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Eunice Becenti (#313)

Removal Site Evaluation Report

Final | September 23, 2018

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

Eunice Becenti (#313) Removal Site Evaluation Report - Final

September 23, 2018

Prepared for:

Navajo Nation AUM Environmental Response Trust – First Phase

Prepared by:

Stantec Consulting Services Inc.

Title and Approval Sheet

Title: Eunice Becenti Removal Site Evaluation Report - Final

Approvals

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

10/12/2018

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10/12/18

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Revision Log

Revision No.	Date	Description
0	April 13, 2018	Submission of Draft RSE report to Agencies for review
1	September 23, 2018	Submission of Final RSE report to Agencies

Sign-off Sheet

This document entitled *Eunice Becenti 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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Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ATTACHMENTS – PROVIDED ELECTRONICALLY TO THE AGENCIES

- Site-specific geodatabase
- Tabular database files
- 2017 Cooper aerial survey orthophotographs and data files
- Historical documents referenced in this RSE Report (refer to Section 7 for complete citation)
    - Anderson, 1980 - Abandoned or Inactive Uranium Mines in New Mexico. New Mexico Bureau of Mines and Mineral Resources. Open-File Report 148.
    - Chenoweth, 1985 - Historical Review of Uranium Production from the Todilto Limestone Cibola and McKinley Counties, New Mexico. New Mexico Geology.
    - Chenoweth, 1989 - Geology and Production History of Uranium Deposits in the Dakota Sandstone, McKinley County, New Mexico. New Mexico.
    - Hilpert, 1969 - Uranium Resources of Northwestern New Mexico.
    - Kelly, 1967 - Tectonics of the Zuni-Defiance region, New Mexico and Arizona

- McLemore, 1983 - Uranium and Thorium Occurrences in New Mexico: Distribution, Geology, Production, and Resources, with Selected Bibliography.
- Pierson and Green, 1980 - Factors that Localized Uranium Deposition in the Dakota Sandstone, Gallup and Ambrosia Lake Mining Districts, McKinley County, New Mexico.
- USEPA, 2007a - Abandoned Uranium Mines and the Navajo Nation. Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data.
- Weston Solutions, 2009 - Navajo Abandoned Uranium Mine Site Screen Report Eunice Becenti AUM Site.

Executive Summary

Introduction

The Eunice Becenti site (the Site) is located within the Navajo Nation, Eastern Navajo Bureau of Indian Affairs (BIA) Agency, Church Rock Chapter in northwestern New Mexico. 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 September 2017 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 potential mining-related impacts. The area inclusive of the Site has naturally occurring radioactive materials (NORM), which was the reason the area was prospected and mined.

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

Site History and Physical Characteristics

The Site is located within the Colorado Plateau physiographic province, which is an area of approximately 240,000 square miles in the Four Corners region of Utah, Colorado, Arizona, and New Mexico. Regionally, the Site is located in the Gallup-Grants uranium mining district and the Dakota Sandstone was the host rock for uranium on-site. The Site is also located within the Little Colorado River Valley watershed, an area of approximately 27,000 square miles spanning Arizona and New Mexico. Topographically the Site is located along a steeply dipping hogback at a maximum elevation of 8,000 ft above mean sea level. On-site overland surface water flow, when present, is controlled by a decrease in elevation from the hogback ridge to the surrounding plains.

Mine workings on-site consisted of an open pit and an adit. Between 1952 and 1959 the United States Atomic Energy Commission (USAEC) records reported total ore production from the Site was 846 tons (approximately 1.7×10^6 pounds) of ore that contained 3,350 pounds of 0.20 percent U_3O_8 (uranium oxide) and 2,266 pounds of 0.14 percent V_2O_5 (vanadium oxide).

In 2009 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 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 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 to establish ILs for the

Site. Data collected from the site gamma radiation survey 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 and sediment sampling. The results of the surface and subsurface soil and sediment sampling analyses were used to evaluate mining impacts and define the lateral and vertical extent of TENORM at the Site.

In addition, during the RSE work, the Trust performed an "Interim Action" to close an open adit to prevent human and livestock (animal) access.

Findings and Discussion

Surface and subsurface soil and sediment sampling results. Five background reference areas were selected to develop surface gamma, subsurface static gamma, Ra-226, and metals ILs for the Site. Arsenic, molybdenum, selenium, uranium, vanadium, and Ra-226 concentrations and gamma radiation measurements in soil/sediment exceeded their respective ILs and are confirmed constituents of potential concern (COPCs) for the Site. Based on the data analyses performed for this report along with the multiple lines of evidence, approximately 19.8 acres, out of the 30.9 acres of the Survey Area (i.e., the full areal extent of the Site surface gamma survey), were estimated to contain TENORM. Of the 19.8 acres that contain TENORM, 13.0 acres contain TENORM exceeding the surface gamma ILs. The volume of TENORM in excess of ILs was estimated to be 22,964 cubic yards (yd^3) (approximately 17,557 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 locations. Additional correlation studies may be needed to refine the relationship between gamma and Ra-226.

Based on the Site Clearance and RSE data collection and analyses for the Site, potential data gaps were identified and are presented in Section 4.8 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
yd^3	cubic yards
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
Cooper	Cooper Aerial Surveys Company
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
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
NORM	Naturally Occurring Radioactive Material
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
R^2	Pearson's Correlation Coefficient
Ra-226	Radium-226
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
TENORM	Technologically Enhanced Naturally Occurring Radioactive Material
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
USDA	US Department of Agriculture
USDOI	US Department of the Interior
USEPA	US Environmental Protection Agency
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey

V_2O_5	vanadium oxide
Weston	Weston Solutions

Glossary

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

Alluvium – material deposited by flowing water.

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

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

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

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

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

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

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

Earthworks – human-caused disturbance of the land surface related to mining or reclamation.

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

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

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

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

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

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

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

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

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).

Monocline – A unit of folded strata that dips from the horizontal in one direction only, is not part of an anticline or syncline, and occurs at the earth's surface. This structure is typically present in plateau areas where nearly flat strata locally assume steep dips caused by differential vertical movements without faulting (Enacademic, 2018).

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).

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

Pan Evaporation – evaporative water losses from a standardized pan.

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

Remedial Action (or remedy) – "those actions consistent with permanent remedy taken instead of, or in addition to, removal action in the event of a release or threatened release of a hazardous substance into the environment, to prevent or minimize the release of hazardous substances so that they do not migrate to cause substantial danger to present or future public health or welfare or the environment…For the purpose of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the term also includes enforcement activities related thereto" (USEPA, 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 September 2017 at the Eunice Becenti site (the Site) located in northwestern New Mexico, as shown in Figure 1-1. The Site is also identified by the United States Environmental Protection Agency (USEPA) as abandoned uranium mine (AUM) identification #313 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 1.2 acres (52,272 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[2]: (a) at or in excess of 10 times the background levels and the existence of a potentially inhabited structure located within 0.25 miles of AUM features; or (b) at or in excess of two times background levels and the existence of a potentially inhabited structure located within 200 feet (ft)." *Trust Agreement*, Recitals.

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

1.2 OBJECTIVES AND PURPOSE OF THE REMOVAL SITE EVALUATION

The primary objectives of the 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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[2] 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)(2009) report
- Mapping of site features and boundaries
- Evaluation of potential background reference areas
- Biological surveys (wildlife and vegetation)
- Cultural resource surveys

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

Site Characterization Activities and Assessment – included the following:

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

Details regarding the Site Clearance activities are provided in the *Eunice Becenti Site Clearance Data Report* (*Site Clearance Data Report*; MWH, 2016c) and summarized in Section 3.2 of this report. Details regarding the Baseline Study activities are provided in the *Draft Eunice Becenti 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 approximately 5.5 miles southeast of Gallup, New Mexico, (refer to Figure 1-1 inset), on the steeply dipping Nutria monocline (i.e., The Hogback) (refer to Figure 2-1). A summary of historical mining on-site is presented below.

In 1947, the US Atomic Energy Commission (USAEC) began a procurement program for uranium concentrate and in 1950, mineable uranium was first discovered in the Gallup-Grants uranium mining district (Chenoweth, 1985). Though uranium was known to exist within the Gallup-Grants area for several years, this discovery of mineable uranium showed that there were vast mineable uranium resources. The uranium resources in the Gallup-Grants uranium mining district were found within geologic formations of the Jurassic Todilto Limestone, the Jurassic Morrison, and the Cretaceous Dakota Sandstone.

In early 1952, uranium was first discovered on the Nutria monocline (Chenoweth, 1989). The Site is located along the Nutria Monocline, as shown in Figure 2-1. In May 1952, mining rights for the Site were assigned to A.W. Tucker, Tom Hyde, and E.D. Davenport (Chenoweth, 1989). The mining rights were on lease number I-149-IND-9294, which was issued by the Bureau of Indian Affairs (BIA). The Site was also located on a Navajo allotment that was held by Eunice Becenti. The uranium deposit on the Site was mined from an open pit that had a short decline off of the pit wall.

In June 1952, the first shipment of ore from the Site was delivered to the USAEC ore-buying station in Shiprock, New Mexico. In 1953, 1954, 1956, 1958, and 1959 subsequent shipments of ore were delivered from the Site to either the Shiprock or Bluewater ore-buying stations, both of which were located in New Mexico. The USAEC records reported total ore production from the Site was 846 tons (approximately 1.7×10^6 pounds) of ore that contained 3,350 pounds of 0.20 percent U_3O_8 (uranium oxide) and 2,266 pounds of 0.14 percent V_2O_5 (vanadium oxide) (McLemore, 1983 and Chenoweth, 1989).

2.1.2 Ownership and Surrounding Land Use

The Site is located within the Navajo Nation, Eastern Navajo BIA Agency in Section 28 of Township 15 North, Range 17 West, New Mexico Principal Meridian. Land ownership where the Site is located falls under Allotted Trust lands. The Site is located within the Church Rock Chapter of the Navajo Nation, as shown in Figure 1-1, and is in Grazing Unit 16, as designated by the Navajo Nation Division of Natural Resources (NNDNR, 2006). The Site is currently uninhabited, but three home-sites are located east of and 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 notified allotment owners via mail and also obtained individual written access agreements from residents living at or near the Site, or with an interest in lands at or near the Site, such as allotted land, home-site leases, and grazing rights, as applicable. In addition, the Trustee consulted with the Church Rock Chapter officials and nearby residents and notified them of the work.

2.1.4 Previous Work at the Site

2.1.4.1 1974 through 1975 Geologic Study

Between 1974 and 1975, the US Department of the Interior (USDOI) performed a geologic study on the origin of uranium deposition in the Dakota sandstone. The study included site visits to some of the uranium mines and prospects located in the Gallup-Grants uranium mining district (specifically within the Dakota Sandstone) to produce in-depth geological descriptions of the uranium mines and prospects (Pierson and Green, 1980). The Site was visited on August 8, 1974 and an in-depth geologic description of the Dakota Sandstone on-site was recorded by Charles T. Pierson and Morris W. Green (1980). Refer to Section 2.2.2.2 for Site geology.

2.1.4.2 1978 through 1980 Abandoned or Inactive Uranium Mines Investigation

Between 1979 and 1980, the New Mexico Bureau of Mines and Mineral Resources investigated approximately 200 abandoned or inactive uranium mines in New Mexico (Anderson, 1980). The investigation included verifying the location, type and size of the mine, condition of the mine, ore host geologic formation, dimension of remaining mine features, proximity to residences or villages, water quality data, and radiation levels. On December 4, 1979 the New Mexico Bureau of Mines and Mineral Resources investigated the Site and the following information was reported:

- The ore host geologic formation was the Dakota Sandstone.
- The historical mining pit measured 175 ft along the hogback crest and up to 80 ft in the down dip direction (the dip is about 30 ft in a southwesterly direction).
- A mine waste pile was located immediately west of and downslope from the mine. The waste pile measured approximately 160 ft by 50 ft and up to 30 ft high. The width of the waste pile was difficult to determine and could have been between 25 ft and 100 ft.
- Radiation levels were collected using a gamma ray scintillometer, and measured levels were up to 900 counts per second.

Anderson (1980) did not report details regarding proximity to residences or villages or water quality data for the Site.

2.1.4.3 2009 Site Screening

In 2009, Weston performed site screening on behalf of the USEPA (Weston, 2009). The screening included: (1) recording site observations (i.e., number of homes, water sources, and sensitive environments[3] around the Site); (2) recording the type, number, and reclamation status of mine features; and (3) performing a surface gamma survey. Weston reported five home-sites were within 0.25 miles of the Site, two water tanks (one 10,000 gallons and one 30,000 gallons) were within a one-mile radius of the Site and located 0.25 miles east and southeast of the Site, respectively, and no sensitive environments were identified. Weston also reported no known reclamation associated with the Site. Based on Weston's performance of a surface gamma survey, Weston determined that the highest gamma measurements were greater than 35 times the lowest site-specific background level used for its gamma screening. Weston used three different background levels 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 2-2 presents a current regional aerial photograph (ESRI, 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.

The Site is located in the southeast portion of the Colorado Plateau. Figure 2-3 presents the regional US Geological Survey (USGS) topographic map of a portion of the Colorado Plateau in the vicinity of the Site. The Site is located just west of the Zuni uplift, along the Nutria monocline (i.e. The Hogback). The Nutria monocline is a steeply dipping hogback, and the Site is located at a maximum elevation of 8,000 ft above mean sea level (amsl), as shown in Figure 2-4.

[3] 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"

2.2.2 Geologic Conditions

2.2.2.1 Regional Geology

Regionally the Site is located within the southeastern portion of the Colorado Plateau. This region of the plateau is structurally dominated by the Zuni uplift and the Gallup sag (Kelly, 1967). The Zuni uplift is a northwesterly trending uplift that is oval-shaped with a length of approximately 75 miles and a width of approximately 30 miles. Precambrian rocks are exposed in several large areas along the crest of the uplift. Surrounding the Precambrian outcrops is a wide band of Permian strata that surfaces as the main portion of the uplift. Outside the Permian outcrops Mesozoic rocks form valleys, hogbacks, and mesas which mark the outer boundaries of the uplift. Approximately the northern two-thirds of the uplift is bounded on the west by the Gallup sag, along the Nutria monocline. The monocline is about 32 miles long, 1 to 2 miles wide, with dips ranging from low to steeply overturned. The Nutria monocline (i.e. The Hogback), where the Site is located, is along the northwestern boundary of the Zuni uplift. The Zuni uplift, the Nutria monocline, the Gallup sag, and most of the Colorado Plateau structures formed during the Laramide orogeny of Late Cretaceous through Eocene.

The portion of the Gallup-Grants uranium mining district, where the Site is located, is made up of the following Mesozoic geologic formations: Mancos Shale, Twowells Sandstone Tongue of Dakota Sandstone, Whitewater Arroyo Shale Tongue of Mancos Shale, Dakota Sandstone, Westwater Canyon Member of the Morrison Formation, and Cow Springs Sandstone. Figure 2-5 depicts a regional geology map showing the Site in relation to the regional extent of the Mesozoic formations.

2.2.2.2 Site Geology

Bedrock outcrops on or adjacent to the Site are of the Westwater Canyon Member of the Morrison Formation, Dakota Sandstone, Whitewater Arroyo Shale Tongue of the Mancos Shale, and Cow Springs Sandstone, as shown in Figure 2-6a. A geologic profile of bedrock on-site is shown in Figure 2-6a and exposed bedrock on or near the Site is shown in Figure 2-6b. Descriptions of geologic units are provided by Green and Jackson (1976), and Hackman and Olson (1977) as follows:

- Westwater Canyon Member of the Morrison Formation – yellowish-gray to reddish-brown fine- to coarse-grained fluvial cross-bedded sandstone; locally contains stringers and layers of pebbles and lenses of reddish-brown to purplish-gray claystone and siltstone.
- Dakota Sandstone – cliff-forming layers of lenticular fluvial and littoral commonly cross-bedded fine- to coarse-grained sandstone interbedded with slope-bench- or niche-forming mudstone and carbonaceous shale and coal.
- Whitewater Arroyo Shale Tongue of the Mancos Shale – yellowish-brown to yellow fossiliferous shale.

- Cow Springs Sandstone – Light greenish-gray to gray and light reddish-brown to pale-orange fine- to medium-grained cross-bedded and flat-bedded sandstone and silty sandstone.

The Dakota Sandstone was the host rock for uranium on-site and the USAEC (Hilpert, 1969) described the uranium deposit on-site as follows:

> The uranium deposit occurred in the upper portion of a 10 ft to 15 ft thick sandstone layer located at the base of the Dakota Sandstone (i.e., the deposit sandstone). The sandstone layer was overlain by carbonaceous shale that was approximately2 ft to 3 ft thick. The deposit sandstone consisted of scour-filled channels where crossbeds dipped approximately North-30 degrees-East (N30°E). The deposit sandstone was limonite stained and contained seams and small pockets of carbonized plant material. Yellow uranium minerals including meta-autunite, metatyuyamunite, and uranophane were disseminated in the sandstone as well as along joint and bedding surfaces. Joint sets trended N50°E and N15°W.

Unconsolidated deposits on-site are alluvium, colluvium, and eolian deposits consisting of variable amounts of clay, silt, sand, and gravel. During the Site Characterization field activities, boreholes were advanced through the unconsolidated deposits using a hand auger until refusal at hard rock or a hard surface (refer to Section 3.3.2.2 and Appendix C.2 for borehole logs). The unconsolidated deposits ranged in depth from 0.5 ft to 3.5 ft below ground surface (bgs).

According to the US Department of Agriculture (USDA) Soil Survey for McKinley County, New Mexico, soils on-site that have not been disturbed by mining are most likely classified as soil type Atchee, which is derived from sandstone (USDA, 2005).

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 293422, Gallup Municipal airport, New Mexico (Western Regional Climate Center, 2017) located approximately 8 miles northwest of the Site, ranges between 44.3 degrees Fahrenheit (°F) in January to 87.5°F in July. Daily temperature extremes reach as high as 100°F in summer and as low as -34°F in winter. Gallup airport receives an average annual precipitation of 11 inches, with August being the wettest month, averaging 1.9 inches, and June being the driest month, averaging 0.42 inches.

Potential evaporation in the area is greater than the area's average annual precipitation. The potential evaporation noted at the Gallup Ranger Station, New Mexico weather station, located approximately 5.7 miles southeast of the Site, averages 62 inches of pan evaporation annually (Western Regional Climate Center, 2017). Average wind speeds in the area are generally moderate, although relatively strong winds often accompany occasional frontal activity, especially during late winter and spring months. Blowing dust, soil erosion, and local sand-dune migration/formation are common during dry months. Gallup airport had the most complete record of wind conditions within the region of the Site. A wind rose for the Gallup 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 west-southwest (refer to the wind rose on Figure 1-1).

2.2.4 Surface Water Hydrology

The Site is located within the Little Colorado River Valley watershed, an area of approximately 27,000 square miles spanning Arizona and New Mexico, as shown in Figure 1-1. On-site surface water flow (i.e. overland flow) is controlled along the approximate watershed divide line (refer to Figures 2-7a and 2-7b) by a decrease in elevation (refer to Figure2-4) from the hogback ridge to the surrounding plains. Overland water flow direction arrows and the approximate extent of the watershed divide line are shown in Figures 2-7a and 2-7b. Precipitation run-off on-site either terminates within the unconsolidated deposits or drains into several radial patterned ephemeral drainages. The radial patterned ephemeral drainages drain: (1) north from the approximate watershed divide line; and/or (2) southeast and southwest from the approximate watershed divide line and converge into one drainage. The converged drainage then drains southwest to northwest, toward an unnamed drainage. Drainages are shown in Figures 2-1, 2-7a, and 2-7b.

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 May 2016, Adkins conducted a wildlife survey. In May 2016 and July 2016, Redente Ecological Consultants (Redente), under contract to Stantec, conducted spring and summer vegetation surveys. 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 Site is predominantly steep sandstone with scattered shrubs and numerous pinyon pine and juniper trees (refer to Appendix E). During the surveys, Stantec and/or its subcontractors observed on-site wildlife including turkey vulture, common raven, mule deer, and cottontail rabbit (refer to Appendix E).

2.2.6 Cultural Resources

In May 2016, as part of Site Clearance activities, Dinétahdóó Cultural Resource Management (Dinétahdóó), under contract to Stantec, conducted a cultural resource survey, as well as ethnographic and historical data reviews, and interviewed local residents familiar with the Site (Dinétahdóó, 2016). The local residents stated that mining began around 1950 and ended around 1958. The residents also stated they think on the southwest side of The Hogback there is still an open mine adit present and what appears to be an open mine or ventilation tunnel (Dinétahdóó, 2016).

During the cultural resource survey Dinétahdóó identified 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 potential mining activities at the Site: adit, potential haul roads, excavation area, waste piles, and blasted areas. Details regarding these observations are presented in Section 3.2.2.1. These observations were used, along with additional lines of evidence (refer to Section 3.3.3), to identify areas at the Site where TENORM was present (refer to Section 4.6).

3.0 SUMMARY OF SITE INVESTIGATION ACTIVITIES

3.1 INTRODUCTION

This section summarizes Site Clearance and other RSE activities conducted between August 2015 and September 2017. 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[4] 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).

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

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

1. Background reference area soil/sediment sampling, laboratory analyses, surface gamma surveying, and subsurface static gamma measurements to establish background analyte concentrations and gamma measurements, which will be used as the ILs, for the Site.
2. Site sampling (soil and sediment), laboratory analyses, surface gamma surveying, and subsurface static gamma measurements for comparison with ILs, to define the lateral and vertical extent of contamination at the Site to characterize the Site to support future Removal or Remedial Action evaluations.

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

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

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

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

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

Sections 3.2 and 3.3 summarize the 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/sediment sample field forms and Appendix C.2 includes borehole logs.

3.2 SUMMARY OF SITE CLEARANCE ACTIVITIES

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

3.2.1 Desktop Study

The desktop study included:

- Review of historical aerial photographs (USGS, 2016). Photographs were selected based on sufficient scale, quality, resolution, and whether the photograph met one or more of the following criteria:
  - o 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).
  - o Showed evidence of reclamation (e.g., soil covers).
  - o 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, 1962, 1997, and 2005 for comparison against a current 2017 image (Cooper, 2017). The selected historical photographs are shown in Figure 3-1a. Figure 3-1b compares the aerial photograph from 1952 and the current 2017 image. The topographical features in the1952 and current image photographs appear to be similar. However, in the 1952 photograph a disturbed area is present in the central area of the Site. The 1952 historical photograph is presented because it provides the best resolution of what the Site looked like after mining began on-site.

- The current aerial photograph review confirmed that the Site was uninhabited, but three home-sites were located east of and within 0.25 miles of the Site, as shown in Figure 2-1. Numerous dirt roads were identified within 0.25 miles of the Site, refer to Figure 21. 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 two water storage tanks identified by Weston (2009) are not connected to a local well water source but instead are only holding tanks for water that is trucked to them.

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

As part of the desktop study a request was made by Stantec to NAML and New Mexico Mining and Mineral Division for any information regarding reclamation activities occurring on-site. The two departments contacted did not have any reclamation records for the Site. Previous studies and information related to past mining 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 2-7a, were marked in the field with stakes and/or flagging and mapped with a global positioning system (GPS).
- Drainages – Field personnel mapped several radial patterned ephemeral drainages, as shown in Figure 2-7a. The radial patterned ephemeral drainages drained: (1) north from the approximate watershed divide line; and/or (2) southeast and southwest from the approximate watershed divide line and converged into one drainage. The converged drainage then drained southwest to northwest, toward an unnamed drainage. One of the drainages located on the Site is shown in Appendix B photograph number 9.
- Topographic features – The Site is located along a hogback ridge of the northwest-striking Nutria monocline. The mapped area can be divided into four topographic areas: (1) the hogback dip slope; (2) the hogback scarp slope; (3) the monocline bench; and (4) the plains. The hogback dip slope is located to the west of the ridge-crest and is characterized by two southwest-facing bedding-plane surfaces that dip steeply to the southwest at approximately 30 degrees. The steeply dipping strata form two parallel ridges with a small intervening terrace. The hogback scarp slope is located to the east of the ridge-crest, and consists of erosional surfaces that cut across the bedding strata to form steep cliffs or bedrock slopes. The monocline bench, located west of the hogback dip slope, locally resembles the surrounding plains that are located east of the Site. However, regionally this area is better characterized as an erosional terrace that is situated between the Site hogback and a smaller hogback within the monocline to the west. Site topography and the topographic features are shown in Figure 2-4, and Appendix B photograph numbers 7 and 13.
- Adit – An open adit located approximately 200 ft west of the claim boundary was mapped, as shown in Figure 2-7a and Appendix B photograph number 1. Of note, the historical document review conducted for the Site did not identify an adit associated with the Site (refer to Sections 2.1.1 and 2.1.4). However, this may be the same adit that the local residents identified during the cultural resource survey ethnographic interview (refer to Section 2.2.6). The entrance to the adit was approximately 12 ft by 8 ft, and the adit workings continued approximately 75 ft at a 20 degree downward angle. Wood structure remnants were observed approximately 5 ft into the interior of the adit. The working dimensions are based on field personnel observations made from the adit entrance and appeared to change with depth. The front of the adit was partially blocked by boulders of various sizes. However, some small openings existed with the largest measuring 2 ft by 2 ft. Field personnel did not observe airflow into or out of the adit, ponded water, seeps, and/or moving water. Because the adit was open, the Agencies and Trustee decided this posed a safety risk. To mitigate the safety hazard, in April 2018 the Trust conducted an interim closure, pursuant to the Trust provisions for interim actions, and installed a steel cable mesh over the adit. The steel cable mesh was designed to limit access by humans or large animals. The constructed

mesh grate was of sufficient quality that access to the interior of the adit was only possible by cutting and removing materials with heavy tools. Because this work was completed separately from the RSE, it is not reported herein, and instead was reported to the Agencies in an interim action summary letter (Stantec, 2018)

- Waste Pile – Six waste piles were mapped, as shown in Figure 2-7a. The waste piles are also shown as part of the earthworks in Figures 2-6a and 2-6b. Photographs of Waste Piles 1 through 4 are shown in Appendix B as follows: Waste Pile 1 is shown in Appendix B photograph number 6, Waste Pile 2 is shown in Appendix B photograph number 16, Waste Pile 3 is shown in Appendix B photograph numbers 2 through 4, and Waste Pile 4 is shown in Appendix B photograph number 14.

- Excavation – An excavation area was mapped, as shown in Figures 2-7a, 2-7b, and Appendix B photograph number 13. The excavation area is coincident with the historical mining pit. The excavation area is also shown as part of the earthworks in Figures 2-6a and 2-6b.

- Debris – A debris pile was mapped, as shown in Figure 2-7a. The debris pile consisted of various metal, wood, and plastic debris that did not appear to be associated with mining and it is located approximately 600 ft northeast of the claim boundary away from any obvious mining related disturbance. A photograph of the debris pile is shown in Appendix B photograph number 18.

- Potential haul road – Two potential haul roads were mapped, as shown in Figure 2-7a. The potential haul roads provided access to the Site from either the dip slope or the scarp slope side of the Site. Portions of the potential haul roads contained bedrock, cut surfaces where bedrock was exposed at the surface, and other portions on the road contained significant amounts of fill that were added to maintain a level road base surface. A view of the potential haul road along the base of Waste Pile 4 is shown in photograph number 15. Rock embankments used to construct the potential haul roads are shown in Appendix B photograph numbers 8 and 9.

- Blasted Area – Two blasted areas were mapped, as shown in Figure 2-7b. The blasted areas are also shown as part of the earthworks in Figures 2-6a and 2-6b. The northwest blasted area is shown in Appendix B photograph numbers 5 and 10. The southeast blasted area is shown in Appendix B photograph numbers 12, 13, and 17.

- Structures – Three home-sites were located east of and within 0.25 miles of the Site, as shown in Figure 2-1. Weston (2009) identified five home-sites within 0.25 miles of the Site, it is unknown if some of the uninhabitable buildings (refer to Figure 2-1) identified by field personnel were labelled as home-sites by Weston.

- 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.

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

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

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

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

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

3.2.2.2 Potential Background Reference Area Evaluation

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

- BG-1 encompassed an area of 549 ft^2 (approximately 0.01 acres), was located 790 ft northwest of the Site, cross-wind and hydrologically cross-gradient from the Site, and across a drainage divide. The thin soils, colluvium-covered slopes, and bedrock outcrops represented the portions of the Survey Area that consisted of the Westwater Canyon Member of the Morrison Formation. The vegetation and ground cover at BG-1 were similar to the Site.

- BG-2 encompassed an area of 1,417 ft^2 (approximately 0.03 acres), was located 1,100 ft northwest of the Site, cross-wind and hydrologically cross-gradient from the Site, and on the other side of a drainage channel. The thin soils, colluvium-covered slopes, and bedrock outcrops represented the portions of the Survey Areas that consisted of the Dakota Sandstone, including the Twowells Sandstone Tongue of the Dakota Sandstone. The vegetation and ground cover at BG-2 were similar to areas of the Site that lie within the Dakota Sandstone.

- BG-3 encompassed an area of 2,655 ft^2 (approximately 0.06 acres), was located 900 ft northwest of the Site, cross-wind and hydrologically cross-gradient from the Site, and on the other side of a drainage channel. The thicker soils and colluvium-covered slopes and benches represented the portions of the Survey Area that consisted of Mancos Shale, and vegetation and ground cover at BG-3 were similar to areas of the Site that lie within the Mancos Shale.

- BG-4 encompassed an area of 1,170 ft^2 (approximately 0.03 acres), was located 650 ft southwest of the Site, and was upwind from the Site. Regionally, BG-4 was hydrologically downgradient from the Site, but on the other side of a drainage channel from the Site and does not receive surface water runoff from the Site. The sediments in BG-4 represented the portions of the Survey Area southwest of the Site that consisted of Quaternary alluvium, colluvium, and eolian sands, and vegetation and ground cover at BG-4 were similar to areas of the Site that lie within the Quaternary deposits.

- BG-5 encompasses an area of 6,275 ft^2 (approximately 0.14 acres), was located 430 ft east of the Site, and was cross-wind and hydrologically cross-gradient from the Site. The thin soils, colluvium-covered slopes, and bedrock outcrops at BG-5 represent the portions of the Survey Area that consist of the Cow Springs Sandstone. The vegetation and ground cover at BG-5 were similar to areas of the Site that lie within the Cow Springs Sandstone.

- BG-8 encompasses an area of 3,068 ft^2 (approximately 0.07 acres), was located 950 ft east of the Site, and was cross-wind (potentially downwind) and hydrologically cross-gradient from the Site. The soils at BG-8 represent the portions of the Survey Area that consist of Quaternary deposits containing alluvium and eolian deposits or older pediments northeast of the claim boundary.

BG-6 and BG-7were not selected as background reference areas for the Site for the reasons described in Appendix D.1 While the extent of the background area for the Morrison Formation (BG-1) is adequate for the purposes of this report, the coverage area is considered less than ideal (refer to discussion in Appendix D.1). Exposure of the Morrison Formation near the Site is limited. The need for an updated or improved upon background reference area for the Morrison Formation is identified as a data gap in Section 4.8.

The potential background reference areas were 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 these areas. Stantec does not view the size of the selected background reference areas as affecting the validity of the background concentrations. The sizes were based on professional judgment that the identified areas were generally representative of the Site.

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

3.2.2.3 Biological Surveys

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

The Federal Endangered Species Act (ESA) of 1973, 16 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 May and July 2016, Redente performed a spring and a summer vegetation survey as part of the Site Clearance field investigations. Complete details of the vegetation surveys, including the *NNDFW Biological Resources Compliance Form*, are included in Appendix E and summarized below.

In preparation for the vegetation surveys, 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[5]. A copy of this letter is included in Appendix E.

The NNDFW listed four T&E plant species that may occur on-site; Parish's alkali grass (G4), Navajo bladderpod (G3), Sivinski's fleabane (G4), and Acoma fleabane (G3). The USFWS also listed Zuni fleabane (threatened) as a T&E species that may occur on-site. Parish's alkali grass is a native annual grass that grows in a series of widely discontinuous populations ranging from southern California to eastern Arizona and western New Mexico in alkaline seeps, springs and seasonally

[5] 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).

wet areas and washes at elevations from 5,000 ft to 7,200 ft amsl. Navajo bladderpod is a native perennial forb that has a general distribution in Apache (Arizona) and McKinley (New Mexico) Counties and occurs mostly on windward, windswept mesa rims with little vegetation cover and high solar radiation. Populations are known to occur at elevations from 7,218 ft to 7,874 ft amsl. Sivinski's fleabane is a native perennial forb that grows in Apache and McKinley Counties, New Mexico, and inhabits steep barren shale slopes in desert shrub and pinyon-juniper communities at elevations from 6,100 ft to 7,380 ft amsl. Acoma fleabane is a native perennial forb found in McKinley County, New Mexico, and occurs on sandy slopes, primarily beneath sandstone cliffs in pinyon-juniper communities at elevations around 7,005 ft amsl. Zuni fleabane is native perennial forb found in McKinley, San Juan, and Catron Counties, New Mexico, and is found growing on fine textured clay hillsides primarily in pinyon-juniper communities at elevations from 7,000 ft to 8,300 ft amsl.

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

The Redente botanist did not identify any of the four T&E species at the Site, based on observations he made during the on-site survey, even though habitat at the Site may be suitable for all four T&E species.

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

Adkins performed the survey under a permit issued by NNDFW for the purpose of assessing habitat potential for ESA-listed or NNESL animal species. Adkins biologists with experience identifying local wildlife species led the field survey, which consisted of walking transects 10 ft apart throughout the Site, including a 100-ft buffer beyond the claim 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 four ESA-species with the potential to occur in the area of the Site; three birds (southwestern willow flycatcher, Mexican spotted owl, and western yellow-billed cuckoo), and one fish (Zuni bluehead sucker). The NNDFW included: three birds (American peregrine falcon [G4], golden eagle [G3], and western burrowing owl [G4]), and one mammal (black footed ferret [USFWS endangered]). All species on the USFWS list and all 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 remained as species of concern warranting further analysis during the Site survey: the golden eagle and American peregrine falcon.

In addition, Adkins reviewed species protected under the MBTA that have the potential to occur in the area of the Site. The MBTA review resulted in the potential for identification of 15 bird species in addition to those listed above, known as "Priority Birds of Conservation Concern with the Potential to Occur"[6] 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, and prairie falcon. These 15 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 has the potential to occur within or near the Site based on habitat suitability or actual recorded observation: the golden eagle and American peregrine falcon. Based on these findings Adkins recommended the use of best management practices to protect potential habitat during RSE activities, specifically: (1) confining equipment travel to within the boundaries of the Site; (2) minimizing travel corridors as much as possible; (3) limiting truck and equipment travel within the Site when surfaces are wet and soil may become deeply rutted; and (4) using previously disturbed areas for travel when possible. The recommended best management practices were followed to protect potential habitat during RSE activities.

3.2.2.4 Cultural Resource Survey

In May 2016, Dinétahdóó conducted a cultural resource survey as part of the Site Clearance field investigations. Navajo Nation Historic Preservation Department (NNHPD) issued a Class B permit to Dinétahdóó 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[7]).

The survey included the areas within the claim boundary and the 100-ft claim boundary buffer, as shown in Figure 2-7a. Dinétahdóó did not survey areas on steep terrain due to safety concerns. The survey identified one isolated occurrence. For confidentiality reasons, details regarding the isolated occurrence are not provided herein. NNHPD can be contacted for

[6] 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.
[7] Call with Sadie Hoskie, Tamara Billie of NNHPD, and Linda Reeves, June 8, 2018.

additional information. NNHPD contact information is located on the *Cultural Resource Compliance Form* included in Appendix E.

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

3.3 SUMMARY OF REMOVAL SITE EVALUATION ACTIVITIES

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

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

The background reference area surface gamma survey at BG-1 was completed in May 2016, and at BG-2 through BG-5 in June 2017. ERG performed the surface gamma surveys 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 surveys by walking the background reference areas with the detector carried by hand, along transects that varied depending on encountered topography. The gamma measurements were collected with the height of the detector varying from 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 surveys 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 surveys was also used to collect static one-minute gamma measurements at the ground surface and down-hole (subsurface) at borehole locations S313-BG1-011(BG-1), S313-BG2-011 (BG-2), S313-BG3-011 (BG-3), S313-BG4-011 (BG-4), and S313-BG5-011 (BG-5). 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/sediment samples collected as part of the background study are detailed in Table 3-1 and sample locations are shown in Figures 3-3a and 3-3b. Soil/sediment samples were categorized as surface samples where sample depths ranged from 0.0 to 0.5 ft bgs and as subsurface samples where sample depths were greater than 0.5 ft bgs. Samples collected in drainages were classified as sediment samples. Field personnel collected the following samples from the background reference areas:

- BG-1 – In November 2016 and March 2017, 11 surface soil grab samples were collected from 11 locations. A borehole could not be advanced beyond 0.2 ft at borehole S313-BG1-011, so no subsurface samples were collected at BG-1.

- BG-2 – In September 2017, 11 surface soil grab samples were collected from 11 locations and one subsurface soil grab sample was collected from borehole S313-BG2-011.
- BG-3 – In September 2017, 11 surface soil grab samples were collected from 11 locations. A borehole could not be advanced beyond 0.5 ft at borehole S313-BG3-011, so no subsurface samples were collected at BG-3.
- BG-4 – In September 2017, 11 surface sediment grab samples were collected from 11 locations and one subsurface sediment grab sample was collected from borehole S313-BG4-011.
- BG-5 – In September 2017, 11 surface soil grab samples were collected from 11 locations. A borehole could not be advanced beyond 0.5 ft at borehole S313-BG5-011, so no subsurface samples were collected at BG-5.

The lack of subsurface soil samples from BG-1, BG-3, and BG-5 will not affect the derivation of Ra-226 or metal ILs because the Ra-226 and metals ILs (i.e., surface and subsurface) were based on surface soil samples (refer to Section 4.1).

In June 2017, a gamma survey was completed in BG-8. However, soil samples were not collected from BG-8. Based on review of the RSE results it was determined that mining-related impacts extend onto the Quaternary deposits northeast of the claim boundary. Because of these findings, the lack of soil samples from BG-8 is identified as a data gap, as listed in Section 4.8.

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

3.3.1.2 Site Gamma Radiation Surveys

Baseline Studies activities included a surface gamma survey of the Site in accordance with the *RSE Work Plan,* Section 4.2 and Appendix E. Approximately 0.5 acres of the of the hogback dip slope and the hogback scarp slope were not surveyed because field personnel were unable to safely access these areas, as shown in Figure 3-4. This is identified as a data gap in Section 4.8. In addition, for approximately 250 ft of the potential haul road east of the claim boundary only the centerline of the potential haul road was surveyed, and the shoulders were not, due to miscommunication with the field personnel. This is identified as a potential data gap in Section 4.8.

The surface gamma survey was 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 and sediment samples were also collected and used to evaluate mining-related impacts (refer to Section 3.3.2).

In November 2016 and June 2017, the surface gamma survey was performed using the methods and equipment described in Section 3.3.1.1 with the exception that the detector was carried in a backpack when topographical features did not allow field personnel to carry the detector by hand for safety reasons. The surface gamma survey included the claim area, a 100-ft buffer around the claim area, and roads and drainages out to approximately 0.25 miles from the Site. Photographs of the gamma survey are shown in Appendix B photograph number 8 and 11. The *RSE Work Plan* specified that the surface gamma survey would be an iterative process where the surface gamma survey would be extended laterally until gamma measurements appeared to be within background levels. Subsequent to each workday, the gamma measurements were evaluated by ERG and Stantec, and compared to the background reference areas to determine if additional surface gamma surveying was needed.

The full areal extent of the surface gamma survey is referred to as the Survey Area, as shown in Figure 3-4. The Survey Area was 30.9 acres and was subdivided into five separate survey areas, as shown in Figure 3-4, based on *MARSSIM* criteria, including different geologic conditions on-site. Survey Area A is within the Westwater Canyon Member of the Morrison Formation (based on BG-1), Survey Area B is within the Dakota Sandstone (based on BG-2), Survey Area C is within the Whitewater Arroyo Shale Tongue of the Mancos Shale (based on BG-3), Survey Area D is within the Quaternary deposits (based on BG-4), and Survey Area E is within the Cow Springs Sandstone (based on BG-5).

It was necessary to subdivide the Survey Area based on geologic conditions and present the findings in Section 4.0 based on the subdivision, because geologic formations can have different geochemical compositions (i.e., gamma levels and concentrations of Ra-226, uranium, arsenic, molybdenum, selenium, and vanadium). The surface gamma survey results are presented in Section 4.2. 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 March 2017, field personnel identified five areas for the Gamma Correlation Study, as shown in Figure 3-5, by considering the results of the Site surface gamma survey (described in Section 3.3.1.2), field conditions (e.g., suitable terrain), and feasibility of sampling. To minimize variability when determining a correlation between gamma measurements (in cpm) and concentrations of Ra-226 in soil, the study area soils must: (1) represent a specific gamma measurement within the range of gamma measurements collected at the Survey Area; and (2) be as homogenous as possible with respect to soil type, and gamma measurement within the correlation area. At each area, field personnel completed a high-density surface gamma survey (intended to cover 100 percent of the survey area) and collected one five-point composite surface soil sample per area (refer to Table 3-1). Field personnel made a field modification from the *RSE Work Plan* by adjusting the size of the 900 ft^2 smaller at 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 considered. 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 and Sediment Sampling

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

In May and September 2017, samples were collected from the locations shown in Figure 3-6a and are summarized in Table 3-1. Sample locations and the locations of mining-related features are shown in Figure 3-6b. The number of surface samples collected within specific mine features are listed in Table 3-2. Thirty-three surface soil/sediment grab samples were collected from 33 locations in the Survey Area (eight from Survey Area A, 10 from Survey Area B, four from Survey Area C, two form Survey Area D, and nine from Survey Area E). Field personnel collected, logged, classified, packaged, and shipped the samples in accordance with the *RSE Work Plan,* Sections 4.4, 4.9, 4.11, and Appendix E. Samples were shipped to ALS Environmental Laboratories in Fort Collins, Colorado for analyses of: Ra-226, uranium, arsenic, molybdenum, selenium, and vanadium, as described in the *RSE Work Plan,* Section 4.13.1. The surface soil and sediment analytical results are presented in Section 4.3. Field forms are provided in Appendix C.1 and the laboratory analytical data, data validation reports, and Data Usability Report for the analyses are provided in Appendix F.

3.3.2.2 Subsurface Soil and Sediment Sampling

Site Characterization activities included subsurface soil and sediment sampling and associated laboratory analyses. Similar to the surface soil/sediment sampling discussed in Section 3.3.2.1, subsurface sampling locations were selected based on professional judgment (i.e., non-randomly) to evaluate concentrations of Ra-226 and metals in relation to the surface gamma survey measurements and site features (e.g., historical mining features and geologic features). Grab samples were collected with the intent to characterize specific intervals of interest (e.g., material within zones with elevated static gamma measurements). Composite samples were collected to provide a screening level assessment across an interval (e.g., sediment collected from a drainage). 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.

Twenty-two boreholes were advanced in the Survey Area (five in Survey Area A, six in Survey Area B, three in Survey Area C, two in Survey Area D, and six in Survey Area E). The boreholes were advanced through the unconsolidated deposits (from 0.5 ft to 3.5 ft bgs; refer to Table 3-1 and Appendix C.2) until refusal at hard rock or a hard surface. 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 variable amounts of clay, silt, sand, and gravel (refer to Appendix C.2 for borehole information). Subsurface sampling was limited in some areas on the hogback dip slope and the hogback scarp slope due to unsafe terrain. A drill rig was not employed at the Site because only limited areas of the Site would have been accessible with a drill rig due to steep terrain.

In May and September 2017, samples were collected from the locations shown in Figure 3-6a and are summarized in Table 3-1. Sample locations and the locations of mining-related features are shown in Figure 3-6b. The number of subsurface samples collected within specific mine features are listed in Table 3-2. Eighteen subsurface soil/sediment samples were collected from 14 borehole locations in the Survey Area (multiple subsurface samples were collected from multiple boreholes). Two subsurface samples were collected from Survey Area A, six from Survey Area B, four from Survey Area C, two from Survey Area D, and four from Survey Area E.

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.

3.3.3 Identification of TENORM Areas

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

1. Historical Data Review
    a. Aerial photographs
    b. USAEC records
    c. Reclamation records
    d. Other documents relevant to the Site, including those in the *2007 AUM Atlas*
    e. Interviews with residents living closest to the Site (for those sites where residents were available for interview)
    f. Consultation and site visits with NAML staff to identify reclamation features (for those sites reclaimed by NAML)

2. Geology/Geomorphology
    a. Hydrology/transport pathways with drainage delineation
    b. Site-specific geologic mapping including areas of mineralization
    c. Topography
3. Disturbance Mapping
    a. Exploration
    b. Mining
    c. Reclamation
4. Site Characterization
    a. Surface gamma surveys and subsurface static gamma measurements
    b. Soil/sediment sampling and analyses

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

3.4 DATA MANAGEMENT AND DATA QUALITY ASSESSMENT

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

3.4.1 Data Management

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

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

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

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

3.4.2 Data Quality Assessment

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

- **Data Verification** – The data were verified to confirm that standard operating procedures (SOPs) specified in the *RSE Work Plan* and *FSP* were followed and that the measurement systems were performed in accordance with the criteria specified in the QAPP. Any deviations or modifications from the *RSE Work Plan* are described in the appropriate RSE report sections. The USEPA definition (USEPA, 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, 2002b) for data validation is provided in the glossary. A copy of the Data Usability Report is included in Appendix F.1 and a summary of the validation results is presented below:

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

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

  - **Representativeness** Based on the results of the sample preservation and holding time evaluation, the method and initial/continuing calibration blank (ICB/CCB) sample results, the field duplicate sample evaluation, and the reporting limit evaluation, the data are considered representative of the Site as reported.

- **Completeness** All media and QC sample results were valid and collected as scheduled (i.e., as planned in the *RSE Work Plan*); therefore, completeness for these is 100 percent.

- **Comparability** Standard methods of sample collection and standard units of measure were used during this project. The analyses performed by the laboratory were in accordance with current USEPA methodology and the QAPP.

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

4.0 FINDINGS AND DISCUSSION

4.1 BACKGROUND REFERENCE AREA STUDY RESULTS AND CALCULATION OF INVESTIGATION LEVELS

The results of the background reference area surface gamma survey are shown in Figures 4-1a through 4-f. Sample locations in the background reference areas are shown for BG-1, BG-2, BG-3, BG-4, and BG-5 on Figures 4-1b, 4-1c, 4-1d, 4-1e and 4-1f, respectively. The surface gamma surveys in BG-1, BG-3, and BG-4 did not cover the areal extent of the sample locations. Analytical results of the samples collected from BG-1, BG-2, BG-3, BG-4 and BG-5 are summarized in Table 4-1. The gamma measurements and surface soil sample analytical results collected from BG-1, BG-2, BG-3, BG-4 and BG-5 were evaluated statistically to calculate ILs (refer to Appendix D.2) for each corresponding Survey Area (i.e., Survey Areas A, B, C, D and E, respectively). As previously discussed in Section 3.3.1.2, the Site was subdivided into five separate Survey Areas based on the geologic formations on-site. As discussed in Section 3.2.2.2, while the extent of the BG-1 surface gamma survey is adequate for the purposes of this report, the coverage area is considered less than ideal and the need for an updated or improved upon background reference area for the Morrison Formation is identified as a data gap in Section 4.8. After review of the RSE results it was determined that mining-related impacts extend onto the Quaternary deposits northeast of the claim boundary. Based on these findings, the lack of soil samples from BG-8 was identified as a data gap, as listed in Section 4.8.

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

The DQOs presented in the RSE Work Plan indicate that the ILs would be developed using the 95 percent UCL on the mean of the background sample results. However, the 95-95 UTL was used as the basis for the ILs instead because it better reflects the natural variability in the background data and lends itself to single-point comparisons to the Survey Area data. This was a change from the *RSE Work Plan*, as agreed upon with the Agencies, 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 Survey Area A (i.e., Westwater Canyon Member of the Morrison Formation; refer to Figures 2-6a, 2-6b, and 3-4), were established using statistical analyses of background data collected from BG-1(refer to Figures 3-3a and 3-4), and are as follows:

- Arsenic – 7.92 milligrams per kilogram (mg/kg)
- Molybdenum – 12.8 mg/kg
- Selenium – 3.26 mg/kg
- Uranium – 31.4 mg/kg
- Vanadium – 21.3 mg/kg
- Ra-226 – 12.7 pCi/g
- Surface gamma measurements - 12,184 cpm

The ILs for Survey Area B (i.e., the Dakota Sandstone; refer to Figures 2-6a, 2-6b, and 3-4), were established using statistical analyses of background data collected from BG-2 (refer to Figures 3-3a and 3-4), and are as follows:

- Arsenic – 9.06 mg/kg
- Molybdenum – 8.08 mg/kg
- Selenium – 2.67 mg/kg
- Uranium – 2.12 mg/kg
- Vanadium – 29.7 mg/kg
- Ra-226 – 3.86 pCi/g
- Surface gamma measurements - 16,336 cpm

The ILs for Survey Area C (i.e., the Whitewater Arroyo Shale Tongue of the Mancos Shale; refer to Figures 2-6a, 2-6b, and 3-4), were established using statistical analyses of background data collected from BG-3 (refer to Figures 3-3a and 3-4), and are as follows:

- Arsenic – 17.4 mg/kg
- Molybdenum – 1.47 mg/kg
- Selenium – 1.55 mg/kg
- Uranium – 1.46 mg/kg
- Vanadium – 13.7 mg/kg
- Ra-226 – 2.09 pCi/g
- Surface gamma measurements - 15,223 cpm

The ILs for Survey Area D (i.e., the Quaternary deposits; refer to Figures 2-6a, 2-6b, and 3-4), were established using statistical analyses of background data collected from BG-4 (refer to Figures 3-3b and 3-4), and are as follows:

- Arsenic – 14.8 mg/kg
- Molybdenum – 1.87 mg/kg
- Selenium – 2.09 mg/kg
- Uranium – 1.36 mg/kg
- Vanadium – 32.8 mg/kg
- Ra-226 – 1.87 pCi/g
- Surface gamma measurements - 14,697 cpm

The ILs for Survey Area E (i.e., the Cow Springs Sandstone; refer to Figures 2-6a, 2-6b, and 3-4), were established using statistical analyses of background data collected from BG-5 (refer to Figures 3-3b and 3-4), and are as follows:

- Arsenic – 7.51 mg/kg
- Molybdenum – 0.707 mg/kg
- Selenium – an IL for selenium was not identified because selenium sample results in BG-3 were all non-detect.
- Uranium – 1.27 mg/kg
- Vanadium – 29.2 mg/kg

- Ra-226 – 2.05 pCi/g
- Surface gamma measurements - 10,189 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 background reference areas, subsurface static gamma measurements were collected in the boreholes completed in the background reference areas. These measurements were used to establish a subsurface static gamma screening level for all survey areas. Where possible, the selected subsurface static gamma screening level values 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. These subsurface static gamma screening levels provide a comparison and assessment tool and are included as ILs 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.

Background subsurface static gamma measurements are summarized in Table 4-2 and in Appendix C.2. Subsurface static gamma measurements that were used as ILs were as follows:

- One subsurface static gamma measurement of 8,480 cpm was collected from BG-1 borehole S313-BG1-011 at a down-hole depth of 0.2 ft bgs, and therefore, 8,480 cpm is considered the subsurface static gamma IL for Survey Area A.
- Two subsurface static gamma measurements of 26,769 and 30,106 cpm were collected from BG-2 borehole S313-BG2-011 at down-hole depths of 0.5 and 0.8 ft bgs, respectively. The lowest value (26,769 cpm) was used as the subsurface static gamma IL for Survey Area B.
- One subsurface static gamma measurement of 15,432 cpm was obtained from BG-3 borehole S313-BG3-011 at the down-hole refusal depth of 0.5 ft bgs, and therefore, 15,432 cpm is considered the subsurface static gamma IL for Survey Area C.
- Two subsurface static gamma measurements of 15,012 and 18,699 cpm were collected from BG-4 borehole S313-BG4-011 at down-hole depths of 0.5 and 0.8 ft bgs, respectively. The lowest value (15,012 cpm) was used as the subsurface static gamma IL for Survey Area D.
- One subsurface static gamma measurement of 13,197 cpm was obtained from BG-5 borehole S313-BG5-011 at the down-hole refusal depth of 0.5 ft bgs, and therefore, 13,197 cpm is considered the subsurface static gamma IL for Survey Area E.

Note that refusal in BG1-011, BG3-011, and BG5-011 were confirmed to be on bedrock (i.e., the Westwater Canyon Member of the Morrison Formation, Mancos Shale, and Cow Springs Sandstone, respectively) and therefore, these subsurface static gamma measurements may be elevated as a result of the close proximity to bedrock with naturally elevated concentrations of radionuclides.

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

Due to the differing geometric effects, surface static gamma measurements at borehole locations may only be qualitatively compared to subsurface static gamma measurements, and the subsurface static gamma IL does not apply to the surface static gamma measurements. Instances where the surface static gamma measurement is greater than subsurface static gamma measurements suggest higher levels of radionuclides 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 and sediment 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 4-1a where the calculated surface gamma ILs for some of the background reference area are used to set bin ranges with color coding to illustrate the spatial extent and patterns of surface gamma measurements within the entire Survey Area. The first four bins were based on the surface gamma IL for Survey Areas A, B, D and E, and were set from the lowest IL (BG-5 IL) to the highest IL (BG-2 IL). The last two bin ranges were set from greater than two times the highest IL (BG-2 IL) to the maximum gamma survey measurement (401,121 cpm), which was greater than 10 times the highest IL (BG-2 IL), and occurred in the eastern portion of the claim boundary near Waste Pile 6 and the identified blasted area (refer to Figure 2-7b alongside Figure 4-1c).

Surface gamma measurements were generally highest in three areas: (1) along the hogback dip slope within the western claim boundary, coincident with mine excavation, southeast blasted area, and Waste Piles 4, 5, and 6 (refer to Section 3.2.2.1 and Appendix B, photograph numbers 12, 13, 14, 15, and 17); (2) along the hogback scarp slope just east of the ridge crest and claim boundary (refer to Section 3.2.2.1 and Appendix B, photograph numbers 11); and (3) on the hogback dip slope west of the claim boundary, near the adit and coincident with Waste Pile 3 (refer to Section 3.2.2.1 and Appendix B, photograph numbers 1, 2, 3, and 4).

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

- Survey Area A (refer to Figure 4-1b) – Surface gamma IL exceedances (greater than 12,184 cpm) were observed primarily in areas along the hogback scarp slope north and east of the claim boundary, and in locations adjacent to Waste Pile 2 and the upper potential haul road in the northern portion of the survey area.

- Survey Area B (refer to Figure 4-1c) – Surface gamma IL exceedances (greater than 16,336 cpm) were observed primarily in up-gradient portions of the hogback dip slope in identified earthworks areas including: within the western claim boundary (mine excavation and Waste Piles 4, 5, and 6), along the potential haul roads, and within and down-slope from Waste Pile 1. Locations down-slope from the aforementioned earthworks areas contained sparse, but relatively consistent minor surface gamma IL exceedances (most measurements were less than two times the IL).

- Survey Area C (refer to Figure 4-1d) – Surface gamma IL exceedances (greater than 15,233 cpm) were observed primarily adjacent to the adit and coincident with Waste Pile 3. Minor, sparse exceedances (less than two times the IL) were observed in the area immediately down-slope from Waste Pile 3.

- Survey Area D (refer to Figure 4-1e) – Surface gamma IL exceedances (greater than 14,697 cpm) were observed primarily within the downstream section of the surveyed drainage. Upstream drainage sections within this survey area (i.e., those receiving potential runoff from historical mining operational areas) predominantly contained surface gamma measurements below the IL.

- Survey Area E (refer to Figure 4-1f) – Surface gamma IL exceedances (greater than 10,189 cpm) were observed primarily in up-slope portions of the survey area nearer the hogback ridge crest, and along portions of the potential haul road. Gamma measurements decrease to the north and east with measurements generally below the BG-5 IL, but exceed the BG-8 IL along the eastern portion of the potential haul road and within the ephemeral drainage pathways.

Figure 4-1d also compares Survey Area C to the surface gamma IL calculated for BG-8 (7,326 cpm; refer to Appendix D.1 and Table D.1-2), which represents the Quaternary deposits northeast of the claim boundary (refer to Section 2.2.2.2 and Figure 2-6a). Surface gamma measurements within the Quaternary deposits that exceeded the BG-8 IL were detected near the potential haul road and downslope from mining-disturbed areas of the Cow Springs Sandstone; gamma survey measurements at the far extent of the survey exceed the BG-8 IL. Based on professional judgement, it is assumed that mining-related impacts do not extend east of the eastern-most drainage that crosses the potential haul road due to the bank on the eastern side of the drainage.

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

1. The gamma survey was not conducted in overly steep areas due to safety concerns (refer to Figure 3-4); however, the total area not surveyed was small (0.5 acres) and some of it consisted of exposed bedrock

2. For approximately 250 ft of the eastern potential haul road, the gamma survey (the most eastern extent) was limited to the centerline of the road, and the shoulders were not surveyed, as the result of an oversight by field personnel.

3. The gamma survey was not extended in limited areas within Survey Area A (northwestern extent) and Survey Area E (eastern extent) until all gamma measurements were less than the respective surface gamma ILs based on professional judgment that those areas were not impacted by mining-related disturbance.

4. The survey was not extended laterally from the western drainage where gamma measurements were greater than the IL as the result of an oversight by field personnel. The drainage channel receives surface flow from the Site and from an area south of the Site. The channel is deeply incised in the area of the IL exceedances, and presents safety concerns.

4.2.1.2 Subsurface Gamma Survey

Surface and subsurface static gamma measurements were collected at each borehole location. Surface and subsurface static gamma measurement locations are shown in Figures 4-1a through 4-1f. Measurements and corresponding measurement depths are provided in Table 4-2 and are shown on the borehole logs in Appendix C.2. Surface and subsurface static gamma measurements from the boreholes are presented below by Survey Area:

- Survey Area A – Five boreholes were completed in Survey Area A (S313-SCX-005, -SCX-006, -SCX-007, -SCX-010, and –SCX-012). The maximum subsurface measurement (63,803 cpm) was measured at a depth of 0.8 ft bgs in borehole S313-SCX-012, which was located along the hogback scarp slope near the ridge crest and within 100 ft of the claim boundary. Each of the other subsurface static gamma measurements in the survey area were above the IL (8,480 cpm), with the next highest measurement at S313-SCX-006 (30,395 cpm) down-slope from Waste Pile 2, and the lowest subsurface measurement at S313-SCX-007 (13,233 cpm) at the potential haul road along Waste Pile 1. Static gamma measurements increased with depth at locations S313-SCX-005, -SCX-007, and -SCX-012, and decreased from the surface to depth at locations S313-SCX-006 and -SCX-010.

- Survey Area B – Six boreholes were completed in Survey Area B (S313-SCX-003, -SCX-011, -SCX-013, -SCX-014, -SCX-015, and –SCX-016). The maximum subsurface measurement (121,683 cpm) was measured at a depth of 1.5 ft bgs in borehole S313-SCX-014, which was located within Waste Pile 4 in the western portion of the claim boundary. Most other subsurface static gamma measurements at other locations within the survey area were above the IL (27,769 cpm), and ranged between 34,609 and 65,887 cpm (S313-SCX-011 and –SCX-013, respectively). The two exceptions to the above are S313-SCX-003 and –SCX-015 where subsurface static gamma measurements were below the IL; these measurements were collected from soil/sediment down-slope from Waste Pile 1 and Waste Pile 4, respectively. Static gamma measurements generally increased or remained constant with depth, with the exception of S313-SCX-011 where 49,242 cpm was measured at the surface and 34,609 cpm was measured at the bottom of the borehole at 0.5 ft bgs.

- Survey Area C – Three boreholes were completed in Survey Area C (S313-SCX-001, -SCX-002, and –SCX-019). The maximum subsurface measurement (34,998 cpm) was measured at a depth of 1.5 ft bgs in borehole S313-SCX-001, which was targeting the drainage pathway down-slope (northwest) from Waste Pile 3. All subsurface static gamma measurements within the survey area exceeded the IL (15,432 cpm); observed subsurface static gamma exceedances within the survey area were less than or approximately equal to two times the IL. Static gamma measurements within Survey Area C increased moderately or remained relatively constant with depth, with the exception of location S313-SCX-002 where static gamma measurements decreased slightly from 29,203 to 25,489 cpm from 1.5 to 2.1 ft bgs.

- Survey Area D – Two boreholes were completed in Survey Area D (S313-SCX-017 and -SCX-018). The maximum subsurface measurement (20,249 cpm) was measured at a depth of 2.0 ft bgs in borehole S313-SCX-018. Both locations measured static gamma radiation in sediment within an ephemeral drainage pathway receiving runoff from the hogback dip slope; S313-SCX-018 is located approximately 150 ft downstream from S313-SCX-017. All subsurface static gamma measurements at S313-SCX-018 were less than 1.5 times the IL (15,012 cpm), and all subsurface measurements at S313-SCX-017 were slightly below the IL (between 14,100 and 14,673 cpm). Static gamma measurements at S313-SCX-017 increased from 10,908 to 14,629 cpm between the surface and subsurface (from 0.0 to 0.6 ft bgs) and remained relatively constant with depth in the subsurface. Static gamma measurements increased with depth at S313-SCX-018.

- Survey Area E – Six boreholes were completed in Survey Area E (S313-SCX-004, -SCX-008, -SCX-009, -SCX-020, -SCX-021, and -SCX-022). The maximum subsurface measurement (175,472 cpm) was measured at a depth of 0.5 ft bgs in borehole S313-SCX-008, which was located along the potential haul road. Measurements observed at the other locations within this survey area were much lower (up to 39,988 cpm at S313-SCX-004 at 0.5 ft bgs). Subsurface static gamma measurements were generally above, or approximately equal to the IL (13,197 cpm) with the exception of results at S313-SCX-009 and –SCX-022, the two locations furthest down-slope from the hogback ridge, which were all below the IL. Static gamma measurements showed no discernible pattern across the survey area. Measurements increased with depth at S313-SCX-008, -SCX-009, and –SCX-022, decreased with depth at S313-SCX-020 and –SCX-021, and increased between the surface and subsurface (from 0.0 to 0.5 ft bgs) at S313-SCX-004 and decreased within the subsurface with depth.

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 0.92 which is within the acceptance criterion of 0.8 to 1.0 described in the *RSE Work Plan* and indicates that surface gamma results correlate with Ra-226 concentrations in soil. The correlation model may have been influenced by 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:

$$\text{Gamma (cpm)} = 1{,}630 \times \text{Surface Soil Ra-226 (pCi/g)} + 5{,}945$$

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 (7,411 cpm) and greater than the maximum (57,769 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 0.9 pCi/g and the concentration associated with the maximum mean gamma measurement is 37.8 pCi/g. Therefore, predicted Ra-226 concentrations less than 0.9 pCi/g and greater than 37.8 pCi/g should be limited to qualitative use only. The correlation locations were intentionally selected to be focused on the lower range of gamma measurements observed at the Site. Mean gamma measurements for correlation locations ranged from 7,411 to 57,769 cpm. The correlation was focused on the lower range because future Removal or

Remedial Action decisions are more critical at lower Ra-226 concentrations where the limits of remediation may be defined.

The correlation equation predicted Ra-226 concentrations that were less than zero for gamma survey measurements below 5,945 cpm. The predicted concentrations are shown in Figure 4-2a and the values less than zero are generally located in undisturbed areas 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 -0.9 to 242.44 pCi/g, with a mean of 7.4 pCi/g, and a standard deviation, of 12.7 pCi/g. Bin ranges in Figure 4-2a are based on these mean and standard deviation values.

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

When comparing the predicted Ra-226 concentrations to the Ra-226 laboratory concentrations, soil/sediment sample locations are generally not co-located with specific gamma measurement locations (refer to Figure 4-2b). Therefore, the measured Ra-226 laboratory concentrations can only be qualitatively compared to the nearby predicted Ra-226 concentrations. With the exception of 13 (out of 33) sample locations, the measured Ra-226 laboratory concentrations were within the applicable predicted Ra-226 bin ranges. In all 13 locations where the predicted Ra-226 concentration and the Ra-226 concentration detected in the soil/sediment sample did not agree, the predicted concentration was higher than the reported laboratory concentration detected in the soil/sediment sample. Of the 13 locations with high predicted Ra-226 values, five locations (S313-SCX-006, -SCX-010, -SCX-19, -SCX-020 and -SCX-021) predicted notably higher Ra-226 concentrations with greater than one standard deviation (12.7 pCi/g) difference between the measured and predicted values. Sample locations that were within areas with a predicted Ra-226 concentration lower than 7.5 pCi/g (blue bin) generally had measured Ra-226 laboratory concentrations that agreed with the predicted Ra-226 concentration. 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.

The predicted Ra-226 concentrations were also compared to the Ra-226 ILs from each Survey Area, as shown in Figure 4-2c. The symbols for surface sample locations and boreholes where Ra-226 concentrations in surface soil/sediment samples exceeded the IL are highlighted with yellow halos. The predicted Ra-226 concentrations exceeded the Ra-226 ILs for the majority of the Site, with portions of Survey Areas A and B being the exceptions. With the exception of S313-CX-007, surface soil/sediment samples with Ra-226 laboratory concentrations that exceeded the ILs occurred in the same areas where the predicted Ra-226 concentrations exceeded the ILs. However, predicted Ra-226 concentrations exceeded the ILs in some areas where surface Ra-226 laboratory concentrations did not exceed the ILs (particularly in the northern portion of the site). 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 33 surface soil/sediment grab samples (24 soil and nine sediment) from 33 locations, and 18 subsurface soil/sediment grab samples (12 soil and six sediment) from 14 borehole locations were collected in Survey Areas A, B, C, D and E (refer to Table 3-1). The metals and Ra-226 analytical results for each Survey Area are compared to their respective ILs and presented in Tables 4-4a, 4-4b, 4-4c, 4-4d and 4-4e. Sample locations and the locations of mining-related features are shown in Figure 3-6b and Figure 4-3 present the spatial patterns, both laterally and vertically, of metals and Ra-226 detections and IL exceedances in the soil/sediment samples.

Ra-226 and/or metals concentrations exceeded their respective ILs in 21 of the 33 surface soil/sediment samples and in 13 of 18 subsurface samples, primarily on the hogback dip slope. As seen in Figure 4-3, ten sample locations did not exceed any ILs: S313-CX-001, -CX-002, -CX-008,

-CX-009, -CX-010, -CX-011, -SCX-006, -SCX-007, -SCX-009, and -SCX-022. In general, the greatest exceedances of Ra-226 and metals ILs were associated with the hogback scarp slope immediately east of the ridge, Waste Piles 3 and 4, and areas immediately down-slope of these waste piles. The maximum concentrations for all analytes were generally detected at locations S313-SCX-014 and S313-CX-007, which were respectively within and down-slope from Waste Pile 4 in Survey Area B, and S313-SCX-012, near an area where elevated gamma measurements were observed in undisturbed bedrock on the hogback scarp slope immediately east of the ridge (refer to Appendix B photograph numbers 11). Surface and subsurface soil/sediment IL exceedances for each analyte, with respect to each of the five survey areas, are described below:

- Ra-226
  - Survey Area A – the Ra-226 IL (12.7 pCi/g) was exceeded in one out of eight surface soil samples (S313-SCX-012 and its duplicate), and one of two subsurface samples (S313-SCX-012). Survey Area A Ra-226 concentrations ranged from 1.17 to 18.9 pCi/g. Ra-226 was detected at a concentration above the IL at only one location within Survey Area A (S313-SCX-012) with the highest detection (18.9 pCi/g) in the subsurface sample. S313-SCX-012 is located near an area where elevated gamma measurements were observed in undisturbed bedrock on the hogback scarp slope immediately east of the ridge.
  - Survey Area B – the Ra-226 IL (3.86 pCi/g) was exceeded in eight out of ten surface soil/sediment samples and all six subsurface samples. Survey Area B Ra-226 concentrations ranged from 2.49 to 29 pCi/g. At one surface location (S313-SCX-003) Ra-226 was detected at a concentration slightly below the IL in the primary sample, but slightly above the IL in the duplicate sample at that location. The maximum Ra-226 detection (29 pCi/g) was from subsurface soil sample S313-SCX-014 located at Waste Pile 4. Ra-226 concentrations generally decreased with distance downgradient from former mining operational areas.
  - Survey Area C – the Ra-226 IL (2.09 pCi/g) was exceeded in each of the four surface soil/sediment samples and each of the four subsurface samples. Survey Area C Ra-226 concentrations ranged from 2.55 to 34.3 pCi/g. The maximum Ra-226 detection (34.3 pCi/g) was from surface sediment sample S313-CX-005 collected down-slope from Waste Pile 3.
  - Survey Area D – the Ra-226 IL (1.87 pCi/g) was exceeded in one of two surface sediment samples (S313-SCX-017) and one of two subsurface samples (S313-SCX-018). Ra-226 concentrations in Survey Area D ranged from 1.49 to 3.29 pCi/g, and the maximum Ra-226 detection (3.29 pCi/g) was from surface sediment sample S313-SCX-017 collected from an ephemeral drainage down-slope from former mining operational areas on the hogback dip slope.
  - Survey Area E – the Ra-226 IL (2.05 pCi/g) was exceeded in four of nine surface soil/sediment samples, but was not detected above the IL in any of the four subsurface samples. Survey Area E Ra-226 concentrations ranged from 0.44 to 15.2 pCi/g. The Ra-226 IL was exceeded in the primary surface sample at S313-SCX-020 but was

detected at a concentration (2.01 pCi/g) slightly below the IL in the duplicate sample collected at that location. The maximum Ra-226 detection (15.2 pCi/g) was from surface soil sample S313-SCX-008 collected from the potential haul road.

- Uranium
  - Survey Area A – The uranium IL (31.4 mg/kg) was exceeded in one out of eight surface soil samples (S313-SCX-010), and one of two subsurface samples (S313-SCX-012). Survey Area A uranium concentrations ranged from 2.2 to 48 mg/kg. The maximum uranium detection (48 mg/kg) was from surface soil sample S313-SCX-010 collected on the hogback scarp slope immediately east of the ridge.
  - Survey Area B – The uranium IL (2.12 mg/kg) was exceeded in nine out of ten surface soil/sediment samples and in all six subsurface samples. Survey Area B uranium concentrations ranged from 1.8 to 120 mg/kg. The maximum uranium detection (120 mg/kg) was from subsurface soil sample S313-SCX-014 collected from Waste Pile 4. Uranium concentrations generally decreased with distance from the claim boundary.
  - Survey Area C – The uranium IL (1.46 mg/kg) was exceeded in each of the four surface soil/sediment samples and each of the four subsurface samples. Survey Area C uranium concentrations ranged from 3.8 to 50 mg/kg. The maximum uranium detection (50 mg/kg) was from surface sediment sample S313-CX-005 collected down-slope from Waste Pile 3.
  - Survey Area D – The uranium IL (1.36 mg/kg) was exceeded in one of two surface sediment samples (S313-SCX-017) and one of two subsurface samples (S313-SCX-017). Survey Area D uranium concentrations ranged from 0.99 to 2.3 mg/kg. The maximum uranium detection (2.3 mg/kg) was from the surface sediment sample at S313-SCX-017 collected from an ephemeral drainage down-slope from historical mining areas on the hogback dip slope.
  - Survey Area E – The uranium IL (1.27 mg/kg) was exceeded in four of nine surface soil/sediment samples but was not detected above the IL in any of the four subsurface samples. Survey Area E uranium concentrations ranged from 0.46 to 25 mg/kg. The maximum uranium detection (25 mg/kg) was from surface soil sample S313-SCX-008 collected from the potential haul road.

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 exceeded the maximum regional value in some soil/sediment samples from all survey areas except Survey Area D.

- Arsenic
  - Survey Area A – the arsenic IL (7.92 mg/kg) was exceeded in one of two subsurface soil samples (S313-SCX-012) with a concentration of 13 mg/kg. Arsenic was detected in all but one of the samples collected from Survey Area A, with detected concentrations ranging from 0.23 to 13 mg/kg. S313-SCX-012 is located near an area where elevated gamma measurements were observed near an undisturbed layer in bedrock on the

hogback scarp slope immediately east of the ridge. Arsenic was not detected above the IL in any of the eight surface soil samples.

- Survey Area B – the arsenic IL (9.06 mg/kg) was exceeded in one out of ten surface soil/sediment samples (S313-CX-007) and in one out of six subsurface samples (S313-SCX-014). Survey Area B arsenic concentrations ranged from 0.44 to 27 mg/kg. The maximum arsenic detection (27 mg/kg) was from surface soil sample S313-CX-007 located down-slope from Waste Pile 4.

- Survey Area C – the arsenic IL (17.4 mg/kg) was not exceeded in any of the four surface soil/sediment samples or four subsurface samples. Survey Area C arsenic concentrations ranged from 6.7 to 12 mg/kg.

- Survey Area D – the arsenic IL (14.8 mg/kg) was not exceeded in either of the two surface sediment samples or either of the two subsurface samples. Survey Area D arsenic concentrations ranged from 6.0 to 7.5 mg/kg.

- Survey Area E – the arsenic IL (7.51 mg/kg) was not exceeded in any of the nine surface soil/sediment samples or the four subsurface samples. Survey Area E arsenic concentrations ranged from 0.39 to 4.6 mg/kg.

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). Arsenic concentrations were within the typical range of regional values in soil/sediment samples from all survey areas.

- Molybdenum

  - Survey Area A – the molybdenum IL (12.8 mg/kg) was exceeded in one of two subsurface soil samples (S313-SCX-012) with a concentration of 18 mg/kg. S313-SCX-012 is located an area where elevated gamma measurements were observed near an undisturbed layer in bedrock on the hogback scarp slope immediately east of the ridge. Molybdenum was not detected in five of ten samples collected from Survey Area A; detected concentrations ranged from 0.56 to 18 mg/kg. Molybdenum was not detected above the IL in any of the eight surface soil samples.

  - Survey Area B – the molybdenum IL (8.08 mg/kg) was not exceeded in any of ten surface soil/sediment samples, but did exceed the IL in one of six subsurface samples (S313-SCX-014) with a concentration of 13 mg/kg. Survey Area B molybdenum concentrations ranged from 0.48 to 13 mg/kg. S313-SCX-014 was soil collected from Waste Pile 4.

  - Survey Area C – the molybdenum IL (1.47 mg/kg) was exceeded in two of the four surface soil/sediment samples and two of the four subsurface samples. Survey Area C molybdenum concentrations ranged from 0.59 to 2.3 mg/kg. The maximum molybdenum detection (2.3 mg/kg) was from surface sediment sample S313-CX-005 collected down-slope from Waste Pile 3.

- Survey Area D – the molybdenum IL (1.87 mg/kg) was not exceeded in either of the two surface sediment samples or either of the two subsurface samples. Survey Area D molybdenum concentrations ranged from 0.72 to 0.94 mg/kg.

- Survey Area E – the molybdenum IL (0.707 mg/kg) was exceeded in one of nine surface soil/sediment samples (S313-SCX-008) with a concentration of 6.5 mg/kg. S313-SCX-008 was collected from the potential haul road. Molybdenum was not detected at a concentration above the IL in any of the four subsurface soil/sediment samples. Molybdenum was not detected in 10 of 13 samples collected from Survey Area E; detected concentrations ranged from 0.26 to 6.5 mg/kg.

As a broader point of reference, a regional study of the Western US documented molybdenum concentrations in soil that ranged from less than 3 to 7 mg/kg, with a mean value of 0.85 mg/kg (USGS, 1984). Molybdenum concentrations were within the typical range of regional values in soil/sediment samples from all survey areas, with the exception of location S313-SCX-012 in Survey Area A and locations S313-SCX-013 and –SCX-014 in Survey Area B.

- Selenium

  - Survey Area A – The selenium IL (3.26 mg/kg) was exceeded in one of two subsurface soil samples (S313-SCX-012) with a concentration of 19 mg/kg. S313-SCX-012 is located near an area where elevated gamma measurements were observed near an undisturbed layer in bedrock on the hogback scarp slope immediately east of the ridge. Selenium was not detected in five of ten samples collected from Survey Area A; detected concentrations ranged from 1.1 to 19 mg/kg. Selenium was not detected above the IL in any of the eight surface soil samples.

  - Survey Area B – The selenium IL (2.67 mg/kg) was exceeded in three out of ten surface soil/sediment samples and in two of six subsurface samples. Selenium was not detected in three of 16 samples collected from Survey Area B; detected concentrations ranged from 1.2 to 10 mg/kg. The maximum selenium detection (10 mg/kg) was at subsurface soil sample S313-SCX-014, collected from Waste Pile 4. Samples with elevated selenium concentrations were all collected from within, or immediately down-slope from Waste Pile 4.

  - Survey Area C – The selenium IL (1.55 mg/kg) was exceeded in one of the four surface soil/sediment samples (S313-CX-005) and two of the four subsurface samples (each of the deepest samples from locations S313-SCX-001 and –SCX-002). Selenium was not detected in one of eight samples collected from Survey Area C; detected concentrations ranged from 1.3 to 2.2 mg/kg. The maximum selenium detection (2.2 mg/kg) was from surface sediment sample S313-CX-005 collected down-slope from Waste Pile 3.

  - Survey Area D – The selenium IL (2.09 mg/kg) was not exceeded in either of the two surface sediment samples or either of the two subsurface samples. Selenium was detected at one subsurface location (S313-SCX-018) at 1 mg/kg, and was not detected in the three other samples at Survey Area D.

- Survey Area E – Selenium was detected in one of nine surface soil/sediment samples (S313-SCX-008) with a concentration of 5.2 mg/kg. S313-SCX-008 was collected from the upper potential haul road. Selenium was not detected in the other 12 samples collected from Survey Area E. A selenium IL was not identified for Survey Area E because selenium sample results in the background area were all non-detect.

As a broader point of reference, a regional study of the Western US documented selenium concentrations in soil that typically ranged from less than 0.10 to 4.3 mg/kg, with a mean value of 0.23 mg/kg (USGS, 1984). Selenium concentrations were within the typical range of regional values in all survey areas, with the exception of locations S313-SCX-012 in Survey Area A, S313-SCX-014 in Survey Area B, and S313-SCX-008 in Survey Area E.

- Vanadium
  - Survey Area A – The vanadium IL (21.3 mg/kg) was exceeded in one out of eight surface soil samples (S313-SCX-005), and one of two subsurface samples (S313-SCX-012). Survey Area A vanadium concentrations ranged from 7.2 to 30 mg/kg. The maximum vanadium detection (30 mg/kg) was from subsurface soil sample S313-SCX-012 located near an area where elevated gamma measurements were observed near an undisturbed layer in bedrock on the hogback scarp slope immediately east of the ridge.
  - Survey Area B – The vanadium IL (29.7 mg/kg) was exceeded in one out of ten surface soil/sediment samples (S313-CX-007) and in one of six subsurface samples (S313-SCX-014). Survey Area B vanadium concentrations ranged from 9 to 170 mg/kg. The maximum vanadium detection (170 mg/kg) was from surface soil sample S313-CX-007 located down-slope from Waste Pile 4.
  - Survey Area C – The vanadium IL (13.7 mg/kg) was exceeded in two of the four surface soil/sediment samples and two of the four subsurface samples. Survey Area C vanadium concentrations ranged from 10 to 18 mg/kg. The maximum vanadium detection (18 mg/kg) was from surface soil sample S313-SCX-019 collected from Waste Pile 3.
  - Survey Area D – The vanadium IL (32.8 mg/kg) was not exceeded in either of the two surface sediment samples or either of the two subsurface samples. Survey Area D vanadium concentrations ranged from 11 to 13 mg/kg.
  - Survey Area E – The vanadium IL (29.2 mg/kg) was not exceeded in any of the nine surface soil/sediment samples or any of the four subsurface samples. Survey Area E vanadium concentrations ranged from 4.6 to 24 mg/kg.

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 background values in all survey areas.

4.4 CONSTITUENTS OF POTENTIAL CONCERN

Based on the results presented in Sections 4.2 and 4.3, gamma radiation and concentrations of Ra-226, arsenic, molybdenum, selenium, uranium, and vanadium in soil/sediment exceeded their respective ILs at the Site. Therefore, these constituents were confirmed COPCs for the Site.

4.5 AREAS THAT EXCEED THE INVESTIGATION LEVELS

The approximate lateral extent of surface gamma IL exceedances in soil/sediment is 16.3 acres, as shown in Figure 4-4a. To estimate this area, polygons were contoured around portions of the Site that had multiple, contiguous surface gamma IL exceedances and then the total area within the polygons was calculated. Figures 4-4b and 4-4f show larger scale views of each of the five Survey Areas to better display those areas with multiple, contiguous surface gamma IL exceedances.

With the exception of three areas, the 16.3 acre area estimate also included the surface and/or subsurface soil/sediment locations where Ra-226, metals, and static gamma ILs were exceeded. The three areas with surface and/or subsurface soil/sediment IL exceedances that were excluded from the area estimate were located in portions of the Site where the surface gamma measurements did not exceed the ILs, and were inclusive of:

- The upgradient portion of the drainage channel located within the monocline bench west of the hogback dip slope (sample locations S313-SCX-017 and –SCX-018)
- The drainage channel down-slope from Waste Pile 1 (sample location S313-CX-004)
- The area down-slope from Waste Pile 4 (sample locations S313-CX-007 and –SCX-015)

IL exceedances in the monocline bench drainage channel consisted of minor subsurface static gamma, uranium, and Ra-226 exceedances that were less than two times their respective ILs (refer to Tables 4-2 and 4-4d). In addition, all measurements were lower than or approximately equal to the up-gradient Survey Area B ILs. The soil and sediment IL exceedances measured down-slope of Waste Piles 1 and 4 included Ra-226 (S313-CX-007 and –SCX-015), arsenic (S313-CX-007), selenium (S313-SCX-015), uranium (S313-CX-004, -CX-007, and –SCX-015), and vanadium (S313-CX-007) IL exceedances (refer to Table 4-4b). Although these down-slope areas did not have significant surface gamma IL exceedances (refer to Figures 4-4a and 4-4c), these portions of the hogback dip slope were included in area calculations. It should also be noted that static gamma ILs are screening levels and consideration should be given where measurements exceed these ILs absent other IL exceedances for other constituents. Locations S313-SCX-006 and –SCX-007 near Waste Pile 2 in Survey Area A had static gamma measurements exceeding the IL while Ra-226 and metals concentrations were below ILs. Surrounding gamma survey measurements were largely above the IL, and these locations were included in the approximate IL exceedance area (Figure 4-4a).

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

IL exceedances in metals and Ra-226 concentrations at surface and subsurface sample locations were typically, but not always 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 4-4a were compared to the predicted Ra-226 concentrations that exceeded ILs in Figure 4-2c. In general, the lateral extent of the predicted Ra-226 IL exceedances was similar to, but slightly larger than the lateral surface extent of the surface gamma IL exceedances. Exceptions to this include Survey Area C where predicted Ra-226 IL exceedances covered a much larger portion of the survey area than measured gamma exceedances, and Survey Area A where predicted Ra-226 IL exceedances were more spatially limited than measured gamma survey IL exceedances and confined primarily to the central portion of the survey area north of the claim boundary.

4.6 AREAS OF TENORM AND NORM

A multiple lines of evidence approach was used to evaluate the Site and distinguish areas of TENORM from areas of NORM within the Survey Area, as described in Section 3.3.3. Based on this evaluation, 19.8 acres, out of the 30.9 acres of the Survey Area, were estimated to contain TENORM at the Site. This estimate is inclusive of three areas: (1) portions of hogback scarp slope; (2) the hogback dip slope (including primary historical mining operational areas); and (3) the monocline bench. The area containing TENORM is shown in relation to the lateral extent of IL exceedances in Figure 4-6, in relation to the gamma measurements in Figure 4-7a, and compared to exposed bedrock in Figure 4-7b.

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

- Historical Data Review
    - Historical document review (Chenoweth, 1989; Anderson, 1980; Weston Solutions, 2009) indicated that there was one open pit mine and one mine dump (i.e., waste pile). In addition to features described in historical documentation, Stantec field personnel observed one adit, potential haul roads, waste piles, and blasted areas (described below).

- Between 1952 and 1959, 846 tons of ore that contained 3,350 pounds of 0.20 percent U_3O_8 and 2,266 pounds of 0.14 percent V_2O_5 was produced from the Site (McLemore, 1983 and Chenoweth, 1989).

- NAML and New Mexico Mining and Mineral Division did not have any reclamation records for the Site.

- Geology/geomorphology

    - Bedrock at the Site consisted of four geologic formations: (1) the Westwater Canyon Member of the Morrison Formation; (2) the Dakota Sandstone; (3) Whitewater Arroyo Shale Tongue of the Mancos Shale; and (4) the Cow Springs Sandstone. The Dakota Sandstone and the Morrison Formation contain NORM at the Site. In addition, a significant portion 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.

    - Overland flow is controlled by the hogback ridge (the approximate watershed divide), and precipitation runoff either terminates within unconsolidated deposits or drains into one of several radial patterned ephemeral drainages that could transport NORM/TENORM. The radial patterned ephemeral drainages drain: (1) north from the approximate watershed divide line (i.e., hogback ridge); and/or (2) southeast and southwest from the approximate watershed divide line, and converge into one drainage. The converged drainage then drains southeast to northwest, toward an unnamed drainage. The drainages originating on the hogback scarp slope did not systematically contain elevated surface gamma measurements relative to surrounding areas, while the drainages from the hogback dip slope did contain elevated surface gamma measurements. Drainages on both sides of the hogback ridge contained sediment with limited metal (uranium only) IL and subsurface static gamma IL exceedances; however, the exceedances were generally minor and not co-located with surface gamma IL exceedances.

- Disturbance Mapping – Stantec field personnel observed the following features:

    - An excavation area coincident with the historical mining pit.

    - An adit located approximately 200 ft west of the claim boundary. The entrance to the adit was approximately 12 ft by 8 ft, and the adit workings continue approximately 75 ft at a downward angle. The workings dimensions are based on field personnel observations made from the adit entrance and appeared to change with depth. The front of the adit was blocked by boulders of various sizes.

    - Two primary potential haul roads were mapped on or within 0.25 miles of the site. The potential haul roads provided access to the Site from either the dip slope or the scarp slope side of the Site. Portions of the potential haul roads contain bedrock, cut surfaces where bedrock is exposed at the surface, and other portions on the road contain significant amounts of fill that were added to maintain a level road base surface. Characterization of this fill material was not conducted, and further investigation of this material may be warranted as part of future work. This is identified as a potential data gap in Section 4.8.

- Two blasted areas consistent with surface mining activities were observed along the eastern portion of the claim boundary and north of the claim boundary on the hogback scarp slope.

- Six waste piles that consisted of waste rock assumed to be related to historical mining activities were observed at the Site. Waste Piles 1 and 4 are the largest and consisted of unsorted fine-grained to boulder-sized material located along identified potential haul roads associated with the open pit mine. Waste Piles 2, 5, and 6 were smaller and also located along these potential haul roads. Waste Pile 3 was located outside of the adit entrance.

- Site Characterization

  - The hogback scarp slope comprises the majority of Survey Areas A and E, and is inclusive of the scarp slope portion of the potential haul road, Waste Pile 2, and the northern blasted area. Surface gamma IL exceedances were generally observed along the hogback ridge, coincident with Waste Pile 2, along portions of the potential haul road, and in surrounding areas. The highest surface gamma measurements were observed northeast of the hogback ridge. Similarly, the highest Ra-226 and metals concentrations measured in surface or subsurface soil/sediment samples for this area were located near an area where elevated gamma measurements were observed near an undisturbed layer in bedrock on the hogback scarp slope immediately east of the ridge. Limited areas on the northern and eastern portions of the Site had gamma survey measurements exceeding the IL while being excluded from the TENORM identification. These areas were not identified as TENORM because they are cross-gradient and not downwind from historical mining areas, and/or had a relatively low density of surface gamma measurements exceeding the IL.

  - The hogback dip slope comprises much of Survey Areas B and C, and is inclusive of the mining pit, dip slope potential haul roads, Waste Piles 1, 3, 4, 5, and 6, the southern blasted area, and the adit. The majority of surface gamma IL exceedances on the hogback dip slope were coincident with, and down-slope from the claim boundary, mine pit, adit, and associated waste piles, with the highest measurements in the eastern portion of the claim boundary near the mine pit and Waste Pile 6. The greatest surface or subsurface soil/sediment static gamma measurement, Ra-226, or metals ILs exceedances were generally associated with Waste Pile 4 and the area immediately down-slope of the waste pile.

  - The monocline bench comprises Survey Area D, and is inclusive of the drainage pathways down-slope from the primary historical mining area (i.e., the hogback dip slope). The majority of the surface gamma exceedances were located in the western, downstream portion of the drainage pathway. Surface gamma measurements in the up-slope portion of monocline bench are characterized by sporadic, non-contiguous IL exceedances. Surface and subsurface sediment samples were collected from the upstream sections of drainage; these samples contained subsurface static gamma, Ra-226, and uranium IL exceedances that were less than two-times their respective ILs. Other metals were not measured at concentrations exceeding ILs. Sediment samples were not collected further downstream coincident with elevated surface gamma survey measurements.

- The number of surface and subsurface soil/sediment samples within waste piles is limited. The lack of subsurface samples from Waste Piles 1, 3, 5, and 6 is included as a data gap in Section 4.8. Waste rock was not observed in the boreholes that were advanced within Waste Piles 2 and 4 and the excavation area (e.g., S313-SCX-006, -SCX-013 and -SCX-014). However, waste rock is visible at the ground surface (e.g., gray, finer grained material) in Waste Piles 2 and 3, and potentially also in Waste Piles 4, 5 and 6. Waste Pile 1 is comprised of material that was pushed and dumped for construction of the haul road. Waste pile material is not visible anywhere else on the Site.

- Metals concentrations in samples collected outside the area of TENORM (S313-CX-011 and -SCX-022) were less than or within the regional concentration values.

- It is important to consider that with the exception of two locations, the subsurface static gamma ILs were not the only evidence used to delineate the vertical extent of TENORM that exceeded the IL in borehole locations at the Site. In boreholes S313-SCX-006 and -SCX-007 Ra-226 and metals concentrations did not exceed the ILs. However, subsurface static gamma measurements were greater than three times the IL in S313-SCX-006. The two boreholes are located in close proximity to each other and they're also located near S313-SCX-005 where the vanadium concentration exceeded the IL in a surface sample.

The area of the Site considered to contain TENORM (i.e., multiple lines of evidence indicated the presence of mining-related impacts) was 19.8 acres, as shown on Figure 4-8a. Portions of the TENORM exceeded one or more IL, where approximately 13.0 acres contained TENORM that exceeded the surface gamma IL and the majority of the sample locations where TENORM exceeded the ILs. TENORM exceeding the ILs was observed at five sample locations that were not coincident with areas of the Site that exceeded the surface gamma IL. However, these locations are included in estimate of TENORM exceeding the ILs, as discussed below. TENORM that exceeded the ILs in Survey Areas A through E are shown on Figures 4-8b through 4-8f, and are compared to mining-related features in Figure 4-8g.

4.7 TENORM VOLUME ESTIMATE

The volume estimate of TENORM that exceeded one or more ILs is approximately 22,964 cubic yards (yd^3), as shown in Figure 4-9a. The volume and area of TENORM associated with specific mine features is listed in Table 3-2. This estimate was calculated using ESRI ArcGIS Desktop 10.3.1

Spatial Analyst Extension cut/fill tool (ESRI, 2017) utilizing the volume analysis also utilized the ground surface elevation contours developed from the orthophotographs coupled with hand-derived contours based on field personnel observations, depth to bedrock in boreholes, gamma measurements, sample analytical data, and historical mining documentation. Field observations included observations of disturbance, changes in vegetation, estimating/projecting the slope of underlying bedrock, and estimating the shape and topography of waste material and/or soil deposits.

TENORM exceeding the ILs at the Site was split into groups based on the depth or type of material to aid in analysis and describing the basis of the volumes. The locations, volume, and areas of these groups are shown in Figure 4-9a. The individual waste piles are also shown on Figure 4-9a for reference, and the volume and area of the waste piles are listed in Table 3-2. The assumptions that were used to calculate the volume of TENORM with IL exceedances were as follows:

General Assumptions

- It was assumed that subsurface bedrock encountered in boreholes was not previously modified by human activity, and is therefore NORM.
- For areas of TENORM at the Site containing boulders at the surface whose heights exceeded the assumed depth of TENORM in that area (e.g., a 5-ft-tall boulder in an area where TENORM was assumed to extend 1 ft bgs), the additional volume of the boulders was assumed to be accounted for by the overall TENORM depth estimates.
- Portions of the areas delineated as exposed bedrock within the TENORM area on Figure 4-9a contain small amounts of colluvium.
- With the exception of two boreholes, S313-SCX-006 and -SCX-007 (refer to last bullet in Section 4.6), the subsurface static gamma IL values were not used as the only evidence to delineate the vertical extent of TENORM that exceeded the ILs in borehole locations at the Site.

Group Assumptions

- Group 1 (4,905 yd^3) – A polygon was best fit around the area of TENORM for the Mine Area where mining-related disturbance occurred (as shown in Figure 4-9a). Rock was mined and removed from the eastern portions of the Mine Area and waste piles and large boulders are still present within the area. The western portions of the Mine Area were disturbed and graded flat with waste rock. TENORM was assumed to extend to 3.0 ft bgs based on soil borings and visual observation and measurements of the disturbed area. Useful contours for this area cannot be generated as the contours from the high resolution photographs are only accurate to intervals of 2 ft.
- Group 2 (4,497 yd^3) – A polygon was best fit around the area of TENORM for the Mine Access Area (as shown in Figure 4-9a). Cut and fill work was performed in this area to create an access road to the Mine Area and waste rock was pushed along the shoulders of the road

and down the hogback dip slope to the west. TENORM was assumed to extend to 2.5 ft bgs based on soil borings, and field observations and measurements.

- Group 2a (644 yd^3) – This portion of the ridge is considered a subunit of Group 2 where bedrock is shallower than in the rest of Group 2. Bedrock outcrops in some portions of this area. TENORM was assumed to extend to 0.5 ft bgs based on field observations and bedrock mapping.

- Group 2b (3,079 yd^3) – The polygons in these areas were extended beyond the surface gamma IL exceedances as the result of one or more Ra-226/metals ILs being exceeded at S313-CX-004, -CX-007, and –SCX-015.

- Group 3 (6,569 yd^3) – A polygon was best fit around the area of TENORM for the east side of the hogback (Hogback Scarp Slope), as shown in Figure 4-9a. Much of the area consists of bedrock at the surface, though eolian or alluvial transport from the primary mining areas and potential haul roads may have occurred downslope into this area. TENORM was assumed to extend to 0.5 ft bgs based on soil borings (refusal was between 0.5 and 1.0 ft bgs), field observations, and measurements.

- Group 4 (1,153 yd^3) – Based on field observations (e.g., the apparent thickness of soil), TENORM in the area of the potential haul road was assumed to extend to 1.0 ft bgs. Portions of the road contain bedrock, cut surfaces where bedrock is exposed at the surface, and other portions on the road contain significant amounts of fill that was added to maintain a level road base surface.

- Group 5 (579 yd^3) – Waste Pile 3 was estimated to contain 579 yd^3 of TENORM. Contours of the depth of the waste pile were created to support these volume calculations, refer to Figure 4-9b. The contours were based on: (1) profiles of the waste pile created using GIS (ESRI ArcMap 10.3.1, 3D Analyst Extension); (2) the assumption that bedrock beneath the waste pile was a planar surface; (3) the assumption that all material within the footprint of the waste pile was waste rock; and (4) review of oblique imagery in Google Earth (Google Earth, 2018). The profiles were created by cutting a series of cross-sections along and perpendicular to the topographic contours (Cooper, 2017) of the waste pile. Each cross-section visually depicted the depth of the waste pile relative to the assumed depth of bedrock and/or exposed bedrock adjacent to the waste pile. Depth information from each cross-section, in conjunction with the orthophotographs, were then used to create the depth contours that were used to calculate the volume. The portal waste pile depth contours ranged from 0 to 9 ft bgs. Note that the surface extents of Group 5 depicted on Figure 4-9b differ from the Waste Pile 3 boundary. This is because the extent of the Waste Pile 3was based on field mapping alone, whereas the extent of Group 5 on Figure 4-9b was based on a more comprehensive integration of multiple lines of evidence including field mapping, gamma measurements, soil sampling results (surface and subsurface) and critical review of aerial imagery (Cooper, 2017; Google Earth, 2018).

