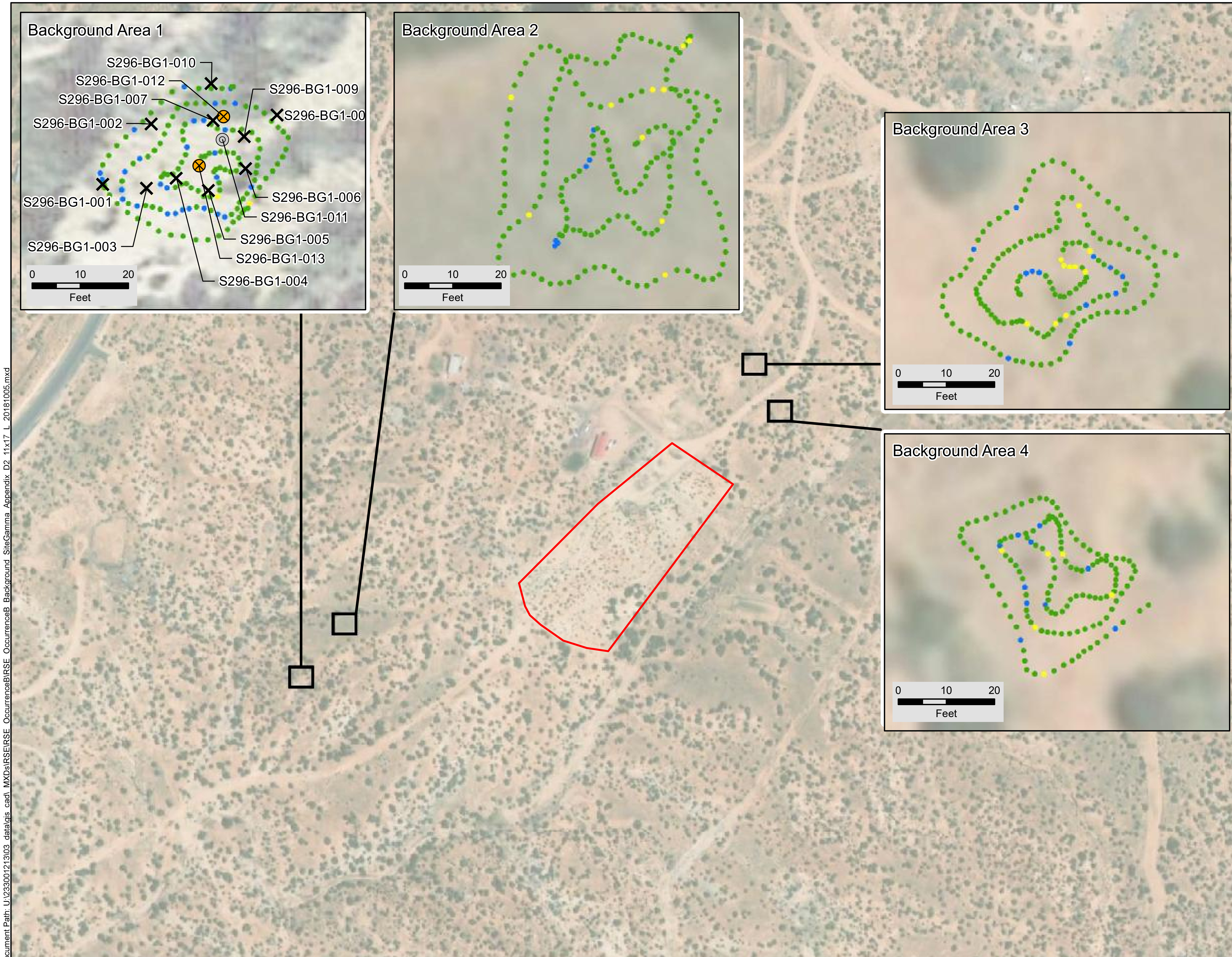
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: D.1-1

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Occurrence B\RSE_OccurrenceB_Site_Geology_AppendixD1_11x17_L_20181004.mxd



Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_OccurrenceB\RSE_OccurrenceB_Background_SiteGamma_Appendix_D2_11x17_L_20181005.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Surface Borehole Location for Background Reference
- Attempted Borehole Location
- Claim Boundary

Gamma Survey
Counts per Minute (CPM)

- 7,910 - 10,000
- 10,001 - 12,500
- 12,501 - 13,860

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 10/4/2018.

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Feet

TITLE:
Potential Background Reference Area
Gamma Radiation Survey Results

PROJECT:
Removal Site Evaluation
Occurrence B Mine Site

DATE: 10/4/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: D.1-2

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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 Occurrence B 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 for both Background Area 1 (BG-1) and the Survey Area. A Background Reference Area (BG-1) was selected that represents the regional around the Site (Survey Area) as described in Appendix D.1. BG-1 is located 700 feet southwest of the Site and is upwind and hydraulically cross-gradient from the Site. The gamma radiation survey data and soil sample analytical results for BG-1 and the Survey Area 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 the Survey Area (boxplots, probability plots, hypothesis testing with Wilcoxon Mann-Whitney test). Soil sample and gamma radiation survey results were compared between BG-1 and the Survey Area qualitatively and quantitatively to evaluate similarity or difference in data distributions between the areas, and as a component of evaluating background reference 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 Occurrence B 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).

At BG-1, soil samples were collected randomly. Potential outliers in the BG-1 dataset were examined using boxplots, probability plots and statistical testing. Descriptive statistics were then calculated, as applicable. Finally, the potential outlier values were evaluated to determine if a reason could be found to remove the data points before calculating the final statistics. The results of these evaluations are described in the following sections.

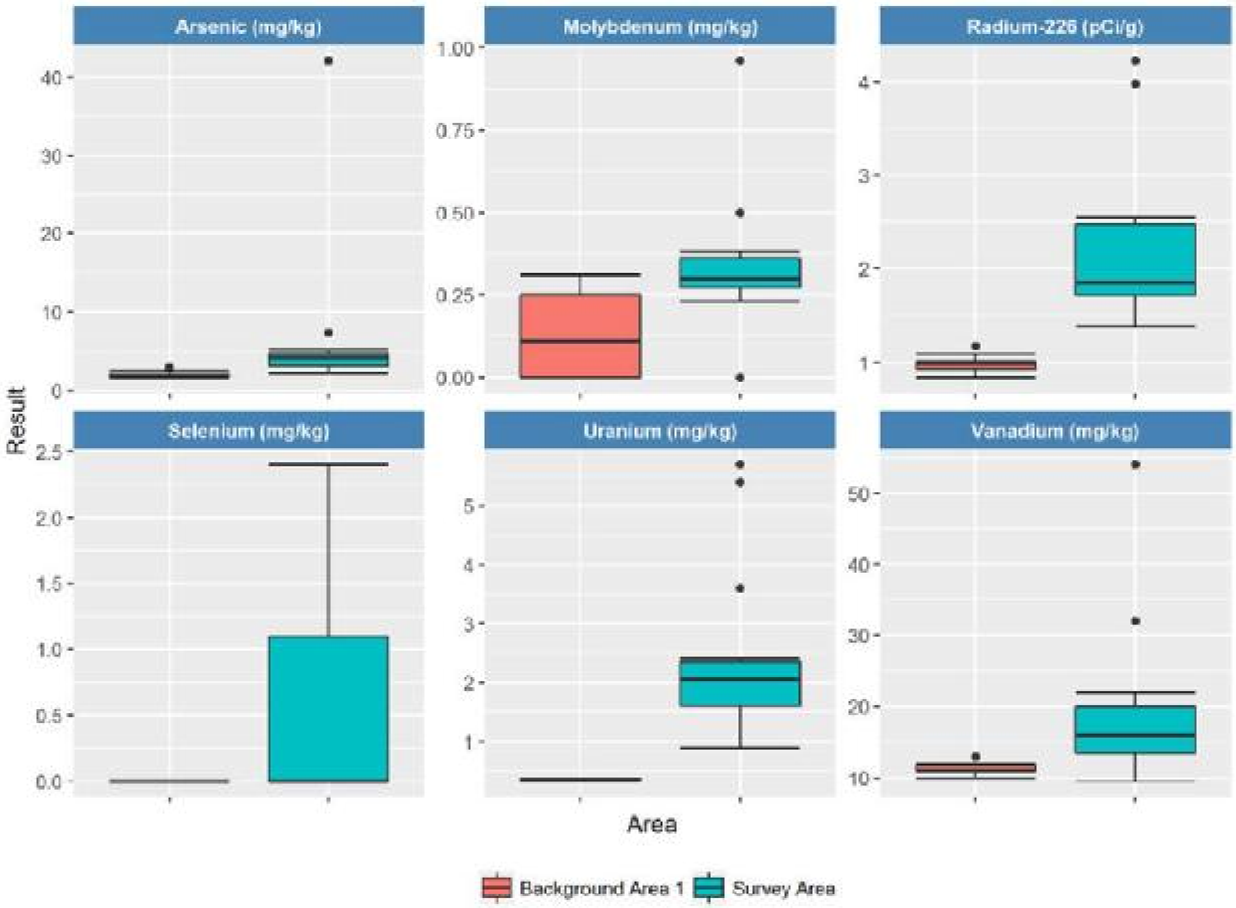
In the Survey Area at Occurrence B, soil samples were collected using a judgmental sampling approach. Specifically, some sample locations were selected to characterize areas of higher gamma radiation; as a result, potential outlier values are not unexpected in the Survey Area sample statistics. Potential 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 and comparisons of the Survey Area to BG-1 are presented for qualitative assessment. However, potential outlier values in the Survey Area are not evaluated further nor removed from the dataset.