- Group 6 (1,538 yd^3) – Drainages west (downgradient) of the site were estimated to contain 1,538 yd^3 of TENORM, as shown in Figure 4-9. Boreholes in the drainage (S313-SCX-017 and -SCX-018) met refusal at 1.5 and 2.0 ft below ground surface. Based on field observations and the boreholes, TENORM in the area of the drainages was estimated to extend the width of the drainage bed and to extend to 1.5 ft bgs on average.

4.8 POTENTIAL DATA GAPS AND SUPPLEMENTAL STUDIES

4.8.1 Data Gaps

Seven 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. 0.5 acres of the hogback dip slope and the hogback scarp slope were not surveyed during the surface gamma survey because field personnel were unable to safely access these areas.
2. For approximately 250 ft of the eastern potential haul road, the gamma survey (the most eastern extent) was limited to the centerline of the road, and the shoulders were not surveyed.
3. The gamma survey was not extended in limited areas within Survey Areas A and E until gamma measurements were less than the respective surface gamma ILs.
4. The survey was not extended laterally from the western drainage where gamma measurements were greater than the IL.
5. An updated or improved upon background reference area is needed to represent the Morrison Formation.
6. Soil and sediment sampling was not conducted within BG-8 for comparison with Quaternary deposits located northeast of the Site.
7. Subsurface samples were not collected at Waste Piles 1, 3, 5, and 6.

4.8.2 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. Investigation or characterization of haul road fill material may be warranted as part of future work.
2. Boulders located on the Site were included in the area of the surface gamma survey but were not otherwise evaluated. Additional characterization of boulders may be warranted in the future.
3. Comparison of Ra-226 and Th-230 concentrations indicated that Ra-226 and Th-230 are in equilibrium, but not in secular equilibrium. This may be an important consideration in the future and further evaluation may be required if a human health and/or ecological risk assessment is performed.

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

5.0 SUMMARY AND CONCLUSIONS

This report details the purpose and objectives, field investigation activities, findings, and conclusions of the Site Clearance and RSE activities conducted for the Site between August 2015 and September 2017. The Site is known as the Eunice Becenti site and is also identified by the USEPA as AUM identification #313 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/sediment sampling and analyses. An estimate of areas containing TENORM was made based on an evaluation of the RSE information/data and multiple lines of evidence. The correlation between gamma measurements (in cpm) and concentrations of Ra-226 in surface soils (pCi/g) was developed as a potential field screening tool for future Removal or Remedial Action evaluations. The gamma correlation was not used for the Site Characterization, which relied instead on the actual gamma radiation measurements and soil/sediment analytical results. However, predicted Ra-226 concentrations were compared to the actual Ra-226 laboratory results and ILs from the surface soil/sediment samples at the Agencies' request.

The Site is located in the Gallup-Grants uranium mining district. Mine workings on-site consisted of an open pit that had a short decline off of the pit wall. Between 1952 and 1959 the Site produced 846 tons (approximately $1.7x10^6$ pounds) of ore that contained 3,350 pounds of 0.20 percent U_3O_8 and 2,266 pounds of 0.14 percent V_2O_5.

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

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

Surface gamma measurements and Ra-226 and metals concentrations were generally highest in areas that were coincident with, and down-slope from, mining-related features (e.g., the mine excavation and Waste Piles 1, 3, 4, and 6), and areas adjacent to an area where elevated gamma measurements were observed near an undisturbed layer in bedrock on the hogback scarp slope east of the ridge. The maximum surface gamma measurement (401,121 cpm) was greater than 10 times the highest surface gamma IL, and occurred in in the eastern portion of the claim boundary approximately coincident with Waste Pile 6 and an identified blasted area. The highest Ra-226 and metals concentrations were generally detected at locations down-slope from Waste Pile 4, and near an area where elevated gamma measurements were observed near an undisturbed natural layer in bedrock on the hogback scarp slope immediately east of the ridge.

Results of the Gamma Correlation Study indicated that surface gamma survey results correlate sufficiently 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.

Based on the data analysis performed for this RSE report along with the multiple lines of evidence, approximately 19.8 acres out of the 30.9 acres of the Survey Area were estimated to contain TENORM. This estimate is inclusive of three areas: (1) portions of the hogback scarp slope; (2) the hogback dip slope (including primary historical mining operational areas); and (3) the monocline bench. 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 19.8 acres that contain TENORM, 13.0 acres contain TENORM exceeding the surface gamma ILs and TENORM that exceeded the ILs at all but five of the soil/sediment sample locations. The volume of TENORM in excess of ILs was estimated to be 22,964 yd^3 (approximately 17,557 cubic meters).

In addition, during the RSE work, the Trust performed an "Interim Action" to close an open adit to prevent human and livestock (animal) access.

Seven potential data gaps were identified based on the Site Clearance and RSE data collection and analyses for the Site, as listed in Section 4.8. 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 Eunice Becenti 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 Eunice Becenti RSE were $598,700. Stantec's costs associated with interim actions (adit closure and sign installation) were $86,500. In addition, Administrative costs provided by the Trust were currently $191,500[8,9]. Administrative costs will change due to continued community outreach and close out activities.

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

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TABLES

Table 3-1
Soil and Sediment Sampling Summary
Eunice Becenti
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											
S313-BG1-001	0 - 0.5	soil	SF	grab	NA	11/19/2016	712937.798	3931636.49	N	N	--
S313-BG1-002	0 - 0.5	soil	SF	grab	NA	11/19/2016	712935.205	3931638.35	N	N	--
S313-BG1-003	0 - 0.5	soil	SF	grab	NA	11/19/2016	712935.612	3931637.18	N	N	--
S313-BG1-004	0 - 0.5	soil	SF	grab	NA	11/19/2016	712935.152	3931640.39	N	N	--
S313-BG1-005	0 - 0.5	soil	SF	grab	NA	11/19/2016	712933.149	3931640.66	N	N	--
S313-BG1-006	0 - 0.5	soil	SF	grab	NA	11/19/2016	712932.766	3931643.54	N	N	--
S313-BG1-007	0 - 0.5	soil	SF	grab	NA	11/19/2016	712939.855	3931638.58	N;FD	N;FD	--
S313-BG1-008	0 - 0.5	soil	SF	grab	NA	11/19/2016	712941.319	3931637.51	N	N	--
S313-BG1-009	0 - 0.5	soil	SF	grab	NA	11/19/2016	712937.689	3931641.48	N	N	--
S313-BG1-010	0 - 0.5	soil	SF	grab	NA	11/19/2016	712931.357	3931642.76	N	N	--
S313-BG1-011	0 - 0.2	soil	SF	grab	NA	3/24/2017	712939.086	3931638.5	N	N	--
Background Reference Area Study - Background Area 2											
S313-BG2-001	0 - 0.5	soil	SF	grab	NA	9/15/2017	712808.247	3931675.52	N	N	--
S313-BG2-002	0 - 0.5	soil	SF	grab	NA	9/15/2017	712806.949	3931672.72	N;MS;MSD	N	--
S313-BG2-003	0 - 0.5	soil	SF	grab	NA	9/15/2017	712810.154	3931675.57	N	N	--
S313-BG2-004	0 - 0.5	soil	SF	grab	NA	9/15/2017	712813.166	3931674.51	N;FD	N;FD	--
S313-BG2-005	0 - 0.5	soil	SF	grab	NA	9/15/2017	712812.032	3931671.88	N	N	--
S313-BG2-006	0 - 0.5	soil	SF	grab	NA	9/15/2017	712809.691	3931670.7	N	N	--
S313-BG2-007	0 - 0.5	soil	SF	grab	NA	9/15/2017	712816.096	3931674.05	N	N	--
S313-BG2-008	0 - 0.5	soil	SF	grab	NA	9/15/2017	712813.93	3931668.38	N	N	--
S313-BG2-009	0 - 0.5	soil	SF	grab	NA	9/15/2017	712815.976	3931668.71	N;FD	N;FD	--
S313-BG2-010	0 - 0.5	soil	SF	grab	NA	9/15/2017	712817.221	3931670.88	N	N	--
S313-BG2-011	0 - 0.5	soil	SF	grab	NA	9/15/2017	712812.939	3931673.51	N	N	--
S313-BG2-011	0.5 - 0.8	soil	SB	grab	NA	9/15/2017	712812.939	3931673.51	N	N	--
Background Reference Area Study - Background Area 3											
S313-BG3-001	0 - 0.5	soil	SF	grab	NA	9/15/2017	712823.362	3931552.94	N	N	--
S313-BG3-002	0 - 0.5	soil	SF	grab	NA	9/15/2017	712820.612	3931551.9	N;MS;MSD	N	--
S313-BG3-003	0 - 0.5	soil	SF	grab	NA	9/15/2017	712824.826	3931557.14	N	N	--
S313-BG3-004	0 - 0.5	soil	SF	grab	NA	9/15/2017	712818.015	3931553.9	N;FD	N;FD	--
S313-BG3-005	0 - 0.5	soil	SF	grab	NA	9/15/2017	712812.58	3931556.1	N	N	--
S313-BG3-006	0 - 0.5	soil	SF	grab	NA	9/15/2017	712820.542	3931560.05	N	N	--
S313-BG3-007	0 - 0.5	soil	SF	grab	NA	9/15/2017	712814.605	3931559.81	N	N	--
S313-BG3-008	0 - 0.5	soil	SF	grab	NA	9/15/2017	712813.671	3931564.25	N	N	--
S313-BG3-009	0 - 0.5	soil	SF	grab	NA	9/15/2017	712817.312	3931566.08	N;FD	N;FD	--
S313-BG3-010	0 - 0.5	soil	SF	grab	NA	9/15/2017	712820.513	3931564.38	N	N	--
S313-BG3-011	0 - 0.5	soil	SF	grab	NA	9/15/2017	712818.274	3931559.67	N	N	--
Background Reference Area Study - Background Area 4											
S313-BG4-001	0 - 0.5	sediment	SF	grab	NA	9/15/2017	712967.016	3931190.49	N	N	--
S313-BG4-002	0 - 0.5	sediment	SF	grab	NA	9/15/2017	712965.05	3931193.61	N;MS;MSD	N	--
S313-BG4-003	0 - 0.5	sediment	SF	grab	NA	9/15/2017	712962.395	3931194.84	N;FD	N;FD	--
S313-BG4-004	0 - 0.5	sediment	SF	grab	NA	9/15/2017	712960.523	3931194.4	N	N	--
S313-BG4-005	0 - 0.5	sediment	SF	grab	NA	9/15/2017	712959.648	3931195.33	N	N	--
S313-BG4-006	0 - 0.5	sediment	SF	grab	NA	9/15/2017	712961.377	3931198.04	N	N	--
S313-BG4-007	0 - 0.5	sediment	SF	grab	NA	9/15/2017	712961.834	3931198.56	N	N	--
S313-BG4-008	0 - 0.5	sediment	SF	grab	NA	9/15/2017	712960.156	3931202.22	N	N	--
S313-BG4-009	0 - 0.5	sediment	SF	grab	NA	9/15/2017	712958.056	3931201.22	N;FD	N;FD	--
S313-BG4-010	0 - 0.5	sediment	SF	grab	NA	9/15/2017	712956.141	3931203.83	N	N	--
S313-BG4-011	0 - 0.5	sediment	SF	grab	NA	9/15/2017	712956.015	3931203.85	N	N	--
S313-BG4-011	0.5 - 0.75	sediment	SB	grab	NA	9/15/2017	712956.015	3931203.85	N	N	--

Notes

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

¹ Coordinate System: NAD 1983 UTM Zone 12N

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Eunice Becenti
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	Ra-226	Thorium
Background Reference Area Study - Background Area 5											
S313-BG5-001	0 - 0.5	soil	SF	grab	NA	9/16/2017	713334.356	3931292.87	N	N	--
S313-BG5-002	0 - 0.5	soil	SF	grab	NA	9/16/2017	713338.344	3931294.75	N;FD	N;FD	--
S313-BG5-003	0 - 0.5	soil	SF	grab	NA	9/16/2017	713331.83	3931296.12	N	N	--
S313-BG5-004	0 - 0.5	soil	SF	grab	NA	9/16/2017	713331.382	3931303.76	N	N	--
S313-BG5-005	0 - 0.5	soil	SF	grab	NA	9/16/2017	713340.633	3931301.24	N	N	--
S313-BG5-006	0 - 0.5	soil	SF	grab	NA	9/16/2017	713336.572	3931305.02	N	N	--
S313-BG5-007	0 - 0.5	soil	SF	grab	NA	9/16/2017	713337.333	3931309.66	N	N	--
S313-BG5-008	0 - 0.5	soil	SF	grab	NA	9/16/2017	713334.273	3931313.37	N	N	--
S313-BG5-009	0 - 0.5	soil	SF	grab	NA	9/16/2017	713329.098	3931313.61	N;FD	N;FD	--
S313-BG5-010	0 - 0.5	soil	SF	grab	NA	9/16/2017	713326.261	3931305.96	N	N	--
S313-BG5-011	0 - 0.5	soil	SF	grab	NA	9/16/2017	713326.722	3931302.4	N	N	--
Correlation											
S313-C01-001	0 - 0.5	soil	SF	5-point composite	NA	3/27/2017	713015.5	3931538.64	--	N	N
S313-C02-001	0 - 0.5	soil	SF	5-point composite	NA	3/27/2017	712987.312	3931489.65	--	N	N
S313-C03-001	0 - 0.5	soil	SF	5-point composite	NA	3/27/2017	713047.45	3931468.11	--	N	N
S313-C04-001	0 - 0.5	soil	SF	5-point composite	NA	3/27/2017	713097.35	3931399.7	--	N	N
S313-C05-001	0 - 0.5	soil	SF	5-point composite	NA	3/27/2017	713249.732	3931537.64	--	N	N
Characterization											
S313-CX-001	0 - 0.5	sediment	SF	grab	E	5/15/2017	713179.702	3931514.76	N	N	--
S313-CX-002	0 - 0.5	soil	SF	grab	E	5/15/2017	713112.294	3931547.24	N	N	--
S313-CX-003	0 - 0.5	soil	SF	grab	B	5/15/2017	713007.77	3931481.72	N	N	--
S313-CX-004	0 - 0.5	sediment	SF	grab	B	5/15/2017	712956.075	3931433.52	N	N	--
S313-CX-005	0 - 0.5	sediment	SF	grab	C	5/15/2017	712996.953	3931356.38	N	N	--
S313-CX-006	0 - 0.5	soil	SF	grab	B	5/15/2017	713052.6	3931395.97	N	N	--
S313-CX-007	0 - 0.5	soil	SF	grab	B	5/15/2017	713039.022	3931366.4	N	N	--
S313-CX-008	0 - 0.5	soil	SF	grab	A	5/15/2017	713147.129	3931434.43	N;MS;MSD	N	--
S313-CX-009	0 - 0.5	soil	SF	grab	A	5/15/2017	713186.396	3931398.98	N;FD	N;FD	--
S313-CX-010	0 - 0.5	soil	SF	grab	A	5/15/2017	713195.793	3931372.53	N	N	--
S313-CX-011	0 - 0.5	sediment	SF	grab	E	5/15/2017	713159.703	3931640.12	N	N	--
S313-SCX-001	0 - 0.5	soil	SF	grab	C	5/16/2017	712974.67	3931377.48	N	N	--
S313-SCX-001	0.5 - 1.5	soil	SB	grab	C	5/16/2017	712974.67	3931377.48	N	N	--
S313-SCX-001	1.5 - 1.8	soil	SB	grab	C	5/16/2017	712974.67	3931377.48	N	N	--
S313-SCX-002	0 - 0.5	soil	SF	grab	C	5/16/2017	712960.217	3931367.71	N	N	--
S313-SCX-002	0.5 - 1.5	soil	SB	grab	C	5/16/2017	712960.217	3931367.71	N	N	--
S313-SCX-002	1.5 - 2.1	soil	SB	grab	C	5/16/2017	712960.217	3931367.71	N	N	--
S313-SCX-003	0 - 0.5	sediment	SF	grab	B	5/16/2017	712969.651	3931472.48	N;FD	N;FD	--
S313-SCX-003	0.5 - 0.8	sediment	SB	grab	B	5/16/2017	712969.651	3931472.48	N	N	--
S313-SCX-004	0 - 0.5	sediment	SF	grab	E	5/17/2017	713268.301	3931509.26	N;MS;MSD	N	--
S313-SCX-004	0.5 - 3	sediment	SB	composite	E	5/17/2017	713268.301	3931509.26	N	N	--
S313-SCX-004	3 - 3.5	sediment	SB	grab	E	5/17/2017	713268.301	3931509.26	N	N	--
S313-SCX-005	0 - 0.5	soil	SF	grab	A	5/16/2017	712989.99	3931555.49	N	N	--
S313-SCX-006	0 - 0.5	soil	SF	grab	A	5/16/2017	712999.438	3931549.46	N	N	--
S313-SCX-006	0.5 - 1	soil	SB	grab	A	5/16/2017	712999.438	3931549.46	N	N	--
S313-SCX-007	0 - 0.5	soil	SF	grab	A	5/16/2017	712993.488	3931540.6	N	N	--
S313-SCX-008	0 - 0.5	soil	SF	grab	E	5/17/2017	713132.396	3931523.2	N	N	--
S313-SCX-009	0 - 0.5	sediment	SF	grab	E	5/17/2017	713151.898	3931588.49	N;MS;MSD	N	--
S313-SCX-009	0.5 - 0.9	sediment	SB	grab	E	5/17/2017	713151.898	3931588.49	N	N	--
S313-SCX-010	0 - 0.5	soil	SF	grab	A	5/17/2017	713064.088	3931491.63	N	N	--
S313-SCX-011	0 - 0.5	soil	SF	grab	B	5/17/2017	713089.546	3931469.35	N	N	--
S313-SCX-012	0 - 0.5	soil	SF	grab	A	5/17/2017	713131.868	3931433.1	N;FD	N;FD	--
S313-SCX-012	0.5 - 0.8	soil	SB	grab	A	5/17/2017	713131.868	3931433.1	N	N	--

Notes

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

¹ Coordinate System: NAD 1983 UTM Zone 12N

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Eunice Becenti
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Navajo Nation AUM Environmental Response Trust - First Phase

Sample Location	Sample Depth (ft bgs)	Sample Media	Sample Category	Sample Collection Method	Survey Area	Sample Date	Easting ¹	Northing ¹	Sample Types: Metals, Total	Sample Types: Ra-226	Sample Types: Thorium
Characterization continued											
S313-SCX-013	0 - 0.5	soil	SF	grab	B	5/17/2017	713116.772	3931394.22	N	N	--
S313-SCX-013	0.5 - 0.8	soil	SB	grab	B	5/17/2017	713116.772	3931394.22	N	N	--
S313-SCX-014	0 - 0.5	soil	SF	grab	B	5/17/2017	713101.78	3931383.28	N	N	--
S313-SCX-014	1 - 1.5	soil	SB	grab	B	5/17/2017	713101.78	3931383.28	N	N	--
S313-SCX-015	0 - 0.5	soil	SF	grab	B	5/17/2017	713057.146	3931357.03	N	N	--
S313-SCX-015	0.5 - 0.8	soil	SB	grab	B	5/17/2017	713057.146	3931357.03	N	N	--
S313-SCX-016	0 - 0.5	soil	SF	grab	B	5/17/2017	713050.534	3931389.11	N	N	--
S313-SCX-016	0.5 - 1	soil	SB	grab	B	5/17/2017	713050.534	3931389.11	N	N	--
S313-SCX-016	1 - 1.6	soil	SB	grab	B	5/17/2017	713050.534	3931389.11	N	N	--
S313-SCX-017	0 - 0.5	sediment	SF	grab	D	9/15/2017	712898.629	3931322.34	N	N	--
S313-SCX-017	0.5 - 1.5	sediment	SB	grab	D	9/15/2017	712898.629	3931322.34	N	N	--
S313-SCX-018	0 - 0.5	sediment	SF	grab	D	9/15/2017	712855.924	3931320.59	N	N	--
S313-SCX-018	0.5 - 2	sediment	SB	composite	D	9/15/2017	712855.924	3931320.59	N	N	--
S313-SCX-019	0 - 0.5	soil	SF	grab	C	9/15/2017	712992.286	3931359.53	N	N	--
S313-SCX-020	0 - 0.5	soil	SF	grab	E	9/16/2017	713176.482	3931474.13	N;FD	N;FD	--
S313-SCX-020	0.5 - 1	soil	SB	grab	E	9/16/2017	713176.482	3931474.13	N	N	--
S313-SCX-021	0 - 0.5	soil	SF	grab	E	9/16/2017	713170.914	3931443.08	N	N	--
S313-SCX-022	0 - 0.5	soil	SF	grab	E	9/16/2017	713131.027	3931625.39	N;MS;MSD	N	--

Notes

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

¹ Coordinate System: NAD 1983 UTM Zone 12N

Table 3-2
Mine Feature Samples and Area
Eunice Becenti
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)
Waste Pile 1	0	0	9,238	818
Waste Pile 2	1	1	575	11
Waste Pile 3	2	0	3,071	374
Waste Pile 4	1	1	15,159	1,674
Waste Pile 5	0	0	510	49
Waste Pile 6	0	0	1,566	174
Excavation	1	1	4,960	534
Northwest Blasted Area	0	0	304	5
Southeast Blasted Area	0	0	1,670	186
Potential Haul Roads	3	0	27,979	1,036
Drainages	8	6	--	986

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 drainages vary throughout the Site

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

Location Identification	S313-BG1-001	S313-BG1-002	S313-BG1-003	S313-BG1-004	S313-BG1-005	S313-BG1-006	S313-BG1-007	S313-BG1-007 Dup	S313-BG1-008	S313-BG1-009	S313-BG1-010	S313-BG1-011
Date Collected	11/19/2016	11/19/2016	11/19/2016	11/19/2016	11/19/2016	11/19/2016	11/19/2016	11/19/2016	11/19/2016	11/19/2016	11/19/2016	3/24/2017
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 - 0.2
Analyte (Units)												
Metals[1] (mg/kg)												
Arsenic	0.58	1.8	4.3	0.78	0.64	5	2	2	5.3	0.39	4.4	0.74
Molybdenum	3.1	4.8	2.4	0.32	1.5	7.5	3.6	3.7	11	0.38	4.1	0.83
Selenium	<0.98	2.6	<1	<1	1.2	1.2	<0.97	<1	2	<0.97	1.3	<0.86
Uranium	1.3	2.3	2	0.6	1.1	14	3.5	3.4	18	0.95	6.9	1
Vanadium	8.3	9.9	15	7.6	11	15	8.2	8.2	11	6	18	8.7
Radionuclides (pCi/g)												
Radium-226	2.74 ± 0.47	2.48 ± 0.42	1.77 ± 0.33	0.82 ± 0.22	1.65 ± 0.36	6.14 ± 0.86	2.17 ± 0.39	2.15 ± 0.35	8.7 ± 1.2 J+	0.87 ± 0.21	3.96 ± 0.61	1.71 ± 0.35

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

Location Identification	S313-BG2-001	S313-BG2-002	S313-BG2-003	S313-BG2-004	S313-BG2-004 Dup	S313-BG2-005	S313-BG2-006	S313-BG2-007	S313-BG2-008	S313-BG2-009	S313-BG2-009 Dup	S313-BG2-010
Date Collected	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017
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
Analyte (Units)												
Metals[1] (mg/kg)												
Arsenic	4	6.8 J	3.9	4.6	5.5	4.8	5.9	4	6.3	6.2	5.8	4.5
Molybdenum	3.2	3.2 J	2.9	3.4	4.2	3.6	3.9	2.5	4.2	3.5	4.4	3.7
Selenium	0.97	1.6	<0.98	1.1	1.2	1.2	1.4	<1	1.4	1.2	1.2	0.98
Uranium	0.99	1.6 J	0.83	0.88	0.96	1	1.2	0.91	1.5	1.3	1.2	0.86
Vanadium	12	23 J	11	12	15	14	18	9.4	20	23	19	13
Radionuclides (pCi/g)												
Radium-226	1.04 ± 0.29	3.24 ± 0.54	1.15 ± 0.27	1.03 ± 0.23	1.58 ± 0.3	1.51 ± 0.38	2.04 ± 0.38	0.94 ± 0.26	2.31 ± 0.42	2.13 ± 0.37	2.24 ± 0.41	1.5 ± 0.33

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

Stantec NAVAJO NATION AUM Environmental Response Trust - First Phase

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

Location Identification	S313-BG2-011	S313-BG2-011	S313-BG3-001	S313-BG3-002	S313-BG3-003	S313-BG3-004	S313-BG3-004 Dup	S313-BG3-005	S313-BG3-006	S313-BG3-007	S313-BG3-008	S313-BG3-009
Date Collected	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017
Depth (feet)	0 - 0.5	0.5 - 0.8	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
Analyte (Units)												
Metals[1] (mg/kg)												
Arsenic	7.8	8.5	13	8.8	7.3	9.4	10	14	4.2	11	11	6
Molybdenum	7.9	6.7	0.77	0.58	0.98	1	0.73	0.98	0.34	1	0.98	0.5
Selenium	2.7	3.2	1.3	1	1.2	1.1	1.3	1.4	<0.98	<1.1	1.3	<1
Uranium	1.8	2.5	1	0.77	0.97	0.67	0.8	1.3	0.59	0.89	0.9	0.49
Vanadium	19	17	10	9	12	10	10	8	5.7	10	10	7.5
Radionuclides (pCi/g)												
Radium-226	2.54 ± 0.46	2.94 ± 0.48 J+	1.28 ± 0.32 J+	1.13 ± 0.27	1.07 ± 0.26	1.17 ± 0.28 J+	1.38 ± 0.33 J+	1.84 ± 0.39 J+	0.7 ± 0.23	1.37 ± 0.34	1.12 ± 0.33 J+	0.71 ± 0.23 J+

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

Location Identification	S313-BG3-009 Dup	S313-BG3-010	S313-BG3-011	S313-BG4-001	S313-BG4-002	S313-BG4-003	S313-BG4-003 Dup	S313-BG4-004	S313-BG4-005	S313-BG4-006	S313-BG4-007	S313-BG4-008
Date Collected	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017
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
Analyte (Units)												
Metals[1] (mg/kg)												
Arsenic	5.9	7.6	8.7	6.6	9	11	12	6.3	6.5	9.7	7.1	6.3
Molybdenum	0.44	0.96	0.78	0.73	1	1.3	1.4	0.64	0.56	1.1	0.75	0.65
Selenium	<1	1.2	1	1.3	1.5	1.8	1.6	<1	<1	1.3	1.2	1
Uranium	0.54	0.63	0.74	0.76	0.91	0.92	1	0.58	0.51	0.89	0.64	0.65
Vanadium	7.4	8.8	9	14	18	24	28	14	13	22	15	13
Radionuclides (pCi/g)												
Radium-226	0.83 ± 0.24	0.89 ± 0.3 J+	1.44 ± 0.32	1.49 ± 0.33	1.49 ± 0.35	1.38 ± 0.28	1.84 ± 0.37	1.17 ± 0.3	1.04 ± 0.27	1.14 ± 0.25	1.25 ± 0.3 J+	1.17 ± 0.29

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

Location Identification	S313-BG4-009	S313-BG4-009 Dup	S313-BG4-010	S313-BG4-011	S313-BG4-011	S313-BG5-001	S313-BG5-002	S313-BG5-002 Dup	S313-BG5-003	S313-BG5-004	S313-BG5-005	S313-BG5-006
Date Collected	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/15/2017	9/16/2017	9/16/2017	9/16/2017	9/16/2017	9/16/2017	9/16/2017	9/16/2017
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 0.75	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Analyte (Units)												
Metals[1] (mg/kg)												
Arsenic	11	13	12	10	9.1	3.3	3.2	4.5	3.1	3.3	3.1	3.2
Molybdenum	1.3	1.5	1.3	1.4	1.4	0.34	0.4	0.57	0.43	0.33	0.35	0.35
Selenium	1.6	1.8	1.6	1.5	1.4	<0.96	<0.98	<0.99	<0.98	<0.97	<0.99	<0.97
Uranium	0.98	1.1	0.99	1.1	1	0.96	0.96	1.3	1.1	0.88	0.97	0.81
Vanadium	26	29	24	22	21	15	16	34	14	16	16	15
Radionuclides (pCi/g)												
Radium-226	1.39 ± 0.29	1.59 ± 0.3	1.47 ± 0.34	1.66 ± 0.38	1.38 ± 0.33 J+	1.42 ± 0.3	1.29 ± 0.26	1.57 ± 0.29	1.79 ± 0.37	1.28 ± 0.29	1.51 ± 0.27	1.54 ± 0.32

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

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AUM Environmental Response Trust - First Phase

Location Identification	S313-BG5-007	S313-BG5-008	S313-BG5-009	S313-BG5-009 Dup	S313-BG5-010	S313-BG5-011
Date Collected	9/16/2017	9/16/2017	9/16/2017	9/16/2017	9/16/2017	9/16/2017
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Analyte (Units)						
Metals[1] (mg/kg)						
Arsenic	4.7	6.3	4.3	4.3	3.8	6.3
Molybdenum	0.42	0.63	0.41	0.42	0.41	0.55
Selenium	<0.98	<0.97	<1	<0.97	<1	<1
Uranium	1.1	1.1	1	1.1	0.81	0.86
Vanadium	21	26	19	19	17	24
Radionuclides (pCi/g)						
Radium-226	1.3 ± 0.31	1.64 ± 0.32	1.66 ± 0.34	1.53 ± 0.33	1.24 ± 0.28	1.74 ± 0.36

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

Table 4-2
Static Gamma Measurement Summary
Eunice Becenti
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)
S313-BG1-011	Background Area 1	*	0.2	soil	8,480**
S313-BG2-011	Background Area 2	*	0.0	soil	12,944
S313-BG2-011	Background Area 2	*	0.5	soil	26,769
S313-BG2-011	Background Area 2	*	0.8	soil	30,106**
S313-BG3-011	Background Area 3	*	0.0	soil	11,902
S313-BG3-011	Background Area 3	*	0.5	soil	15,432**
S313-BG4-011	Background Area 4	*	0.0	soil	13,300
S313-BG4-011	Background Area 4	*	0.5	soil	15,012
S313-BG4-011	Background Area 4	*	0.8	soil	18,699**
S313-BG5-011	Background Area 5	*	0.0	soil	9,575
S313-BG5-011	Background Area 5	*	0.5	soil	13,197**
S313-SCX-005	A	--	0.0	soil	17,971
S313-SCX-005	A	8,480	0.5	soil	20,586**
S313-SCX-006	A	--	0.0	soil	49,019
S313-SCX-006	A	8,480	0.5	soil	30,395
S313-SCX-006	A	8,480	1.0	soil	25,443**
S313-SCX-007	A	--	0.0	soil	12,807
S313-SCX-007	A	8,480	0.5	soil	13,233**
S313-SCX-010	A	--	0.0	soil	34,765
S313-SCX-010	A	8,480	0.5	soil	24,414**
S313-SCX-012	A	--	0.0	soil	35,431
S313-SCX-012	A	8,480	0.5	soil	51,508
S313-SCX-012	A	8,480	0.8	soil	63,803**
S313-SCX-003	B	--	0.0	sediment	15,353
S313-SCX-003	B	26,769	0.5	sediment	18,567
S313-SCX-003	B	26,769	0.8	sediment	20,326**
S313-SCX-011	B	--	0.0	soil	49,242
S313-SCX-011	B	26,769	0.5	soil	34,609**
S313-SCX-013	B	--	0.0	soil	37,531
S313-SCX-013	B	26,769	0.5	soil	55,433
S313-SCX-013	B	26,769	0.8	soil	65,887**
S313-SCX-014	B	--	0.0	soil	34,978
S313-SCX-014	B	26,769	0.5	soil	69,312
S313-SCX-014	B	26,769	1.0	soil	109,249
S313-SCX-014	B	26,769	1.5	soil	121,683**
S313-SCX-015	B	--	0.0	soil	19,583
S313-SCX-015	B	26,769	0.5	soil	24,502
S313-SCX-015	B	26,769	0.8	soil	24,064**
S313-SCX-016	B	--	0.0	soil	28,617
S313-SCX-016	B	26,769	0.5	soil	41,459
S313-SCX-016	B	26,769	1.0	soil	39,099
S313-SCX-016	B	26,769	1.6	soil	35,682**

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
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Stantec NAVAJO NATION AUM Environmental Response Trust - First Phase

Table 4-2
Static Gamma Measurement Summary
Eunice Becenti
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)
S313-SCX-001	C	--	0.0	soil	14,497
S313-SCX-001	C	15,432	0.5	soil	21,348
S313-SCX-001	C	15,432	1.0	soil	31,706
S313-SCX-001	C	15,432	1.5	soil	34,998
S313-SCX-001	C	15,432	1.8	soil	33,899**
S313-SCX-002	C	--	0.0	soil	18,357
S313-SCX-002	C	15,432	0.5	soil	24,250
S313-SCX-002	C	15,432	1.0	soil	27,048
S313-SCX-002	C	15,432	1.5	soil	29,203
S313-SCX-002	C	15,432	2.1	soil	25,489**
S313-SCX-019	C	--	0.0	soil	28,922
S313-SCX-019	C	15,432	0.5	soil	27,855
S313-SCX-017	D	--	0.0	sediment	10,908
S313-SCX-017	D	15,012	0.6	sediment	14,629
S313-SCX-017	D	15,012	1.0	sediment	14,673
S313-SCX-017	D	15,012	1.5	sediment	14,100**
S313-SCX-018	D	--	0.0	sediment	12,033
S313-SCX-018	D	15,012	0.5	sediment	15,381
S313-SCX-018	D	15,012	1.0	sediment	18,073
S313-SCX-018	D	15,012	1.5	sediment	19,312
S313-SCX-018	D	15,012	2.0	sediment	20,249**
S313-SCX-004	E	--	0.0	sediment	32,738
S313-SCX-004	E	13,197	0.5	sediment	39,988
S313-SCX-004	E	13,197	1.0	sediment	24,220
S313-SCX-004	E	13,197	1.5	sediment	16,299
S313-SCX-004	E	13,197	2.0	sediment	14,000
S313-SCX-004	E	13,197	2.5	sediment	13,503
S313-SCX-004	E	13,197	3.0	sediment	13,334
S313-SCX-004	E	13,197	3.5	sediment	12,718**
S313-SCX-008	E	--	0.0	soil	54,896
S313-SCX-008	E	13,197	0.5	soil	175,472**
S313-SCX-009	E	--	0.0	sediment	9,565
S313-SCX-009	E	13,197	0.5	sediment	11,004
S313-SCX-009	E	13,197	0.9	sediment	12,446**
S313-SCX-020	E	--	0.0	soil	24,190
S313-SCX-020	E	13,197	0.5	soil	21,711
S313-SCX-020	E	13,197	1.0	soil	12,847**
S313-SCX-021	E	--	0.0	soil	33,343
S313-SCX-021	E	13,197	0.5	soil	19,209**
S313-SCX-022	E	--	0.0	soil	7,996
S313-SCX-022	E	13,197	0.5	soil	9,509**

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
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Table 4-3
Gamma Correlation Study Soil Sample Analytical Results
Eunice Becenti
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification	S313-C01-001	S313-C02-001	S313-C03-001	S313-C04-001	S313-C05-001
Date Collected	3/27/2017	3/27/2017	3/27/2017	3/27/2017	3/27/2017
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Analyte (Units)					
Radionuclides (pCi/g)					
Radium-226	2.34 ± 0.39	22.3 ± 2.7	15.1 ± 1.9	29.2 ± 3.5	0.45 ± 0.17
Thorium-228	0.78 ± 0.14	0.79 ± 0.16	1.23 ± 0.22	0.88 ± 0.18	0.147 ± 0.048
Thorium-230	1.87 ± 0.31	15 ± 2.4	11.8 ± 1.9	22 ± 3.5	0.196 ± 0.06
Thorium-232	0.74 ± 0.13	0.77 ± 0.16	1.23 ± 0.22	0.98 ± 0.19	0.202 ± 0.049

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

Table 4-4a
Site Characterization Soil Sample Analytical Results for Survey Area A
Eunice Becenti
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification		S313-CX-008	S313-CX-009	S313-CX-009 Dup	S313-CX-010	S313-SCX-005	S313-SCX-006	S313-SCX-006	S313-SCX-007	S313-SCX-010	S313-SCX-012	S313-SCX-012	S313-SCX-012 Dup
Date Collected		5/15/2017	5/15/2017	5/15/2017	5/15/2017	5/16/2017	5/16/2017	5/16/2017	5/16/2017	5/17/2017	5/17/2017	5/17/2017	5/17/2017
Depth (feet)		0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.0	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 0.8	0 - 0.5
Sample Category		surface	surface	surface	surface	surface	surface	subsurface	surface	surface	surface	subsurface	surface
Sample Collection Method		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
Analyte (Units)													
Metals[1] (mg/kg)	Investigation Level												
Arsenic	7.92	1.6	2.5	2.6	2.6	0.92	<0.21	0.23	0.25	1.3	2.9	13	2.3
Molybdenum	12.8	<0.2	0.77	1	0.74	<0.21	<0.21	<0.21	<0.21	0.56	4.3	18	3.3
Selenium	3.26	<1	1.1	1.1	1.2	<1.1	<1	<1.1	<1	1.2	2.9	19	2
Uranium	31.4	5.8	7.8	9	6.5	4.5	2.2	2.5	3	48	23	45	21
Vanadium	21.3	14	14	14	16	25	13	8	10	7.2	18	30	16
Radionuclides (pCi/g)													
Radium-226	12.7	3.02 ± 0.47	4.47 ± 0.67	4.68 ± 0.68	4.03 ± 0.58	1.94 ± 0.37	2.37 ± 0.41	2.38 ± 0.39	1.17 ± 0.26	5.49 ± 0.74	13.4 ± 1.7	18.9 ± 2.3	12.9 ± 1.7

Notes
Bold — Bolded result indicates positively identified compound
Shaded — Shaded result indicates result greater than or equal to the investigation level
mg/kg — milligrams per kilogram
pCi/g — picocuries per gram
1 — Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< — Result not detected above associated laboratory reporting limit

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

Location Identification		S313-CX-003	S313-CX-004	S313-CX-006	S313-CX-007	S313-SCX-003	S313-SCX-003	S313-SCX-003 Dup	S313-SCX-011	S313-SCX-013	S313-SCX-013	S313-SCX-014
Date Collected		5/15/2017	5/15/2017	5/15/2017	5/15/2017	5/16/2017	5/16/2017	5/16/2017	5/17/2017	5/17/2017	5/17/2017	5/17/2017
Depth (feet)		0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 0.8	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 0.8	0 - 0.5
Sample Category		surface	surface	surface	surface	surface	subsurface	surface	surface	surface	subsurface	surface
Sample Collection Method		grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
Media		soil	sediment	soil	soil	sediment	sediment	sediment	soil	soil	soil	soil
Analyte (Units)												
Metals[1] (mg/kg)	Investigation Level											
Arsenic	9.06	5.2	7	6.3	27	4.2	4.4	4.1	0.44	6.6	7.8	6.8
Molybdenum	8.08	4.9	1.2	4	4.2	0.58	1	0.51	0.48	7.2	5.7	3.5
Selenium	2.67	2.1	1.2	2.6	1.7	<1	<1	<1	<1	3.8	4.1	4.1
Uranium	2.12	16	16	4.4	3.8	1.8	5.2	1.5	9	39	42	25
Vanadium	29.7	18	19	13	170	17	16	18	9	11	13	21
Radionuclides (pCi/g)												
Radium-226	3.86	14.4 ± 1.8	2.62 ± 0.42	8.7 ± 1.2	4.11 ± 0.58	2.49 ± 0.42	3.92 ± 0.58	3.98 ± 0.57	9.2 ± 1.2	9.9 ± 1.3	16.9 ± 2.2	11.9 ± 1.6

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

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

Location Identification		S313-SCX-014	S313-SCX-015	S313-SCX-015	S313-SCX-016	S313-SCX-016	S313-SCX-016
Date Collected		5/17/2017	5/17/2017	5/17/2017	5/17/2017	5/17/2017	5/17/2017
Depth (feet)		1.0 - 1.5	0 - 0.5	0.5 - 0.8	0 - 0.5	0.5 - 1.0	1.0 - 1.6
Sample Category		subsurface	surface	subsurface	surface	subsurface	subsurface
Sample Collection Method		grab	grab	grab	grab	grab	grab
Media		soil	soil	soil	soil	soil	soil
Analyte (Units)							
Metals[1] (mg/kg)	Investigation Level						
Arsenic	9.06	13	6.4	6.1	5.7	5.8	6.1
Molybdenum	8.08	13	2.2	2.5	2.9	2.4	4.8
Selenium	2.67	10	3.2	1.5	2	1.6	2.4
Uranium	2.12	120 D	14	6.5	8.2	6.5	9.4
Vanadium	29.7	33	16	26	18	22	21
Radionuclides (pCi/g)							
Radium-226	3.86	29 ± 3.5	7.24 ± 0.97	6.45 ± 0.87	12.8 ± 1.6	8.4 ± 1.1	6.32 ± 0.91 J+

Notes

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

Table 4-4c
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area C
Eunice Becenti
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

	Location Identification	S313-CX-005	S313-SCX-001	S313-SCX-001	S313-SCX-001	S313-SCX-002	S313-SCX-002	S313-SCX-002	S313-SCX-019
	Date Collected	5/15/2017	5/16/2017	5/16/2017	5/16/2017	5/16/2017	5/16/2017	5/16/2017	9/15/2017
	Depth (feet)	0 - 0.5	0 - 0.5	0.5 - 1.5	1.5 - 1.8	0 - 0.5	0.5 - 1.5	1.5 - 2.1	0 - 0.5
	Sample Category	surface	surface	subsurface	subsurface	surface	subsurface	subsurface	surface
	Sample Collection Method	grab	grab	grab	grab	grab	grab	grab	grab
	Media	sediment	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)									
Metals[1] (mg/kg)	Investigation Level								
Arsenic	17.4	7	6.7	6.9	8.6	8.8	12	9.3	8.3
Molybdenum	1.47	2.3	0.59	1.6	1.9	0.94	0.67	0.79	1.5
Selenium	1.55	2.2	<1.2	1.5	2	1.5	1.5	1.7	1.3
Uranium	1.46	50	3.9	15	16	5	6.7	3.8	7.3
Vanadium	13.7	16	12	15	14	13	10	12	18
Radionuclides (pCi/g)									
Radium-226	2.09	34.3 ± 4.1	2.58 ± 0.53 J+	9.3 ± 1.2 J+	11.1 ± 1.5 J+	4.07 ± 0.63	3.79 ± 0.57	2.55 ± 0.42	6.13 ± 0.87

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

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

	Location Identification	S313-SCX-017	S313-SCX-017	S313-SCX-018	S313-SCX-018
	Date Collected	9/15/2017	9/15/2017	9/15/2017	9/15/2017
	Depth (feet)	0 - 0.5	0.5 - 1.5	0 - 0.5	0.5 - 2.0
	Sample Category	surface	subsurface	surface	subsurface
	Sample Collection Method	grab	grab	grab	composite
	Media	sediment	sediment	sediment	sediment
Analyte (Units)					
Metals[1] (mg/kg)	Investigation Level				
Arsenic	14.8	6.1	6	6.4	7.5
Molybdenum	1.87	0.94	0.72	0.83	0.89
Selenium	2.09	<0.99	<1	<1	1
Uranium	1.36	2.3	1.4	0.99	1.2
Vanadium	32.8	12	11	13	13
Radionuclides (pCi/g)					
Radium-226	1.87	3.29 ± 0.49	1.49 ± 0.3	1.72 ± 0.33	2.09 ± 0.41

Notes
Bold Bolded result indicates positively identified compound
Shaded Shaded result indicates result greater than or equal to the investigation level
mg/kg milligrams per kilogram
pCi/g picocuries per gram
1 Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< Result not detected above associated laboratory reporting limit

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

Location Identification		S313-CX-001	S313-CX-002	S313-CX-011	S313-SCX-004	S313-SCX-004	S313-SCX-004	S313-SCX-008	S313-SCX-009	S313-SCX-009	S313-SCX-020	S313-SCX-020	S313-SCX-020 Dup	S313-SCX-021	S313-SCX-022
Date Collected		5/15/2017	5/15/2017	5/15/2017	5/17/2017	5/17/2017	5/17/2017	5/17/2017	5/17/2017	5/17/2017	9/16/2017	9/16/2017	9/16/2017	9/16/2017	9/16/2017
Depth (feet)		0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 3.0	3.0 - 3.5	0 - 0.5	0 - 0.5	0.5 - 0.9	0 - 0.5	0.5 - 1.0	0 - 0.5	0 - 0.5	0 - 0.5
Sample Category		surface	surface	surface	surface	subsurface	subsurface	surface	surface	subsurface	surface	subsurface	surface	surface	surface
Sample Collection Method		grab	grab	grab	grab	composite	grab	grab	grab	grab	grab	grab	grab	grab	grab
Media		soil	soil	sediment	sediment	sediment	sediment	soil	sediment	sediment	soil	soil	soil	soil	soil
Analyte (Units)	Investigation Level														
Metals[1] (mg/kg)															
Arsenic	7.51	0.86	1.5	0.46	1	0.87	0.79	4.6	0.58	0.39	1.4	0.76	1.2	1.3	1.4
Molybdenum	0.707	<0.2	<0.21	<0.2	0.26	<0.2	<0.19	6.5	<0.21	<0.21	0.31	<0.19	<0.2	<0.2	<0.2
Selenium	NA	<1	<1	<0.99	<1	<0.98	<0.96	5.2	<1	<1.1	<0.99	<0.95	<1	<1	<0.99
Uranium	1.27	0.95	0.83	0.46	2.9 J-	1.1	0.87	25	0.5	0.64	1.4	0.67	1.3	1.7	0.49
Vanadium	29.2	9.1	14	4.6	8.8	7.6	7	12	5.2	5.9	17	13	16	24	10
Radionuclides (pCi/g)															
Radium-226	2.05	1.38 ± 0.27	1.47 ± 0.3	0.63 ± 0.19	3.73 ± 0.54	0.49 ± 0.23	0.86 ± 0.19 J-	15.2 ± 1.9	0.44 ± 0.17	0.59 ± 0.28	3.71 ± 0.56	1.3 ± 0.3	2.01 ± 0.35	3.91 ± 0.57	0.88 ± 0.21

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 is not identified because selenium sample results in BG-5 were all non-detect
[1] Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
< Result not detected above associated laboratory reporting limit
J- Data are estimated and are potentially biased low due to associated quality control data

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

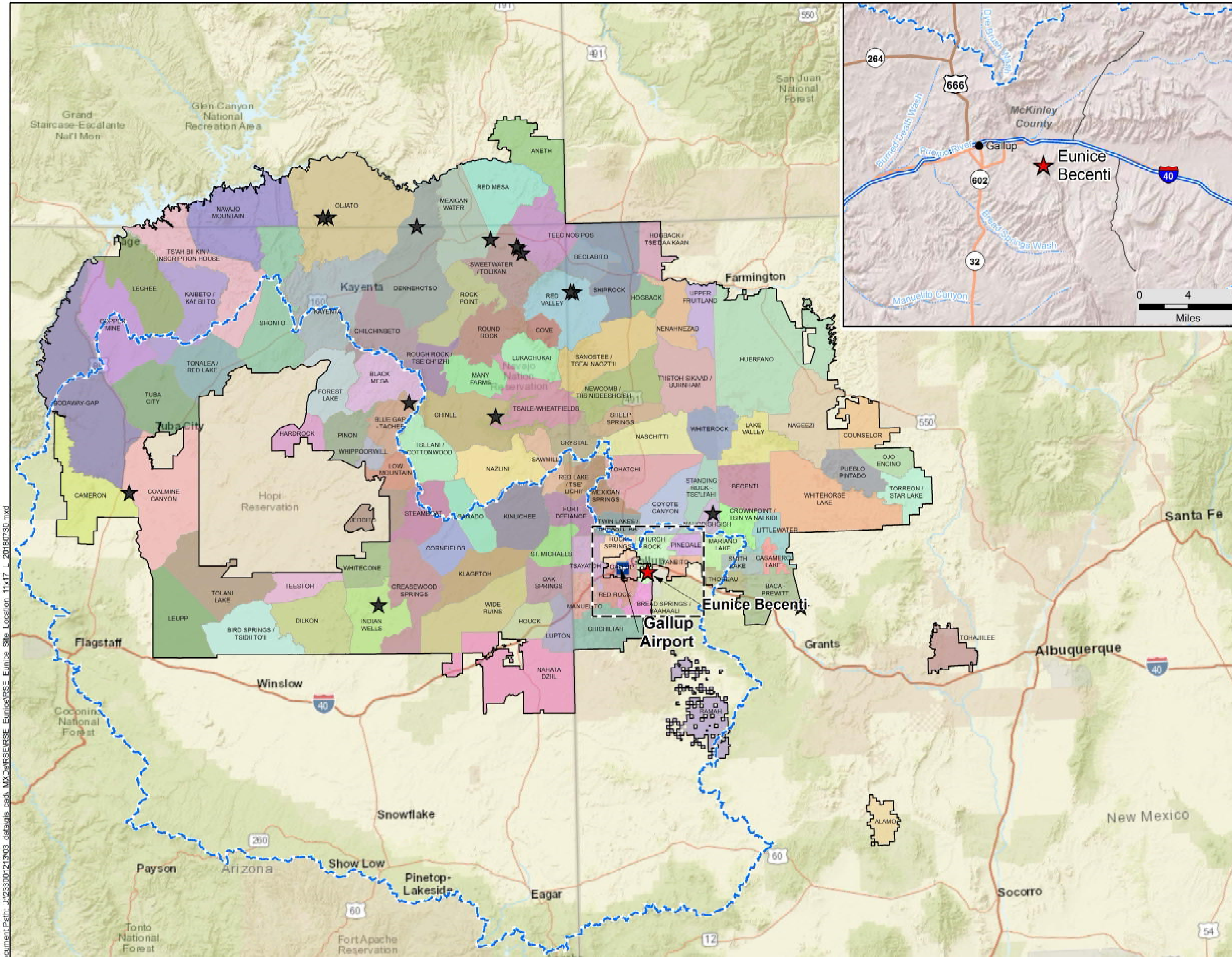
Sample Location	Survey Area	Investigation Level Exceedances
S313-SCX-001	C	Mo, Se, U, V, Ra-226, static gamma
S313-SCX-002	C	Se, U, Ra-226, static gamma
S313-SCX-003	B	U, Ra-226
S313-SCX-004	E	U, Ra-226, static gamma
S313-SCX-005	A	V, static gamma
S313-SCX-006	A	static gamma
S313-SCX-007	A	static gamma
S313-SCX-008[1]	E	Mo, Se, U, Ra-226, static gamma
S313-SCX-010	A	U, static gamma
S313-SCX-011	B	U, Ra-226, static gamma
S313-SCX-012	A	As, Mo, Se, U, V, Ra-226, static gamma
S313-SCX-013	B	Se, U, Ra-226, static gamma
S313-SCX-014	B	As, Mo, Se, U, V, Ra-226, static gamma
S313-SCX-015	B	Se, U, Ra-226
S313-SCX-016	B	U, Ra-226, static gamma
S313-SCX-017	D	U, Ra-226
S313-SCX-018	D	Ra-226, static gamma
S313-SCX-019	C	Mo, U, V, Ra-226, static gamma
S313-SCX-020	E	U, Ra-226, static gamma
S313-SCX-021	E	U, Ra-226, static gamma

Notes
[1] Detections of Se included for reference, no IL is established for Se
As - Arsenic
Mo - Molybdenum
Ra-226 - Radium 226
Se - Selenium
U - Uranium
V - Vanadium

FIGURES

FIGURE ACRONYMS/ABBREVIATIONS

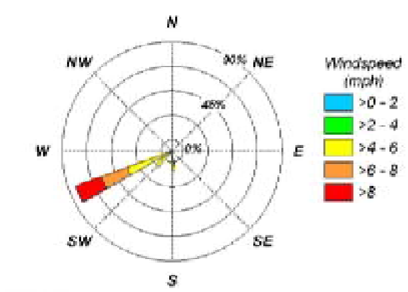
As	arsenic
BG	potential background reference area
bgs	below ground surface
cpm	counts per minute
ft	feet
IL	investigation level
mg/kg	milligrams per kilogram
Mo	molybdenum
NAD	North American Datum
pCi/g	picocuries per gram
Ra	radium-226
Ra-226	radium-226
Se	selenium
TENORM	Technologically Enhanced Naturally Occurring Radioactive Materials
uk	unknown
U	uranium
UTL	upper tolerance limit
UTM	Universal Transverse Mercator
V	vanadium



LEGEND

- ★ (red) Eunice Becenti Mine Site
- ★ Priority Abandoned Uranium Mine (AUM) Site
- ● Populated Place
- Interstate
- US Highway
- State Highway
- Major Road
- Intermittent Stream
- Little Colorado River Valley Watershed
- Navajo Nation Boundary
- Navajo Nation Chapter

Gallup Airport, New Mexico Wind Rose (KGUP), 1996-2006



REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap: ESRI World Street Map and World Shaded Relief accessed 07/2018.

Wind Rose: USEPA, 2007a

N W E S

0 25 50 Miles

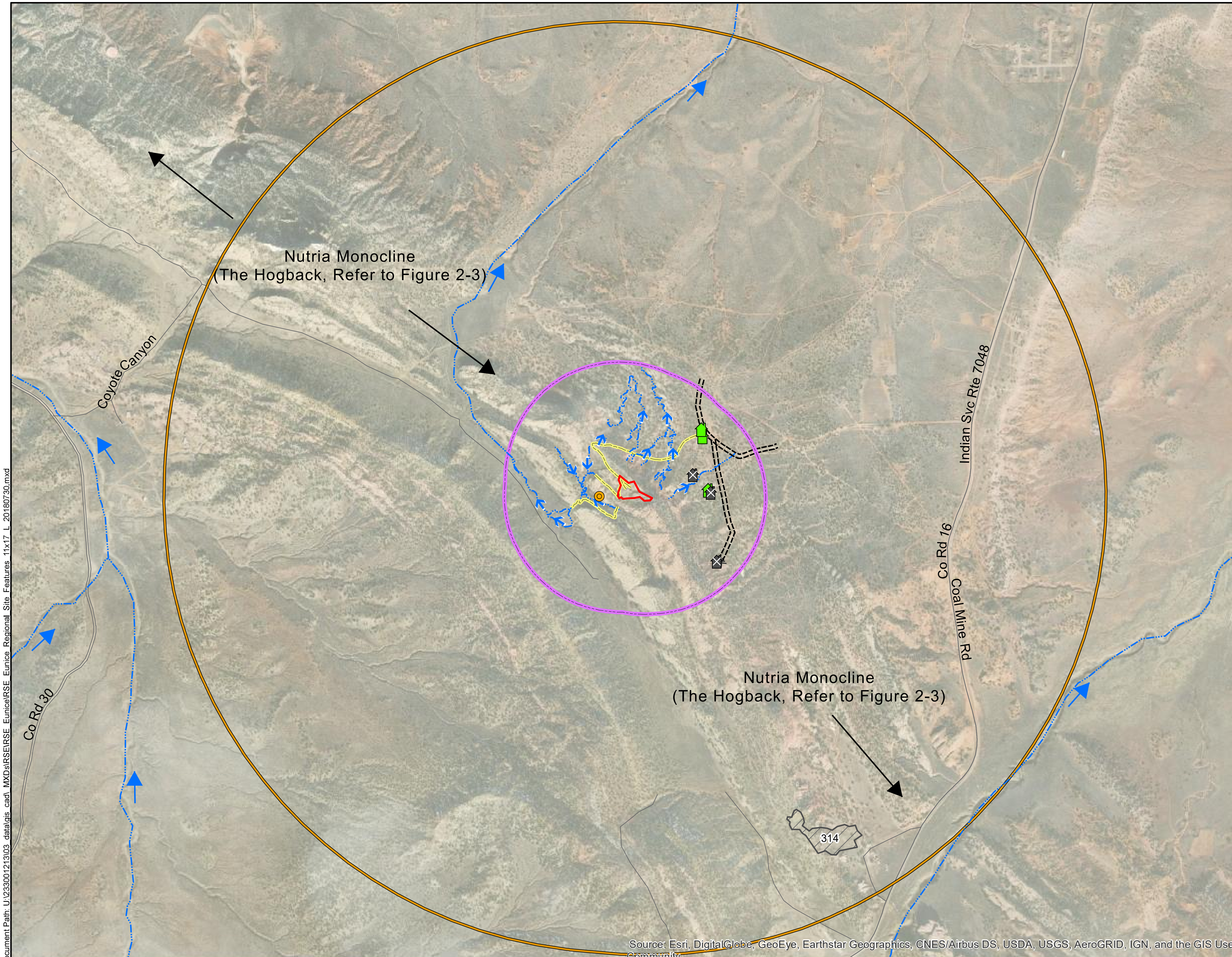
TITLE:

Site Location

PROJECT:

Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 7/30/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: WDC / REVIEWER: CBB
	FIGURE: 1-1



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Adit
- Habitable Building
- Uninhabitable Building
- Flow Direction
- Intermittent Stream/River
- Drainage
- Fence
- Potential Haul Road
- Road
- County Road
- Local Road
- Claim Boundary
- 1/4-Mile Claim Boundary
- 1-Mile Claim Boundary Buffer
- Other Claim Boundary

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from ESRI world imagery map service (http://www.esri.com/data/imagery) on 07/2018.

N W E S

0 1,120 2,240
Feet

TITLE: Site Features

PROJECT: Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 7/30/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: WDC

REVIEWER: CBB

FIGURE: 2-1

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\RSE_Eunice_Regional_Site_Features_11x17_L_20180730.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from ESRI world imagery map service (http://www.esri.com/data/imagery) on 07/2018.

N W E S

0 2,000 4,000
Feet

TITLE: Regional Aerial Photograph

PROJECT: Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 7/30/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: WDC

REVIEWER: CBB

Stantec

FIGURE: 2-2

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\RSE_Eunice_Regional_Aerial_11x17_L_20180730.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Claim Boundary
- Other Claim Boundary

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap: ESRI USA Topo Maps service accessed 07/2018.

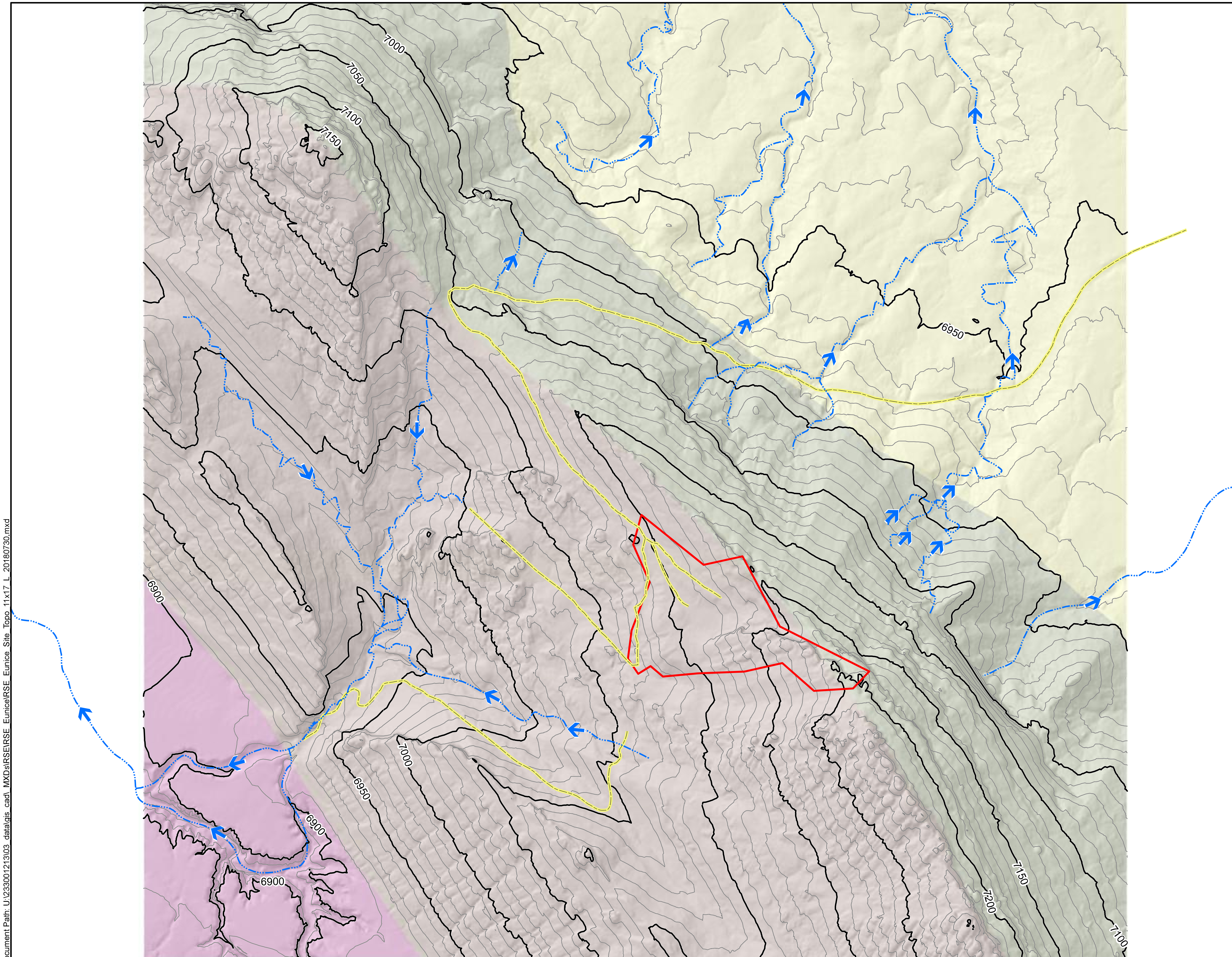
N W E S

0 2,000 4,000
Feet

TITLE:
Regional Topographic Map

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 7/30/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: WDC	REVIEWER: CBB
	FIGURE: 2-3	



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Flow Direction
- Drainage
- Potential Haul Road
- Index Contour (50 ft Interval)
- Intermediate Contour (10 ft Interval)
- Claim Boundary

Geomorphology Features

- Monocline Bench
- Hogback Dip Slope
- Hogback Scarp Slope
- Plains

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

Coordinate System: NAD 1983 UTM Zone 12N

N W E S

0 160 320
Feet

TITLE:
Site Topography

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 7/30/2018

DOCUMENT NAME: Removal Site Evaluation Report

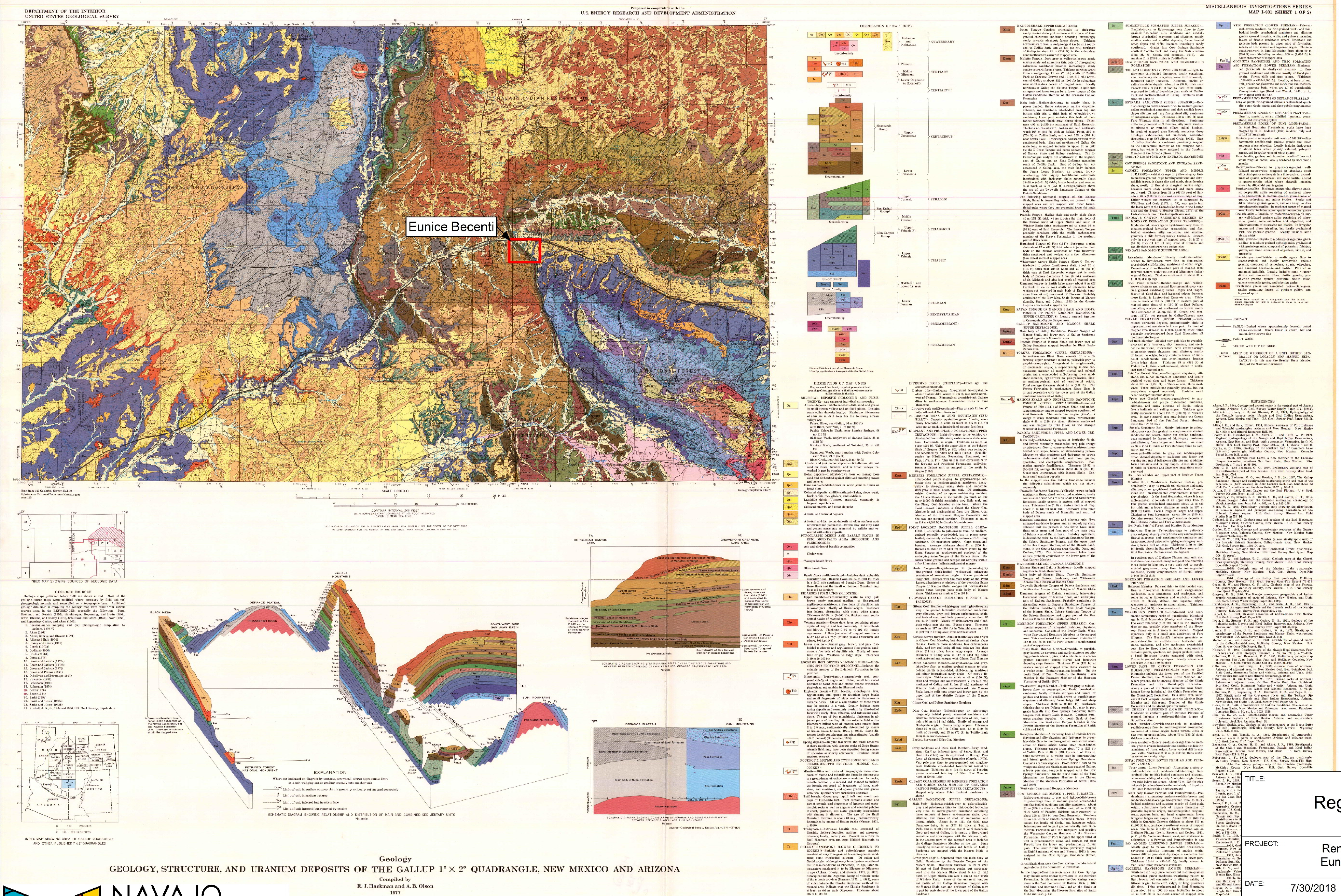
AUTHOR: WDC

REVIEWER: CBB

FIGURE: 2-4

Stantec

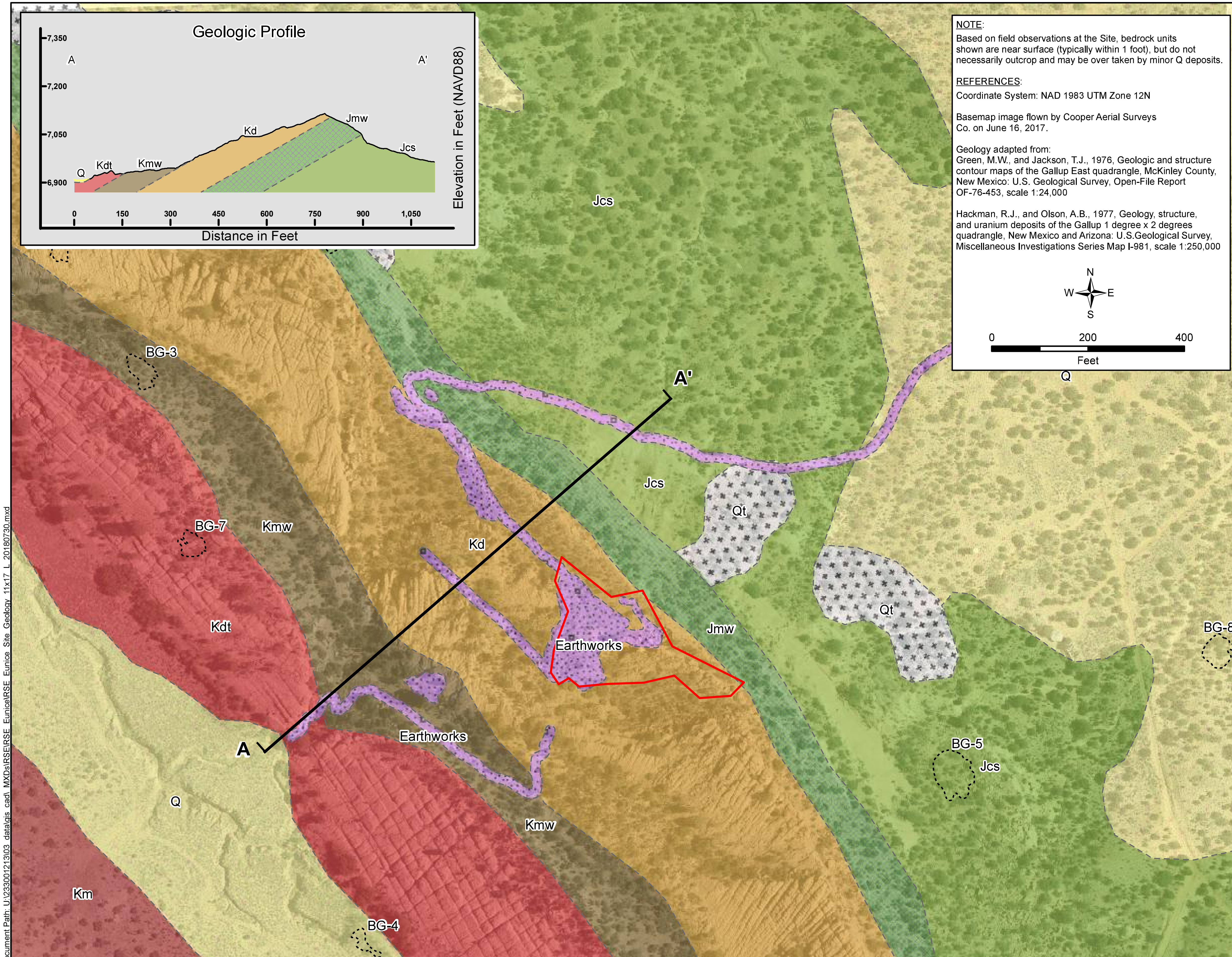
Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\RSE_Eunice_Site_Topo_11x17_L_20180730.mxd



NAVAJO NATION

AUM Environmental Response Trust-First Phase

TITLE:	Regional Geology
PROJECT:	Removal Site Evaluation Eunice Becenti Mine Site
DATE: 7/30/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: CBB REVIEWER: CBB
	FIGURE: 2-5



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

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

Geology adapted from:
Green, M.W., and Jackson, T.J., 1976, Geologic and structure contour maps of the Gallup East quadrangle, McKinley County, New Mexico: U.S. Geological Survey, Open-File Report OF-76-453, scale 1:24,000

Hackman, R.J., and Olson, A.B., 1977, Geology, structure, and uranium deposits of the Gallup 1 degree x 2 degrees quadrangle, New Mexico and Arizona: U.S.Geological Survey, Miscellaneous Investigations Series Map I-981, scale 1:250,000

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

Site Geology

HOLOCENE

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

Qt: Talus deposits

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

MESOZOIC

Km: Mancos Shale (Upper Cretaceous) – Medium-dark-gray to nearly black, in places banded, fissile calcareous marine claystone, siltstone, and mudstone, interbedded near top and bottom with thin to thick beds of yellowish-brown sandstone. Forms slopes.

Kdt: Twowells Sandstone Tongue of Dakota Sandstone (Upper Cretaceous) – yellowish-brown to buff medium-to fine-grained well-sorted sandstone; locally contains lenticular beds of silty shale and fossiliferous limestone.

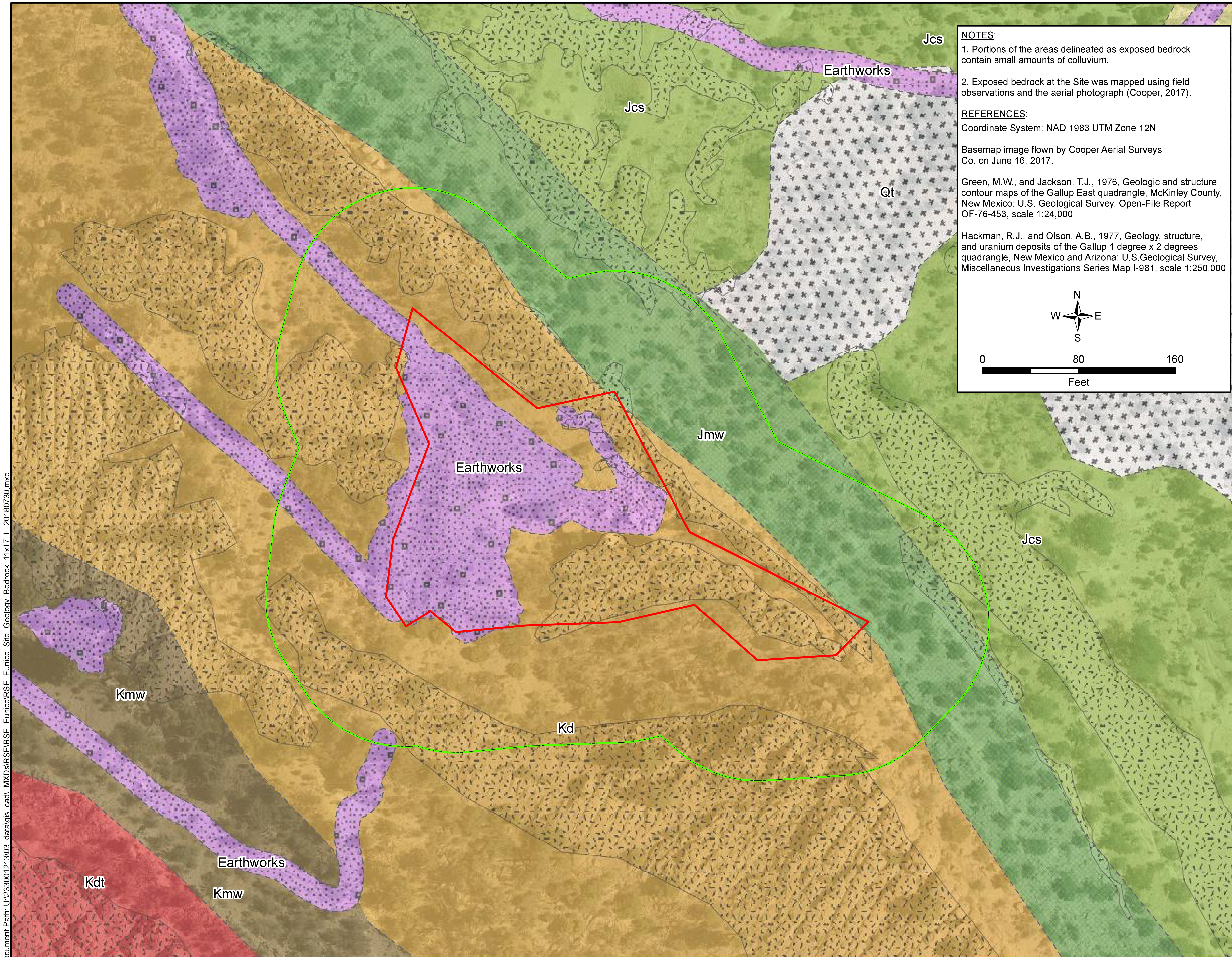
Kmw: Whitewater Arroyo Shale Tongue of Mancos Shale (Upper Cretaceous) – Yellowish-brown to yellow fossiliferous shale.

Kd: Dakota Sandstone (Upper and Lower Cretaceous) – Cliff-forming layers of lenticular fluvial and littoral commonly crossbedded fine- to coarse-grained sandstone interbedded with slope-bench- or niche-forming mudstone and carbonaceous shale and coal.

Jmw: Westwater Canyon Member of the Morrison Formation – Yellowish-gray to reddish-brown fine- to coarse-grained fluvial crossbedded sandstone; locally contains stringers & layers of pebbles & lenses of reddish-brown to purplish-gray claystone & siltstone.

Jcs: Cow Springs Sandstone (Upper Jurassic) – Light-greenish-gray to gray and light-reddish-brown to pale-orange fine- to medium-grained crossbedded and flat-bedded sandstone and silty sandstone.

TITLE:	Site Geology
PROJECT:	Removal Site Evaluation Eunice Becenti Mine Site
DATE: 8/24/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: WDC / REVIEWER: CBB
	FIGURE: 2-6a



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

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

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

Green, M.W., and Jackson, T.J., 1976, Geologic and structure contour maps of the Gallup East quadrangle, McKinley County, New Mexico: U.S. Geological Survey, Open-File Report OF-76-453, scale 1:24,000

Hackman, R.J., and Olson, A.B., 1977, Geology, structure, and uranium deposits of the Gallup 1 degree x 2 degrees quadrangle, New Mexico and Arizona: U.S.Geological Survey, Miscellaneous Investigations Series Map I-981, scale 1:250,000

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Claim Boundary
- 100-Foot Claim Buffer
- Geologic Contact (Inferred)
- Exposed Bedrock[1]

Site Geology

HOLOCENE

- Earthworks: Human-caused disturbance of the land surface potentially related to mining.
- Qt: Talus deposits
- Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly colluvial and alluvial deposits, and eolian sand deposits.

MESOZOIC

- Kdt: Twowells Sandstone Tongue of Dakota Sandstone (Upper Cretaceous) – yellowish-brown to buff medium-to fine-grained well-sorted sandstone; locally contains lenticular beds of silty shale and fossiliferous limestone.
- Kmw: Whitewater Arroyo Shale Tongue of Mancos Shale (Upper Cretaceous) – Yellowish-brown to yellow fossiliferous shale.
- Kd: Dakota Sandstone (Upper and Lower Cretaceous) – Cliff-forming layers of lenticular fluvial and littoral commonly crossbedded fine- to coarse-grained sandstone interbedded with slope-bench- or niche-forming mudstone and carbonaceous shale and coal.
- Jmw: Westwater Canyon Member of the Morrison Formation – Yellowish-gray to reddish-brown fine- to coarse-grained fluvial crossbedded sandstone; locally contains stringers & layers of pebbles & lenses of reddish-brown to purplish-gray claystone & siltstone.
- Jcs: Cow Springs Sandstone (Upper Jurassic) – Light-greenish-gray to gray and light-reddish-brown to pale-orange fine- to medium-grained crossbedded and flat-bedded sandstone and silty sandstone.

TITLE:	Site Exposed Bedrock
PROJECT:	Removal Site Evaluation Eunice Becenti Mine Site
DATE: 7/30/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: WDC / REVIEWER: CBB
	FIGURE: 2-6b

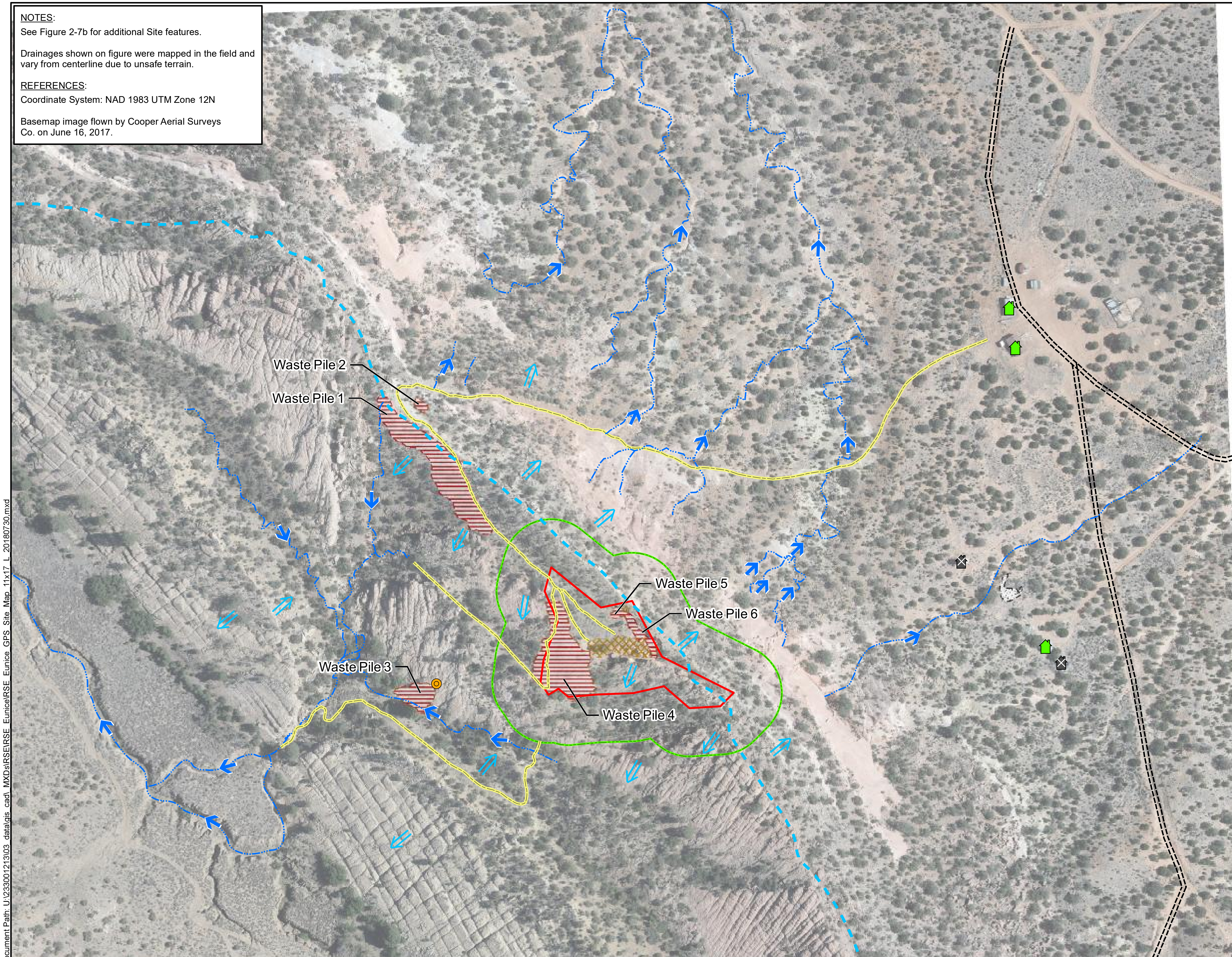
Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\RSE_Eunice_Site_Geology_Bedrock_11x17_L_20180730.mxd

NOTES:
See Figure 2-7b for additional Site features.

Drainages shown on figure were mapped in the field and vary from centerline due to unsafe terrain.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Adit
- Habitable Building
- Uninhabitable Building
- Flow Direction
- Approximate Overland Water Flow Direction
- Approximate Watershed Divide Line
- Drainage
- Potential Haul Road
- Road
- Debris
- Excavation
- Waste Pile
- Claim Boundary
- 100-Foot Claim Buffer

N W E S

0 200 400
Feet

TITLE: Site Map

PROJECT: Removal Site Evaluation Eunice Becenti Mine Site

DATE: 7/30/2018

DOCUMENT NAME: Removal Site Evaluation Report

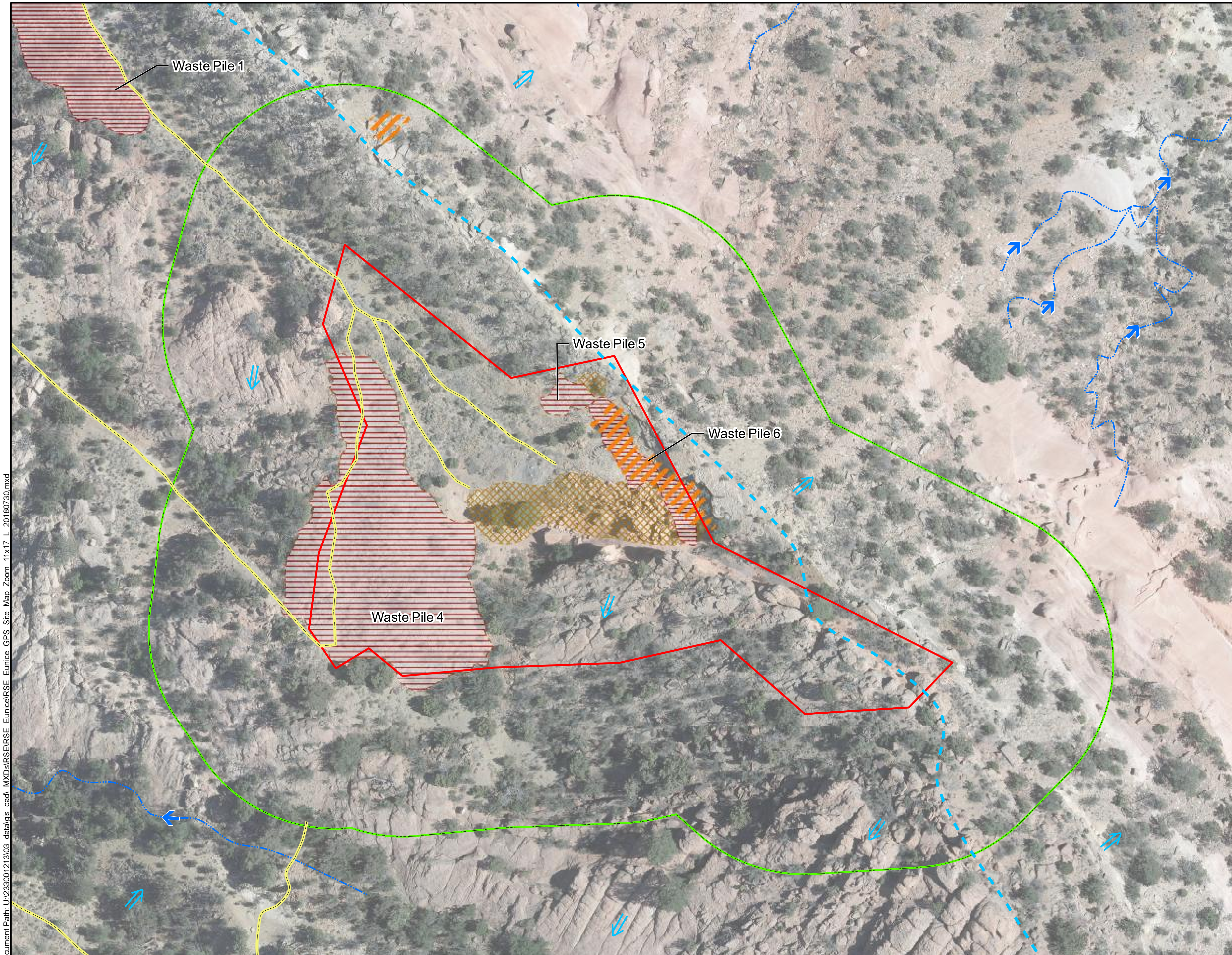
AUTHOR: WDC

REVIEWER: CBB

Stantec

FIGURE: 2-7a

Document Path: U:\123300121\03_data\gis_cad_MXDs\RSE\RSE_Eunice\RSE_Eunice_GPS_Site_Map_11x17_L_20180730.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Flow Direction
- Approximate Overland Water Flow Direction
- Approximate Watershed Divide Line
- Drainage
- Potential Haul Road
- Excavation
- Waste Pile
- Blasted Area
- Claim Boundary
- 100-Foot Claim Buffer

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N E S W

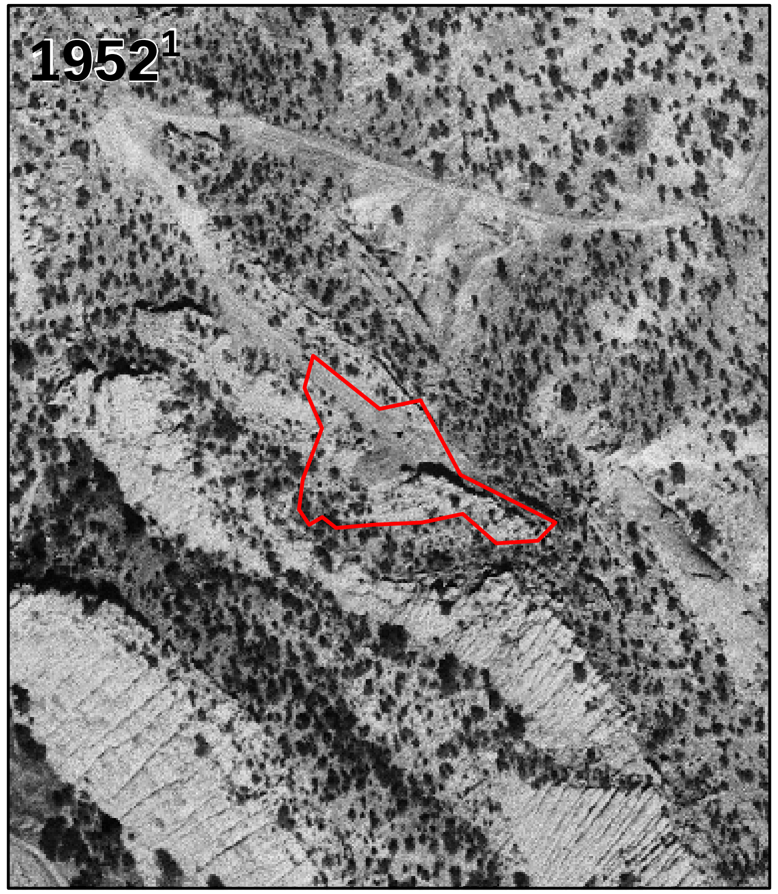
0 60 120
Feet

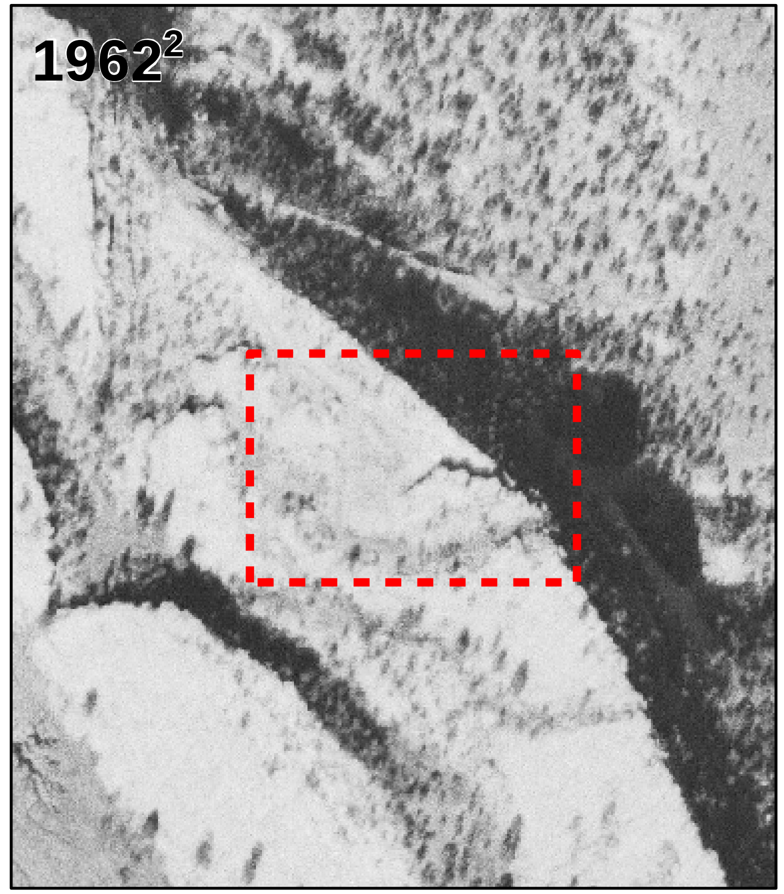
TITLE:
Mine Claim Area
Site Map

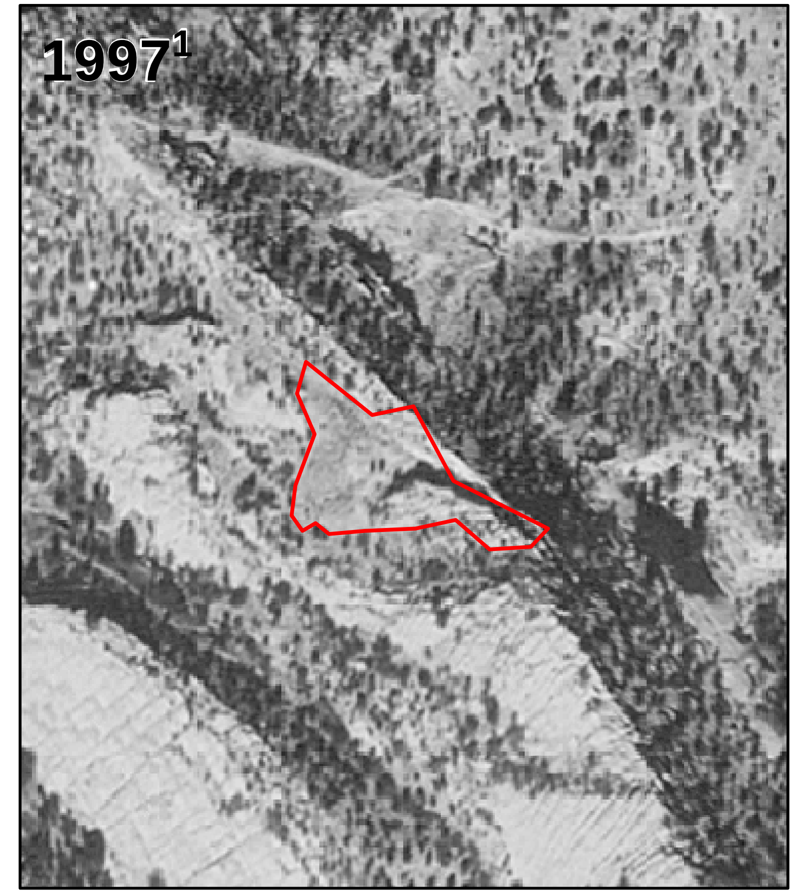
PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

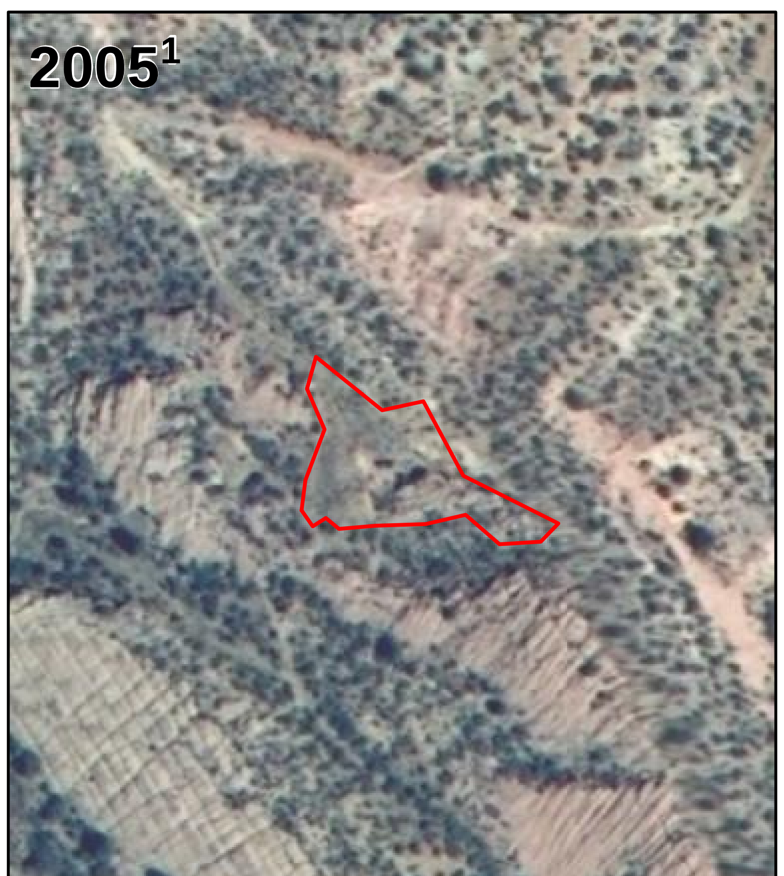
DATE: 7/30/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: WDC / REVIEWER: CBB
	FIGURE: 2-7b

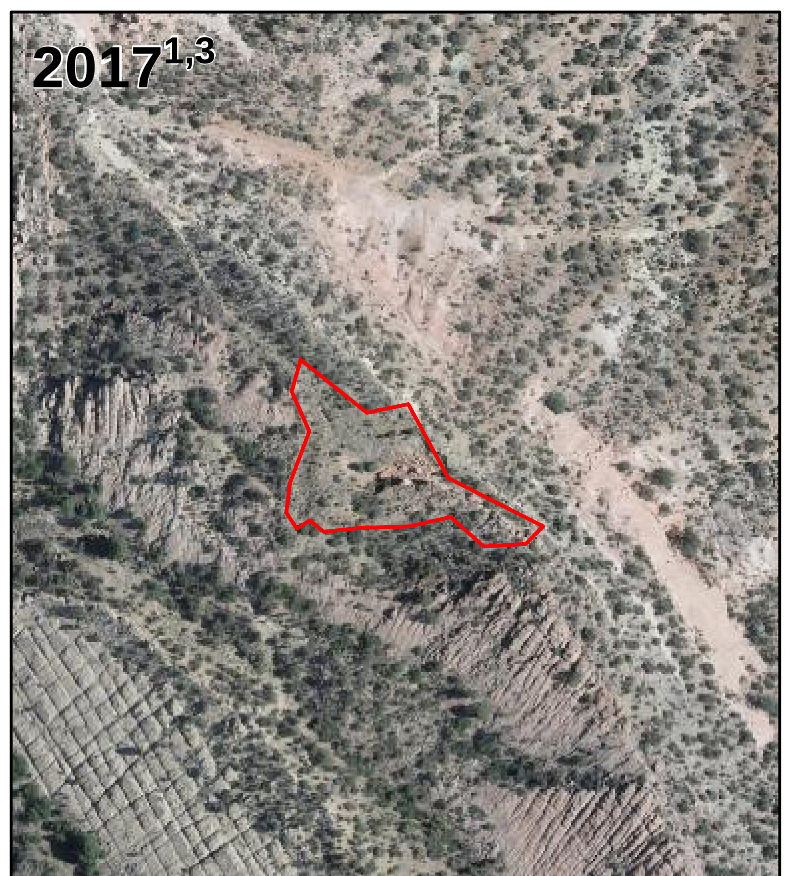
Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\RSE_Eunice_GPS_Site_Map_Zoom_11x17_L_20180730.mxd











NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Eunice Becenti Claim Boundary

Approximate Site Location, not georeferenced

NOTES:

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

2. Image is not georeferenced, scale not available.

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

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

N
W E
S

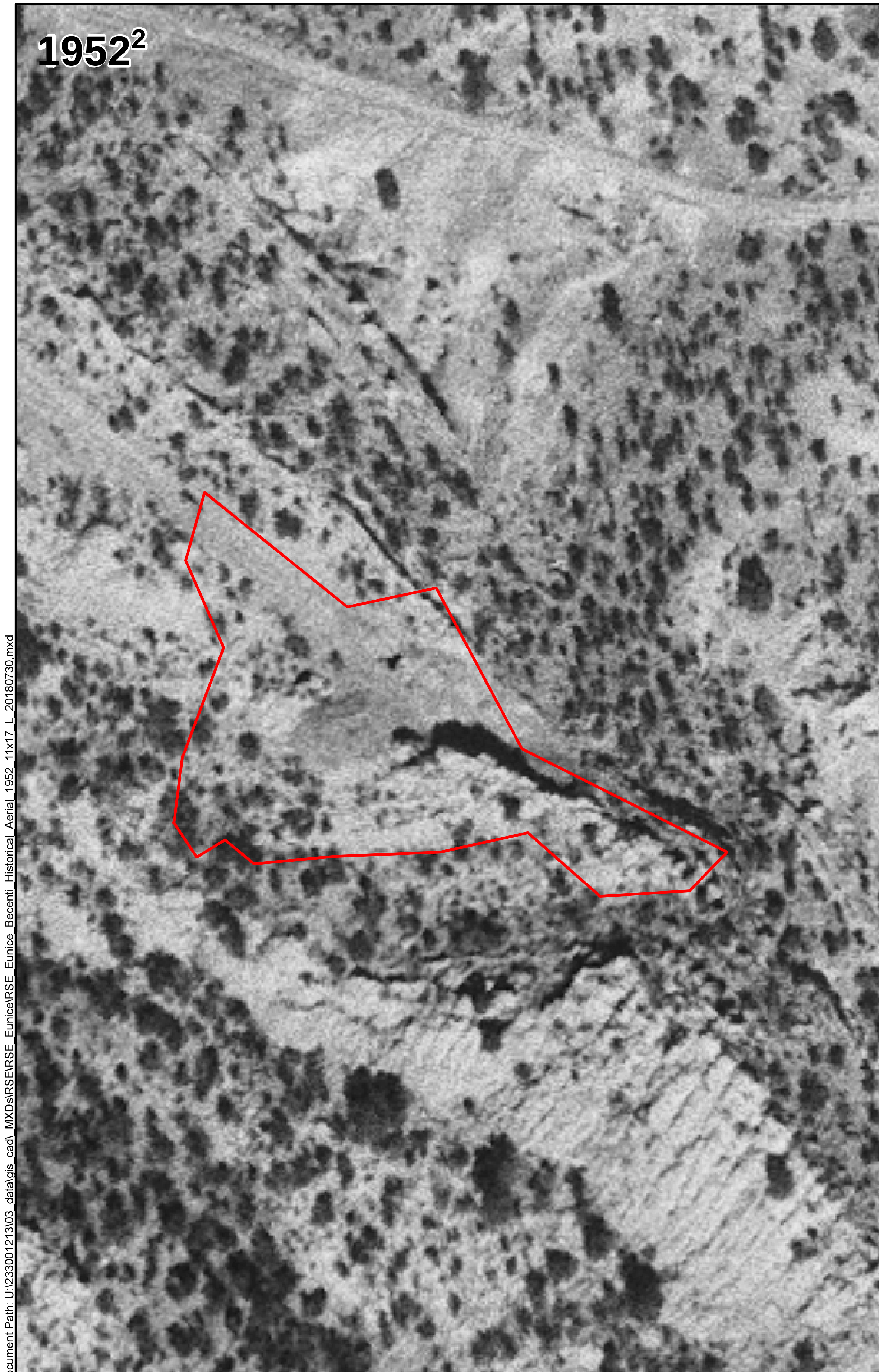
0 300 600
Feet

TITLE:
Historical Aerial Photograph Comparison

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 7/30/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: WDC	REVIEWER: CBB
	FIGURE: 3-1a	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\RSE_Eunice_Historical_Aerial_Compilation_11x17_L_20180730.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Claim Boundary

REFERENCES:

1. Coordinate System: NAD 1983 UTM Zone 12N
2. 1952 aerial image downloaded from https://earthexplorer.usgs.gov/ (01/2016) and georeferenced using current image from BING (03/2016).
3. Site-specific imagery flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 100 200
Feet

TITLE: 1952 Historical Aerial Photograph Comparison

PROJECT: Removal Site Evaluation Eunice Becenti Mine Site

DATE: 7/30/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: WDC	REVIEWER: CBB
	FIGURE: 3-1b	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\RSE_Eunice_Becenti_Historical_Aerial_1952_11x17_L_20180730.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 8/24/2018

TITLE:
Potential Background Reference Areas

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 8/24/2018

DOCUMENT NAME: Removal Site Evaluation Report

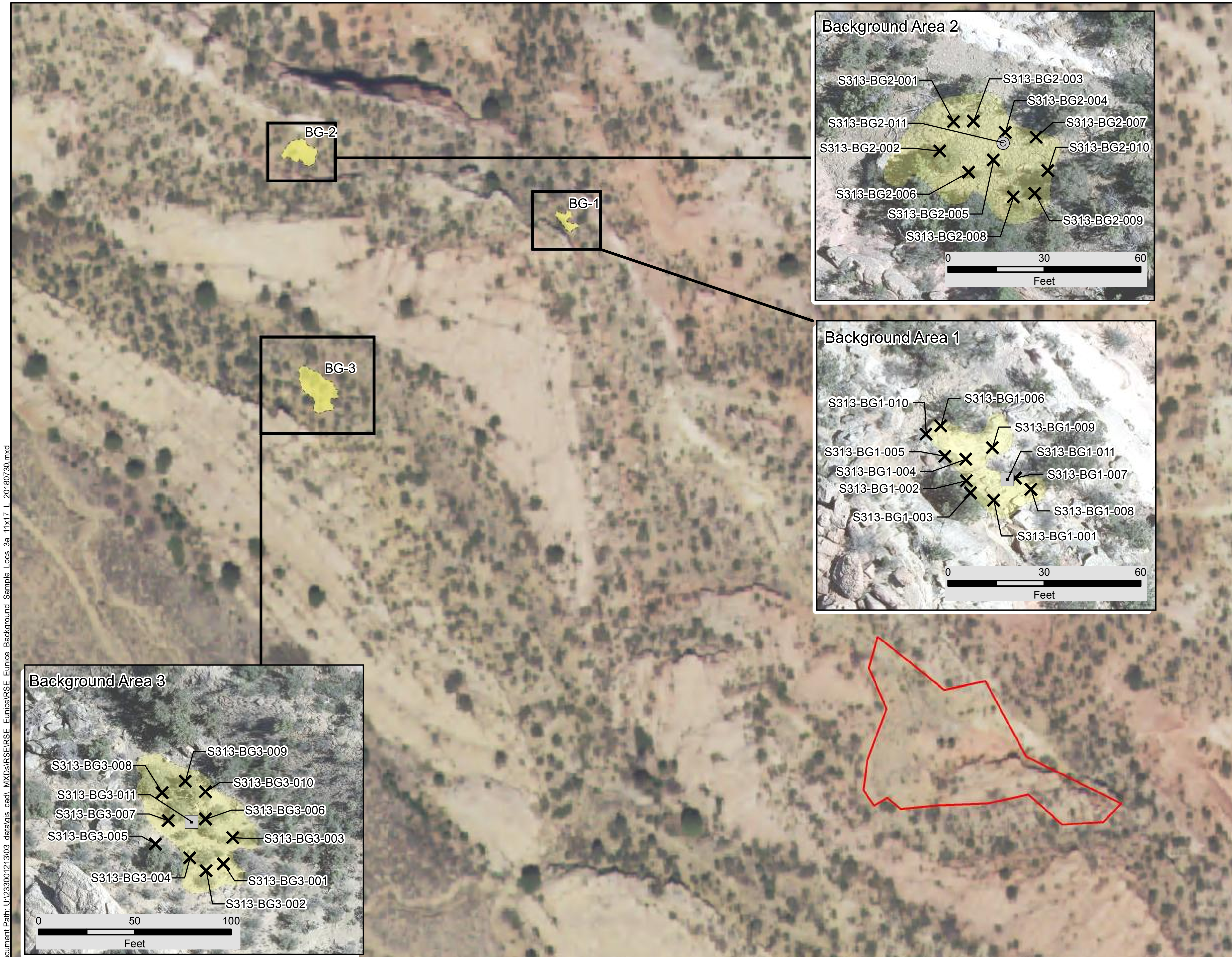
AUTHOR: WDC

REVIEWER: CBB

FIGURE: 3-2

Stantec

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\RSE_Eunice_Background_Areas_11x17_L_20180730.mxd



Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_Eunice\RSE_Eunice_Background_Sample_Locs_3a_11x17_L_20180730.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Main display basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 8/24/2018

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

N
W E
S

0 150 300
Feet

TITLE:
Background Reference Areas - Sample Locations

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 8/24/2018

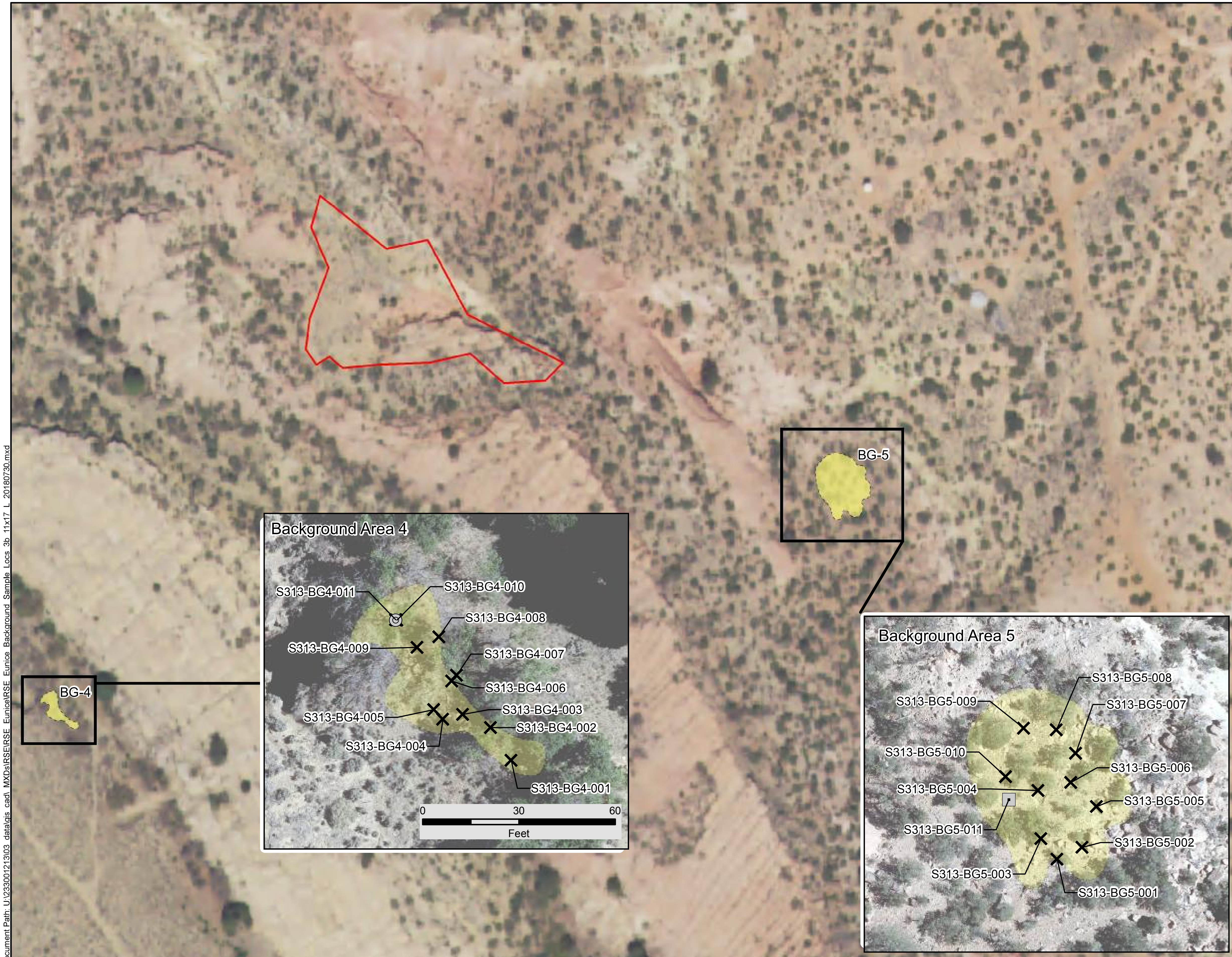
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: WDC

REVIEWER: CBB

FIGURE: 3-3a



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Main display basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 8/24/2018

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

N W E S

0 150 300

Feet

TITLE:

Background Reference Areas - Sample Locations

PROJECT:

Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 8/24/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: WDC

REVIEWER: CBB

FIGURE: 3-3b

Document Path: U:\233001213\03 data\gis cad\MXDs\RSE\RSE Eunice\RSE Eunice Background Sample Locs 3b 11x17 L 20180730.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

NOTES:
1. Areas within Survey Areas that were not surveyed (0.50 acres) due to steep/unsafe terrain.

2. Gamma survey area is approximately 30.9 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 8/24/2018

N
W E
S

0 250 500
Feet

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

TITLE:
Gamma Radiation Survey Areas

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 8/24/2018

DOCUMENT NAME: Removal Site Evaluation Report

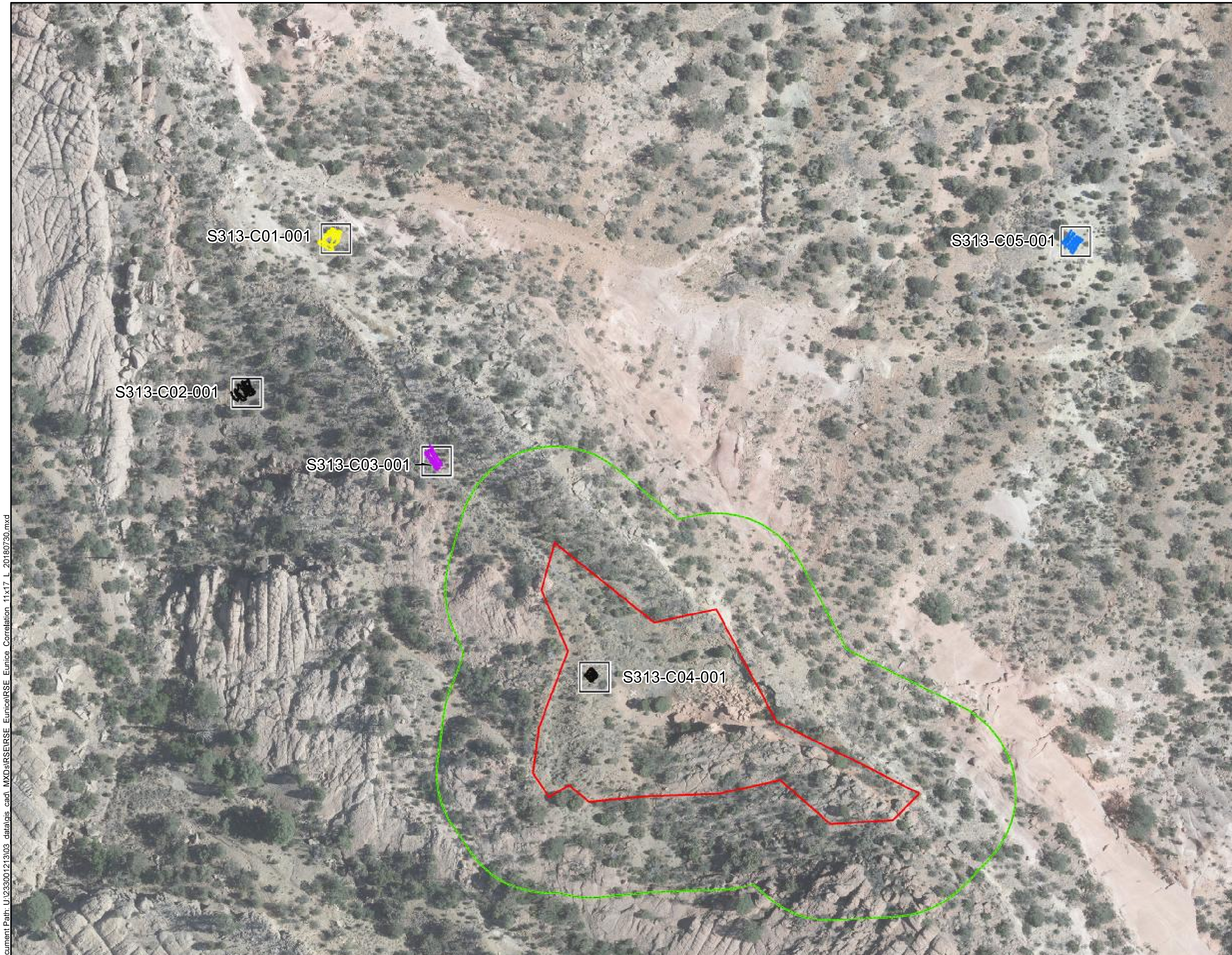
Stantec

AUTHOR: WDC

REVIEWER: CBB

FIGURE: 3-4

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Eunice\RSE Eunice Gamma Survey Areas 11x17 L 20180730.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

S313-C01-001 Correlation Location (30' x 30')

Claim Boundary

100-Foot Claim Buffer

Gamma Survey

Counts per Minute (CPM)

- 6,251 - 10,189 (Minimum to BG-5 UTL)
- 10,190 - 12,184 (>BG-5 UTL to BG-1 UTL)
- 12,185 - 14,697 (>BG-1 UTL to BG-4 UTL)
- 14,698 - 16,336 (>BG-4 UTL to BG-2 UTL)
- 16,337 - 29,394 (>BG-2 UTL to 2x BG-4 UTL)
- 29,395 - 67,682 (>2x BG-4 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 flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 100 200
Feet

TITLE:
Gamma Correlation Study Locations

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 7/30/2018

DOCUMENT NAME: Removal Site Evaluation Report

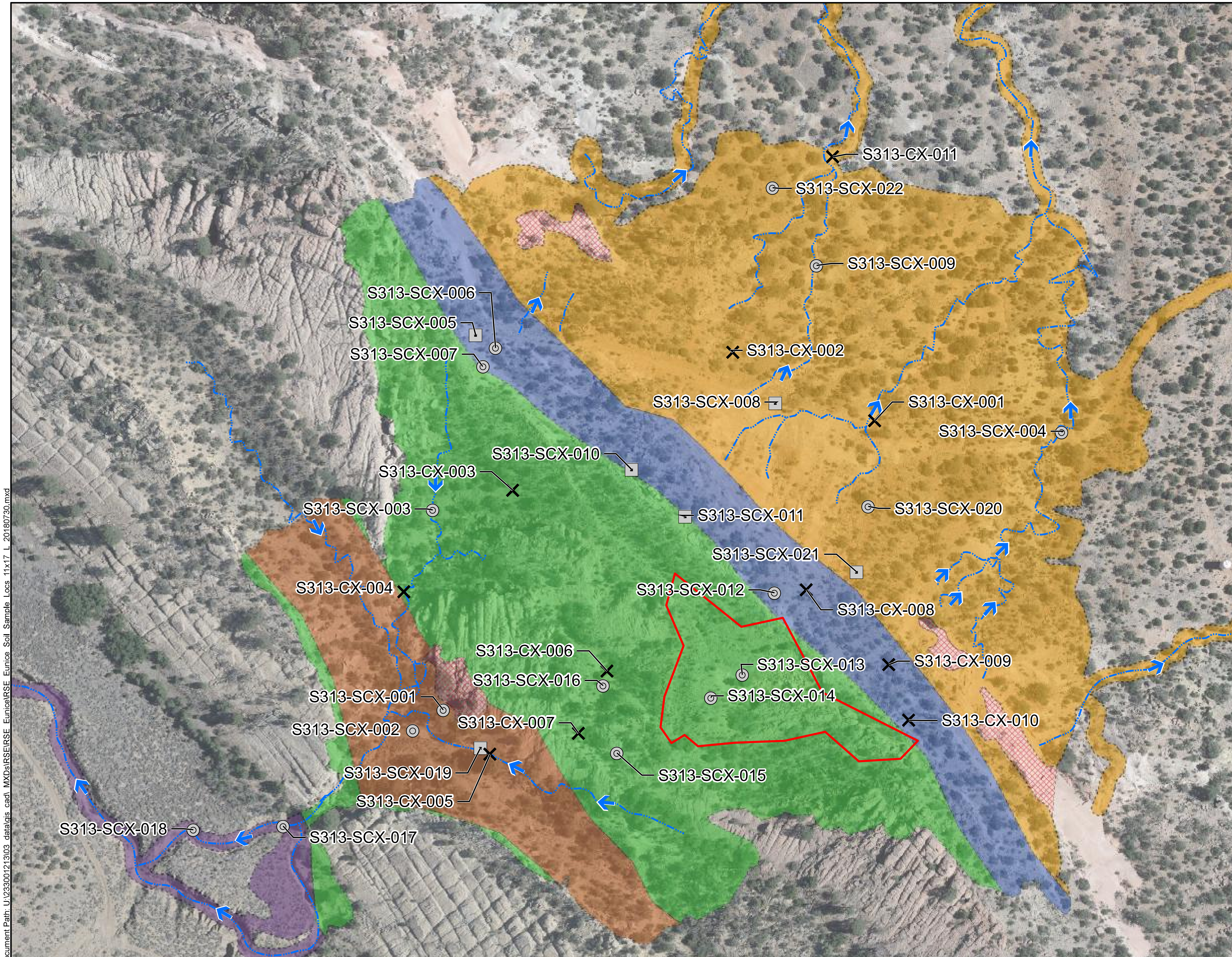
Stantec

AUTHOR: WDC

REVIEWER: CBB

FIGURE: 3-5

Document Path: U:\2330012130\03_data\gis_cad_MXDs\RSE\RSE_Eunice\RSE_Eunice_Correlation_11x17_L_20180730.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

NOTES:

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

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

Subsurface samples range from 0.5 - 3.5 ft bgs.

Static gamma measurements range from 0.0 - 3.5.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

N W E S

0 150 300

Feet

TITLE:

Site Characterization Surface and Subsurface Sample Locations

PROJECT:

Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 8/24/2018

DOCUMENT NAME: Removal Site Evaluation Report

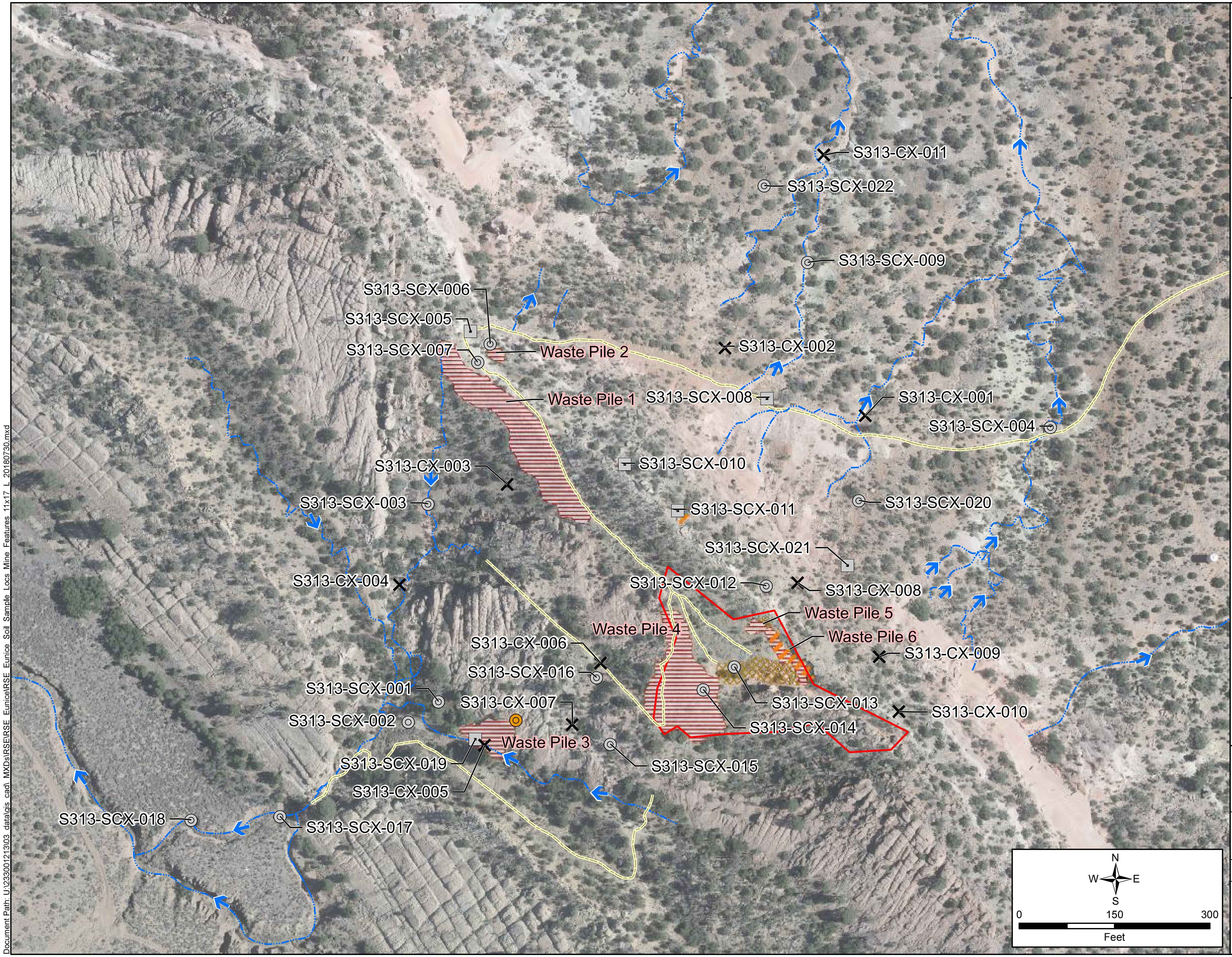
AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: 3-6a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\RSE_Eunice_Soil_Sample_Locs_11x17_L_20180730.mxd



Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\RSE_Eunice_Soil_Sample_Locs_Mine_Features_11x17_L_20180730.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Adit
- Flow Direction
- Drainage
- Potential Haul Road
- Blasted Area
- Debris
- Excavation
- Waste Pile
- Claim Boundary

NOTES:

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

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

Subsurface samples range from 0.5 - 3.5 ft bgs.

Static gamma measurements range from 0.0 - 3.5.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

TITLE:
Sample Locations Compared to Mining-Related Features

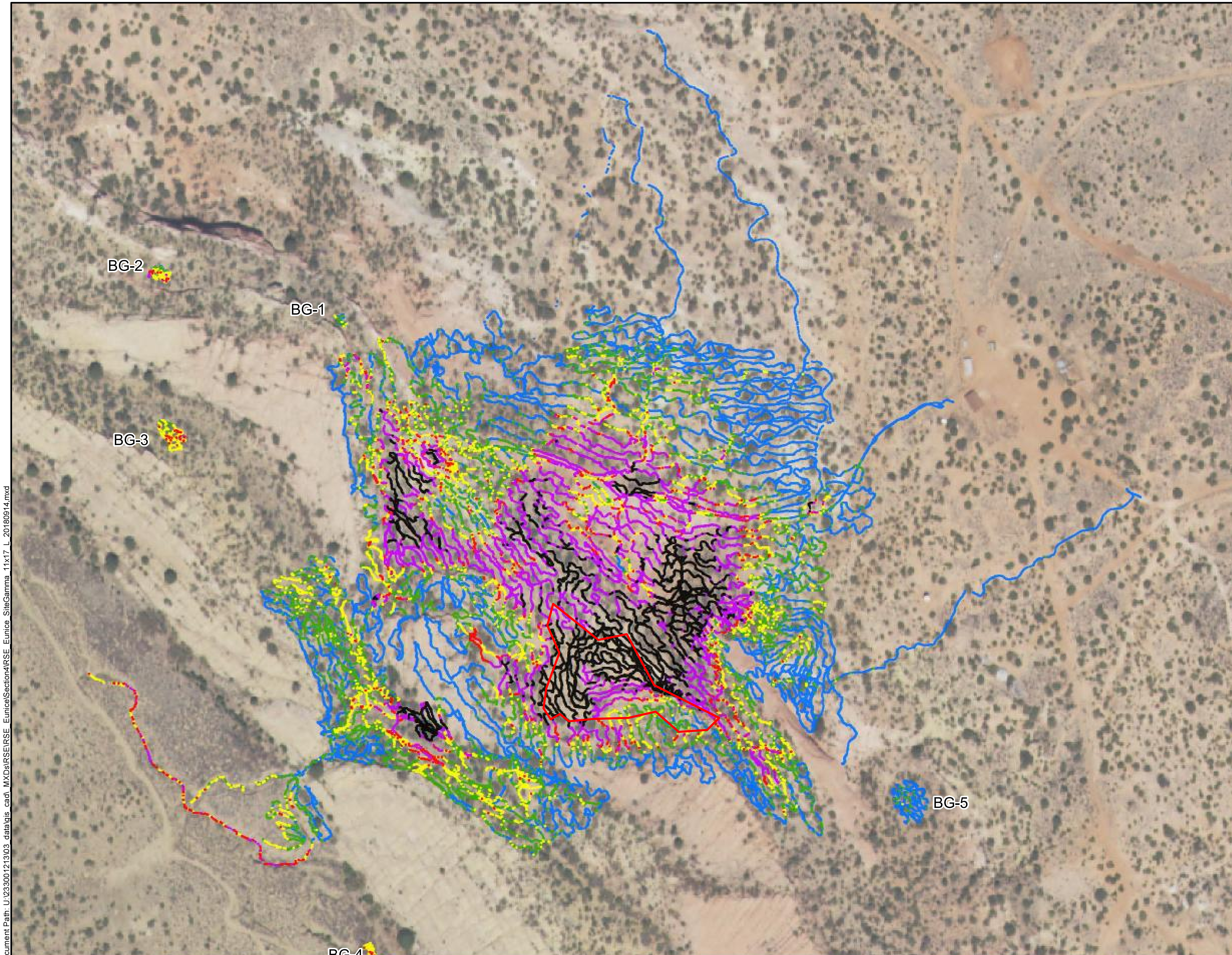
PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE:	DOCUMENT NAME:
8/24/2018	Removal Site Evaluation Report

Stantec

AUTHOR:	REVIEWER:
CBB	EDZ

FIGURE: 3-6b



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 4,543 - 10,189 (Minimum to BG-5 IL)
- 10,190 - 12,184 (>BG-5 IL to BG-1 IL)
- 12,185 - 14,697 (>BG-1 IL to BG-4 IL)
- 14,698 - 16,336 (>BG-4 IL to BG-2 IL)
- 16,337 - 29,394 (>BG-2 IL to 2x BG-4 IL)
- 29,395 - 401,121 (>2x BG-4 IL to Maximum)

NOTE:
Refer to Figure 3-4 for Survey Area delineation.

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 9/14/2018

N W E S

0 220 440
Feet

TITLE: Gamma Radiation Survey Results

PROJECT: Removal Site Evaluation Eunice Becenti Mine Site

DATE: 9/14/2018

DOCUMENT NAME: Removal Site Evaluation Report

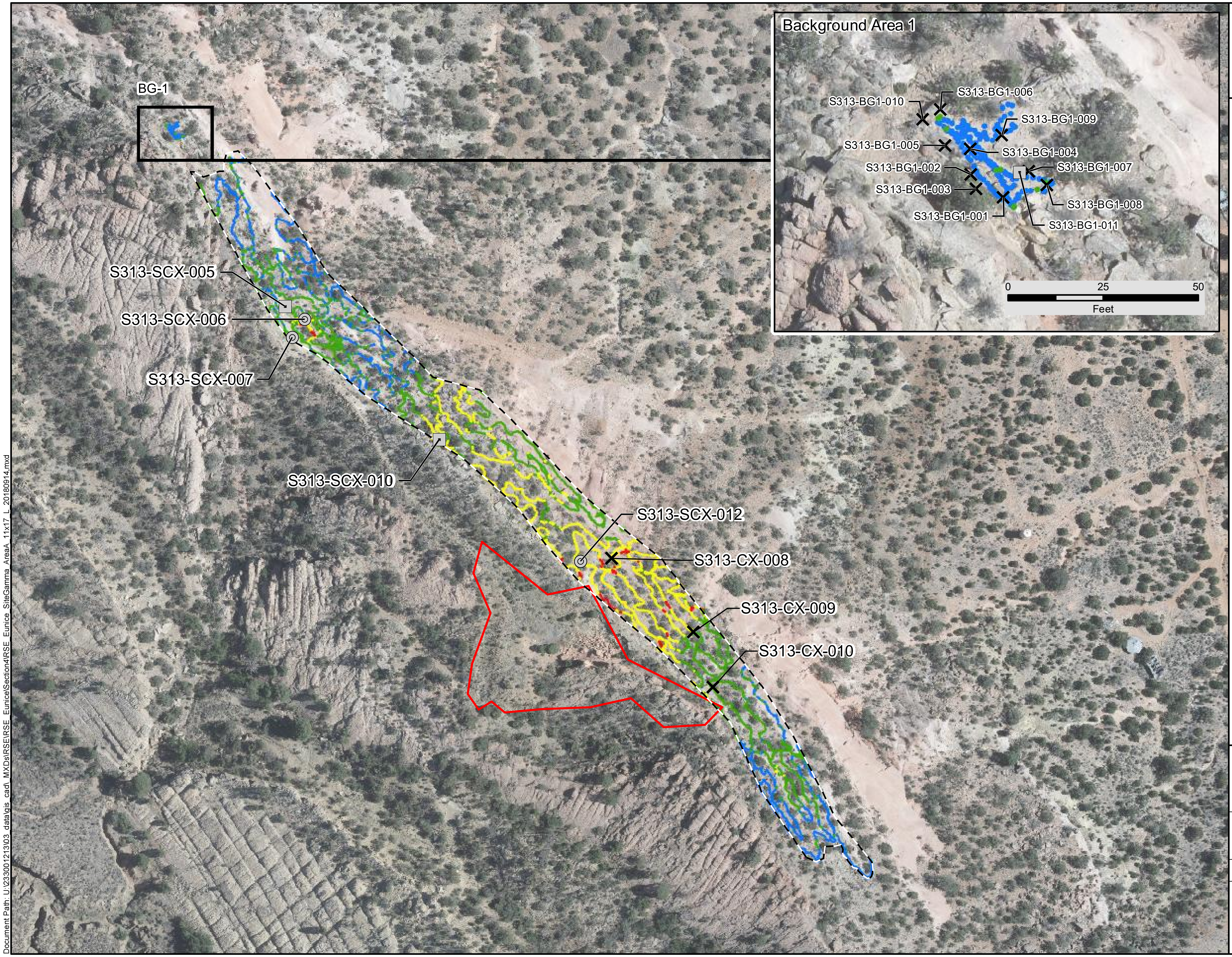
AUTHOR: WDC

REVIEWER: CBB

Stantec

FIGURE: 4-1a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_SiteGamma_11x17_L_20180914.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

Gamma Survey

Counts per Minute (CPM)

- 5,203 - 12,184 (Minimum to BG-1 IL)
- 12,185 - 24,368 (>BG-1 IL to 2x BG-1 IL)
- 24,369 - 60,920 (>2x BG-1 IL to 5x BG-1 IL)
- 60,921 - 114,187 (>5x BG-1 IL to Maximum)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N W E S

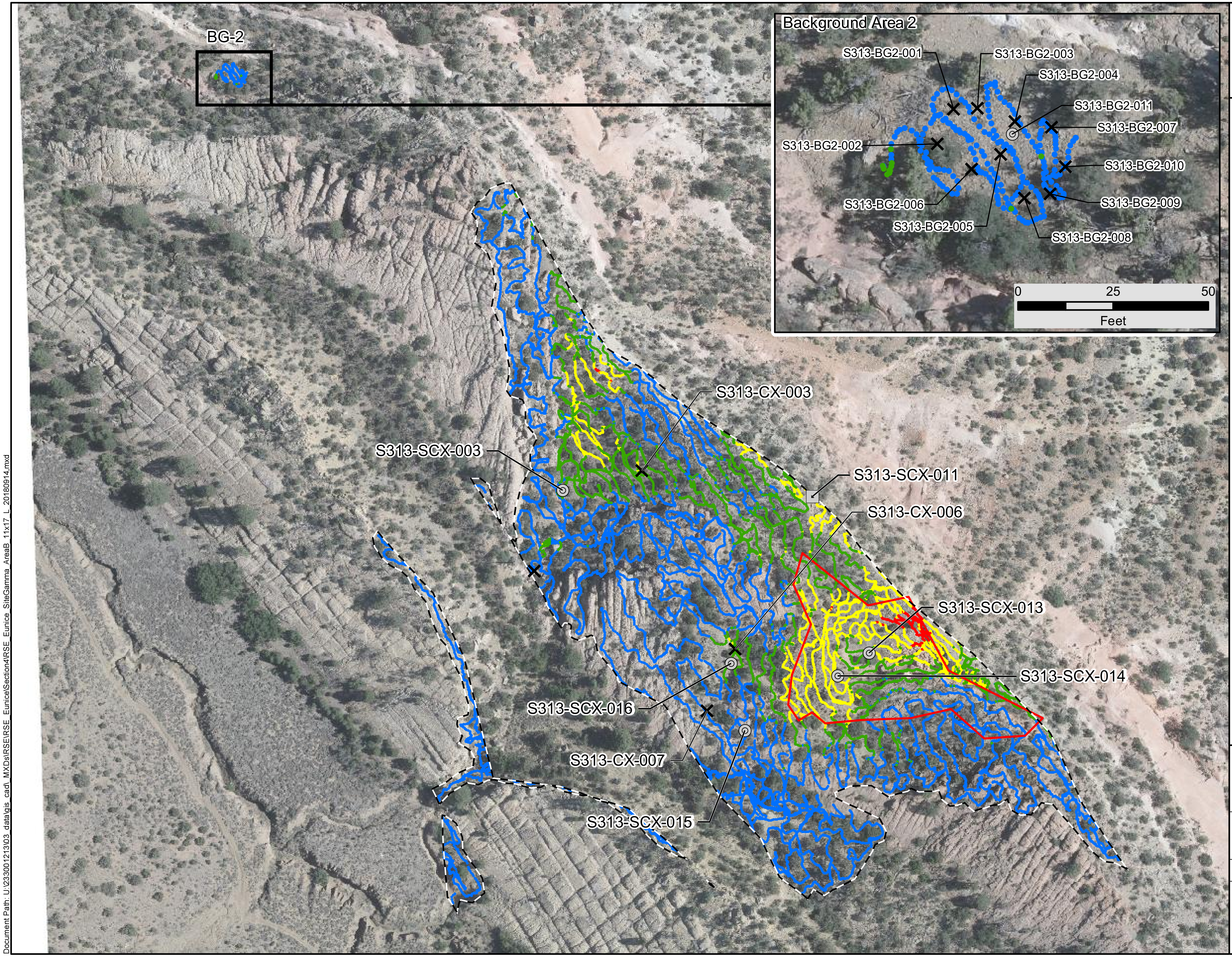
0 150 300
Feet

TITLE:
Gamma Radiation Survey Results for Survey Area A

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

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

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_SiteGamma_AreaA_11x17_L_20180914.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

Gamma Survey

Counts per Minute (CPM)

- 5,368 - 16,336 (Minimum to BG-2 IL)
- 16,337 - 32,672 (>BG-2 IL to 2x BG-2 IL)
- 32,673 - 163,360 (>2x BG-2 IL to 10x BG-2 IL)
- 163,361 - 401,121 (>10x BG-2 IL to Maximum)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N W E S

0 150 300
Feet

TITLE:
Gamma Radiation Survey Results for Survey Area B

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 9/14/2018

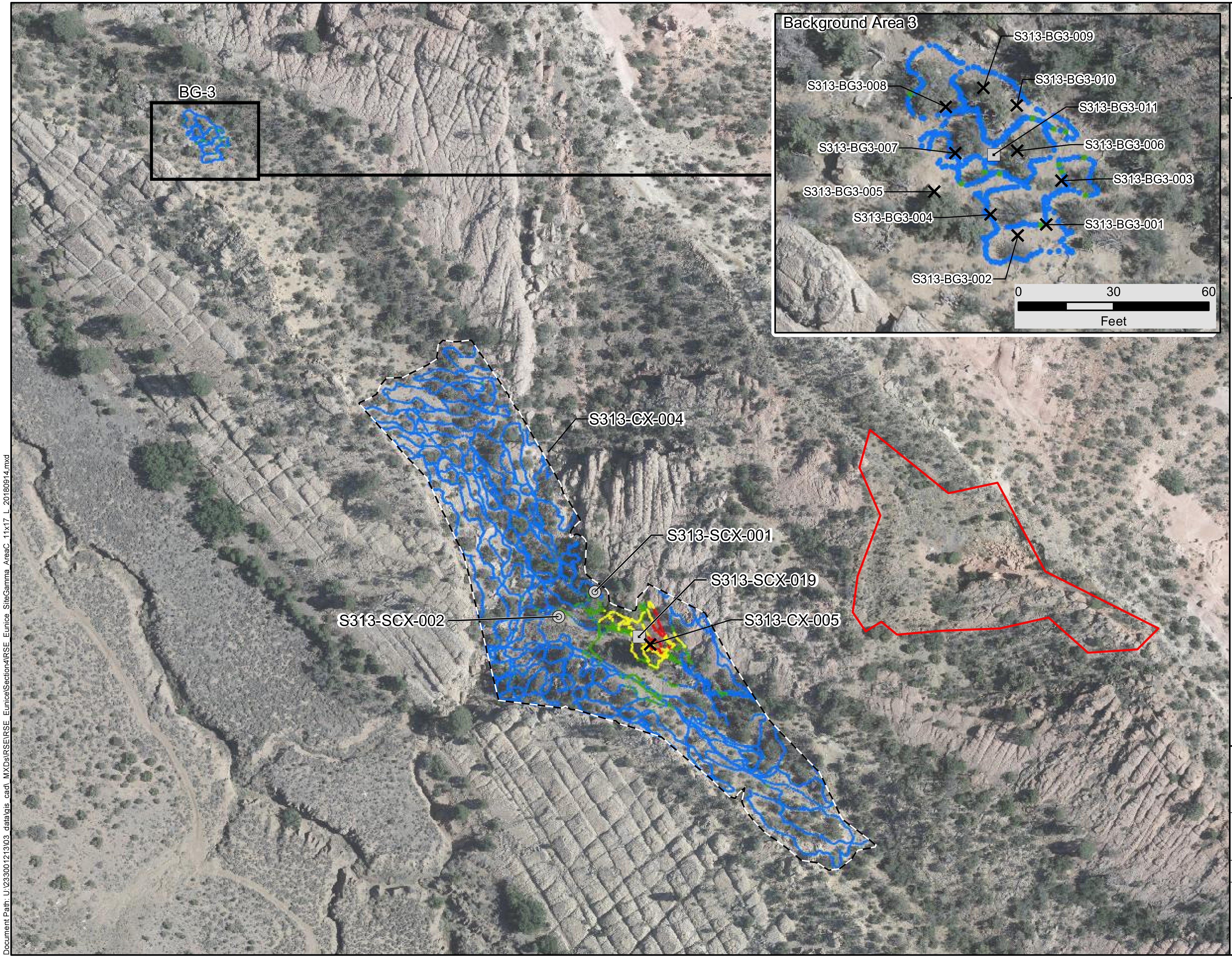
DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: WDC
REVIEWER: CBB

Stantec

FIGURE: 4-1c

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_SiteGamma_AreaB_11x17_L_20180914.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

Gamma Survey

Counts per Minute (CPM)

- 6,855 - 15,233 (Minimum to BG-3 IL)
- 15,234 - 30,446 (>BG-3 IL to 2x BG-3 IL)
- 30,447 - 76,115 (>2x BG-3 IL to 5x BG-3 IL)
- 76,116 - 136,164 (>5x BG-3 IL to Maximum)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N
W E
S

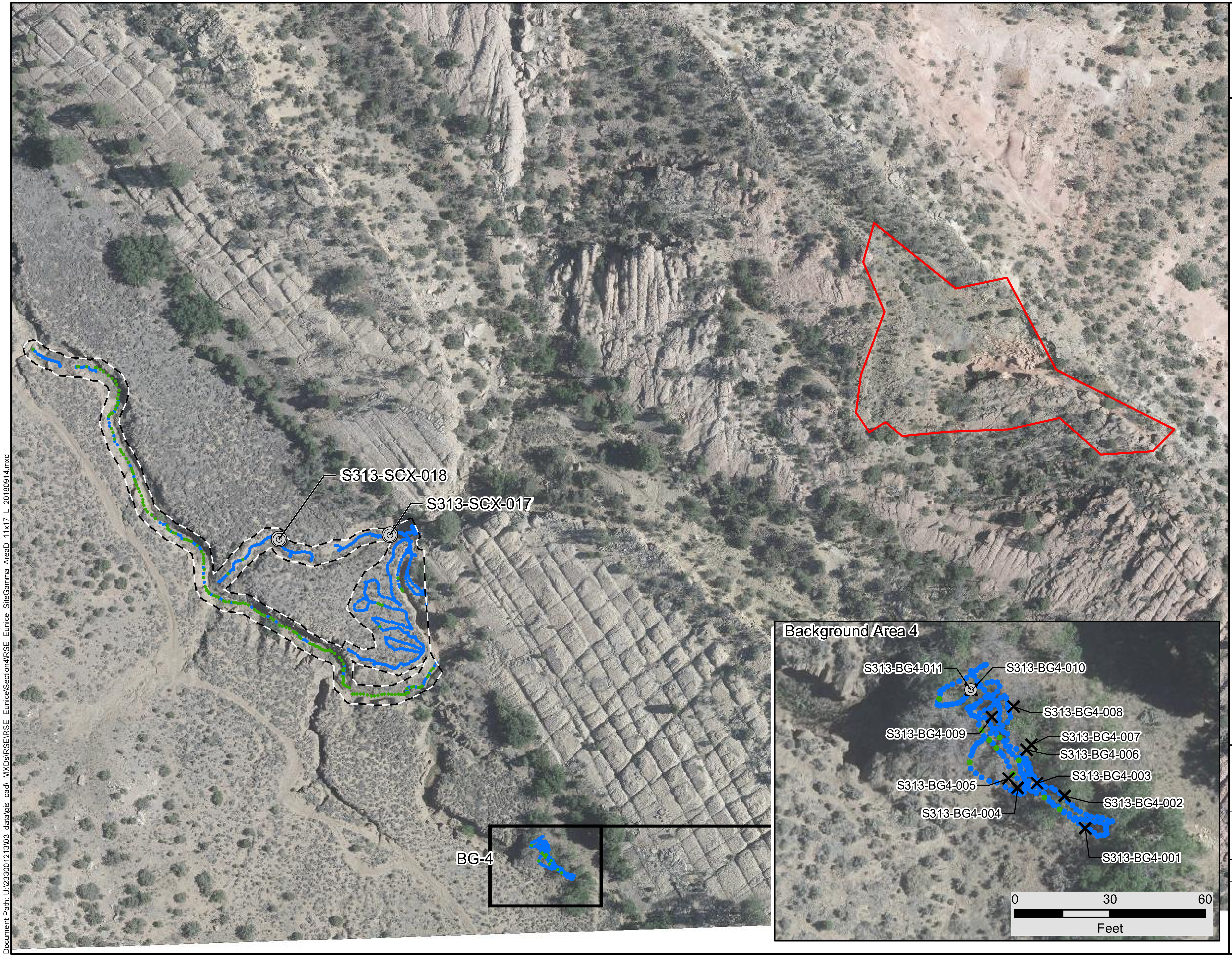
0 125 250
Feet

TITLE:
Gamma Radiation Survey Results for Survey Area C

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

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

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_SiteGamma_AreaC_11x17_L_20180914.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

Gamma Survey

Counts per Minute (CPM)

- 7,430 - 14,697 (Minimum to BG-4 IL)
- 14,698 - 18,510 (>BG-4 IL to Maximum)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N / E / S / W

0 120 240
Feet

TITLE:
Gamma Radiation Survey Results for Survey Area D

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

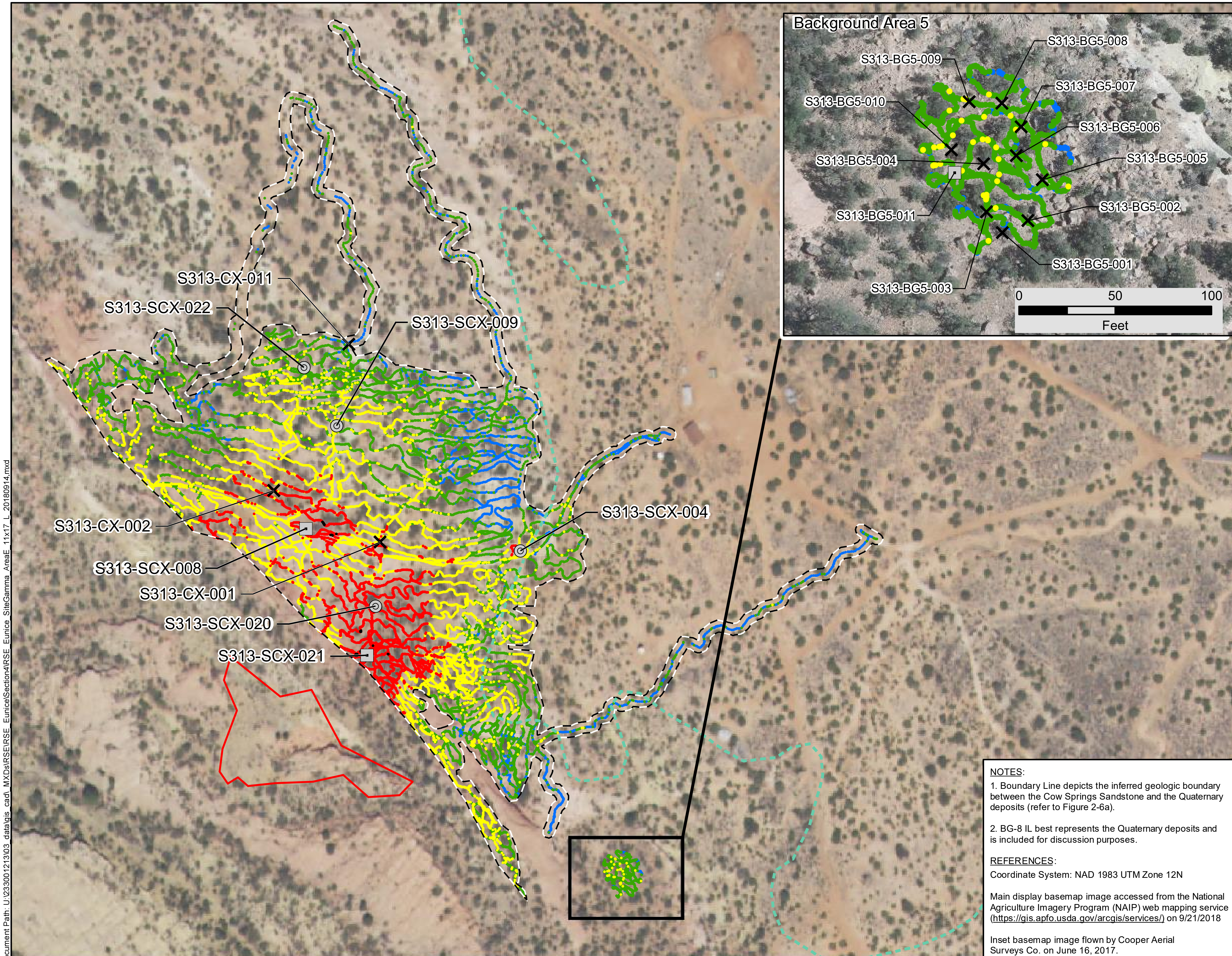
DATE:	DOCUMENT NAME:
9/14/2018	Removal Site Evaluation Report

AUTHOR:	REVIEWER:
WDC	CBB

Stantec

FIGURE: 4-1e

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_SiteGamma_AreaD_11x17_L_20180914.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Cow Springs Sandstone / Quaternary Deposits Geologic Contact (inferred) [1]
- Survey Area E
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 4,543 - 7,326 (Minimum to BG-8 [2] IL)
- 7,327 - 10,189 (>BG-8 IL to BG-5 IL)
- 10,190 - 20,378 (>BG-5 IL to 2x BG-5 IL)
- 20,379 - 101,890 (>BG-5 IL to 5x BG-5 IL)
- 101,891 - 199,804 (>5x BG-5 IL to Maximum)

N W E S

0 200 400
Feet

NOTES:

1. Boundary Line depicts the inferred geologic boundary between the Cow Springs Sandstone and the Quaternary deposits (refer to Figure 2-6a).

2. BG-8 IL best represents the Quaternary deposits and is included for discussion purposes.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Main display basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 9/21/2018

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

TITLE:
Gamma Radiation Survey Results for Survey Area E

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

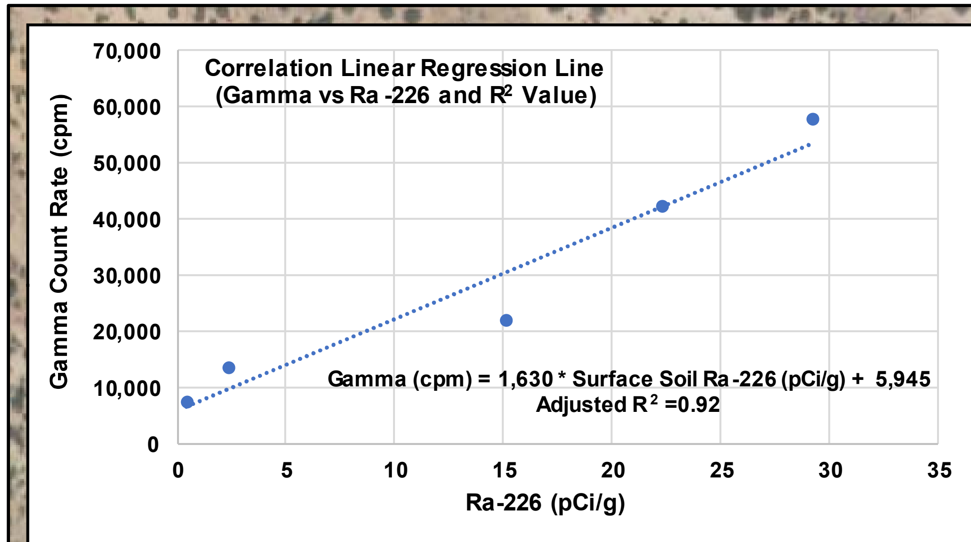
DATE:	DOCUMENT NAME:
9/21/2018	Removal Site Evaluation Report

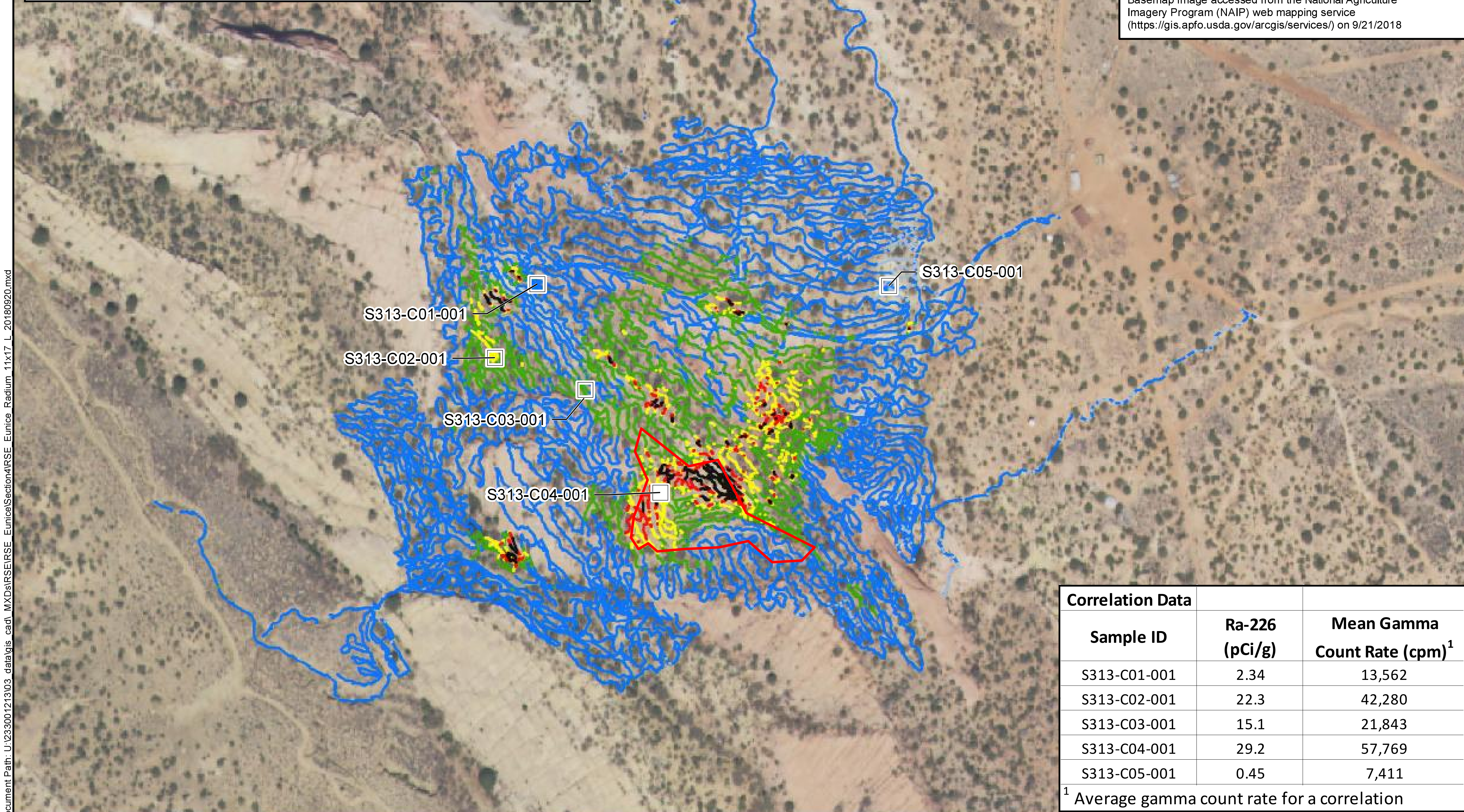
AUTHOR:	REVIEWER:
WDC	CBB

Stantec

FIGURE: 4-1f

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_SiteGamma_AreaE_11x17_L_20180914.mxd





NOTES:

1. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
Gamma (CPM) = 1,630 x Surface Soil Ra-226 (pCi/g) + 5,945

2. The correlation equation predicted Ra-226 concentrations that are less than zero for gamma survey measurements less than 5,945.

3. Mean (μ) of predicted concentrations of Ra-226 in soil (7.4 pCi/g).

4. Standard deviation (σ) of predicted concentrations of Ra-226 in soil (12.7 pCi/g).

5. Ra-226 concentrations predicted from gamma measurements exceeding approximately 58,000 CPM or less than approximately 7,400 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 9/21/2018

Correlation Data		
Sample ID	Ra-226 (pCi/g)	Mean Gamma Count Rate (cpm)[1]
S313-C01-001	2.34	13,562
S313-C02-001	22.3	42,280
S313-C03-001	15.1	21,843
S313-C04-001	29.2	57,769
S313-C05-001	0.45	7,411

[1] Average gamma count rate for a correlation

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

S313-C01-001 Correlation Location (30' x 30')

Claim Boundary

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

- Less than 0[2]
- 0 - 7.4 (μ)[3]
- 7.5 - 20.1 (μ + 1σ[4])
- 20.2 - 32.8 (μ + 2σ)
- 32.9 - 45.5 (μ + 3σ)
- 45.6 - 242.4[5]

N W E S

0 250 500
Feet

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

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 9/21/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: WDC

REVIEWER: CBB

FIGURE: 4-2a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_Radium_11x17_L_20180920.mxd

NOTES:

1. The number in parantheses 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) = 1,630 x Surface Soil Ra-226 (pCi/g) + 5,945

3. The correlation equation predicted Ra-226 concentrations that are less than zero for gamma survey measurements less than 5,945.

4. Mean (μ) of predicted concentrations of Ra-226 in soil (7.4 pCi/g).

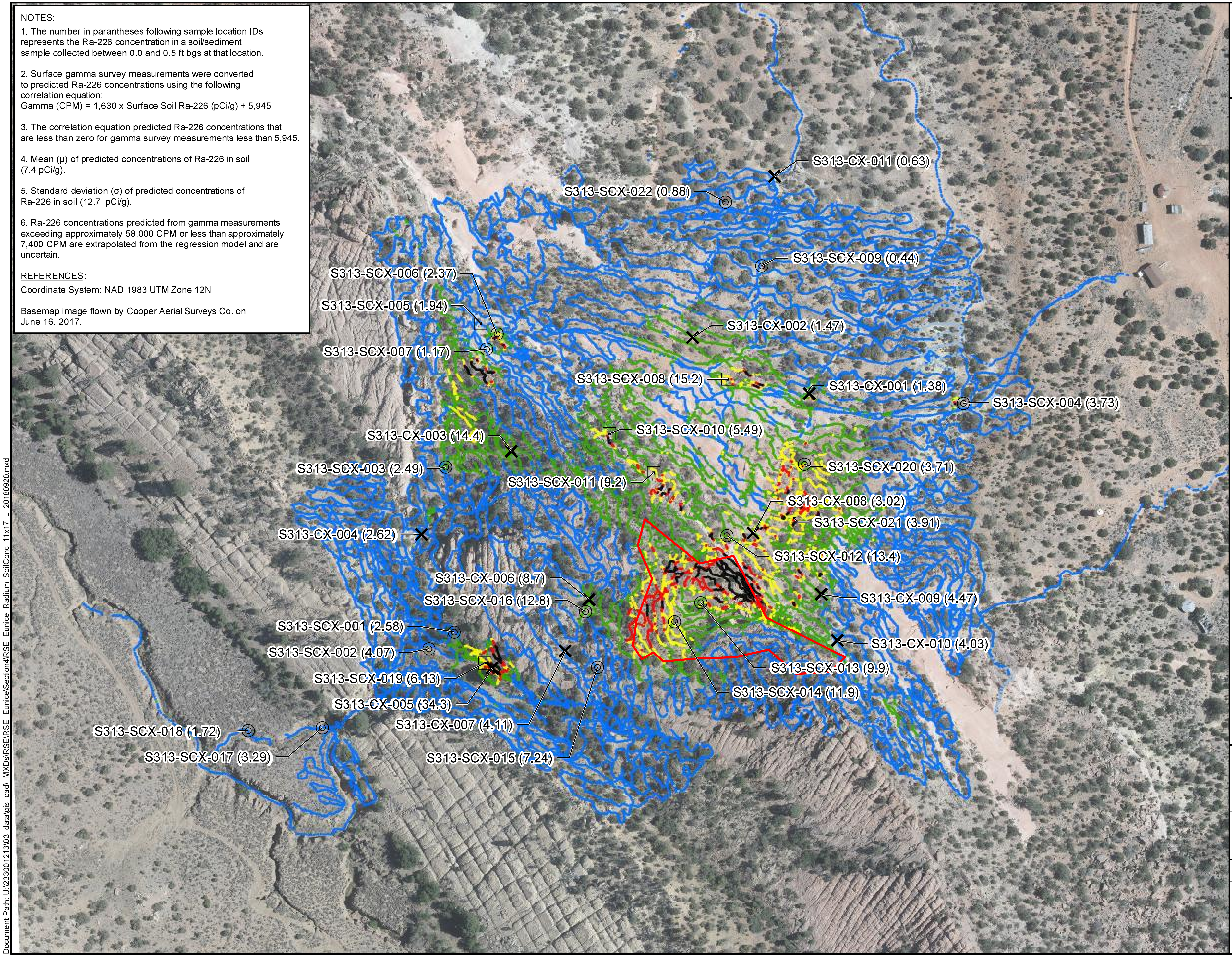
5. Standard deviation (σ) of predicted concentrations of Ra-226 in soil (12.7 pCi/g).

6. Ra-226 concentrations predicted from gamma measurements exceeding approximately 58,000 CPM or less than approximately 7,400 CPM are extrapolated from the regression model and are uncertain.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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



Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE_Eunice\RSE_Eunice\Section4\RSE_Eunice_Radium_SoilConc_11x17_L_20180920.mxd

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 - 7.4 (μ)[4]
- 7.5 - 20.1 (μ + 1σ[5])
- 20.2 - 32.8 (μ + 2σ)
- 32.9 - 45.5 (μ + 3σ)
- 45.6 - 242.4[6]

N W E S

0 180 360
Feet

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

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

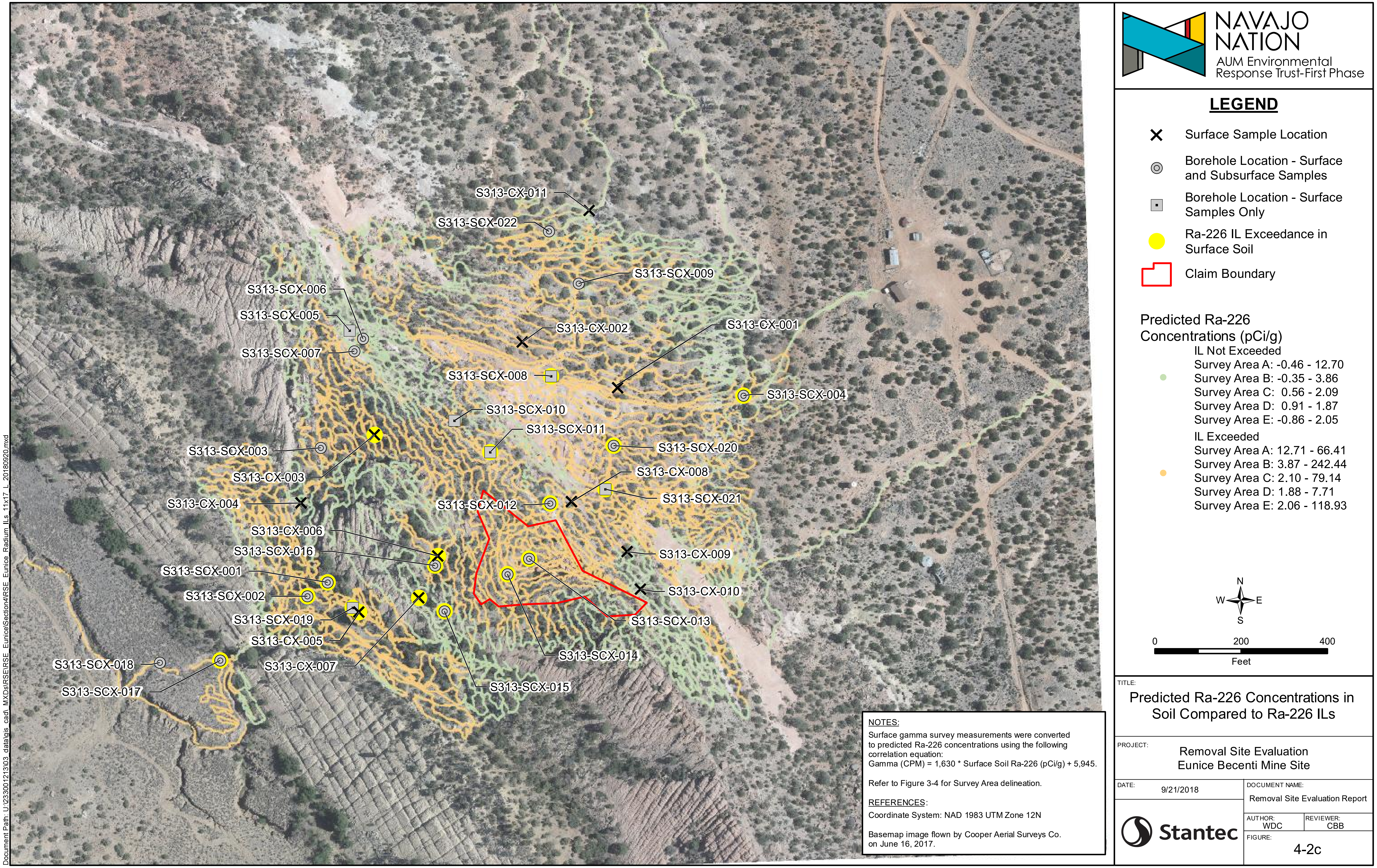
DATE: 9/21/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: WDC
REVIEWER: CBB

FIGURE: 4-2b



NAVAJO NATION
AUM Environmental Response Trust-First Phase

NOTES:
Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
Gamma (CPM) = 1,630 * Surface Soil Ra-226 (pCi/g) + 5,945.

Refer to Figure 3-4 for Survey Area delineation.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

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

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE:	DOCUMENT NAME:
9/21/2018	Removal Site Evaluation Report

Stantec

AUTHOR:	REVIEWER:
WDC	CBB

FIGURE:
4-2c

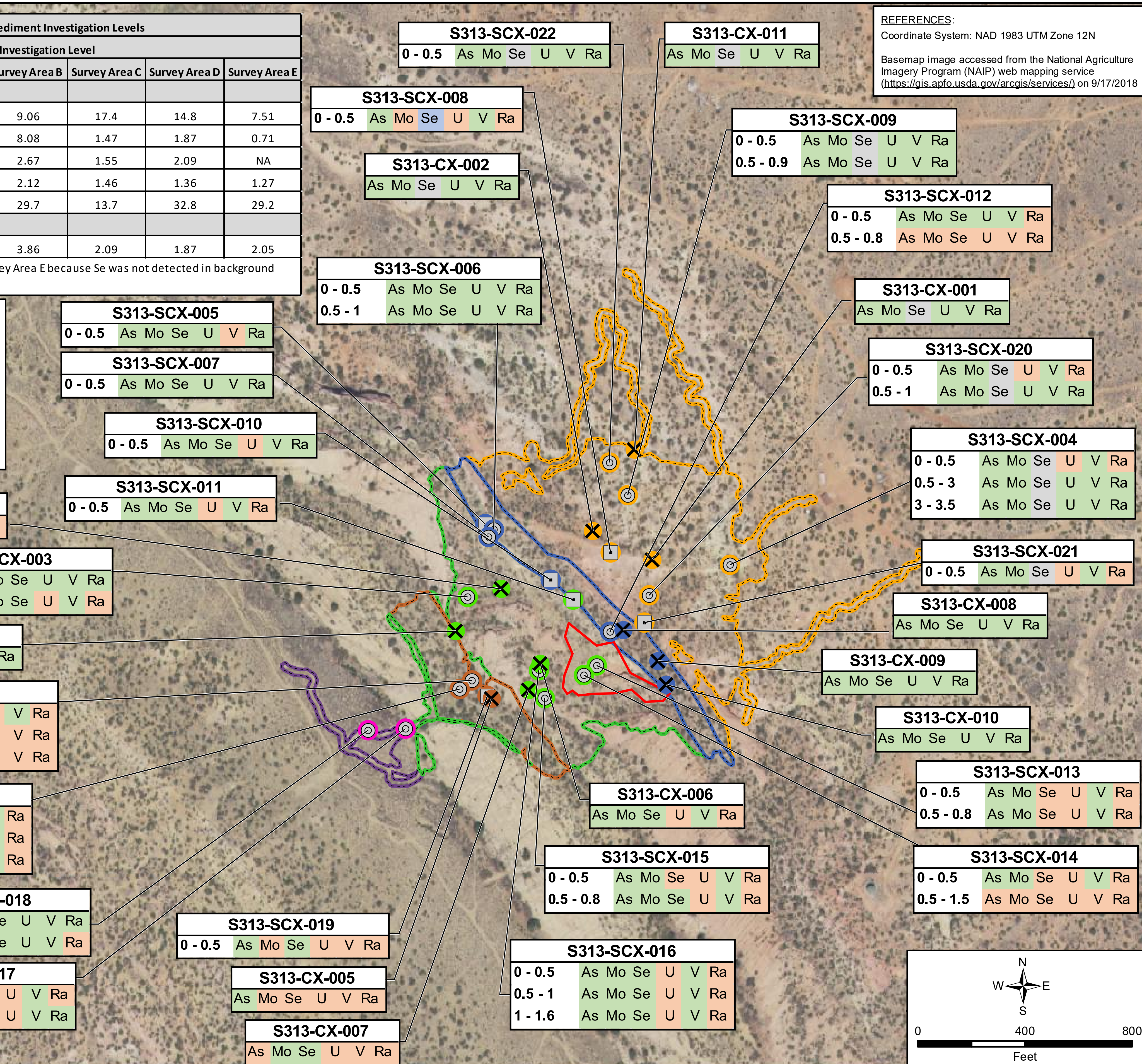
Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_Radium_ILs_11x17_L_20180920.mxd

Soil and Sediment Investigation Levels

Analyte (Units)	Survey Area A	Survey Area B	Survey Area C	Survey Area D	Survey Area E
	Investigation Level				
Metals (mg/kg)					
Arsenic	7.92	9.06	17.4	14.8	7.51
Molybdenum	12.8	8.08	1.47	1.87	0.71
Selenium	3.26	2.67	1.55	2.09	NA
Uranium	31.4	2.12	1.46	1.36	1.27
Vanadium	21.3	29.7	13.7	32.8	29.2
Radionuclides (pCi/g)					
Radium-226	12.71	3.86	2.09	1.87	2.05

NA - No IL was established for Se in Survey Area E because Se was not detected in background reference area BG-5

Investigation Level Not Exceeded
Investigation Level Exceeded
Analyte Detected - No Investigation Level
Non-detect - No Investigation Level



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 9/17/2018

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

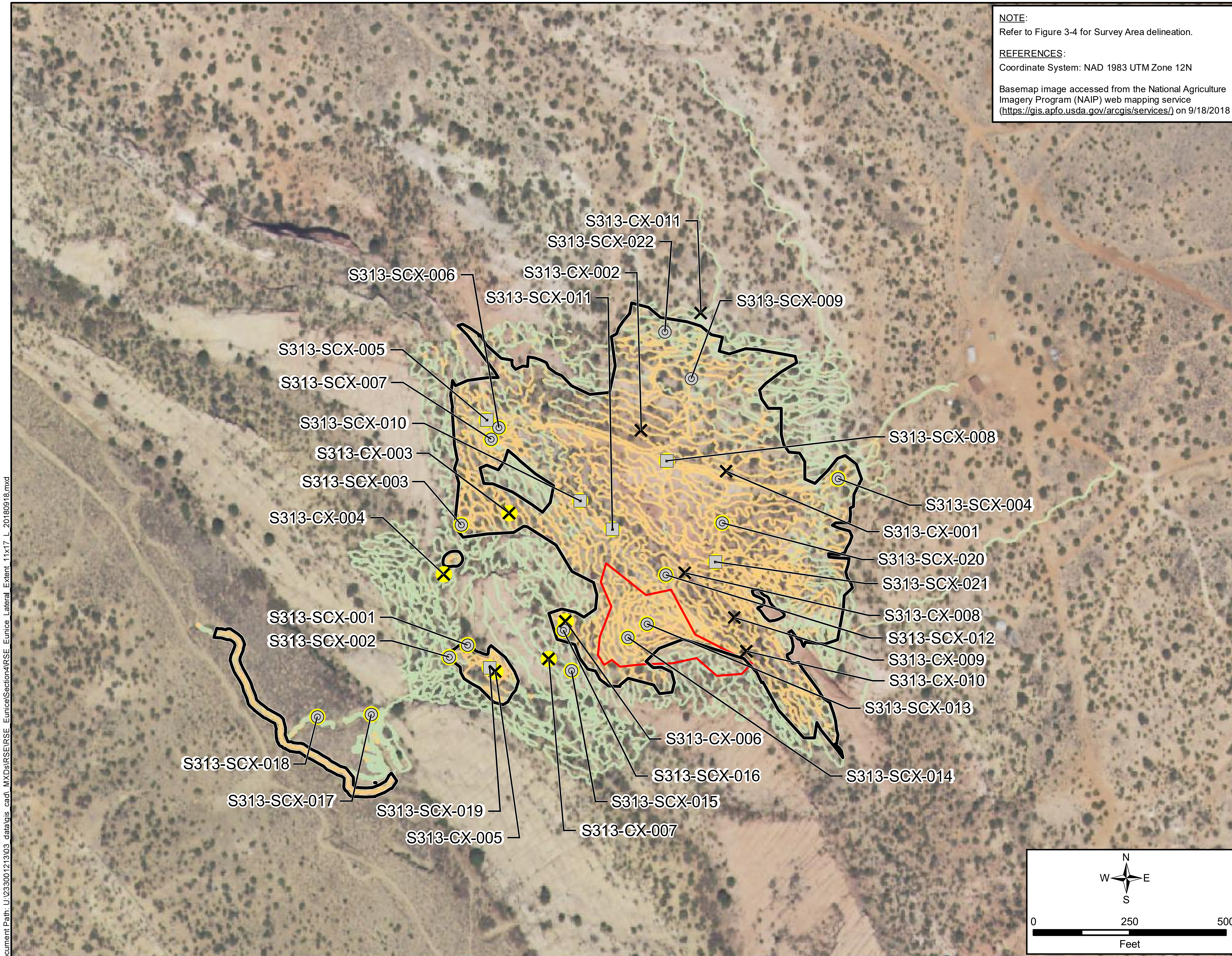
- Survey Area A - Surface Sample
- Survey Area A - Borehole Location - Surface and Subsurface Samples
- Survey Area A - Borehole Location - Surface Samples Only
- Survey Area B - Surface Sample
- Survey Area B - Borehole Location - Surface and Subsurface Samples
- Survey Area B - Borehole Location - Surface Samples Only
- Survey Area C - Surface Sample
- Survey Area C - Borehole Location - Surface and Subsurface Samples
- Survey Area C - Borehole Location - Surface Samples Only
- Survey Area D - Borehole Location - Surface and Subsurface Samples
- Survey Area E - Surface Sample
- Survey Area E - Borehole Location - Surface and Subsurface Samples
- Survey Area E - Borehole Location - Surface Samples Only
- Survey Area A
- Survey Area B
- Survey Area C
- Survey Area D
- Survey Area E
- Claim Boundary

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

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 9/17/2018
DOCUMENT NAME: Removal Site Evaluation Report
AUTHOR: WDC
REVIEWER: CBB
FIGURE: 4-3

Stantec



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma ILs are Exceeded (16.3 acres)
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

IL Not Exceeded
Survey Area A: 5,203 - 12,184
Survey Area B: 5,368 - 16,336
Survey Area C: 6,855 - 15,223
Survey Area D: 7,430 - 14,697
Survey Area E: 4,543 - 10,189

IL Exceeded
Survey Area A: 12,185 - 114,187
Survey Area B: 16,337 - 401,121
Survey Area C: 15,224 - 136,164
Survey Area D: 14,698 - 18,510
Survey Area E: 10,190 - 199,804

TITLE:
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE:	DOCUMENT NAME:
9/18/2018	Removal Site Evaluation Report

Stantec

AUTHOR:	REVIEWER:
WDC	CBB

FIGURE:
4-4a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_Lateral_Extent_11x17_L_20180918.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma IL is Exceeded (2.7 acres)
- Claim Boundary

Gamma Survey
Counts per Minute (CPM)

- 5,203 - 12,184 (IL Not Exceeded)
- 12,185 - 114,187 (IL Exceeded)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N W E S

0 150 300
Feet

TITLE: Lateral Extent of Surface and Subsurface IL Exceedances for Survey Area A

PROJECT: Removal Site Evaluation Eunice Becenti Mine Site

DATE: 9/18/2018

DOCUMENT NAME: Removal Site Evaluation Report

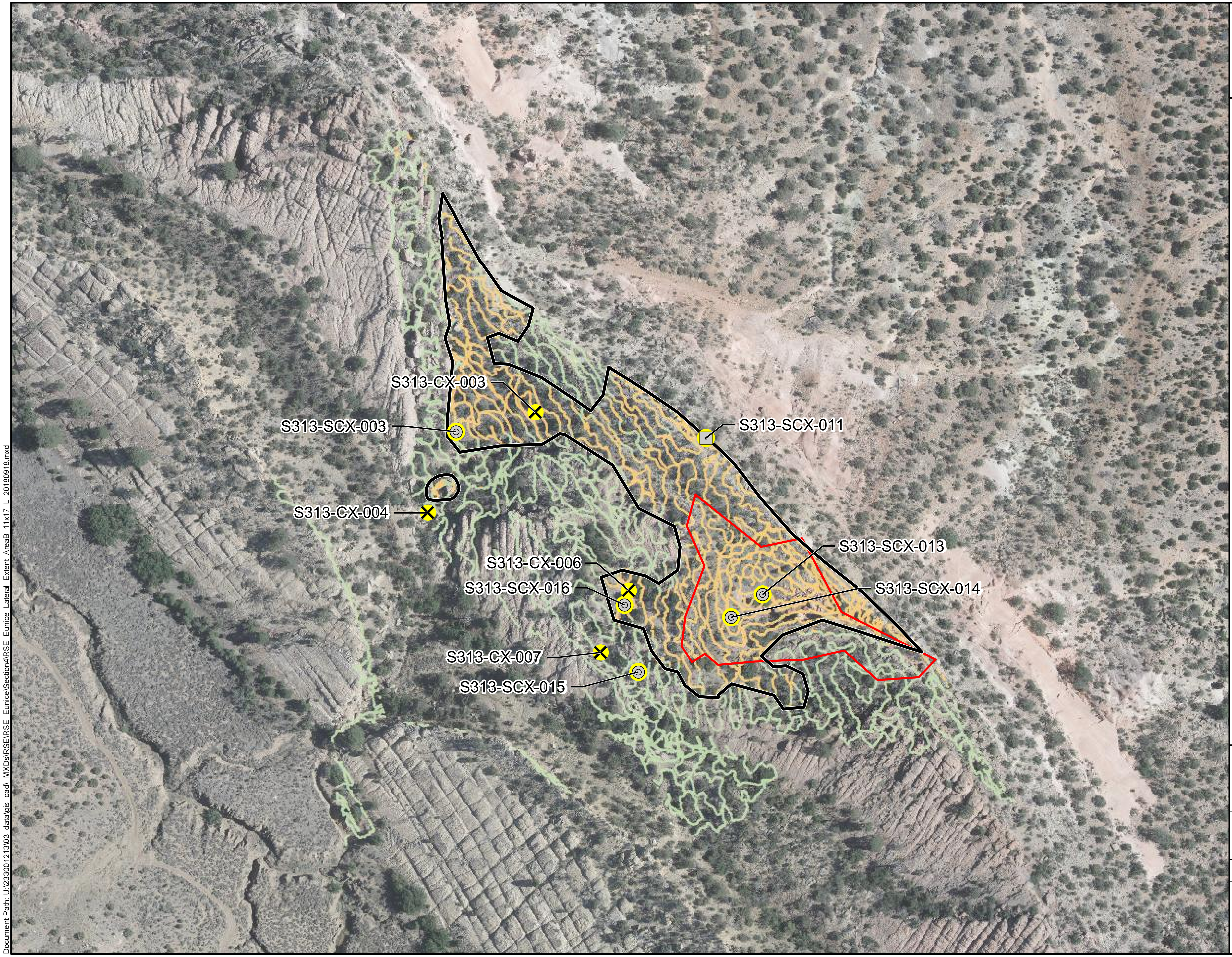
AUTHOR: WDC

REVIEWER: CBB

Stantec

FIGURE: 4-4b

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_Lateral_Extent_AreaA_11x17_L_20180918.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma IL is Exceeded (3.6 acres)
- Claim Boundary

Gamma Survey
Counts per Minute (CPM)

- 5,368 - 16,336 (IL Not Exceeded)
- 16,337 - 401,121 (IL Exceeded)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N W E S

0 150 300
Feet

TITLE: Lateral Extent of Surface and Subsurface IL Exceedances for Survey Area B

PROJECT: Removal Site Evaluation Eunice Becenti Mine Site

DATE: 9/18/2018

DOCUMENT NAME: Removal Site Evaluation Report

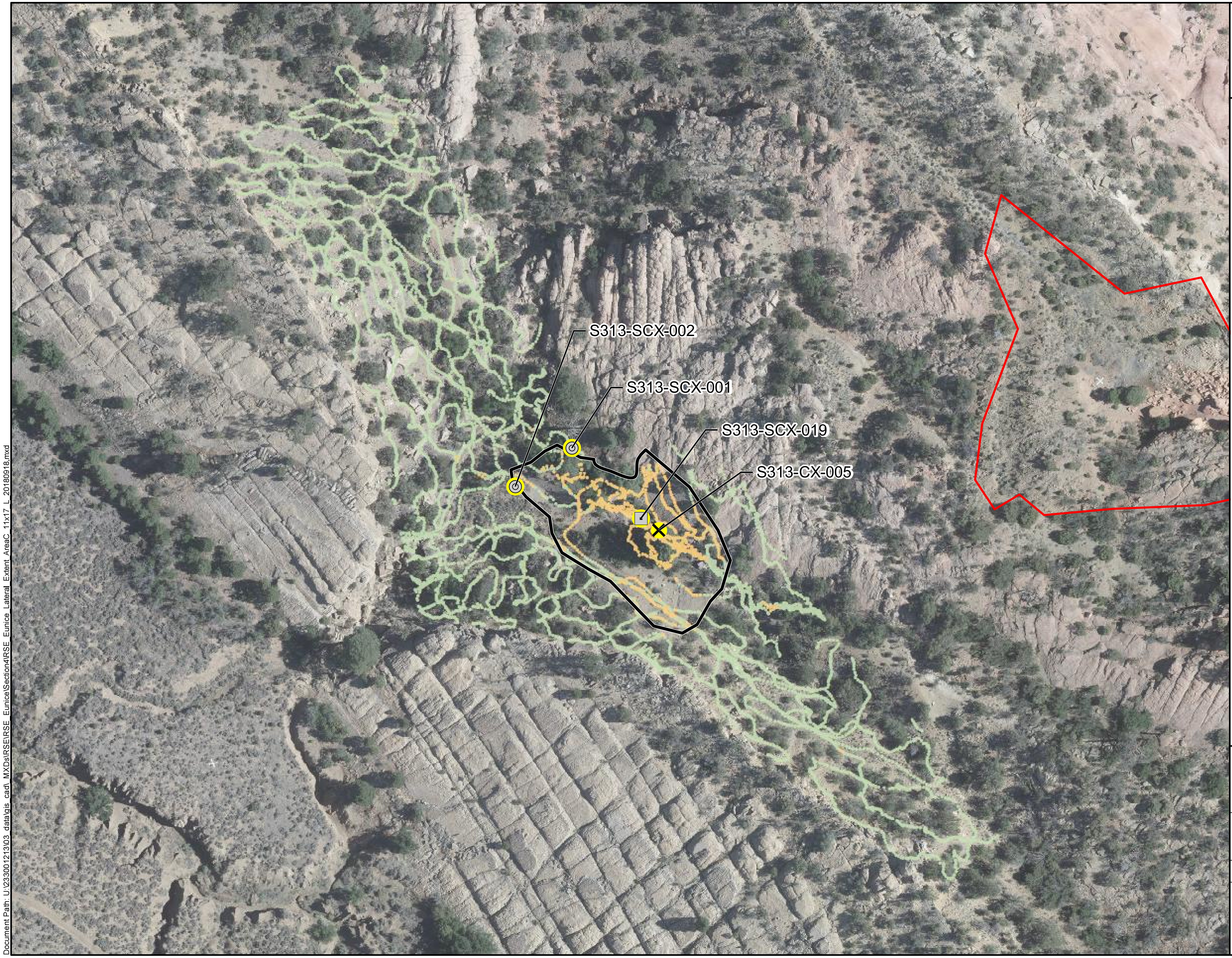
AUTHOR: WDC

REVIEWER: CBB

FIGURE: 4-4c

Stantec

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_Lateral_Extent_AreaB_11x17_L_20180918.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma IL is Exceeded (0.4 acres)
- Claim Boundary

Gamma Survey
Counts per Minute (CPM)

- 6,855 - 15,223 (IL Not Exceeded)
- 15,224 - 136,164 (IL Exceeded)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N
W E
S

0 80 160
Feet

TITLE: Lateral Extent of Surface and Subsurface IL Exceedances for Survey Area C

PROJECT: Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 9/18/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: WDC

REVIEWER: CBB

Stantec

FIGURE: 4-4d

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_Lateral_Extent_AreaC_11x17_L_20180918.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Borehole Location - Surface and Subsurface Samples
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma IL is Exceeded (0.4 acres)
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 7,430 - 14,697 (IL Not Exceeded)
- 14,698 - 18,510 (IL Exceeded)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N
W E
S

0 60 120
Feet

TITLE: Lateral Extent of Surface and Subsurface IL Exceedances for Survey Area D

PROJECT: Removal Site Evaluation Eunice Becenti Mine Site

DATE: 9/18/2018

DOCUMENT NAME: Removal Site Evaluation Report

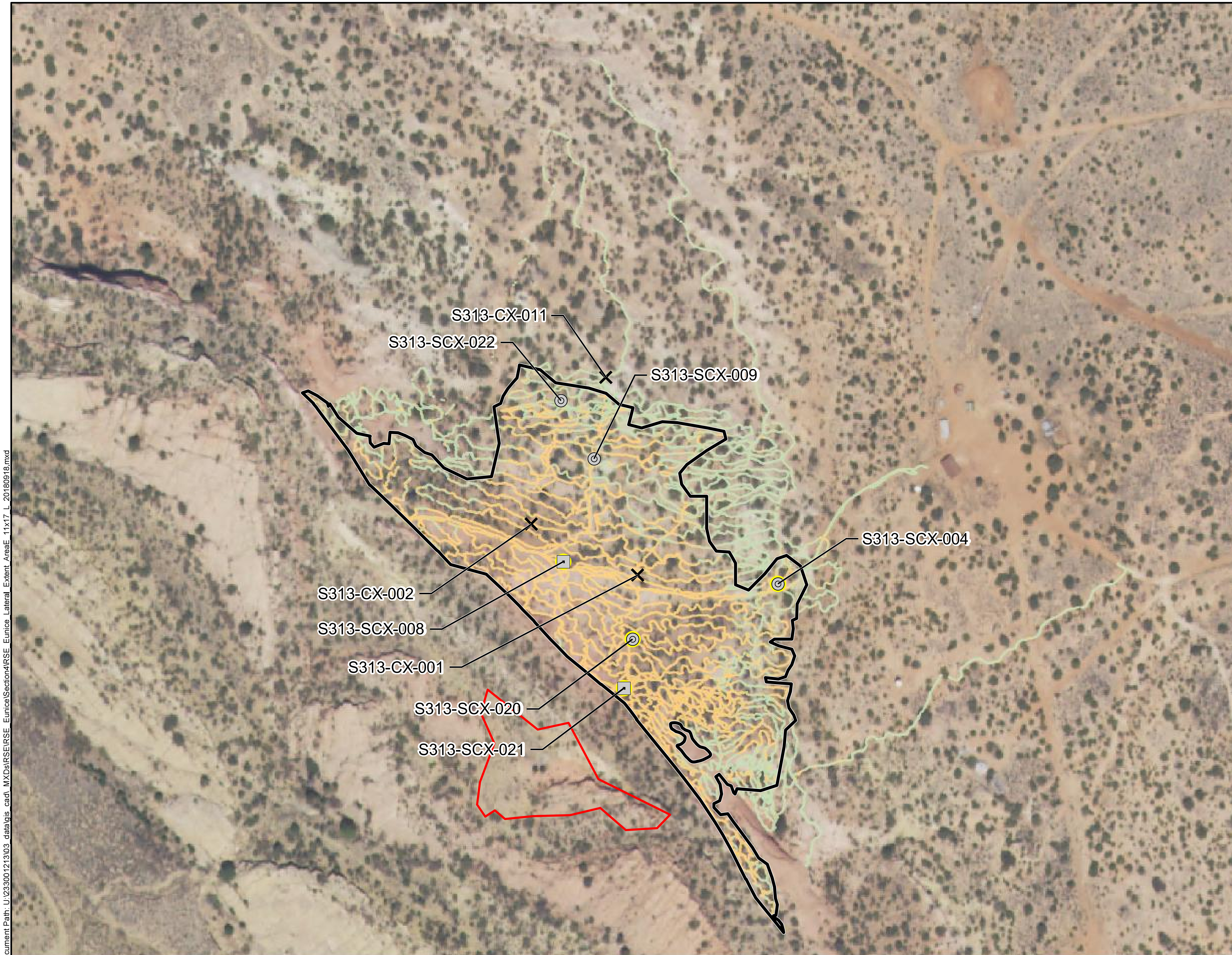
AUTHOR: WDC

REVIEWER: CBB

Stantec

FIGURE: 4-4e

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_Lateral_Extent_AreaD_11x17_L_20180918.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma IL is Exceeded (9.2 acres)
- Claim Boundary

Gamma Survey
Counts per Minute (CPM)
- 4,543 - 10,189 (IL Not Exceeded)
- 10,190 - 199,804 (IL Exceeded)

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 9/18/2018

N W E S

0 200 400
Feet

TITLE: Lateral Extent of Surface and Subsurface IL Exceedances for Survey Area E

PROJECT: Removal Site Evaluation Eunice Becenti Mine Site

DATE: 9/18/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: WDC

REVIEWER: CBB

Stantec

FIGURE: 4-4f

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_Lateral_Extent_AreaE_11x17_L_20180918.mxd

NOTES:

1. Range of Investigation Level (IL) Exceedance in unconsolidated material selected based on unconsolidated material analytical results, subsurface gamma mesurements, and subsurface observation.