3.1.1 Boxplots

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 Boxplots

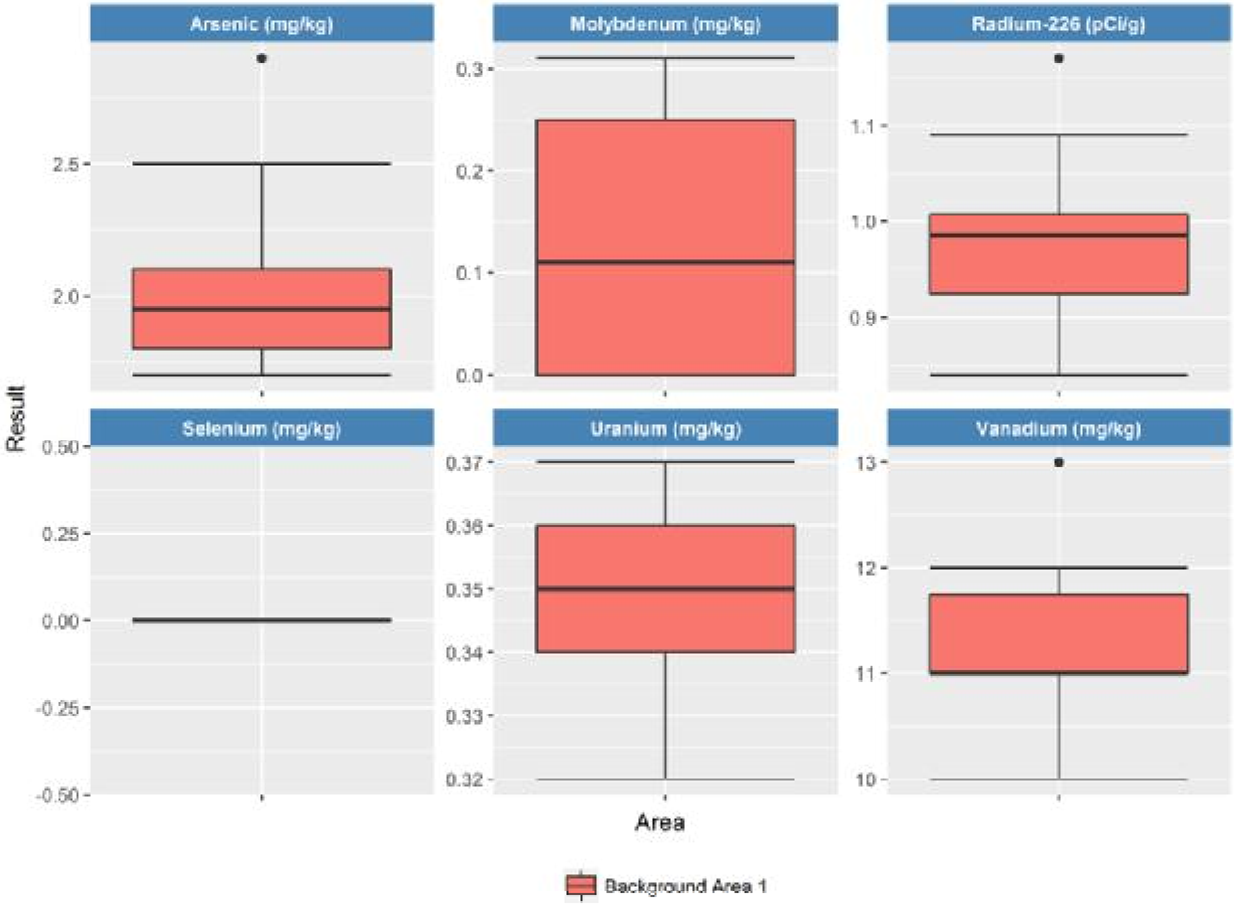
Figure 1A. Survey Area and BG-1 Soil Sample Boxplots



The soil sample boxplots shown on Figure 1A depict differences in the data distribution for analytical constituent concentrations between BG-1 and the Survey Area. Some potential outlier values are shown for both BG-1 and the Survey Area at Occurrence B.

Potential outlier values are of greatest concern in the BG-1 datasets as the data from BG-1 are used to determine the ILs. Background reference area data are presented alone in Figure 1B.

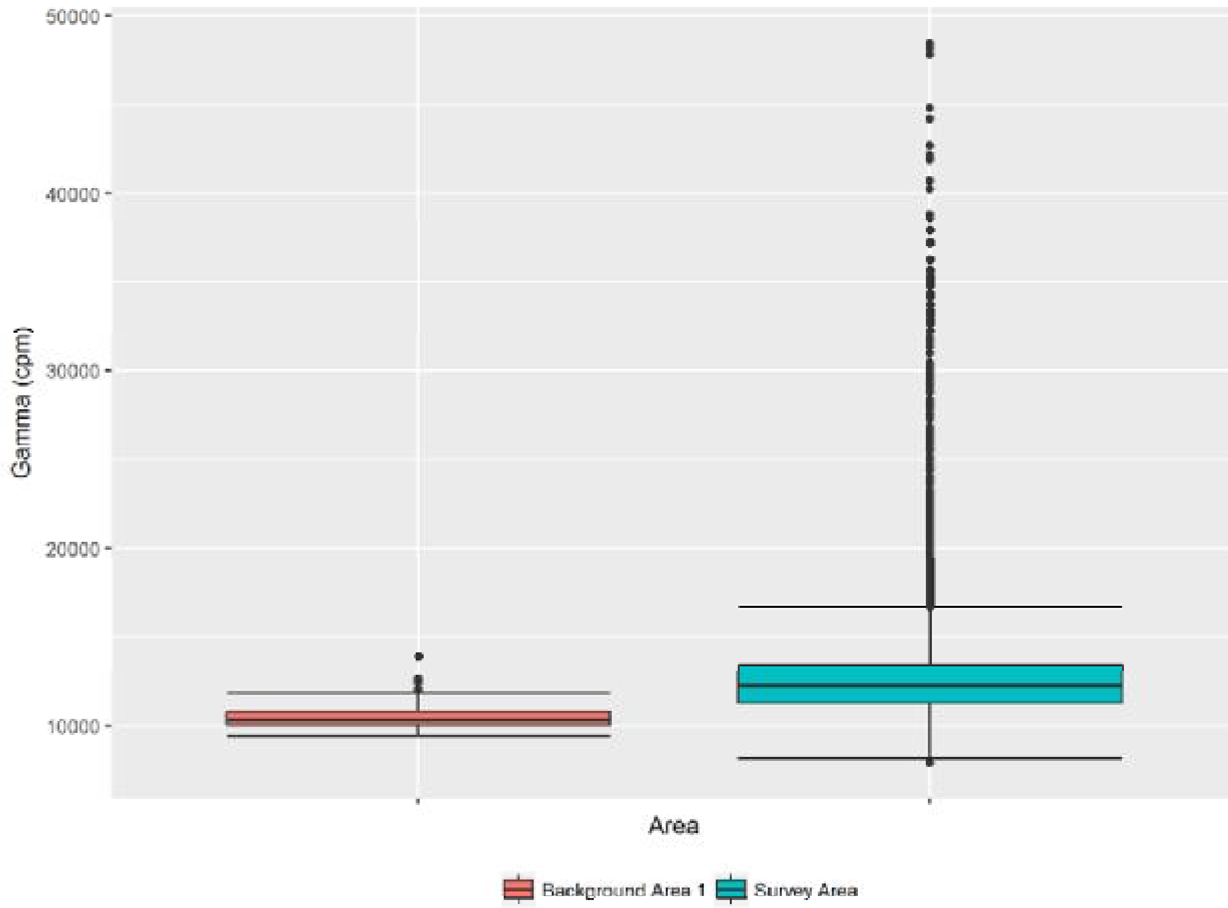
Figure 1B. BG-1 Soil Sample Boxplots



As shown in Figure 2B, no very high potential outlier values were observed in the Occurrence B BG-1 dataset, though one value each for arsenic (As), Ra-226 and vanadium (V) are identified as potential outliers (i.e., outside 1.5 times the interquartile range).

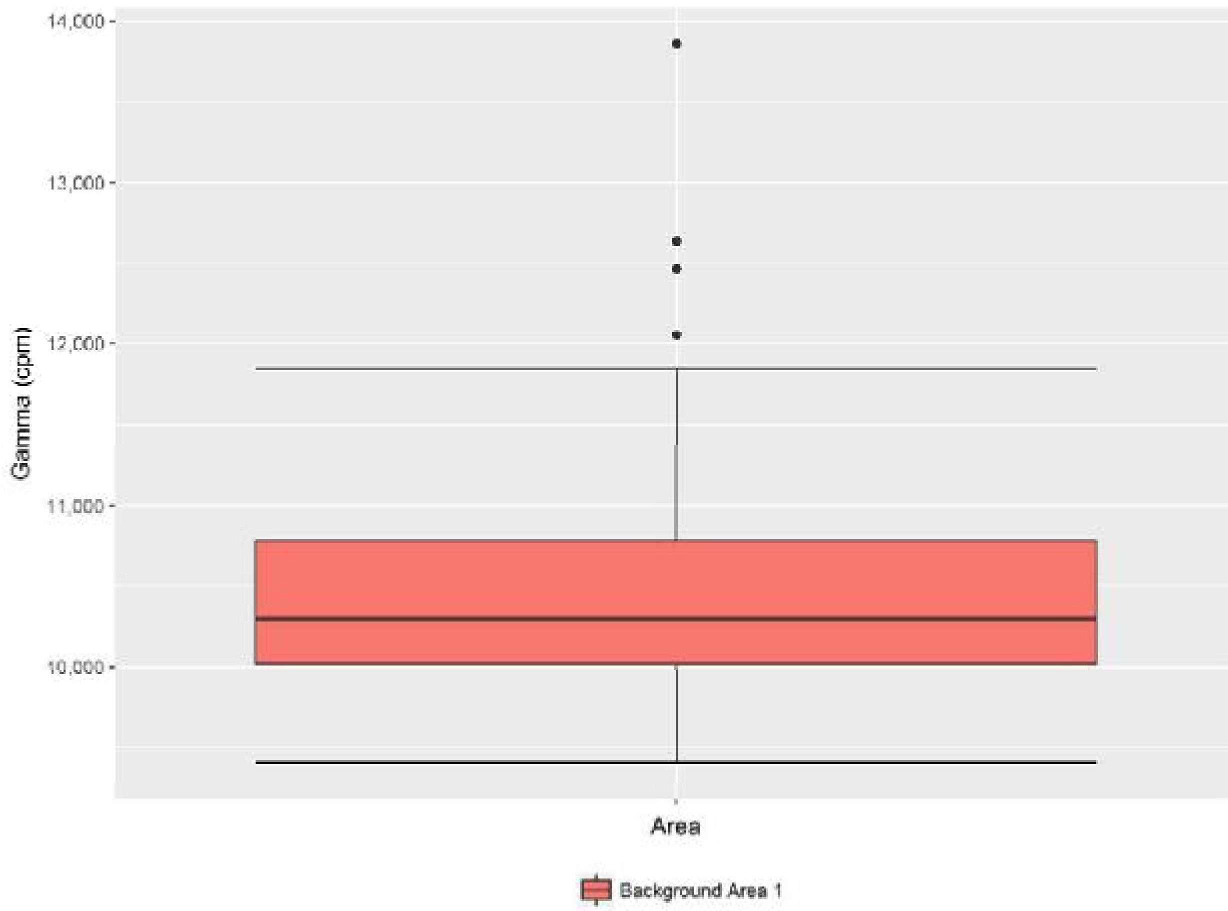
3.1.1.2 Gamma Radiation Results Boxplots

Figure 2A. Survey Area and BG-1 Gamma Radiation Boxplots



The gamma radiation survey results box plots shown on Figure 2A depict differences in the data distribution for gamma measurements between BG-1 and the Survey Area. The large number of potential outlier values in the Survey Area box plot indicate high skewness or possibly lognormally distributed data, instead of outlier values. This has been further evaluated with the use of probability plots in Section 3.1.2 and statistical testing in Section 3.1.4. Based on a review of the Site geology, the gamma radiation potential outlier values observed for the Survey Area on Figure 2A represent localized areas of higher gamma radiation with respect to other parts of the Survey Area, as would be expected in areas with varying levels of mineralization, NORM and potential TENORM.

Figure 2B. BG-1 Gamma Radiation Boxplots



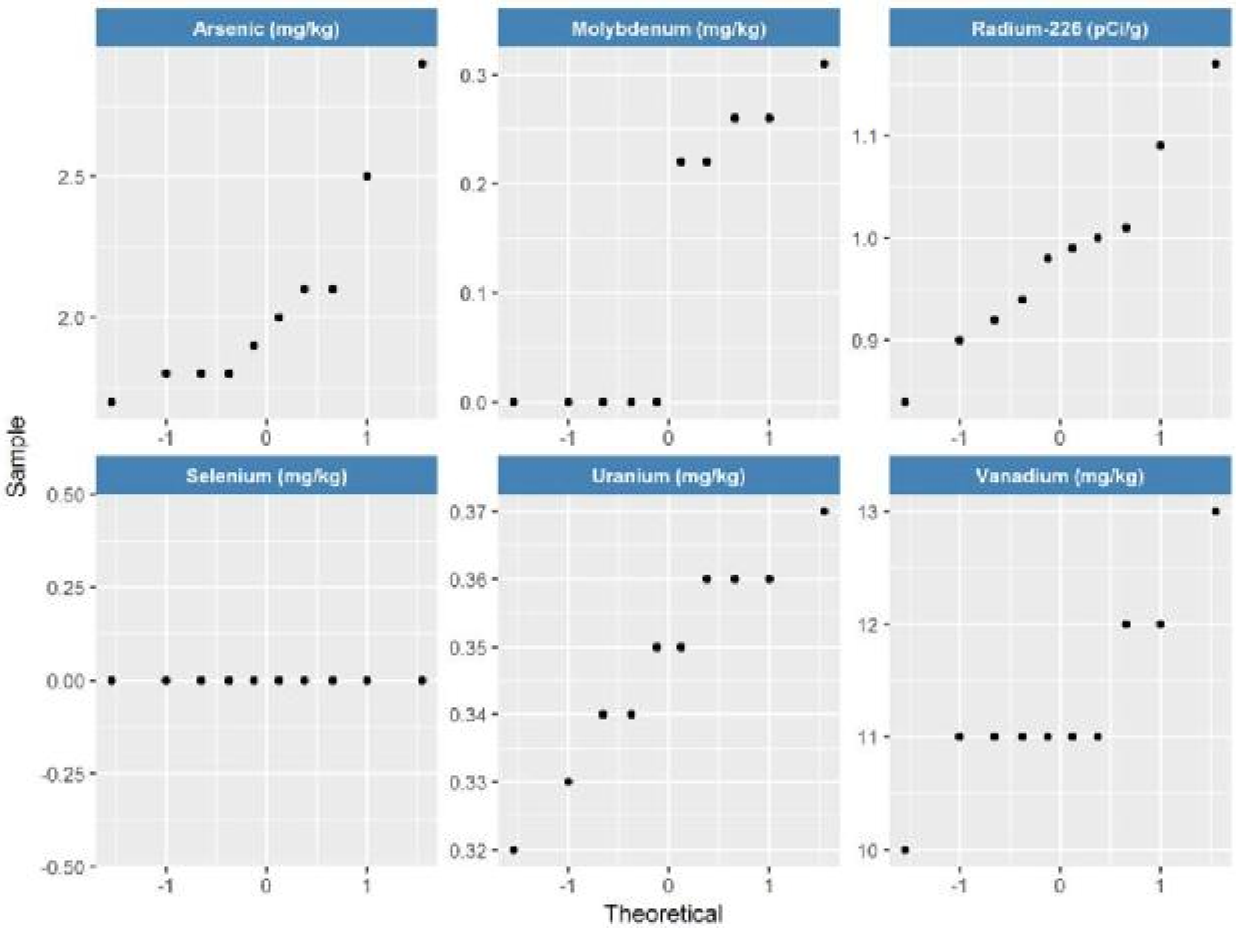
As shown in Figure 2B, there are four potential outlier values shown for gamma data in the BG-1 dataset; however, they are not very high, represent a very small proportion of the total BG-1 gamma data values, and there is no other compelling rationale to reject these data based on the box-plot evaluation alone.