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

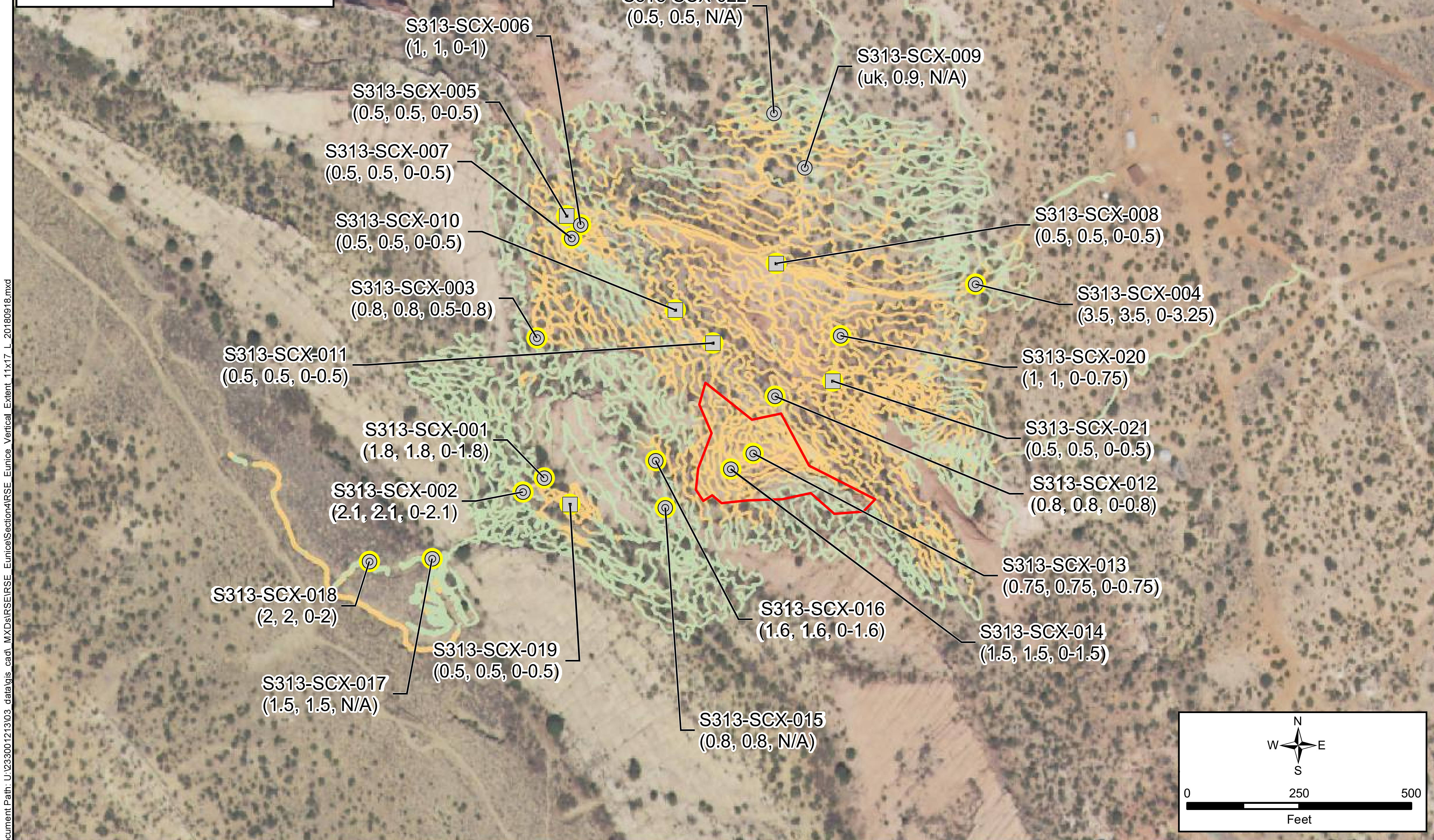
3. uk = Unknown, no confirmation if refusal in borehole was on bedrock.

4. Refer to Figure 3-4 for Survey Area delineation.

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 9/18/2018



Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_Vertical_Extent_11x17_L_20180918.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Borehole Surface and Subsurface Sample Location (Depth of Bedrock, Borehole Depth, Depth Range of IL Exceedance in Unconsolidated Material[1])
- Borehole Location - Surface Samples Only (Depth Range of IL Exceedance in Unconsolidated Material[1])
- IL Exceedance in Unconsolidated Material at Location
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

IL Not Exceeded
Survey Area A: 5,203 - 12,184
Survey Area B: 5,368 - 16,336
Survey Area C: 6,855 - 15,223
Survey Area D: 7,430 - 14,697
Survey Area E: 4,543 - 10,189

IL Exceeded
Survey Area A: 12,185 - 114,187
Survey Area B: 16,337 - 401,121
Survey Area C: 15,224 - 136,164
Survey Area D: 14,698 - 18,510
Survey Area E: 10,190 - 199,804

TITLE: Vertical Extent of IL Exceedances in Soil

PROJECT: Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 9/18/2018

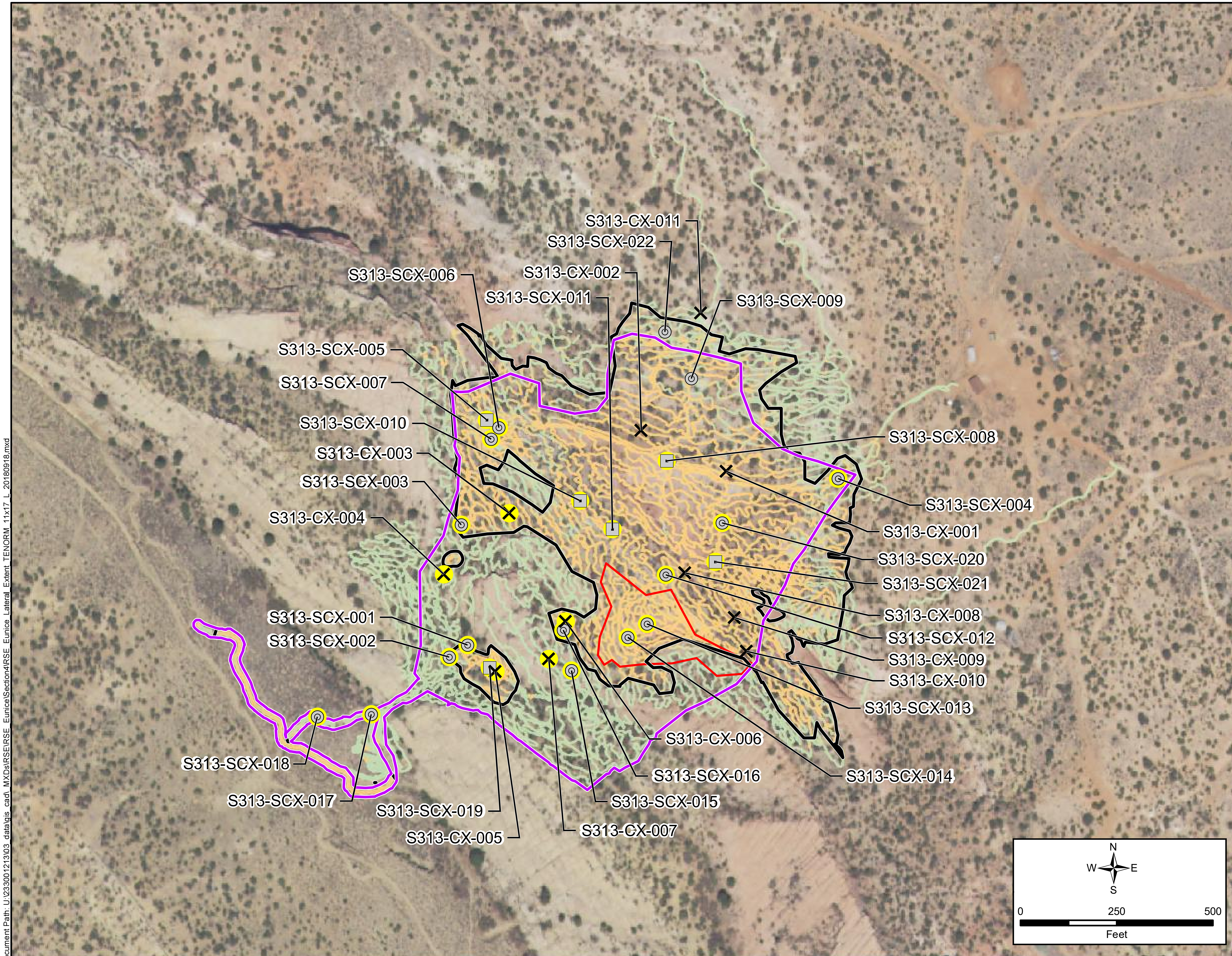
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: WDC

REVIEWER: CBB

FIGURE: 4-5



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- IL Exceedance in Unconsolidated Material at Location
- TENORM (19.8 acres)
- Approximate Area where Surface Gamma ILs are Exceeded (16.3 acres)
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

IL Not Exceeded
Survey Area A: 5,203 - 12,184
Survey Area B: 5,368 - 16,336
Survey Area C: 6,855 - 15,223
Survey Area D: 7,430 - 14,697
Survey Area E: 4,543 - 10,189

IL Exceeded
Survey Area A: 12,185 - 114,187
Survey Area B: 16,337 - 401,121
Survey Area C: 15,224 - 136,164
Survey Area D: 14,698 - 18,510
Survey Area E: 10,190 - 199,804

NOTE:
Refer to Figure 3-4 for Survey Area delineation.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

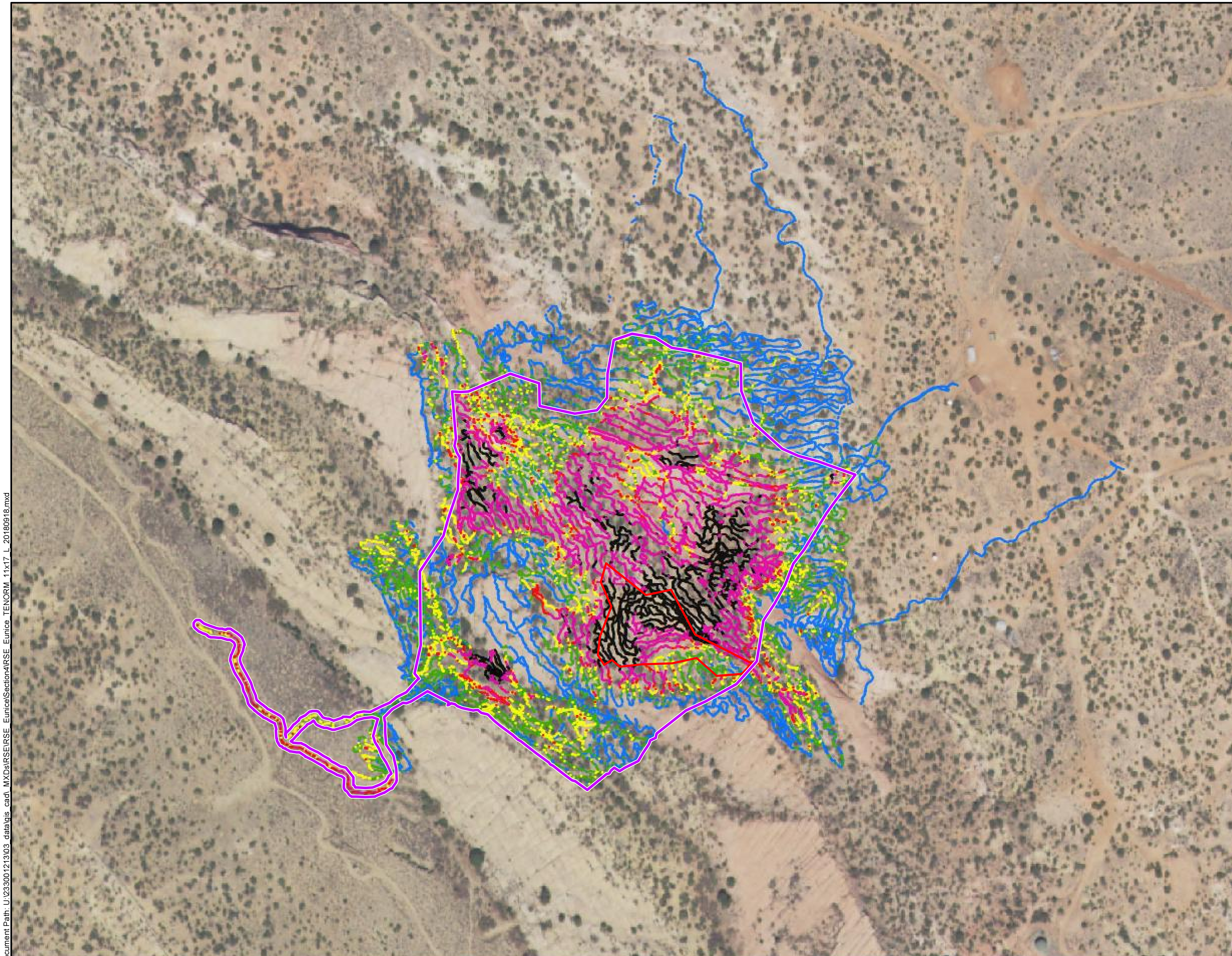
Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (https://gis.apfo.usda.gov/arcgis/services/) on 9/18/2018

TITLE:
TENORM Compared to Lateral Extent of IL Exceedances

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE:	DOCUMENT NAME:	
9/18/2018	Removal Site Evaluation Report	
Stantec	AUTHOR: WDC	REVIEWER: CBB
	FIGURE: 4-6	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_Lateral_Extent_TENORM_11x17_L_20180918.mxd



TITLE: TENORM Compared to Gamma Radiation Survey Results

PROJECT: Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 9/18/2018

DOCUMENT NAME: Removal Site Evaluation Report

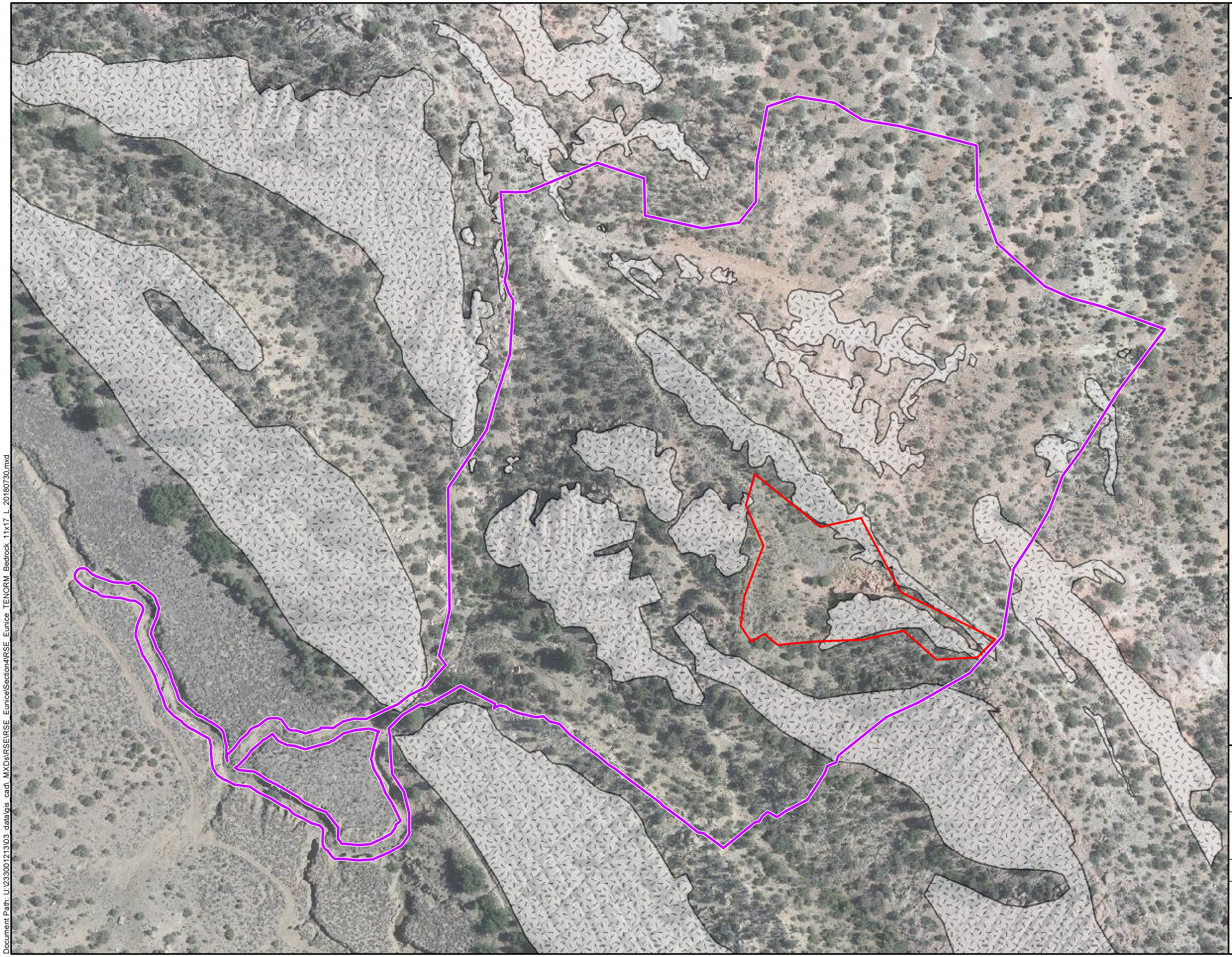
Stantec

AUTHOR: WDC

REVIEWER: CBB

FIGURE: 4-7a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_TENORM_11x17_L_20180918.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- TENORM (19.8 acres)
- Exposed Bedrock[1]
- Claim Boundary

NOTE:
1. Portions of the areas delineatd as exposed bedrock contain small amounts of colluvium.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N
W E
S

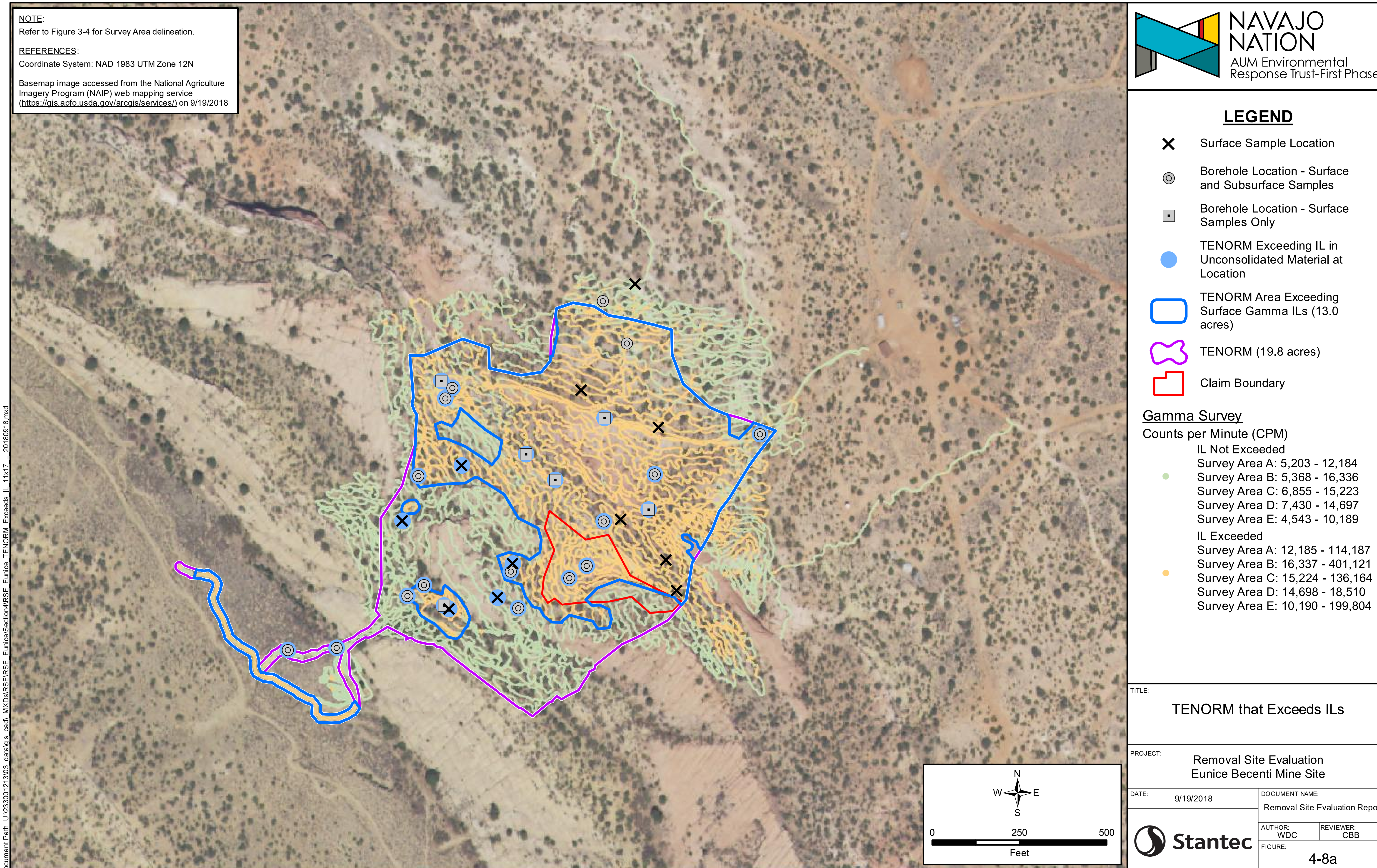
0 150 300
Feet

TITLE: TENORM Compared to Exposed Bedrock

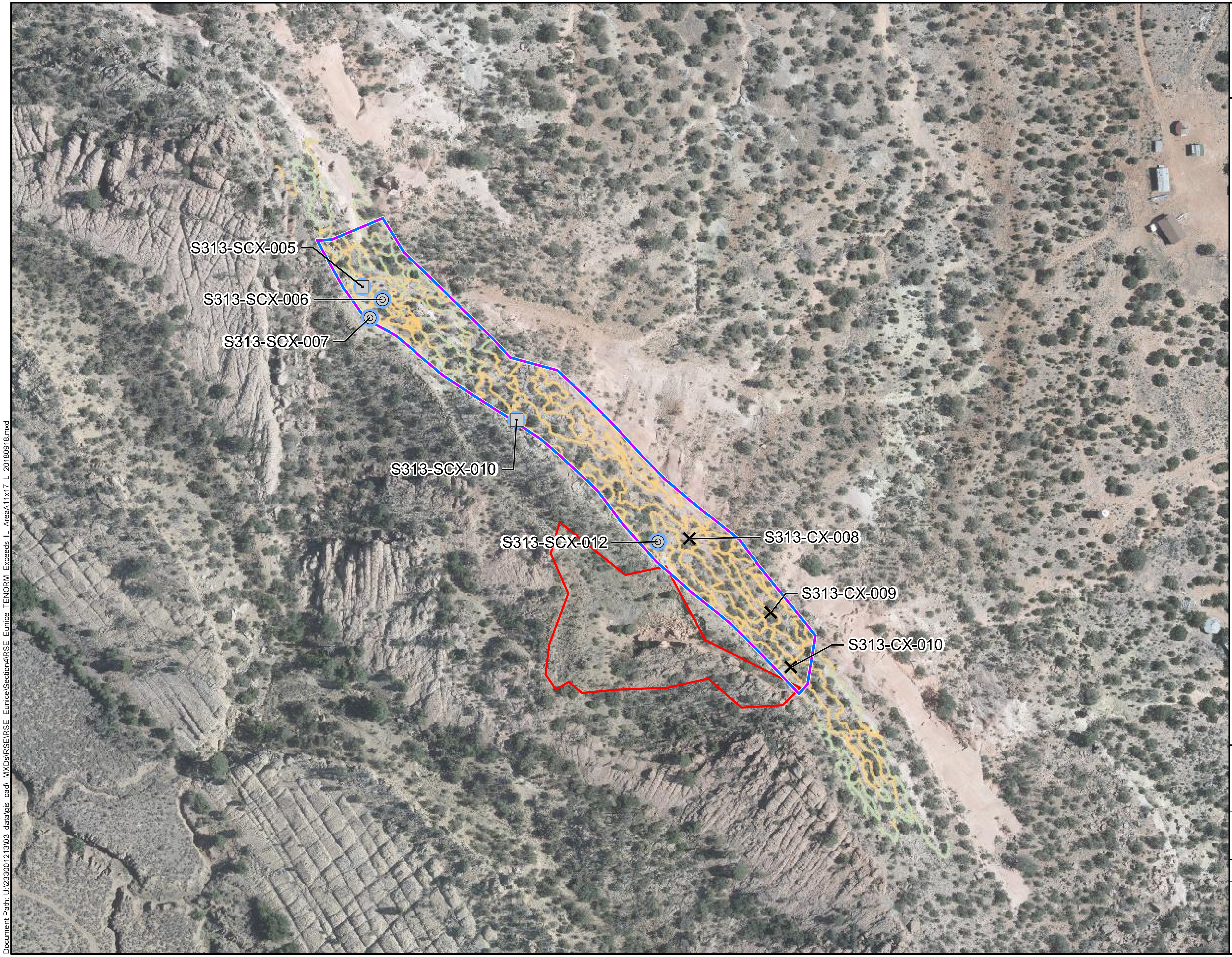
PROJECT: Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 7/30/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: WDC; REVIEWER: CBB
	FIGURE: 4-7b

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_TENORM_Bedrock_11x17_L_20180730.mxd



NOTE:
Refer to Figure 3-4 for Survey Area delineation.
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 9/19/2018
NAVAJO NATION
AUM Environmental Response Trust-First Phase
LEGEND
Surface Sample Location
Borehole Location - Surface and Subsurface Samples
Borehole Location - Surface Samples Only
TENORM Exceeding IL in Unconsolidated Material at Location
TENORM Area Exceeding Surface Gamma ILs (13.0 acres)
TENORM (19.8 acres)
Claim Boundary
Gamma Survey
Counts per Minute (CPM)
IL Not Exceeded
Survey Area A: 5,203 - 12,184
Survey Area B: 5,368 - 16,336
Survey Area C: 6,855 - 15,223
Survey Area D: 7,430 - 14,697
Survey Area E: 4,543 - 10,189
IL Exceeded
Survey Area A: 12,185 - 114,187
Survey Area B: 16,337 - 401,121
Survey Area C: 15,224 - 136,164
Survey Area D: 14,698 - 18,510
Survey Area E: 10,190 - 199,804
N
W
E
S
0
250
500
Feet
TITLE:
TENORM that Exceeds ILs
PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site
DATE: 9/19/2018
DOCUMENT NAME: Removal Site Evaluation Report
Stantec
AUTHOR: WDC
REVIEWER: CBB
FIGURE: 4-8a
Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_TENORM_Exceeds_IL_11x17_L_20180918.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (2.3 acres)
- TENORM (2.3 acres)
- Claim Boundary

Gamma Survey
Counts per Minute (CPM)

- 5,203 - 12,184 (IL Not Exceeded)
- 12,185 - 114,187 (IL Exceeded)

NOTE:
1. Gamma Survey Area A is approximately 3.2 acres

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N W E S

0 150 300
Feet

TITLE: TENORM that Exceeds ILs for Survey Area A

PROJECT: Removal Site Evaluation Eunice Becenti Mine Site

DATE: 9/18/2018

DOCUMENT NAME: Removal Site Evaluation Report

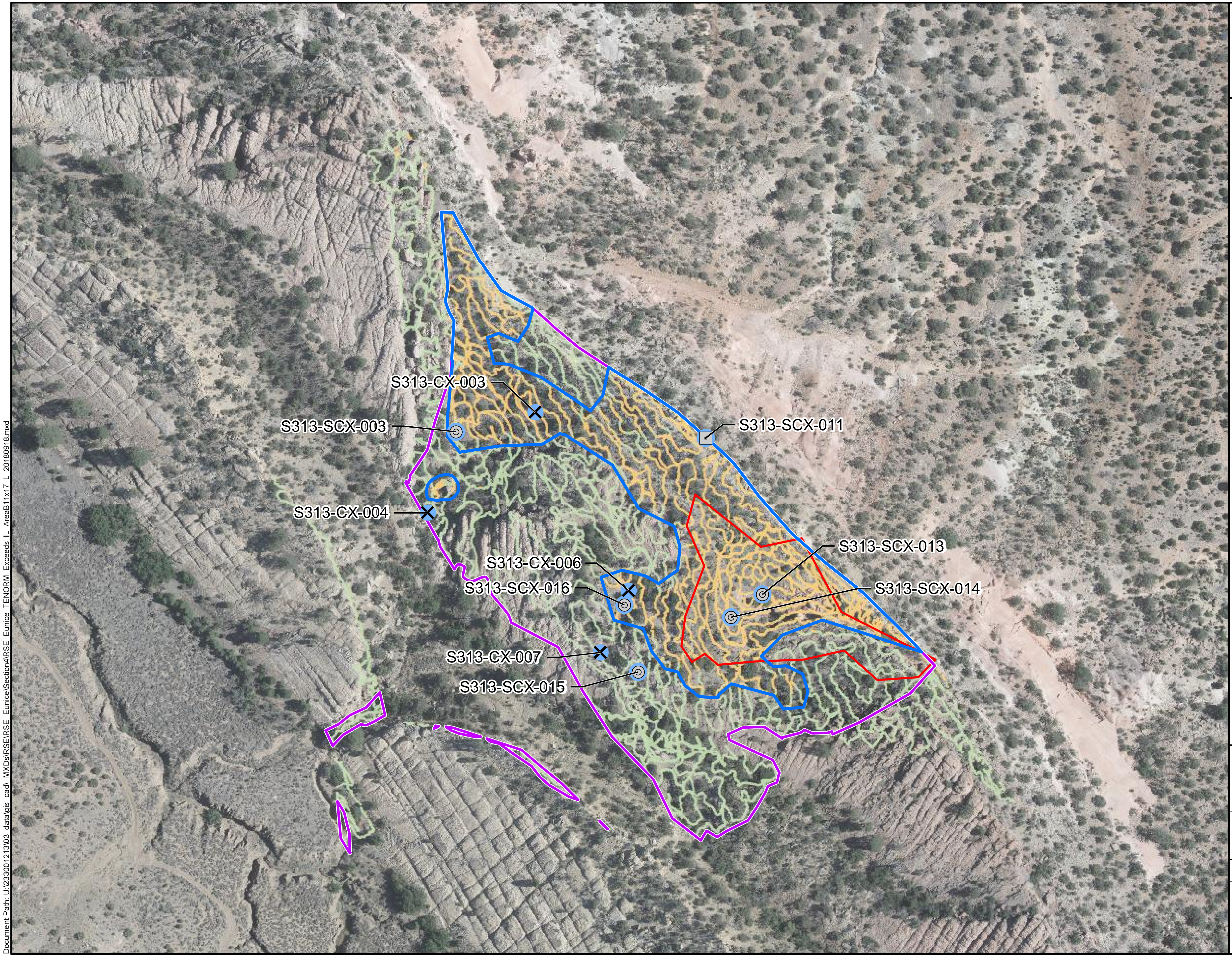
AUTHOR: WDC

REVIEWER: CBB

Stantec

FIGURE: 4-8b

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE\RSE_Eunice\Section4\RSE_Eunice_TENORM_Exceeds_IL_AreaA11x17_L_20180918.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (3.5 acres)
- TENORM (8.0 acres)
- Claim Boundary

Gamma Survey
Counts per Minute (CPM)

- 5,368 - 16,336 (IL Not Exceeded)
- 16,337 - 401,121 (IL Exceeded)

NOTE:
1. Gamma Survey Area B is approximately 9.5 acres

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N W E S

0 150 300
Feet

TITLE:
TENORM that Exceeds ILs for Survey Area B

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE:	DOCUMENT NAME:
9/18/2018	Removal Site Evaluation Report

AUTHOR:	REVIEWER:
WDC	CBB

Stantec

FIGURE: 4-8c

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_TENORM_Exceeds_IL_AreaB11x17_L_20180918.mxd

NOTES:

1. Area within Survey Areas that was not surveyed due to steep/unsafe terrain.

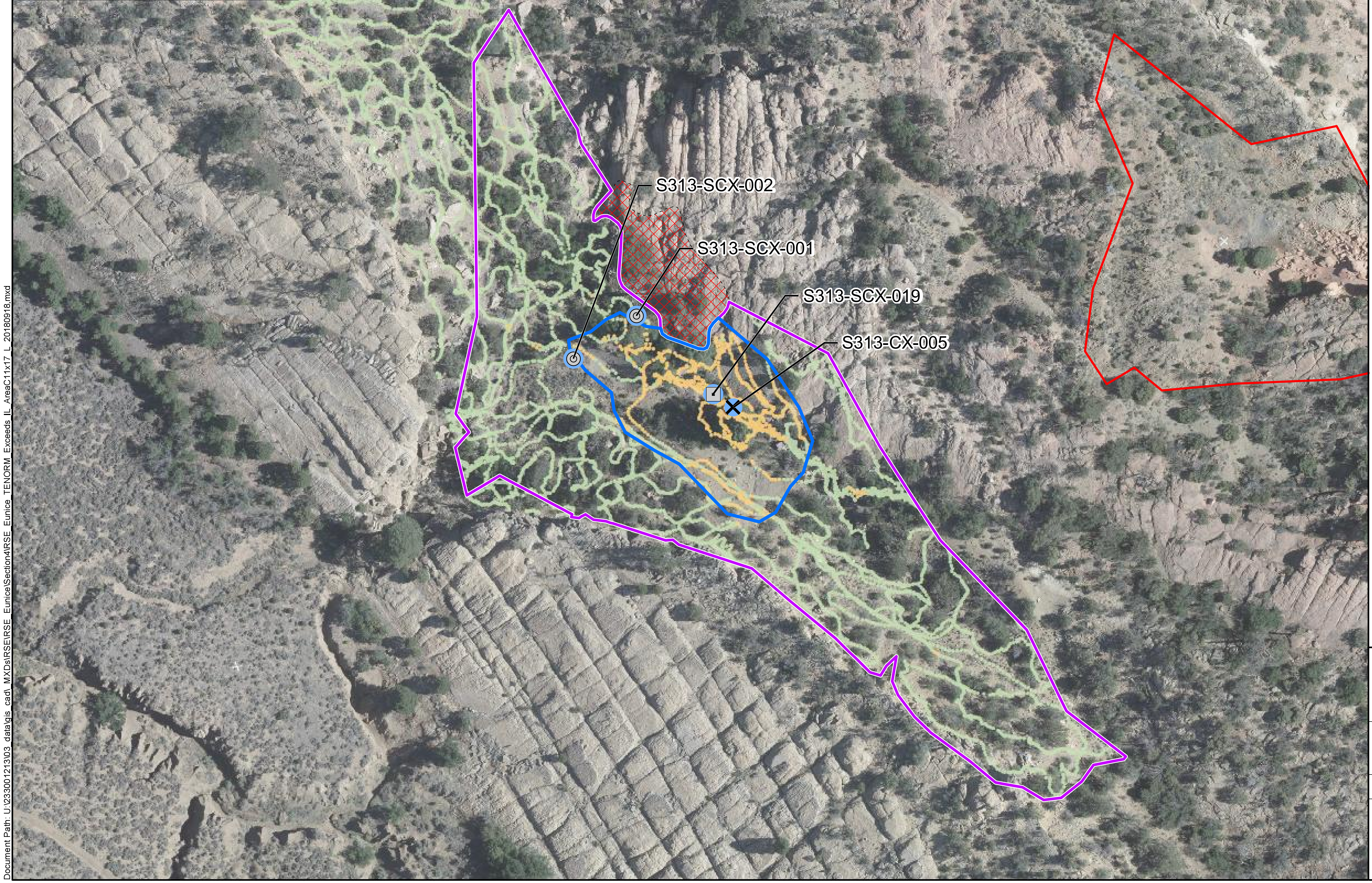
2. Gamma Survey Area C is approximately 2.9 acres

3. Unsurveyed area is included in TENORM area estimate.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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



NAVAJO NATION

AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (0.4 acres)
- TENORM (2.1 acres)
- TENORM Unsurveyed [1] (0.1 acres)
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 6,855 - 15,223 (IL Not Exceeded)
- 15,224 - 136,164 (IL Exceeded)

N W E S

0 80 160

Feet

TITLE:

TENORM that Exceeds ILs for Survey Area C

PROJECT:

Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 9/21/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: WDC / REVIEWER: CBB
	FIGURE: 4-8d

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_TENORM_Exceeds_IL_AreaC11x17_L_20180918.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Borehole Location - Surface and Subsurface Samples
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (0.4 acres)
- TENORM (0.7 acres)
- Claim Boundary

Gamma Survey
Counts per Minute (CPM)

- 7,430 - 14,697 (IL Not Exceeded)
- 14,698 - 18,510 (IL Exceeded)

NOTE:
1. Gamma Survey Area D is approximately 1.0 acres

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N W E S

0 60 120
Feet

TITLE: TENORM that Exceeds ILs for Survey Area D

PROJECT: Removal Site Evaluation Eunice Becenti Mine Site

DATE: 9/18/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: WDC

REVIEWER: CBB

Stantec

FIGURE: 4-8e

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_TENORM_Exceeds_IL_AreaD11x17_L_20180918.mxd

NOTES:

1. Area within Survey Areas that was not surveyed due to steep/unsafe terrain.

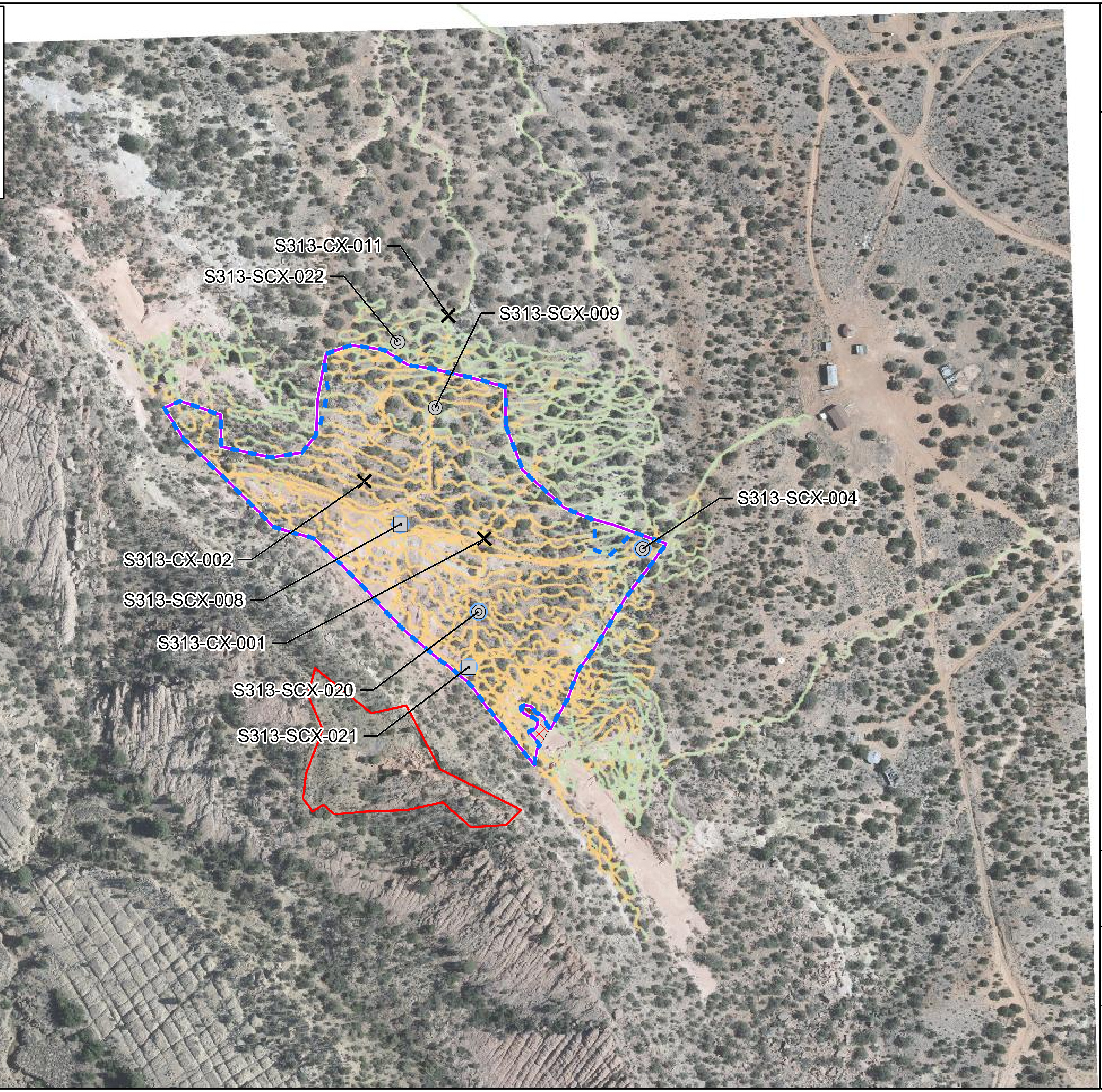
2. Gamma Survey Area E is approximately 14.3 acres.

3. Unsurveyed area is included in TENORM area estimate.

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 9/21/2018



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (6.4 acres)
- TENORM (6.5 acres)
- TENORM Unsurveyed [1] (less than 0.1 acres)
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 4,543 - 10,189 (IL Not Exceeded)
- 10,190 - 199,804 (IL Exceeded)

N W E S

0 200 400

Feet

TITLE:

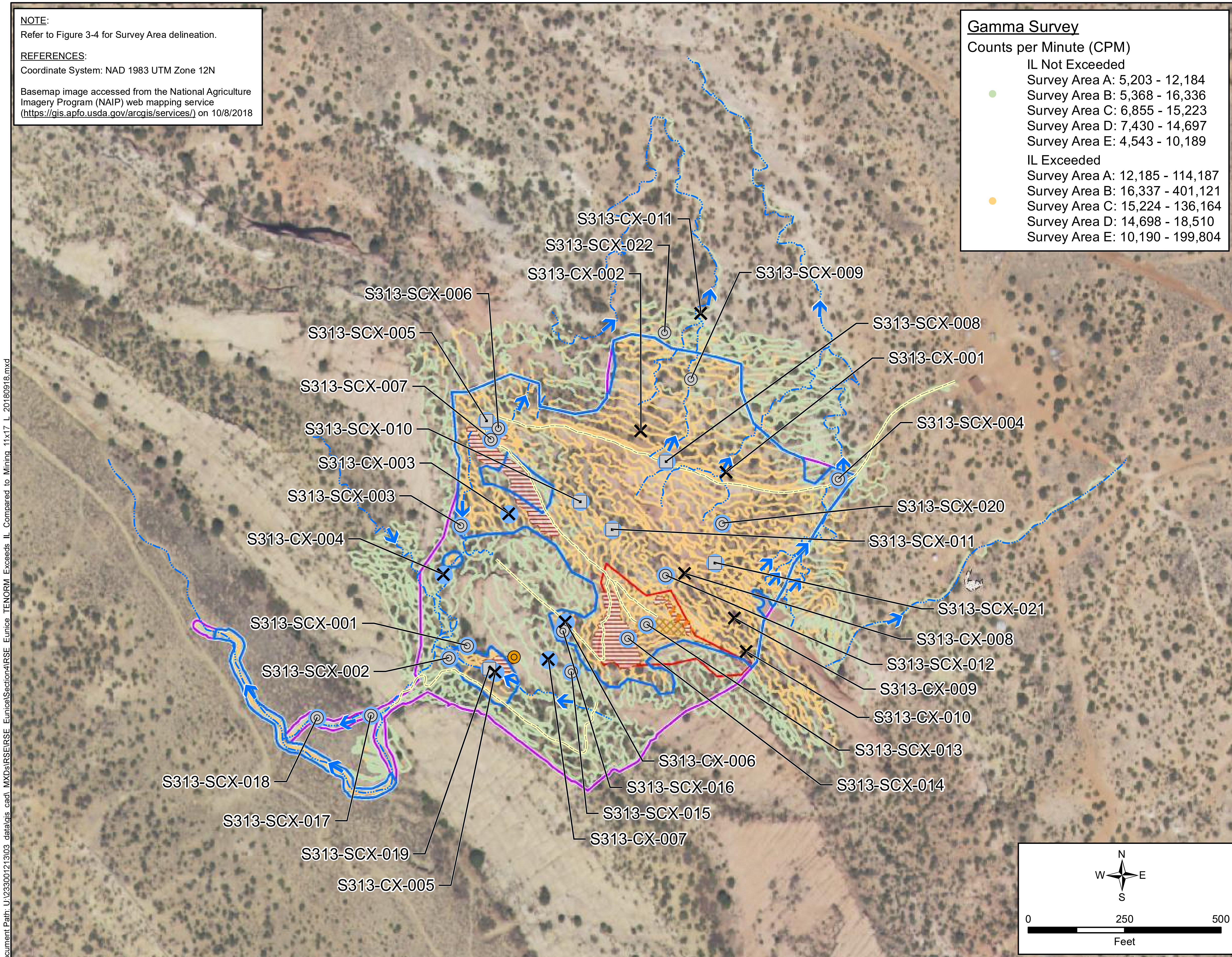
TENORM that Exceeds ILs for Survey Area E

PROJECT:

Removal Site Evaluation
Eunice Becenti Mine Site

DATE:	DOCUMENT NAME:	
9/21/2018	Removal Site Evaluation Report	
Stantec	AUTHOR: WDC	REVIEWER: CBB
	FIGURE: 4-8f	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_TENORM_Exceeds_IL_AreaE11x17_L_20180918.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- TENORM Exceeding IL in Unconsolidated Material at Location
- Adit
- Flow Direction
- Drainage
- Potential Haul Road
- Blasted Area
- Debris
- Excavation
- Waste Pile
- TENORM Area Exceeding Surface Gamma ILs (13.0 acres)
- TENORM (19.8 acres)
- Claim Boundary

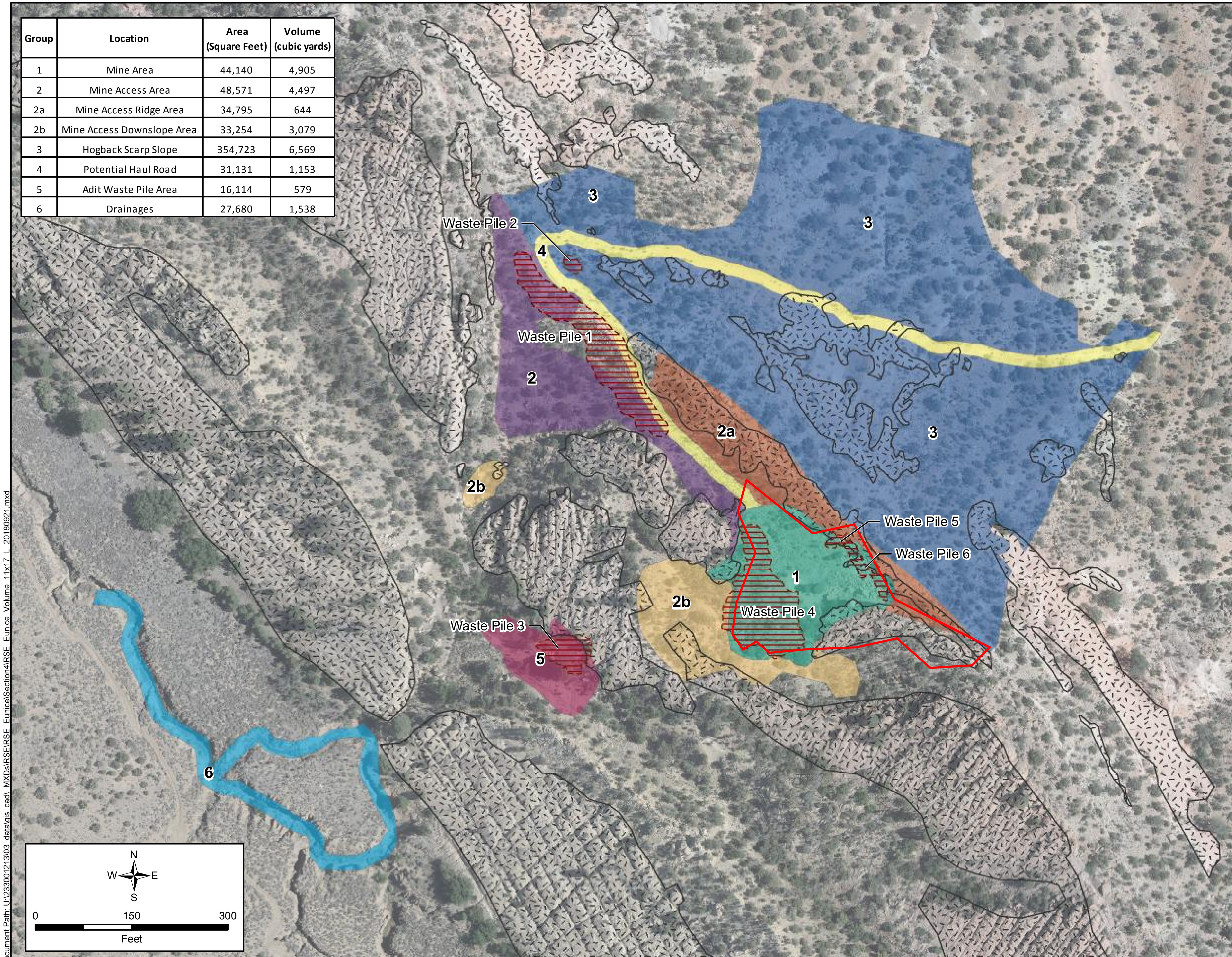
TITLE:
TENORM that Exceeds ILs Compared to Mining Related Features

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 10/8/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: WDC	REVIEWER: CBB
	FIGURE: 4-8g	

Document Path: U:\1233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_TENORM_Exceeds_IL_Compared_to_Mining_11x17_L_20180918.mxd

Group	Location	Area (Square Feet)	Volume (cubic yards)
1	Mine Area	44,140	4,905
2	Mine Access Area	48,571	4,497
2a	Mine Access Ridge Area	34,795	644
2b	Mine Access Downslope Area	33,254	3,079
3	Hogback Scarp Slope	354,723	6,569
4	Potential Haul Road	31,131	1,153
5	Adit Waste Pile Area	16,114	579
6	Drainages	27,680	1,538



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Exposed Bedrock[1]
Waste Pile
Claim Boundary

Average Depth by Group (feet below ground surface)

- Group 1 - Mine Area - 3 ft
- Group 2 - Mine Access Area - 2.5 ft
- Group 2a - Mine Access Ridge Area - 0.5 ft
- Group 2b - Mine Access Downslope Area - 2.5 ft
- Group 3 - Hogback Scarp Slope - 0.5 ft
- Group 4 - Potential Haul Road - 1 ft
- Group 5 - Adit Waste Pile Area - Variable
- Group 6 - Drainages - 1.5 ft

NOTE:
1. Portions of the areas delineatd as exposed bedrock contain small amounts of colluvium.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

TITLE:
Volume Estimate of TENORM that Exceeds ILs

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 9/21/2018

DOCUMENT NAME: Removal Site Evaluation Report

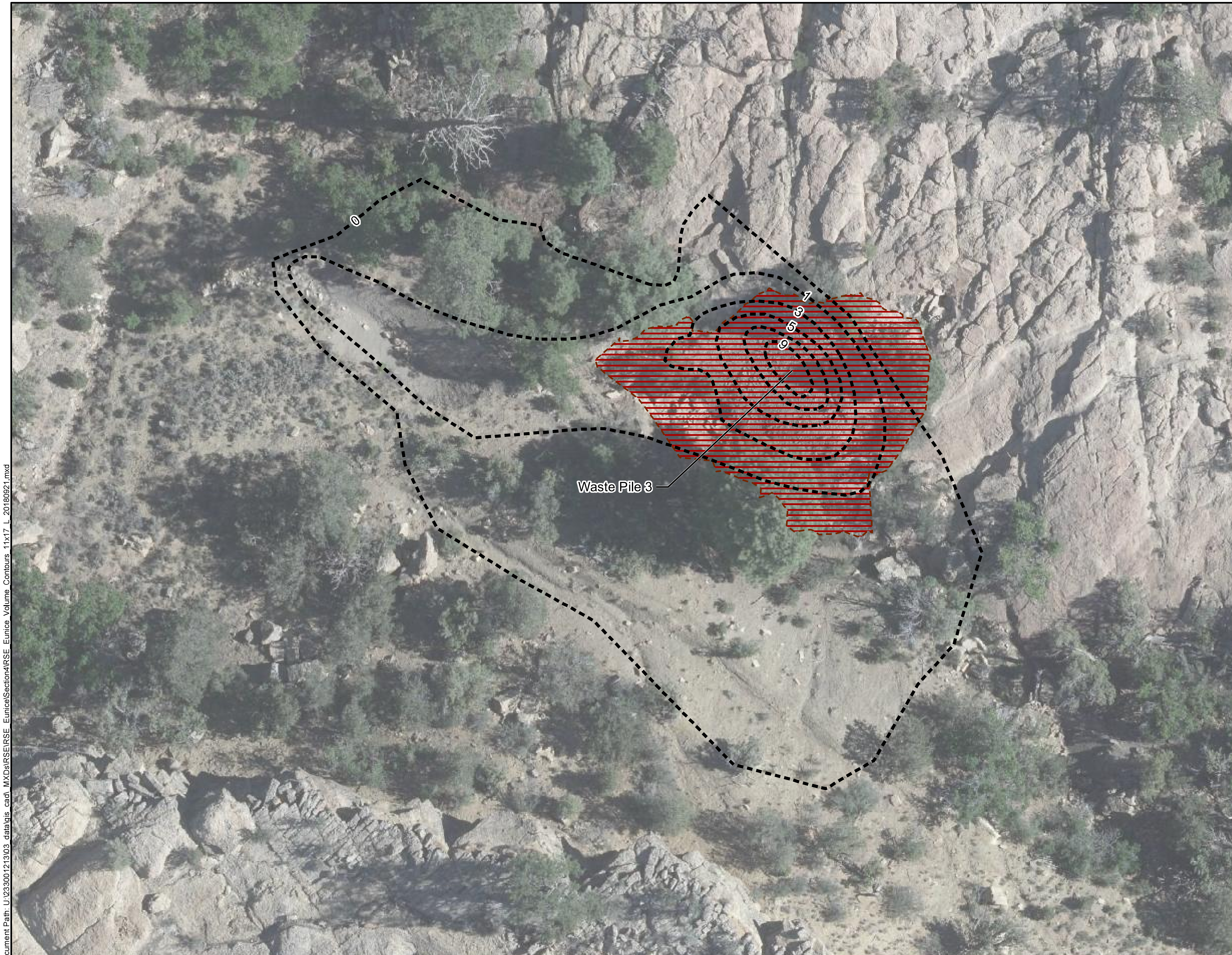
Stantec

AUTHOR: CBB

REVIEWER: KJJ

FIGURE: 4-9a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_Volume_11x17_L_20180921.mxd



Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\Section4\RSE_Eunice_Volume_Contours_11x17_L_20180921.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Approximate Group 5 Contour (thickness in feet)
- Waste Pile

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

N W E S

0 25 50

Feet

TITLE: Group 5 Contours for Volume Estimate

PROJECT: Removal Site Evaluation Eunice Becenti Mine Site

DATE: 9/21/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: KJJ
	FIGURE: 4-9b	

APPENDICES

Appendix A Radiological Characterization of the Eunice Becenti Abandoned Uranium Mine

Radiological Characterization of the Eunice Becenti Abandoned Uranium Mines

September 19, 2018

prepared for:

Stantec Consulting Services Inc.

2130 Resort Drive, Suite 350
Steamboat Springs, CO 80487

prepared by:

ERG

Environmental Restoration Group, Inc.

8809 Washington St. NE
Suite 150
Albuquerque, NM 87113

Contents

Tables

Figures

Appendices

Acronyms

ANSI	American National Standards Institute
AUM	abandoned uranium mine
BG1	Background Reference Area 1
BG2	Background Reference Area 2
BG3	Background Reference Area 3
BG4	Background Reference Area 4
BG5	Background Reference Area 5
cpm	counts per minute
DQOs	data quality objectives
EPA	U.S. Environmental Protection Agency
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 Eunice Becenti abandoned uranium mine (AUM) located in the Church Rock Chapter of the Navajo Nation southeast of Gallup, New Mexico. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. (ERG) of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase.

This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of the gamma count rates at this AUM to exposure rates and concentrations of radium-226 in surface soils, and 3) an assessment of equilibrium in the uranium series. The field activities addressed in this report were conducted on May 6 and November 19, 2016; March 24 and 27, 2017; June 27 to 29, 2017; and September 15, 2017. They included a GPS-based radiological survey of land surfaces over a Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, and areas where the survey was extended; and correlation studies.

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in the "Eunice Becenti 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 largely on naturally occurring outcrops and waste rock in and extending outward from the mine claim; and a waste pile associated with a portal outside the mine claim.

- Five potential Background Reference Areas were established for this AUM.

- 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) = 1630 x [radium-226 (pCi/g)] + 5945

- 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 -0.9 to 242.4 pCi/g, with a central tendency (median) of 3.4 pCi/g.

- The thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226 in surface soil from gamma count rates.

- There is evidence that the uranium series radionuclides are in equilibrium, but not secular equilibrium.

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

$$\text{Exposure Rate } (\mu R/h) = 4\text{x}10^{-4} \text{ x Gamma Count Rate (cpm)} + 8.9902$$

- The distribution of exposure rates predicted using this model is rightward tailed. The values in the Survey Area range from 10.8 to 169.4, with a central tendency (median) of 13.6 μR/h.

1.0 Introduction

This report addresses the radiological characterization of the Eunice Becenti abandoned uranium mine (AUM) located in the Church Rock Chapter of the Navajo Nation southeast of Gallup, New Mexico. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. (ERG) of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase.

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

The 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 addressed in this report were conducted on May 6 and November 19, 2016; March 24 and 27, 2017; June 27 to 29, 2017; and September 15, 2017 in accordance with the methods described in the RSE Work Plan. They included a GPS-based radiological survey of land surfaces over an approximately 31-acre Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, and areas where the survey was extended; and correlation studies. Section 3.0 of the RSE Workplan 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 "Eunice Becenti 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 "Eunice Becenti Removal Site Evaluation Report" (Stantec, 2018).

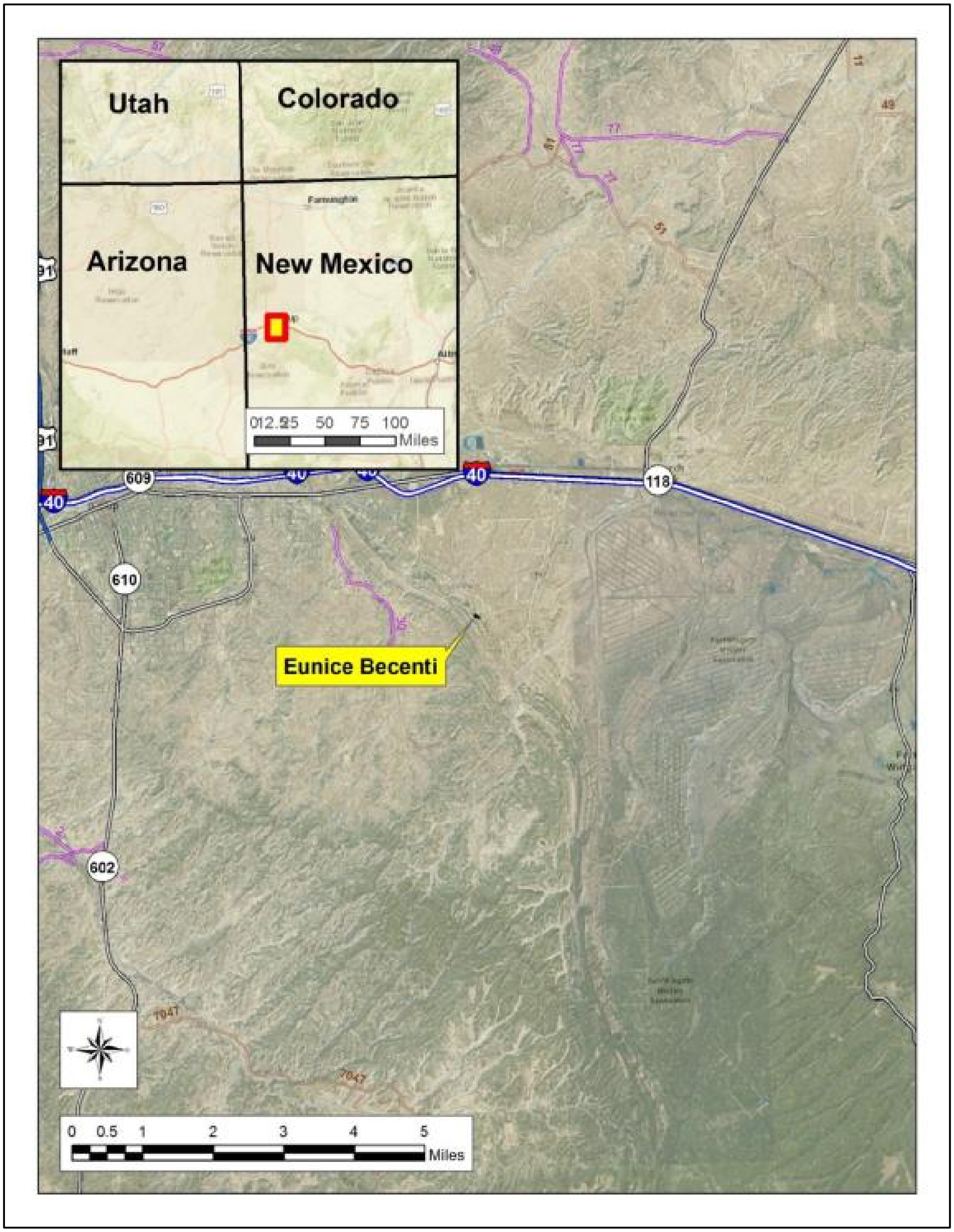


Figure 1. Location of the Eunice Becenti Abandoned Uranium Mine.

2.0 GPS-Based Gamma Survey

This section addresses the GPS-based surveys conducted in five potential Background Reference Areas and the Survey Area. The survey was extended to bound areas in which elevated count rates were observed. Table 1 lists the detection systems used in the survey. Pursuant to the approved RSE 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 workplan.

It cannot be easily determined what detector in Table 1 collected a specific set of data. ERG makes every attempt to match detector responses for all detectors used on a project. ERG expects any differences between detectors used on the same site to be smaller than the statistical variability associated with the regression models used to predict radium-226 concentrations and exposure rate. Use of gamma count rates should be limited to screening purposes.

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.

Area	Ludlum Model 44-10	Ludlum Model 2221 Ratemeter/Scaler
Potential Background Reference Areas	PR295014	196086
	PR303727[a]	254772[a]
	PR321872	108878
Survey Area	PR150507	282966
	PR295014	196086
	PR320678	282971
	PR321872	108878
	PR355763[b]	138368[b]

Notes:
[a]Detection system used in the correlation study described in Section 3.1.
[b]Detection system used in the correlation study described in Section 3.3.

2.1 Potential Background Reference Areas

Five potential Background Reference Areas were surveyed, the locations and results of which are depicted on Figure 2. BG1, BG2, BG3, BG4, and BG5 in the figure are Background Reference Areas 1 through 5, respectively.

Table 2 lists a summary of the gamma count rates, which in:

- BG1 ranged from 7,029 to 13,185 counts per minute (cpm), with a mean and median of 9,739 and 9,626 cpm, respectively.
- BG2 ranged from 8,871 to 19,139 cpm, with a mean and median of 12,922 and 12,851 cpm, respectively.
- BG3 ranged from 8,694 to 16,609 cpm, with a mean and median of 12,804 and 12,948 cpm, respectively.
- BG4 ranged from 10,729 to 15,777 cpm, with a mean and median of 12,927 and 12,839 cpm, respectively.
- BG5 ranged from 5,705 to 12,233 cpm, with a mean and median of 8,443 and 8,457 cpm, respectively.

Table 2. Summary statistics for gamma count rates in the potential Background Reference Areas.

	Gamma Count Rate (cpm)					
Potential Background Reference Area	**n**	**Minimum**	**Maximum**	**Mean**	**Median**	**Standard Deviation**
1	188	7,029	13,185	9,739	9,626	1,327
2	242	8,871	19,139	12,922	12,851	1,879
3	419	8,694	16,609	12,804	12,948	1,364
4	226	10,729	15,777	12,927	12,839	971
5	804	5,705	12,233	8,443	8,457	1,005

Notes:
cpm = counts per minute

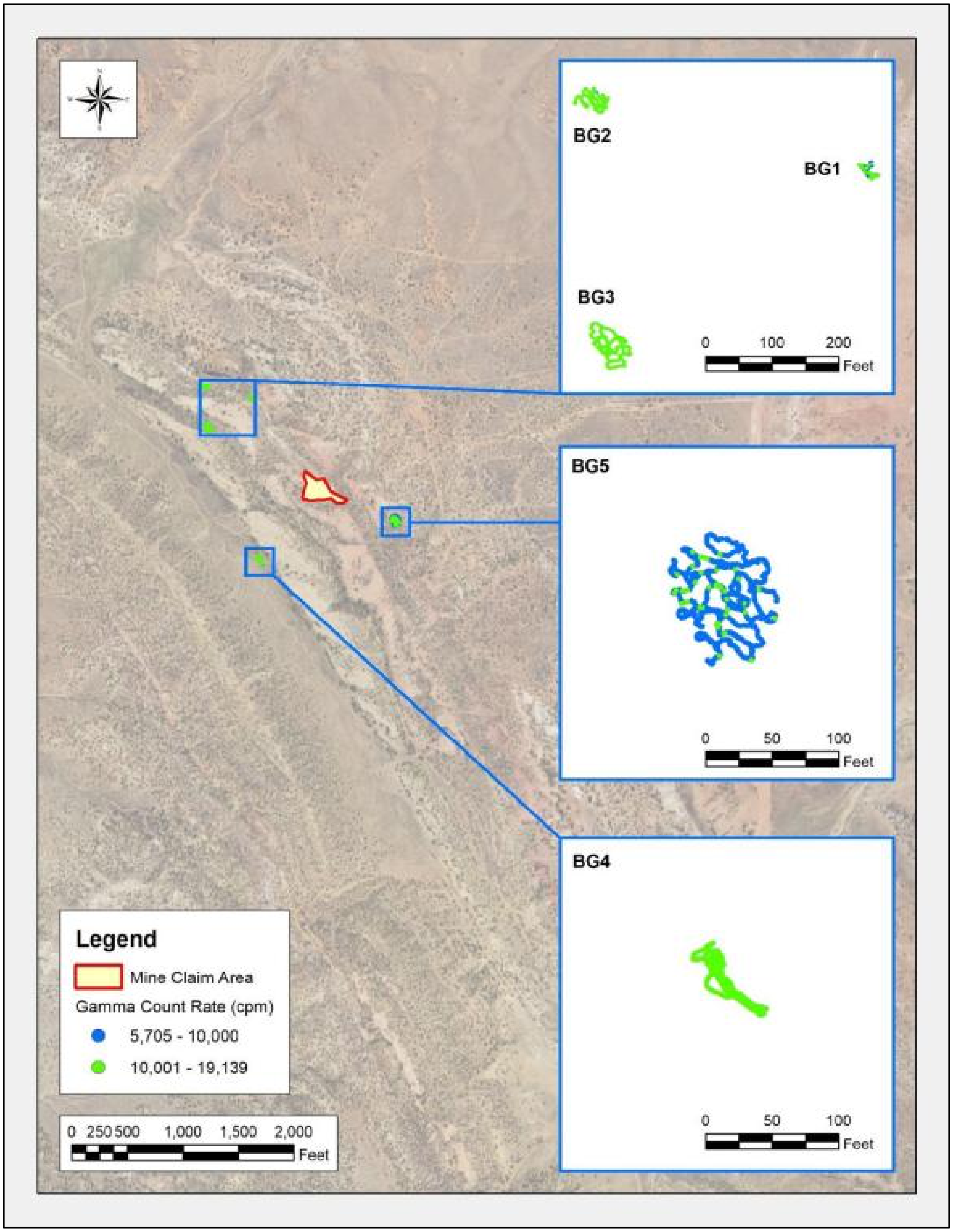


Figure 2. Gamma count rates in the potential Background Reference Areas.

Figure 3 depicts a histogram of the gamma count rates in BG1 through BG5. 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.

2.2 Survey Area

The gamma count rates observed in the Survey Area are depicted in Figure 4. Elevated count rates were observed largely on and in naturally occurring outcrops and in waste rock extending from the mine claim; and a waste pile associated with a portal outside the mine claim.

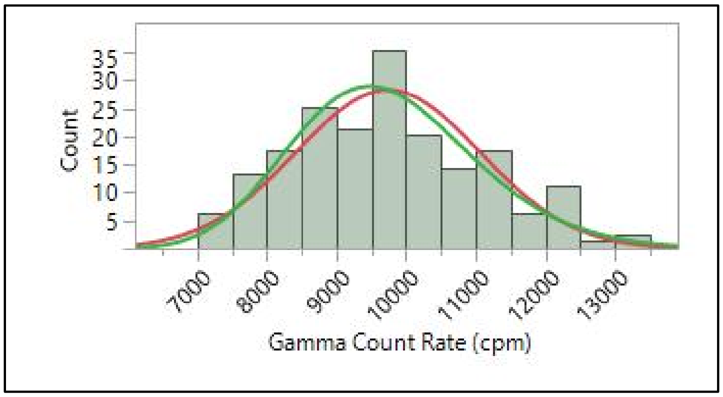
Figure 5 is a histogram of the gamma count rate measurements made in the Survey Area. The red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could be expected if the distributions were normal or lognormal. The distribution 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 left to right, 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 9,145, 11,436, and 18,248 cpm, respectively.

Table 3 is a statistical summary of the measurements, which range from 4,543 to 401,121 cpm and have a central tendency (median) of 11,436 cpm.

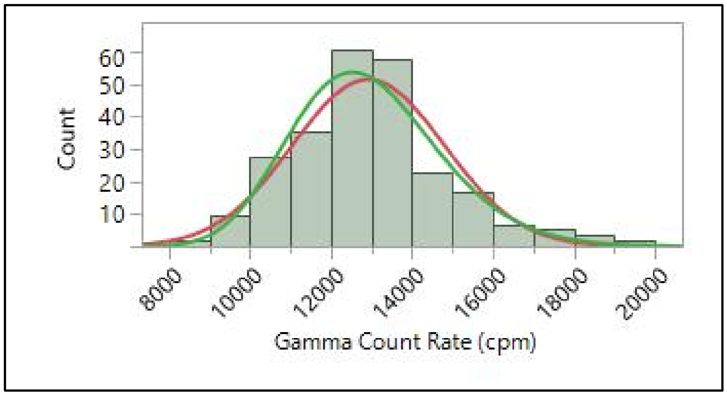
Table 3. Summary statistics for gamma count rates in the Survey Area.

Parameter	Gamma Count Rate (cpm)
n	67,220
Minimum	4,543
Maximum	401,121
Mean	18,025
Median	11,436
Standard Deviation	20,613

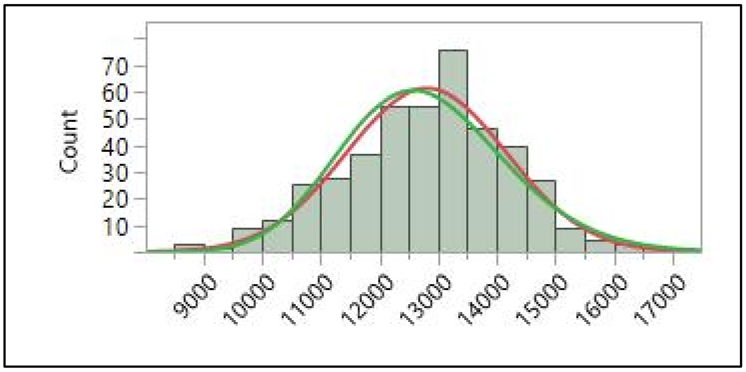
Notes:
cpm = counts per minute



a. **Background Reference Area 1**

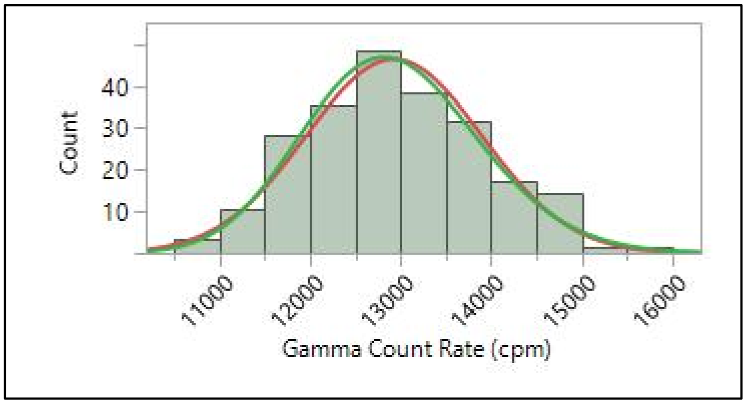


b. **Background Reference Area 2**

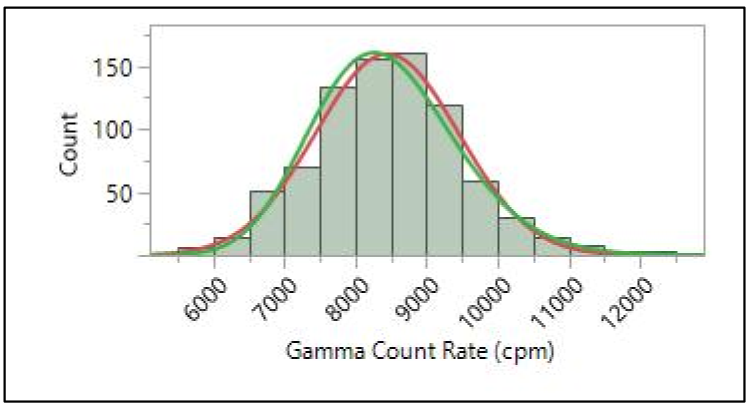


c. **Background Reference Area 3**

Figure 3 (1st of 2). Histograms of gamma count rates in the potential Background Reference Areas.



a. **Background Reference Area 4**



b. **Background Reference Area 5**

Figure 3 (2nd of 2). Histograms of gamma count rates in the potential Background Reference Areas.

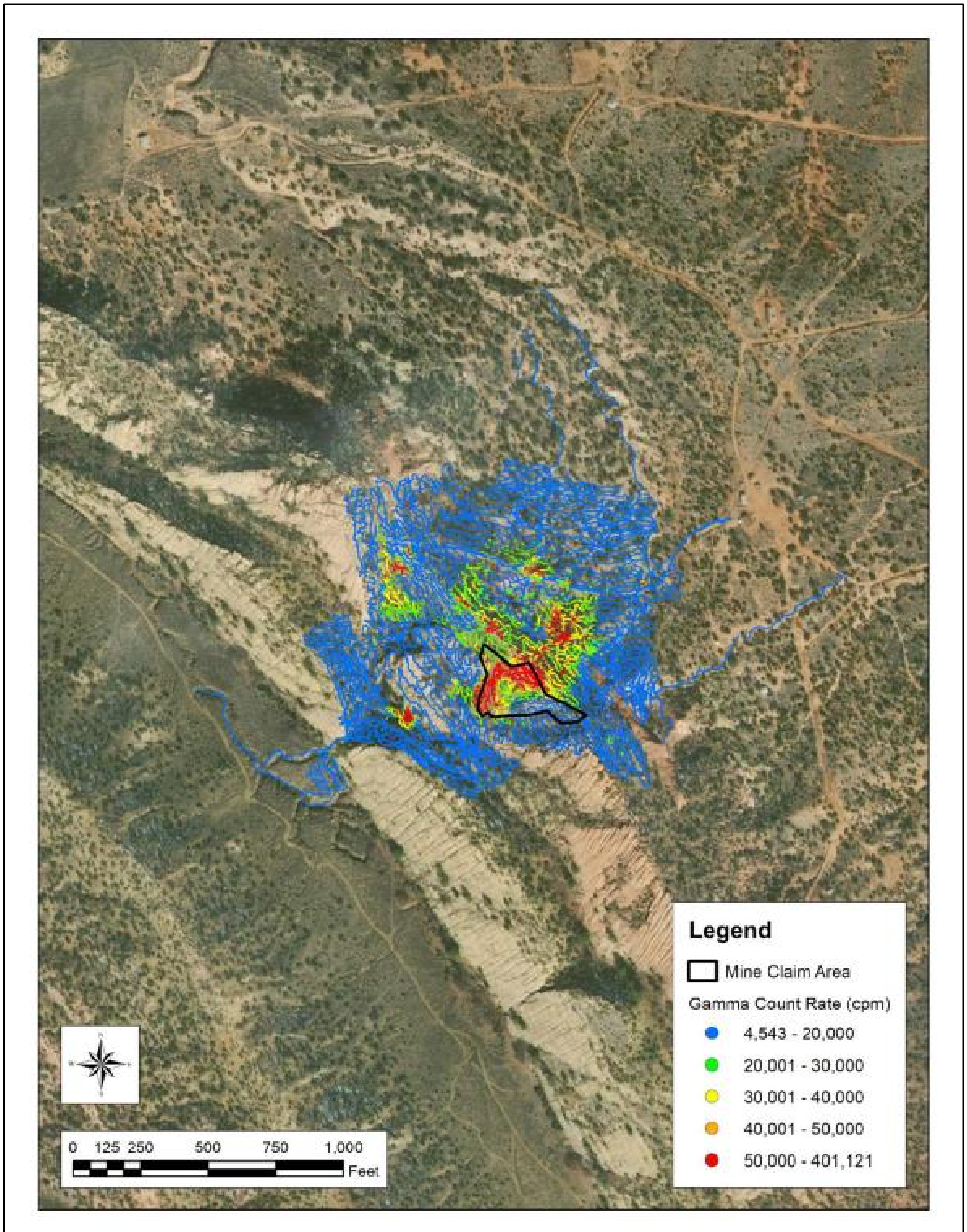


Figure 4. Gamma count rates in the Survey Area.

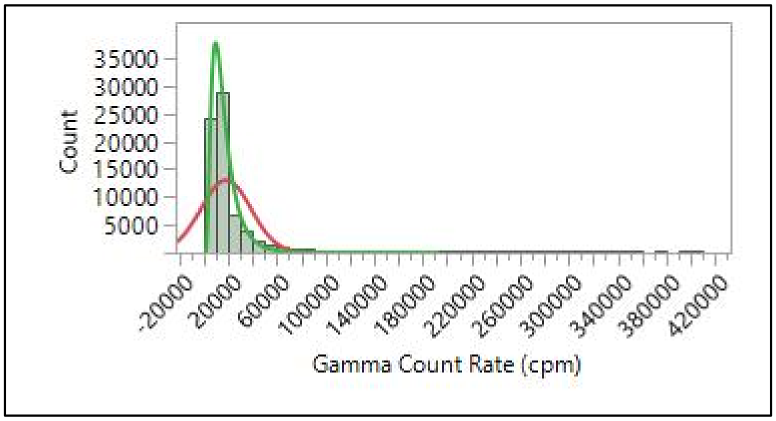


Figure 5. Histogram of gamma count rates in the Survey Area.

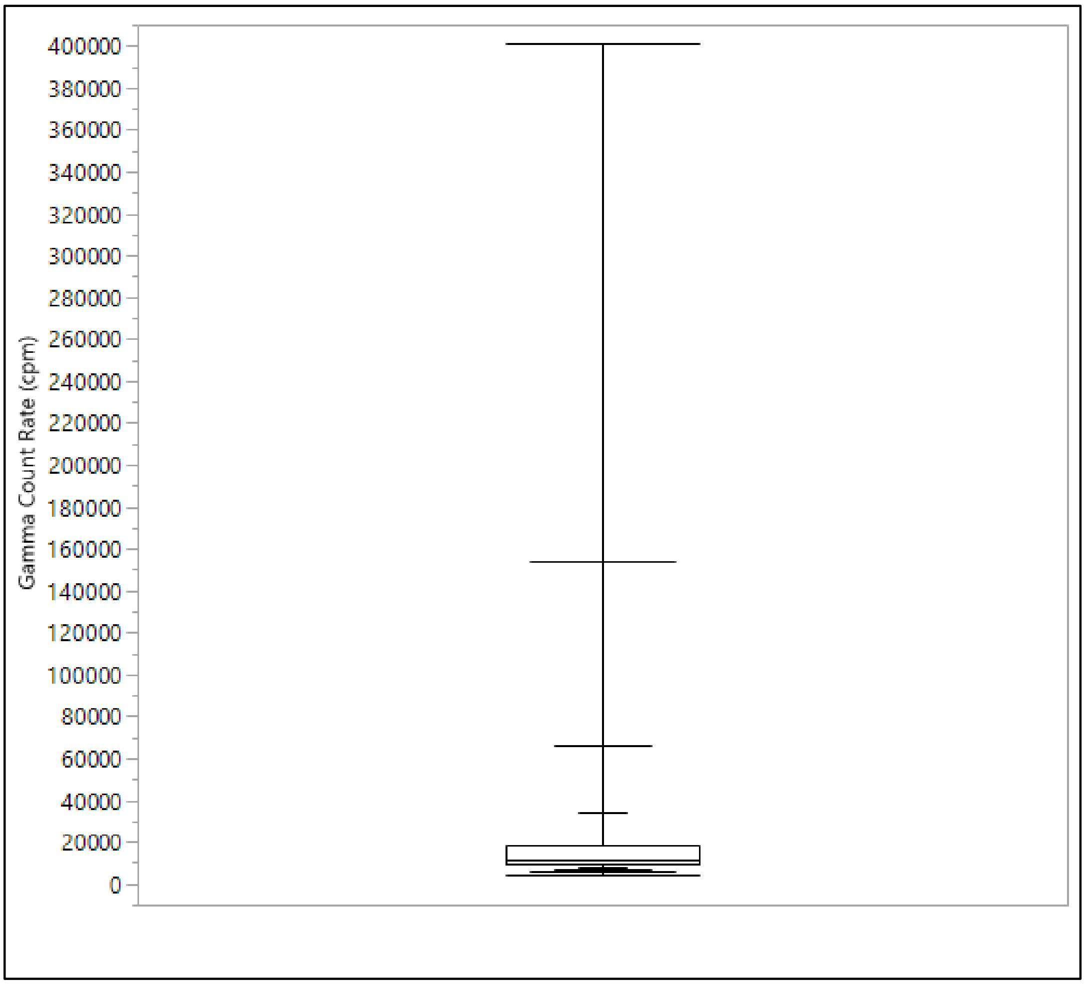


Figure 6. Box plot of gamma count rates in the Survey Area.

3.0 Correlation Studies

The following sections address the activities under two types of correlation studies outlined in the RSE Work Plan: comparisons of 1) radium-226 concentrations in surface soils and gamma count rates and 2) exposure rates and gamma count rates. GPS-based gamma count rate measurements were made over small areas for the former study. The means of the measurements were used in this case. Static gamma count rate measurements, co-located with exposure rate measurements, were used in the latter study.

3.1 Radium-226 concentrations in surface soils and gamma count rates

On March 27, 2017 field personnel made GPS-based gamma count rates measurements and collected five-point composite samples of surface soils in each of five areas at the 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 variations in the gamma count rate measurements could be limited largely to those posed by the soils and rocks at the locations. Figure 7 shows the GPS-based gamma count rate measurements in the five areas (labeled with location identifiers).

The soil samples were analyzed by ALS Laboratories in Ft Collins, CO for radium-226 and isotopic thorium. The latter analysis was included to assess the potential effects of thorium series isotopes on the correlation and evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series.

Table 4 lists the results of the gamma count rate measurements and radium-226 concentrations in the soil samples. The means of the gamma count rate measurements range from 7,411 to 57,769 cpm. The concentrations of radium-226 in the soil samples range from 0.45 to 29.2 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 Reports, in “Eunice Becenti Removal Site Evaluation Report” (Stantec, 2017).

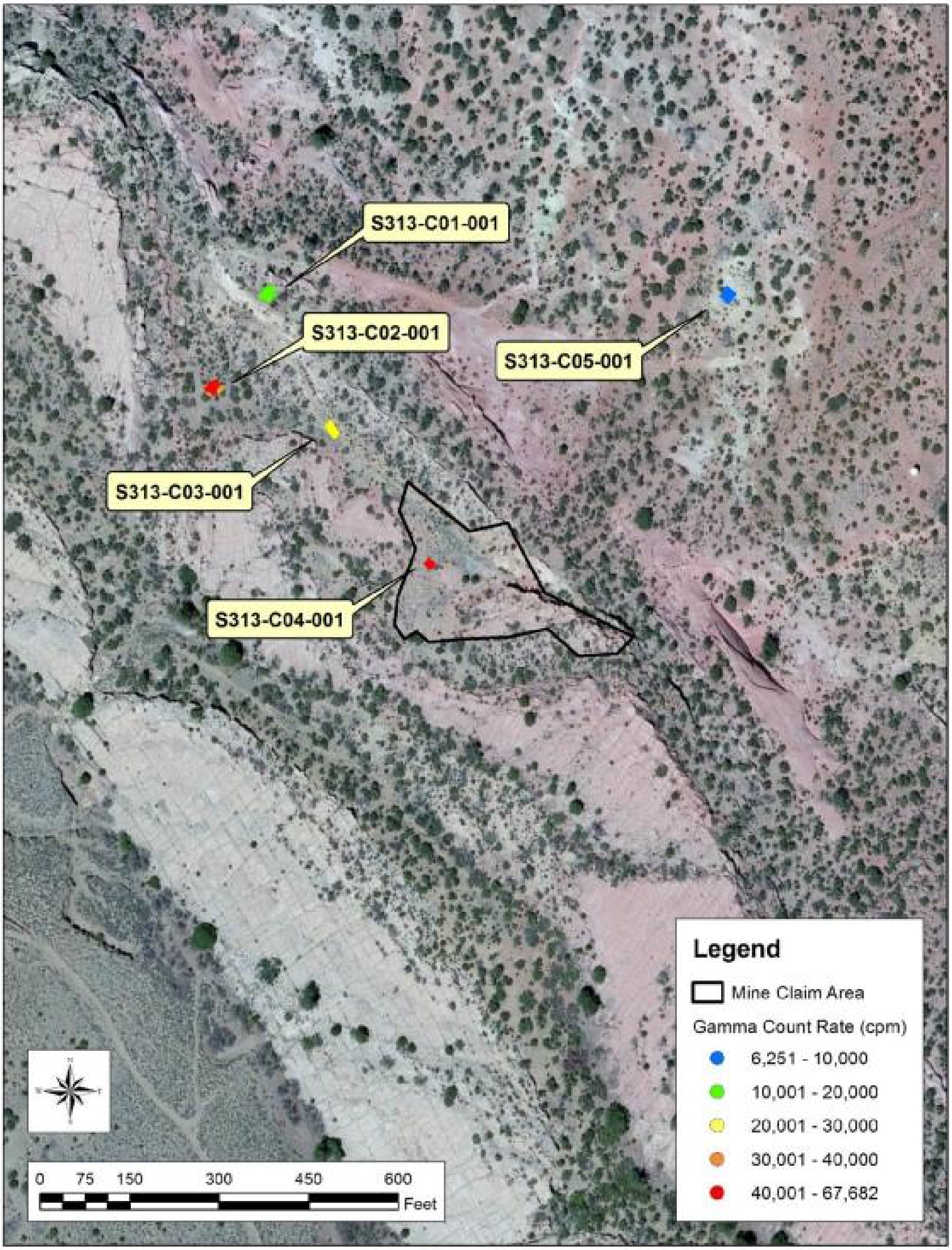


Figure 7. GPS-based gamma count rate measurements made for the correlation study.

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	Area (m^2)	Mean	Minimum	Maximum	σ	Result	Error ±2σ	MDC
S313-C01-001	44.3	13,562	12,796	14,242	367	2.34	0.39	0.35
S313-C02-001	46.4	42,280	36,165	49,577	3,900	22.3	2.7	0.7
S313-C03-001	32.0	21,843	18,936	23,797	1,172	15.1	1.9	0.6
S313-C04-001	19.8	57,769	53,556	67,682	2,632	29.2	3.5	0.8
S313-C05-001	43.5	7,411	6,251	8,631	448	0.45	0.17	0.29

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 (pCi/g)			Thorium-230 (pCi/g)			Thorium-232 (pCi/g)		
Sample ID	Result	Error ± 2 σ	MDC	Result	Error ± 2 σ	MDC	Result	Error ± 2 σ	MDC
S313-C01-001	0.78	0.14	0.05	1.87	0.31	0.07	0.74	0.13	0.02
S313-C02-001	0.79	0.16	0.09	15	2.4	0.1	0.77	0.16	0.03
S313-C03-001	1.23	0.22	0.06	11.8	1.9	0.1	1.23	0.22	0.02
S313-C04-001	0.88	0.18	0.09	22	3.5	0.1	0.98	0.19	0.02
S313-C05-001	0.147	0.048	0.051	0.196	0.06	0.066	0.202	0.049	0.016

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 0.92, as expressed in the equation:

Gamma Count Rate (cpm) = 1630 x [radium-226 (pCi/g)] + 5945

The root mean square error and p-value for the model are 6.0×10^3 and 0.007, 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 -0.9 to 242.4 pCi/g, with a mean and median of 7.4 and 3.4 pCi/g, respectively. Note that the radium-226 concentrations predicted from gamma count rate measurements exceeding approximately 58,000 cpm are extrapolated from the regression model and are outside of the correlation dataset and therefore inherently uncertain. 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.

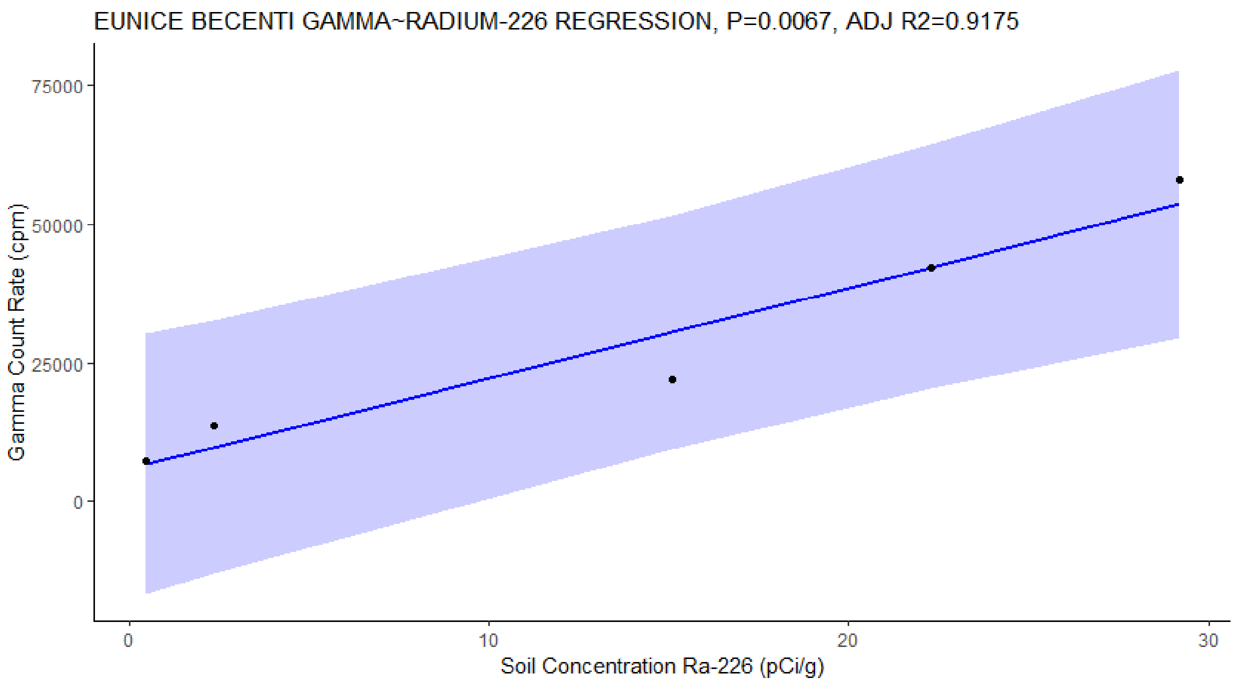


Figure 8. Correlation of gamma count rates and concentrations of radium-226 in surface soils (blue line) with 95% upper prediction level bands plotted (shaded area).

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

Parameter	Radium-226 (pCi/g)
n	67,220
Minimum	-0.9
Maximum	242.4
Mean	7.4
Median	3.4
Standard Deviation	12.6

Notes:
pCi/g = picocuries per gram

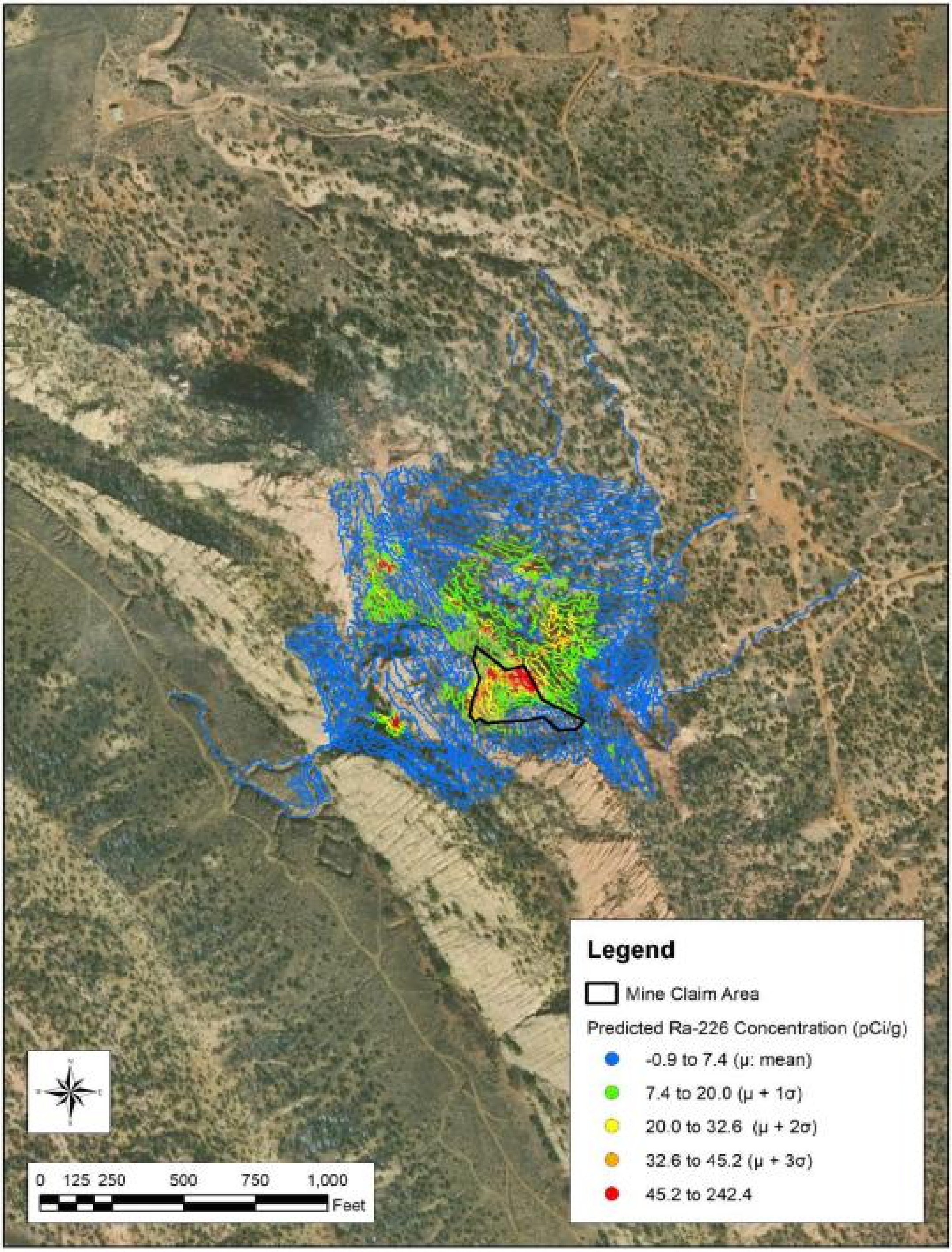

Legend
Mine Claim Area
Predicted Ra-226 Concentration (pCi/g)
-0.9 to 7.4 (μ: mean)
7.4 to 20.0 (μ + 1σ)
20.0 to 32.6 (μ + 2σ)
32.6 to 45.2 (μ + 3σ)
45.2 to 242.4
0 125 250 500 750 1,000
Feet

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 was significant ($p = 0.027$), while that for thorium-232 was not ($p = 0.41$), implying that thorium-232 does not need to be accounted for when predicting concentrations of radium-226 from gamma survey data. 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 0.4 with an adjusted R^2 of -0.02. The thorium-232 coefficient is not significant 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 ($p = 0.007$), as described above, and the adjusted R^2 value (0.92) exceeded the applicable project DQO ($R^2 > 0.8$).