3.1.2 Probability Plots

The normal probability plot is a graphical technique for assessing whether 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

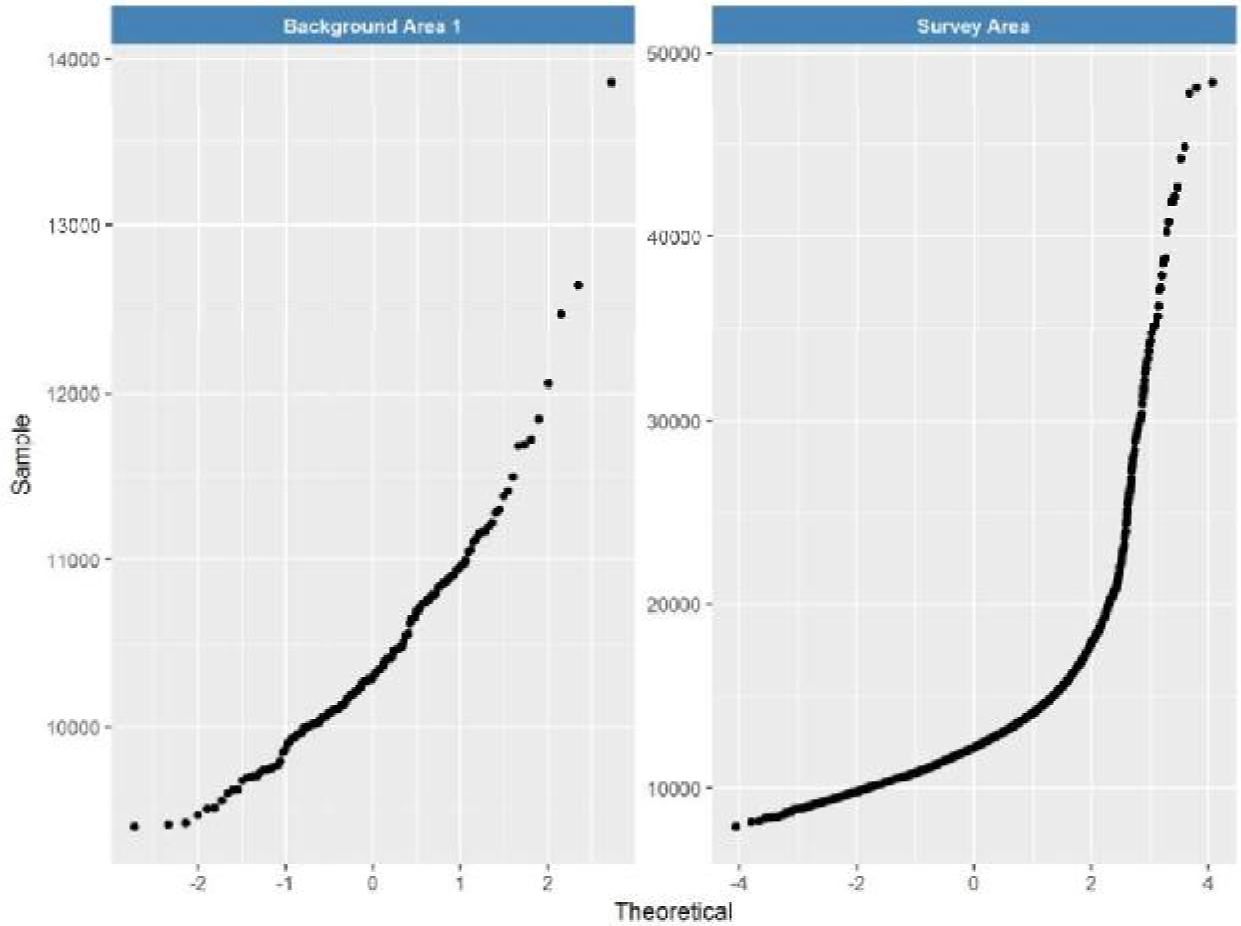
Figure 3. BG-1 Soil Sample Probability Plots



One value each for arsenic, Ra-226 and vanadium were identified as potential outliers in the box plots in Figure 1B. When viewed in the probability plots in Figure 3, these values do not appear to be as far removed from the rest of their respective datasets as they may appear in the box plots. These three values were tested for statistical significance as potential outliers in Section 3.1.3. All 10 soil samples at BG-1 were non-detect for selenium, and five samples were non-detect for molybdenum.

3.1.2.2 Gamma Survey Results Probability Plots

Figure 4. Survey Area and BG-1 Gamma Probability Plots



Gamma survey results indicate generally normal distribution of data in BG-1 and likely lognormal distribution in the Survey Area (Figure 4). When viewed in the probability plot, the three or four highest BG-1 gamma values appear removed from the distribution of the rest of the dataset, suggesting they are potential outliers as observed in the boxplot on Figure 2B.

The shape and smoothness of the gamma probability plot in the Survey Area confirms that the gamma radiation data are more lognormally distributed than in the background reference area. This means that these higher values are not potential outliers but rather representative of the spatial variability of gamma radiation in the Survey Area.

3.1.3 Potential Soil Sample Data Outliers

Three potential outlier values are identified in the boxplots in Figure 1B for arsenic, Ra-226 and vanadium at BG-1 with values of 2.9 mg/kg, 1.17 mg/kg, and 13 mg/kg, respectively. However, these values did not appear largely different from the rest of their respective datasets when viewed in the probability plots in Figure 2B.

Dixon’s Test (Dixon, 1953) is designed to be used for datasets containing only one or two potential outlier values. Therefore, Dixon's Test was performed to the 95% confidence level on each of the potential outlier values for arsenic, Ra-226 and vanadium in the BG-1 datasets. The results of Dixon’s Test are summarized in Table 1.

Table 1. Summary of Dixon's Test on Maximum Values

Constituent	Location ID	Method	Hypothesis	p_Value	Conclusion
As	S296-BG1-003	Dixon test for potential outliers	Highest value 2.9 is a potential outlier	> 0.05	Hypothesis rejected
Ra-226	S296-BG1-010	Dixon test for potential outliers	Highest value 1.17 is a potential outlier	> 0.05	Hypothesis rejected
V	S296-BG1-003	Dixon test for potential outliers	Highest value 13 is a potential outlier	> 0.05	Hypothesis rejected

The test confirms that the three potential outliers observed are not statistically significant (p value <0.05). Because these values were not found to represent potential statistical outliers, they are considered representative and there is no basis to remove the values from the dataset prior to calculating statistics.

3.1.4 Potential Gamma Data Outliers

Four high gamma survey potential outlier values are observed for the BG-1 gamma dataset shown in the boxplot in Figure 2B. When viewed in the probability plot in Figure 4, the four values do appear removed from the remainder of the dataset. Because there are greater than one potential outlier values in the BG-1 gamma dataset, and the number of values in the dataset is >30, Dixon’s Test was not appropriate for testing these values. 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.

Table 2. Potential Gamma Outlier Interquartile Range, Z Score, t Score and Chi Squared Score Results

Value (cpm)	Interquartile Range Result	Z Score Result	t Score Result	Chi Sq Score Result	Chi Sq Score Result
13,860	High	Potential Outlier	Potential Outlier	Potential Outlier	Potential Outlier
12,639	High	Potential Outlier	Potential Outlier	Potential Outlier	Potential Outlier
12,467	High	Potential Outlier	Potential Outlier	Potential Outlier	Potential Outlier
12,056	High	Potential Outlier	Potential Outlier	Potential Outlier	Potential Outlier

While these four values are deemed potential outliers, they represent 4 out of 156 data points (2.6 percent). One possible reason for the potential outlier values in a gamma radiation dataset may be the presence of a localized source of radiation within the BG-1 area. This was evaluated by viewing the relative position of the potential outlier values to each other. The four potential outlier values are indeed located within less than 10 feet of each other when viewed spatially, supporting this hypothesis. There is no scientific reason to reject these values. However, descriptive statistics for gamma were calculated with and without these values for comparison (Section 3.3.2).

Potential outlier values in the gamma dataset for the Survey Area appear in the Figure 2A box plot. However, because of the smooth and possibly lognormal distribution of these gamma results shown in the probability plot in Figure 4, these higher values are not outliers but rather represent the spatial variability of gamma radiation in the Survey Area.

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 consideration 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 there is only one background area). Alternatively, testing of this kind may reveal background concentrations statistically higher than the corresponding Survey Area, 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, aspect, vegetation cover, wind direction and soil depth 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 at Occurrence B presented in this evaluation. Relative data distributions were investigated by evaluating the boxplots and probability plots in Figures 1A through 4, and by hypothesis testing with the non-parametric Mann-Whitney test, as applicable.

3.2.1 Evaluation of Boxplots

3.2.1.1 Soil Sample Boxplots

The boxplot comparison in Figures 1A and 1B suggests that mean metals and Ra-226 values may differ between BG-1 and the Survey Area, with all constituents being elevated in the Survey Area compared to BG-1.

When interpreting the soil sample boxplots in Figures 1A and 1B, it is important to note that samples at BG-1 were collected randomly, while samples in the Survey Area were collected judgmentally. Mann-Whitney testing is not appropriate for comparative analysis if one or both groups contain data collected using a judgmental approach, and therefore the Mann-Whitney test was not performed between BG-1 and Survey Area soil sample results.

3.2.1.2 Gamma Radiation Boxplots

The boxplot comparison in Figures 2A and 2B suggests possible differing gamma data distributions between BG-1 and the Survey Area with likely a higher mean gamma value in the Survey Area compared to BG-1. This observation is 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 for determining 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 the other 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.