The depletion of surface 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 of the correlation locations, 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 Workplan 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 therefore it was not 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.

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).

3. 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 there is evidence that thorium-230 and radium-226 are in equilibrium, but not secular equilibrium (Figure 10).

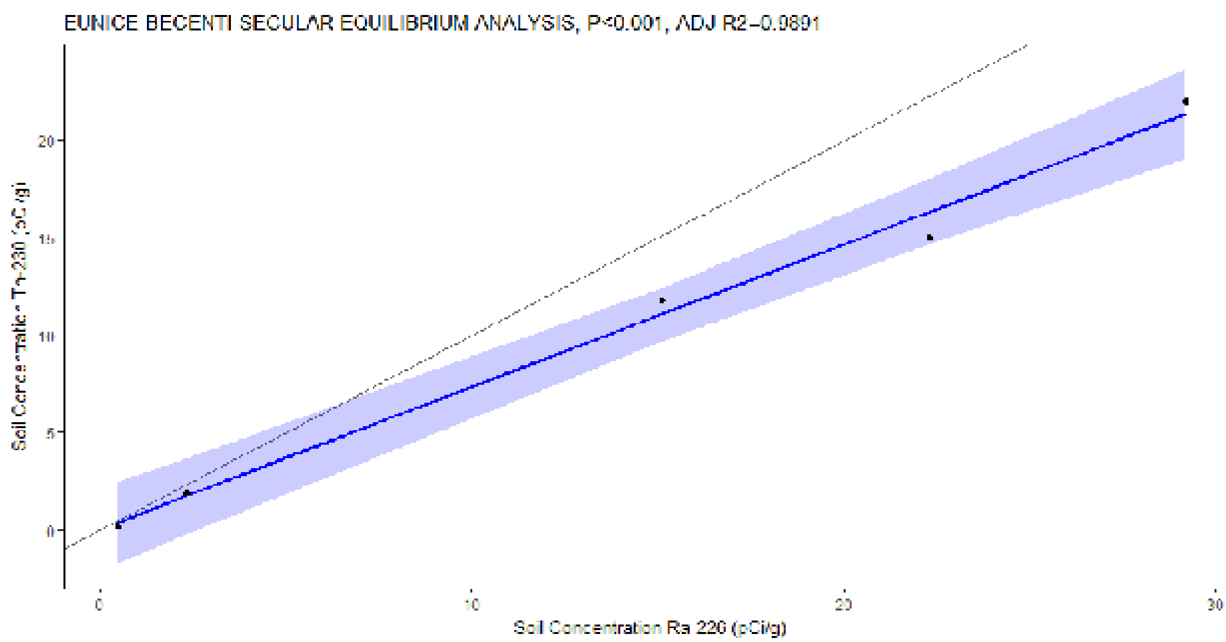


Figure 10. Evaluation of secular equilibrium in the uranium decay series.

3.3 Exposure rates and gamma count rates

On September 15, 2017, field personnel made co-located one-minute static count rate and exposure rate measurements at the same five locations within the Survey Area described in Section 3.1. Figure 7 shows the locations of the co-located measurements, which were made in the centers of the areas.

The gamma count rate and exposure rate measurements were made at 0.5 m and 1 m above the ground surface, respectively. The gamma count rate measurements were made using a Ludlum Model 44-10/2221 sodium iodide detection system (Serial Number PR355763/138368), which is the same model used in the GPS-based gamma survey of the AUM. The exposure rate measurements were made using a Reuter Stokes Model RS-S131-200-ER000 (Serial Number 1000992) high pressure ionization chamber (HPIC) at 1-second intervals for about 10 minutes. The HPIC outputs the 1-second measurements as 1-minute averages. The exposure rate used in the comparison was the mean of these measurements, less those occurring in initial instrument warm-ups. The HPIC was in current calibration and function-checked before and after use. 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 minute) exposure rate measurements.

The best predictive relationship between the measurements is linear with a R^2 of 0.9951. The root mean square error and p-value for the correlation are 1.16103 and 0.0001, 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:

Exposure Rate (in microRoentgens per hour [μR/h]) = 4×10^{-4} x Gamma Count Rate (cpm) + 8.9902

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 Areas and Survey Area, respectively.

The range of predicted exposure rates at:

- BG1 is 11.8 to 14.3 µR/h, with a mean and median of 12.9 and 12.8 µR/h, respectively.
- BG2 is 12.5 to 16.6 µR/h, with a mean and median of 14.2 and 14.1 µR/h, respectively.
- BG3 is 12.5 to 15.6 µR/h, with a mean and median of 14.1 and 14.2 µR/h, respectively.
- BG4 is 13.3 to 15.3 µR/h, with a mean and median of 14.2 and 14.1 µR/h, respectively.
- BG5 is 11.3 to 13.9 µR/h, with a mean and median of 12.4 µR/h.

The range of predicted exposure rates in the Survey Area is 10.8 to 169.4 µR/h, with a mean and median of 16.2 and 13.6 µR/h, respectively.

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

Location	Gamma Count Rate (cpm)	Exposure Rate (µR/h)
S313-C01-001	14502	15.6
S313-C02-001	47589	31.4
S313-C03-001	24708	19.7
S313-C04-001	89009	47.2
S313-C05-001	7909	11.5

Notes:
cpm = counts per minute
µR/h = microRoentgens per hour

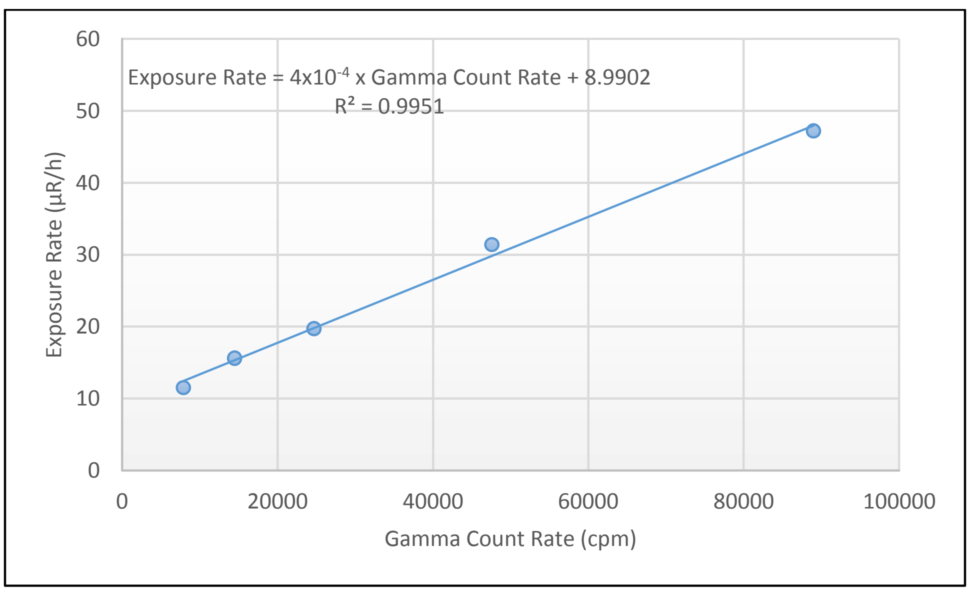


Figure 11. Correlation of gamma count rates and exposure rates.

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

Potential Background Reference Area	BG1	BG2	BG3	BG4	BG5
Parameter	Exposure Rate (µR/h)				
n	188	242	419	226	804
Minimum	11.8	12.5	12.5	13.3	11.3
Maximum	14.3	16.6	15.6	15.3	13.9
Mean	12.9	14.2	14.1	14.2	12.4
Median	12.8	14.1	14.2	14.1	12.4
Standard Deviation	0.5	0.8	0.5	0.4	0.4

Notes:
BG1 = Background Reference Area 1
BG2 = Background Reference Area 2
BG3 = Background Reference Area 3
BG4 = Background Reference Area 4
BG5 = Background Reference Area 5
µR/h = microRoentgens per hour

Table 9. Predicted exposure rates in the Survey Area.

Parameter	Exposure Rate (µR/h)
n	67,220
Minimum	10.8
Maximum	169.4
Mean	16.2
Median	13.6
Standard Deviation	8.2

Notes:
µR/h = microRoentgens per hour

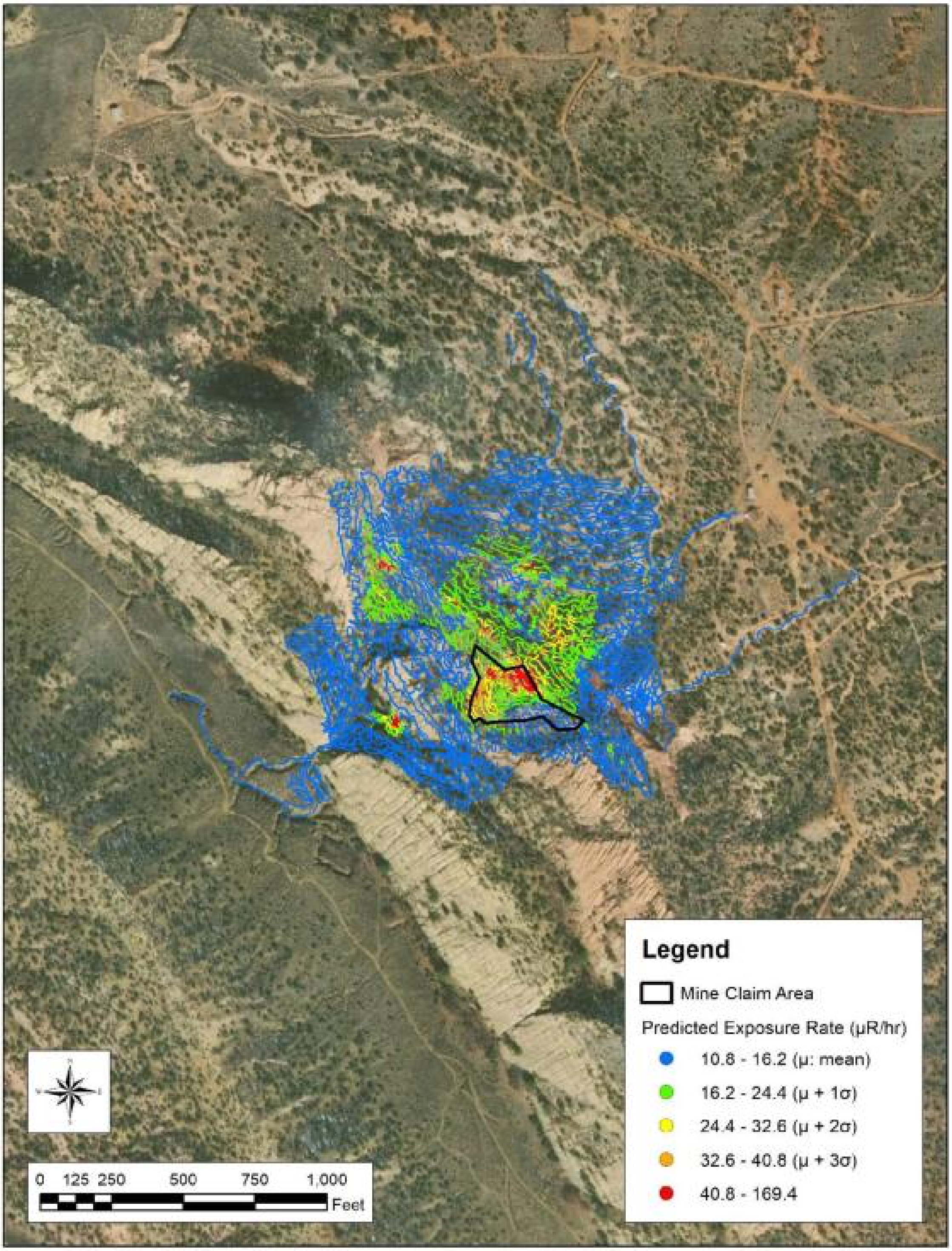


Figure 12. Predicted exposure rates in the Survey Area.

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 largely on naturally occurring outcrops and waste rock in and extending outward from the mine claim; and a waste pile associated with a portal outside the mine claim.
- Five potential Background Reference Areas were established for this AUM.
- The relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface) is described by a linear regression model:

$$\text{Gamma Count Rate (cpm)} = 1630 \times [\text{radium-226 (pCi/g)}] + 5945$$

- 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 -0.9 to 242.4 pCi/g, with a central tendency (median) of 3.4 pCi/g.
- The thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226 from gamma count rates.
- There is evidence that the uranium decay series radionuclides are in equilibrium, but not secular equilibrium
- The relationship between gamma count rates and exposure rates is described by a linear regression model:

$$\text{Exposure Rate } (\mu R/h) = 4\text{x}10^{-4} \text{ x Gamma Count Rate (cpm)} + 8.9902$$

- The distribution of exposure rates predicted using this model is rightward tailed. The values in the Survey Area range from 10.8 to 169.4, with a central tendency (median) of 13.6 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. Eunice Becenti Removal Site Evaluation Report, October 2018.

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

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

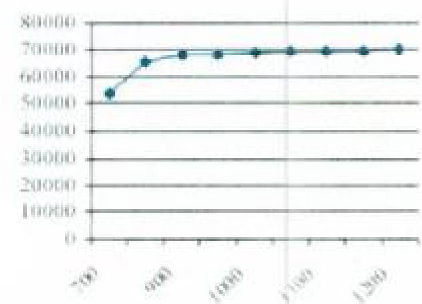
✔ Mechanical Check ✔ THR/WIN Operation HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
✔ F/S Response Check ✔ Reset Check Cable Length: ☐ 39-inch ✔ 72-inch Other:
✔ Geotropism ✔ Audio Check
✔ Meter Zeroed ✔ Battery Check (Min 4.4 VDC) Barometric Pressure: 24.75 inches Hg
Source Distance: ☐ Contact ✔ 6 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	398857	400
x 1000	100	100	100		100
x 100	400	400	400	39913	400
x 100	100	100	100		100
x 10	400	400	400	3992	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	53620	
800	64979	
900	67955	
950	67795	
1000	68536	9542
1050	69153	
1100	69331	
1150	69346	
1200	69492	

Voltage Plateau



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

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932 Fluke multimeter serial number: 87490128
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03 ✔ Gamma Source: Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03 ☐ Other Source:

Calibrated By: Calibration Date: 7-6-16 Calibration Due: 7-6-17

Reviewed By: 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:	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

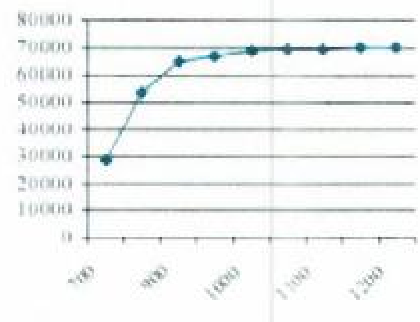
Source Geometry: ✔ Side Below Other: Window: Relative Humidity: 20 %

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 Fluke multimeter serial number: 87490128

Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03 ✔ Gamma Source: Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03 Other Source:

Calibrated By: Calibration Date: 7 [illegible] 16 Calibration Due: 7-[illegible]-17

Reviewed By: Date: 7/20/16

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Albuquerque, NM 87113
(505) 298-4224
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Certificate of Calibration

Calibration and Voltage Plateau

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	282966
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR150507

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

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V

Cable Length: ☐ 39-inch ☐ 72-inch ☑ Other: 60"

Source Distance: ☐ Contact ☑ 6 inches ☐ Other:

Source Geometry: ☑ Side ☐ Below ☐ Other:

Threshold: 10 mV

Window:

Barometric Pressure: 24.89 inches Hg

Temperature: 73 °F

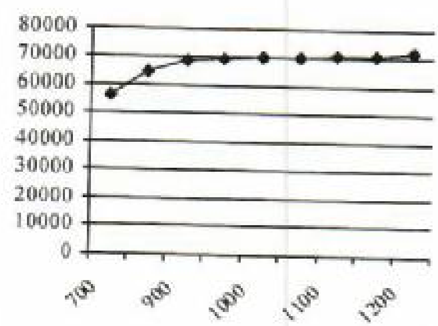
Relative Humidity: 20 %

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:

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

Reviewed By: Date: 10/31/16

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of [illegible]

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
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Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

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)
Source Distance: ☐ Contact ✔ 6 inches ☐ Other:
Source Geometry: ✔ Side ☐ Below ☐ Other:

HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:

Threshold: 10 mV
Window:

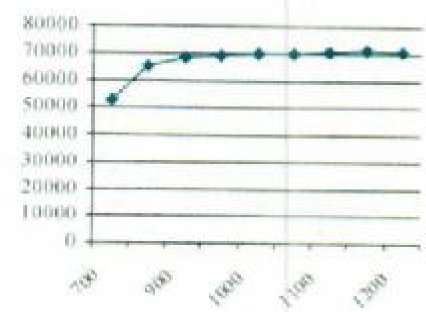
Barometric Pressure: 24.24 inches Hg
Temperature: 78 °F
Relative Humidity: 20 %

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	399859	400
x 1000	100	100	100		100
x 100	400	400	400	39991	400
x 100	100	100	100		100
x 10	400	400	400	4001	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	52821	
800	65213	
900	68644	
950	69245	
1000	69492	9111
1050	69792	
1100	70472	
1150	71183	
1200	70571	

Voltage Plateau



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

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By: [signature] Calibration Date: ~~2 March 17~~ 2/28/17 ASH Calibration Due: ~~2 March~~ 2/28/18 ASH 18

Reviewed By: [signature] Date: 3-1-17

ERG Form ITC. 101.A

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

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	196086
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR295014

✔ 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:

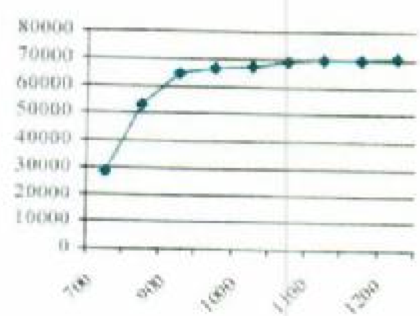
Barometric Pressure: 24.27 inches Hg
Temperature: 78 °F
Relative Humidity: 20 %

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	399386	400
x 1000	100	100	100		100
x 100	400	400	400	39949	400
x 100	100	100	100		100
x 10	400	400	400	3995	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	28235	
800	52834	
900	64481	
950	66468	
1000	67321	
1050	69009	
1100	69981	9079
1150	69564	
1200	70538	

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: 2/28/17 ~~1 March 17~~ Calibration Due: 2/28/18 ~~1 March 18~~

Reviewed By: [signature] Date: 3/1-17

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Certificate of Calibration

Calibration and Voltage Plateau

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Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	271435
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR295017

☐ 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:

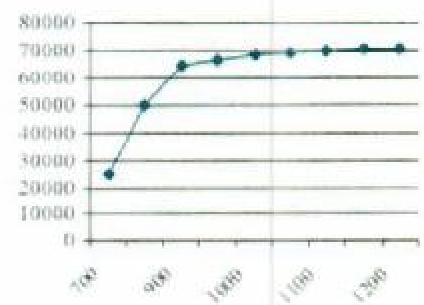
Barometric Pressure: 24.66 inches Hg
Temperature: 76 °F
Relative Humidity: 20 %

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				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

High Voltage	Source Counts	Background
700	24824	
800	50232	
900	64285	
950	66354	
1000	68179	
1050	69312	9393
1100	69955	
1150	70625	
1200	70633	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1050

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932
Fluke multimeter serial number: ☐ 87490128
☐ Alpha Source: Th-230 sn: 4098-03 @ 12,800dpm/6,520 cpm (1/4/1
✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc-99 sn: 4099-03 @ 17,700dpm/11,100cpm (1/4/12
☐ Other Source:

Calibrated By: [signature] Calibration Date: 3-13-17 Calibration Due: 3-13-18

Reviewed By: [signature] Date: 14 March 2017

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

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Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
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Albuquerque, NM 87113
(505) 298-4224
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Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	282971
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR320678

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

HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V

Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:

Source Distance: ☐ Contact ✔ 6 inches ☐ Other:

Source Geometry: ✔ Side ☐ Below ☐ Other:

Threshold: 10 mV

Window:

Barometric Pressure: 24.63 inches Hg

Temperature: 75 °F

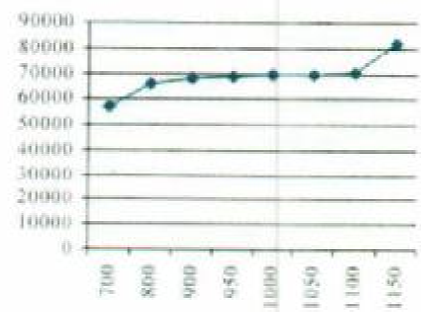
Relative Humidity: 20 %

Instrument found within tolerance: ✔ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399936	400
x 1000	100	100	100		100
x 100	400	400	400	39984	400
x 100	100	100	100		100
x 10	400	400	400	3998	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	57641	
800	65850	
900	68414	
950	68639	
1000	69410	9773
1050	69358	
1100	70301	
1150	81822	

Voltage Plateau



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

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932

Fluke multimeter serial number: ☐ 87490128

☐ Alpha Source: Th-230 sn: 4098-03 @ 12,800dpm/6,520 cpm (1/4/1

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

☐ Beta Source: Tc-99 sn: 4099-03 @ 17,700dpm/11,100cpm (1/4/12

☐ Other Source:

Calibrated By: [signature]

Calibration Date: 3-13-17

Calibration Due: 3-13-18

Reviewed By: [signature]

Date: 14 March 2017

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
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Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter: Manufacturer: Ludlum Model Number: 2221r Serial Number: 108878

Detector: Manufacturer: Ludlum Model Number: 44-10 Serial Number: PR321872

✔ 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: 24.45 inches Hg

Source Distance: Contact ✔ 6 inches Other: Threshold: 100 mV Temperature: 75 °F

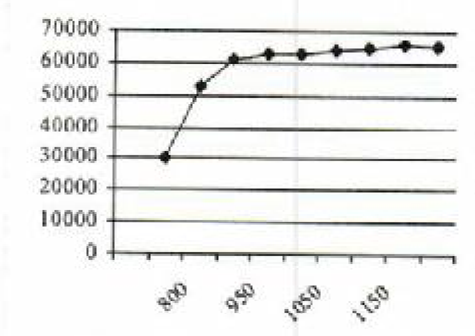
Source Geometry: ✔ Side Below Other: Window: Relative Humidity: 20 %

Instrument found within tolerance: ✔ Yes No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	401515	400
x 1000	100	100	100		100
x 100	400	400	400	40124	400
x 100	100	100	100		100
x 10	400	400	400	4009	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	30049	
800	52595	
900	61211	
950	62937	
1000	62955	
1050	64212	10044
1100	64857	
1150	65633	
1200	65476	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV =1050

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 ✔ 201932 Fluke multimeter serial number: 87490128

Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12) ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12) Other Source:

Calibrated By: [signature] Calibration Date: 5 June 17 Calibration Due: 5 June 18

Reviewed By: [signature] Date: 5 June 17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

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Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
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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:	PR355763

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

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch ☐ Other:

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

Threshold: 10 mV
Window:

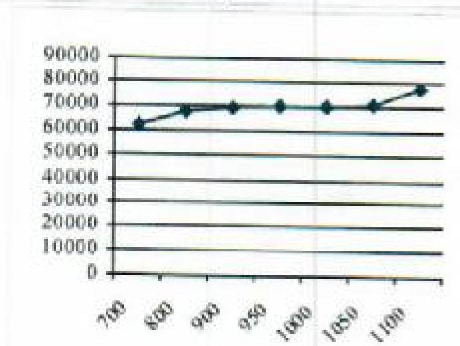
Barometric Pressure: 24.75 inches Hg
Temperature: 76 °F
Relative Humidity: 20 %

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	398875	400
x 1000	100	100	100		100
x 100	400	400	400	39883	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	398	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	62275	
800	68049	
900	69726	
950	70112	9509
1000	70068	
1050	71042	
1100	77619	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 950

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
Fluke multimeter serial number: ☐ 87490128
☐ Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12)
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12)
☐ Other Source:

Calibrated By: [signature]
Calibration Date: 9-17-17
Calibration Due: 9-17-18

Reviewed By: T. [signature]
Date: 09/08/17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

Reuter-Stokes

Calibration Certificate

Reuter-Stokes certifies that the Environmental Radiation Monitor, identified below, has been calibrated for output using the shadow shield technique*, and calibrated with radiation sources traceable to the National Institute of Standards and Technology.

Sensor Type: 100 R/Hr

Serial Number: 1000992

Calibration Date: 03/16/2017

Sensitivity: -2.281E-8 A/R/h

Authorized Signature

*Calibration Procedure: RS-SOP 238.1

Reuter-Stokes

Calibration Data

Sensor Type:	100 R/Hr	Source (CS-137):	BB-400
Serial Number:	1000992	Date of Certification:	12/01/1994
Calibration Date:	03/16/2017	Exposure Rate at 1 meter:	4.226 mR/h

Customer Name: STOCK

Sensitivity (Ra-226): -2.281E-8 A/R/h

Distance		Exposure Rate	P+S+A	S+A	P	k(CS-137)
Feet	cm	μR/h	A	A	A	A/R/h
12	366	185.323	-5.403E-12	-1.164E-12	-4.239E-12	-2.287E-08
14	427	135.592	-4.135E-12	-1.012E-12	-3.123E-12	-2.303E-08
16	488	103.384	-3.294E-12	-9.029E-13	-2.391E-12	-2.313E-08
18	549	81.348	-2.708E-12	-8.209E-13	-1.887E-12	-2.319E-08

k(CS-137) = -2.306E-8 A/R/h

k = -2.306E-8 A/R/h

k(Ra-226) = 0.9892 k(CS-137)

σ = 1.39E-10 A/R/h

k(Ra-226) = -2.281E-8 A/R/h

$V = \frac{\sigma}{k} =$ -0.603%

By: John Lak

Date: 3-17-17

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	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
11-18-16	0829	5.4	1015	101	51216	13360	37856	NW	Standing Rock
11-18-16	1517	5.3	1006	100	48629	10616	38013	NW	Gallup lot
11-19-16	0808	5.3	1014	100	43603	5712	37891	NW	Eunice Bicenti
11-19-16	1400	5.1	1005	100	44923	5058	39865	NW	Eunice Bicenti

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.:	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

Serial No.: 333-94

Activity: 5.12 uCi

Emission Rate: NA cpm/emissions

Source Date: 6-6-94

Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project Reference Points
11-16-16	0812	5.7	1110	101	49614	11731	37883	NW	Standing Rock
11-16-16	1515	5.6	1104	100	48046	10720	37326	NW	Gallup lot
11-18-16	0826	5.7	1116	102	51120	13035	38085	NW	Standing Rock
11-18-16	1512	5.6	1126	101	48583	10155	38428	NW	Gallup lot
11-19-16	0817	5.6	1115	102	44225	4772	39453	NW	Eunice Becente
11-19-16	1403	5.5	1102	100	43512	4751	38761	NW	Eunice Becente

12-6-16

Reviewed by: [signature]

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:

NN EAT

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
11-12-16	0827	5.7	1010	102	48550	9744	38806	NW	Hoskie Tso
11-12-16	1351	5.6	1000	101	47089	8725	38364	NW	Hoskie Tso
11-16-16	0826	5.7	1011	102	50569	12266	38303	NW	Standing Rock
11-16-16	1518	5.6	1006	103	50039	11202	38837	NW	Gallup lot
11-18-16	0836	5.7	1017	104	52221	13620	38601	NW	Standing Rock
11-18-16	1530	5.6	1009	103	48820	10831	37989	NW	Gallup lot
11-19-16	0812	5.6	1016	104	44700	4940	39760	NW	Eunice Becenti
11-19-16	1407	5.5	1004	102	44961	4975	39986	NW	Eunice Becenti
					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.:	254772
Cal. Due Date:	2-28-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	2-28-18

Comments:
NNGAT

Source: Cs-137　Activity: 4 uCi　Source Date: 4-18-96　Distance to Source: 6 inches

Serial No.: 544-96　Emission Rate: N/a cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-22-17	0658	5.9	948	100	37553	5150	32403	NW	Goulding's lot
3-22-17	1432	5.7	944	100	35555	4865	30690	NW	Charles keith shooting range
3-23-17	0903	5.8	949	100	35647	5062	30585	NW	NA-0928
3-23-17	1918	5.7	950	101	41998	10371	31627	NW	Gallup lot
3-24-17	0812	5.7	953	100	36633	4660	31973	NW	Eunice Becenti
3-24-17	1740	5.6	947	100	42350	11142	31208	NW	Gallup lot
3-27-17	0830	5.6	952	100	36518	4677	31841	NW	Eunice Becenti
3-27-17	1230	5.5	949	100	36189	4090	32099	NW	Eunice Becenti
						NW 4-2-17			

Reviewed by: [signature]　Review Date: 11/06/17

2

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	196086
Cal. Due Date:	2-28-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR 295014
Cal. Due Date:	2-28-18

Comments:
NNEAT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-20-17	0905	5.7	1003	101	40471	8507	31964	NW	Claim 28
3-20-17	1547	5.6	996	101	36470	5494	30976	NW	Chinle lot
3-21-17	0641	5.7	1004	101	37904	5597	32307	NW	Chinle lot
3-21-17	1654	5.6	999	101	36212	4929	31283	NW	Goulding's lot
3-22-17	0702	5.6	1001	101	35714	5119	30595	NW	Goulding's lot
3-22-17	1437	5.4	995	101	35087	4539	30548	NW	Charles Keith shooting range
3-23-17	0907	5.6	1004	101	36031	4879	31152	NW	NA-0928
3-23-17	1922	5.5	1004	101	41793	9955	31838	NW	Gallup lot
3-24-17	0810	5.5	1007	101	35608	4282	31326	NW	Eunice Becenti
3-24-17	1785	5.5	1000	101	41923	10785	31138	NW	Gallup lot
3-27-17	0833	5.5	1005	101	36943	4282	32661	NW	Eunice Becenti
3-27-17	1235	5.4	1000	101	35141	4013	31128	NW	Eunice Becenti

Reviewed by: [signature] Review Date: 10/9/17

4

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	271435
Cal. Due Date:	3-13-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR295017
Cal. Due Date:	3-13-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-22-17	0705	5.6	1050	100	35820	5210	30610	NW	Goulding's lot
3-22-17	1425	5.5	1049	101	36169	4648	31521	NW	Charles Keith shooting range
3-23-17	0908	5.6	1056	102	35972	4828	31144	NW	NA-0928
3-23-17	1915	5.5	1055	102	41686	10757	30929	NW	Gallup lot
3-24-17	0805	5.5	1060	102	36151	4442	31709	NW	Eunice Becenti
3-24-17	1744	5.4	1051	101	41975	10973	31002	NW	Gallup lot
3-25-17	0908	5.5	1057	102	37581	5827	31754		Section 26
3-25-17				DID	NOT USE				
					4-2-17				

Reviewed by: [signature] Review Date: ~~9~~ 10/9/17

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.:	282971
Cal. Due Date:	3-13-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR320678
Cal. Due Date:	3-13-18

Comments:
NNERT - Soils Characterization

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-20-17	1334	5.7	1046	100	37108	6411	30697	NW	Charles Keith
6-20-17	1651	5.6	1035	98	36894	5907	30987	NW	Charles Keith
6-21-17	0720	5.7	1045	100	38258	6568	31690	NW	Charles Keith
6-21-17	1400	5.5	1035	99	36426	5473	30953	NW	Charles Keith
6-22-17	0732	5.6	1044	100	37058	5300	31758	NW	Charles Keith
6-22-17	1710	5.5	1042	99	37441	6708	30733	NW	Tsosie I
6-24-17	0901	5.6	1047	100	38218	7111	31107	NW	Tsosie I
6-24-17	1655	5.5	1041	99	36728	6080	30648	NW	Tsosie I
6-26-17	0852	5.6	1048	100	38982	7442	31540	NW	Tsosie I
6-26-17	1632	5.4	1040	99	38932	7627	31305	NW	Tsosie I
6-27-17	1238	5.5	1047	100	36268	5913	30355	NW	Eunice Becenti
6-27-17	1403	5.5	1044	100	36016	5567	30449	NW	Eunice Becenti

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Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	282971
Cal. Due Date:	3-13-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR 320678
Cal. Due Date:	3-13-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 54496 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-28-17	0734	5.5	1048	100	37396	6070	31326	NV	Eunice Becenti
6-28-17	1754	5.4	1044	100	37285	6171	36608	NV	Gallup; Garden Inn lot
6-29-17	0652	5.5	1048	100	43496	12192	31305	NV	Gallup; Fairfield Inn lot
6-30-17	0947	5.4	1045	100	42152	9043	33109	NV	ERG office

7-5-17

Reviewed by: ~~AD~~ MA Review Date: 10/4/17

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	196086
Cal. Due Date:	2-28-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR295014
Cal. Due Date:	2-28-18

Comments:

NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 Inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-26-17	0900	6.2	1109	101	38088	6806	31282	NW	Tsosie 1
6-26-17	1619	6.0	1095	99	38337	6166	32171	NW	Tsosie 1
6-27-17	1247	6.1	1108	100	36994	5161	31833	NW	Eunice Becenti
6-27-17	1358	6.0	1102	101	36293	5017	31276	NW	Eunice Becenti
6-28-17	0730	6.1	1111	101	36814	5111	31703	NW	Eunice Becenti
6-28-17	1752	5.9	1101	100	37391	5304	32087	NW	Gallup Garden Inn lot
6-29-17	0908	5.9	1106	100	35972	6002	29970	NW	Section 26
6-30-17	0855	5.9	1107	100	40749	9057	31692	NW	ERG office
						7-5-17			

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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.:	108878
Cal. Due Date:	6-5-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR 321872
Cal. Due Date:	6-5-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-15-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: N/A cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-28-17	1100	5.9	1146	100	36066	5437	30629	MW	Eunice Becenti
6-28-17	1747	5.7	1143	100	38916	5995	32921	MW	Gallup Garden Inn Lot

MW 7-5-17

Reviewed by: MA Review Date: 10/9/17

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	138368
Cal. Due Date:	9-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR355763
Cal. Due Date:	9-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 Inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
9-12-17	0914	5.4	950	101	36935	6331	30604	NW	Barton 3
9-12-17	1432	5.3	944	99	38043	6468	31575	NW	Tsosie 1
9-13-17	0906	5.4	951	99	37146	6538	30608	NW	Alongo
9-13-17	1600	5.3	944	99	35587	5991	29596	NW	Barton 3
9-14-17	0909	5.4	950	100	36080	6176	29904	NW	NA-0904
9-14-17	1255	5.3	948	100	36099	5764	30335	NW	NA-0904
9-15-17	0920	5.4	954	101	35208	5551	29657	NW	Eunice Becenti
9-15-17	1729	5.3	957	109	35937	5261	30676	NW	Eunice Becenti
9-19-17	0831	5.4	958	105	36467	6034	30433	NW	Section 26 @ trailer
9-19-17	1453	5.3	946	99	44454	14748	29706	NW	Section 26 @ corral
9-20-17	0736	5.3	953	102	37676	6987	30689	NW	Mexican Hat
9-20-17	1611	5.2	947	100	36842	6252	30590	NW	Mexican Hat

Reviewed by: MA Review Date: 10/9/17

Appendix B Exposure Rate Measurements

Date and Time	Exposure Rate (mR/h)	Location	Date and Time	Exposure Rate (mR/h)	Location
09/15/2017 10:14	0.0107	Correlation Location 1	09/15/2017 10:58	0.0198	Correlation Location 3
09/15/2017 10:15	0.0154	Correlation Location 1	09/15/2017 10:59	0.0194	Correlation Location 3
09/15/2017 10:16	0.0161	Correlation Location 1	09/15/2017 11:00	0.0194	Correlation Location 3
09/15/2017 10:17	0.0158	Correlation Location 1	09/15/2017 11:01	0.0193	Correlation Location 3
09/15/2017 10:18	0.0155	Correlation Location 1	09/15/2017 11:02	0.0194	Correlation Location 3
09/15/2017 10:19	0.0156	Correlation Location 1	09/15/2017 11:12	0.0314	Correlation Location 4
09/15/2017 10:20	0.0156	Correlation Location 1	09/15/2017 11:13	0.0461	Correlation Location 4
09/15/2017 10:21	0.0155	Correlation Location 1	09/15/2017 11:14	0.0463	Correlation Location 4
09/15/2017 10:22	0.0155	Correlation Location 1	09/15/2017 11:15	0.0470	Correlation Location 4
09/15/2017 10:23	0.0155	Correlation Location 1	09/15/2017 11:16	0.0473	Correlation Location 4
09/15/2017 10:33	0.0249	Correlation Location 2	09/15/2017 11:17	0.0479	Correlation Location 4
09/15/2017 10:34	0.0323	Correlation Location 2	09/15/2017 11:18	0.0475	Correlation Location 4
09/15/2017 10:35	0.0318	Correlation Location 2	09/15/2017 11:19	0.0477	Correlation Location 4
09/15/2017 10:36	0.0316	Correlation Location 2	09/15/2017 11:20	0.0477	Correlation Location 4
09/15/2017 10:37	0.0309	Correlation Location 2	09/15/2017 11:21	0.0469	Correlation Location 4
09/15/2017 10:38	0.0305	Correlation Location 2	09/15/2017 11:22	0.0472	Correlation Location 4
09/15/2017 10:39	0.0308	Correlation Location 2	09/15/2017 11:52	0.0095	Correlation Location 5
09/15/2017 10:40	0.0313	Correlation Location 2	09/15/2017 11:53	0.0121	Correlation Location 5
09/15/2017 10:41	0.0316	Correlation Location 2	09/15/2017 11:54	0.0115	Correlation Location 5
09/15/2017 10:42	0.0319	Correlation Location 2	09/15/2017 11:55	0.0114	Correlation Location 5
09/15/2017 10:52	0.0081	Correlation Location 3	09/15/2017 11:56	0.0115	Correlation Location 5
09/15/2017 10:53	0.0173	Correlation Location 3	09/15/2017 11:57	0.0113	Correlation Location 5
09/15/2017 10:54	0.0198	Correlation Location 3	09/15/2017 11:58	0.0118	Correlation Location 5
09/15/2017 10:55	0.0202	Correlation Location 3	09/15/2017 11:59	0.0113	Correlation Location 5
09/15/2017 10:56	0.0199	Correlation Location 3	09/15/2017 12:00	0.0111	Correlation Location 5
09/15/2017 10:57	0.0198	Correlation Location 3	09/15/2017 12:01	0.0116	Correlation Location 5

Appendix C Technical Memo from ERG to Stantec. "Statistical Analysis of the Navajo Trustee Mines Dataset: Multivariate Linear Regression for Evaluation of Gamma Correlation with Ra-226 and Evaluation of Secular Equilibrium Between Ra-226 and Th-230"

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113

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fax: (505) 797-1404
www.ERGoffice.com

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.

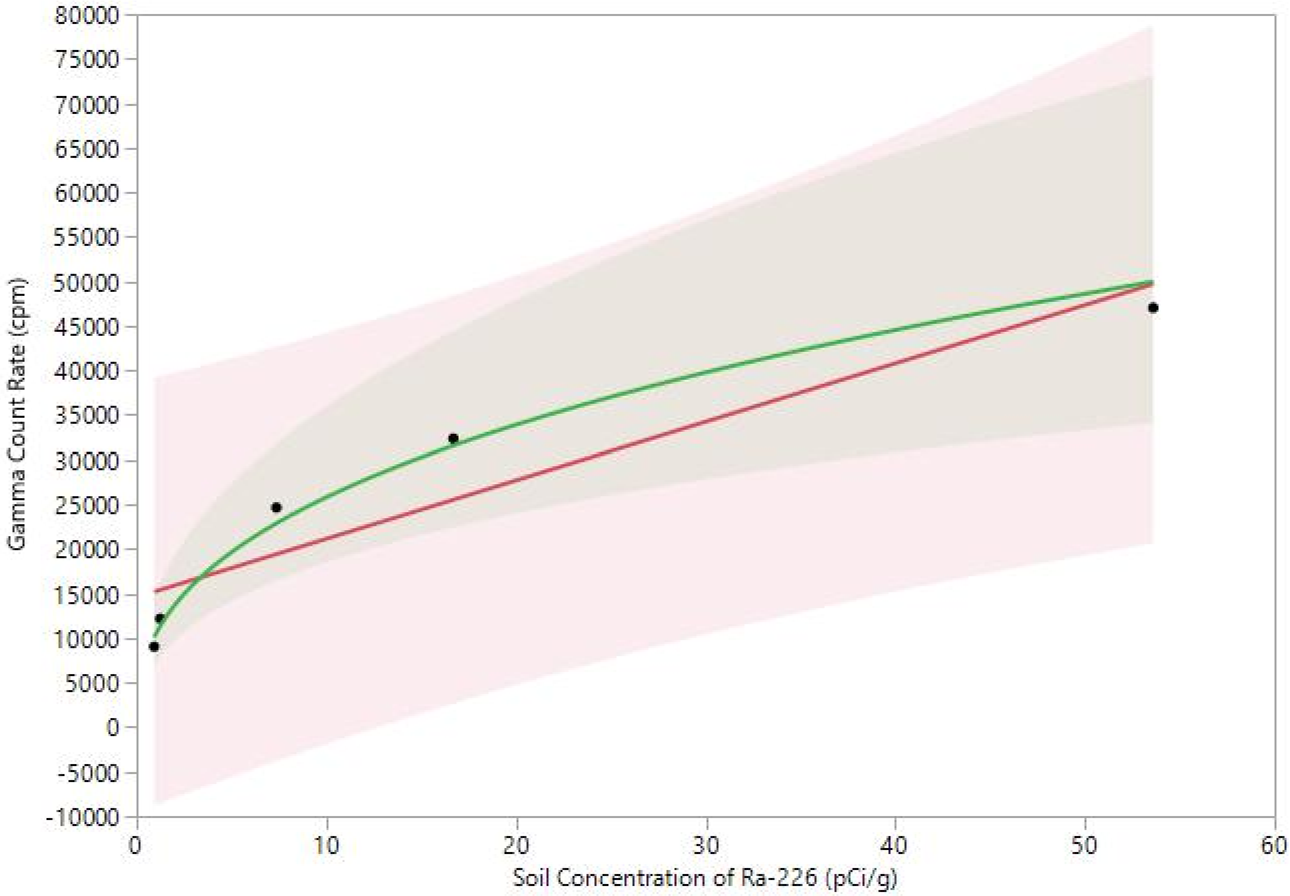

Figure 1. Regression models (linear versus power curve) for gamma count rate regressed on radium-226 showing 95% UPLs (upper prediction limits). Both models meet the study DQO for adjusted R^2 (greater than 0.8). Gamma count rate is not an especially strong predictor of soil concentration of radium-226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

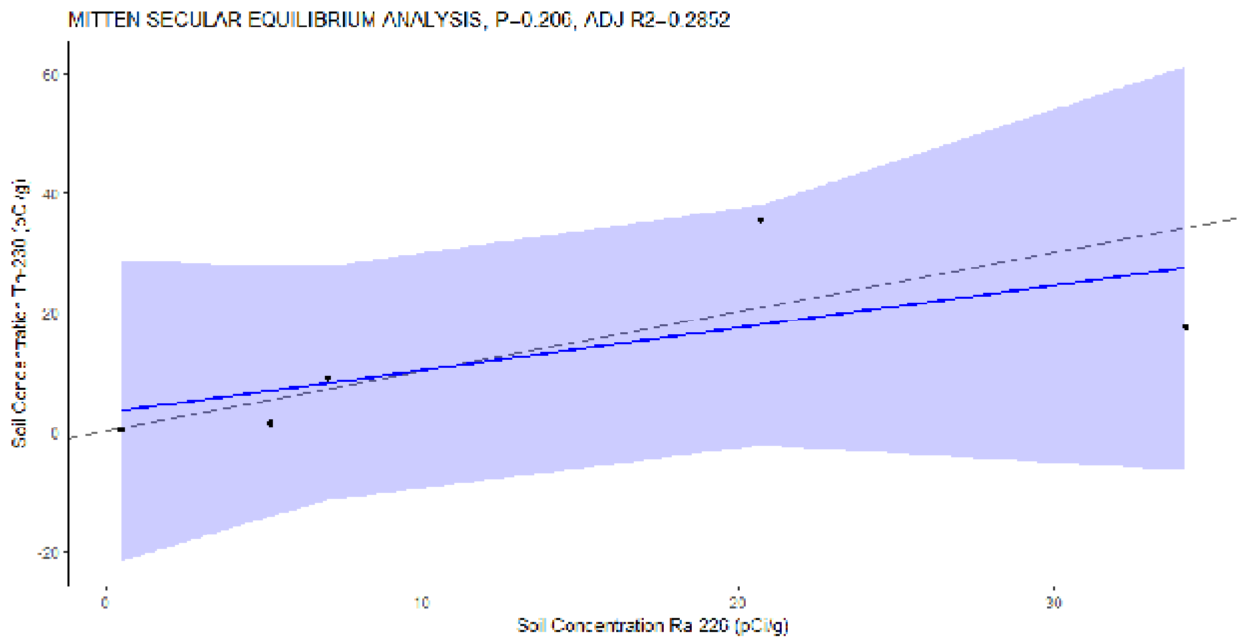

Figure 2. Result for Mitten secular equilibrium analysis, showing failure to meet p-value and adjusted R^2 criteria, i.e., the data are poorly correlated.

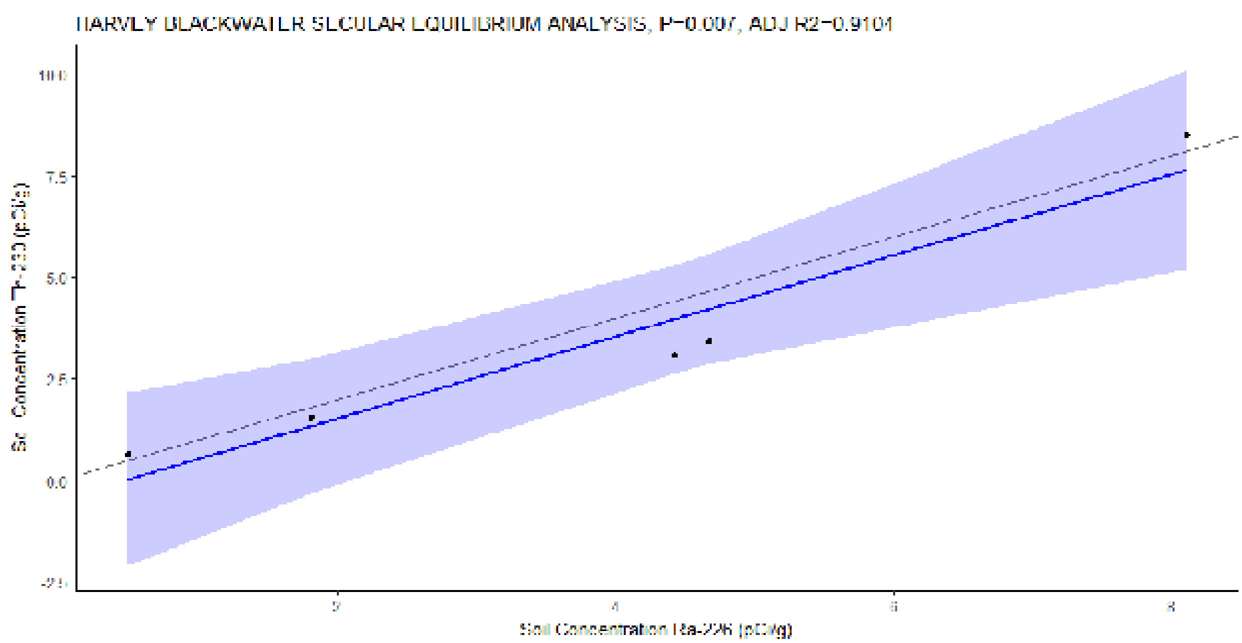

Figure 3. Result for Harvey Blackwater secular equilibrium analysis, showing excellent correlation between the data and the y=x line, i.e., Th-230 and Ra-226 are in secular equilibrium.

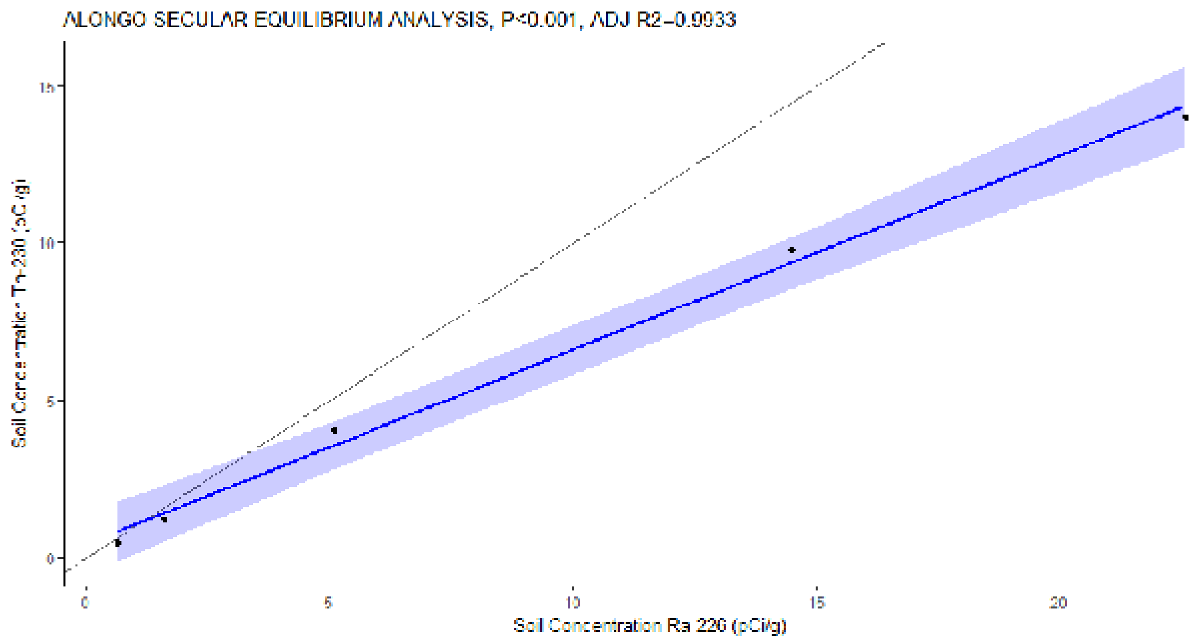

Figure 4. Result for Alongo Mines secular equilibrium analysis, showing excellent correlation between the data, but poor agreement with the y=x line, i.e., Th-230 and Ra-226 are in equilibrium, but not secular equilibrium.

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 "Eunice Becenti Abandoned Uranium Mine"

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

Radiological Characterization of the Eunice Becenti Abandoned Uranium Mines

Preliminary

February 20, 2018

prepared for:

Stantec Consulting Services Inc.

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ERG

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Contents

Tables

Figures

Appendices

Acronyms

ANSI	American National Standards Institute
AUM	abandoned uranium mine
BG1	Background Reference Area 1
BG2	Background Reference Area 2
BG3	Background Reference Area 3
BG4	Background Reference Area 4
BG5	Background Reference Area 5
cpm	counts per minute
DQOs	data quality objectives
EPA	U.S. Environmental Protection Agency
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 Eunice Becenti abandoned uranium mine (AUM) located in the Church Rock Chapter of the Navajo Nation southeast of Gallup, New Mexico. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase.

This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of the gamma count rates at 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 May 6 and November 19, 2016; March 24 and 27, 2017; June 27 to 29, 2017; and September 15, 2017. They included a GPS-based radiological survey of land surfaces over a Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, and areas where the survey was extended; and correlation studies.

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in "Eunice Becenti 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 largely on naturally occurring outcrops and waste rock in and extending outward from the mine claim; and a waste pile associated with a portal outside the mine claim.
- Five potential Background Reference Areas were established for this AUM.
- The relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface) is described by a linear regression model:

$$\text{Radium-226 concentration (in picocuries per gram [pCi/g])} =$$
$$6 \times 10^{-4} \times \text{Gamma Count Rate (in counts per minute [cpm])} - 2.5619$$

- 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 0.2 to 238, with a central tendency (median) of 4.3 pCi/g.

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

- The uranium series radionuclides appear not to be in secular equilibrium.

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

  Exposure Rate (in microRoentgens per hour [μR/h]) = Gamma Count Rate (cpm) x 4×10^{-4} + 8.9902

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 10.8 to 169.4, with a central tendency (median) of 13.6 μR/h.

1.0 Introduction

This report addresses the radiological characterization of the Eunice Becenti abandoned uranium mine (AUM) located in the Church Rock Chapter of the Navajo Nation southeast of Gallup, New Mexico. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase.

This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of the gamma count rates at 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 May 6 and November 19, 2016; March 24 and 27, 2017; June 27 to 29, 2017; and September 15, 2017 in accordance with the methods described in the RSE Work Plan. They included a GPS-based radiological survey of land surfaces over an approximately 30-acre Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, and areas where the survey was extended; and correlation studies.

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in "Eunice Becenti 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 "Eunice Becenti Removal Site Evaluation Report" (Stantec, 2018).

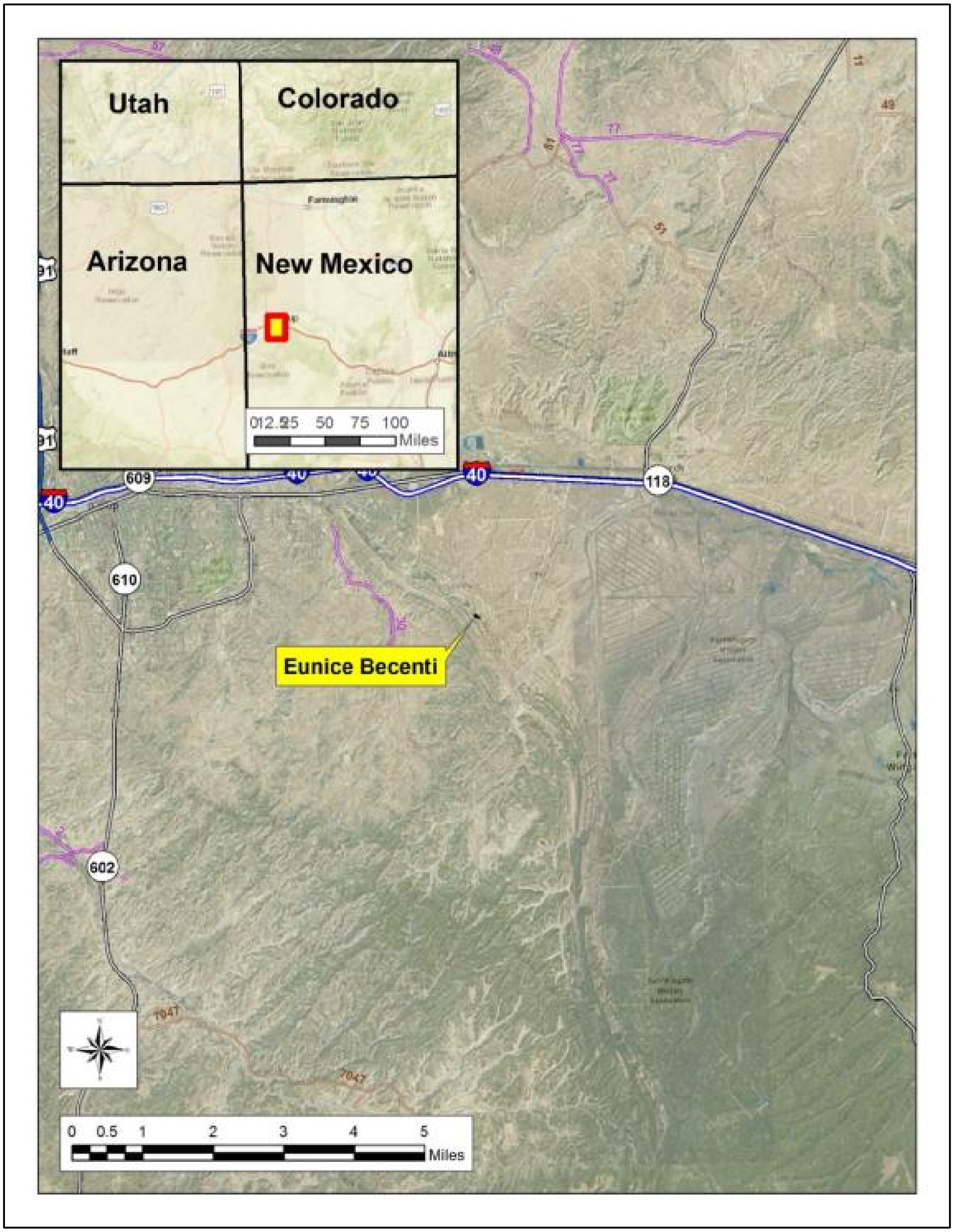


Figure 1. Location of the Eunice Becenti Abandoned Uranium Mine.

2.0 GPS-Based Gamma Survey

This section addresses the GPS-based survey conducted in five potential Background Reference Areas 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.

Area	Ludlum Model 44-10	Ludlum Model 2221 Ratemeter/Scaler
Potential Background Reference Areas	PR295014	196086
	PR303727[a]	254772[a]
	PR321872	108878
Survey Area	PR150507	282966
	PR295014	196086
	PR320678	282971
	PR321872	108878
	PR355763[b]	138368[b]

Notes:
[a]Detection system used in the correlation study described in Section 3.1.
[b]Detection system used in the correlation study described in Section 3.3.

2.1 Potential Background Reference Areas

Five potential Background Reference Areas were surveyed, the locations and results of which are depicted on Figure 2. BG1, BG2, BG3, BG4, and BG5 in the figure are Background Reference Areas 1 through 5, respectively.

Table 2 lists a summary of the gamma count rates, which in:

- BG1 ranged from 7,029 to 13,185 counts per minute (cpm), with a mean and median of 9,739 and 9,626 cpm, respectively.
- BG2 ranged from 8,871 to 19,139 cpm, with a mean and median of 12,922 and 12,851 cpm, respectively.
- BG3 ranged from 8,694 to 16,609 cpm, with a mean and median of 12,804 and 12,948 cpm, respectively.
- BG4 ranged from 10,729 to 15,777 cpm, with a mean and median of 12,927 and 12,839 cpm, respectively.
- BG5 ranged from 5,705 to 12,233 cpm, with a mean and median of 8,443 and 8,457 cpm, respectively.

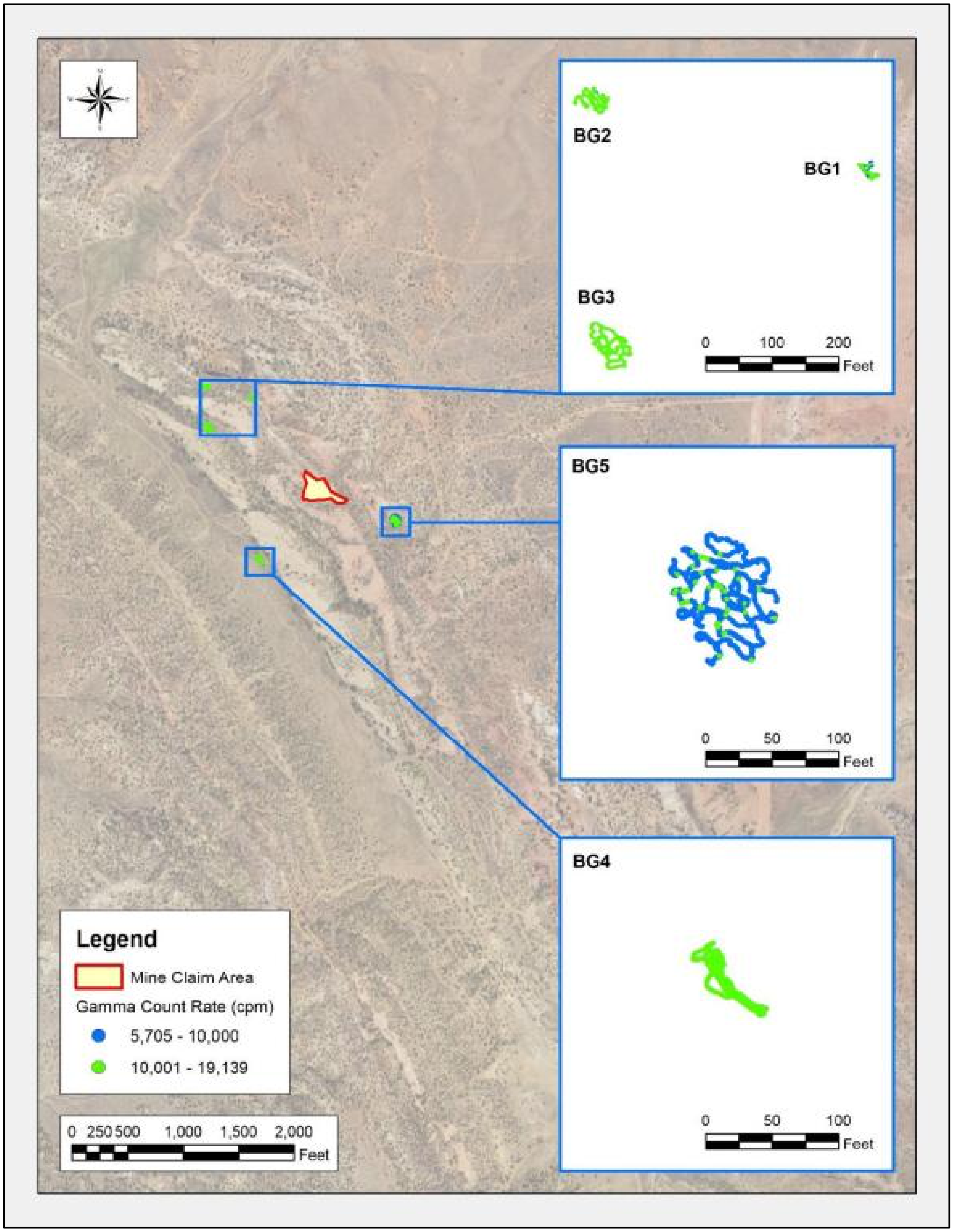


Figure 2. Gamma count rates in the potential Background Reference Areas.

Figure 3 depicts a histogram of the gamma count rates in BG1 through BG5. The red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could be expected if the distributions were normal or lognormal.

Table 2. Summary statistics for gamma count rates in the potential Background Reference Areas.

	Gamma Count Rate (cpm)					
Potential Background Reference Area	**n**	**Minimum**	**Maximum**	**Mean**	**Median**	**Standard Deviation**
1	188	7,029	13,185	9,739	9,626	1,327
2	242	8,871	19,139	12,922	12,851	1,879
3	419	8,694	16,609	12,804	12,948	1,364
4	226	10,729	15,777	12,927	12,839	971
5	804	5,705	12,233	8,443	8,457	1,005

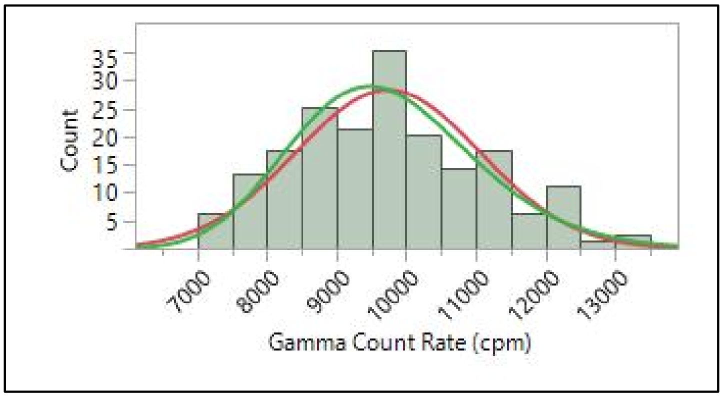
Notes:
cpm = counts per minute

2.2 Survey Area

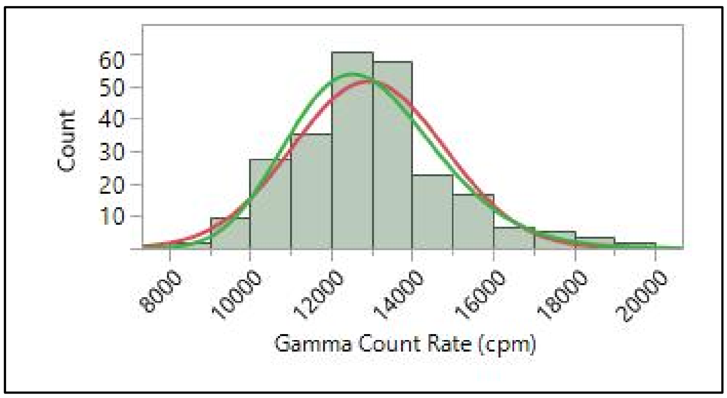
The gamma count rates observed in the Survey Area are depicted in Figure 4. Elevated count rates were observed largely on naturally occurring outcrops in and waste rock in and extending from the mine claim; and a waste pile associated with a portal outside the mine claim.

Figure 5 is a histogram of the gamma count rate measurements made in the Survey Area. 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 nor logarithmic. The box plot in Figure 6 depicts cutoffs as horizontal bars, from left to right, 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 9,147, 11,439, and 18,231 cpm, respectively.

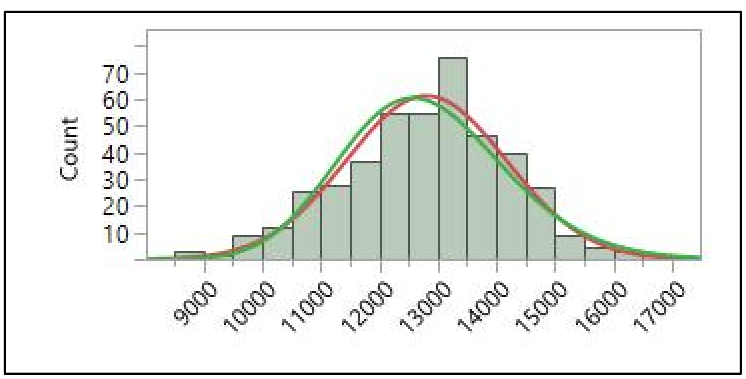
Table 3 is a statistical summary of the measurements, which range from 4,543 to 401,121 cpm and have a central tendency (median) of 11,439 cpm.



a. **Background Reference Area 1**

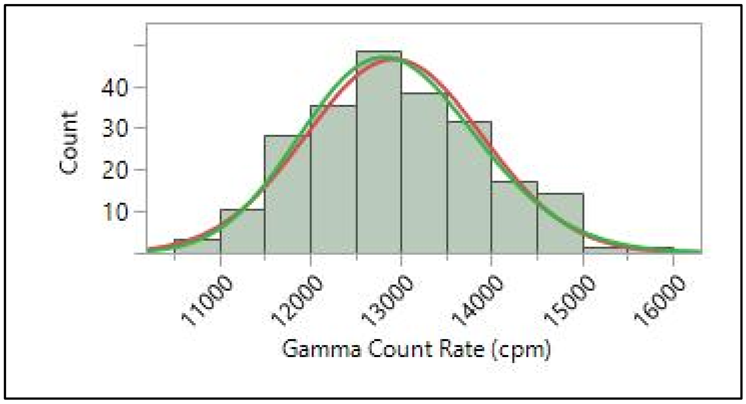


b. **Background Reference Area 2**

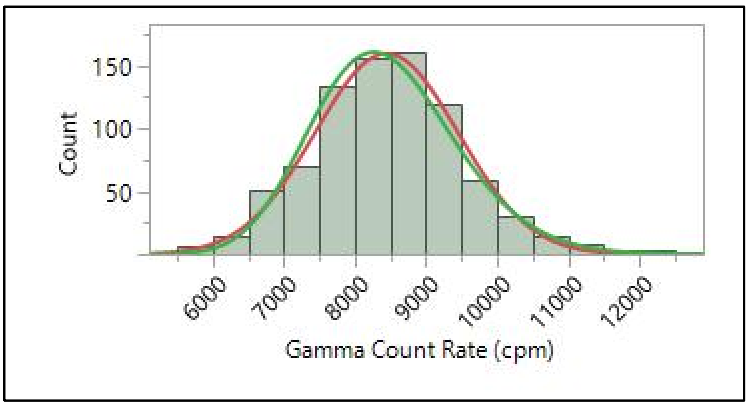


c. **Background Reference Area 3**

Figure 3 (1st of 2). Histograms of gamma count rates in the potential Background Reference Areas.



a. **Background Reference Area 4**



b. **Background Reference Area 5**

Figure 3 (2nd of 2). Histograms of gamma count rates in the potential Background Reference Areas.

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

Parameter	Gamma Count Rate (cpm)
n	67,273
Minimum	4,543
Maximum	401,121
Mean	18,022
Median	11,439
Standard Deviation	20,605

Notes:
cpm = counts per minute

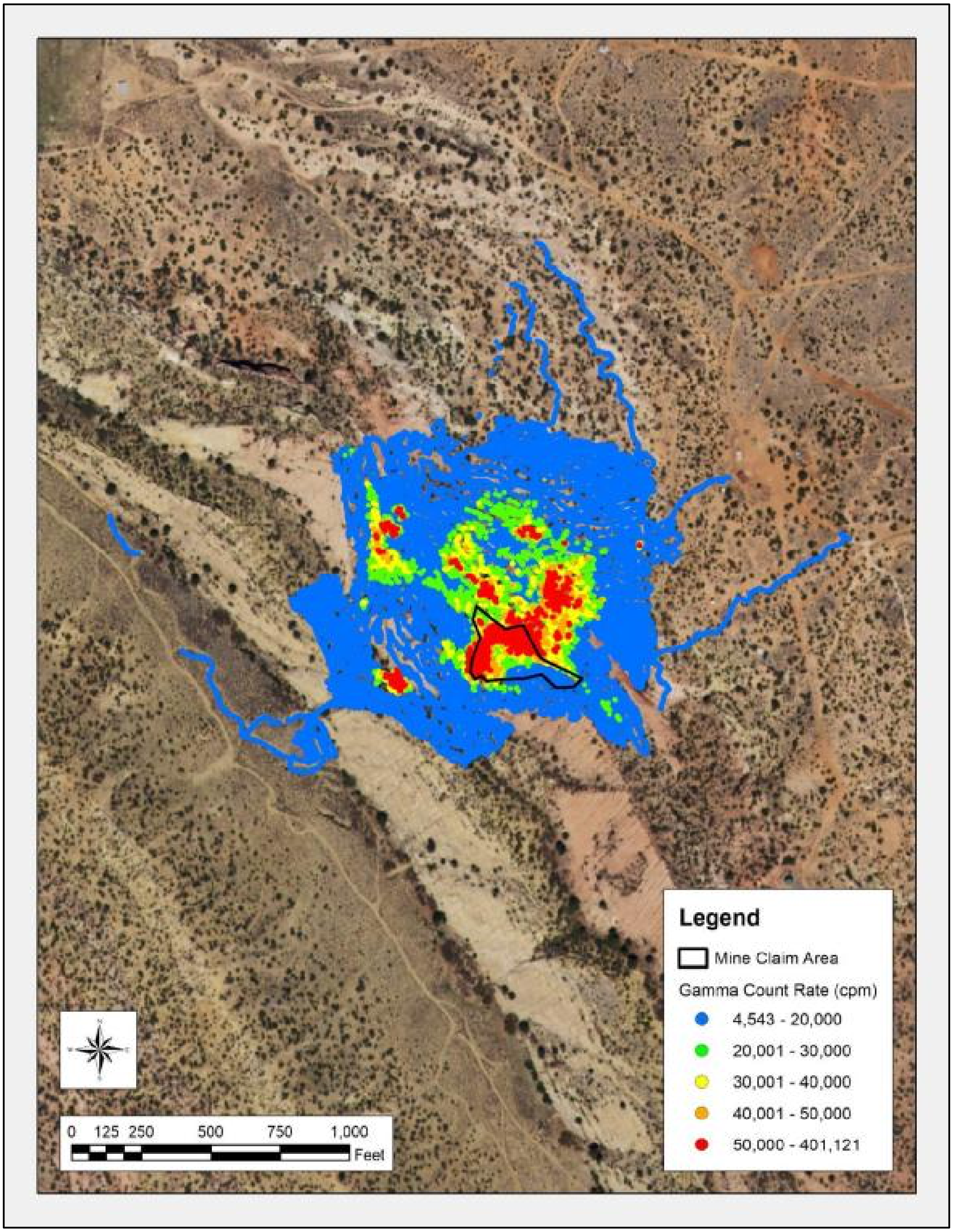


Figure 4. Gamma count rates in the Survey Area.

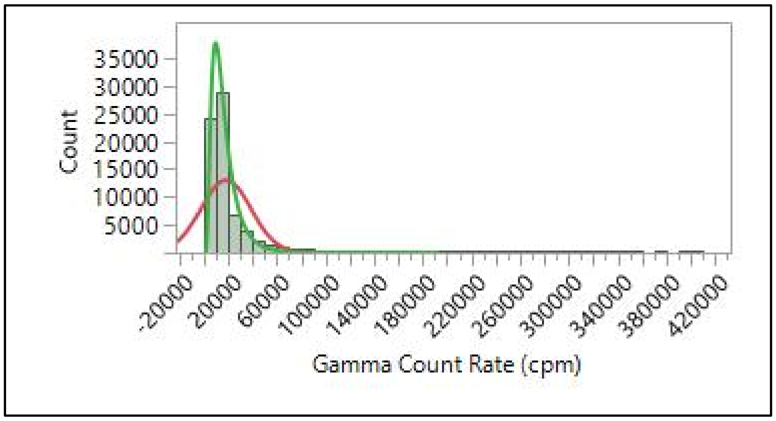


Figure 5. Histogram of gamma count rates in the Survey Area.

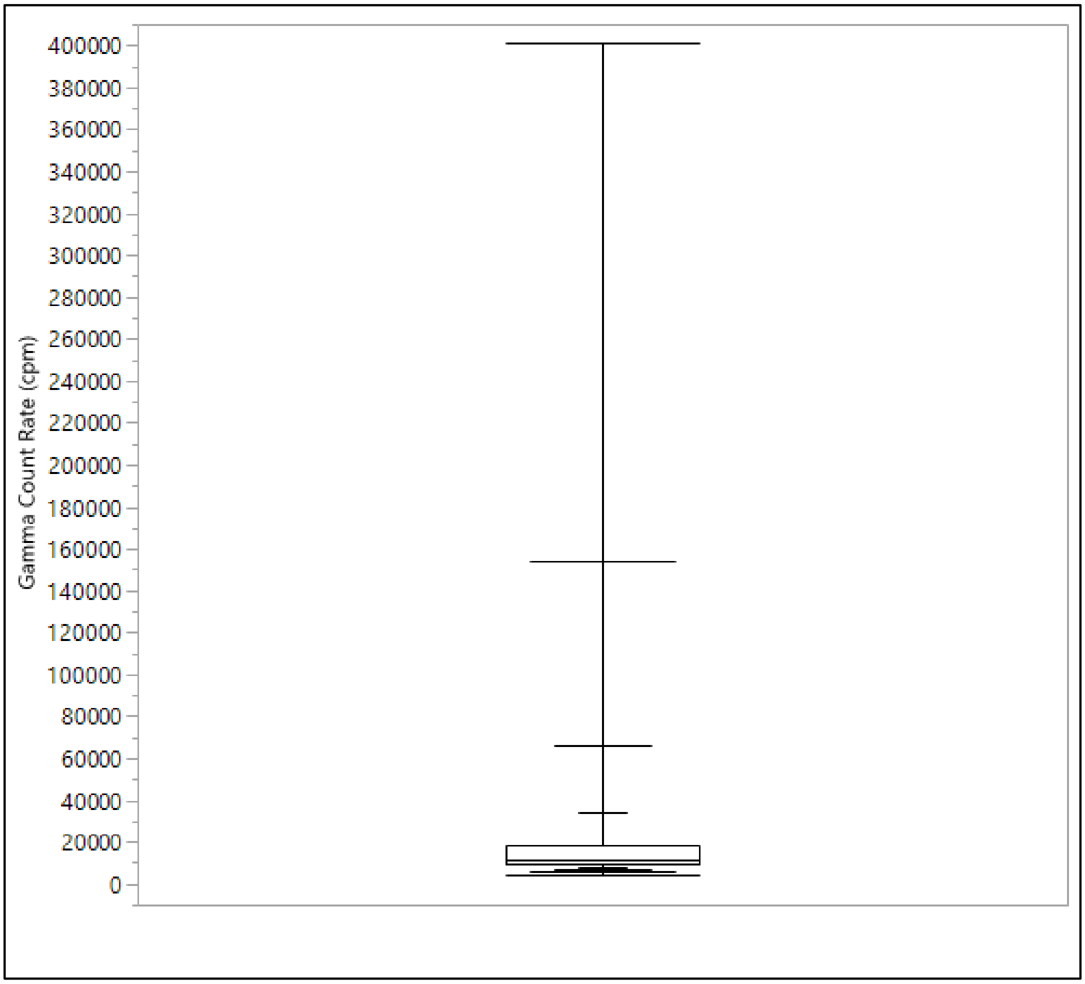


Figure 6. Box plot of gamma count rates in the Survey Area.

3.0 Correlation Studies

The following sections address the activities under two types of correlation studies outlined in the RSE Work Plan: comparisons of 1) radium-226 concentrations in surface soils and gamma count rates and 2) exposure rates and gamma count rates. GPS-based gamma count rate measurements were made over small areas for the former study. The means of the measurements were used in this case. Static gamma count rate measurements, co-located with exposure rate measurements, were used in the latter study.

3.1 Radium-226 concentrations in surface soils and gamma count rates

On March 27, 2017 field personnel made GPS-based gamma count rates measurements and collected five-point composite samples of surface soils in each of five areas at the AUM. The activities were performed contemporaneously, by area and all on the same day, such that variations in the gamma count rate measurements could be limited largely to those posed by the soils and rocks at the locations. Figure 7 shows the GPS-based gamma count rate measurements in the six areas (labeled with location identifiers).

The soil samples were analyzed by ALS Laboratories in Ft Collins, CO for radium-226 and isotopic thorium. The latter analysis was included to assess the potential effects of thorium series isotopes on the correlation and evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series.

Table 4 lists the results of the gamma count rate measurements and radium-226 concentrations in the soil samples. The means of the gamma count rate measurements range from 7,411 to 53,556 cpm. The concentrations of radium-226 in the soil samples range from 0.45 to 29.2 pCi/g.

Table 5 lists the concentrations of isotopes of thorium (thorium-228, -230, and -232) in the same soil samples.

Laboratory analyses are presented in Appendix D, Laboratory Analytical Data and Data Usability Report, in “Eunice Becenti Removal Site Evaluation Report” (Stantec, 2017).

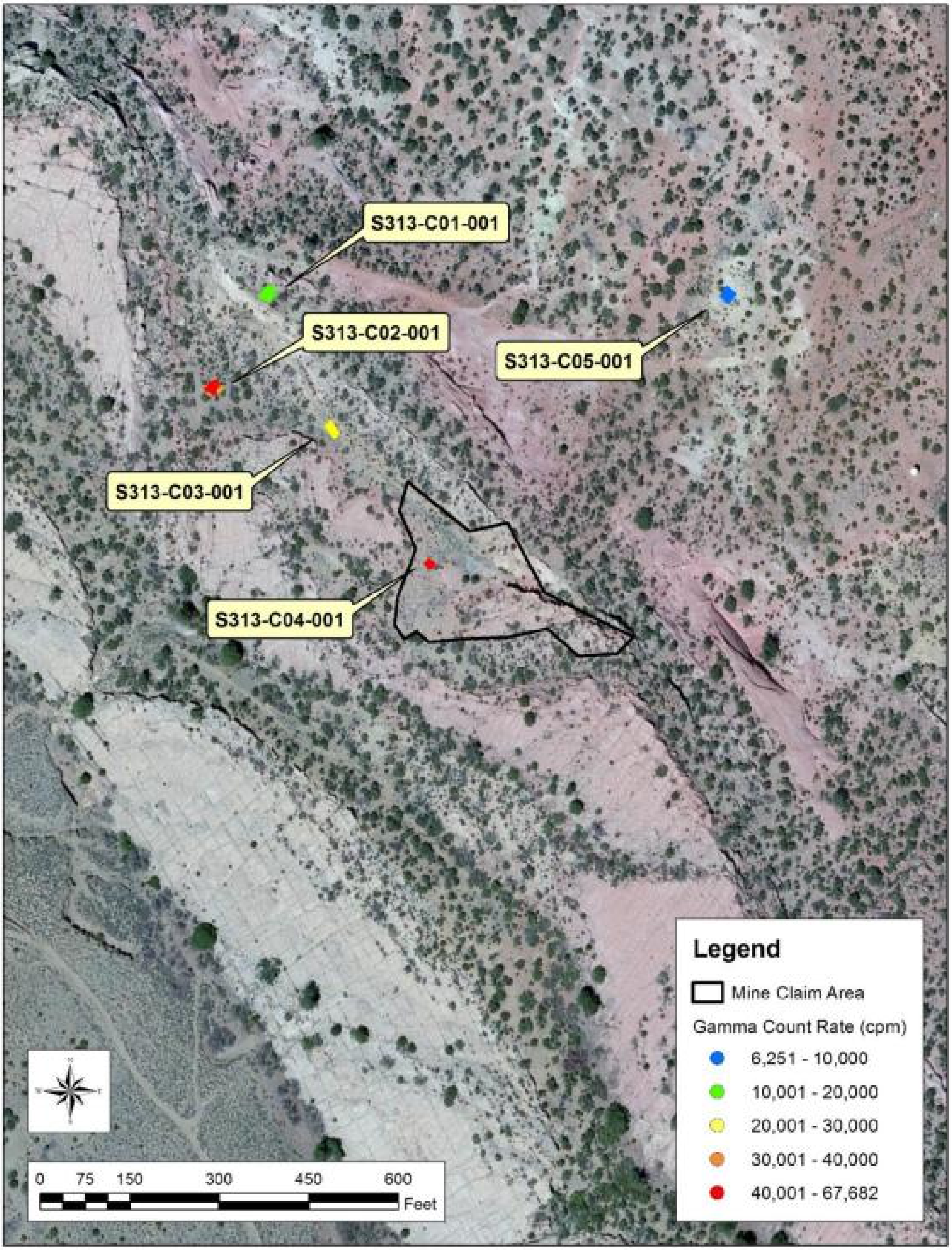


Figure 7. GPS-based gamma count rate measurements made for the correlation study.

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**
S313-C01-001	13,562	12,796	14,242	367	2.34	0.39	0.35
S313-C02-001	42,280	36,165	49,577	3,900	22.3	2.7	0.7
S313-C03-001	21,843	18,936	23,797	1,172	15.1	1.9	0.6
S313-C04-001	57,769	53,556	67,682	2,632	29.2	3.5	0.8
S313-C05-001	7,411	6,251	8,631	448	0.45	0.17	0.29

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**
S313-C01-001	0.78	0.14	0.05	1.87	0.31	0.07	0.74	0.13	0.02
S313-C02-001	0.79	0.16	0.09	15	2.4	0.1	0.77	0.16	0.03
S313-C03-001	1.23	0.22	0.06	11.8	1.9	0.1	1.23	0.22	0.02
S313-C04-001	0.88	0.18	0.09	22	3.5	0.1	0.98	0.19	0.02
S313-C05-001	0.147	0.048	0.051	0.196	0.06	0.066	0.202	0.049	0.016

Notes:
MDL = method detection limit
pCi/g = picocuries per gram
σ = standard deviation

A model was made of the results in Table 4, predicting the concentrations of radium-226 in surface soils from the mean gamma count rate in each area. The best predictive relationship between the measurements, shown in Figure 8 is a strong, linear function with a Pearson's Correlation Coefficient (R^2) of 0.9084, as expressed in the equation:

$$\text{Radium-226 concentration (pCi/g)} = 6 \times 10^{-4} \times \text{Gamma Count Rate (cpm)} - 2.5619$$

R^2 is a measure of the dependence between two variables and is expressed as a value between -1 and +1 where +1 is a positive correlation, 0 is no correlation, and -1 is a negative correlation. The root mean square error and p-value for the model are 0.917498 and 0.0067, 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 1.23 pCi/g. Given these low concentrations and the high R^2 of the linear function, the thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226, using gamma count rates.

This equation was used to convert the gamma count rate measurements observed in the gamma surveys to predicted concentrations of radium-226. Table 6 presents summary statistics for the predicted concentrations of radium-226 in the Survey Area. The range of the predicted concentrations of radium-226 in the Survey Area is 0.2 to 238 pCi/g, with a mean and median of 8.3 and 4.3 pCi/g, respectively. Note that the radium-226 concentrations predicted from gamma count rate measurements exceeding approximately 58,000 cpm are extrapolated from the regression model and are uncertain.

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

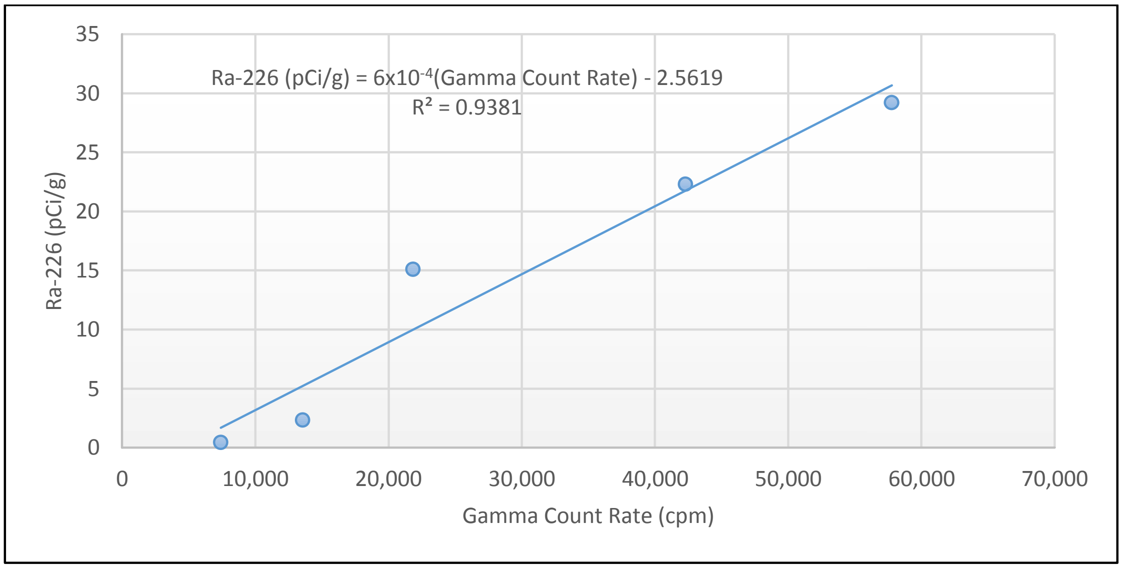


Figure 8. Correlation of gamma count rates and concentrations of radium-226 in surface soils.

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

Parameter	Radium-226 (pCi/g)
n	67,273
Minimum	0.2
Maximum	238
Mean	8.3
Median	4.3
Standard Deviation	12.4

Notes:
pCi/g = picocuries per gram

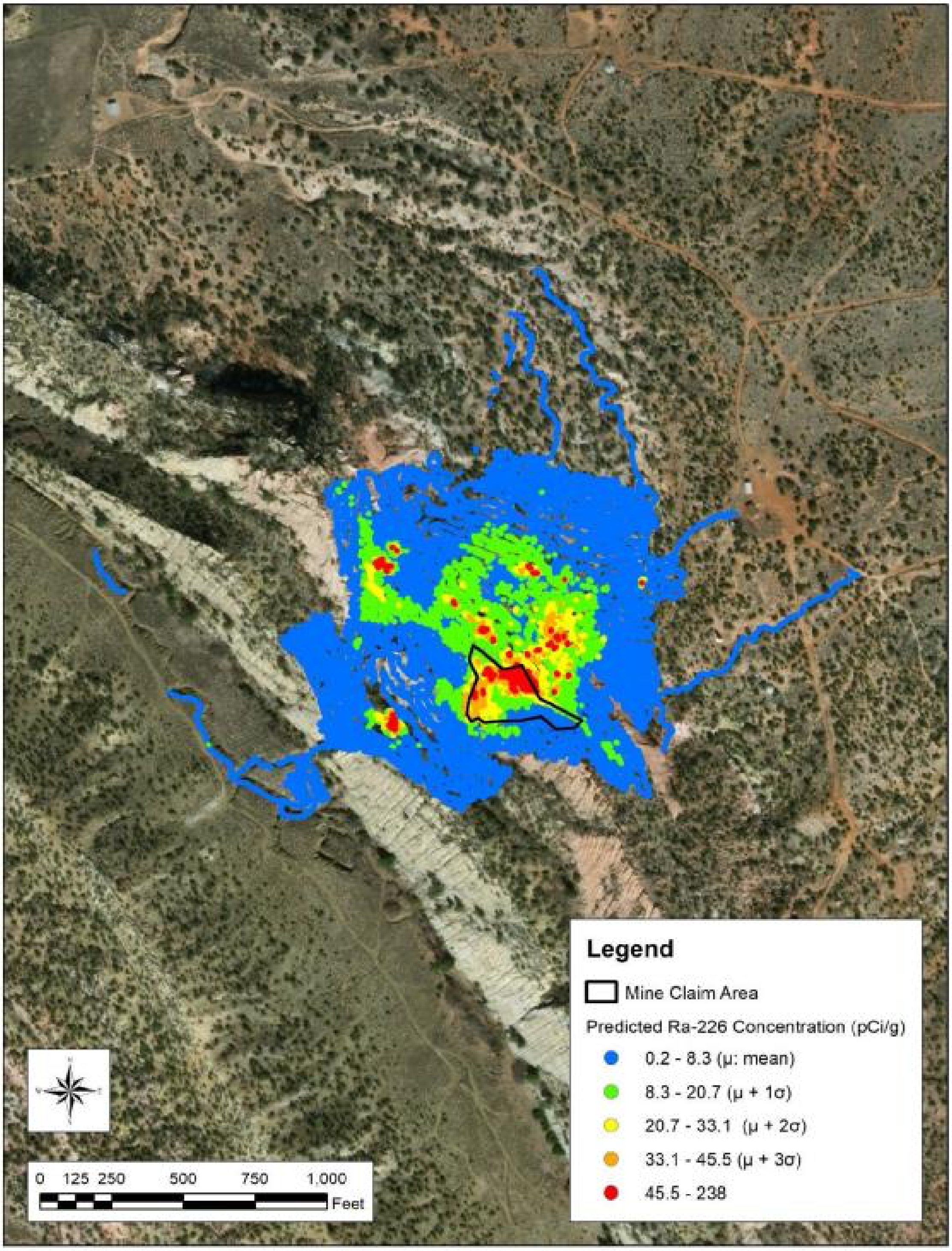


Figure 9. Predicted concentrations of radium-226 in the Survey Area.

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 1.3 (Sample S313-C01-001), 1.5 (Sample S313-C02-001), 1.3 (Sample S313-C03-001), 1.3 (Sample S313-C04-001), and 2.3 (Sample S313-C05-001) indicating that thorium-230 is depleted in relation to radium-226 and, by extrapolation, the uranium series itself is not in secular equilibrium.

Note this observation is based on the results of five samples, subject to differing analytical methods. Gamma spectroscopy, the method used to determine the concentration of radium-226, assesses an intact portion of the whole sample as it was collected. The concentration of thorium-230 was determined by alpha spectroscopy of an acid-leached aliquot of the sample.

This evaluation is not related to the correlation of radium-226 concentrations in surface soils and gamma count rates. It may be used for a future risk assessment.

3.3 Exposure rates and gamma count rates

On September 15, 2017, field personnel made co-located one-minute static count rate and exposure rate measurements at the same five locations within the Survey Area described in Section 3.1. Figure 7 shows the locations of the co-located measurements, which were made in the centers of the areas.

The gamma count rate and exposure rate measurements were made at 0.5 m and 1 m above the ground surface, respectively. The gamma count rate measurements were made using a Ludlum Model 44-10/2221 sodium iodide detection system (Serial Number PR355763/138368), which is the same model used in the GPS-based gamma survey of the AUM. The exposure rate measurements were made using a Reuter Stokes Model RS-S131-200-ER000 (Serial Number 1000992) high pressure ionization chamber (HPIC) at 1-second intervals for about 10 minutes. The HPIC output the 1-second measurements as 1-minute averages. The exposure rate used in the comparison was the mean of these measurements, less those occurring in initial instrument warm-ups. The HPIC was in current calibration and function-checked before and after use. Calibration forms for the HPIC are provided in Appendix A. Table 7 presents the results for the two types of measurements made at each of the five locations. Appendix B presents the individual (one minute) exposure rate measurements.

The best predictive relationship between the measurements is linear with a R^2 of 0.9951, strongly indicating a positive correlation. The root mean square error and p-value for the correlation are 1.16103 and 0.0001, respectively; these parameters are not DQOs and are included only as information.

The following equation is the linear regression (shown in Figure 10) between the mean exposure rate and gamma count rate results in Table 7 that was generated using MS Excel:

Exposure Rate (in microRoentgens per hour [μR/h]) = 4×10^{-4} x Gamma Count Rate (cpm) + 8.9902

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 Areas and Survey Area, respectively.

The range of predicted exposure rates at:

- BG1 is 11.8 to 14.3 μR/h, with a mean and median of 12.9 and 12.8 μR/h, respectively.
- BG2 is 12.5 to 16.6 μR/h, with a mean and median of 14.2 and 14.1 μR/h, respectively.
- BG3 is 12.5 to 15.6 μR/h, with a mean and median of 14.1 and 14.2 μR/h, respectively.
- BG4 is 13.3 to 15.3 μR/h, with a mean and median of 14.2 and 14.1 μR/h, respectively.
- BG5 is 11.3 to 13.9 μR/h, with a mean and median of 12.4 μR/h.

The range of predicted exposure rates in the Survey Area is 10.8 to 169.4 μR/h, with a mean and median of 16.2 and 13.6 μR/h, respectively.