As previously mentioned soil samples at BG-1 were collected randomly, while soil samples in the Survey Area 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 BG-1 and the Survey Area. Gamma radiation data, however, do represent non-judgmental sampling, and so the Mann-Whitney test was appropriate for comparison between the background reference area and Survey Area (Table 3). The test was performed 2-sided on the BG-1 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 the Mann-Whitney testing are presented in Table 3.

Table 3. Summary of Gamma Survey Mann-Whitney Test Results

Comparison	p_Value	Description
Background Area 1 (BG-1) All Data vs Survey Area	<0.05	Significant Difference
BG-1 All Data vs BG-1 Potential Outliers Excluded	0.698	No Significant Difference
BG-1 Potential Outliers Excluded vs Survey Area	<0.05	Significant Difference

The results of the Mann-Whitney testing on gamma radiation survey results in Table 3 indicate the following:

- There is a statistically significant difference in gamma results between BG-1 and the Survey Area. This result likely is due to a greater presence of mineralization in the Survey Area (see RSE Report Section 3.2.2.2)
- The inclusion or removal of potential outlier values from the BG-1 gamma dataset has no effect on the results of the Mann-Whitney Test between BG-1 and the Survey Area (i.e., there is a statistically significant difference in gamma results between BG-1 and the Survey Area with and without potential outlier values included).

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 dataset 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 are taken from the descriptive statistics, namely the 95-95 UTL. The UTL value is selected by ProUCL as the maximum value in the dataset when the data are determined to be non-parametric. The parameters and constituents evaluated include gamma radiation, arsenic, molybdenum, selenium, uranium, vanadium, and radium-226.

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 have been calculate inclusive of potential outlier values 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.

As described in Section 3.2.1.1, all metals and Ra-226 results appear elevated for the Survey Area relative to BG-1. However, an important consideration when comparing concentrations of metals and Ra-226 between BG-1 and the Survey Area is that the background reference area was 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 area was conducted in a random manner, whereas soil sampling for metals and Ra-226 in the Survey Area was judgmental. As a result, it's not surprising that metals and Ra-226 concentrations in the Survey Area appear to be elevated relative to metals and Ra-226 concentrations in BG-1. It should be noted, however, that metals concentrations measured in the Survey Area 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 all metals in the Survey Area are within typical ranges reported for Western U.S soils.

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 Area 1 (BG-1)	Total Number of Observations	10	10	10	10	10	10
	Percent Non-Detects	--	50%	100%	--	--	--
	Minimum¹	1.70	--	--	0.320	10.0	0.840
	Minimum Detect²	--	0.220	N/A	--	--	--
	Mean¹	2.06	--	--	0.348	11.3	0.984
	Mean Detects²	--	0.254	N/A	--	--	--
	Maximum¹	2.90	--	--	0.370	13.0	1.17
	Maximum Detect²	--	0.310	N/A	--	--	--
	Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation¹	0.182	--	--	0.045	0.073	0.096
	CV Detects²	--	0.146	--	--	--	--
	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	2.28	0.218	Not Calculated	0.357	11.8	1.04
	UTL Type	UTL Normal	UTL KM Normal	--	UTL Normal	UTL Normal	UTL Normal
	UTL Result	3.15	0.467	--	0.393	13.7	1.26
Survey Area	Total Number of Observations	14	14	14	14	14	14
	Percent Non-Detects	--	14%	64%	--	--	--
	Minimum¹	2.20	--	--	0.890	9.50	1.38
	Minimum Detect²	--	0.230	1.10	--	--	--
	Mean¹	6.77	--	--	2.39	19.2	2.23
	Mean Detects²	--	0.382	1.62	--	--	--
	Maximum¹	42.0	--	--	5.70	54.0	4.22
	Maximum Detect²	--	0.960	2.40	--	--	--
	Distribution	Unknown	Normal	Normal	Gamma	Normal	Normal
	Coefficient of Variation¹	1.51	--	--	0.626	0.602	0.386
	CV Detects²	--	0.512	0.336	--	--	--
	UCL Type	95% Chebyshev (Mean, Sd) UCL	95% KM (t) UCL	95% KM (t) UCL	95% Adjusted Gamma UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	18.7	0.437	1.04	3.31	24.6	2.64
	UTL Type	UTL Non-Parametric	UTL KM Normal	UTL KM Normal	UTL Gamma WH	UTL Normal	UTL Normal
	UTL Result	42.0	0.883	2.71	7.33	49.4	4.49

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	Kapplan 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

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 Area 1 (BG-1) All Data	Total Number of Observations	156
	Minimum	9,405
	Mean	10,436
	Median	10,298
	Maximum	13,860
	Distribution	Normal
	Coefficient of Variation	0.062
	UCL Result	10,522
	UTL Type	UTL Normal
	UTL Result	11,649
Background Area 1 (BG-1) Excluding Potential Outliers	Total Number of Observations	152
	Minimum	9,405
	Mean	10,375
	Median	10,289
	Maximum	11,845
	Distribution	Gamma
	Coefficient of Variation	0.051
	UCL Result	10,445
	UTL Type	UTL Gamma WH
	UTL Result	11,372
Survey Area	Total Number of Observations	20,123
	Minimum	7,910
	Mean	12,611
	Median	12,238
	Maximum	48,436
	Distribution	Normal
	Coefficient of Variation	0.183
	UCL Result	12,638
	UTL Type	UTL Normal
	UTL Result	16,458

CPM Counts per minute
WH Wilson Hilferty

As noted for metals and Ra-226 in Section 3.3.1, gamma results measured within the Survey Area appear to be elevated relative to gamma results measured in BG-1 because the background reference area was 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 radiation values within the Survey Area are somewhat higher than gamma radiation results at BG-1.

4.0 INVESTIGATION LEVELS

The calculated 95-95 UTL values from BG-1 described in Section 3.3 and listed in Tables 4 and 5 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 calculated ILs are summarized below.

- Arsenic (mg/kg): 3.15
- Molybdenum (mg/kg): 0.467
- Selenium (mg/kg): None (all results non-detect)
- Uranium (mg/kg): 0.393
- Vanadium (mg/kg): 13.7
- Ra-226 (pCi/g): 1.26
- Gamma (cpm): 11,649

5.0 REFERENCES

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Appendix E Cultural and Biological Resource Clearance Documents

BIOLOGICAL EVALUATION

For the Proposed:

Occurrence B
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 US established The Navajo Nation AUM Environmental Response Trust—First Phase (the ERT) for the Navajo Nation to evaluate certain abandoned uranium mines located across Navajo lands. The ERT requires scientific 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 Occurrence B 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

Occurrence B is located in Apache County, Arizona approximately 6.7 miles northeast of Chinle, Arizona and 0.4 miles southeast of Del Muerto, Arizona at an elevation of approximately 6,469 feet. Global Positioning System coordinates are 36^{o} 10.88’ N by 109^{o} 26.14’ W NAD 83. Legal location of the site is Section 15, Township 32 North, Range 27 East, Gila and Salt River Principal Meridian. The site is located on Navajo Tribal Trust Lands within the Bureau of Indian Affairs (BIA) Chinle Agency. Project area maps are provided in Appendix A.

2.2. Estimated Disturbance

MWH proposes a phased approach to scientific investigations at the Occurrence B AUM. The study area encompasses the claim boundary and a 100-foot perimeter buffer zone for a total of approximately 9.8 acres. Please refer to Appendix A for maps delineating the mine claim boundary and buffer zone.

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) at Occurrence B includes the mine boundary with a 100-foot buffer zone surrounding the perimeter of the boundary. 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 northeastern Arizona 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.

Occurrence B is located within gently rolling sagebrush terrain with scattered pinon-juniper and previously disturbed areas. There are numerous residences within a 0.5-mile radius of the project site with the closest residency 90 feet to the north-northwest.

Flora

Vegetation communities found within the region 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 Occurrence B is sparsely vegetated grassland with sporadic shrubs and scattered piñon/juniper on the eastern and southernmost boundaries. Understory vegetative cover is estimated to be approximately 15-20 percent in areas undisturbed by residences or unmaintained roads.

Fauna

Wildlife or evidence of wildlife observed within the PPA included common raven (*Corvus corax*), cottontail rabbit (S*ylvilagus* 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 south-southeast into an ephemeral / intermittent ravine that runs into Far Spiral Canyon approximately 1.0 mile southwest of the project area. Seasonal flow follows Far Spiral Canyon to Slim Canyon and eventually into Chinle Wash approximately 5 miles southwest 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. ESA-listed fish species are not known to occur in Chinle Wash, nor is it considered critical habitat of any ESA-listed species within 20 miles of the PPA.

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 (02EAAZ00-2016-SLI-0361) 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 Occurrence B Project

Species	Status	Occurrence Within Region	Habitat	Potential to Occur within Action Area
BIRDS				
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.
FISHES				
Roundtail chub (*Gila robusta*)	Proposed Threatened	San Juan and Mancos Rivers. Rarely encountered in recent surveys; some found from Shiprock to near Lake Powell with most between Shiprock and Aneth.[2,3]	Rocky runs, rapids, and pools of creeks and small to large rivers; also large reservoirs in the upper Colorado River system.[2]	No potential. No perennial waters in or near the PPA. Action area is within the San Juan River watershed; however, negligible effects from the project to any drainage system are expected.

Table 1: USFWS Species List for the Occurrence B Project

Species	Status	Occurrence Within Region	Habitat	Potential to Occur within Action Area
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.
FLOWERING PLANTS				
Navajo sedge (*Carex specuicola*)	Threatened	From the Navajo Creek drainage in Coconino Co, east to the Tsegi Canyon Watershed in Navajo Co, south to the Rock Point/Mexican Water & Canyon de Chelly National Monument, Apache Co, AZ area. Also known from Chinle Creek, San Juan Co, UT.	Typically found in seeps and hanging gardens, on vertical sandstone cliffs and alcoves. Known populations occur from 4600ft to 7200ft.	No potential. Action area does not provide suitable habitat for species to occur. No individuals found during Redente plant investigations.[5]
MAMMALS				
Black-Footed ferret (*Mustela nigripes*)	Experimental Population, Non-Essential	Reintroduced into Coconino County.[1]	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.
Gray wolf (*Canus lupus*)	Proposed Experimental	In NE AZ, South of Hwy 60 in Apache, Coconino, and Navajo County; In NW NM, south of I-40 in Cibola, McKinley and Catron County.[2]	Not limited to any particular habitat type. Viable populations occur only where human population density and persecution level are low and prey densities are high. Birthing dens may be on bluffs or slopes among rocks or in enlarged badger holes. In Arizona and New Mexico, diet includes primarily elk and sometimes livestock, deer, rodents, or lagomorphs.[2]	No potential. Action area does not provide suitable habitat for species to occur. Human activity and lack of appropriate den sites a limiting factor.
REPTILES				

Table 1: USFWS Species List for the Occurrence B Project

Species	Status	Occurrence Within Region	Habitat	Potential to Occur within Action Area
Northern Mexican gartersnake (*Thamnophis eques megalops*)	Threatened	Most of AZ; In SE NM including Catron, Grant and Hildago County [2]	Considered a riparian obligate except during dispersal behavior. Occurs chiefly in the following general habitat types: (1) Source-area wetlands [e.g., cienegas (mid-elevation wetlands with highly organic, reducing (basic, or alkaline) soils), stock tanks (small earthen impoundment), etc.]; (2) large river riparian woodlands and forests; and (3) streamside gallery forests (as defined by well-developed broadleaf deciduous riparian forests with limited, if any, herbaceous ground cover or dense grass). Occurs at elevations from 130 to 8,497 (ft).[2]	No potential. Action area does not provide suitable habitat for species to occur.

[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 eight (8) 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 1have been eliminated from further discussion in this report. There would be no direct, indirect or cumulative impacts to the eliminated 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 plant and animal 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, Golden Eagle (*Aquila chrysaetos*) and Navajo Sedge (*Carex specuicola*) are known to occur within a 3-mile radius of 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			
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.
Northern Leopard Frog (*Lithobates pipiens*)	NESL G2	Springs, slow streams, marshes, bogs, ponds, canals, flood plains, reservoirs, and lakes; usually permanent water with rooted aquatic vegetation. In summer, commonly inhabits wet meadows and fields. Takes cover underwater, in damp niches, or in caves when inactive. Over winters usually underwater. Eggs are laid and larvae develop in shallow, still, permanent water (typically), generally in areas well exposed to sunlight.[3,4]	No potential. Action area does not provide suitable habitat for species to occur.
Southwestern Willow Flycatcher (*Empidonax traillii extimus*)	NESL G2 USFWS-E	Breeds in dense riparian habitat.[2]	No potential. Action area does not provide suitable habitat for species to occur.
American Dipper (*Cinclus mexicanus*)	NESL G3	Nests near clear, unpolluted streams usually <=15 m in width and <=2 m in depth, with a variety of riffles, pools, and waterfalls with substrate of rocks, sand, and rubble; instream and streamside boulders are necessary for perches. [3]	No potential. Action area does not provide suitable habitat for species to occur.
PLANTS			
Alcove Death Camass (*Zigadenus vaginatus*)	NESL G3	Hanging gardens in seeps and alcoves, mostly on Navajo Sandstone, 3700 – 6700ft.[3]	No potential. Action area does not provide suitable habitat for species to occur. No individuals found during Redente plant investigations.[5]
Alcove Bog-orchid (*Platanthera zothecina*)	NESL G3	Seeps, hanging gardens, and moist stream areas from the desert shrub to pinion-juniper & Ponderosa pine/mixed conifer communities. Known populations occur between 4000 and 7200ft elevation. [3]	No potential. Action area does not provide suitable habitat for species to occur. No individuals found during Redente plant investigations.[5]
Utah Bladder-fern (*Cystopteris utahensis*)	NESL G4	Seepages, cracks and ledges on cliffs; on calcareous substrates including sandstone, limestone, and dacite. Populations are known from 4200 to 8800 ft elevation. [3]	No potential. Action area does not provide suitable habitat for species to occur. No individuals found during

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area
			Redente plant investigations.[5]
Rydberg's Thistle (*Cirsium rydbergii*)	NESL G4	Hanging gardens, seeps and sometimes stream banks below hanging gardens, 3300-6500 ft. [3]	No potential. Action area does not provide suitable habitat for species to occur. No individuals found during Redente plant investigations.[5]
Gooding's Onion (*Allium gooddingii*)	NESL G3	Generally in spruce-fir forests and mixed conifer forests; in the Chuska Mts also under Gambel oak thickets interspersed with aspen, dogwood, and Douglas fir; in moist, shady canyon bottoms and north-facing slopes, often along streams. 6400 – 9400 ft elevation. [3]	No potential. Action area does not provide suitable habitat for species to occur. No individuals found during Redente plant investigations.[5]

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 ten (10) 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: Northern Leopard Frog (*Lithobates pipiens*), Southwestern Willow Flycatcher (*Empidonax traillii extimus*), American Dipper (*Cinclus mexicanus*), Alcove Death Camass (*Zigadenus vaginatus*), Alcove Bog-orchid (*Platanthera zothecina*),Utah Bladder-fern (*Cystopteris utahensis*), Rydberg's Thistle (*Cirsium rydbergii*), and Gooding's Onion (*Allium gooddingii*). 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.[1,3]	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	Action area provides potential foraging habitat for species to occur.

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area
		km. Nest in ledges or potholes on cliffs in wooded/forested habitats; Forage over riparian woodlands, coniferous & deciduous forests, shrublands, prairies. [3]	

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	No suitable habitat is present within the action area for species to occur.

	nesting.	
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.
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.
Mountain plover (*Charadrius montanus*)	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	No suitable habitat present within the action area for species to occur.

	old cow manure pile. Migration habitat is similar to breeding habitat.	
Burrowing owl (*Athene cunicularia*),	Open grasslands and sometimes other open areas (such as vacant lots). Nests in abandoned burrows, such as those dug by prairie dogs.	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 zone for a total of approximately 9.8 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 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.

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 9.8 acres of potential migratory bird habitat in the form of Great Basin Desert scrub and approximately 50-60 pinon-juniper trees.

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. 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 9.8 acres of potential migratory bird habitat in the form of Great Basin Desert scrub with a moderate pinon-juniper component.

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. 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, nor critical habitats thereof, within greater than 20 miles of the PPA.