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

Location	Gamma Count Rate (cpm)	Exposure Rate (μR/h)
S313-C01-001	14502	15.6
S313-C02-001	47589	31.4
S313-C03-001	24708	19.7
S313-C04-001	89009	47.2
S313-C05-001	7909	11.5

Notes:
cpm = counts per minute
μR/h = microRoentgens per hour

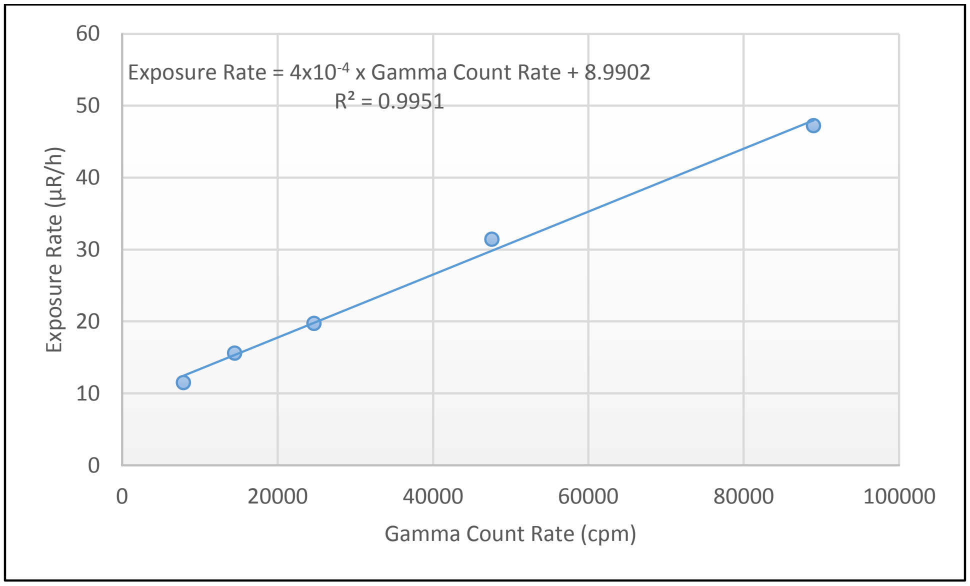


Figure 10. Correlation of gamma count rates and exposure rates.

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

Potential Background Reference Area	BG1	BG2	BG3	BG4	BG5
Parameter	**Exposure Rate (µR/h)**				
n	188	242	419	226	804
Minimum	11.8	12.5	12.5	13.3	11.3
Maximum	14.3	16.6	15.6	15.3	13.9
Mean	12.9	14.2	14.1	14.2	12.4
Median	12.8	14.1	14.2	14.1	12.4
Standard Deviation	0.5	0.8	0.5	0.4	0.4

Notes:
BG1 = Background Reference Area 1
BG2 = Background Reference Area 2
BG3 = Background Reference Area 3
BG4 = Background Reference Area 4
BG5 = Background Reference Area 5
µR/h = microRoentgens per hour

Table 9. Predicted exposure rates in the Survey Area.

Parameter	Exposure Rate (µR/h)
n	67,273
Minimum	10.8
Maximum	169.4
Mean	16.2
Median	13.6
Standard Deviation	8.2

Notes:
µR/h = microRoentgens per hour

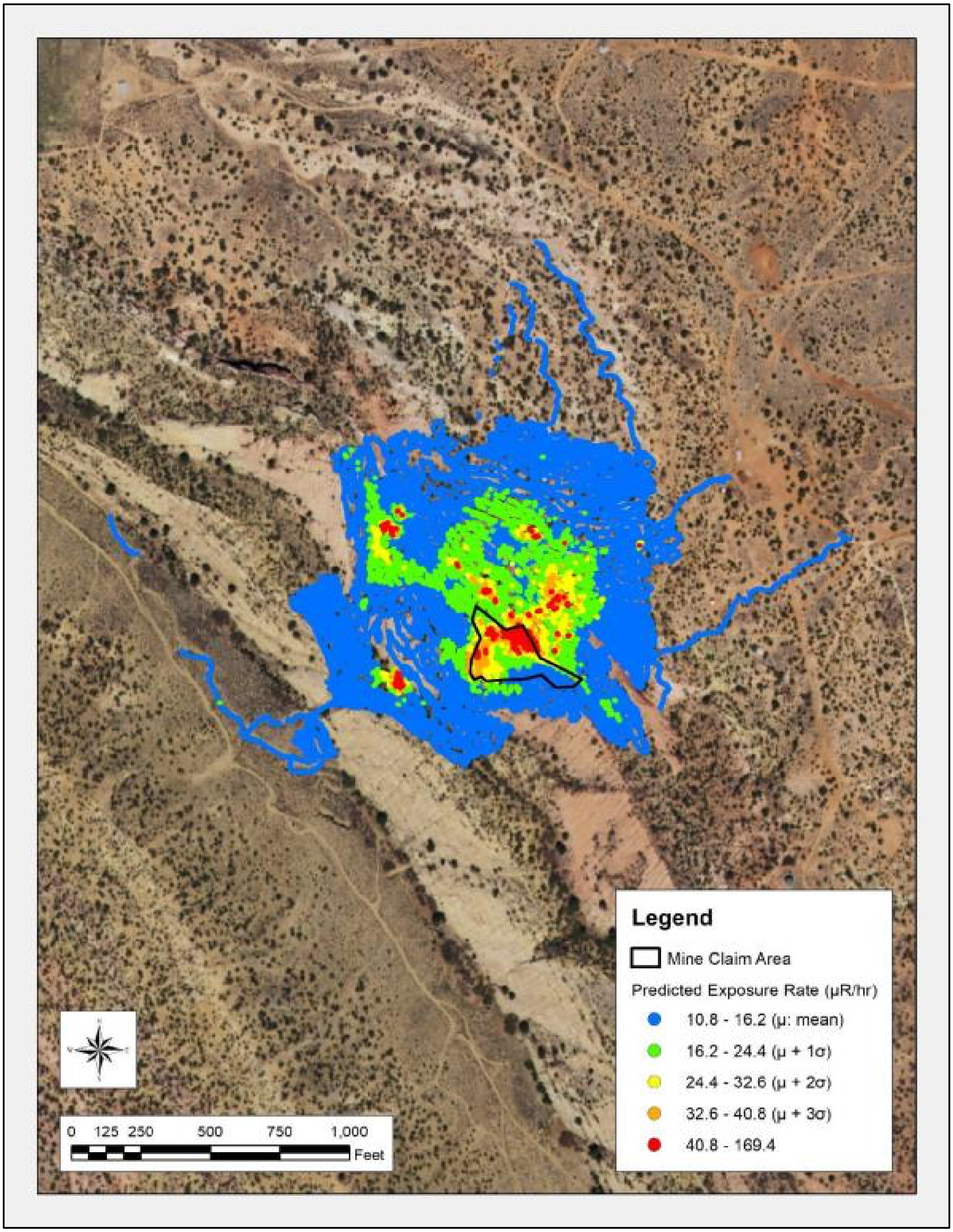


Figure 11. Predicted exposure rates in the Survey Area.

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 largely on naturally occurring outcrops and waste rock in and extending outward from the mine claim; and a waste pile associated with a portal outside the mine claim.

- Five potential Background Reference Areas were established for this AUM.

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

  Radium-226 concentration (pCi/g) = 6×10^{-4} x Gamma Count Rate (cpm) – 2.5619

- 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 0.2 to 238, with a central tendency (median) of 4.3 pCi/g.

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

- The uranium series radionuclides appear not to be in secular equilibrium.

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

  Exposure Rate (µR/h) = Gamma Count Rate (cpm) x 4×10^{-4} + 8.9902

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 10.8 to 169.4, with a central tendency (median) of 13.6 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, 2018. Eunice Becenti Removal Site Evaluation Report, January 2018.

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

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

✔ 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: 24.75 inches Hg

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

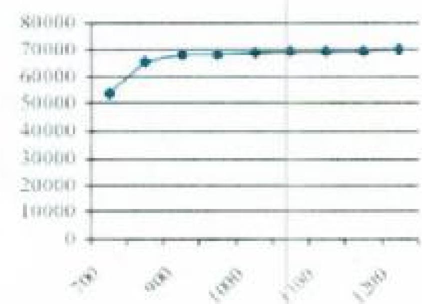
Source Geometry: ✔ Side ☐ Below ☐ Other: Window: Relative Humidity: 20 %

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	398857	400
x 1000	100	100	100		100
x 100	400	400	400	39913	400
x 100	100	100	100		100
x 10	400	400	400	3992	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	53620	
800	64979	
900	67955	
950	67795	
1000	68536	9542
1050	69153	
1100	69331	
1150	69346	
1200	69492	

Voltage Plateau



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

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932 Fluke multimeter serial number: 87490128

☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03 ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03 ☐ Other Source:

Calibrated By: [signature] Calibration Date: 7-6-16 Calibration Due: 7-6-17

Reviewed By: Cf Date: 7/20/16

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

Certificate of Calibration

Calibration and Voltage Plateau

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

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	196086
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR295014

✔ Mechanical Check ✔ THR/WIN Operation
✔ F/S Response Check ✔ Reset Check
✔ Geotropism ✔ Audio Check
✔ Meter Zeroed ✔ Battery Check (Min 4.4 VDC)
Source Distance: Contact ✔ 6 inches Other:
Source Geometry: ✔ Side Below Other:

HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
Cable Length: 39-inch ✔ 72-inch Other:
Threshold: 10 mV
Window:

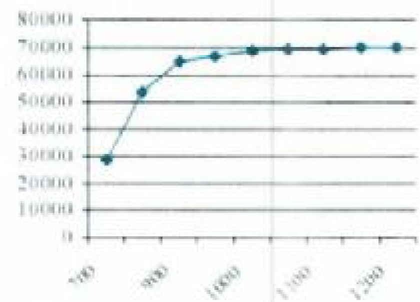
Barometric Pressure: 24.78 inches Hg
Temperature: 74 °F
Relative Humidity: 20 %

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	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: 7/8/16 Calibration Due: 7/8/17

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

ERG Form ITC. 101.A

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Certificate of Calibration

Calibration and Voltage Plateau

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

Meter: Manufacturer: Ludlum Model Number: 2221r Serial Number: 282966

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

☑ 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: 60"

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

Threshold: 10 mV
Window:

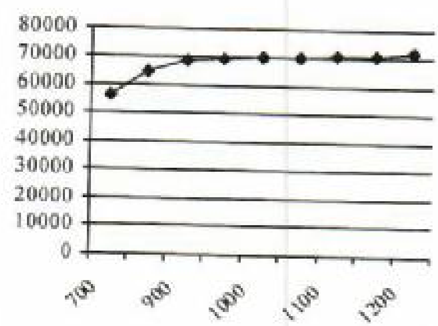
Barometric Pressure: 24.89 inches Hg
Temperature: 73 °F
Relative Humidity: 20 %

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:

Calibrated By:
Reviewed By:

Calibration Date: 10-31-16 Calibration Due: 10-31-17
Date: 10/31/16

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Certificate of Calibration

Calibration and Voltage Plateau

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

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

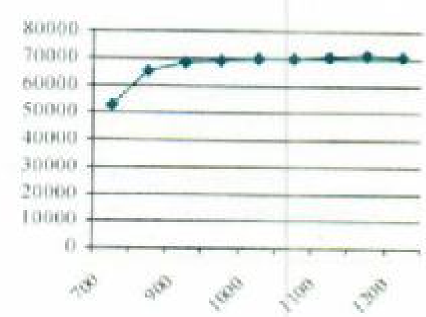
✔ Mechanical Check ✔ THR/WIN Operation HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
✔ F/S Response Check ✔ Reset Check Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:
✔ Geotropism ✔ Audio Check
✔ Meter Zeroed ✔ Battery Check (Min 4.4 VDC) Barometric Pressure: 24.24 inches Hg
Source Distance: ☐ Contact ✔ 6 inches ☐ Other: Threshold: 10 mV Temperature: 78 °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	399859	400
x 1000	100	100	100		100
x 100	400	400	400	39991	400
x 100	100	100	100		100
x 10	400	400	400	4001	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	52821	
800	65213	
900	68644	
950	69245	
1000	69492	9111
1050	69792	
1100	70472	
1150	71183	
1200	70571	

Voltage Plateau



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

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932 Fluke multimeter serial number: ☐ 87490128
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03 ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03 ☐ Other Source:

Calibrated By: Calibration Date: ~~2 March 17~~ 2/28/17 ASH Calibration Due: ~~2 March~~ 2/28/18 ASH 18

Reviewed By: Date: 3-1-17

Certificate of Calibration

Calibration and Voltage Plateau

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

Meter: Manufacturer: Ludlum Model Number: 2221r Serial Number: 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)

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

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

Barometric Pressure: 24.27 inches Hg

Temperature: 78 °F

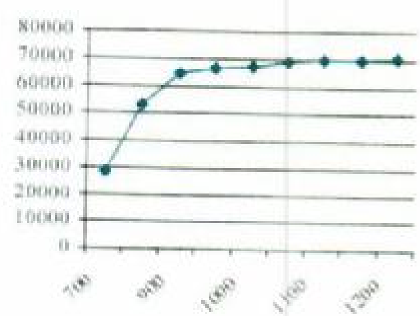
Relative Humidity: 20 %

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	399386	400
x 1000	100	100	100		100
x 100	400	400	400	39949	400
x 100	100	100	100		100
x 10	400	400	400	3995	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	28235	
800	52834	
900	64481	
950	66468	
1000	67321	
1050	69009	
1100	69981	9079
1150	69564	
1200	70538	

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]

Reviewed By: [signature]

Calibration Date: 2/28/17 ~~1 March 17~~

Calibration Due: 2/28/18 ~~1 March 18~~

Date: 3/1/17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

ERG

Certificate of Calibration

Calibration and Voltage Plateau

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

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	271435
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR295017

☐ 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: 24.66 inches Hg

Source Distance: ☐ Contact ✔ 6 inches ☐ Other: Threshold: 10 mV Temperature: 76 °F

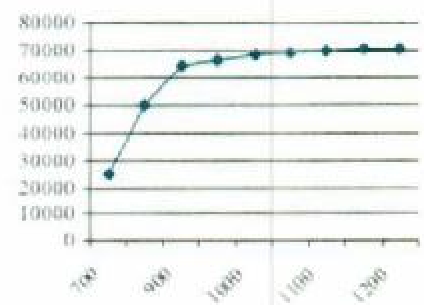
Source Geometry: ✔ Side ☐ Below ☐ Other: Window: Relative Humidity: 20 %

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				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

High Voltage	Source Counts	Background
700	24824	
800	50232	
900	64285	
950	66354	
1000	68179	
1050	69312	9393
1100	69955	
1150	70625	
1200	70633	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1050

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932 Fluke multimeter serial number: ☐ 87490128

☐ Alpha Source: Th-230 sn: 4098-03 @ 12,800dpm/6,520 cpm (1/4/1 ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

☐ Beta Source: Tc-99 sn: 4099-03 @ 17,700dpm/11,100cpm (1/4/12 ☐ Other Source:

Calibrated By: Calibration Date: 3-13-17 Calibration Due: 3-13-18

Reviewed By: Date: 14 March 2017

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

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

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Meter:	Manufacturer: Ludlum	Model Number:	2221r	Serial Number:	282971
Detector:	Manufacturer: Ludlum	Model Number:	44-10	Serial Number:	PR320678

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

HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V

Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:

Source Distance: ☐ Contact ✔ 6 inches ☐ Other:

Source Geometry: ✔ Side ☐ Below ☐ Other:

Threshold: 10 mV

Window:

Barometric Pressure: 24.63 inches Hg

Temperature: 75 °F

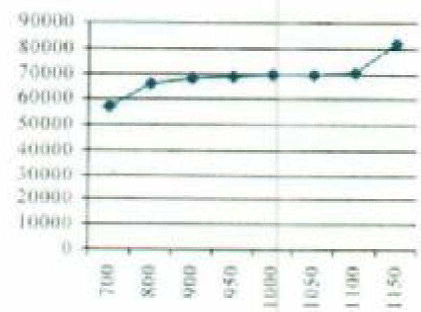
Relative Humidity: 20 %

Instrument found within tolerance: ✔ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399936	400
x 1000	100	100	100		100
x 100	400	400	400	39984	400
x 100	100	100	100		100
x 10	400	400	400	3998	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	57641	
800	65850	
900	68414	
950	68639	
1000	69410	9773
1050	69358	
1100	70301	
1150	81822	

Voltage Plateau



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

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932

Fluke multimeter serial number: ☐ 87490128

☐ Alpha Source: Th-230 sn: 4098-03 @ 12,800dpm/6,520 cpm (1/4/1

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

☐ Beta Source: Tc-99 sn: 4099-03 @ 17,700dpm/11,100cpm (1/4/12

☐ Other Source:

Calibrated By: [signature]

Calibration Date: 3-13-17

Calibration Due: 3-13-18

Reviewed By: [signature]

Date: 14 March 2017

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:	108878
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR321872

✔ 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: 24.45 inches Hg

Source Distance: Contact ✔ 6 inches Other: Threshold: 100 mV Temperature: 75 °F

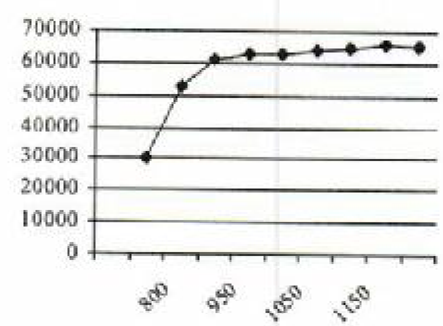
Source Geometry: ✔ Side Below Other: Window: Relative Humidity: 20 %

Instrument found within tolerance: ✔ Yes No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	401515	400
x 1000	100	100	100		100
x 100	400	400	400	40124	400
x 100	100	100	100		100
x 10	400	400	400	4009	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	30049	
800	52595	
900	61211	
950	62937	
1000	62955	
1050	64212	10044
1100	64857	
1150	65633	
1200	65476	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV =1050

Reference Instruments and/or Sources:

Ludlum pulser serial number: 97743 ✔ 201932 Fluke multimeter serial number: 87490128

Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12) ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12) Other Source:

Calibrated By: [signature] Calibration Date: 5 June 17 Calibration Due: 5 June 18

Reviewed By: [signature] Date: 5 June 17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

Certificate of Calibration

Calibration and Voltage Plateau

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

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	138368
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR355763

☑ 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:

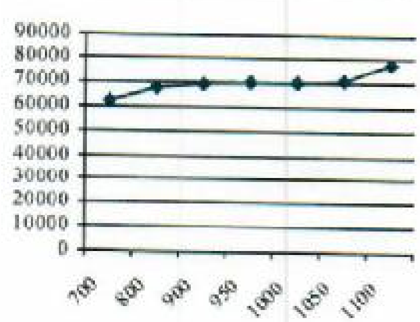
Barometric Pressure: 24.75 inches Hg
Temperature: 76 °F
Relative Humidity: 20 %

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	398875	400
x 1000	100	100	100		100
x 100	400	400	400	39883	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	398	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	62275	
800	68049	
900	69726	
950	70112	9509
1000	70068	
1050	71042	
1100	77619	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 950

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
Fluke multimeter serial number: ☐ 87490128
☐ Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12)
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12)
☐ Other Source:

Calibrated By: [signature] Calibration Date: 9-17-17 Calibration Due: 9-17-18

Reviewed By: T. [signature] Date: 09/08/17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

Reuter-Stokes

Calibration Certificate

Reuter-Stokes certifies that the Environmental Radiation Monitor, identified below, has been calibrated for output using the shadow shield technique*, and calibrated with radiation sources traceable to the National Institute of Standards and Technology.

Sensor Type: 100 R/Hr

Serial Number: 1000992

Calibration Date: 03/16/2017

Sensitivity: -2.281E-8 A/R/h

Authorized Signature

*Calibration Procedure: RS-SOP 238.1

Reuter-Stokes

Calibration Data

Sensor Type:	100 R/Hr	Source (CS-137):	BB-400
Serial Number:	1000992	Date of Certification:	12/01/1994
Calibration Date:	03/16/2017	Exposure Rate at 1 meter:	4.226 mR/h

Customer Name: STOCK

Sensitivity (Ra-226): -2.281E-8 A/R/h

Distance		Exposure Rate	P+S+A	S+A	P	k(CS-137)
Feet	cm	μR/h	A	A	A	A/R/h
12	366	185.323	-5.403E-12	-1.164E-12	-4.239E-12	-2.287E-08
14	427	135.592	-4.135E-12	-1.012E-12	-3.123E-12	-2.303E-08
16	488	103.384	-3.294E-12	-9.029E-13	-2.391E-12	-2.313E-08
18	549	81.348	-2.708E-12	-8.209E-13	-1.887E-12	-2.319E-08

k(CS-137) = -2.306E-8 A/R/h

k(Ra-226) = 0.9892 k(CS-137)

k(Ra-226) = -2.281E-8 A/R/h

k = -2.306E-8 A/R/h

σ = 1.39E-10 A/R/h

$V = \frac{\sigma}{k}$ = -0.603%

By: John Lak

Date: 3-17-17

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	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
11-18-16	0829	5.4	1015	101	51216	13360	37856	NW	Standing Rock
11-18-16	1517	5.3	1006	100	48629	10616	38013	NW	Gallup lot
11-19-16	0808	5.3	1014	100	43603	5712	37891	NW	Eunice Bicenti
11-19-16	1400	5.1	1005	100	44923	5058	39865	NW	Eunice Bicenti

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

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

Comments:

NNEAT

Source: Cs-137
Serial No.: 333-94
Activity: 5.12 uCi
Emission Rate: NA cpm/emissions
Source Date: 6-6-94
Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project Reference Points
11-16-16	0812	5.7	1110	101	49614	11731	37883	NW	Standing Rock
11-16-16	1515	5.6	1104	100	48046	10720	37326	NW	Gallup lot
11-18-16	0826	5.7	1116	102	51120	13035	38085	NW	Standing Rock
11-18-16	1512	5.6	1126	101	48583	10155	38428	NW	Gallup lot
11-19-16	0817	5.6	1115	102	44225	4772	39453	NW	Eunice Becenti
11-19-16	1403	5.5	1102	100	43512	4751	38761	NW	Eunice Becenti

NW 12-6-16

Reviewed by: [signature]

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:
NN EAT

Source: Cs-137

Serial No.: 333-94

Activity: 5.12 uCi

Emission Rate: NA cpm/emissions

Source Date: 6-6-94

Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project Reference Points
11-12-16	0827	5.7	1010	102	48550	9744	38806	NW	Haskie Tso
11-12-16	1351	5.6	1000	101	47089	8725	38364	NW	Haskie Tso
11-16-16	0826	5.7	1011	102	50569	12266	38303	NW	Standing Rock
11-16-16	1518	5.6	1006	103	50039	11202	38837	NW	Gallup lot
11-18-16	0836	5.7	1017	104	52221	13620	38601	NW	Standing Rock
11-18-16	1530	5.6	1009	103	48820	10831	37989	NW	Gallup lot
11-19-16	0812	5.6	1016	104	44700	4940	39760	NW	Eunice Becenti
11-19-16	1407	5.5	1004	102	44961	4975	39986	NW	Eunice Becenti

NW 12-6-16

Reviewed by: MV

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.:	254772
Cal. Due Date:	2-28-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR 303727
Cal. Due Date:	2-28-18

Comments:
NNERT

Source: Cs-137   Activity: 4 uCi   Source Date: 4-18-96   Distance to Source: 6 inches

Serial No.: 544-96   Emission Rate: N/a cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-22-17	0658	5.9	948	100	37553	5150	32403	NW	Goulding's lot
3-22-17	1432	5.7	944	100	35555	4865	30690	NW	Charles Keith shooting range
3-23-17	0903	5.8	949	100	35647	5062	30585	NW	NA-0928
3-23-17	1918	5.7	950	101	41998	10371	31627	NW	Gallup lot
3-24-17	0812	5.7	953	100	36633	4660	31973	NW	Eunice Becenti
3-24-17	1740	5.6	947	100	42350	11142	31208	NW	Gallup lot
3-27-17	0830	5.6	952	100	36518	4677	31841	NW	Eunice Becenti
3-27-17	1230	5.5	949	100	36189	4090	32099	NW	Eunice Becenti

NW 4-2-17

Reviewed by: [signature]   Review Date: 11/06/17

2

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	196086
Cal. Due Date:	2-28-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR 295014
Cal. Due Date:	2-28-18

Comments:
NNEAT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-20-17	0905	5.7	1003	101	40471	8507	31964	NW	Claim 28
3-20-17	1547	5.6	996	101	36470	5494	30976	NW	Chinle lot
3-21-17	0641	5.7	1004	101	37904	5597	32307	NW	Chinle lot
3-21-17	1654	5.6	999	101	36212	4929	31283	NW	Goulding's lot
3-22-17	0702	5.6	1001	101	35714	5119	30595	NW	Goulding's lot
3-22-17	1437	5.4	995	101	35087	4539	30548	NW	Charles Keith shooting range
3-23-17	0907	5.6	1004	101	36031	4879	31152	NW	NA-0928
3-23-17	1922	5.5	1004	101	41793	9955	31838	NW	Gallup lot
3-24-17	0810	5.5	1007	101	35608	4282	31326	NW	Eunice Becenti
3-24-17	1735	5.5	1000	101	41923	10785	31138	NW	Gallup lot
3-27-17	0833	5.5	1005	101	36943	4282	32661	NW	Eunice Becenti
3-27-17	1235	5.4	1000	101	35141	4013	31128	NW	Eunice Becenti

Reviewed by: [signature] Review Date: 10/9/17

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	271435
Cal. Due Date:	3-13-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR295017
Cal. Due Date:	3-13-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-22-17	0705	5.6	1050	100	35820	5210	30610	NW	Goulding's lot
3-22-17	1425	5.5	1049	101	36169	4648	31521	NW	Charles Keith shooting range
3-23-17	0908	5.6	1056	102	35972	4828	31144	NW	NA-0928
3-23-17	1915	5.5	1055	102	41686	10757	30929	NW	Gallup lot
3-24-17	0805	5.5	1060	102	36151	4442	31709	NW	Eunice Becenti
3-24-17	1744	5.4	1051	101	41975	10973	31002	NW	Gallup lot
3-25-17	0908	5.5	1057	102	37581	5827	31754		Section 26
3-25-17				DID	NOT USE				
					4-2-17				

Reviewed by: [signature] Review Date: ~~9~~ 10/9/17

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ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	282971
Cal. Due Date:	3-13-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR320678
Cal. Due Date:	3-13-18

Comments:
NNERT - Soils Characterization

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-20-17	1334	5.7	1046	100	37108	6411	30697	NW	Charles Keith
6-20-17	1651	5.6	1035	98	36894	5907	30987	NW	Charles Keith
6-21-17	0720	5.7	1045	100	38258	6568	31690	NW	Charles Keith
6-21-17	1400	5.5	1035	99	36426	5473	30953	NW	Charles Keith
6-22-17	0732	5.6	1044	100	37058	5300	31758	NW	Charles Keith
6-22-17	1710	5.5	1042	99	37441	6708	30733	NW	Tsosie 1
6-24-17	0901	5.6	1047	100	38218	7111	31107	NW	Tsosie 1
6-24-17	1655	5.5	1041	99	36728	6080	30648	NW	Tsosie 1
6-26-17	0852	5.6	1048	100	38982	7442	31540	NW	Tsosie 1
6-26-17	1632	5.4	1040	99	38932	7627	31305	NW	Tsosie 1
6-27-17	1238	5.5	1047	100	36268	5913	30355	NW	Eunice Becenti
6-27-17	1403	5.5	1044	100	36016	5567	30449	NW	Eunice Becenti

Reviewed by: [signature] Review Date: 10/19/17

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	282971
Cal. Due Date:	3-13-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR 320678
Cal. Due Date:	3-13-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 54496 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-28-17	0734	5.5	1048	100	37396	6070	31326	NV	Eunice Becenti
6-28-17	1754	5.4	1044	100	37285	6171	36608	NV	Gallup: Garden Inn lot
6-29-17	0652	5.5	1048	100	43496	12192	31305	NV	Gallup: Fairfield Inn lot
6-30-17	0847	5.4	1045	100	42152	9043	33109	NV	ERG office

7-5-17

Reviewed by: ~~AB~~ MH Review Date: 10/4/17

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	196086
Cal. Due Date:	2-28-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR295014
Cal. Due Date:	2-28-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 Inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-26-17	0900	6.2	1109	101	38088	6806	31282	NW	Tsosie 1
6-26-17	1619	6.0	1095	99	38337	6166	32171	NW	Tsosie 1
6-27-17	1247	6.1	1108	100	36994	5161	31833	NW	Eunice Becenti
6-27-17	1358	6.0	1102	101	36293	5017	31276	NW	Eunice Becenti
6-28-17	0730	6.1	1111	101	36814	5111	31703	NW	Eunice Becenti
6-28-17	1752	5.9	1101	100	37391	5304	32087	NW	Gallup Garden Inn lot
6-29-17	0908	5.9	1106	100	35972	6002	29970	NW	Section 26
6-30-17	0855	5.9	1107	100	40749	9057	31692	NW	ERG office

7-5-17

Reviewed by: MJA Review Date: 10/9/17

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	108878
Cal. Due Date:	6-5-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR 321872
Cal. Due Date:	6-5-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-15-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-28-17	1100	5.9	1146	100	36066	5437	30629	MW	Eunice Becenti
6-28-17	1747	5.7	1143	100	38916	5995	32921	MW	Gallup Garden Inn Lot

MW 7-5-17

Reviewed by: MM

Review Date: 10/9/17

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	138368
Cal. Due Date:	9-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR355763
Cal. Due Date:	9-7-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 Inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
9-12-17	0914	5.4	950	101	36935	6331	30604	NW	Barton 3
9-12-17	1432	5.3	944	99	38043	6468	31575	NW	Tsosie 1
9-13-17	0906	5.4	951	99	37146	6538	30608	NW	Alongo
9-13-17	1600	5.3	944	99	35587	5991	29596	NW	Barton 3
9-14-17	0909	5.4	950	100	36080	6176	29904	NW	NA-0904
9-14-17	1255	5.3	948	100	36099	5764	30335	NW	NA-0904
9-15-17	0920	5.4	954	101	35208	5551	29657	NW	Ennice Benali
9-15-17	1729	5.3	957	109	35937	5261	30676	NW	Eunice Benali
9-19-17	0831	5.4	958	105	36467	6034	30433	NW	Section 26 @ trailer
9-19-17	1453	5.3	946	99	44454	14748	29706	NW	Section 26 @ corral
9-20-17	0736	5.3	953	102	37676	6987	30689	NW	Mexican Hat
9-20-17	1611	5.2	947	100	36842	6252	30590	NW	Mexican Hat

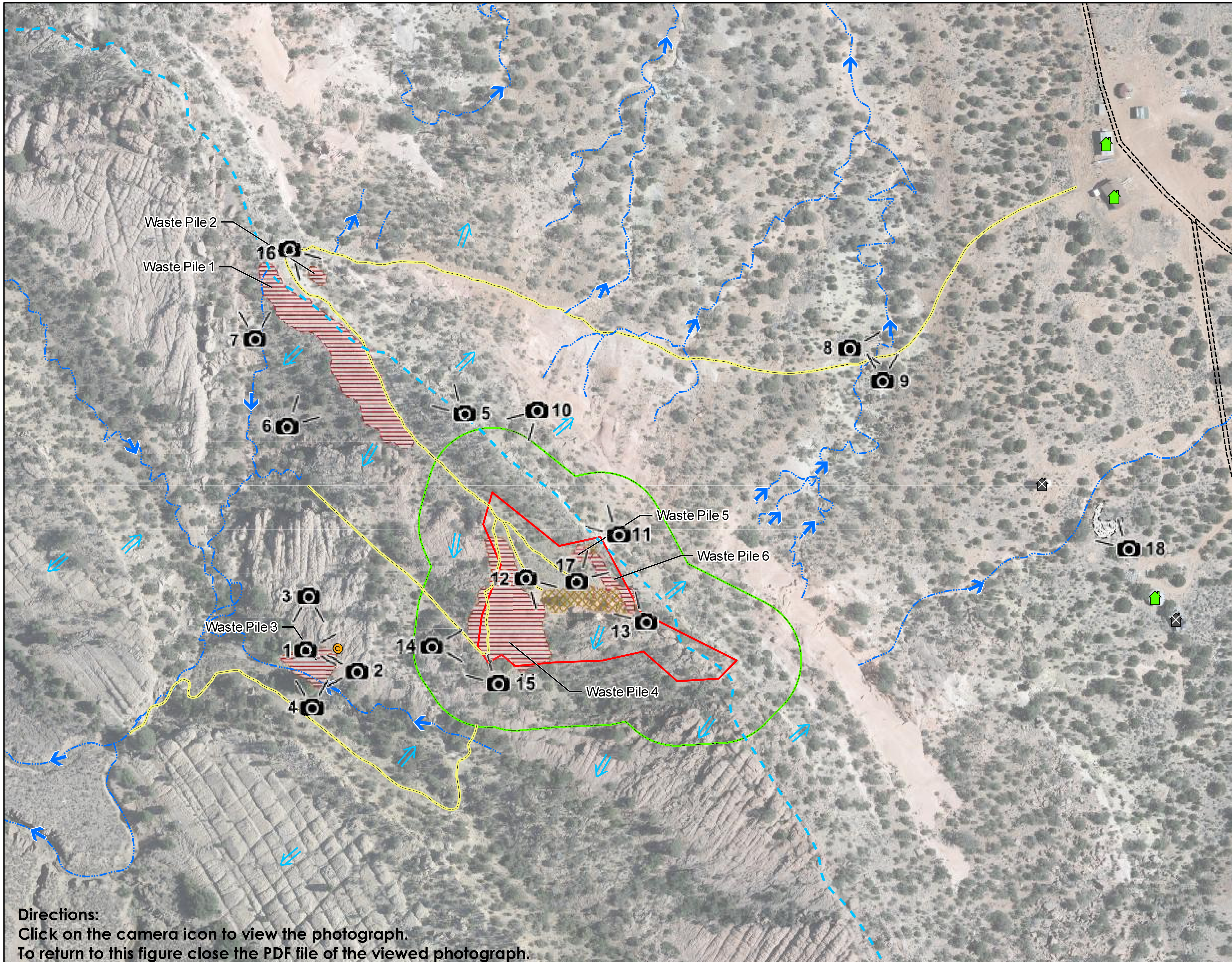
Reviewed by: MM Review Date: 10/19/17

Appendix B Exposure Rate Measurements

Date and Time	Exposure Rate (mR/h)	Location
09/15/2017 10:14	0.0107	Correlation Location 1
09/15/2017 10:15	0.0154	Correlation Location 1
09/15/2017 10:16	0.0161	Correlation Location 1
09/15/2017 10:17	0.0158	Correlation Location 1
09/15/2017 10:18	0.0155	Correlation Location 1
09/15/2017 10:19	0.0156	Correlation Location 1
09/15/2017 10:20	0.0156	Correlation Location 1
09/15/2017 10:21	0.0155	Correlation Location 1
09/15/2017 10:22	0.0155	Correlation Location 1
09/15/2017 10:23	0.0155	Correlation Location 1
09/15/2017 10:33	0.0249	Correlation Location 2
09/15/2017 10:34	0.0323	Correlation Location 2
09/15/2017 10:35	0.0318	Correlation Location 2
09/15/2017 10:36	0.0316	Correlation Location 2
09/15/2017 10:37	0.0309	Correlation Location 2
09/15/2017 10:38	0.0305	Correlation Location 2
09/15/2017 10:39	0.0308	Correlation Location 2
09/15/2017 10:40	0.0313	Correlation Location 2
09/15/2017 10:41	0.0316	Correlation Location 2
09/15/2017 10:42	0.0319	Correlation Location 2
09/15/2017 10:52	0.0081	Correlation Location 3
09/15/2017 10:53	0.0173	Correlation Location 3
09/15/2017 10:54	0.0198	Correlation Location 3
09/15/2017 10:55	0.0202	Correlation Location 3
09/15/2017 10:56	0.0199	Correlation Location 3
09/15/2017 10:57	0.0198	Correlation Location 3

Date and Time	Exposure Rate (mR/h)	Location
09/15/2017 10:58	0.0198	Correlation Location 3
09/15/2017 10:59	0.0194	Correlation Location 3
09/15/2017 11:00	0.0194	Correlation Location 3
09/15/2017 11:01	0.0193	Correlation Location 3
09/15/2017 11:02	0.0194	Correlation Location 3
09/15/2017 11:12	0.0314	Correlation Location 4
09/15/2017 11:13	0.0461	Correlation Location 4
09/15/2017 11:14	0.0463	Correlation Location 4
09/15/2017 11:15	0.0470	Correlation Location 4
09/15/2017 11:16	0.0473	Correlation Location 4
09/15/2017 11:17	0.0479	Correlation Location 4
09/15/2017 11:18	0.0475	Correlation Location 4
09/15/2017 11:19	0.0477	Correlation Location 4
09/15/2017 11:20	0.0477	Correlation Location 4
09/15/2017 11:21	0.0469	Correlation Location 4
09/15/2017 11:22	0.0472	Correlation Location 4
09/15/2017 11:52	0.0095	Correlation Location 5
09/15/2017 11:53	0.0121	Correlation Location 5
09/15/2017 11:54	0.0115	Correlation Location 5
09/15/2017 11:55	0.0114	Correlation Location 5
09/15/2017 11:56	0.0115	Correlation Location 5
09/15/2017 11:57	0.0113	Correlation Location 5
09/15/2017 11:58	0.0118	Correlation Location 5
09/15/2017 11:59	0.0113	Correlation Location 5
09/15/2017 12:00	0.0111	Correlation Location 5
09/15/2017 12:01	0.0116	Correlation Location 5

Appendix B Site Photographs



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Photograph Indicating Direction Taken
- Adit
- Habitable Building
- Uninhabitable Building
- Flow Direction
- Approximate Overland Water Flow Direction
- Approximate Watershed Divide Line
- Drainage
- Potential Haul Road
- Road
- Debris
- Excavation
- Waste Pile
- Claim Boundary
- 100-Foot Claim Buffer

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N
W E
S

0 150 300
Feet

TITLE:
Site Photographs

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 7/30/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: WDC	REVIEWER: CBB
	FIGURE: Appendix B	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Eunice\RSE_Eunice_Appendix_B1_11x17_L_20180730.mxd

Appendix C Field Activity Forms

C.1 Soil Sample Field Forms

C.2 Hand Auger Borehole Logs

C.1 Soil Sample Field Forms

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S313-BG1-001 (Eunice Becenti)

SAMPLE I.D. S313-BG1-001

SAMPLE COLLECTION DATE 11/19/16

SAMPLE COLLECTION TIME 955

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS ~40° F, sunny calm

FIELD USCS DESCRIPTIONS chalky grey crushed sandstone and sand

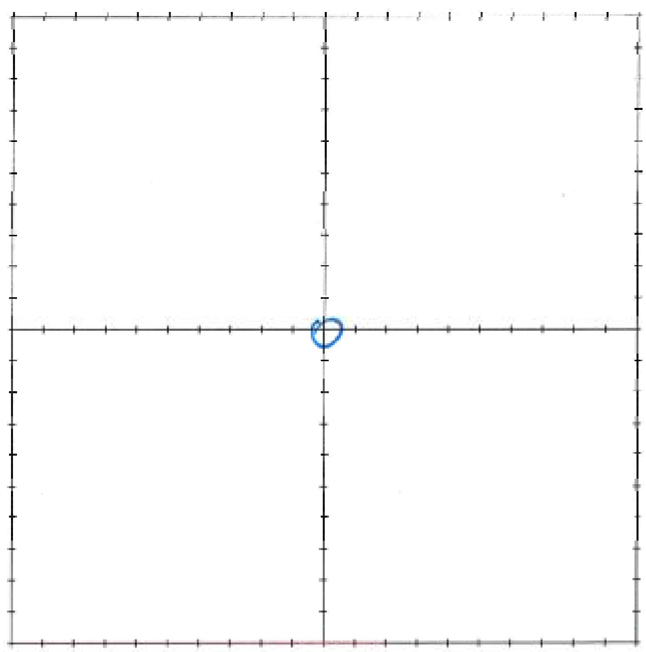
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 Ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S313-BG1-002 (Eunice Becenti)

SAMPLE I.D. S313-BG1-002

SAMPLE COLLECTION DATE 11/19/16

SAMPLE COLLECTION TIME 1005

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS ~40°F, sunny, calm

FIELD USCS DESCRIPTIONS

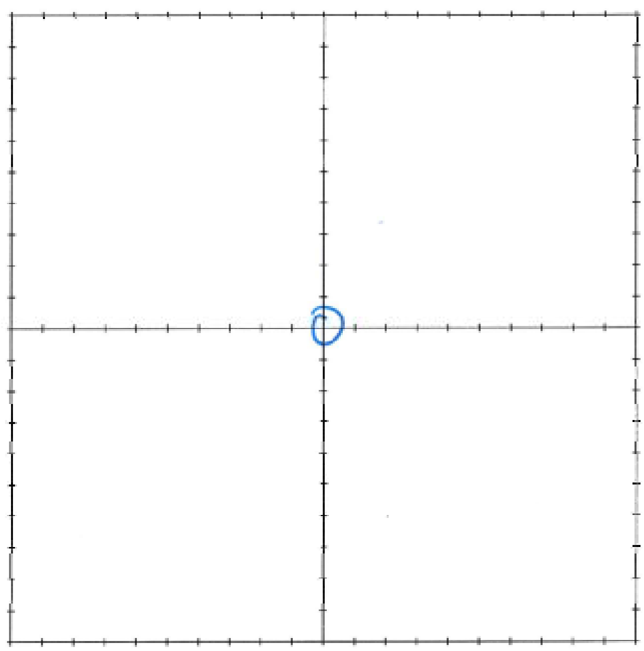
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 S313-BG1-003 (Eunice Becenti)

SAMPLE I.D. S313-BG1-003

SAMPLE COLLECTION DATE 11/19/16

SAMPLE COLLECTION TIME 1015

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS ~40°F, clear, sunny, calm

FIELD USCS DESCRIPTIONS greyish brown, flaky, dry

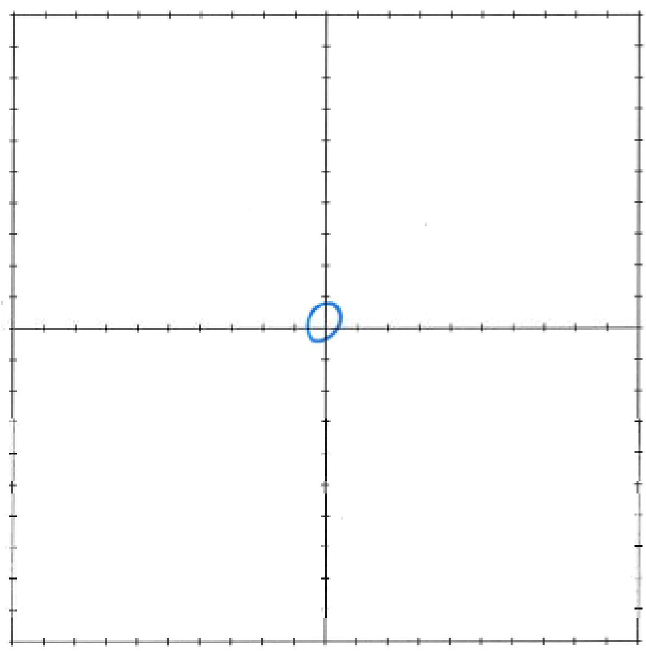
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S313-BG1-004 (Eunice Berenti)

SAMPLE I.D. S313-BG1-004

SAMPLE COLLECTION DATE 11/19/16

SAMPLE COLLECTION TIME 1025

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS ~45°F, calm, sunny

FIELD USCS DESCRIPTIONS tan/brown, dry sand w/ fine gravel

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: Ra226, metals

MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S313-BG1-005 (Eunice Becenti)

SAMPLE I.D. S313-BG1-005

SAMPLE COLLECTION DATE ~~tol~~ 11/19/16

SAMPLE COLLECTION TIME 1040

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS ~50°F, sunny

FIELD USCS DESCRIPTIONS chalky grey silty sand

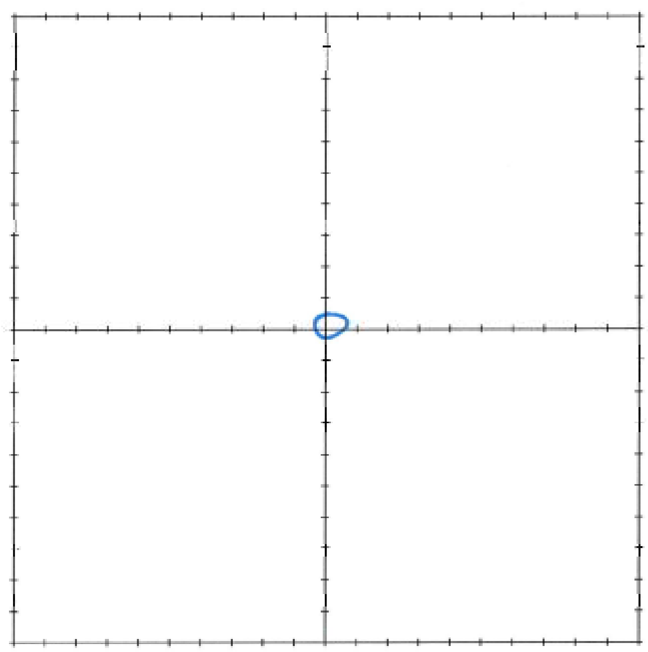
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 Ziplock

ANALYSES: Ra226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S313-BG1-006 (Eunice Becenti)

SAMPLE I.D. S313-BG1-006

SAMPLE COLLECTION DATE 11/17/16

SAMPLE COLLECTION TIME 1055

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS ~50F, sunny

FIELD USCS DESCRIPTIONS dark brown silty sand

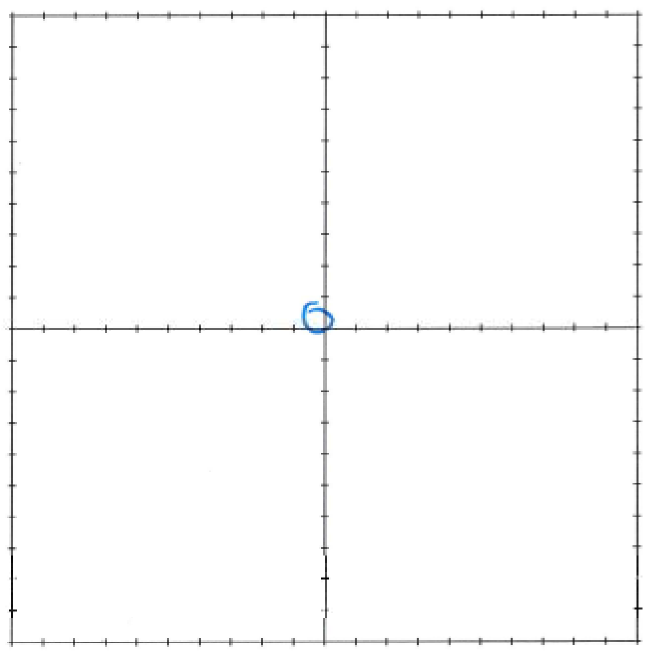
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S313-BG1-007 (Eunice Becenti)

SAMPLE I.D. S313-BG1-007

SAMPLE COLLECTION DATE 11/19/16

SAMPLE COLLECTION TIME 1110

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS ~50F, sunny

FIELD USCS DESCRIPTIONS dark brown and dark gray silty sand

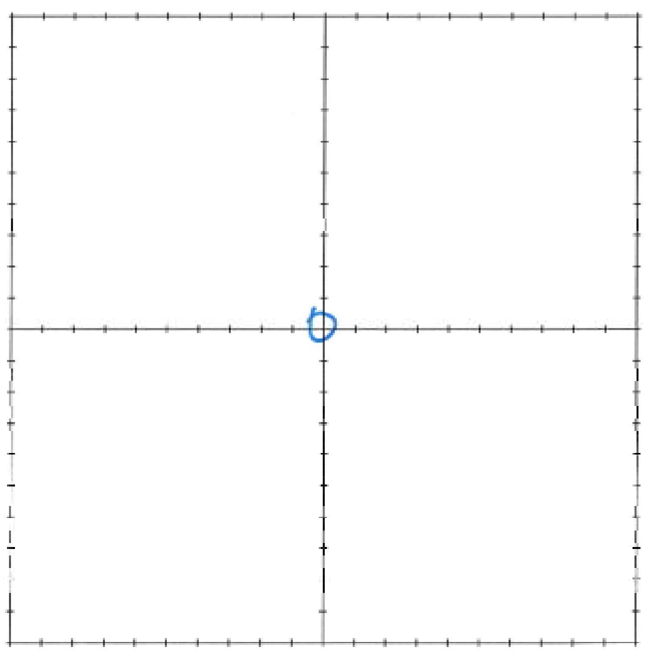
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S313-BG1-007 (Eunice Becenti)

SAMPLE I.D. S313-BG1-207

SAMPLE COLLECTION DATE 11/19/16

SAMPLE COLLECTION TIME 1110

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS ~50F, sunny

FIELD USCS DESCRIPTIONS dark brown and dark grey silty sand

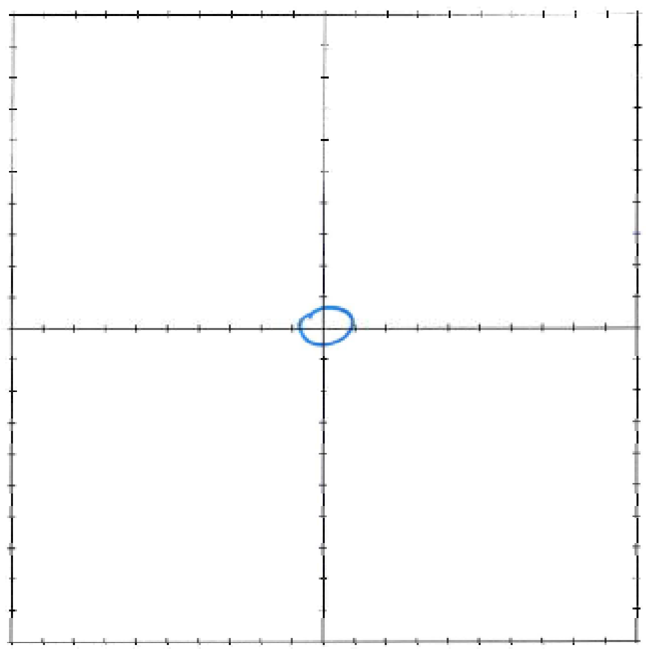
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S313-BG1-008 (Eunice Becenti)

SAMPLE I.D. S313-BG1-008

SAMPLE COLLECTION DATE 11/19/16

SAMPLE COLLECTION TIME 1130

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS ~55°F, clear, sunny

FIELD USCS DESCRIPTIONS dark brown silty sand

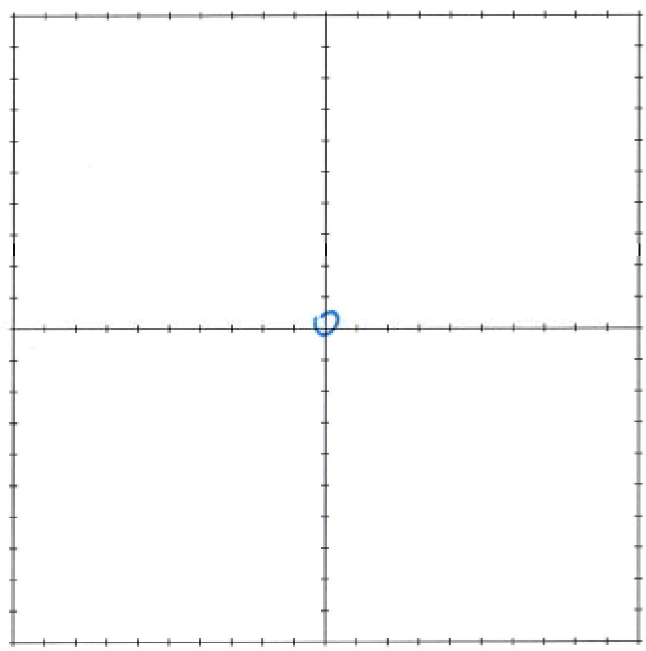
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S313-BG1-009 (Eunice Becati)

SAMPLE I.D. S313-BG1-009

SAMPLE COLLECTION DATE 11/19/16

SAMPLE COLLECTION TIME 1145

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS ~55°F, sunny

FIELD USCS DESCRIPTIONS tan silty sand

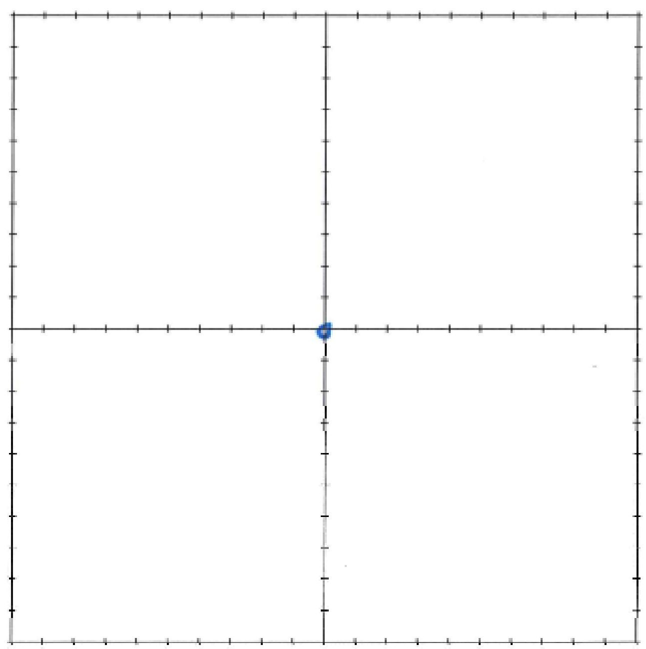
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S313-BG1-010 (Eunice Becenti)

SAMPLE I.D. S313BG1-010

SAMPLE COLLECTION DATE 11/19/16

SAMPLE COLLECTION TIME 1200

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS ~055°F, sunny

FIELD USCS DESCRIPTIONS brown silty sand

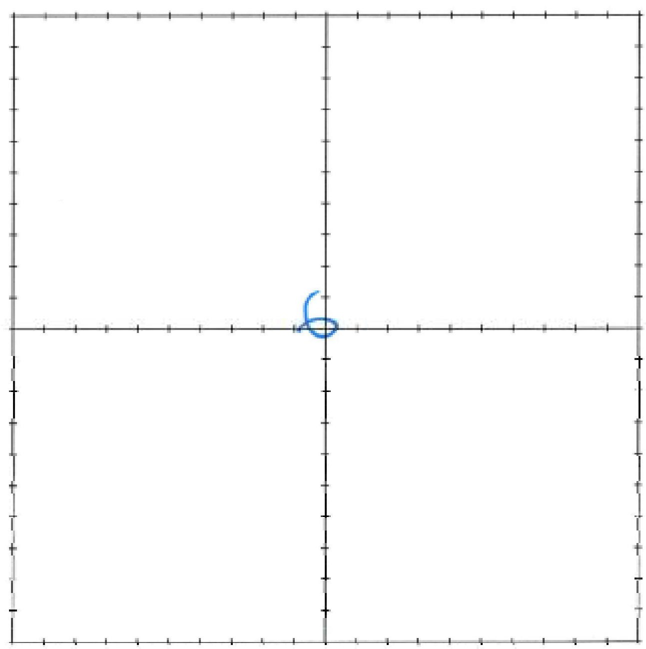
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziplock

ANALYSES: Ra226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME ~~S313-BG2-001~~ Eunice Becenti

SAMPLE I.D. S313-BG2-001

SAMPLE COLLECTION DATE 9/15/17

SAMPLE COLLECTION TIME 1558

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS poorly graded sand (SP), brown (7.5 YR 4/3), fine to medium sand, dry, loose

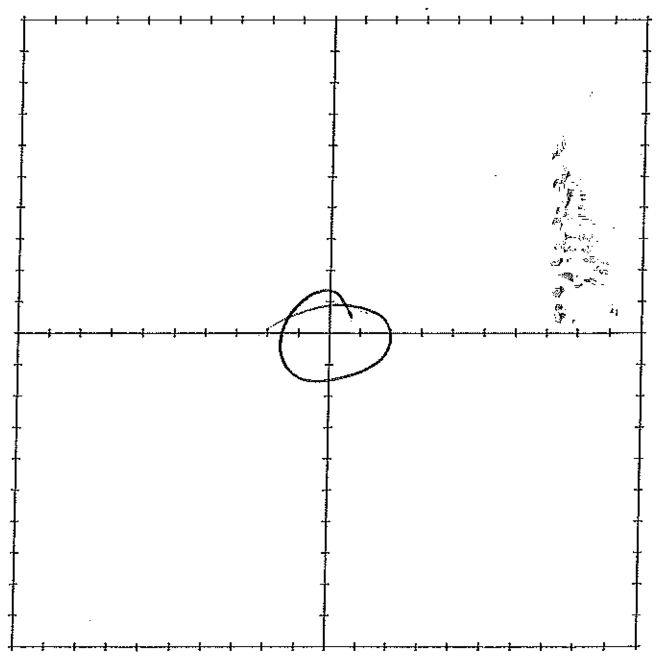
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Fence Parent.

SAMPLE I.D. S313-8G2-002

SAMPLE COLLECTION DATE 9/15/17

SAMPLE COLLECTION TIME 1603

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS poorly graded Sand (SP), brown (7.5 YR 4/3), fine to medium grained Sand, dry, loose,

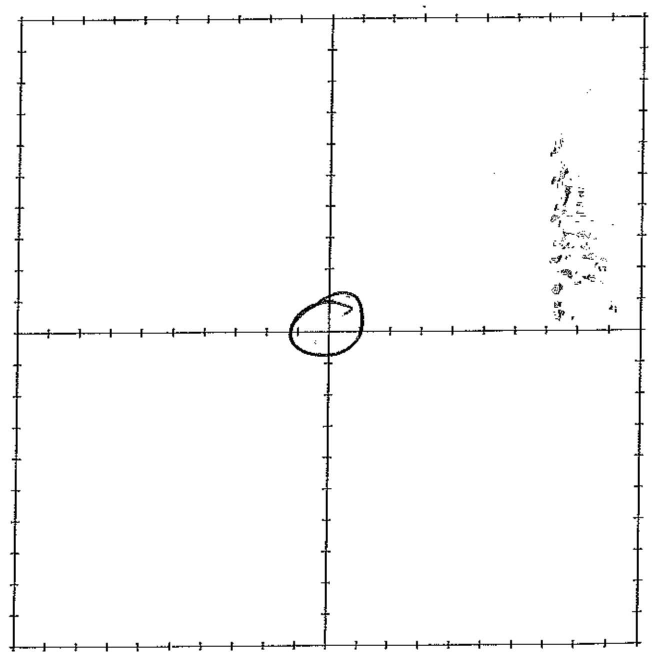
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☐ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BG2-003

SAMPLE COLLECTION DATE 9/15/17

SAMPLE COLLECTION TIME 1612

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 75 °F

FIELD USCS DESCRIPTIONS Poorly graded Sand (SP) brown (7.5YR 4/3), fine to medium grained sand, dry, loose

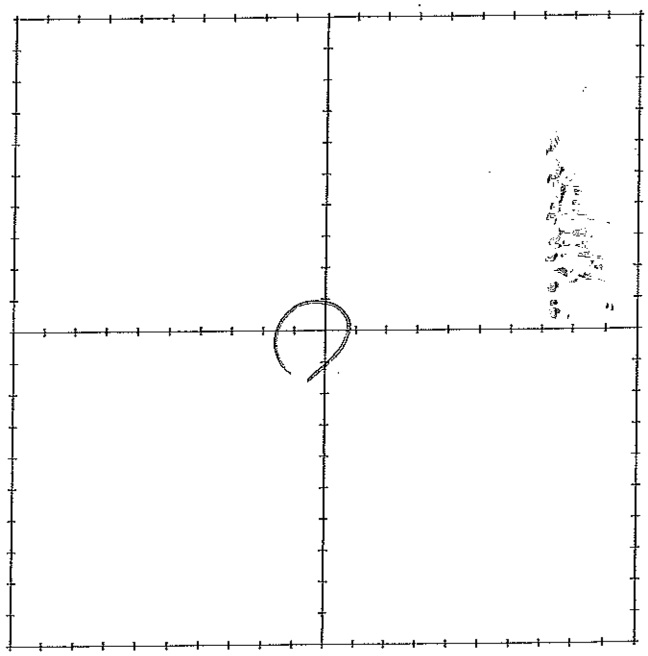
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Pecanti

SAMPLE I.D. S313-OG-2-004

SAMPLE COLLECTION DATE 9/18/17

SAMPLE COLLECTION TIME 1615

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny °75°F

FIELD USCS DESCRIPTIONS Poorly graded Sand (SP) brown (7.5 YR 4/5) fine to medium grained Sand, dry, Loose.

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

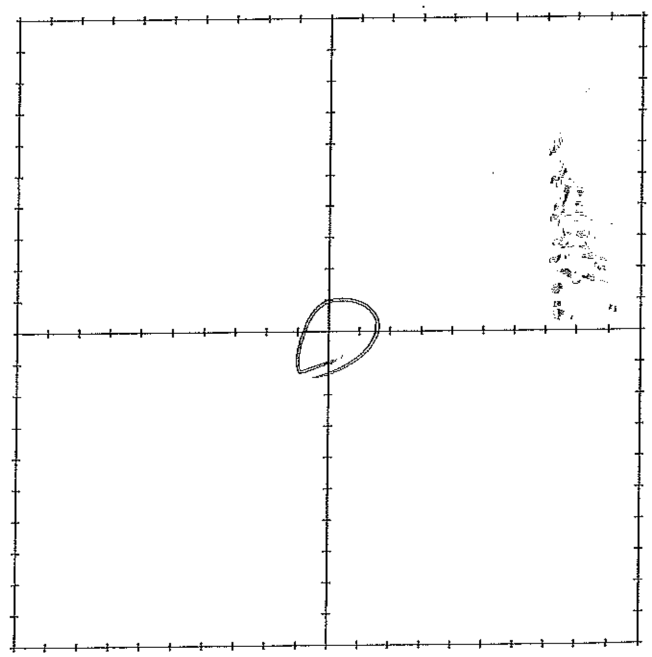
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: RA-226, Metals.



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Peccenti

SAMPLE I.D. 5313-862-005

SAMPLE COLLECTION DATE 9/15/17

SAMPLE COLLECTION TIME 1622

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS poorly graded sand (SP), brown (7.5 YR 4/3), fine to medium grained, dry, loose.

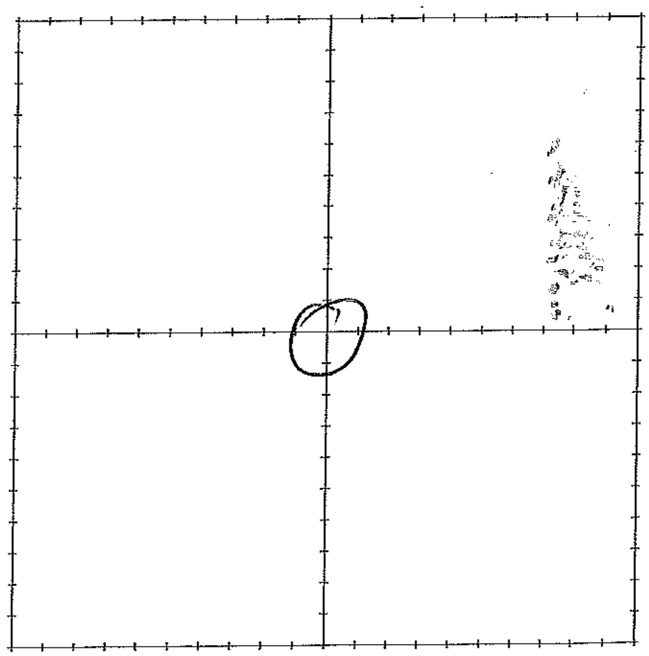
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplocks bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BG2-006

SAMPLE COLLECTION DATE 9/15/17

SAMPLE COLLECTION TIME 1627

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 75 °F

FIELD USCS DESCRIPTIONS poorly graded sand with gravel (SP), brown (7.5 YR 4/4), fine to coarse sands, fine to medium gravel, loose, dry

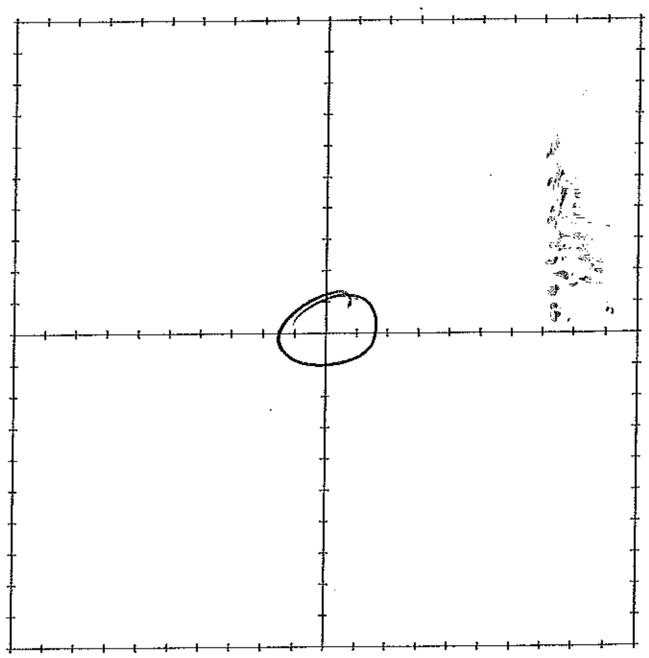
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-862-007

SAMPLE COLLECTION DATE 9/15/17

SAMPLE COLLECTION TIME 1631

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded Sand (SP), light brown (7.5 YR 6/3), fine grained Sand, dry loose

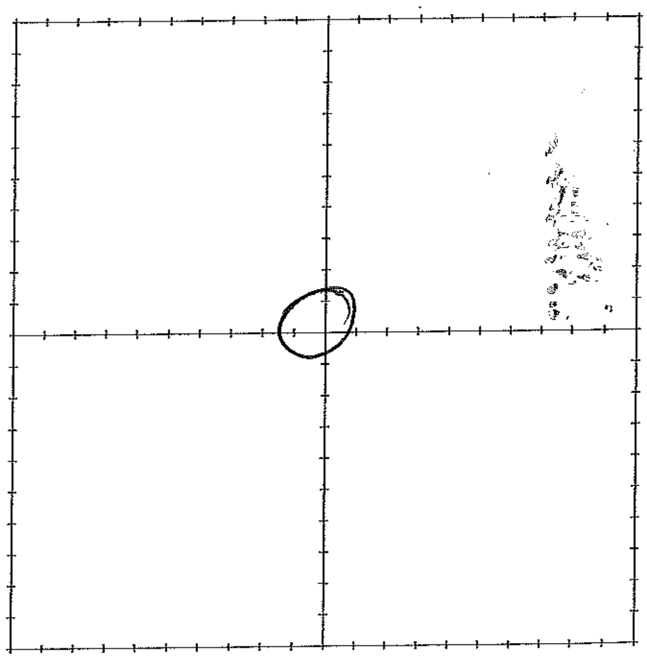
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals.



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-062-008

SAMPLE COLLECTION DATE 9/15/17

SAMPLE COLLECTION TIME 1636

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), brown (7.5 YR 4/3), fine to medium grained, dry, loose.

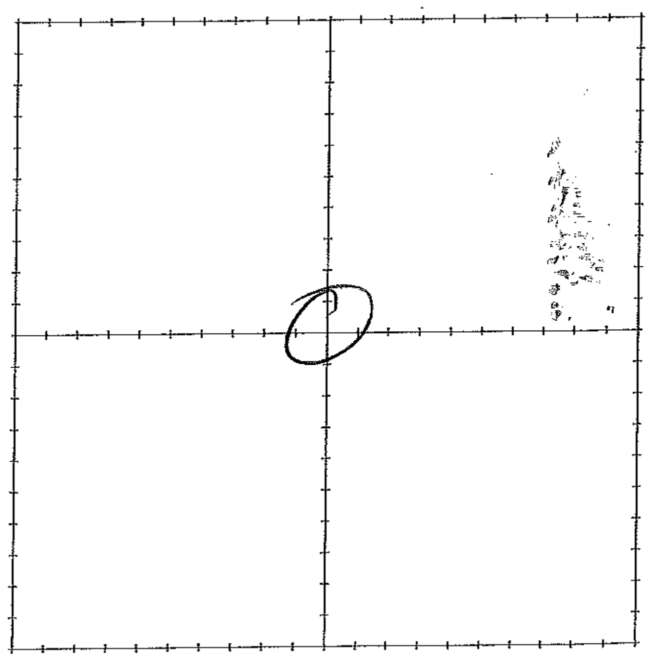
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. 8313-062-009

SAMPLE COLLECTION DATE 9/15/17

SAMPLE COLLECTION TIME 1640

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), brown (7.5YR 4/3), fine to medium grained, dry, loose

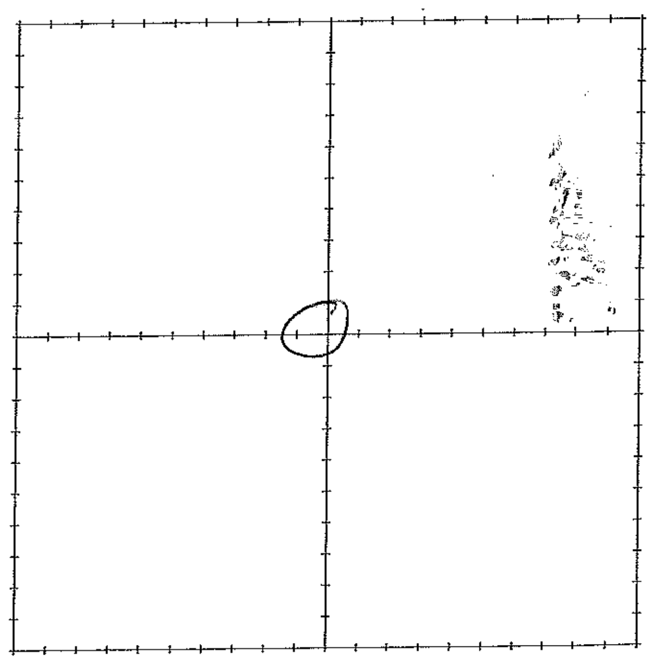
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. 5313-BG2-010

SAMPLE COLLECTION DATE 9/15/17

SAMPLE COLLECTION TIME 1645

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded Sand (SP), brown (7.5 YR 4/3), fine to medium grained sand, dry, loose.

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

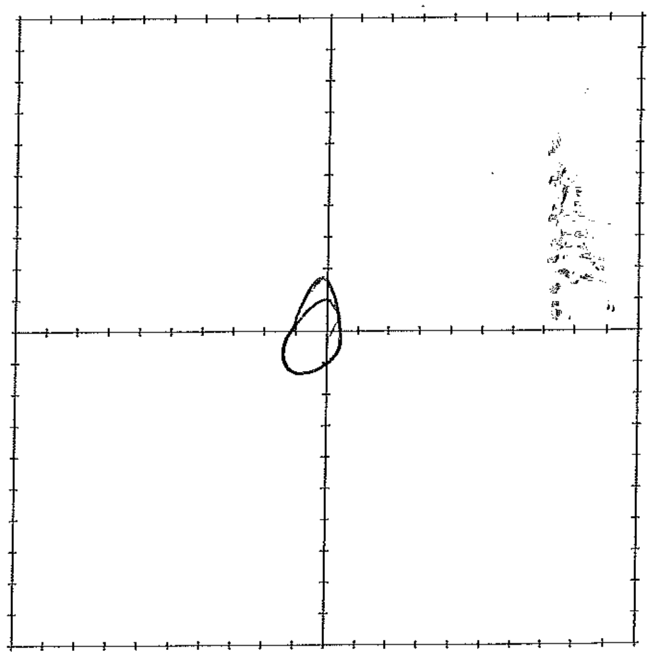
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BG3-001

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1343

SAMPLE COLLECTED BY JK

WEATHER CONDITIONS 80°F Sunny

FIELD USCS DESCRIPTIONS Sand with gravel (sp), grayish brown (10YR 5/2), dry, loose, gravels are shale.

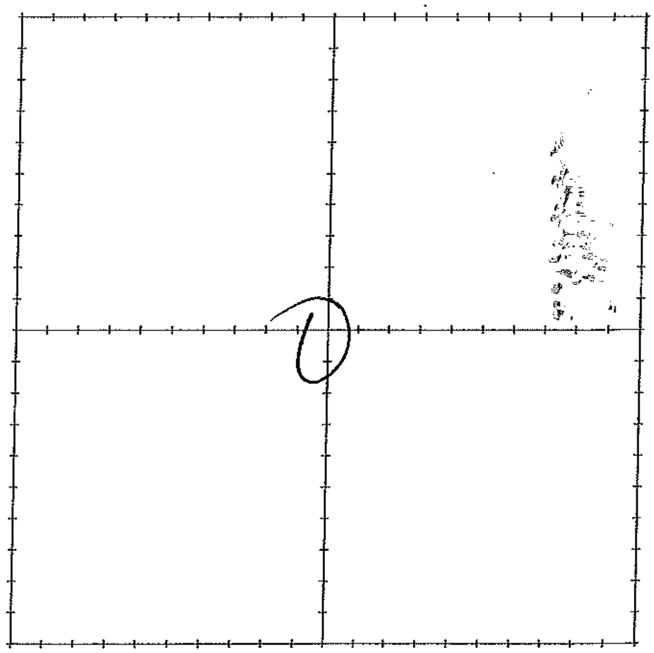
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BG3-002

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1348

SAMPLE COLLECTED BY JC

WEATHER CONDITIONS Sunny 80 °F

FIELD USCS DESCRIPTIONS Sand with gravel (sp), gray (10YR 5/1), dry, loose- gravels are shale.

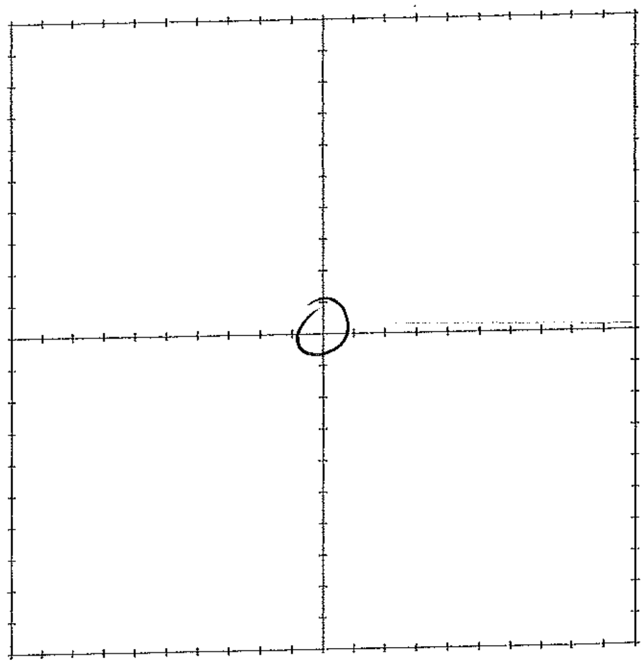
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☐ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S3B-BG3-003

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1353

SAMPLE COLLECTED BY JL

WEATHER CONDITIONS 80°F Sunny

FIELD USCS DESCRIPTIONS Sand with gravel (sp), gray (10YR 5/1), dry, loose, gravels are shale.

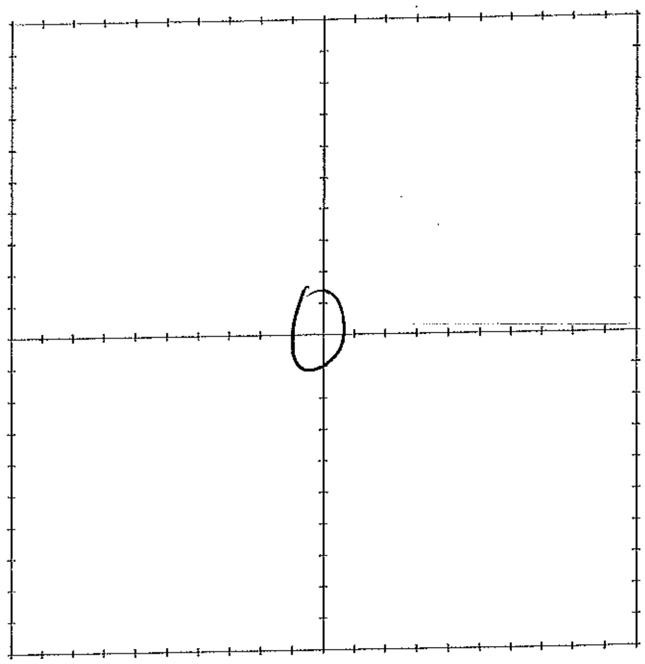
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziploc

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BG3-004

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1400

SAMPLE COLLECTED BY R

WEATHER CONDITIONS 80°F Sunny

FIELD USCS DESCRIPTIONS Poorly graded sand (sp), dark gray (10YR 4/1), dry, loose.

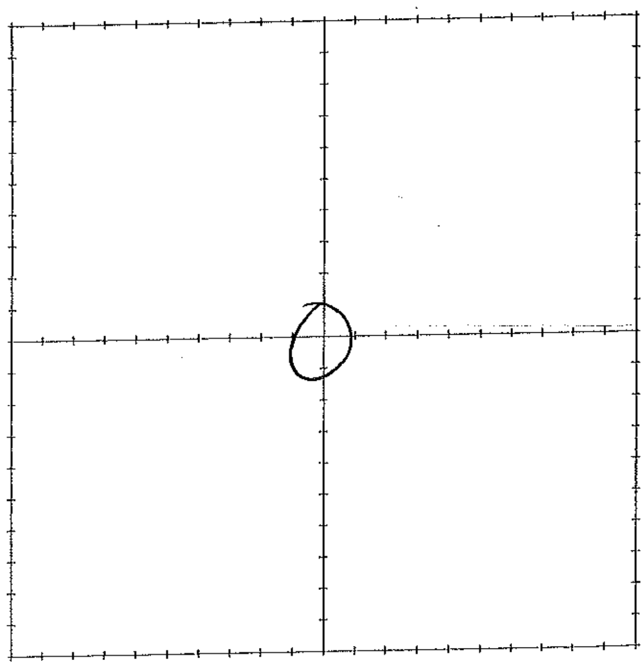
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☐ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals.



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BG3-005

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1404

SAMPLE COLLECTED BY ~~Z~~ MW

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Sand with gravel (sp), gray (10YR 5/1), dry, loose, gravels are shale.

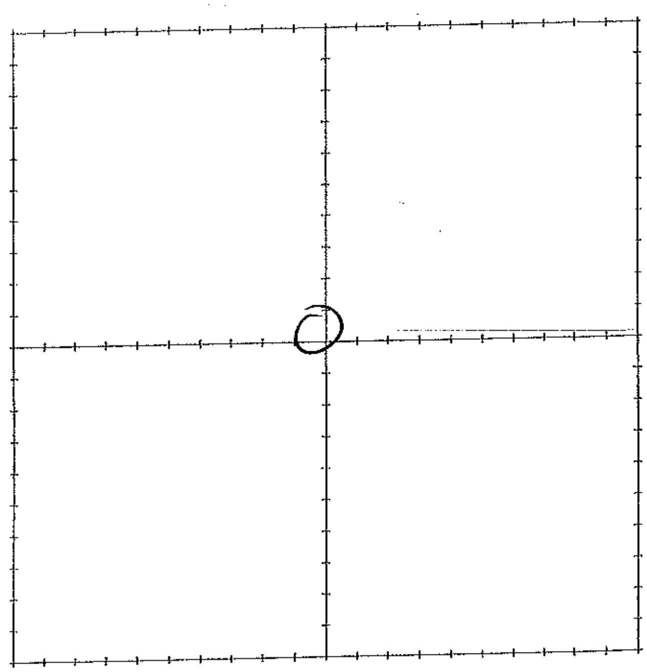
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BG3-006

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1410

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Sand with gravel (sp), gray (10YR 5/1), dry, loose, gravels are shale.

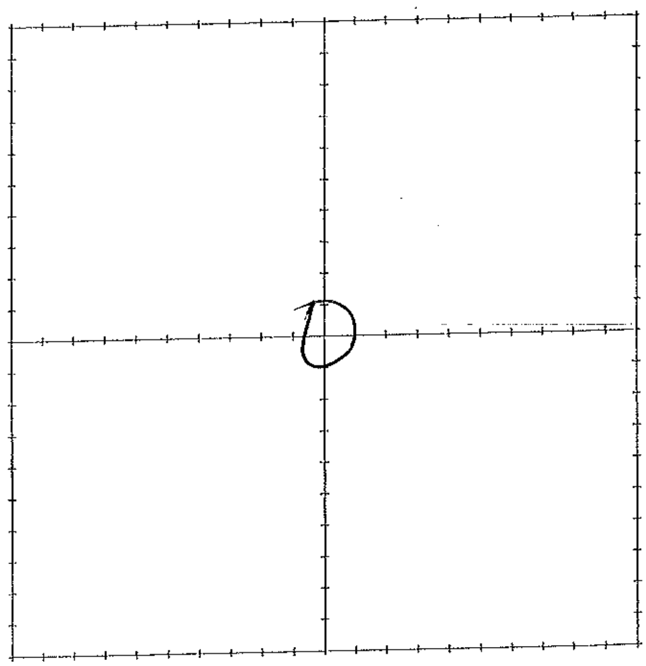
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Beccuti

SAMPLE I.D. S313-BG3-007

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1414

SAMPLE COLLECTED BY ~~MW~~ MW

WEATHER CONDITIONS 80°F Sunny

FIELD USCS DESCRIPTIONS Sand with gravel (SP), gray (10YR 6/1), dry, loose, gravels are shale.

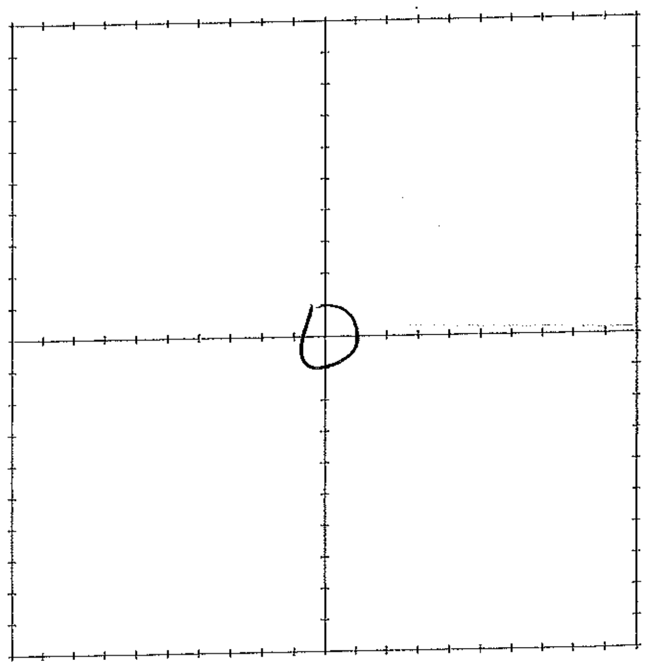
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BG3-008

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1418

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly sorted sand (sp), gray 10YR 5/1), fine grained sand, dry, loose.

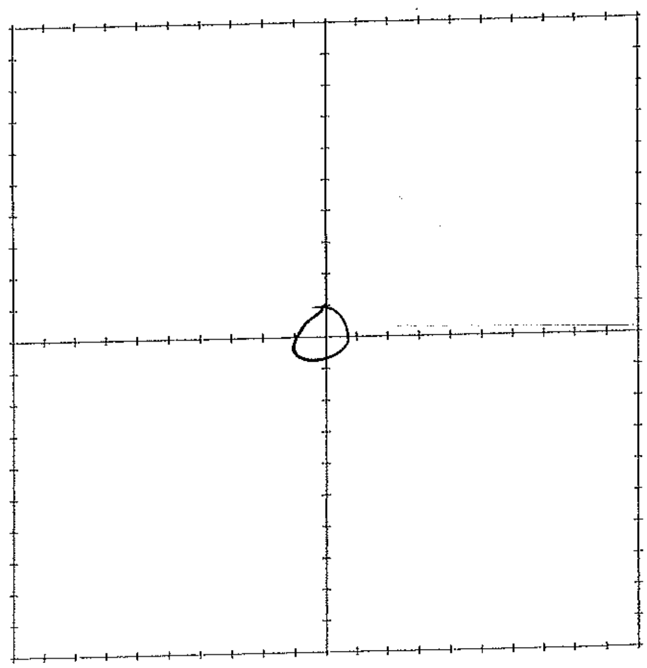
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock.

ANALYSES: Ra-226, metals.



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BG3-009

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1423

SAMPLE COLLECTED BY L

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly sorted sand (sp), gray (10YR 5/1), fine grained sand, dry, loose.

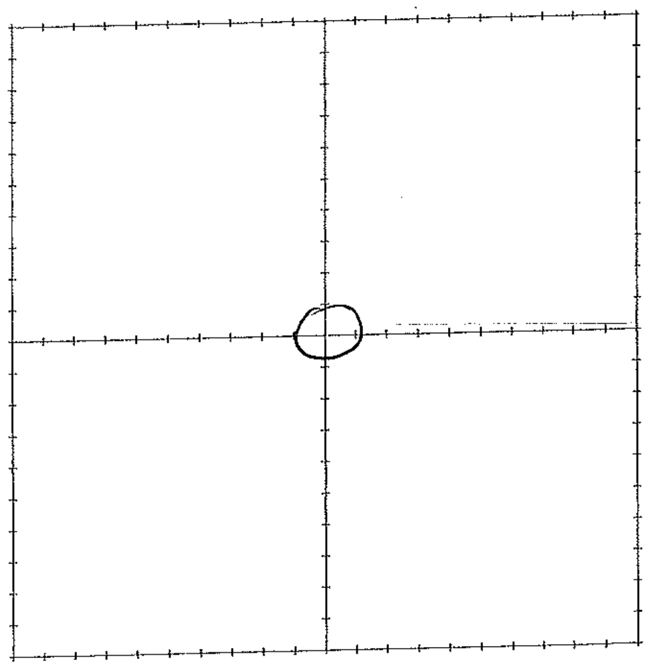
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BG3-010

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1425

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS Sunny 80°F

FIELD USCS DESCRIPTIONS Poorly sorted sand (sp), gray (10YR 8/1), fine grained sand, dry, loose.

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

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals

MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Bocenti

SAMPLE I.D. S313-B64-001

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1020

SAMPLE COLLECTED BY JL

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand (sp), dark brown (7.5YR 4/2), fine to medium graded sand, dry, loose, ~~period~~ ③

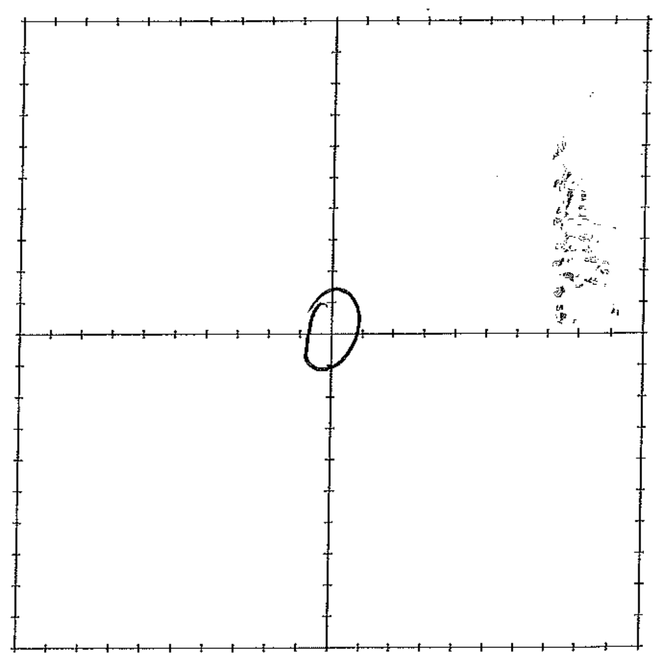
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-B64-002

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1028

SAMPLE COLLECTED BY JC

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), dark brown (7.5YR 4/2), fine to medium graded sand, dry, loose.

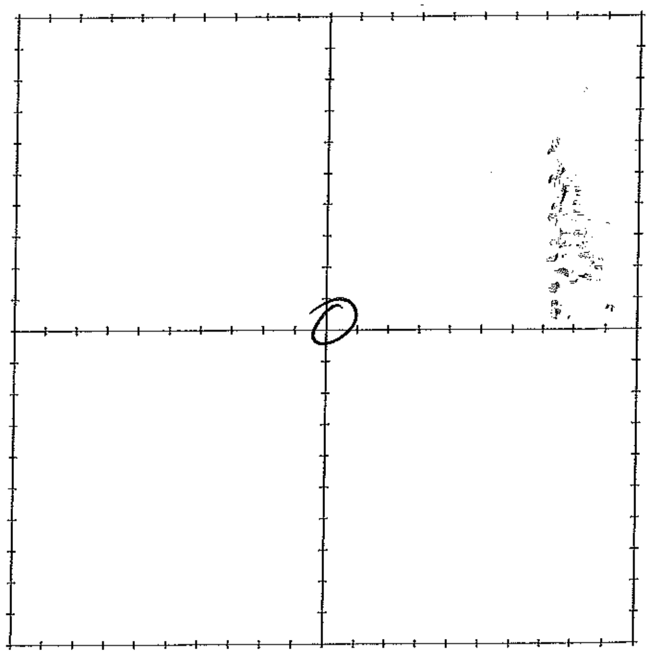
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. 5313-B64-003

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1036

SAMPLE COLLECTED BY X

WEATHER CONDITIONS 75 °F, Sunny

FIELD USCS DESCRIPTIONS Poorly graded sand with gravel (sp), dark brown (7.5 YR 4/2), fine to coarse graded sand (gravel ≈15%), dry, loose.

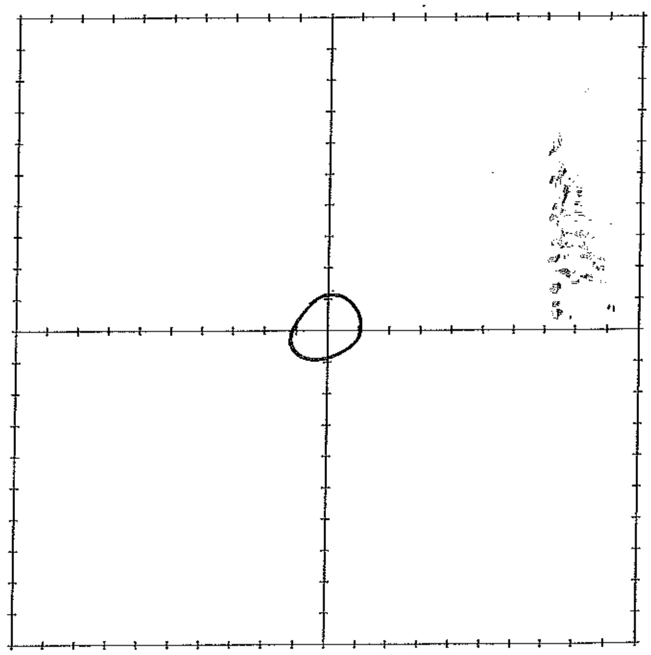
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BG4-004

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1043

SAMPLE COLLECTED BY JC

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand (sp), dark brown (7.5YR 4/2), fine to medium graded sand, dry, loose.

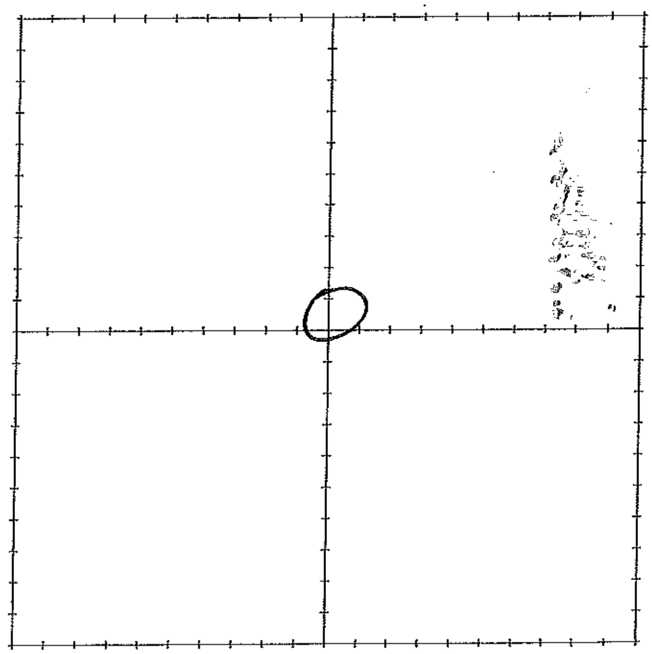
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals.



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. 5313-B64-005

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1050

SAMPLE COLLECTED BY JL

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand(sp), dark brown (7.5YR 4/2), Fine to medium graded sand, dry, loose.

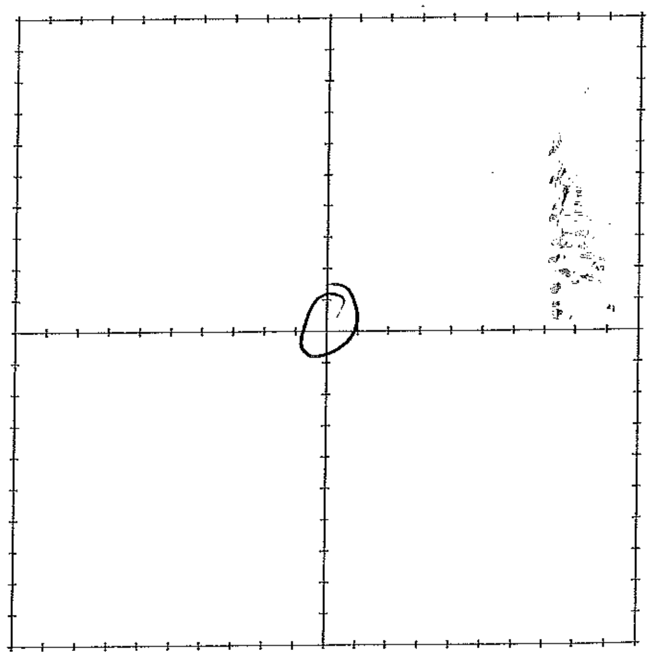
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-B64-006

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1055

SAMPLE COLLECTED BY R

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), dark brown (7.5YR 4/2), fine to medium graded sand, dry, loose.

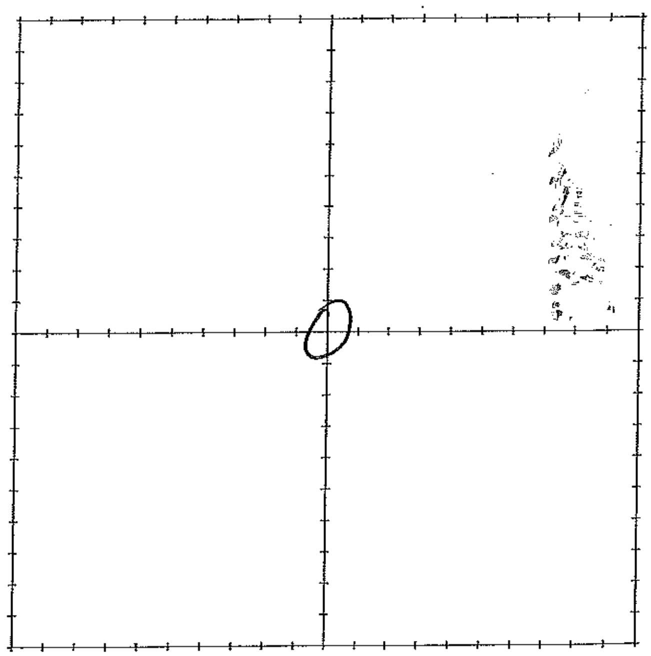
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BG4-007

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1104

SAMPLE COLLECTED BY JL

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand (sp), dark brown (7.5YR 4/2), fine to medium graded sand, dry, loose.