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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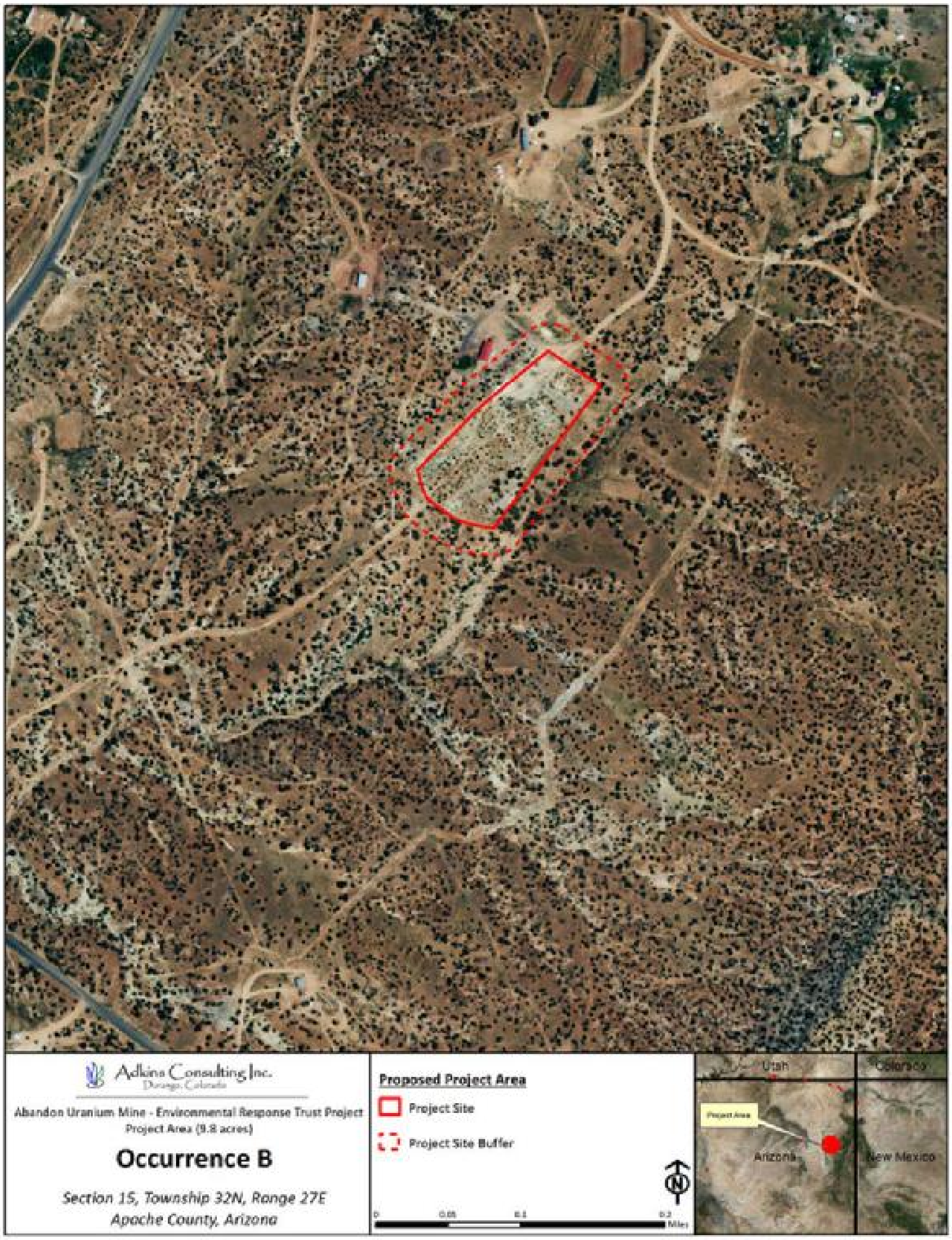
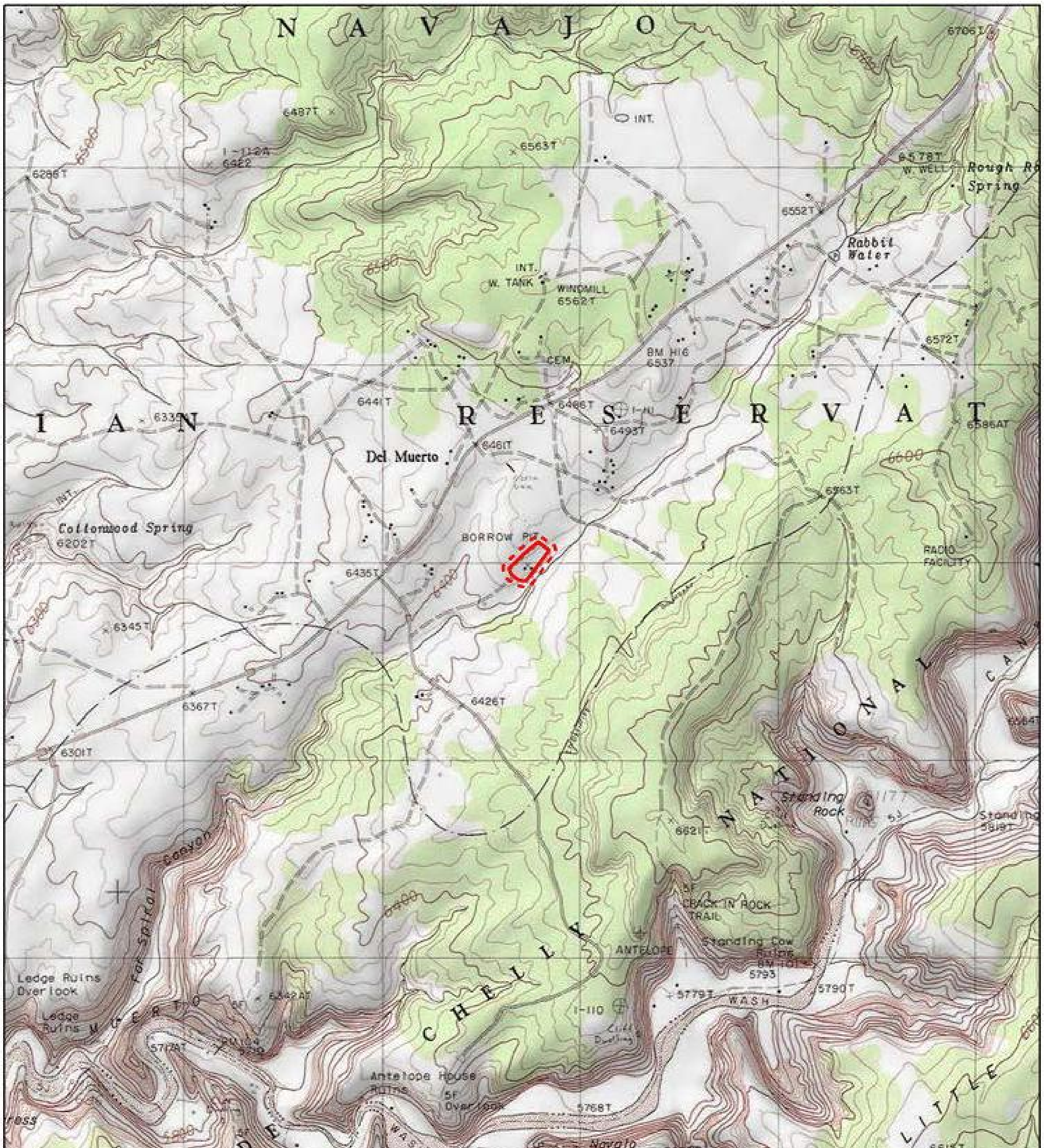
APPENDIX A. MAPS





Adkins Consulting Inc.
Durango, Colorado

Abandon Uranium Mine - Environmental Response Trust Project
Project Area (9.8 acres)

Occurrence B

Section 15, Township 32N, Range 27E
Apache County, Arizona

Proposed Project Area

Project Site

Project Site Buffer

0 0.25 0.5 1 Miles

APPENDIX B. PHOTOGRAPHS

View north from site

View south from site

View southwest from site

APPENDIX C. REDENTE PLANT SURVEY REPORT

Navajo Nation AUM Environmental Response Trust

Plant Survey Report for Species of Concern At Occurrence B Project Site Apache County, Arizona 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 Occurrence B site as part of the Navajo Nation AUM Environmental Response Trust Project. 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

Occurrence B is located in Apache County Arizona, approximately 9 km (5.6 miles) east of Chinle, Arizona at an elevation of approximately 1,950 m (6,400 ft). Global Positioning System coordinates are 36^{o} 10' 52" N by 109^{o} 26' 08" W (North American Datum of 1983). The site is located on Tribal Trust Land (TTL).

Environmental Setting

Climate

The climate of the Occurrence B site is classified as semiarid, with an average annual precipitation of 244 mm (9.6 in) with the greatest precipitation months occurring between July and October. Average annual temperature is 11.8^{o} C (53^{o} F).

Soils

The U.S. Department of Agriculture (USDA) Soil Survey of the Chinle Area, Parts of Apache and Navajo Counties, Arizona and San Juan County, New Mexico was published in 2011 in cooperation with the Bureau of Indian Affairs. The soil mapping unit for the area is Aquima-Ustic Haplocambids Complex (USDA 2011). The Ustic-Haplocambids soil formed in eolian sands that were derived from sandstone. Slopes range from 0 to 6% on structural benches and plateaus and soils are well drained.

Plant Community Type

The vegetation on the Occurrence B site is part of the Colorado Plateau Shrub-Grassland type (USDA 2011). The most common species on the site include pinyon pine (*Pinus edulis*), oneseeded juniper (*Juniperus monosperma*), blue grama (*Bouteloua gracilis*), galleta (*Pleuraphis jamesii*), Indian ricegrass (*Achnatherum hymenoides*), broom snakeweed (*Gutierrizia sarathrae*), rubber rabbitbrush (*Ericameria nauseosa*), big sagebrush (*Artemisia tridentata*), and prickly pear (*Opuntia* spp.)

Land Use

The land type on the Occurrence B site is rangeland and the principal land use is livestock 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 identified six endangered plant species that may occur in the project area— Alcove death camas (*Zigadenus vaginatus*), Alcove bog-orchid (*Platanthera zothecina*), Rydberg's thistle (*Cirsium rydbergii*), Navajo sedge (*Carex specuicola*), Utah bladder fern (*Cystopteris utahensis*), and Gooding's onion (*Allium gooddingii*). The USFWS also listed Navajo sedge as a threatened species that may occur in the area.