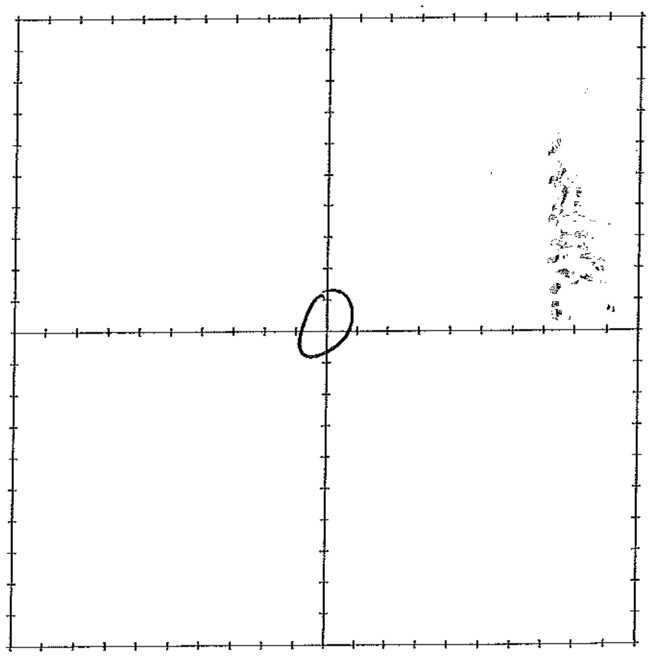
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BG4-008

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1111

SAMPLE COLLECTED BY R

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand(sp), dark brown (7.5YR 4/2), fine to medium graded sand, dry, loose

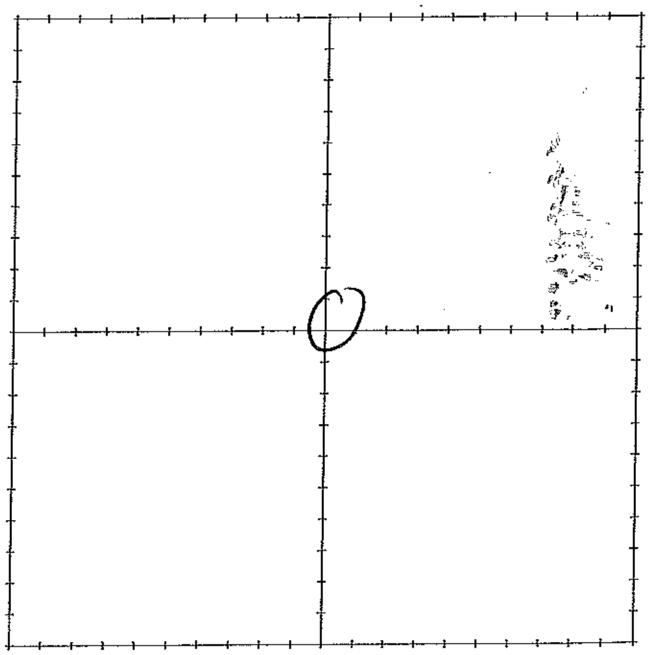
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BG4-009

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1116

SAMPLE COLLECTED BY JC

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand (sp), dark brown (7.5YR 4/2), fine to medium graded sand, dry, loose.

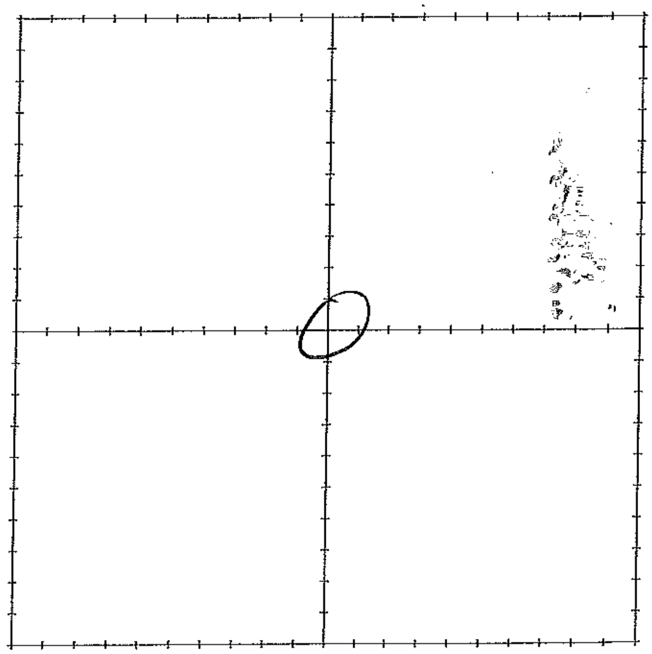
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BG4-010

SAMPLE COLLECTION DATE 9/15/2017

SAMPLE COLLECTION TIME 1123

SAMPLE COLLECTED BY JC

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand (sp), dark brown (7.5YR 4/2), fine to medium graded sand, dry, loose.

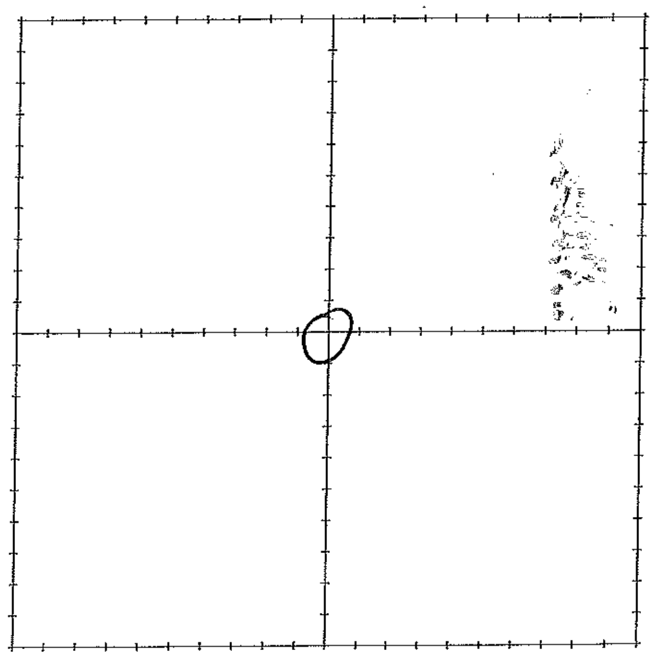
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BGS-001

SAMPLE COLLECTION DATE 9/16/2017

SAMPLE COLLECTION TIME 0946

SAMPLE COLLECTED BY ~~EB~~ CL

WEATHER CONDITIONS 65°F, Sunny

FIELD USCS DESCRIPTIONS Poorly graded sand (sp), dark brown (7.5YR 3/4), fine graded sand, dry, loose.

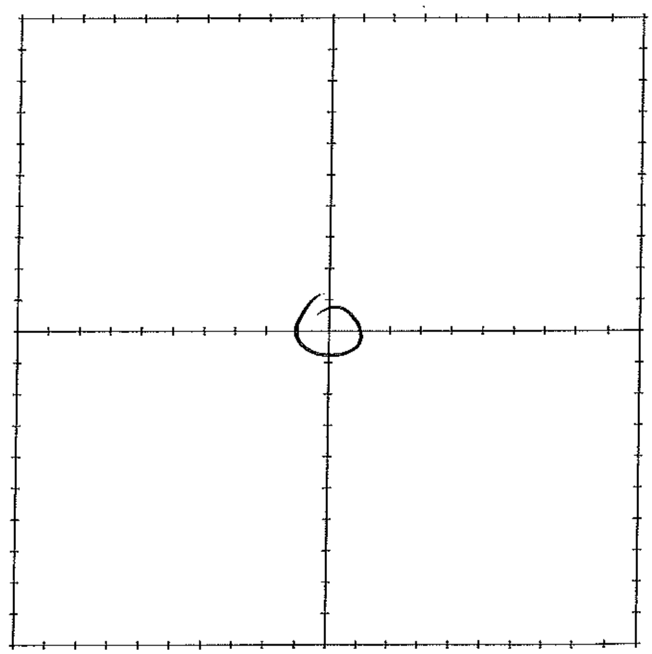
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-B65-002

SAMPLE COLLECTION DATE 9/16/2017

SAMPLE COLLECTION TIME 0954

SAMPLE COLLECTED BY ~~#~~ CL

WEATHER CONDITIONS Sunny, 65°F

FIELD USCS DESCRIPTIONS Poorly graded sand (sp), brown (7.5YR 4/6), fine graded sand, dry, loose.

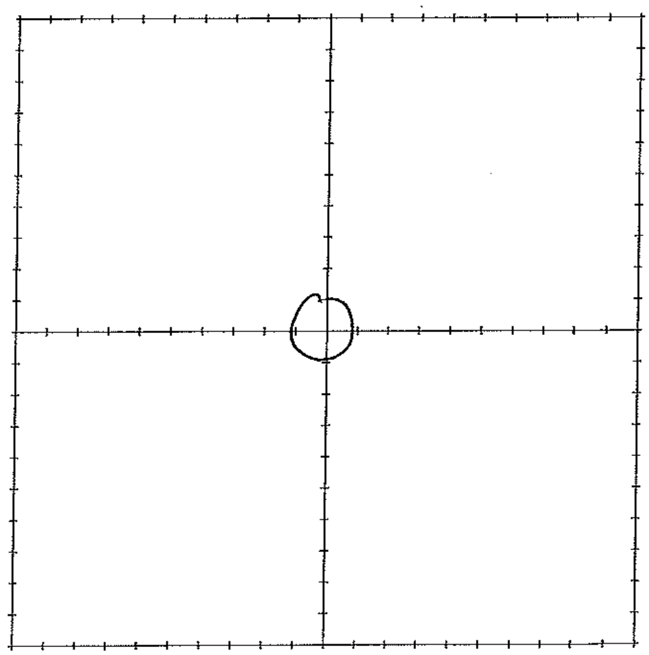
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunick Becenti

SAMPLE I.D. S313-~~BG~~ 1 BG9-003

SAMPLE COLLECTION DATE 9/16/2017

SAMPLE COLLECTION TIME ~~0945~~ 2 1001

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 65°F

FIELD USCS DESCRIPTIONS Poorly graded sand (sp), brown (7.5YR 5/3), fine graded sand, dry, loose.

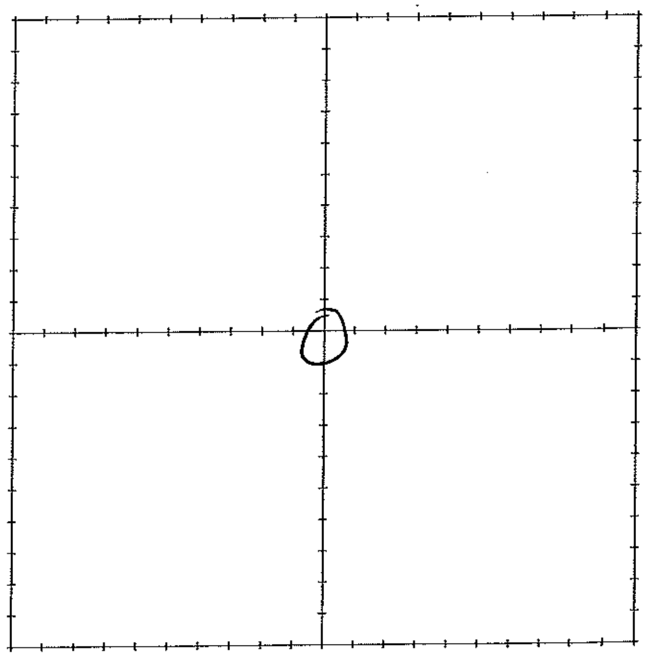
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. 5313-BGS-004

SAMPLE COLLECTION DATE 9/16/2017

SAMPLE COLLECTION TIME 1007

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 70°F

FIELD USCS DESCRIPTIONS Poorly graded sand (sp), brown (7.5YR 4/3), fine graded sand, dry, loose.

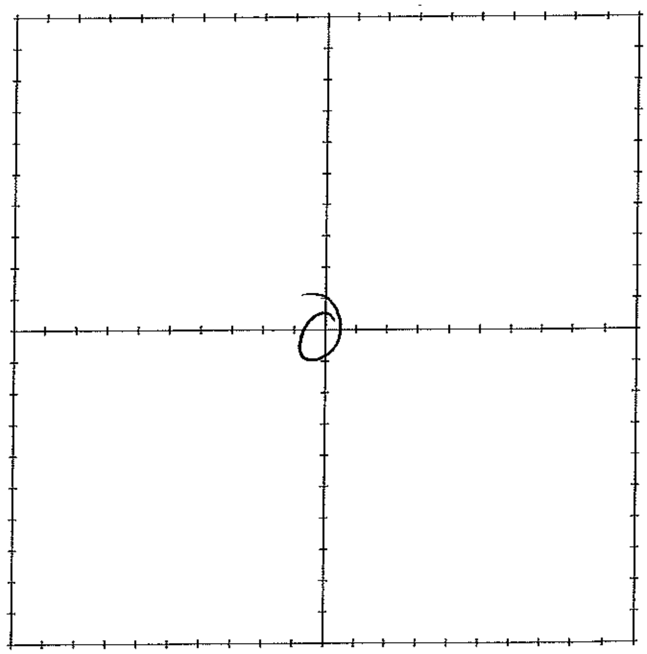
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BGS-005

SAMPLE COLLECTION DATE 9/16/2017

SAMPLE COLLECTION TIME 1013

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS 70°F Sunny

FIELD USCS DESCRIPTIONS Poorly graded sand (sp), brown (7.5YR 5/3), fine graded sand, dry, loose.

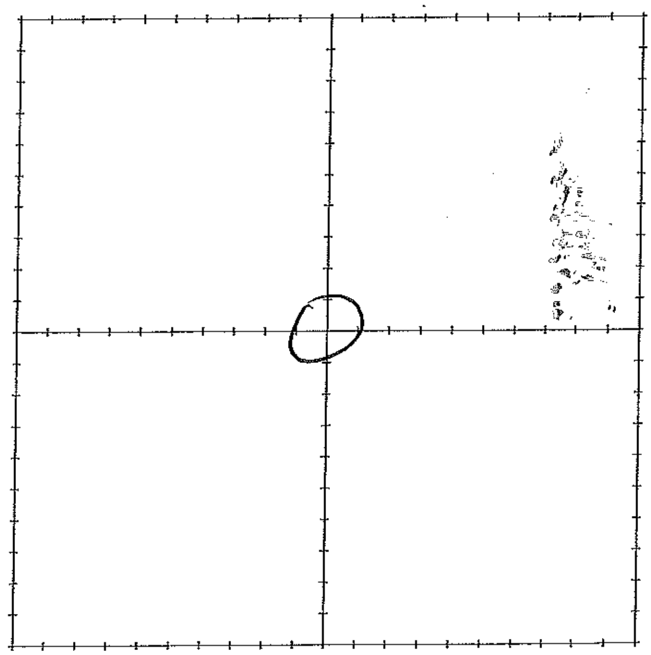
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-865-006

SAMPLE COLLECTION DATE 9/16/2017

SAMPLE COLLECTION TIME 1019

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS 70 °F Sunny

FIELD USCS DESCRIPTIONS Poorly graded sand (sp), brown (7.5YR 4/4), fine graded sand, dry loose.

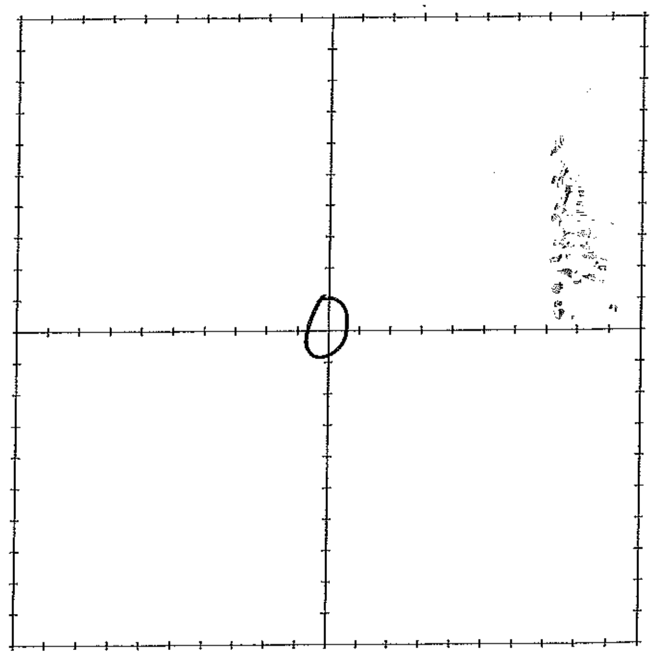
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BG5-007

SAMPLE COLLECTION DATE 9/16/2017

SAMPLE COLLECTION TIME 1026

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS 70°F Sunny

FIELD USCS DESCRIPTIONS Poorly graded sand (sp), brown (7.5YR 5/3), fine graded sand, dry, loose.

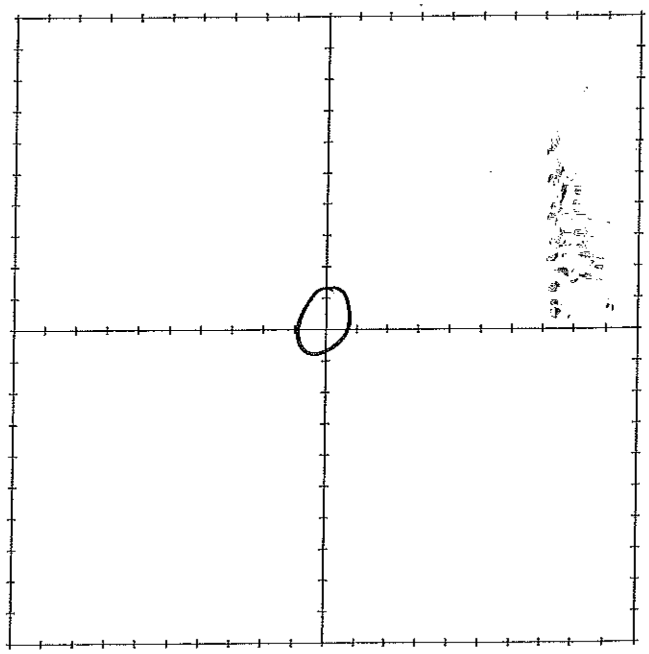
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BGS-008

SAMPLE COLLECTION DATE 9/16/2017

SAMPLE COLLECTION TIME 1033

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS 70°F Sunny

FIELD USCS DESCRIPTIONS ~~fin~~ Poorly graded sand (sp), dark brown (7.5YR 3/4), fine graded sand, dry, loose.

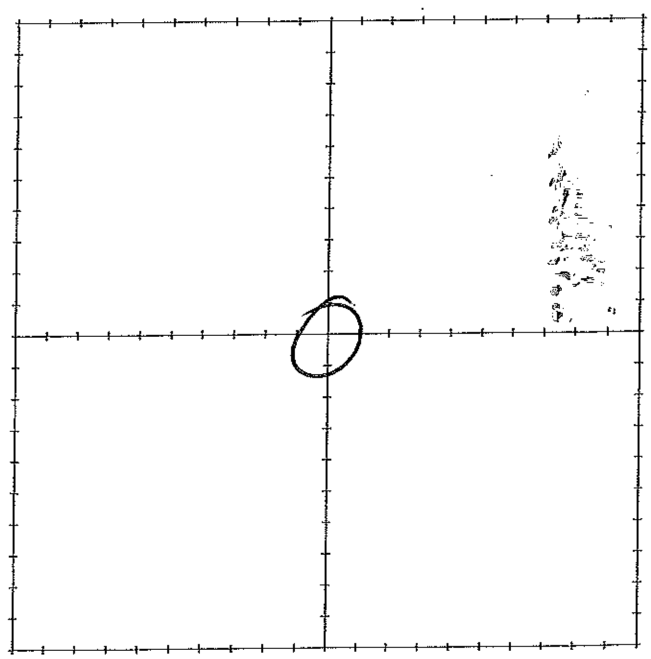
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals.



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BGS-009

SAMPLE COLLECTION DATE 9/16/2017

SAMPLE COLLECTION TIME 1040

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand(sp), brown (7.5YR 4/4), fine graded sand, dry, loose.

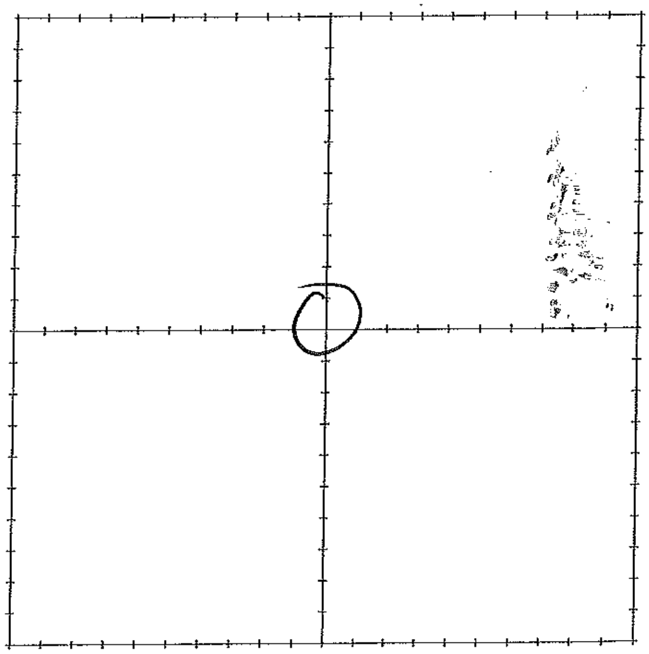
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-BGS-010

SAMPLE COLLECTION DATE 9/16/2017

SAMPLE COLLECTION TIME 1055

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS 75°F Sunny

FIELD USCS DESCRIPTIONS Poorly graded sand (sp), brown (7.5YR 4/2), fine graded sand, dry, loose.

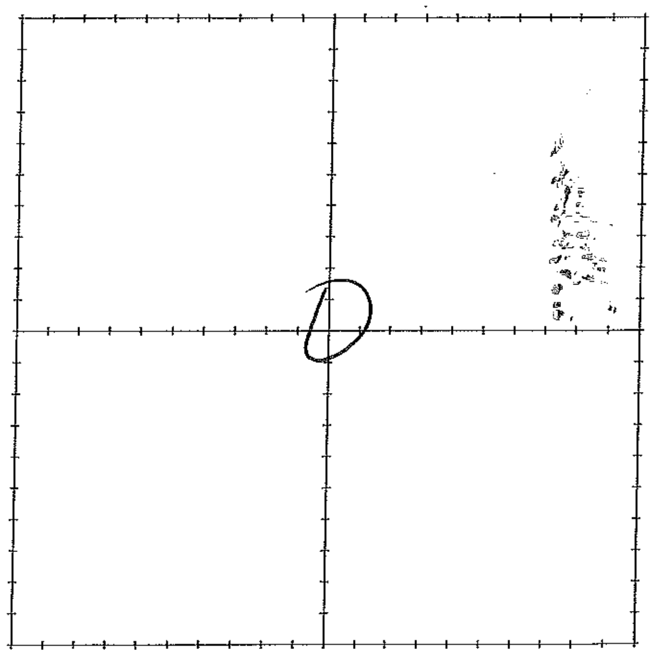
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-C01-001

SAMPLE COLLECTION DATE 3/27/17

SAMPLE COLLECTION TIME 10:15

SAMPLE COLLECTED BY C. Lee T. Osborn

WEATHER CONDITIONS 63° and windy

FIELD USCS DESCRIPTIONS Sandy silt medium brown/light red

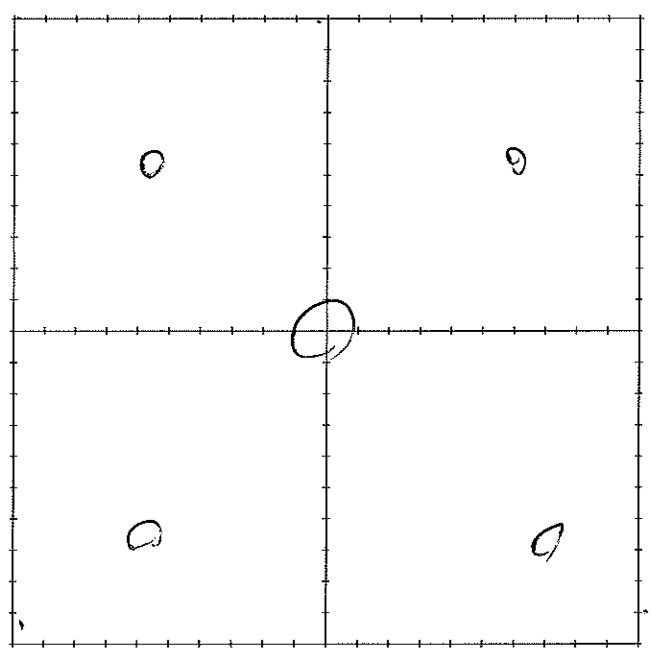
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) Bag 1

ANALYSES: Ra-226, Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-002-001

SAMPLE COLLECTION DATE ~~10:40~~ 3/27/17

SAMPLE COLLECTION TIME 10:40

SAMPLE COLLECTED BY T. Osborn, C. Lee

WEATHER CONDITIONS 63° + Windy

FIELD USCS DESCRIPTIONS Sandy silt, medium brown / light red

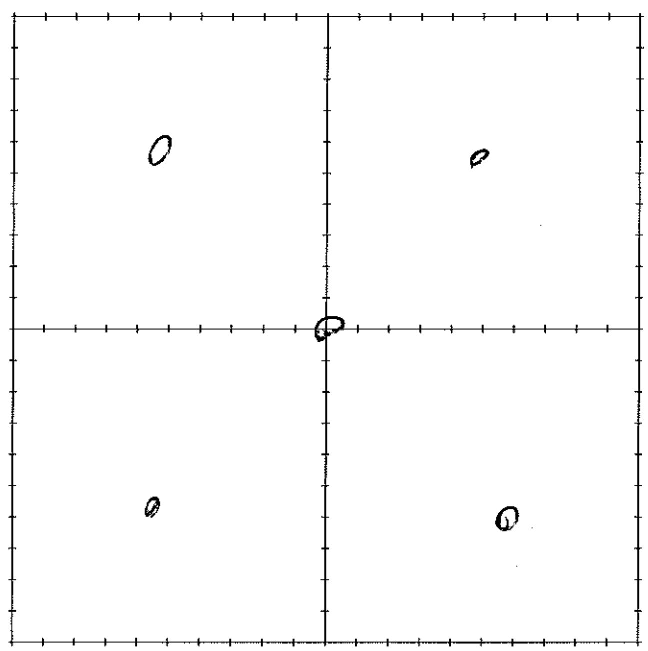
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) Bag 2

ANALYSES: Ra-226, ~~Metals~~ Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. 5313-C03-001

SAMPLE COLLECTION DATE 3/27/17

SAMPLE COLLECTION TIME 1100

SAMPLE COLLECTED BY C Lee T Osborn

WEATHER CONDITIONS 63° F and windy

FIELD USCS DESCRIPTIONS sandy silt, medium brown

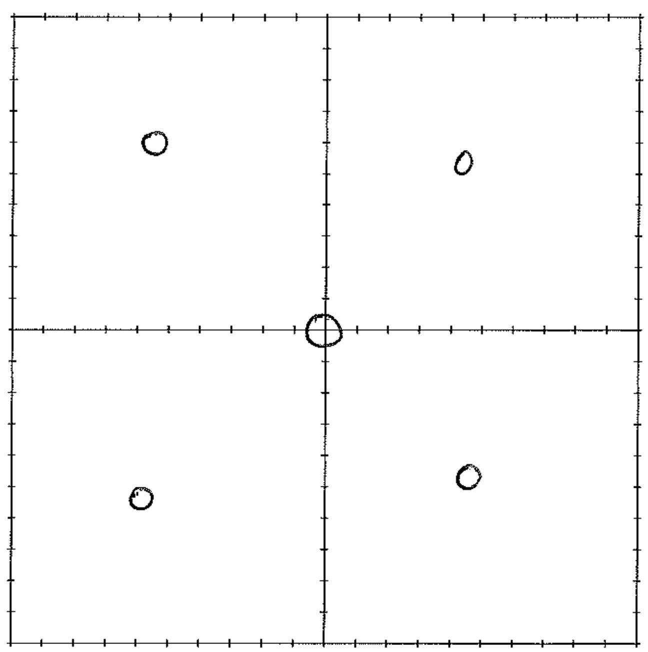
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 Bag 3

ANALYSES: Ra-226, Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becenti

SAMPLE I.D. S313-C04-001

SAMPLE COLLECTION DATE 3/27/17

SAMPLE COLLECTION TIME 1115

SAMPLE COLLECTED BY C Lee T Osborn

WEATHER CONDITIONS ~~68°~~ CL 60°F windy

FIELD USCS DESCRIPTIONS fine sand, minor silt, trace gravel

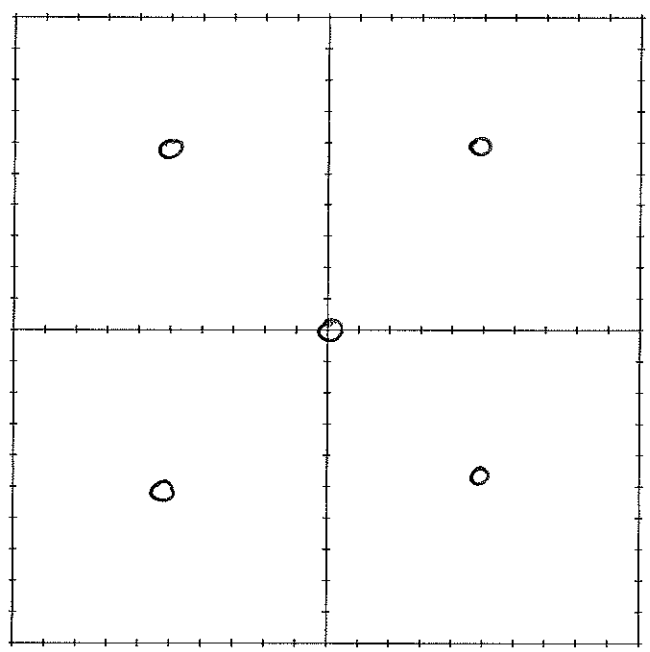
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 BAG 4

ANALYSES: Ra-226, Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Becent :

SAMPLE I.D. S313-C05-001

SAMPLE COLLECTION DATE 3/27/17

SAMPLE COLLECTION TIME 12:10

SAMPLE COLLECTED BY T. Osborn, C. Lee

WEATHER CONDITIONS 60° Windy

FIELD USCS DESCRIPTIONS Fine sand, poorly graded, tan / Yellow

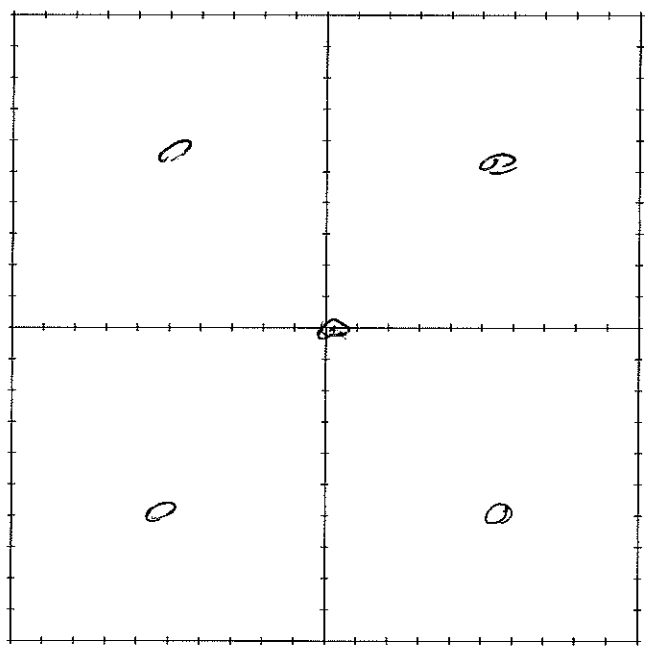
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) Bag 5

ANALYSES: Ra-226, ~~Metals~~ Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Emma Beach (S313)

SAMPLE I.D. S313-CX-001

SAMPLE COLLECTION DATE 5/15/17

SAMPLE COLLECTION TIME 0900

SAMPLE COLLECTED BY CL/MW

WEATHER CONDITIONS 60's, sunny

FIELD USCS DESCRIPTIONS Fine light brown sand

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

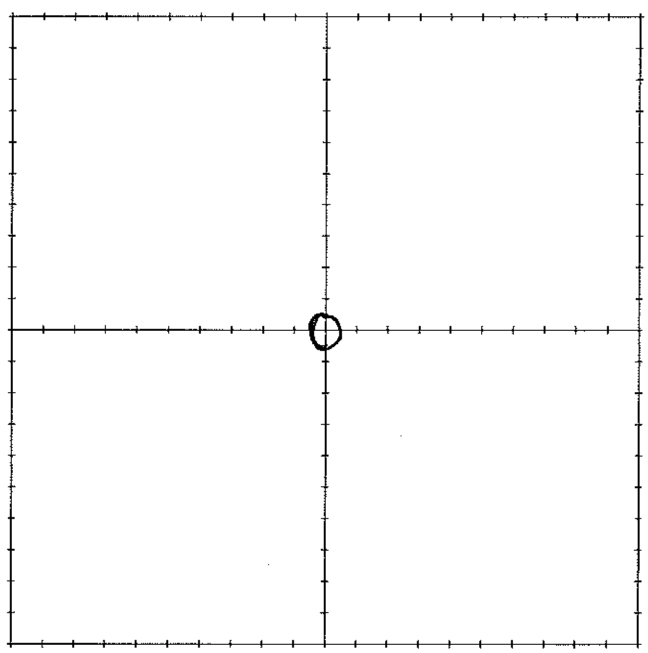
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: Ervin Becenti (5313)

SAMPLE I.D.: 5313-CX-002

SAMPLE COLLECTION DATE: 5/15/17

SAMPLE COLLECTION TIME: 0914

SAMPLE COLLECTED BY: CL/MW

WEATHER CONDITIONS: 60's, sunny

FIELD USCS DESCRIPTIONS: Fine light brown sand

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

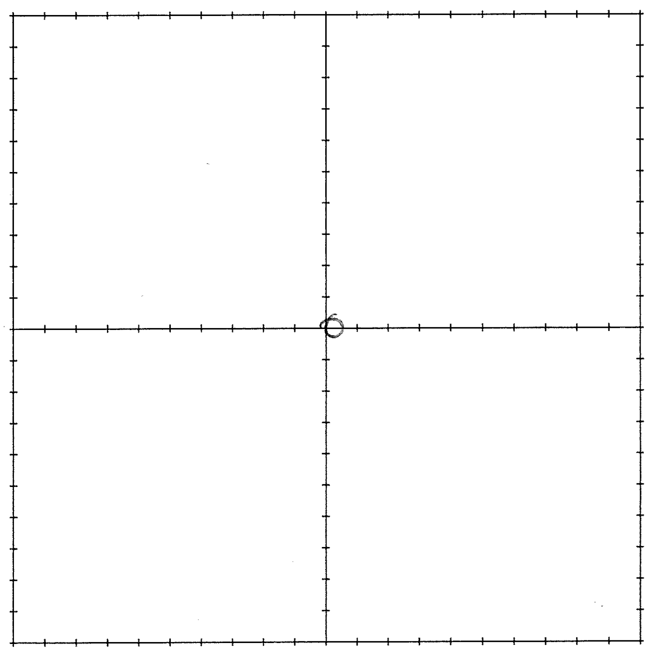
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR: —

SAMPLE CONTAINERS (NUMBER AND TYPE): 2 zips

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Boccuti (S313)

SAMPLE I.D. S313-6X-003

SAMPLE COLLECTION DATE 5/15/17

SAMPLE COLLECTION TIME 0930

SAMPLE COLLECTED BY MW/LL

WEATHER CONDITIONS 60's, sunny

FIELD USCS DESCRIPTIONS Fine Brown sand

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

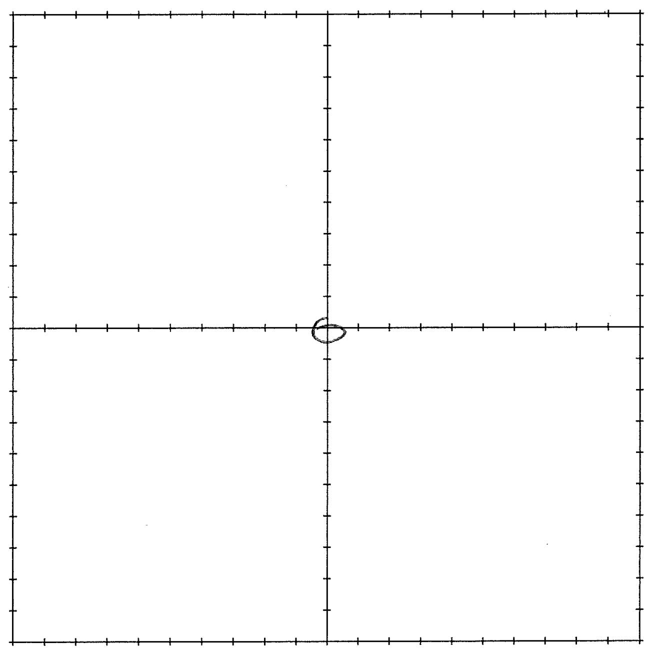
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Emine Beauti (5313)

SAMPLE I.D. 5313 - ux-009

SAMPLE COLLECTION DATE 8/15/17

SAMPLE COLLECTION TIME 0945

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 60's, sunny

FIELD USCS DESCRIPTIONS Moist to wet, coarse gravels to subangular cobbles, sand

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

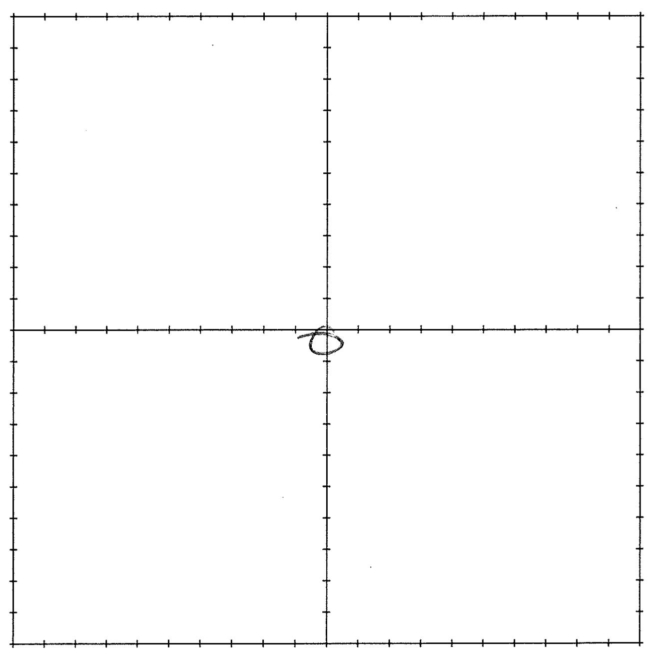
QUALIFIERS: ☒ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☒ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

MUNSELL COLOR –

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Emma Boccuti (S313)

SAMPLE I.D. S313-Lx-005

SAMPLE COLLECTION DATE 5/15/17

SAMPLE COLLECTION TIME 1001

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 60's sunny

FIELD USCS DESCRIPTIONS Fine brown sand

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

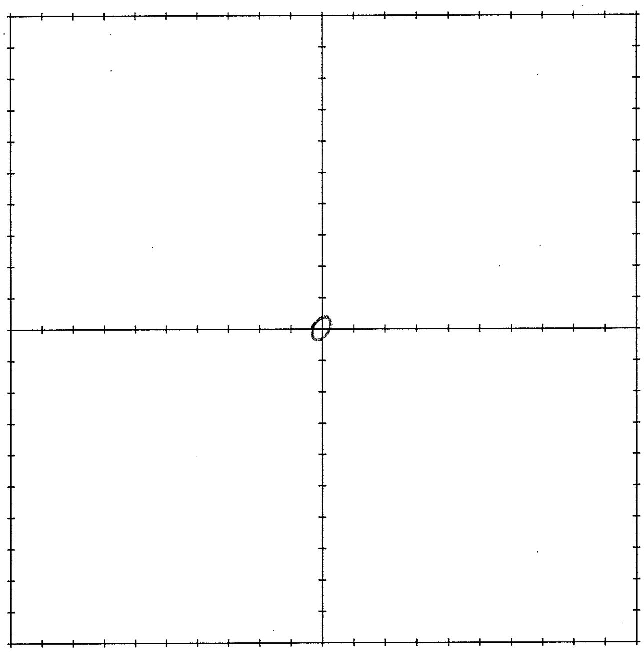
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: [x] DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Boccuti (S313)

SAMPLE I.D. S313-Cx-006

SAMPLE COLLECTION DATE 5/15/17

SAMPLE COLLECTION TIME 1018

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 60's, sunny

FIELD USCS DESCRIPTIONS Fine sand w/ gravels (coarse to cobbles)

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

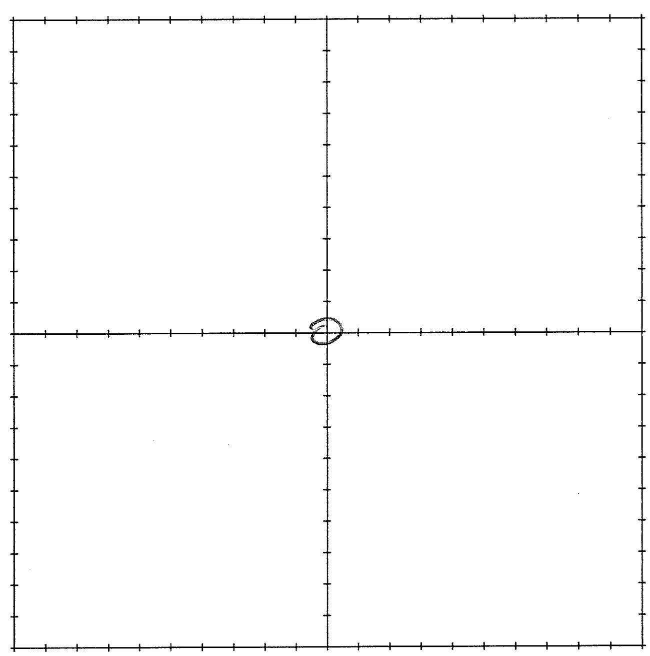
QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☒ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: Eunice Boccelli (S313)

SAMPLE I.D.: S313-EX-007

SAMPLE COLLECTION DATE: 5/15/17

SAMPLE COLLECTION TIME: 1030

SAMPLE COLLECTED BY: MW/LL

WEATHER CONDITIONS: 60's Sunny

FIELD USCS DESCRIPTIONS: Fine brown sand, slightly moist (1/4"-1/2" gravels)

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

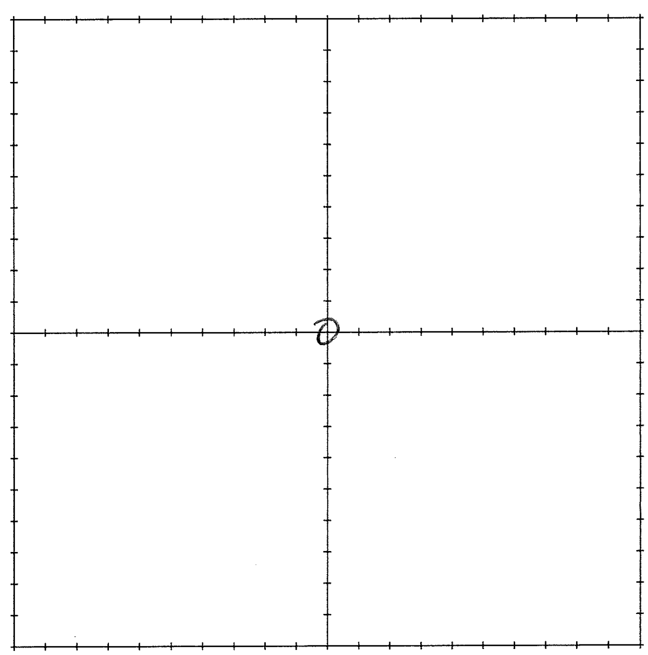
QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☒ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR: —

SAMPLE CONTAINERS (NUMBER AND TYPE): 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Beauti (S313)

SAMPLE I.D. S313-CX-008 MS/MSD

SAMPLE COLLECTION DATE 5/15/17

SAMPLE COLLECTION TIME

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 60's, sunny

FIELD USCS DESCRIPTIONS Fine red / light brown sand, slightly moist

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

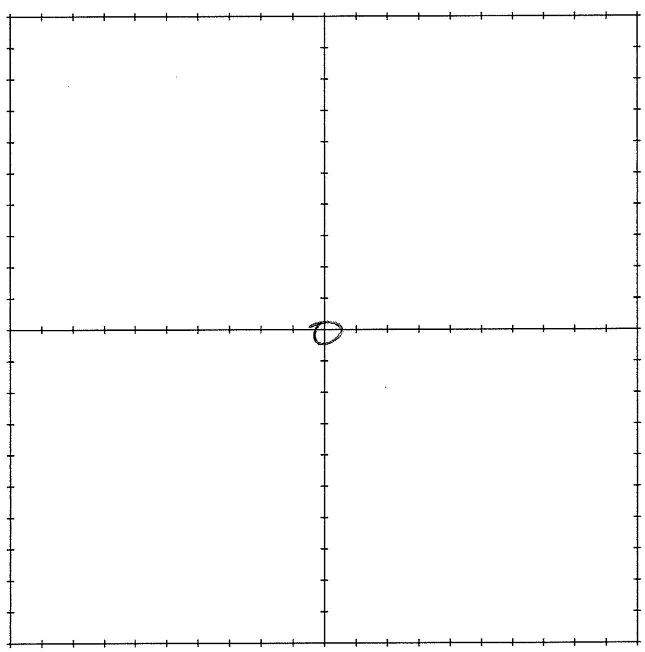
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Boccuti (S313)

SAMPLE I.D. S313 - CX - 009

SAMPLE COLLECTION DATE 5/15/17

SAMPLE COLLECTION TIME 1111

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 60's sunny

FIELD USCS DESCRIPTIONS Fine tan/gray sand

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

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals

MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Euminie Beach (S313)

SAMPLE I.D. S313-GX-010

SAMPLE COLLECTION DATE 5/15/17

SAMPLE COLLECTION TIME 1130

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 60's, sunny

FIELD USCS DESCRIPTIONS Fine light brown sand

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

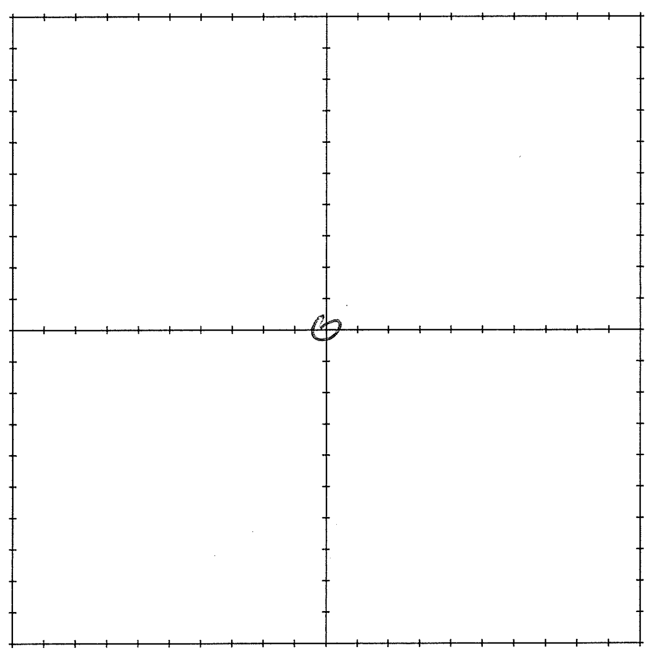
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Eunice Beenoti (S313)

SAMPLE I.D. S313-CX-011

SAMPLE COLLECTION DATE 5/15/17

SAMPLE COLLECTION TIME 1152

SAMPLE COLLECTED BY MW/CC

WEATHER CONDITIONS 60's, sunny

FIELD USCS DESCRIPTIONS Fine tan sand

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

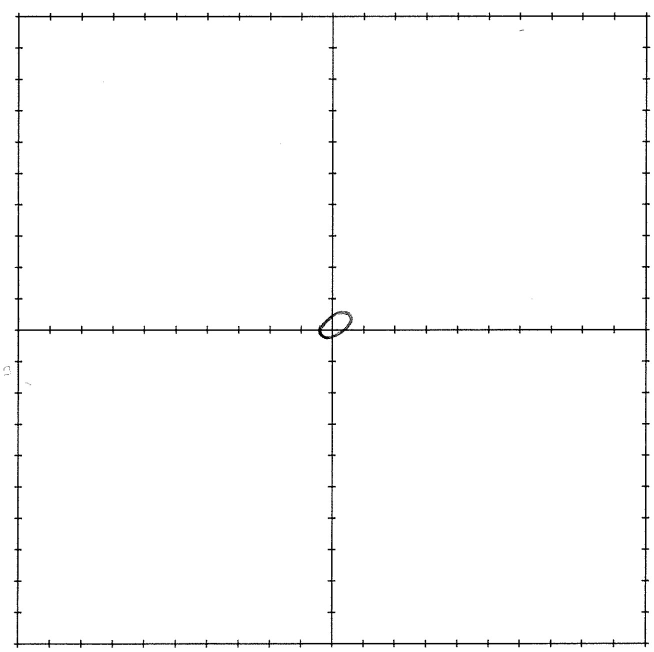
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

C.2 Hand Auger Borehole Logs

Stantec | NAVAJO NATION AUM Environmental Response Trust - First Phase

BOREHOLE ID:	**S313-BG1-011**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
DRILLING METHOD:	Hand auger	EASTING:	712939.09	NORTHING:	3931638.5
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	3/24/2017	DATE STARTED:	3/24/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.2	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Kelly Johnson		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		SILTY SAND (SM): dark brown and gray, fine grained sand, dry, trace gravels.	8480	S313-BG1-011-1	0-0.2	grab	1.71
		Terminated hand auger borehole at 0.5 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

Stantec

NAVAJO NATION
AUM Environmental Response Trust - First Phase

BOREHOLE ID:	**S313-BG2-011**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 712811.6	NORTHING: 3931673.11
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 9/15/2017	DATE STARTED: 9/15/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 0.8	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Michael Ward	

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): brown (7.5 YR 4/2), 90% fine to coarse sand, few gravels, few fines, some organics, dry, loose.	12944	S313-BG2-011-01	0-0.5	grab	2.54
		increase in gravel.	26769	S313-BG2-011-02	0.5-0.8	grab	2.94
		Terminated borehole at 0.8 ft. below ground surface. Refusal on rock.	30106				
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:	**S313-BG3-011**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 712817.03	NORTHING: 3931559.58
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 9/15/2017	DATE STARTED: 9/15/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 0.5	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Michael Ward	

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0–0.5	POORLY GRADED SAND (SP): brown (7.5 YR 4/3), medium grained sand, dry, loose.	11902 – 15432	S313-BG3-011-01	0-0.5	grab	1.44
0.5	Terminated borehole at 0.5 ft. below ground surface. Refusal on rock.					

Gamma (cpm) scale: 0, 25000, 50000, 75000, 100000

Depth scale: 0, 1, 2, 3, 4, 5

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

BOREHOLE ID:	**S313-BG4-011**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
DRILLING METHOD:	Hand auger	EASTING:	712954.05	NORTHING:	3931204.34
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	9/15/2017	DATE STARTED:	9/15/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.75	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	POORLY GRADED SAND (SP): brown (7.5 YR 4/2), fine to coarse sand, dry, loose. Trace white gravel and trace organics.	13300	S313-BG4-011-01	0-0.5	grab	1.66
	POORLY GRADED SAND WITH GRAVEL (SP): brown (7.5 YR 4/2), fine to coarse sand, dry, loose. 30-40% white gravel and trace organics.	15012	S313-BG4-011-02	0.5-0.75	grab	1.38
	Terminated borehole at 0.75 ft. below ground surface. Refusal on rock.	18699				
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: **S313-BG5-011**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Eunice Becenti

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: 713325.66 NORTHING: 3931302.41
DATE STARTED: 9/16/2017 DATE STARTED: 9/16/2017
TOTAL DEPTH (ft.): 0.5 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Michael Ward

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP) brown (7.5 YR 4/3), fine to medium gravels, dry, loose.	9575 13197	S313-BG5-011-01	0-0.5	grab	1.74
		Terminated borehole at 0.5 ft. below ground surface. Refusal on rock.					
1							
2							
3							
4							
5							

SUBSURFACE SAMPLE INFORMATION

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

Stantec | NAVAJO NATION AUM Environmental Response Trust - First Phase

BOREHOLE ID:	**S313-SCX-001**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 712974.66	NORTHING: 3931377.47
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 5/16/2017	DATE STARTED: 5/16/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 1.8	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Michael Ward

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 / 25000 / 50000 / 75000 / 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		SANDY LEAN CLAY WITH GRAVEL (CL): dark brown, dark red, low plasticity, soft, moist, with roots and organics.	14497				
			21348	S313-SCX-001-1	0-0.5	grab	2.58
1			31706	S313-SCX-001-2	0.5-1.5	grab	9.30
			34998				
			33899	S313-SCX-001-3	1.5-1.8	grab	11.10
2		Terminated hand auger borehole at 1.8 ft. below ground surface. Refusal on hard rock.					
3							
4							
5							

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

BOREHOLE ID:	**S313-SCX-002**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

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:	712960.21	NORTHING:	3931367.7
DATE STARTED:	5/16/2017	DATE STARTED:	5/16/2017
TOTAL DEPTH (ft.):	2.1	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	LEAN CLAY WITH SAND (CL): dark brown, low plasticity, moist, fluvial.	18357	S313-SCX-002-1	0-0.5	grab	4.07
0.5	light brown.	24250	S313-SCX-002-2	0.5-1.5	grab	3.79
1		27048				
1.5	FAT CLAY WITH SAND (CH): dark gray and brown, moist, stiff, some trace organics and roots.	29203	S313-SCX-002-3	1.5-2.1	grab	2.55
2.1	Terminated hand auger borehole at 2.1 ft. below ground surface. Refusal on hard rock.	25489				

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

BOREHOLE ID:	**S313-SCX-003**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

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:	712969.65	NORTHING:	3931472.48
DATE STARTED:	5/16/2017	DATE STARTED:	5/16/2017
TOTAL DEPTH (ft.):	0.8	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	POORLY GRADED SAND (SP): light brown, red, fine to coarse grained sand, some minor small gravels, moist, fluvial deposition from small drainage.	15353	S313-SCX-003-1 S313-SCX-203-1	0-0.5	grab	2.49 3.98
		18567 20326	S313-SCX-003-2	0.5-0.8	grab	3.92
0.8	Terminated hand auger borehole at 0.8 ft. below ground surface. Refusal on hard rock.					

Gamma (cpm) scale: 0, 25000, 50000, 75000, 100000

Depth scale: 0, 1, 2, 3, 4, 5

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

grab = grab sample
comp = composite sample

- - - - = approximate contact

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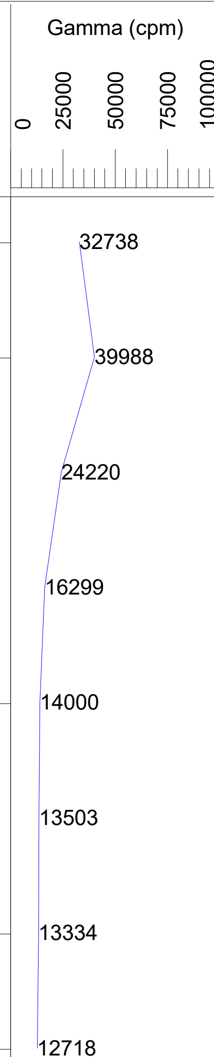
BOREHOLE ID:	**S313-SCX-004**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

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:	713268.3	NORTHING:	3931509.26
DATE STARTED:	5/17/2017	DATE STARTED:	5/17/2017
TOTAL DEPTH (ft.):	3.5	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	SILTY SAND (SM): light brown, 80% fine to medium grained sand, 20% silts, loose, soft, unconsolidated, moist.
0.5	with some white.
1	
2	becoming dark brown.
3	becoming reddish brown.
3.5	Terminated hand auger borehole at 3.5 ft. below ground surface. Refusal on hard rock.
4	
5	



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S313-SCX-004-1	0-0.5	grab	3.73
S313-SCX-004-2	0.5-3	comp	0.49
S313-SCX-004-3	3-3.5	grab	0.86

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:	**S313-SCX-005**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
DRILLING METHOD:	Hand auger	EASTING:	712989.99	NORTHING:	3931555.49
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	5/16/2017	DATE STARTED:	5/16/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.5	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		LEAN CLAY WITH SAND (CL): brown, purple, light brown, low plasticity, mottled, soft to medium stiff, minor roots.	17971	S313-SCX-005-1	0-0.5	grab	1.94
		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on hard rock.	20586				
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:	**S313-SCX-006**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 712999.43	NORTHING: 3931549.46
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 5/16/2017	DATE STARTED: 5/16/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 1	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Michael Ward

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm) (0–100000)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	SANDY LEAN CLAY WITH GRAVEL (CL): with some silt, brown, gray, trace white, low to moderate plasticity, medium to stiff.	49019				
		30395	S313-SCX-006-1	0-0.5	grab	2.37
			S313-SCX-006-2	0.5-1	grab	2.38
1	Terminated hand auger borehole at 1 ft. below ground surface. Refusal on hard rock.	25443				
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:	**S313-SCX-007**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 712993.48	NORTHING: 3931540.59
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 5/16/2017	DATE STARTED: 5/16/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 0.5	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Michael Ward

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0–0.5	CLAYEY SAND (SC): brown and trace white, dry.	12807 – 13233	S313-SCX-007-1	0-0.5	grab	1.17
0.5	Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on hard rock.					

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:	**S313-SCX-008**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

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:	713132.39	NORTHING:	3931523.19
DATE STARTED:	5/17/2017	DATE STARTED:	5/17/2017
TOTAL DEPTH (ft.):	0.5	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 100000 200000 300000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL (SP): brown, black and trace white, 60% sand, 30% gravels, 10% silt and clays, unconsolidated, loose, moist. Soil is part of embankment for old road.	54896 175472	S313-SCX-008-1	0-0.5	grab	15.20
		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on hard rock.					
1							
2							
3							
4							
5							

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

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S313-SCX-009**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

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:	713151.89	NORTHING:	3931588.48
DATE STARTED:	5/17/2017	DATE STARTED:	5/17/2017
TOTAL DEPTH (ft.):	0.9	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): light brown, light red, medium grained, moist.	9565	S313-SCX-009-1	0-0.5	grab	0.44
		light gray and white.	11004	S313-SCX-009-2	0.5-0.9	grab	0.59
		Terminated hand auger borehole at 0.9 ft. below ground surface. Refusal on hard rock.	12446				
1							
2							
3							
4							
5							

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

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S313-SCX-010**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
DRILLING METHOD:	Hand auger	EASTING:	713064.08	NORTHING:	3931491.63
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	5/17/2017	DATE STARTED:	5/17/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.5	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): light brown, medium grained, some fines, moist, loose, unconsolidated.	34765	S313-SCX-010-1	0-0.5	grab	5.49
0.5		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on hard rock.	24414				
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:	**S313-SCX-011**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
DRILLING METHOD:	Hand auger	EASTING:	713089.54	NORTHING:	3931469.34
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	5/17/2017	DATE STARTED:	5/17/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.5	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0–0.5		POORLY GRADED SAND WITH GRAVEL (SP): light brown, trace white, loose, dry.	49242 / 34609	S313-SCX-011-1	0-0.5	grab	9.20
0.5		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on hard rock.					

Depth scale: 0, 1, 2, 3, 4, 5

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

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BOREHOLE ID:	**S313-SCX-012**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
DRILLING METHOD:	Hand auger	EASTING:	713131.86	NORTHING:	3931433.1
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	5/17/2017	DATE STARTED:	5/17/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.8	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000
0		POORLY GRADED SAND WITH GRAVEL AND SILT (SP-SM): dark brown, trace white, loose, medium grained sand, angular to semi rounded gravel, dry.	35431 51508
0.8		Terminated hand auger borehole at 0.8 ft. below ground surface. Refusal on hard rock.	63803
1			
2			
3			
4			
5			

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S313-SCX-012-1 S313-SCX-212-1	0-0.5	grab	13.40 12.90
S313-SCX-012-2	0.5-0.8	grab	18.90

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

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S313-SCX-013**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
DRILLING METHOD:	Hand auger	EASTING:	713116.77	NORTHING:	3931394.22
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	5/17/2017	DATE STARTED:	5/17/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.75	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		FAT CLAY WITH SAND (CH): dark gray, stiff, high plasticity.	37531	S313-SCX-013-1	0-0.5	grab	9.90
			55433	S313-SCX-013-2	0.5-0.75	grab	16.90
		Terminated hand auger borehole at 0.75 ft. below ground surface. Refusal on hard surface.	65887				
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:	**S313-SCX-014**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
DRILLING METHOD:	Hand auger	EASTING:	713101.78	NORTHING:	3931383.27
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	5/17/2017	DATE STARTED:	5/17/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	1.5	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) (0 – 300000)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL AND SILT (SP-SM): brown, light brown, trace white, loose, unconsolidated, dry.	34978	S313-SCX-014-1	0-0.5	grab	11.90
0.5		becoming moist.	69312				
1			109249	S313-SCX-014-2	1-1.5	grab	29.00
1.5		Terminated hand auger borehole at 1.5 ft. below ground surface. Refusal on hard surface.	121683				
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:	**S313-SCX-015**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 713057.14	NORTHING: 3931357.02
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 5/17/2017	DATE STARTED: 5/17/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 0.8	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Michael Ward

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	POORLY GRADED SAND WITH GRAVEL AND SILT (SP-SM): dark brown, trace white, loose, unconsolidated, dry, alluvial.	19583	S313-SCX-015-1	0-0.5	grab	7.24
		24502	S313-SCX-015-2	0.5-0.8	grab	6.45
0.8	Terminated hand auger borehole at 0.8 ft. below ground surface. Refusal on hard rock.	24064				

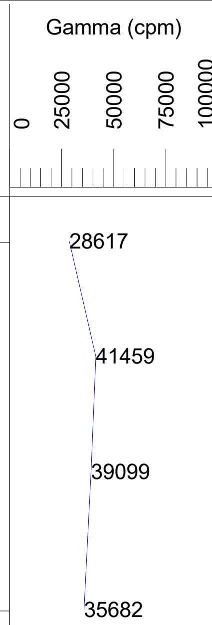
Depth scale: 0, 1, 2, 3, 4, 5. Gamma scale: 0, 25000, 50000, 75000, 100000.

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

BOREHOLE ID:	**S313-SCX-016**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 713050.53	NORTHING: 3931389.1
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 5/17/2017	DATE STARTED: 5/17/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 1.6	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Michael Ward

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL AND SILT (SP-SM): dark brown, trace white, fine to medium grained sand, loose, unconsolidated, moist.	28617	S313-SCX-016-1	0-0.5	grab	12.80
			41459	S313-SCX-016-2	0.5-1	grab	8.40
1			39099	S313-SCX-016-3	1-1.6	grab	6.32
		Terminated hand auger borehole at 1.6 ft. below ground surface. Refusal on hard rock.	35682				
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:	**S313-SCX-017**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
DRILLING METHOD:	Hand auger	EASTING:	712898.17	NORTHING:	3931323.19
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	9/15/2017	DATE STARTED:	9/15/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	1.5	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 / 25000 / 50000 / 75000 / 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): light brownish gray (2.5 YR 6/2), fine to medium grained sand, loose, dry. Borehole in dry fluvial drainage located just after junction of sandstone outcrop and in sedimentary valley fill.	10908				
				S313-SCX-017-01	0-0.5	grab	3.29
			14629				
1			14673	S313-SCX-017-02	0.5-1.5	grab	1.49
1.5		Terminated hand auger borehole at 1.5 ft. below ground surface. Refusal on hard rock.	14100				
2							
3							
4							
5							

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

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S313-SCX-018**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 712854.95	NORTHING: 3931320.66
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 9/15/2017	DATE STARTED: 9/15/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 2	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Michael Ward

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)
0	POORLY GRADED SAND (SP): light brownish gray (2.5 YR 6/2), fine to medium grained sand, loose, dry. Sampled from former fluvial dry creek bed that has incised a drainage.	12033
0.5		15381
1		18073
1.5		19312
2	Terminated hand auger borehole at 2 ft. below ground surface. Refusal on hard rock.	20249

Gamma scale (cpm): 0, 25000, 50000, 75000, 100000

SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S313-SCX-018-01	0-0.5	grab	1.72
S313-SCX-018-02	0.5-2	comp	2.09

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

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S313-SCX-019**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N		
DRILLING METHOD:	Hand auger	EASTING:	712993.29	NORTHING:	3931357.8
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	9/15/2017	DATE STARTED:	9/15/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.5	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0–0.5		POORLY GRADED SAND (SP): dark brown (7.5 YR 3/2), fine to coarse sands, mainly medium grained, dry, loose.	28922 27855	S313-SCX-019-01	0-0.5	grab	6.13
0.5		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on hard rock.					

Gamma scale: 0, 25000, 50000, 75000, 100000. Depth scale: 0, 1, 2, 3, 4, 5.

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

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S313-SCX-020**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 713174.51	NORTHING: 3931443.28
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 9/15/2017	DATE STARTED: 9/15/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 1	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Michael Ward

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): strong brown (7.5 YR 5/6), fine to medium grained sand, dry, loose, alluvial sands on hillside.	24190	S313-SCX-020-01	0-0.5	grab	3.71
			21711	S313-SCX-020-02	0.5-1	grab	1.30
1		Terminated hand auger borehole at 1 ft. below ground surface. Refusal on hard rock.	12847				
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:	**S313-SCX-021**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 713169.78	NORTHING: 3931443.28
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 9/15/2017	DATE STARTED: 9/15/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 0.5	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Michael Ward

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): strong brown (7.5 YR 5/6), fine to medium grained sand, dry, loose. Sand from alluvial setting.	33343	S313-SCX-021-01	0-0.5	grab	3.91
0.5		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on hard rock.	19209				
1							
2							
3							
4							
5							

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

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S313-SCX-022**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Eunice Becenti

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
DRILLING METHOD:	Hand auger	EASTING:	713129.54	NORTHING:	3931626.14
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	9/15/2017	DATE STARTED:	9/15/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.5	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): strong brown (7.5 YR 5/6), medium grained sand, dry, loose.	7996	S313-SCX-022-01	0-0.5	grab	0.88
0.5		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on hard rock.	9509				
1							
2							
3							
4							
5							

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

Appendix D Evaluation of RSE Data

D.1 Background Reference Area Selection

D.2 Statistical Evaluation

BACKGROUND REFERENCE AREA SELECTION

1.0 INTRODUCTION

This appendix presents the rationale for selection of the background reference areas for the Eunice Becenti Site (Site). To select the background reference areas for the Site, personnel considered geology, predominant wind direction, hydrologic influence, similarities of vegetation and ground cover, distance from the Site, and visual evidence of impacts due to mining (or other anthropogenic sources) in accordance with the *Multi-Agency Radiation Survey and Site Investigation Manual – Appendix A* ([MARSSIM] USEPA, 2000).

2.0 POTENTIAL BACKGROUND REFERENCE AREAS

The potential background reference area study was initiated during the Site Clearance desktop study and field investigations. In May 2016, one potential background reference area (BG-1) was identified to represent the geologic formation at the Site where mining-impacted material was assumed to be present, the Westwater Canyon Member of the Morrison Formation (the Morrison Formation). A surface gamma survey was conducted at BG-1 in May 2016 and surface soil samples were collected in November 2016. As shown in Figure D.1-2, the areal extent of the May 2016 surface gamma survey was smaller than the areal extent of the surface soil samples. As a result, BG-1 was re-surveyed in March 2017 in an attempt to obtain better coverage of the soil sample locations. However, a poor GPS signal during the 2017 surface gamma survey resulted in an even smaller survey area than the 2016 survey. GPS satellite coverage was affected by the steep terrain/cliff face in the area of BG-1; this likely affected both the precision of the GPS unit when surveying the potential background reference area and the GPS data collected during both the 2016 and 2017 surveys. The May 2016 surface gamma survey data were used for the RSE.

Following review of the data collected during the Baseline Studies for BG-1 and the Site, Stantec observed that mining-related impacts extended beyond the area of the Site within the Morrison Formation and that additional potential background reference areas were required to represent the additional geologic formations. Potential mining-related impacts were observed in the following geologic formations (see Figure D.1-1:

- Morrison Formation (BG-1)
- Dakota Sandstone (BG-2 and BG-6)
- Whitewater Arroyo Shale Tongue of the Mancos Shale (BG-3)
- Quaternary deposits (BG-4 and BG-8)

- Cow Springs Sandstone (BG-5)
- Twowells Sandstone Tongue of the Dakota Sandstone (BG-7)

Section 3.3.1.2 in the RSE report discusses the extent of the surface gamma survey at the Site, the geologic formations present within the Survey Area, and how the Survey Area is broken up into individual Survey Areas (Survey Area A, Survey Area B, etc.) based on the geologic formations. Figure 3-4 in the RSE Report shows the separate Survey Areas. Seven additional potential background reference areas were identified to represent the geologic formations where potential mining-related impacts were observed, and gamma surveys were conducted in June 2017. The locations of the eight potential background reference areas (BG-1 through BG-8), geology, and predominant wind direction are shown in Figure D.1-2. The potential background reference areas are described below.

- BG-1 encompasses an area of 549 ft2 (approximately 0.01 acres), is located 790 ft northwest of the Site, is cross-wind and hydrologically cross-gradient from the Site, and is across a drainage divide. The thin soils, colluvium-covered slopes, and bedrock outcrops represent the portions of the Survey Area that consist of the Westwater Canyon Member of the Morrison Formation. The vegetation and ground cover at BG-1 are similar to the Site.
- BG-2 encompasses an area of 1,417 ft2 (approximately 0.03 acres), is located 1,100 ft northwest of the Site, is cross-wind and hydrologically cross-gradient from the Site, and on the other side of a drainage channel. The thin soils, colluvium-covered slopes, and bedrock outcrops represent the portions of the Survey Areas that consist of the Dakota Sandstone, including the Twowells Sandstone Tongue of the Dakota Sandstone. The vegetation and ground cover at BG-2 are similar to areas of the Site that lie within the Dakota Sandstone.
- BG-3 encompasses an area of 2,655 ft2 (approximately 0.06 acres), is located 900 ft northwest of the Site, is cross-wind and hydrologically cross-gradient from the Site, and on the other side of a drainage channel. The thicker soils and colluvium-covered slopes and benches represent the portions of the Survey Area that consists of Mancos Shale, and vegetation and ground cover at BG-3 are similar to areas of the Site that lie within the Mancos Shale.
- BG-4 encompasses an area of 1,170 ft2 (approximately 0.03 acres), is located 650 ft southwest of the Site, and is upwind from the Site. Regionally, BG-4 is hydrologically downgradient from the Site, but on the other side of a drainage channel from the Site and does not receive surface water runoff from the Site. The sediments in BG-4 represent the portions of the Survey Area southwest of the Site that consist of Quaternary alluvium, colluvium, and eolian sands, and vegetation and ground cover at BG-4 are similar to areas of the Site that lie within the Quaternary deposits.
- BG-5 encompasses an area of 6,275 ft2 (approximately 0.14 acres), is located 430 ft east of the Site, and is cross-wind and hydrologically cross-gradient from the Site. The thin soils, colluvium-covered slopes, and bedrock outcrops at BG-5 represent the portions of the Survey Area that consist of the Cow Springs Sandstone. The vegetation and ground cover at BG-5 are similar to areas of the Site that lie within the Cow Springs Sandstone.

- BG-6 encompasses an area of 1,804 ft2 (approximately 0.04 acres), is located 1,200 ft northwest of the Site, and is cross-wind and hydrologically cross-gradient from the Site and on the other side of a drainage channel. The bedrock outcrop at BG-6 represents the portions of the Survey Areas that consist of the Dakota Sandstone. The limited vegetation and ground cover at BG-6 are similar to some areas of the Site that lie within the Dakota Sandstone.

- BG-7 encompasses an area of 2,108 ft2 (approximately 0.05 acres), is located 730 ft west of the Site, and is upwind and hydrologically cross-gradient from the Site and on the other side of a drainage channel. The thin soils, colluvium-covered slopes, and bedrock outcrops represent the portions of the Survey Area that consist of the Twowells Sandstone Tongue of the Dakota Sandstone. The vegetation and ground cover at BG-7 are similar to the limited areas of the Site that lie within the Twowells Sandstone Tongue of the Dakota Sandstone.

- BG-8 encompasses an area of 3,052 ft2 (approximately 0.07 acres), is located 950 ft east of the Site, and is cross-wind (potentially downwind) and hydrologically cross-gradient from the Site. The soils represent the portions of the Survey Area that consist of Quaternary deposits containing alluvium and eolian deposits or older pediments northeast of the claim boundary.

During further review of the Baseline Studies data, it was determined that BG-6 and BG-7would not be used to represent the Site, as described in Section 3.0 below. BG-8 was not initially selected as well. It was later determined that BG-8 should have been sampled to provide a background reference area to represent the Quaternary deposits northeast of the claim boundary. The need to collect soil/sediment samples in BG-8 is identified as a data gap in the RSE Report. Soil and sediment samples were collected at BG-2, BG-3, BG-4, and BG-5 in September 2017.

The potential background reference area evaluation included surface gamma surveys, surface static gamma measurements, subsurface static gamma measurements, and collecting surface soil/sediment samples and subsurface soil/sediment samples, as described below.

- BG-1: 11 surface soil grab samples were collected from 11 locations; a borehole could not be advanced beyond 0.2 ft at S313-BG1-011, so no subsurface samples were collected at BG-1; and one subsurface static gamma measurement was collected from S313-BG-011.

- BG-2: 11 surface soil grab samples were collected from 11 locations; one subsurface soil grab sample and surface and subsurface static gamma measurements were collected from S313-BG2-011.

- BG-3: 11 surface soil grab samples were collected from 11 locations; a borehole could not be advanced beyond 0.5 ft at S313-BG3-011, so no subsurface samples were collected at BG-3; surface and subsurface static gamma measurements were collected from S313-BG3-011.

- BG-4: 11 surface sediment grab samples were collected from 11 locations, one subsurface sediment grab sample and surface and subsurface static gamma measurements were collected from S313-BG4-011.

- BG-5: 11 surface soil grab samples were collected from 11 locations; a borehole could not be advanced beyond 0.5 ft at S313-BG5-011, so no subsurface samples were collected at BG-5; surface and subsurface static gamma measurements were collected from S313-BG5-011.

The sample locations and surface gamma survey data for BG-1, BG-2 and BG-3, and surface gamma survey data for BG-6 and BG-7, are shown in Figure D.1-2. Sample locations and surface gamma survey data for BG-4 and BG-5, and surface gamma survey data for BG-8 are shown in Figure D.1-3. Samples were categorized as surface soil or sediment samples where sample depths were up to 0.5 ft bgs, as subsurface soil or sediment samples where sample depths were greater than 0.5 ft bgs, and static gamma measurements were categorized as subsurface where static gamma was measured at or greater than 0.1 ft bgs. 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 borehole locations. Soil samples, sediment samples, and gamma measurements were collected according to the methods described in the *Removal Site Evaluation Work Plan* (MWH, 2016).

3.0 SELECTION OF BACKGROUND REFERENCE AREA

Background reference areas were selected to represent the areas of the Site where mining-related disturbances may have occurred or otherwise come to be located including downgradient drainages. BG-1, BG-2, BG-3, BG-4 and BG-5 were selected to represent their respective geologic formations described above.

Both BG-2 and BG-6 adequately represent the physical properties of the Dakota Sandstone. However, BG-6 was not selected as a background reference area because it is not representative of the general radiological conditions of the Site, and statistical values developed for BG-6 were also disproportionately influenced due to the small size of BG-6. BG-6 displayed naturally elevated gamma measurements (maximum in BG-6 was 239,788 counts per minute [cpm] compared to maximum in BG-2 of 15,166 cpm).The elevated gamma measurements in BG-6 do provide an important example of the heterogeneity and localized mineralization that may be observed in naturally occurring materials.

BG-7 was not selected as a background reference area because it is not representative of the general ground and vegetation cover of areas of the Site within the Dakota Sandstone. Near the Site, this member of the Dakota Sandstone is almost entirely bare, exposed bedrock. BG-2 adequately represents both members of the Dakota Formation.

The need to collect soil samples from BG-8 to represent the Quaternary deposits northeast of the claim boundary is identified as a data gap in the RSE report. Gamma measurements from BG-8 were considered for the estimation of the location and volume of mining-impacted material for the RSE.

Surface gamma survey measurements, soil and sediment sample results, and subsurface static gamma measurements collected from BG-1, BG-2, BG-3, BG-4, and BG-5 and the gamma survey measurements collected from BG-8 were used for the remainder of the Removal Site Evaluation of the Site.

4.0 REFERENCES

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

USEPA, 2000. *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM), EPA 402-R-97-016, Rev. 1.

Table D.1-1
Soil and Sediment Sampling Summary
Eunice Becenti
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 - Morrison Formation						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	--	55%	--	--	--
Minimum[1]	0.390	0.320	--	0.600	6.00	0.820
Minimum Detect[2]	--	--	1.20	--	--	--
Mean[1]	2.36	3.59	--	4.70	10.8	3.00
Mean Detects[2]	--	--	1.66	--	--	--
Median[1]	1.80	3.10	--	2.00	9.90	2.17
Median Detects[2]	--	--	1.30	--	--	--
Maximum[1]	5.30	11.0	--	18.0	18.0	8.70
Maximum Detect[2]	--	--	2.60	--	--	--
Distribution	Normal	Normal	Normal	Gamma	Normal	Gamma
Coefficient of Variation[1]	0.839	0.908	--	1.26	0.345	0.807
CV Detects[2]	--	--	0.375	--	--	--
UCL Type	95% Student's-t UCL	95% Student's-t UCL	95% KM (t) UCL	95% Adjusted Gamma UCL	95% Student's-t UCL	95% Adjusted Gamma UCL
UCL Result	3.44	5.38	1.33	10.6	12.8	5.02
UTL Type	UTL Normal	UTL Normal	UTL KM Normal	UTL Gamma WH	UTL Normal	UTL Gamma WH
UTL Result	7.92	12.8	3.26	31.4	21.3	12.7
Background Reference Area Study - Background Area 2 - Dakota Sandstone						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	--	18%	--	--	--
Minimum[1]	3.90	2.50	--	0.830	9.40	0.940
Minimum Detect[2]	--	--	0.970	--	--	--
Mean[1]	5.35	3.82	--	1.17	15.9	1.77
Mean Detects[2]	--	--	1.39	--	--	--
Median[1]	4.80	3.50	--	1.00	14.0	1.51
Median Detects[2]	--	--	1.20	--	--	--
Maximum[1]	7.80	7.90	--	1.80	23.0	3.24
Maximum Detect[2]	--	--	2.70	--	--	--
Distribution	Normal	Gamma	Normal	Normal	Normal	Normal
Coefficient of Variation[1]	0.247	0.375	--	0.288	0.309	0.421
CV Detects[2]	--	--	0.381	--	--	--
UCL Type	95% Student's-t UCL	95% Adjusted Gamma UCL	95% KM (t) UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	6.07	4.73	1.60	1.35	18.5	2.17
UTL Type	UTL Normal	UTL Gamma WH	UTL KM Normal	UTL Normal	UTL Normal	UTL Normal
UTL Result	9.06	8.08	2.67	2.12	29.7	3.86

Table D.1-1
Soil and Sediment Sampling Summary
Eunice Becenti
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 3 - Mancos Shale						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	--	27%	--	--	--
Minimum[1]	4.20	0.340	--	0.490	5.70	0.700
Minimum Detect[2]	--	--	1.00	--	--	--
Mean[1]	9.18	0.806	--	0.814	9.09	1.16
Mean Detects[2]	--	--	1.19	--	--	--
Median[1]	8.80	0.960	--	0.770	9.00	1.13
Median Detects[2]	--	--	1.20	--	--	--
Maximum[1]	14.0	1.00	--	1.30	12.0	1.84
Maximum Detect[2]	--	--	1.40	--	--	--
Distribution	Normal	Normal	Normal	Normal	Normal	Normal
Coefficient of Variation[1]	0.319	0.292	--	0.282	0.181	0.286
CV Detects[2]	--	--	0.123	--	--	--
UCL Type	95% Student's-t UCL	95% Student's-t UCL	95% KM (t) UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	10.8	0.935	1.22	0.939	9.99	1.34
UTL Type	UTL Normal	UTL Normal	UTL KM Normal	UTL Normal	UTL Normal	UTL Normal
UTL Result	17.4	1.47	1.55	1.46	13.7	2.09
Background Reference Area Study - Background Area 4 - Quaternary Alluvium						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	--	18%	--	--	--
Minimum[1]	6.30	0.560	--	0.510	13.0	1.04
Minimum Detect[2]	--	--	1.00	--	--	--
Mean[1]	8.68	0.975	--	0.812	18.6	1.33
Mean Detects[2]	--	--	1.42	--	--	--
Median[1]	9.00	1.00	--	0.890	18.0	1.38
Median Detects[2]	--	--	1.5	--	--	--
Maximum[1]	12.0	1.40	--	1.10	26.0	1.66
Maximum Detect[2]	--	--	1.8	--	--	--
Distribution	Normal	Normal	Normal	Normal	Normal	Normal
Coefficient of Variation[1]	0.251	0.327	--	0.238	0.271	0.143
CV Detects[2]	--	--	0.171	--	--	--
UCL Type	95% Student's-t UCL	95% Student's-t UCL	95% KM (t) UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	9.87	1.15	1.50	0.917	21.4	1.44
UTL Type	UTL Normal	UTL Normal	UTL KM Normal	UTL Normal	UTL Normal	UTL Normal
UTL Result	14.8	1.87	2.09	1.36	32.8	1.87

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 5 - Cow Springs Sandstone						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	--	100%	--	--	--
Minimum[1]	3.10	0.330	--	0.810	14.0	1.24
Minimum Detect[2]	--	--	--	--	--	--
Mean[1]	4.06	0.420	--	0.959	18.1	1.49
Mean Detects[2]	--	--	--	--	--	--
Median[1]	3.30	0.410	--	0.960	16.0	1.51
Maximum[1]	6.30	0.630	--	1.10	26.0	1.79
Maximum Detect[2]	--	--	--	--	--	--
Distribution	Normal	Gamma	Not Calculated	Normal	Normal	Normal
Coefficient of Variation[1]	0.303	0.221	--	0.115	0.219	0.133
UCL Type	95% Student's-t UCL	95% Adjusted Gamma UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	4.73	0.482	Not Calculated	1.02	20.3	1.60
UTL Type	UTL Normal	UTL Gamma WH	Not Calculated	UTL Normal	UTL Normal	UTL Normal
UTL Result	7.51	0.707	Not Calculated	1.27	29.2	2.05

Notes

CV	Coefficient of variation
KM	Kaplan Meier
mg/kg	Milligrams per kilogram
--	Not applicable
pCi/g	Picocuries per gram
WH	Wilson Hilferty

[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.

Table D.1-2
Surface Gamma Survey Summary
Eunice Becenti
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

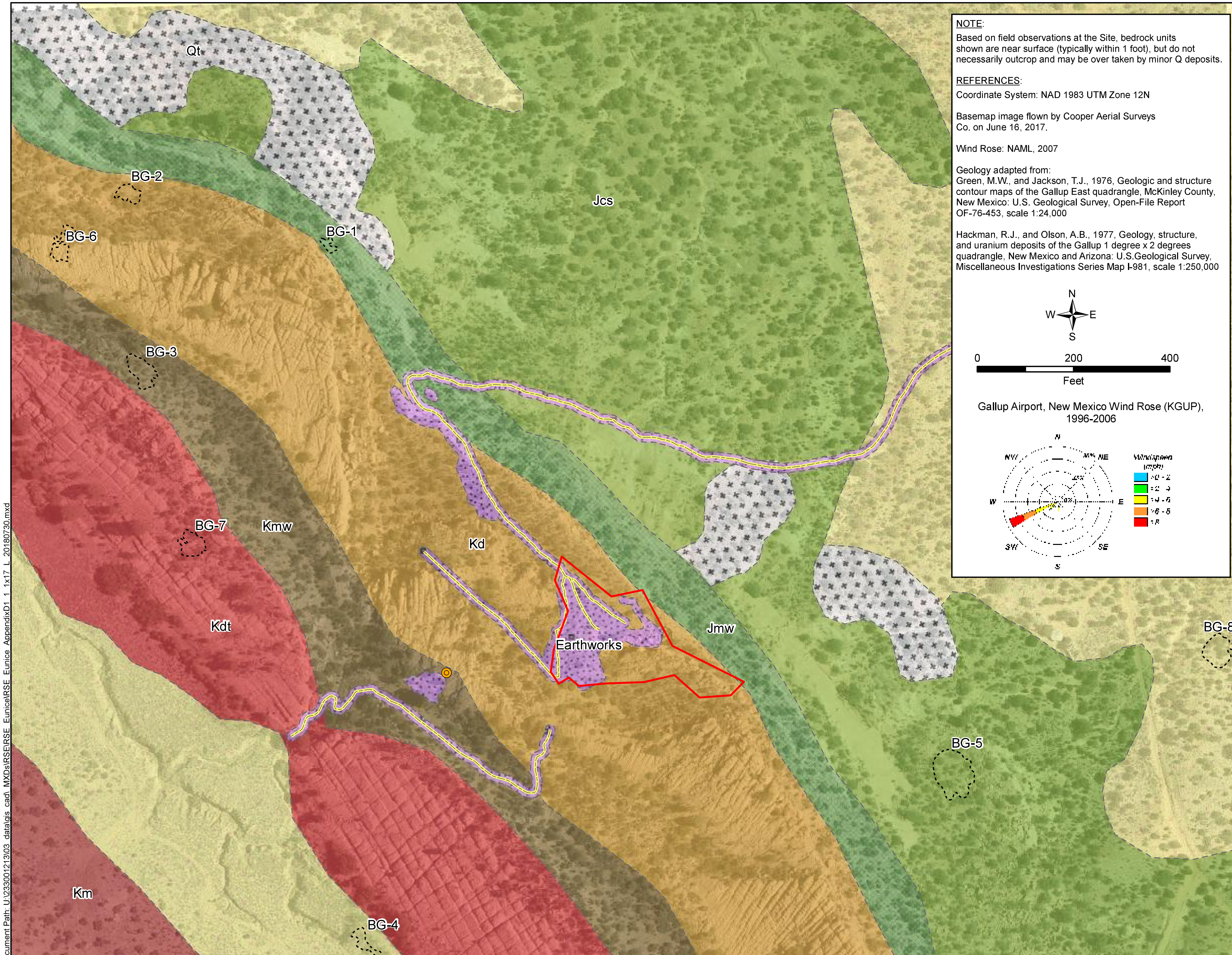
Statistic	Background Reference Area 1 (BG-1)	Background Reference Area 2 (BG-2)	Background Reference Area 3 (BG-3)	Background Reference Area 4 (BG-4)
Geologic Formation	Morrison Formation	Dakota Sandstone	Mancos Shale	Quaternary Alluvium
Total Number of Observations	188	242	419	226
Minimum	7,029	8,871	8,694	10,729
Mean	9,739	12,922	12,804	12,927
Median	9,626	12,851	12,948	12,839
Maximum	13,185	19,139	16,609	15,777
Distribution	Normal	Normal	Normal	Normal
Coefficient of Variation	0.136	0.145	0.107	0.075
UCL Type	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	9,899	13,121	12,914	13,033
UTL Type	UTL Normal	UTL Normal	UTL Normal	UTL Normal
UTL Result	12,184	16,336	15,223	14,697

Notes
cpm Counts per minute
UCL Upper confidence limit
UTL Upper tolerance limit
WH Wilson Hilferty

Table D.1-2
Surface Gamma Survey Summary
Eunice Becenti
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Statistic	Background Reference Area 5 (BG-5)	Background Reference Area 6 (BG-6)	Background Reference Area 7 (BG-7)	Background Reference Area 8 (BG-8)
Geologic Formation	Cow Springs Sandstone	Dakota Sandstone	Twowells Sandstone Tongue of Dakota Sandstone	Quaternary Alluvium and Eolian Deposits
Total Number of Observations	804	390	370	352
Minimum	5,705	13,278	5,407	4,848
Mean	8,443	45,042	7,287	6,229
Median	8,457	31,796	7,223	6,071
Maximum	12,233	239,788	10,027	8,813
Distribution	Normal	UNKNOWN	NORMAL	NORMAL
Coefficient of Variation	0.119	0.829	0.104	0.0986
UCL Type	95% Student's-t UCL	95% Chebyshev (Mean, Sd) UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	8,501	53,284	7,352	6,283
UTL Type	UTL Normal	UTL Non-Parametric	UTL Normal	UTL Normal
UTL Result	10,189	138,414	8,632	7,326

Notes
cpm Counts per minute
UCL Upper confidence limit
UTL Upper tolerance limit
WH Wilson Hilferty



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

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

Wind Rose: NAML, 2007

Geology adapted from:
Green, M.W., and Jackson, T.J., 1976, Geologic and structure contour maps of the Gallup East quadrangle, McKinley County, New Mexico: U.S. Geological Survey, Open-File Report OF-76-453, scale 1:24,000

Hackman, R.J., and Olson, A.B., 1977, Geology, structure, and uranium deposits of the Gallup 1 degree x 2 degrees quadrangle, New Mexico and Arizona: U.S.Geological Survey, Miscellaneous Investigations Series Map I-981, scale 1:250,000

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

Site Geology

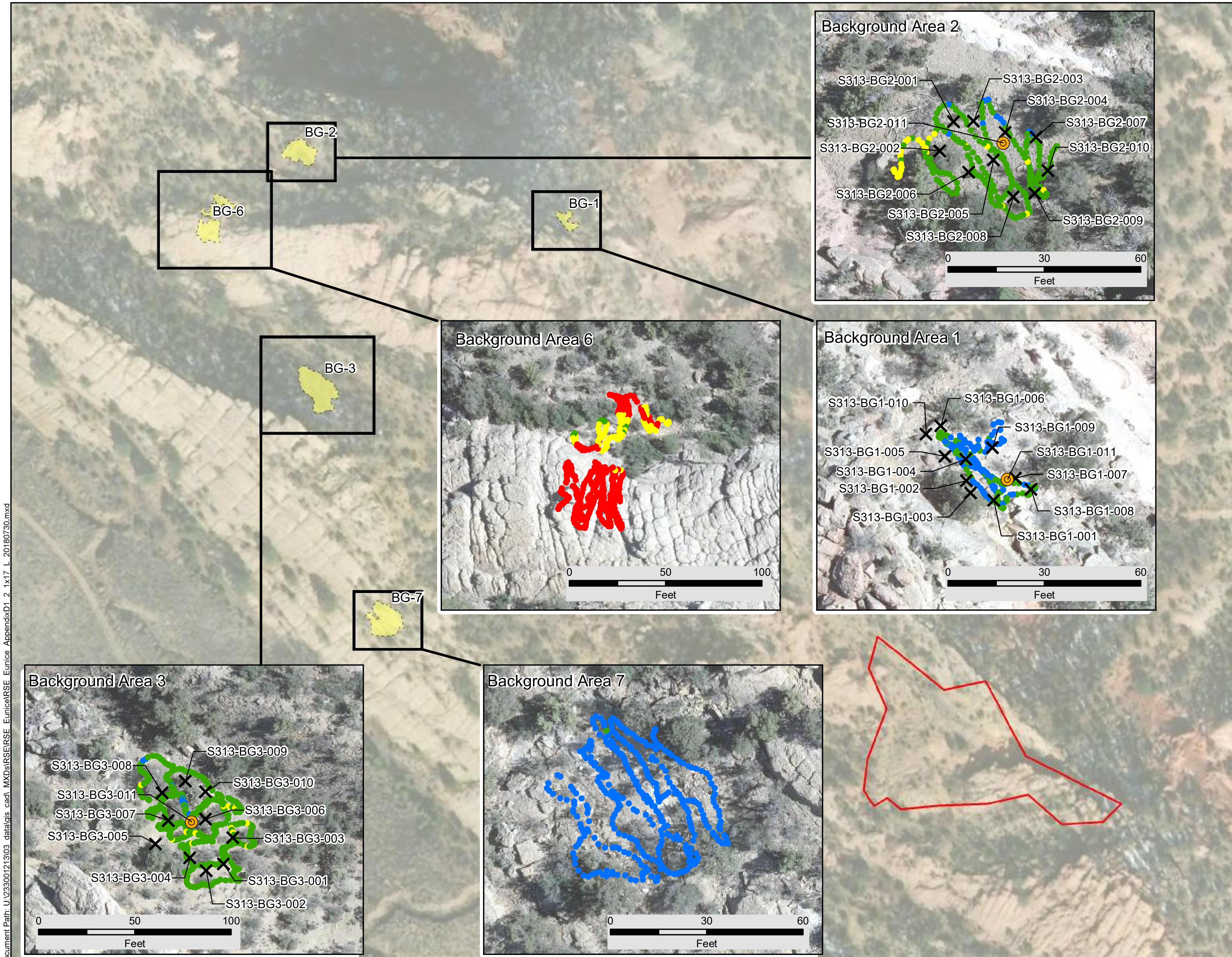
HOLOCENE

- Earthworks: Human-caused disturbance of the land surface potentially related to mining.
- Qt: Talus deposits
- Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly colluvial and alluvial deposits, and eolian sand deposits.

MESOZOIC

- Km: Mancos Shale (Upper Cretaceous) – Medium-dark-gray to nearly black, in places banded, fissile calcareous marine claystone, siltstone, and mudstone, interbedded near top and bottom with thin to thick beds of yellowish-brown sandstone. Forms slopes.
- Kdt: Twowells Sandstone Tongue of Dakota Sandstone (Upper Cretaceous) – yellowish-brown to buff medium-to fine-grained well-sorted sandstone; locally contains lenticular beds of silty shale and fossiliferous limestone.
- Kmw: Whitewater Arroyo Shale Tongue of Mancos Shale (Upper Cretaceous) – Yellowish-brown to yellow fossiliferous shale.
- Kd: Dakota Sandstone (Upper and Lower Cretaceous) – Cliff-forming layers of lenticular fluvial and littoral commonly crossbedded fine- to coarse-grained sandstone interbedded with slope-bench- or niche-forming mudstone and carbonaceous shale and coal.
- Jmw: Westwater Canyon Member of the Morrison Formation – Yellowish-gray to reddish-brown fine- to coarse-grained fluvial crossbedded sandstone; locally contains stringers & layers of pebbles & lenses of reddish-brown to purplish-gray claystone & siltstone.
- Jcs: Cow Springs Sandstone (Upper Jurassic) – Light-greenish-gray to gray and light-reddish-brown to pale-orange fine- to medium-grained crossbedded and flat-bedded sandstone and silty sandstone.

TITLE:	Geologic Map and Potential Background Reference Areas
PROJECT:	Removal Site Evaluation Eunice Becenti Mine Site
DATE: 9/21/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: WDC / REVIEWER: CBB
	FIGURE: D.1-1



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Subsurface Borehole Location for Background Reference
- Potential Background Reference Area
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 5,407 - 10,000
- 10,001 - 15,000
- 15,001 - 20,000
- 20,001 - 239,788

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Main display basemap image accessed from ESRI world imagery map service (http://www.esri.com/data/imagery) on 09/2018.