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 a 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 meandering "transect" lines through each area and looked for suitable habitat for these species, such as seeps and hanging gardens for *Cirsium rydbergii, Platanthera zothecina, Zigadenus vaginatus*, *Carex specuicola,* and *Cystopteris utahensis*, and spruce fir/mixed conifer forests for *Allium gooddingii*. 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

A total of six plant species of concern were identified as potentially occurring within the proximity of the project area. These species included *Zigadenus vaginatus Platanthera zothecina*, *Cirsium rydbergii*, *Carex specuicola*, *Cystopteris utahensis*, and *Allium gooddingii*.

Zigadenus vaginatus is a native perennial forb that grows in hanging gardens in seeps and alcoves, mostly on Navajo sandstone. This species is endemic to the Colorado Plateau in southern Utah and northern Arizona at elevations between 1,127 and 2,042 m (3,698 and 6,999 ft). *Platanthera zothecina* is a native perennial forb that grows in seeps, hanging gardens and moist stream areas from the desert shrub to the Pinyon-Juniper communities. This species is found in New Mexico, Utah and Arizona at elevations between 1,220 and 2,195 m (4,003 and 7,201 ft). *Cirsium rydbergii* is a native perennial forb that occurs in hanging gardens, seeps and stream banks below hanging gardens at elevations between 1,005 and 1,980 m (3,297 and 6,946 ft). Its distribution includes southern San Juan County along with Coconino and Apache Counties in Arizona. *Carex specuicola* is a native perennial grass-like plant that grows in seeps and hanging gardens primarily on sandstone cliffs and alcoves. Known populations occur at elevations between 1,402 and 2,195 m (4,600 and 7,201 ft) in San Juan County and northern Arizona. *Cystopteris utahensis* is a native perennial vascular plant that grows in seeps, cracks and cliff ledges on calcareous substrates. The only known distribution on the Navajo Nation is in the Canyon de Chelly National Monument in Apache County, Arizona. Populations are known to occur between the elevations of 1,280 and 2,682 m (4,200 and 8,800 ft). *Allium gooddingii* is a native perennial herb that grows in spruce-fir and mixed-conifer forests between the elevations of 1,950 and 2,865 m (6,400 and 9,400 ft). Potential distribution on the Navajo Nation include the Chuska Mountains and the Defiance Plateau.

The survey at Occurrence B on July 20, 2016 did not identify any of the six species that have been listed as potential species of concern for this site. These six species occur in habitats that are distinctly different than the habitats that exist on Occurrence B.

Photo #1—Overview of general landscape and plant community at Occurrence B.

Photo #2—Overview of general landscape and plant community at Occurrence B.

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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.
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

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-16-589
☑ DCRM	OTHER PROJECT NO.: DCRM 2016-07

PROJECT TITLE: A Cultural Resource Inventory of Two Abandoned Uranium Mines for MWH Global, Inc. (Claim 28 and Occurrence B) in Apache County, Arizona.

LEAD AGENCY: BIA/NR

SPONSOR: Sadie Hoskie, Trustee, The Navajo Nation Abandoned Uranium Mines, Environmental Response Trust, P.O. Box 3330, Window Rock, AZ 86515

PROJECT DESCRIPTION: The proposed undertaking involves the completion of Removal Site Evaluations (RSEs) to define the horizontal extent of contamination in surface soils and sediments at the two former uranium mine areas. Ground disturbing activities will be intensive and extensive with the use of heavy equipment and hand tools. The area of effect is 20.1-acres.

LAND STATUS:	Navajo Tribal Trust															
CHAPTER:	Blue Gap, Chinle															
LOCATION:	T.	33	N.,	R.	23	E-	Sec.	UP;	Blue Gap	Quadrangle,	Apache	County	Arizona	G&SRPM		
LOCATION:	T.	32	N.,	R.	27	E-	Sec.	UP;	Del Muerto	Quadrangle,	Apache	County	Arizona	G&SRPM		
PROJECT ARCHAEOLOGIST:	Jeremy Begay, Jeffrey Begay															
NAVAJO ANTIQUITIES PERMIT NO.:	B16040															
DATE INSPECTED:	4/21/2016, 5/4/2016															
DATE OF REPORT:	7/15/2016															
TOTAL ACREAGE INSPECTED:	36.8 – ac															
METHOD OF INVESTIGATION:	Class III pedestrian inventory with transects spaced 10 m apart.															
LIST OF CULTURAL RESOURCES FOUND:	**(2) Sites Previously Recorded (AZ-I-49-31; AZ-I-53-13) (3) Isolated Occurrences (IOs) (1) Traditional Cultural Property (TCP)**															
LIST OF ELIGIBLE PROPERTIES:	**(1) Site, Previously Recorded (AZ-I-49-31) (1) Traditional Cultural Property (TCP)**															
LIST OF NON-ELIGIBLE PROPERTIES:	**(1) Site (AZ-I-53-13) (3) Isolated Occurrences (IOs)**															
LIST OF ARCHAEOLOGICAL RESOURCES:	**(1) Site, Previously Recorded (AZ-I-49-31)**															

EFFECT/CONDITIONS OF COMPLIANCE: No historic properties affected with the following conditions:

Site: AZ-I-49-31:

1. Prior to any construction, the site boundary will be flagged and/or temporarily fenced under the direction of a qualified archaeologist & shown to the construction foreman.
2. All ground disturbance within the 50 ft. of the site boundary will be monitored by a qualified archaeologist.
3. No construction, equipment or vehicular traffic will be allowed within the site boundary.
4. A brief letter/report documenting the result of the monitoring will be submitted to NNHPD within 30 days of monitoring activities.
5. All future maintenance activities shall avoid the site by a minimum of 50 ft. from the site boundary.

Site AZ-I-53-13:
There is no evidence of this site. No further work is warranted.

TCP:
TCP will be avoided by the proposed undertaking.

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 Recommended	☑ Yes	☐ No	The Navajo Nation Historic Preservation Office	Date 9/9/16
Conditions:	☑ Yes	☐ No		
Navajo Region Approval	☒ Yes	☐ No	BIA – Navajo Regional Office Acting	Date 9-28-16

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.: Occurrence B - 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 9.8 acres.

LOCATION: 36°10.88'N 109°26.14'W, Chinle Chapter, Apache County, Arizona

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-Occurrence B Abandoned Uranium Mine Project/AUG 2016/Lori Gregory, Plant Survey Report for Species of Concern At Occurrence B 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/17 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 Gloria M. Tom, Director, Navajo Nation Department of Fish and Wildlife	11/18/16

*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 Occurrence B 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 9 and November 11, 2016 and were analyzed by ALS Environmental of Ft. Collins, Colorado, for all methods except mercury in water. ACZ Laboratories, Inc. of Steamboat Springs, Colorado, analyzed water samples for mercury. 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
- Radium-226 in water by USEPA Method 903.1
- Radium-228 in water by USEPA Method 904
- Gross alpha/beta in water by USEPA Method 900
- Total and dissolved metals in water by USEPA 200.8
- Total dissolved solids in water by USEPA 160.1
- Alkalinity in water by USEPA 310.1
- Chloride and sulfate in water by USEPA 300.0
- Total and dissolved mercury in water by USEPA Method 1631

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 and water data, plus ten percent of the non-radiological data (Level IV only)
- All non-radiological soil and water 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. All MS/MSD RPDs were within acceptance criteria.

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. Sample results qualified due to laboratory duplicate RPDs outside of the acceptance criteria are listed on Table F.1-1. The sample results were qualified with a "J" flag to indicate an estimated result.

Serial Dilution Evaluation. All serial dilution percent differences were within acceptance criteria.

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.

Minimum Detectable Concentration Evaluation. All minimum detectable concentrations met reporting limits.

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 two samples analyzed for radium-226. The sample density exceeded the limit of +/- 15% of the density of the calibration standard. 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 reported.

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 qualified.

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
Occurrence B
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Field Sample Identification	Sample Date	Analysis Code	Analyte	Sample Result	Units	QC Type	QC Result	QC Limit	Added Flag	Comment
S296-BG1-011-1	11/11/16	SW6020	Uranium	0.33	mg/kg	LR	23%	<20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S296-BG1-011-1	11/11/16	SW6020	Vanadium	11	mg/kg	LR	24%	<20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S296-CX-003	11/9/16	E901.1	Radium-226	1.71	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S296-SCX-002-1	11/9/16	E901.1	Radium-226	2.3	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S296-WS-001	11/9/16	E160.1	TDS	280	mg/L	LR	6%	<5%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.

Notes
mg/kg milligrams per kilogram
mg/L milligrams per liter
pCi/g picocuries per gram
LCS laboratory control sample
LR laboratory replicate (duplicate)
RPD relative percent difference