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

N W E S

0 150 300
Feet

TITLE:
Gamma Radiation Survey Results and Soil Sample Locations for Potential Background Reference Areas 1-3, 6, and 7

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE:	DOCUMENT NAME:	
9/21/2018	Removal Site Evaluation Report	
Stantec	AUTHOR: WDC	REVIEWER: CBB
	FIGURE: D.1-2	

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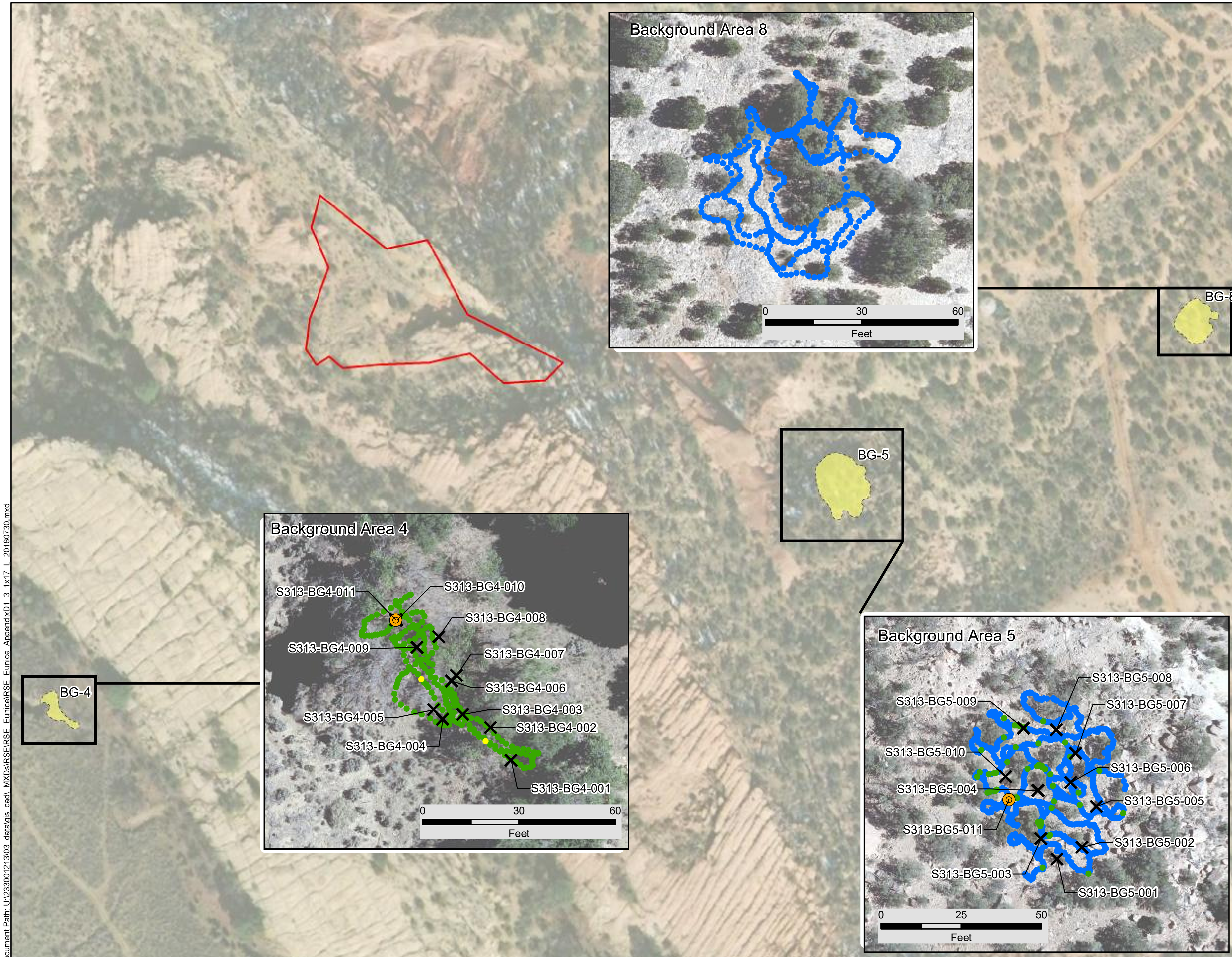

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- × Surface Sample Location
- Subsurface Borehole Location for Background Reference
- Potential Background Reference Area
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 4,848 - 10,000
- 10,001 - 15,000
- 15,001 - 15,777

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Main display basemap image accessed from ESRI world imagery map service (http://www.esri.com/data/imagery) on 09/2018.

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

N W E S

0 150 300
Feet

TITLE:
Gamma Radiation Survey Results and Soil Sample Locations for Potential Background Reference Areas 4, 5 and 8

PROJECT:
Removal Site Evaluation
Eunice Becenti Mine Site

DATE: 9/21/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: WDC	REVIEWER: CBB
	FIGURE: D.1-3	

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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 Eunice Becenti Site (Site). The evaluation includes comparing background reference area and Survey Area data distributions, and documents the decision process followed to select site-specific investigation levels (ILs). The ILs are used to confirm contaminants of potential concern (COPCs) listed in the *RSE Work Plan*, and to support identification of technologically enhanced naturally occurring radioactive materials (TENORM) at the Site.

2.0 EVALUATIONS

The evaluation process included compiling the results for gamma radiation surveys and soil sample analytical results from five background references areas and five Survey Areas. These areas are designated Background Reference Area 1 (BG-1) through Background Reference Area 5 (BG-5), and Survey Area A, Survey Area B, Survey Area C, Survey Area D, and Survey Area E. The Background Reference Areas BG-1 through BG-5 were selected to represent the Site's natural conditions as described in Appendix D.1. The gamma radiation survey data and soil sample analytical results for the background reference areas and Survey Areas were evaluated to determine the appropriate ILs for the Site as follows:

1. Identify and examine potential outlier values. Potential outlier values were identified statistically and, if justified upon further examination, removed from a dataset prior to further evaluation and calculations. No data were removed from the dataset for the calculations presented in this appendix.

2. Compare data populations between BG-1 and Survey Area A, BG-2 and Survey Area B, BG-3 and Survey Area C, BG-4 and Survey Area D, and BG-5 and Survey Area E (box plots, probability plots, hypothesis testing with Wilcoxon Mann-Whitney test). Soil sample and gamma radiation survey results were compared between background reference areas and Survey Areas qualitatively and quantitatively to evaluate similarity or difference in data distributions between the areas, and as a component of evaluating background area adequacy and representativeness.

3. Develop descriptive statistics. Descriptive statistics for gamma survey results and soil sample analytical results (e.g., number of observations, mean, maximum, median, etc.) were generated to facilitate qualitative comparisons of soil sample and gamma radiation survey results from one area to another.

4. Select ILs for the Site based on the results of the statistical evaluations.

3.0 RESULTS

The following sections present the evaluation of potential outlier values in the dataset, calculated descriptive statistics, and comparison of data populations between groups in support of determining ILs for use at the Site.

3.1 POTENTIAL OUTLIER VALUES

A potential outlier is a data point within a random sample of a population that is different enough from the majority of other values in the sample as to be considered potentially unrepresentative of the population, and therefore requires further inspection and evaluation. Unrepresentative values in a dataset have potential to yield distorted estimates of population parameters of interest (e.g., means, upper confidence limits, upper percentiles). Therefore, potential outliers in the Site data were evaluated further prior to performing data comparisons (Section 3.2) and developing the descriptive statistics (Section 3.3). In the context of this statistical evaluation, extreme values and statistical outliers are referred to as potential outliers.

A potential outlier value in a sample may be a true representative value in the test population (not a 'discrepant' value), simply representing a degree of inherent variation present in the population. Furthermore, a statistical determination of one or more potential outliers does not indicate that the measurements are actually discrepant from the rest of the data set. Therefore, general statistical guidance does not recommend that extreme values (potential outliers) be removed from an analysis solely on a statistical basis. Statistical outlier tests can provide supportive information, but a reasonable scientific rationale needs to be identified for the removal of any potential outlier values (e.g., sampling error, records error, or the potential outlier is determined to violate underlying assumptions of the sampling design, such as the targeted geology).

In the background reference areas, soil samples were collected randomly. Potential outliers in the background reference area datasets were examined using box plots, probability plots and statistical testing. Descriptive statistics were then calculated with and without the potential statistical outliers, as applicable. Finally, the potential outlier values were evaluated to determine if a reason could be found to remove the data points before calculating final statistics. The results of these evaluations are described in the following sections.

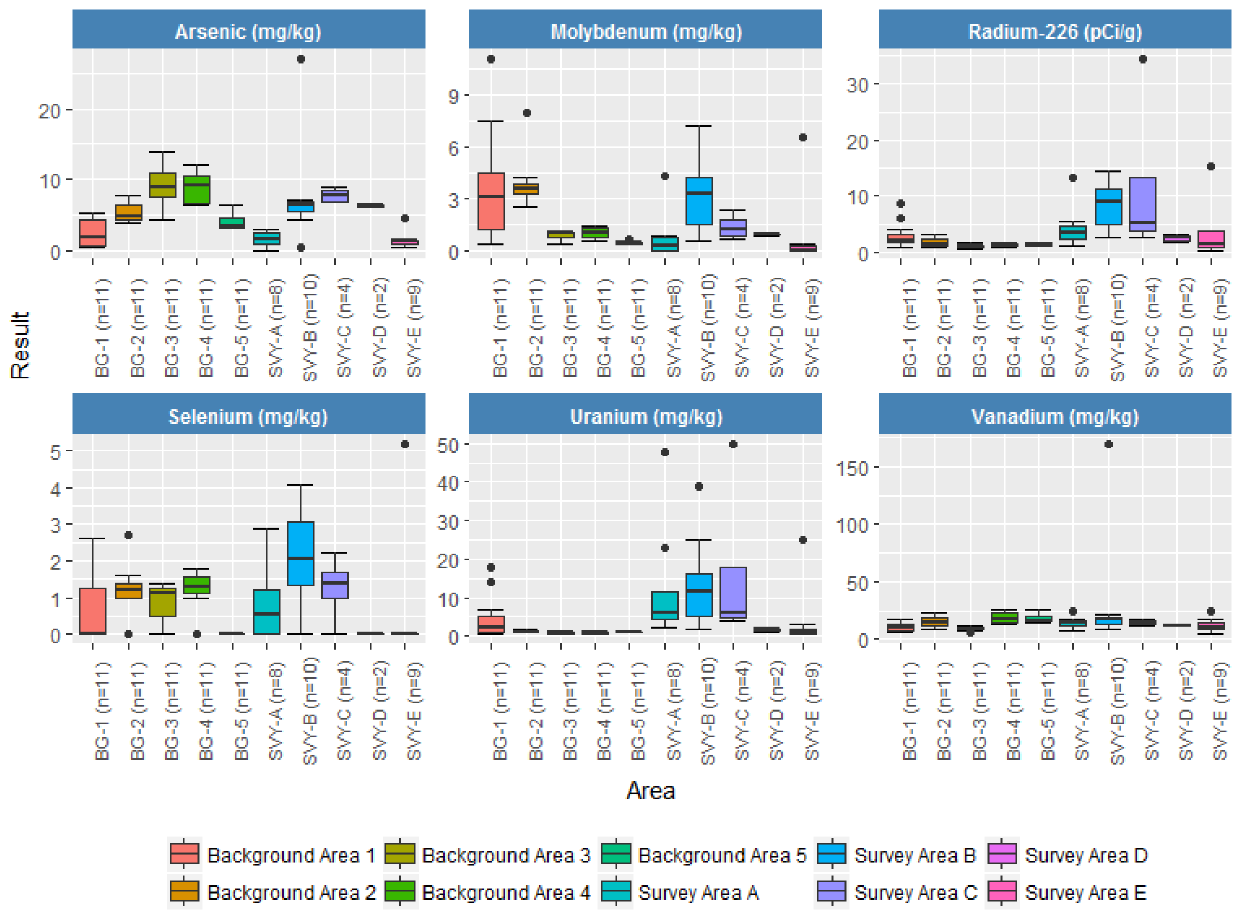
In the survey areas at Eunice Becenti, soil samples were collected using a judgmental sampling approach. Specifically, some sample locations were selected to characterize areas of higher gamma radiation and, as a result, potential outlier values are not unexpected in the Survey Area sample statistics. Potential outliers in this context mean values that are well-separated from the majority of the data set coming from the far/extreme tails of the data distribution (USEPA, 2016a). Descriptive statistics for the survey areas and some comparisons to background reference areas are still presented for qualitative assessment. However, potential outlier values in the survey areas are not evaluated further nor removed from the dataset.

3.1.1 Box Plots

Box plots depict descriptive statistics from a group of data (Figure 1A). The interquartile range is represented by the bounds of the box, the minimum and maximum values, not including potential outlier values (extreme values), are depicted by the whiskers (vertical lines), and any potential outliers are identified as singular dots. Potential outliers in this context are defined as values outside 1.5 times the interquartile range above or below the box.

3.1.1.1 Soil Sample Results Box Plots

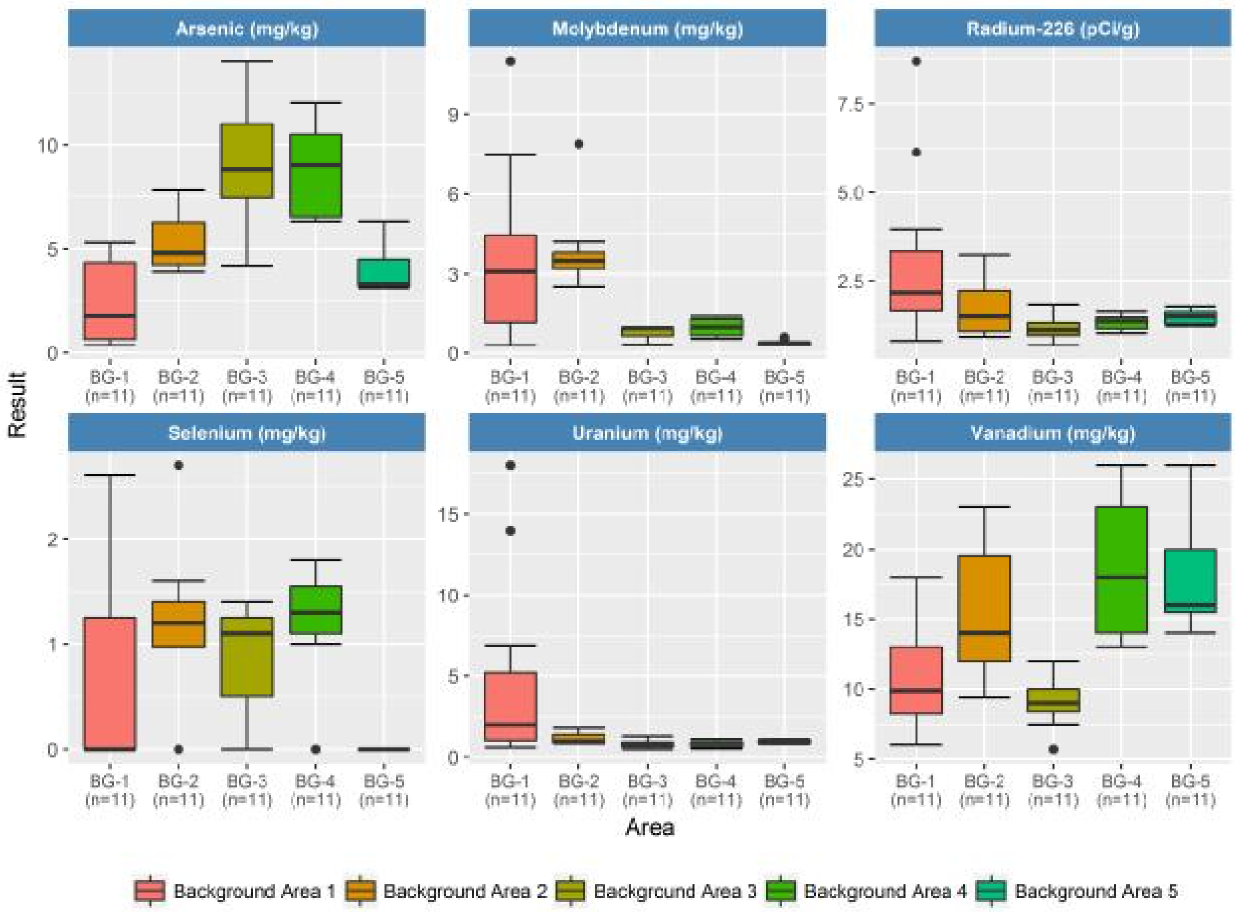
Figure 1A. Survey Areas A, B, C, D and E, and Background Reference Areas 1 (BG-1), 2 (BG-2), 3 (BG-3), 4 (BG-4) and 5 (BG-5) Soil Sample Box Plots



The soil sample box plots shown on Figure 1A depict differences in the data distributions for analytical constituent concentrations between background reference areas and Survey Areas. One or more potential outlier values are present in the datasets for each background reference area and all Survey Areas except Survey Area D.

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

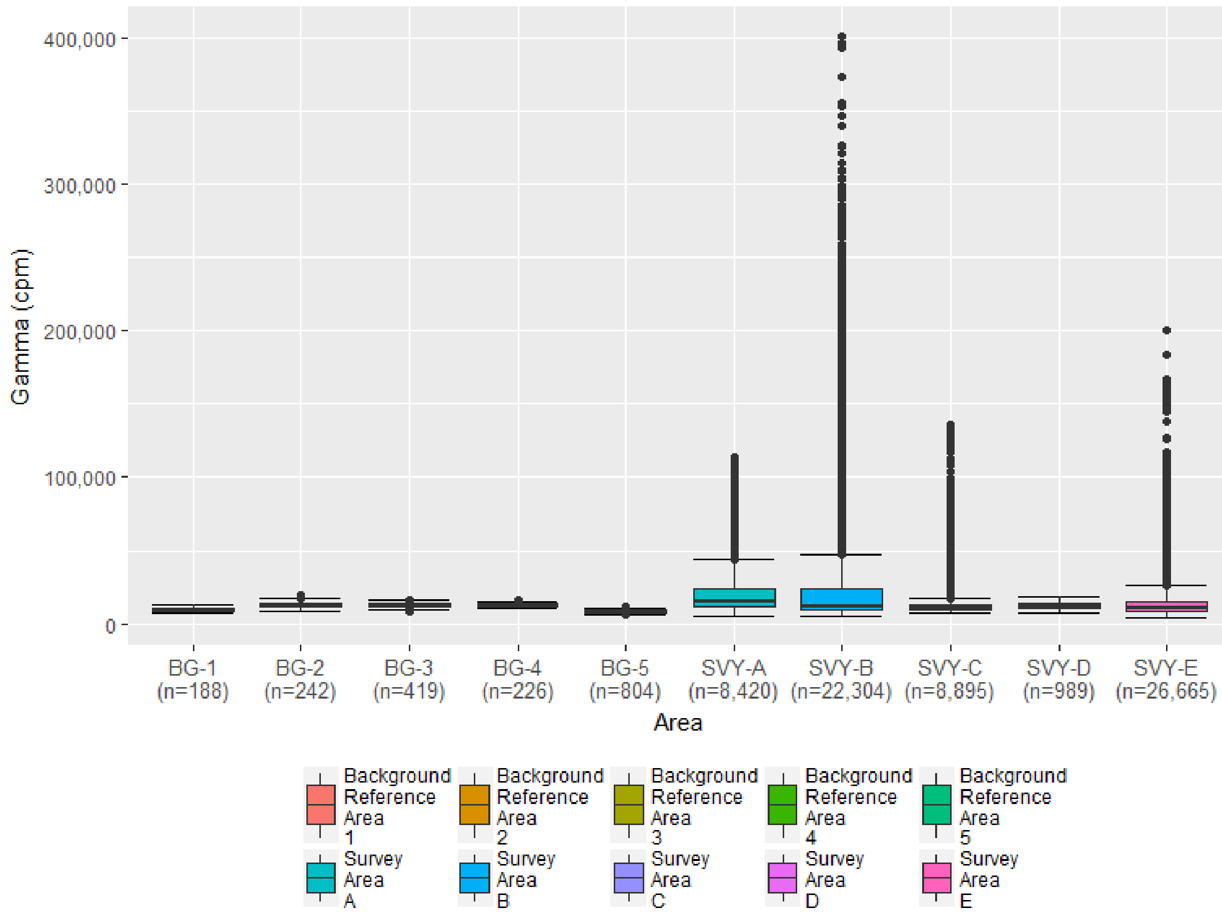
Figure 1B. Background Reference Areas 1 (BG-1), 2 (BG-2), 3 (BG-3), 4 (BG-4) and 5 (BG-5) Soil Sample Box Plots



As shown in Figure 1B, in the boxplots for BG-1, one high value for molybdenum (Mo) and two high values each for Ra-226 and uranium (U) are identified as potential outliers (i.e., outside 1.5 times the interquartile range); in the boxplots for BG-2, one high value for Mo, and one high and one low value for selenium (Se) are identified as potential outliers; in the boxplots for BG-3, one low value for vanadium (V) is identified as a potential outlier; in the boxplots for BG-4, one low value for Se is identified as a potential outlier; and in the boxplots for BG-5, two high values for Mo are identified as potential outliers.

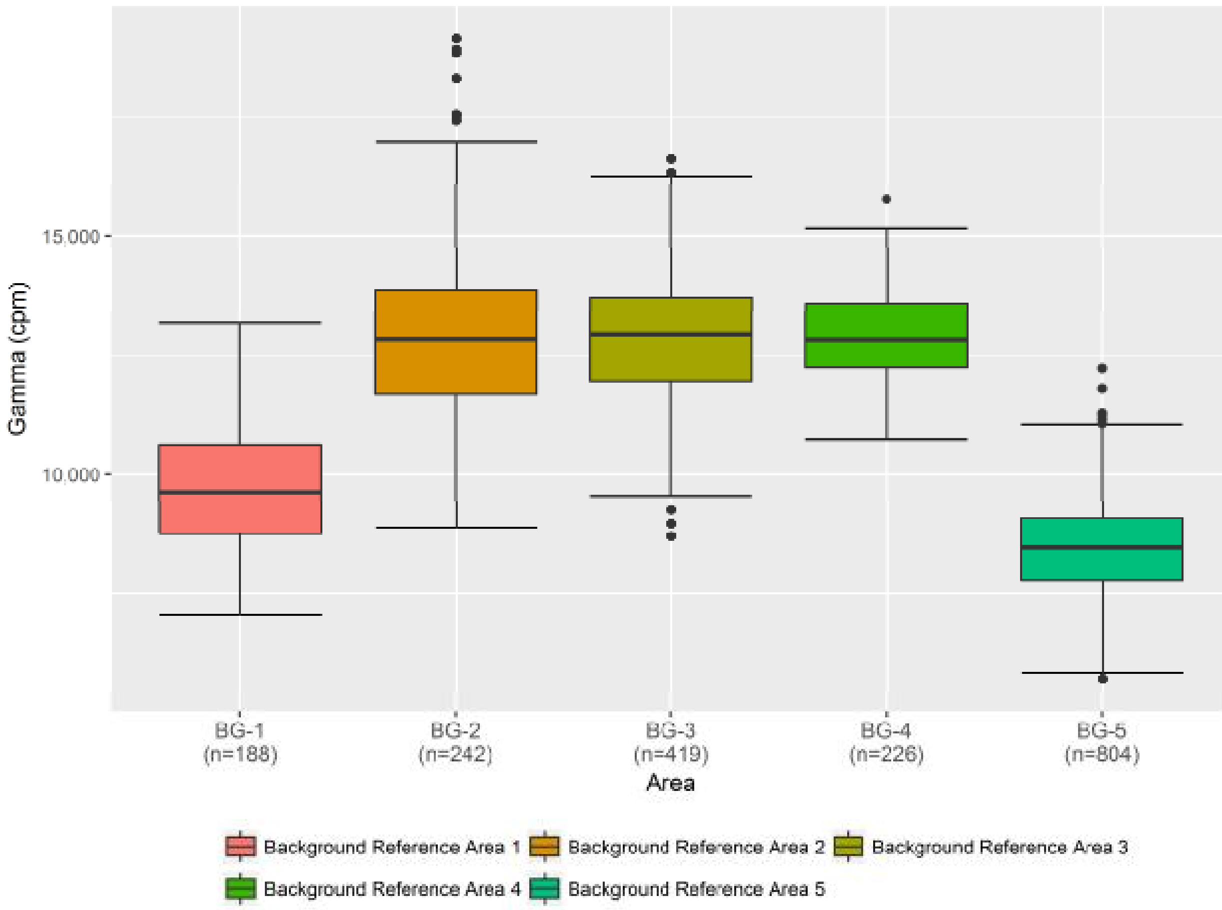
3.1.1.2 Gamma Radiation Results Box Plots

Figure 2A. Survey Area and Background Reference Area Gamma Radiation Box Plots



The gamma radiation survey results box plots shown on Figure 2A depict differences in the data distribution for gamma measurements between background reference areas and Survey Areas. The large number of potential outlier values in the Survey Area A, B, C, and E box plots indicate high skewness or possibly non-normally distributed data, instead of outlier values. Based on Site geology, the potential gamma radiation outlier values observed for the Survey Area data on Figure 2A represent localized areas of higher gamma radiation with respect to the other parts of each Survey Area, as would be expected in areas with varying levels of mineralization, naturally occurring radioactive material (NORM) and potential TENORM.

Figure 2B. Background Reference Area Gamma Radiation Box Plots



As shown in Figure 2B, there are nine, five, one, and eight potential high outlier values shown for gamma data in the BG-2, BG-3, BG-4, and BG-5 datasets, respectively. These potential outlier values do not represent skewed data as do the Survey Area results, and the gamma data are shown to be more normally distributed in the background reference areas than in the Survey Areas. The potential outlier values shown in background reference areas are most likely representative of natural variation of gamma in these areas. These observations are further evaluated with the use of probability plots in Section 3.1.2 and potential statistical outlier testing in Section 3.1.4.

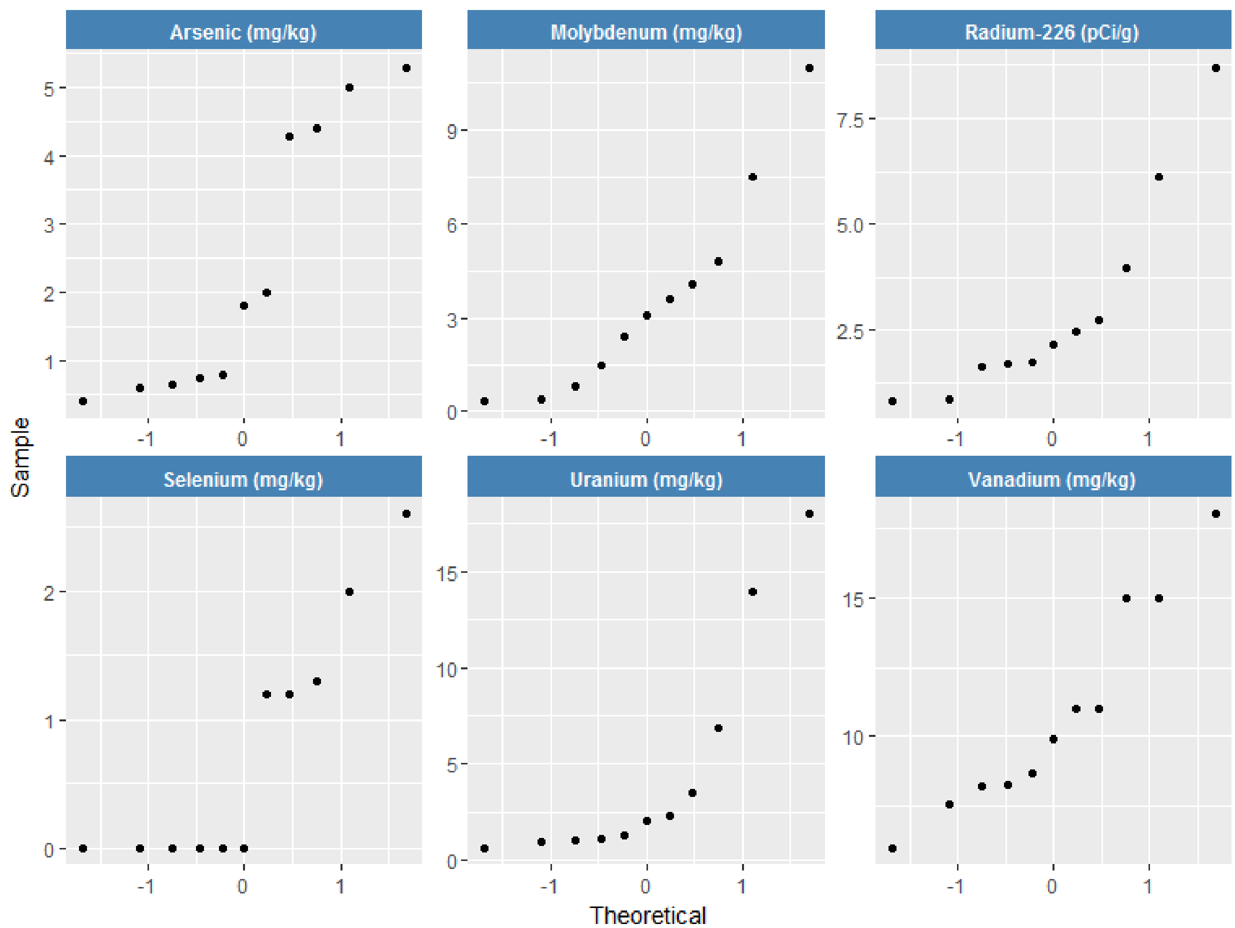
3.1.2 Probability Plots

The normal probability plot is a graphical technique for assessing whether or not a data set is approximately normally distributed and where there may be potential outlier values. The data are plotted against a theoretical normal distribution in such a way that the points, if normally distributed, should form an approximate straight line. Curved lines may indicate non-normally or log-normally distributed data, and "S"-shaped lines may indicate two distinct groups within the dataset.

3.1.2.1 Soil Sample Results Probability Plots

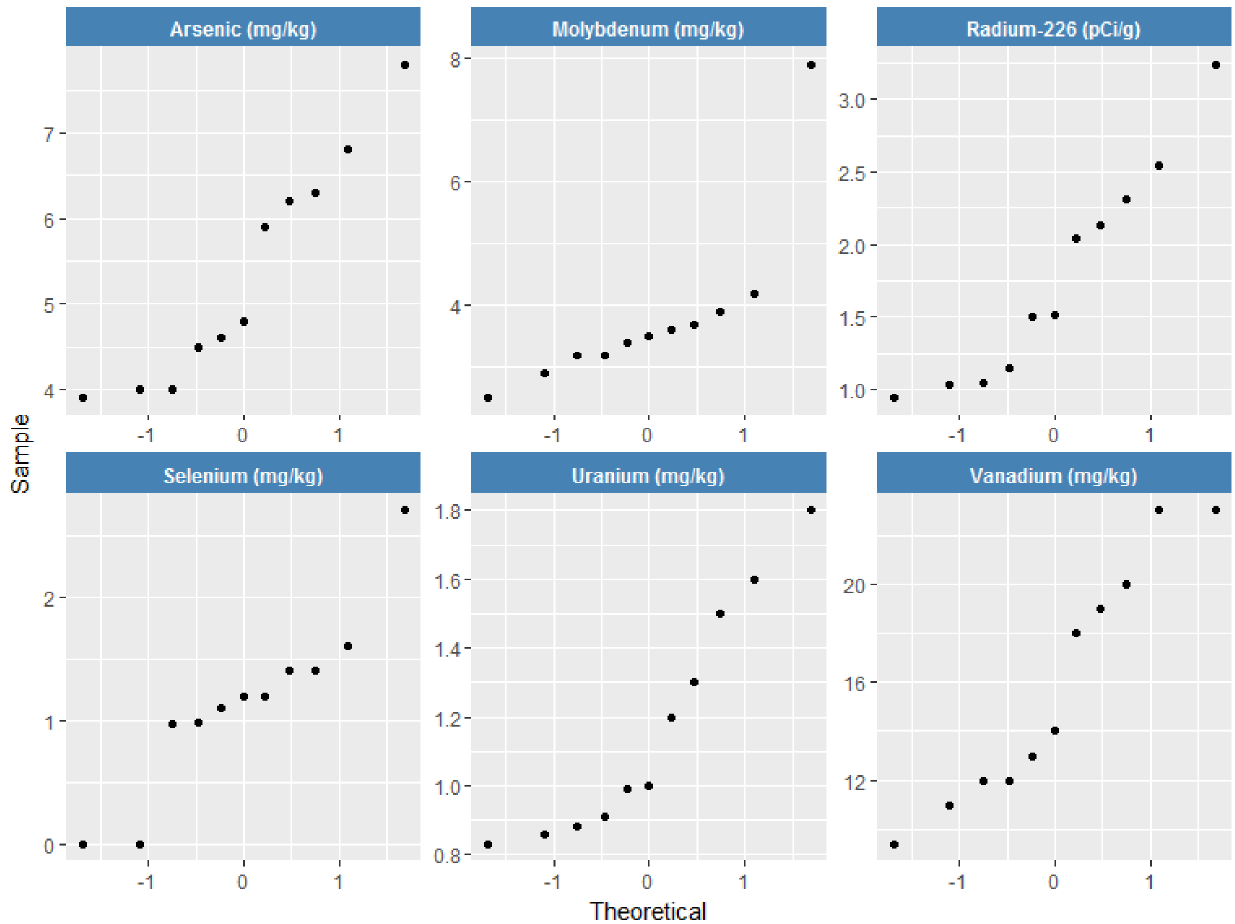
Figures 3 through 7 depict the probability plots for metals and Ra-226 results at background reference areas.

Figure 3. Background Reference Area 1 (BG-1) Soil Sample Probability Plots



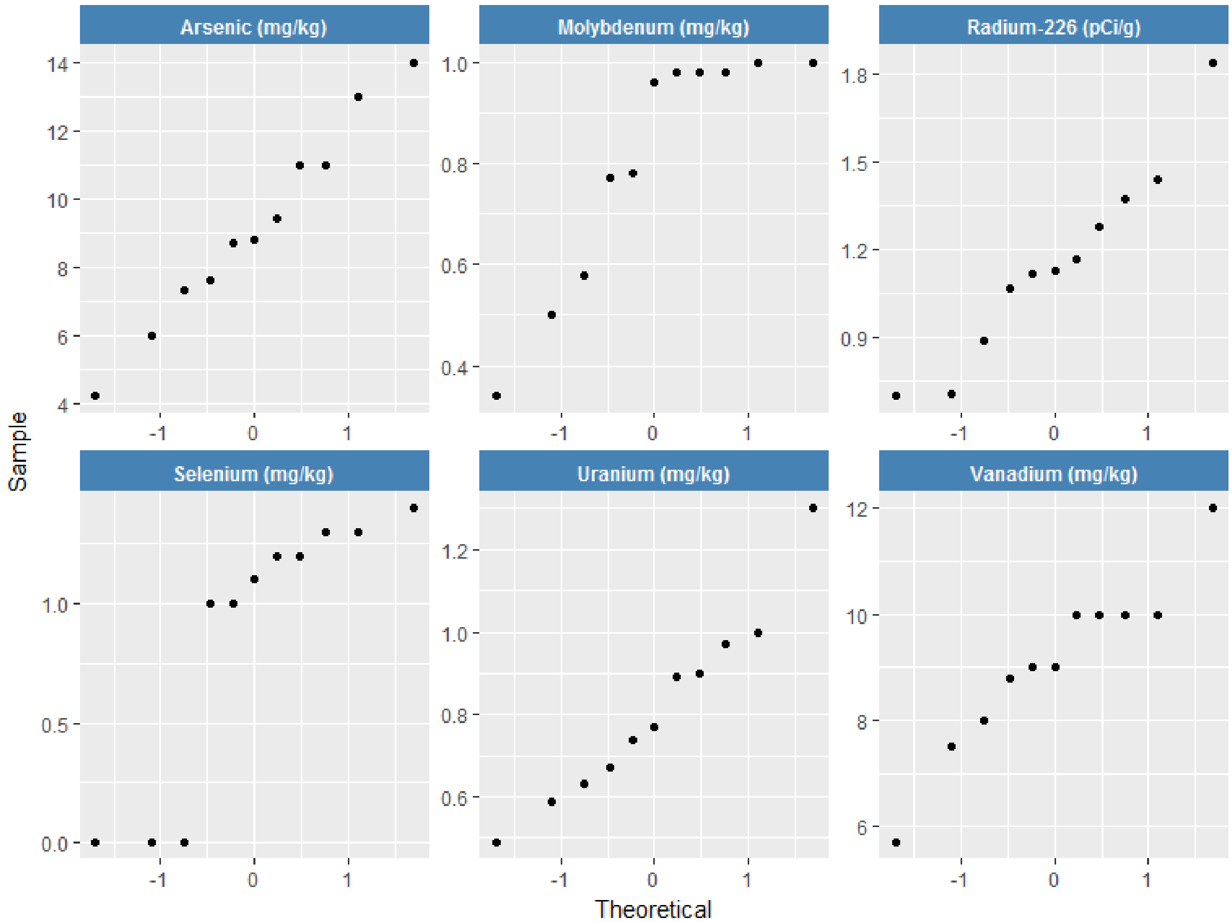
One high value for molybdenum and two high values for Ra-226 and uranium were identified as potential outliers (i.e., outside 1.5 times the interquartile range) in the BG-1 box plots in Figure 1B. When viewed in the probability plots in Figure 3, these values do appear to be substantially higher than the rest of their respective datasets. The values for vanadium are approximately linear in Figure 3, indicating a normally distributed dataset; the values of other metals and Ra-226 are not linear, indicating that these datasets are not normally distributed. The five potential outlier values are tested further for statistical significance in Section 3.1.3.

Figure 4. Background Reference Area 2 (BG-2) Soil Sample Probability Plots



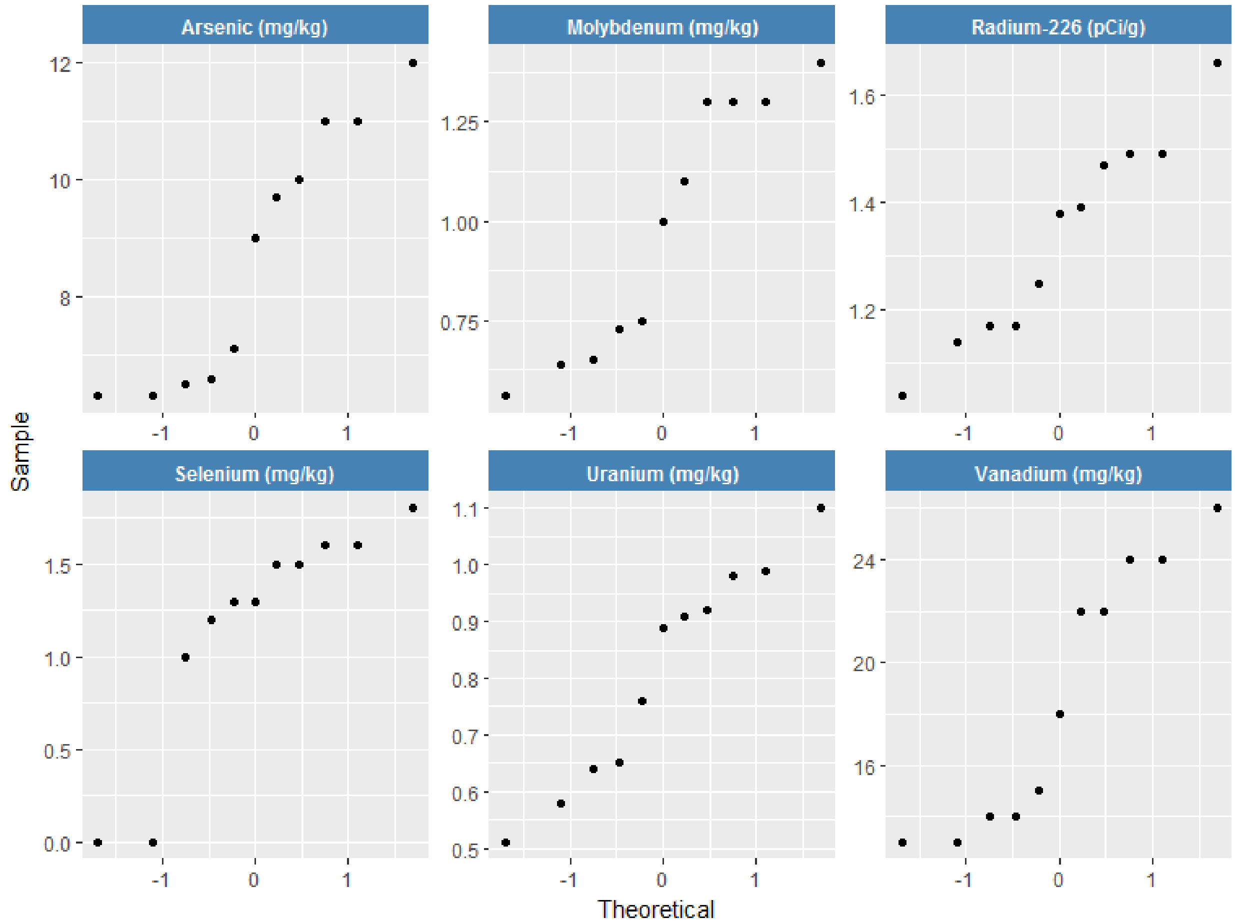
One high value for molybdenum and one high and one low value for selenium were identified as potential outliers (i.e., outside 1.5 times the interquartile range) in the BG-2 box plots in Figure 1B. When viewed in the probability plots in Figure 4, these high and low values do appear to be separate from, and out of line with the rest of their respective datasets, and it is apparent that the one low value for selenium represents two separate non-detect sample results plotted at zero. The four potential outlier values are further tested for statistical significance in Section 3.1.3.

Figure 5. Background Reference Area 3 (BG-3) Soil Sample Probability Plots



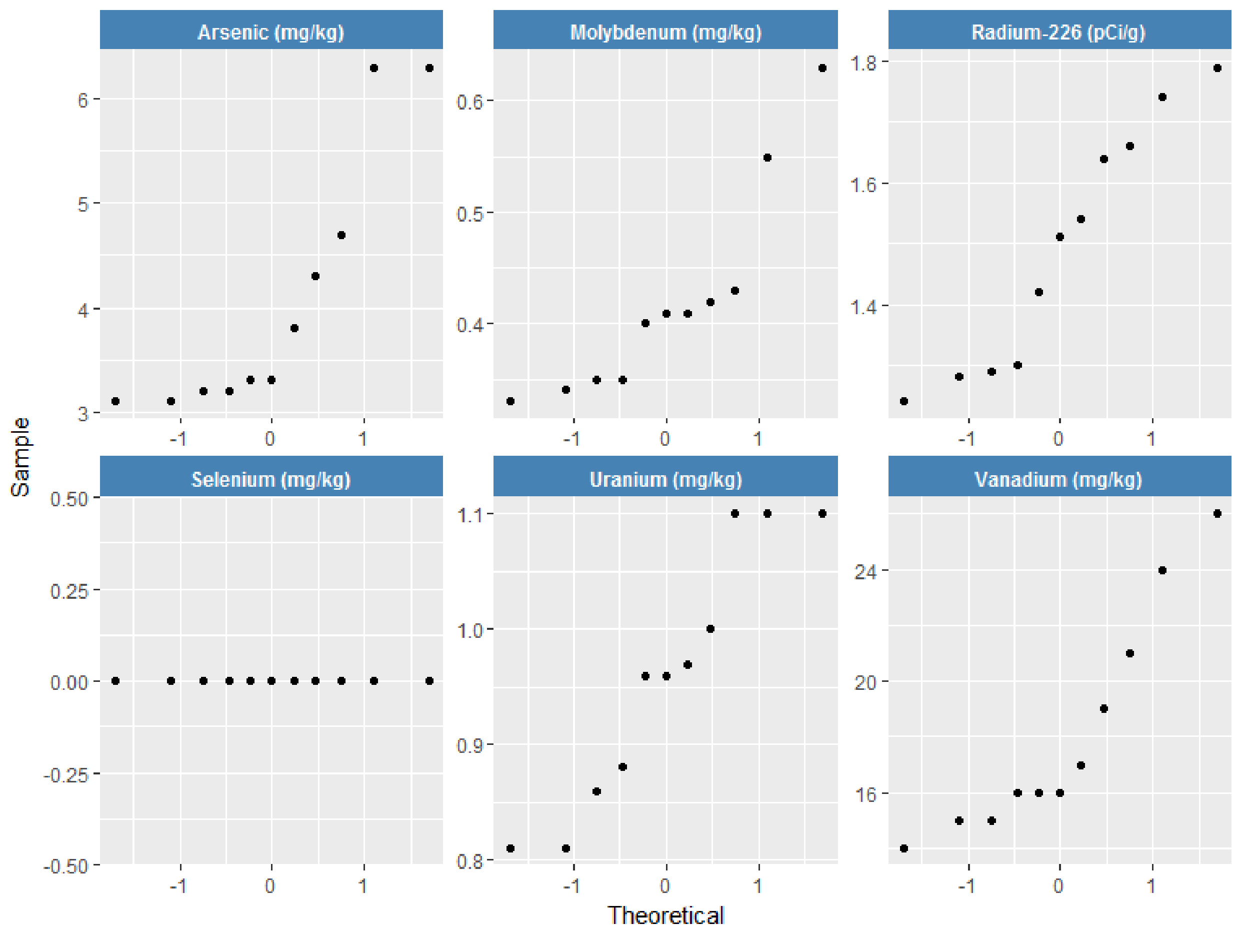
One low value for vanadium was identified as a potential outlier (i.e., outside 1.5 times the interquartile range) in the BG-3 box plots in Figure 1B. When viewed in the probability plot for vanadium in Figure 5, this value does appear to be substantially lower than the rest of the vanadium dataset, however, that lowest value for vanadium is generally in line with the rest of the values in the dataset. The low potential outlier value for vanadium is taken to be representative of the natural range of variability within the dataset. This potential outlier value is tested further for statistical significance in Section 3.1.3.

Figure 6. Background Reference Area 4 (BG-4) Soil Sample Probability Plots



One low value for selenium was identified as a potential outlier (i.e., outside 1.5 times the interquartile range) in the BG-4 box plot in Figure 1B. When viewed in the probability plots in Figure 6, it is apparent that the one low value for selenium represents two separate non-detect sample results plotted at zero. These two potential outlier values are further tested for statistical significance in Section 3.1.3. The detected values for selenium are approximately linear, indicating that selenium concentrations may be normally distributed in soil at BG-4. The values for Ra-226 and for metals other than selenium deviate from a linear pattern (varying degrees, though none extremely), indicating that these analytical constituents are likely normally distributed in soil at BG-4.

Figure 7. Background Reference Area 5 (BG-5) Soil Sample Probability Plots

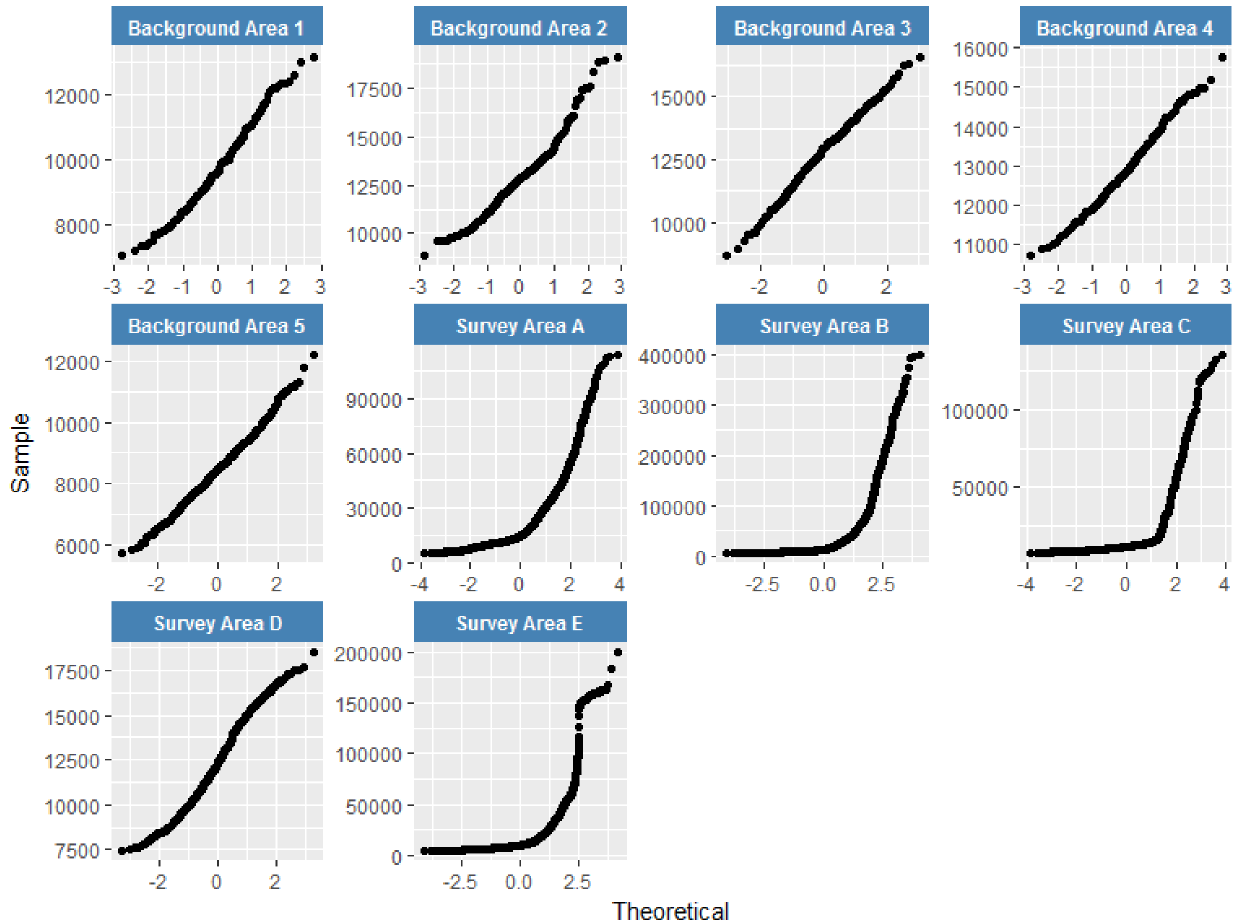


One high value for molybdenum was identified as a potential outlier (i.e., outside 1.5 times the interquartile range) in the BG-5 box plots in Figure 1B. When viewed in the probability plot for molybdenum in Figure 7, this high value does appear to be higher than, but potentially in line with, the rest of the molybdenum dataset. The values for molybdenum are non-linear, indicating that molybdenum is not normally distributed in BG-5 soil. Similarly, arsenic, Ra-226, uranium, and vanadium values are not linear and therefore likely do not follow normal distributions in BG-5 soil. Selenium was not detected in BG-5 soil. The potential outlier for molybdenum is further tested for statistical significance in Section 3.1.3.

3.1.2.2 Gamma Survey Results Probability Plots

Figure 8 depicts the probability plots for gamma radiation results at the background reference areas and the Survey Areas.

Figure 8. Survey Area and Background Reference Area Gamma Probability Plots



The gamma probability plots for the background reference areas in Figure 8 are approximately linear, although the highest values at BG-2 deviate from this pattern. These plots indicate that gamma data at background reference areas are approximately normally distributed. The nine highest values in BG-2, identified as potential outliers in the box plot in Figure 2B, appear to be higher than, and out of line with, the distribution of the rest of the dataset, indicating that they are potential outliers. Other high values at BG-4 and BG-5 also appear to be significantly elevated compared with the rest of the gamma datasets for these background reference areas, while the potential outliers at BG-3 that were identified in Figure 2B are not significantly elevated. The 23 potential outliers in BG-2 through BG-5 are further evaluated for statistical significance in Section 3.1.4. The highest values in the BG-1 dataset also appear elevated relative to the rest of the data, however, these values are not outside 1.5 times the interquartile range for the BG-1 dataset and were not identified as potential outliers.

The gamma probability plots in Figure 8 for Survey Areas A, B, C, D, and E are non-linear or S-shaped, indicating that gamma data from these Survey Areas are not normally distributed. The shape of the Survey Area A, B, C, and E gamma probability plots indicates that the data may represent two or three distinct sub-groups of gamma radiation values within these Survey Areas. The smoothness of the probability plots for the Survey Areas at Eunice Becenti suggests that high values shown in Figure 8 are not potential outliers, but rather are representative of the spatial variability of gamma radiation in these areas.

3.1.3 Potential Soil Sample Data Outliers

Nine high results and five low results are identified as potential outlier values in the box plots in Figure 1B and probability plots in Figures 3 through 7. These values are:

Background Reference Area 1 (BG-1)

- Molybdenum: 11.0 mg/kg
- Ra-226: 6.14 pCi/g, 8.70 pCi/g
- Uranium: 14 mg/kg, 18.0 mg/kg

Background Reference Area 2 (BG-2)

- Molybdenum: 7.90 mg/kg
- Selenium: ND, ND (low); 2.70 mg/kg (high)

Background Reference Area 3 (BG-3)

- Vanadium: 5.70 mg/kg (low)

Background Reference Area 4 (BG-4)

- Selenium: ND, ND (low)

Background Reference Area 5 (BG-5)

- Molybdenum: 0.550 mg/kg, 0.630 mg/kg

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 ten potential soil sample outlier values for the BG-1, BG-2, BG-3, BG-4, and BG-5 datasets. The non-detect results for selenium at BG-2 and BG-4 that were identified as potential outliers were evaluated at one half of the method reporting limit (MRL) because no method detection limit (MDL) was included in the laboratory report for these samples. The MRLs are 1.00 mg/kg for one of the non-detect results at BG-2 and both of the non-detect results at BG-4, and 0.98 mg/kg for the second non-detect at BG-2. The results of Dixon's Test are summarized in Table 1.

Table 1. Summary of Dixon's Test on Potential Outliers

Area	Constituent	Location ID	Method	Hypothesis	p_Value	Conclusion
Background Reference Area 1 (BG-1)	Mo	S313-BG1-008	Dixon test for potential outliers	high value 11.0 is a potential outlier	> 0.05	Hypothesis rejected
	Ra-226	S313-BG1-006	Dixon test for potential outliers	high value 6.14 is a potential outlier	> 0.05	Hypothesis rejected
	Ra-226	S313-BG1-008	Dixon test for potential outliers	high value 8.70 is a potential outlier	> 0.05	Hypothesis rejected
	U	S313-BG1-006	Dixon test for potential outliers	high value 14.0 is a potential outlier	< 0.05	Hypothesis accepted
	U	S313-BG1-008	Dixon test for potential outliers	high value 18.0 is a potential outlier	< 0.05	Hypothesis accepted
Background Reference Area 2 (BG-2)	Mo	S313-BG2-011	Dixon test for potential outliers	high value 7.90 is a potential outlier	< 0.05	Hypothesis accepted
	Se	S313-BG2-003	Dixon test for potential outliers	low value ND is a potential outlier	> 0.05	Hypothesis rejected
	Se	S313-BG2-007	Dixon test for potential outliers	low value ND is a potential outlier	> 0.05	Hypothesis rejected
	Se	S313-BG2-011	Dixon test for potential outliers	high value 2.70 is a potential outlier	> 0.05	Hypothesis rejected
Background Reference Area 3 (BG-3)	V	S313-BG3-006	Dixon test for potential outliers	low value 5.70 is a potential outlier	> 0.05	Hypothesis rejected
Background Reference Area 4 (BG-4)	Se	S313-BG4-004	Dixon test for potential outliers	low value ND is a potential outlier	> 0.05	Hypothesis rejected
	Se	S313-BG4-005	Dixon test for potential outliers	low value ND is a potential outlier	> 0.05	Hypothesis rejected
Background Reference Area 5 (BG-5)	Mo	S313-BG5-011	Dixon test for potential outliers	high value 0.550 is a potential outlier	< 0.05	Hypothesis accepted
	Mo	S313-BG5-008	Dixon test for potential outliers	high value 0.630 is a potential outlier	< 0.05	Hypothesis accepted

Mo = Molybdenum Ra-226 = Radium 226 Se = Selenium U = Uranium V = Vanadium

The test confirms that five of the 14 soil sample potential outliers tested are statistically significant (p value <0.05). These statistically significant potential outlier values were further investigated by reviewing sample forms, notes and laboratory reports. Field staff and field notes indicate nothing abnormal about the locations where these samples were collected, and the laboratory dataset shows no data quality flags were applied to the values that would call their accuracy in to question. Therefore, while these values: 1) are outside the interquartile range of their respective datasets (Figure 1B), 2) do not conform with their dataset distributions in the probability plots (Figures 3, 4, and 7), and 3) are deemed potential statistical outlier by Dixon's Test, they were not removed from the background reference area datasets because no scientific reason was found to justify removing the values, and they are considered representative of the natural variation in the background reference areas. However, Section 3.3 presents statistics calculated both with and without these potential outlier values.

3.1.4 Potential Gamma Data Outliers

There were 23 potential high gamma survey outlier values observed among the background reference area gamma datasets. These values were initially identified in the box plots in Figure 2B.

Potential high gamma survey outlier values were identified for the BG-2, BG-3, BG-4 and BG-5 gamma datasets shown in the boxplots in Figure 2B. When viewed in the probability plots in Figure 8, gamma probability plots for all the background reference areas are largely linear, indicating normal distribution. Because the number of values in the background reference area gamma datasets are each >30, Dixon's Test was not appropriate for potential outlier testing. Instead, because the values appear to be generally normally distributed, it was appropriate to identify potential outliers using Z, t and chi squared scoring methods at the 95% confidence level. These tests were performed in the 'Outliers' package in R (Lukasz Komsta, 2011), and the results are summarized in Table 2. The R programming language complements ProUCL in its ability to provide more meaningful and useful graphics and summarizes the results equivalent to ProUCL. Because ProUCL and R packages follow similar statistical procedures, the results are comparable. The interquartile range evaluation (values outside 1.5 times the interquartile range) results are also provided in Table 2.

The values in Table 2 are deemed potential statistical outliers and represent 23 out of 1,879 data points (1.2 percent). One possible reason for the small number/percentage of potential outliers in the gamma radiation dataset may be the presence of a localized source of radiation within a background reference area. This was evaluated by viewing the relative position of the potential outlier values relative to each other in BG-2, BG-3, BG-4 and BG-5.

In the BG-2 dataset, the potential outlier values are indeed collocated, grouped in the very western portion of BG-2. In the BG-3 dataset, the few low potential outliers are collocated, while the two high values are not collocated. The BG-4 dataset has just one potential outlier value. In the BG-5 dataset, the high potential outlier values are not collocated closely, but generally are in the northern portion of BG-5.

While these observations may explain the presence of these values in the dataset, nothing in field notes or the gamma data records indicates a physical reason for these values to be excluded from the dataset (e.g., data handling error, equipment malfunction), and there is no record of anomalous soil or other material in the background reference areas. Therefore, the values are considered representative of the natural variation present, and there is no scientific basis to remove them from the gamma dataset. However, descriptive statistics were calculated with and without these values for comparison (Section 3.3.2).

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

Area	Value (cpm)	Interquartile Range Result	Z Score Result	t Score Result	Chi Sq Score Result
Background Reference Area 2 (BG-2)	19,139	High	Potential Outlier	Potential Outlier	Potential Outlier
	18,916	High	Potential Outlier	Potential Outlier	Potential Outlier
	18,837	High	Potential Outlier	Potential Outlier	Potential Outlier
	18,305	High	Potential Outlier	Potential Outlier	Potential Outlier
	17,550	High	Potential Outlier	Potential Outlier	Potential Outlier
	17,535	High	Potential Outlier	Potential Outlier	Potential Outlier
	17,517	High	Potential Outlier	Potential Outlier	Potential Outlier
	17,415	High	Potential Outlier	Potential Outlier	Potential Outlier
	17,403	High	Potential Outlier	Potential Outlier	Potential Outlier
Background Reference Area 3 (BG-3)	16,609	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,318	High	Potential Outlier	Potential Outlier	Potential Outlier
	9,254	Low	Potential Outlier	Potential Outlier	Potential Outlier
	8,958	Low	Potential Outlier	Potential Outlier	Potential Outlier
	8,694	Low	Potential Outlier	Potential Outlier	Potential Outlier
Background Reference Area 4 (BG-4)	15,777	High	Potential Outlier	Potential Outlier	Potential Outlier
Background Reference Area 5 (BG-5)	12,233	High	Potential Outlier	Potential Outlier	Potential Outlier
	11,811	High	Potential Outlier	Potential Outlier	Potential Outlier
	11,287	High	Potential Outlier	Potential Outlier	Potential Outlier
	11,259	High	Potential Outlier	Potential Outlier	Potential Outlier
	11,167	High	Potential Outlier	Potential Outlier	Potential Outlier
	11,166	High	Potential Outlier	Potential Outlier	Potential Outlier
	11,070	High	Potential Outlier	Potential Outlier	Potential Outlier
	5,705	Low	Potential Outlier	Potential Outlier	Potential Outlier

cpm = Counts per minute

Potential outlier values in the gamma dataset for the Survey Areas appear in the Figure 2A boxplots. However, because of the non-linear shape and continuous distribution of gamma results shown in the probability plot in Figure 8, these values are thought to be representative of the heterogeneous nature of radioactive materials within the Survey Areas and are not outlier values. Indeed, Figure 4-1 of the RSE Report shows that while gamma results for the majority of each of the Survey Areas are within the range of background, localized areas of elevated gamma results associated with mineralized areas are also present.

3.2 COMPARE DATA POPULATIONS

Group comparison analyses provide insight into the relative concentrations of constituents between background reference areas and the Survey Areas. Observations made during these analyses may indicate the need for further evaluation or discussion regarding the influence of potential outlier values, and the use of background data. For instance, if two or more background areas were determined to be statistically similar to each other, these data could be combined to calculate more robust statistics (not a factor in this evaluation, as one background area each was selected to represent the five Survey Areas). Alternatively, testing of this kind may reveal background concentrations statistically higher than corresponding Survey Area concentrations, requiring additional interpretation or modifications in the use of background area datasets. Finally, results of these evaluations are a component of determining background reference area representativeness, though statistical comparisons are not the only factors to be considered in judging representativeness. Factors such as geologic materials, topographic gradient, distance from the site being represented, wind direction and non-impacted condition are all important to the selection of background reference areas.

Group comparisons, therefore, are considered instructive as a component of the overall evaluation of soil sample and gamma radiation survey results collected from the background reference areas and the Survey Areas. Relative data distributions were investigated by evaluating the box plots and probability plots in Figures 1A through 8, and by hypothesis testing with the non-parametric Mann-Whitney test, as applicable.

3.2.1 Evaluation of Box Plots

3.2.1.1 Soil Sample Box Plots

When interpreting the soil sample boxplots in Figures 1A and 1B, it is important to note that samples at background reference areas were collected randomly, while samples in the Survey Areas were collected judgmentally from areas of suspected contamination. Analytic constituent results from background reference areas tend to be lower than, or similar to, analytical results from their respective Survey Areas. Analytical constituent-specific observations from the boxplots in Figures 1A and 1B indicate:

- **Arsenic.** Arsenic results appear highest at BG-3 and BG-4, and their corresponding Survey Areas C and D. Arsenic results from the five background reference areas are similar to those measured in their corresponding Survey Areas.
- **Molybdenum.** Molybdenum results appear highest at BG-1 and BG-2, and at Survey Area B. Molybdenum results from BG-3, BG-4 and BG-5 are similar to their corresponding Survey Areas C, D and E.

- **Ra-226**. Ra-226 results among the background reference areas appear highest at BG-1 and BG-2. Ra-226 results in Survey Areas A, B and C are higher than those measured in the background reference areas.
- **Selenium**. Selenium results are similar among BG-1, BG-2, BG-3 and BG-4. Selenium was not detected in BG-5, or in Survey Areas D or E. For those areas where selenium results exist, the background reference area concentrations are representative of the Survey Areas.
- **Uranium**. Uranium results appear similar between BG-2, BG-3, BG-4 and BG-5, and elevated at BG-1. Uranium results in Survey Areas A, B and C are higher than in the background reference areas.
- **Vanadium**. Vanadium results appear similar between all background reference areas and Survey Areas.

3.2.1.2 Gamma Radiation Box Plots and Probability Plots

The box plot comparison in Figures 2A and 2B suggests that mean, median and interquartile range gamma values are similar between BG-2, BG-3 and BG-4, while those in BG-1 and BG-5 are lower. Gamma values in the Survey Areas appear higher, and more skewed, than the background reference areas, with this being most pronounced in the Survey Area A and Survey Area B datasets. These observations of relative similarities and differences between the gamma datasets are further evaluated in Section 3.2.2 using the non-parametric Mann-Whitney test.

3.2.2 Mann-Whitney Testing

The Mann-Whitney test (Bain and Engelhardt, 1992) is a nonparametric test used 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 another population. This test was selected over other comparative tests such as the Student's t test and analysis of variance (ANOVA) because it remains robust in the absence of required assumptions that these two tests require such as normally distributed data and equality of variances.

Soil samples at background reference areas were collected randomly, while soil samples in the Survey Areas were collected judgmentally (see Section 3.1). Mann-Whitney testing is not appropriate for comparative analysis if one or both groups contain data collected using a judgmental approach. Therefore, the Mann-Whitney test was not performed for soil sample data between background reference areas and Survey Areas. Gamma radiation data, however, do represent non-judgmental sampling, and so the Mann-Whitney test was appropriate for comparison between background reference areas and Survey Areas (Table 3). Therefore, the test was performed 2-sided on the background reference area and Survey Area gamma radiation data. The two-sided test accounts for results from one group being lower or higher than any other group (i.e., the hypothesis tested whether the two groups differ, independent of which group is higher). A test result p-value of 0.05 or smaller indicates that a significant difference exists between any two groups that are compared. Results of Mann-Whitney testing are presented in Table 3.

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

Comparison	p_Value	Description
Background Reference Area 1 (BG-1) vs Survey Area A	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Survey Area B	0.591	No Significant Difference
Background Reference Area 2 (BG-2) vs Background Reference Area 2 (BG-2) Potential Outliers Excluded	0.483	No Significant Difference
Background Reference Area 2 (BG-2) Potential Outliers Excluded vs Survey Area B	0.828	No Significant Difference
Background Reference Area 3 (BG-3) vs Survey Area C	<0.05	Significant Difference
Background Reference Area 3 (BG-3) vs Background Reference Area 3 (BG-3) Potential Outliers Excluded	0.953	No Significant Difference
Background Reference Area 3 (BG-3) Potential Outliers Excluded vs Survey Area C	<0.05	Significant Difference
Background Reference Area 4 (BG-4) vs Survey Area D	<0.05	Significant Difference
Background Reference Area 4 (BG-4) vs Background Reference Area 4 (BG-4) Potential Outliers Excluded	0.936	No Significant Difference
Background Reference Area 4 (BG-4) Potential Outliers Excluded vs Survey Area D	<0.05	Significant Difference
Background Reference Area 5 (BG-5) vs Survey Area E	<0.05	Significant Difference
Background Reference Area 5 (BG-5) vs Background Reference Area 5 (BG-5) Potential Outliers Excluded	0.796	No Significant Difference
Background Reference Area 5 (BG-5) Potential Outliers Excluded vs Survey Area E	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 2 (BG-2)	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 3 (BG-3)	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 4 (BG-4)	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 5 (BG-5)	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Background Reference Area 3 (BG-3)	0.836	No Significant Difference
Background Reference Area 2 (BG-2) vs Background Reference Area 4 (BG-4)	0.422	No Significant Difference
Background Reference Area 2 (BG-2) vs Background Reference Area 5 (BG-5)	<0.05	Significant Difference
Background Reference Area 3 (BG-3) vs Background Reference Area 4 (BG-4)	0.521	No Significant Difference
Background Reference Area 3 (BG-3) vs Background Reference Area 5 (BG-5)	<0.05	Significant Difference
Background Reference Area 4 (BG-4) vs Background Reference Area 5 (BG-5)	<0.05	Significant Difference
Survey Area A vs Survey Area B	<0.05	Significant Difference
Survey Area A vs Survey Area C	<0.05	Significant Difference
Survey Area A vs Survey Area D	<0.05	Significant Difference
Survey Area A vs Survey Area E	<0.05	Significant Difference
Survey Area B vs Survey Area C	<0.05	Significant Difference
Survey Area B vs Survey Area D	<0.05	Significant Difference
Survey Area B vs Survey Area E	<0.05	Significant Difference
Survey Area C vs Survey Area D	<0.05	Significant Difference
Survey Area C vs Survey Area E	<0.05	Significant Difference
Survey Area D vs Survey Area E	<0.05	Significant Difference

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

- Gamma results are statistically elevated in Survey Area A with respect to BG-1.
- Gamma results are not statistically different between BG-2 and Survey Area B. While there are much higher values in the Survey Area B dataset compared to BG-2, the Mann-Whitney test compares group means and concludes that mean gamma results are not statistically different between BG-2 and Survey Area B. The inclusion or removal of potential outlier values from BG-2 has no effect on this result.
- Gamma results are statistically elevated in Survey Area C with respect to BG-3. The inclusion or removal of potential outlier values from BG-3 has no effect on this result.
- Gamma results are statistically elevated in Survey Area D with respect to BG-4. The inclusion or removal of potential outlier values from BG-4 has no effect on this result.
- Gamma results are statistically elevated in Survey Area E with respect to BG-5. The inclusion or removal of potential outlier values from BG-5 has no effect on this result.
- Gamma datasets from Background Reference Areas 2, 3 and 4 do not differ significantly from each other.
- Gamma datasets from all five Survey Areas differ significantly from each other.
- The observation that gamma results at all five Survey Areas are statistically elevated relative to their respective background reference areas is likely attributable to the fact that background reference areas may not fully represent the degree of natural mineralization present at Survey Areas (see RSE Report Section 3.2.2.2). This latter point does not prohibit use of the gamma ILs calculated from these background reference areas, but this observation should be considered, as Site conditions are further evaluated for remediation.

3.3 DESCRIPTIVE STATISTICS

Descriptive statistics, including the upper confidence limit (UCL) of the mean and the 95-95 upper tolerance limit (UTL), were calculated from gamma survey data and soil sample results. Descriptive statistics are important for any data evaluation to present the basic statistics of a data set with regards to its limits (maximum and minimum), central tendencies (mean and median) as well as data dispersion (coefficient of variance). The ILs for the Site also are taken from the descriptive statistics, namely the 95-95 UTL. The 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 Ra-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 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

The relative levels of arsenic, molybdenum, selenium, uranium, vanadium, and Ra-226 results measured between the background reference areas and Survey Areas are shown in the box plots in Figures 1A and 1B and are described in Section 3.2.1.1. An important consideration when comparing concentrations of metals and Ra-226 between background reference areas and the Survey Areas is that the background reference areas were selected to be representative of the geology present in the region around the Site, whereas the Site was selected as a mine claim because it is in an area of mineralized bedrock likely to have localized, naturally elevated uranium concentrations (see RSE Report Section 3.2.2.2). In addition, soil sampling for metals and Ra-226 in the background reference areas was conducted in a random manner, whereas soil sampling for metals and Ra-226 in the Survey Area was judgmental. As a result, it's not surprising that metals and Ra-226 concentrations in the Survey Areas appear to be elevated relative to the background reference areas. It should be noted, however, that concentrations of several of the metals measured in the Survey Areas are within the range of metals concentrations typically observed in Western U.S. soils (United States Geological Survey [USGS], 1984):

- Arsenic (mean = 5.5 mg/kg; range <0.10 – 97 mg/kg)
- Molybdenum (mean = 0.85 mg/kg; range <3 – 7 mg/kg)
- Selenium (mean = 0.23 mg/kg; range <0.1 – 4.3 mg/kg)
- Uranium (mean = 2.5 mg/kg; range 0.68 – 7.9 mg/kg)
- Vanadium (mean = 70 mg/kg; range 7 – 500 mg/kg)

As shown in Table 4, maximum detected concentrations of arsenic, molybdenum, selenium and vanadium in the Survey Areas are within typical ranges reported for Western U.S soils, and may not be related to the uranium mineralization. Exceptions to the above are Ra-226 and uranium; elevated concentrations of these constituents in the Survey Areas are present in soils associated with the mineralized and/or disturbed portions of the Site (see RSE Report Section 4.6).

Table 4 presents the descriptive statistics output from the ProUCL software for the soil sample results.

Table 4. Summary of Soil Sampling Results

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Reference Area 1 (BG-1) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	--	55%	--	--	--
	Minimum[1]	0.390	0.320	--	0.600	6.00	0.820
	Minimum Detect[2]	--	--	1.20	--	--	--
	Mean[1]	2.36	3.59	--	4.70	10.8	3.00
	Mean Detects[2]	--	--	1.66	--	--	--
	Median[1]	1.80	3.10	--	2.00	9.90	2.17
	Median Detects[2]	--	--	1.30	--	--	--
	Maximum[1]	5.30	11.0	--	18.0	18.0	8.70
	Maximum Detect[2]	--	--	2.60	--	--	--
	Distribution	Normal	Normal	Normal	Gamma	Normal	Gamma
	Coefficient of Variation[1]	0.839	0.908	--	1.26	0.345	0.807
	CV Detects[2]	--	--	0.375	--	--	--
	UCL Type	95% Student's-t UCL	95% Student's-t UCL	95% KM (t) UCL	95% Adjusted Gamma UCL	95% Student's-t UCL	95% Adjusted Gamma UCL
	UCL Result	3.44	5.38	1.33	10.6	12.8	5.02
	UTL Type	UTL Normal	UTL Normal	UTL KM Normal	UTL Gamma WH	UTL Normal	UTL Gamma WH
	UTL Result	7.92	12.8	3.26	31.4	21.3	12.7
Background Reference Area 1 (BG-1) Excluding Potential Outliers[3]	Total Number of Observations	--	--	--	9	--	--
	Minimum[1]	--	--	--	0.600	--	--
	Mean[1]	--	--	--	2.18	--	--
	Median[1]	--	--	--	1.30	--	--
	Maximum[1]	--	--	--	6.90	--	--
	Distribution	--	--	--	Normal	--	--
	Coefficient of Variation[1]	--	--	--	0.908	--	--
	UCL Type	--	--	--	95% Student's-t UCL	--	--
	UCL Result	--	--	--	3.41	--	--
	UTL Type	--	--	--	UTL Normal	--	--
	UTL Result	--	--	--	8.19	--	--
Background Reference Area 2 (BG-2) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	--	18%	--	--	--
	Minimum[1]	3.90	2.50	--	0.830	9.40	0.940
	Minimum Detect[2]	--	--	0.970	--	--	--
	Mean[1]	5.35	3.82	--	1.17	15.9	1.77
	Mean Detects[2]	--	--	1.39	--	--	--
	Median[1]	4.80	3.50	--	1.00	14.0	1.51
	Median Detects[2]	--	--	1.20	--	--	--
	Maximum[1]	7.80	7.90	--	1.80	23.0	3.24
	Maximum Detect[2]	--	--	2.70	--	--	--
	Distribution	Normal	Gamma	Normal	Normal	Normal	Normal
	Coefficient of Variation[1]	0.247	0.375	--	0.288	0.309	0.421
	CV Detects[2]	--	--	0.381	--	--	--
	UCL Type	95% Student's-t UCL	95% Adjusted Gamma UCL	95% KM (t) UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	6.07	4.73	1.60	1.35	18.5	2.17
	UTL Type	UTL Normal	UTL Gamma WH	UTL KM Normal	UTL Normal	UTL Normal	UTL Normal
	UTL Result	9.06	8.08	2.67	2.12	29.7	3.86

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Reference Area 2 (BG-2) Excluding Potential Outliers[3]	Total Number of Observations	--	10	--	--	--	--
	Minimum[1]	--	2.50	--	--	--	--
	Mean[1]	--	3.41	--	--	--	--
	Median[1]	--	3.45	--	--	--	--
	Maximum[1]	--	4.20	--	--	--	--
	Distribution	--	Normal	--	--	--	--
	Coefficient of Variation[1]	--	0.144	--	--	--	--
	UCL Type	--	95% Student's-t UCL	--	--	--	--
	UCL Result	--	3.70	--	--	--	--
	UTL Type	--	UTL Normal	--	--	--	--
	UTL Result	--	4.84	--	--	--	--
Background Reference Area 3 (BG-3) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	--	27%	--	--	--
	Minimum[1]	4.20	0.340	--	0.490	5.70	0.700
	Minimum Detect[2]	--	--	1.00	--	--	--
	Mean[1]	9.18	0.806	--	0.814	9.09	1.16
	Mean Detects[2]	--	--	1.19	--	--	--
	Median[1]	8.80	0.960	--	0.770	9.00	1.13
	Median Detects[2]	--	--	1.20	--	--	--
	Maximum[1]	14.0	1.00	--	1.30	12.0	1.84
	Maximum Detect[2]	--	--	1.40	--	--	--
	Distribution	Normal	Normal	Normal	Normal	Normal	Normal
	Coefficient of Variation[1]	0.319	0.292	--	0.282	0.181	0.286
	CV Detects[2]	--	--	0.123	--	--	--
	UCL Type	95% Student's-t UCL	95% Student's-t UCL	95% KM (t) UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	10.8	0.935	1.22	0.939	9.99	1.34
	UTL Type	UTL Normal	UTL Normal	UTL KM Normal	UTL Normal	UTL Normal	UTL Normal
	UTL Result	17.4	1.47	1.55	1.46	13.7	2.09
Background Reference Area 4 (BG-4) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	--	18%	--	--	--
	Minimum[1]	6.30	0.560	--	0.510	13.0	1.04
	Minimum Detect[2]	--	--	1.00	--	--	--
	Mean[1]	8.68	0.975	--	0.812	18.6	1.33
	Mean Detects[2]	--	--	1.42	--	--	--
	Median[1]	9.00	1.00	--	0.890	18.0	1.38
	Median Detects[2]	--	--	1.50	--	--	--
	Maximum[1]	12.0	1.40	--	1.10	26.0	1.66
	Maximum Detect[2]	--	--	1.80	--	--	--
	Distribution	Normal	Normal	Normal	Normal	Normal	Normal
	Coefficient of Variation[1]	0.251	0.327	--	0.238	0.271	0.143
	CV Detects[2]	--	--	0.171	--	--	--
	UCL Type	95% Student's-t UCL	95% Student's-t UCL	95% KM (t) UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	9.87	1.15	1.50	0.917	21.4	1.44
	UTL Type	UTL Normal	UTL Normal	UTL KM Normal	UTL Normal	UTL Normal	UTL Normal
	UTL Result	14.8	1.87	2.09	1.36	32.8	1.87
	UTL Type						
	UTL Result						

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Reference Area 5 (BG-5) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	--	100%	--	--	--
	Minimum[1]	3.10	0.330	--	0.810	14.0	1.24
	Minimum Detect[2]	--	--	--	--	--	--
	Mean[1]	4.06	0.420	--	0.959	18.1	1.49
	Mean Detects[2]	--	--	--	--	--	--
	Median[1]	3.30	0.410	--	0.960	16.0	1.51
	Maximum[1]	6.30	0.630	--	1.10	26.0	1.79
	Maximum Detect[2]	--	--	--	--	--	--
	Distribution	Normal	Gamma	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation[1]	0.303	0.221	--	0.115	0.219	0.133
	UCL Type	95% Student's-t UCL	95% Adjusted Gamma UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	4.73	0.482	Not Calculated	1.02	20.3	1.60
	UTL Type	UTL Normal	UTL Gamma WH	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	7.51	0.707	Not Calculated	1.27	29.2	2.05
Background Reference Area 5 (BG-5) Excluding Potential Outliers	Total Number of Observations	--	9	--	--	--	--
	Minimum[1]	--	0.330	--	--	--	--
	Mean[1]	--	0.382	--	--	--	--
	Median[1]	--	0.400	--	--	--	--
	Maximum[1]	--	0.430	--	--	--	--
	Distribution	--	Normal	--	--	--	--
	Coefficient of Variation[1]	--	0.102	--	--	--	--
	UCL Type	--	95% Student's-t UCL	--	--	--	--
	UCL Result	--	0.406	--	--	--	--
	UTL Type	--	UTL Normal	--	--	--	--
	UTL Result	--	0.500	--	--	--	--
Survey Area A	Total Number of Observations	8	8	8	8	8	8
	Percent Non-Detects	13%	50%	50%	--	--	--
	Minimum[1]	--	--	--	2.20	7.20	1.17
	Minimum Detect[2]	0.250	0.560	1.10	--	--	--
	Mean[1]	--	--	--	12.6	14.7	4.49
	Mean Detects[2]	1.72	1.59	1.60	--	--	--
	Median[1]	--	--	--	6.15	14.0	3.53
	Median Detects[2]	1.60	0.755	1.20	--	--	--
	Maximum[1]	--	--	--	48.0	25.0	13.4
	Maximum Detect[2]	2.90	4.30	2.90	--	--	--
	Distribution	Normal	Lognormal	Normal	Gamma	Normal	Normal
	Coefficient of Variation[1]	--	--	--	1.25	0.366	0.862
	CV Detects[2]	0.569	1.14	0.542	--	--	--
	UCL Type	95% KM (t) UCL	KM H-UCL	95% KM (t) UCL	95% Adjusted Gamma UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	2.25	2.98	1.77	35.9	18.2	7.08
	UTL Type	UTL KM Normal	UTL Lognormal	UTL KM Normal	UTL Gamma WH	UTL Normal	UTL Normal
	UTL Result	4.68	--	3.25	95.5	31.7	16.8

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Survey Area B	Total Number of Observations	10	10	10	10	10	10
	Percent Non-Detects	--	--	20%	--	--	--
	Minimum[1]	0.440	0.480	--	1.80	9.00	2.49
	Minimum Detect[2]	--	--	1.20	--	--	--
	Mean[1]	7.56	3.12	--	13.7	31.2	8.34
	Mean Detects[2]	--	--	2.59	--	--	--
	Median[1]	6.35	3.20	--	11.5	17.5	8.95
	Median Detects[2]	--	--	2.35	--	--	--
	Maximum[1]	27.0	7.20	--	39.0	170	14.4
	Maximum Detect[2]	--	--	4.10	--	--	--
	Distribution	Unknown	Normal	Normal	Normal	Unknown	Normal
	Coefficient of Variation[1]	0.939	0.676	--	0.826	1.57	0.504
	CV Detects[2]	--	--	0.398	--	--	--
	UCL Type	95% Chebyshev (Mean, Sd) UCL	95% Student's-t UCL	95% KM (t) UCL	95% Student's-t UCL	95% Chebyshev (Mean, Sd) UCL	95% Student's-t UCL
	UCL Result	17.4	4.34	2.93	20.3	98.6	10.8
	UTL Type	UTL Non-Parametric	UTL Normal	UTL KM Normal	UTL Normal	UTL Non-Parametric	UTL Normal
	UTL Result	27.0	9.25	5.39	46.7	170	20.6
Survey Area C	Total Number of Observations	4	4	4	4	4	4
	Percent Non-Detects	--	--	25%	--	--	--
	Minimum[1]	6.70	0.590	--	3.90	12.0	2.58
	Minimum Detect[2]	--	--	1.30	--	--	--
	Mean[1]	7.70	1.33	--	16.6	14.8	11.8
	Mean Detects[2]	--	--	1.67	--	--	--
	Median[1]	7.65	1.22	--	6.15	14.5	5.10
	Median Detects[2]	--	--	1.50	--	--	--
	Maximum[1]	8.80	2.30	--	50.0	18.0	34.3
	Maximum Detect[2]	--	--	2.20	--	--	--
	Distribution	Normal	Normal	Normal	Gamma	Normal	Gamma
	Coefficient of Variation[1]	0.131	0.560	--	1.35	0.187	1.28
	CV Detects[2]	--	--	0.284	--	--	--
	UCL Type	95% Student's-t UCL	95% Student's-t UCL	95% KM (t) UCL	95% Adjusted Gamma UCL	95% Student's-t UCL	95% Adjusted Gamma UCL
	UCL Result	8.89	2.21	2.11	--	18.0	--
	UTL Type	UTL Normal	UTL Normal	UTL KM Normal	UTL Gamma WH	UTL Normal	UTL Gamma WH
	UTL Result	12.9	5.17	3.56	386	28.9	258
Survey Area D	Total Number of Observations	2	2	2	2	2	2
	Percent Non-Detects	--	--	100%	--	--	--
	Minimum[1]	6.10	0.830	--	0.990	12.0	1.72
	Minimum Detect[2]	--	--	--	--	--	--
	Mean[1]	6.25	0.885	--	1.65	12.5	2.51
	Mean Detects[2]	--	--	--	--	--	--
	Median[1]	6.25	0.885	--	1.65	12.5	2.51
	Maximum[1]	6.40	0.940	--	2.30	13.0	3.29
	Maximum Detect[2]	--	--	--	--	--	--
	Distribution	Not Calculated	Not Calculated	Not Calculated	Not Calculated	Not Calculated	Not Calculated
	Coefficient of Variation[1]	0.034	0.088	--	0.563	0.057	0.443
	UCL Type	Not Calculated	Not Calculated	Not Calculated	Not Calculated	Not Calculated	Not Calculated
	UCL Result	Not Calculated	Not Calculated	Not Calculated	Not Calculated	Not Calculated	Not Calculated
	UTL Type	Not Calculated	Not Calculated	Not Calculated	Not Calculated	Not Calculated	Not Calculated
	UTL Result	Not Calculated	Not Calculated	Not Calculated	Not Calculated	Not Calculated	Not Calculated

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Survey Area E	Total Number of Observations	9	9	9	9	9	9
	Percent Non-Detects	--	67%	89%	--	--	--
	Minimum[1]	0.460	--	--	0.460	4.60	0.440
	Minimum Detect[2]	--	0.260	5.20	--	--	--
	Mean[1]	1.46	--	--	3.80	11.6	3.48
	Mean Detects[2]	--	2.36	5.20	--	--	--
	Median[1]	1.30	--	--	0.950	10.0	1.47
	Median Detects[2]	--	0.310	--	--	--	--
	Maximum[1]	4.60	--	--	25.0	24.0	15.2
	Maximum Detect[2]	--	6.50	5.20	--	--	--
	Distribution	Gamma	Normal	Not Calculated	Unknown	Normal	Gamma
	Coefficient of Variation[1]	0.850	--	--	2.10	0.522	1.32
	CV Detects[2]	--	1.52	--	--	--	--
	UCL Type	95% Adjusted Gamma UCL	95% KM (t) UCL	Not Calculated	95% Chebyshev (Mean, Sd) UCL	95% Student's-t UCL	95% Adjusted Gamma UCL
	UCL Result	2.62	2.42	Not Calculated	15.4	15.4	9.09
	UTL Type	UTL Gamma WH	UTL KM Normal	Not Calculated	UTL Non-Parametric	UTL Normal	UTL Gamma WH
	UTL Result	6.37	6.90	Not Calculated	25.0	30.1	25.3

[1] This statistic is reported by ProUCL when the dataset contains 100 percent detections.
[2] This statistic is reported by ProUCL when non-detect values exist in the dataset. The value reported is calculated using detections only.
[3] Statistics shown are for the constituents where potential statistical outliers were identified, calculated with the potential outliers removed.
CV Coefficient of variation
KM Kaplan Meier
mg/kg Milligrams per kilogram
-- Not applicable
pCi/g Picocuries per gram
WH Wilson Hilferty
Note The UTL result that is shown on the table is based on the output from ProUCL. ProUCL evaluates the data and provides all possible UCLs from its UCL module for three possible data distributions, then identifies a recommended UCL value. ProUCL does not identify a recommended UTL value. The UTLs are therefore based on the distribution of the recommended UCL. Please refer to ProUCL Version 5.1 Technical Guide Statistical Software for Environmental Applications for Data Sets with and without Non-detect Observations (EPA, 2015) for further information

3.3.2 Gamma Radiation Results Summary

Table 5 presents the descriptive statistics output from the ProUCL software for the gamma radiation survey results.

Table 5. Summary of Walk-over Gamma Results

Area	Statistic	Gamma (cpm)
Background Reference Area 1 (BG-1) All Data	Total Number of Observations	188
	Minimum	7,029
	Mean	9,739
	Median	9,626
	Maximum	13,185
	Distribution	Normal
	Coefficient of Variation	0.136
	UCL Type	95% Student's-t UCL
	UCL Result	9,899
	UTL Type	UTL Normal
	UTL Result	12,184
Background Reference Area 2 (BG-2) All Data	Total Number of Observations	242
	Minimum	8,871
	Mean	12,922
	Median	12,851
	Maximum	19,139
	Distribution	Normal
	Coefficient of Variation	0.145
	UCL Type	95% Student's-t UCL
	UCL Result	13,121
	UTL Type	UTL Normal
	UTL Result	16,336
Background Reference Area 2 (BG-2) Excluding Potential Outliers	Total Number of Observations	233
	Minimum	8,871
	Mean	12,723
	Median	12,785
	Maximum	16,962
	Distribution	Normal
	Coefficient of Variation	0.126
	UCL Type	95% Student's-t UCL
	UCL Result	12,897
	UTL Type	UTL Normal
	UTL Result	15,649
Background Reference Area 3 (BG-3) All Data	Total Number of Observations	419
	Minimum	8,694
	Mean	12,804
	Median	12,948
	Maximum	16,609
	Distribution	Normal
	Coefficient of Variation	0.107
	UCL Type	95% Student's-t UCL
	UCL Result	12,914
	UTL Type	UTL Normal
	UTL Result	15,223
Background Reference Area 3 (BG-3) Excluding Potential Outliers	Total Number of Observations	414
	Minimum	9,537
	Mean	12,814
	Median	12,950
	Maximum	16,244
	Distribution	Normal
	Coefficient of Variation	0.102
	UCL Type	95% Student's-t UCL
	UCL Result	12,920
	UTL Type	UTL Normal
	UTL Result	15,135
Background Reference Area 4 (BG-4) All Data	Total Number of Observations	226
	Minimum	10,729
	Mean	12,927
	Median	12,839
	Maximum	15,777
	Distribution	Normal
	Coefficient of Variation	0.075
	UCL Type	95% Student's-t UCL
	UCL Result	13,033
	UTL Type	UTL Normal
	UTL Result	14,697
Background Reference Area 4 (BG-4) Excluding Potential Outliers	Total Number of Observations	225
	Minimum	10,729
	Mean	12,914
	Median	12,838
	Maximum	15,162
	Distribution	Normal
	Coefficient of Variation	0.074
	UCL Type	95% Student's-t UCL
	UCL Result	13,019
	UTL Type	UTL Normal
	UTL Result	14,654
Background Reference Area 5 (BG-5) All Data	Total Number of Observations	804
	Minimum	5,705
	Mean	8,443
	Median	8,457
	Maximum	12,233
	Distribution	Normal
	Coefficient of Variation	0.119
	UCL Type	95% Student's-t UCL
	UCL Result	8,501
	UTL Type	UTL Normal
	UTL Result	10,189

Area	Statistic	Gamma (cpm)
Background Reference Area 5 (BG-5) Excluding Potential Outliers	Total Number of Observations	796
	Minimum	5,821
	Mean	8,420
	Median	8,454
	Maximum	11,046
	Distribution	Normal
	Coefficient of Variation	0.115
	UCL Type	95% Student's-t UCL
	UCL Result	8,477
	UTL Type	UTL Normal
	UTL Result	10,096
Survey Area A	Total Number of Observations	8,420
	Minimum	5,203
	Mean	19,735
	Median	14,770
	Maximum	114,187
	Distribution	Unknown
	Coefficient of Variation	0.648
	UCL Type	95% Chebyshev (Mean, Sd) UCL
	UCL Result	20,343
	UTL Type	UTL Non-Parametric
	UTL Result	44,816
Survey Area B	Total Number of Observations	22,299
	Minimum	5,368
	Mean	22,555
	Median	12,247
	Maximum	401,121
	Distribution	Unknown
	Coefficient of Variation	1.28
	UCL Type	95% Chebyshev (Mean, Sd) UCL
	UCL Result	23,395
	UTL Type	UTL Non-Parametric
	UTL Result	68,187
Survey Area C	Total Number of Observations	8,895
	Minimum	6,855
	Mean	14,041
	Median	11,026
	Maximum	136,164
	Distribution	Normal
	Coefficient of Variation	0.861
	UCL Type	95% Student's-t UCL
	UCL Result	14,252
	UTL Type	UTL Normal
	UTL Result	34,250
Survey Area D	Total Number of Observations	941
	Minimum	7,430
	Mean	12,308
	Median	12,107
	Maximum	18,510
	Distribution	Normal
	Coefficient of Variation	0.186
	UCL Type	95% Student's-t UCL
	UCL Result	12,431
	UTL Type	UTL Normal
	UTL Result	16,267
Survey Area E	Total Number of Observations	26,665
	Minimum	4,543
	Mean	15,229
	Median	10,271
	Maximum	199,804
	Distribution	Unknown
	Coefficient of Variation	1.03
	UCL Type	95% Chebyshev (Mean, Sd) UCL
	UCL Result	15,646
	UTL Type	UTL Non-Parametric
	UTL Result	40,569

As noted for metals and Ra-226 in Section 3.3.1, gamma results measured within the Survey Areas are elevated relative to gamma results measured in background reference areas because background reference areas were selected to represent the geology present in the region around the Site, whereas the Site was selected as a mine claim because it is in an area of mineralized bedrock likely to have localized naturally elevated uranium concentrations. Therefore, it's not surprising that gamma results within the Survey Areas are somewhat higher than gamma results at the background reference areas. Elevated gamma results in portions of the Survey Areas are likely attributable to historic waste piles, as well as a higher degree of natural mineralization within the Survey Areas relative to the background reference areas.

4.0 INVESTIGATION LEVELS

The calculated 95-95 UTL values described in Section 3.3 are used as the ILs for gamma measurement results and soil sampling results because they reflect the natural variability in the background data, and provide an upper limit from background data to be used for single-point comparisons to Survey Area data. The ILs for analytical results of soil samples and gamma radiation results in Survey Areas A, B, C, D and E are based on background reference areas BG-1, BG-2, BG-3, BG-4 and BG-5, respectively.

4.1 SURVEY AREA A INVESTIGATION LEVELS

- Arsenic (mg/kg): 7.92
- Molybdenum (mg/kg): 12.8
- Selenium (mg/kg): 3.26
- Uranium (mg/kg): 31.4
- Vanadium (mg/kg): 21.3
- Ra-226 (pCi/g): 12.7
- Gamma radiation measurements (cpm): 12,184

4.2 SURVEY AREA B INVESTIGATION LEVELS

- Arsenic (mg/kg): 9.06
- Molybdenum (mg/kg): 8.08
- Selenium (mg/kg): 2.67
- Uranium (mg/kg): 2.12
- Vanadium (mg/kg): 29.7
- Ra-226 (pCi/g): 3.86
- Gamma radiation measurements (cpm): 16,336

4.3 SURVEY AREA C INVESTIGATION LEVELS

- Arsenic (mg/kg): 17.4
- Molybdenum (mg/kg): 1.47
- Selenium (mg/kg): 1.55
- Uranium (mg/kg): 1.46
- Vanadium (mg/kg): 13.7
- Ra-226 (pCi/g): 2.09
- Gamma radiation measurements (cpm): 15,223

4.4 SURVEY AREA D INVESTIGATION LEVELS

- Arsenic (mg/kg): 14.8
- Molybdenum (mg/kg): 1.87
- Selenium (mg/kg): 2.09
- Uranium (mg/kg): 1.36
- Vanadium (mg/kg): 32.8
- Ra-226 (pCi/g): 1.87
- Gamma radiation measurements (cpm): 14,697

4.5 SURVEY AREA E INVESTIGATION LEVELS

- Arsenic (mg/kg): 7.51
- Molybdenum (mg/kg): 0.707
- Selenium (mg/kg): None (All results non-detect)
- Uranium (mg/kg): 1.27
- Vanadium (mg/kg): 29.2
- Ra-226 (pCi/g): 2.05
- Gamma radiation measurements (cpm): 10,189

5.0 REFERENCES

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Appendix E Cultural and Biological Resource Clearance Documents

BIOLOGICAL EVALUATION

For the Proposed:

Eunice Becenti
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

TABLE OF CONTENTS

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1. INTRODUCTION AND PROJECT BACKGROUND

The federal Endangered Species Act (ESA) of 1973, 16 U.S.C. §1531 et seq., requires all federal departments and agencies to conserve threatened, endangered, and critical and sensitive species and the habitats on which they depend, and to consult with the U.S. Fish and Wildlife Service (USFWS) on all actions authorized, funded, or carried out by each agency to ensure that the action will not likely jeopardize the continued existence of any threatened and endangered species or adversely modify critical habitat [USFWS 1998]. This report describes the potential for federal ESA-listed species and Navajo Nation Endangered Species List (NESL) endangered, threatened, candidate, or otherwise designated sensitive flora and fauna to occur in the proposed action area. The action area with regard to the ESA is defined as any area that may be directly or indirectly impacted by the proposed action [50 CFR §402.02]. This report is intended to provide the responsible official with information to make determinations of effect on species with special conservation status.

As the result of settlement by the United States, the Navajo Nation AUM Environmental Response Trust—First Phase was established to evaluate certain abandoned uranium mines located across the Navajo Nation. The project requires investigation of these sites prior to potential remediation activities in the future. MWH Global, a division of Stantec (MWH), will conduct exploratory activities at the Eunice Becenti 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

The Eunice Becenti site is located in McKinley County New Mexico, approximately 2.5 miles southeast of Gallup, NM at an elevation of approximately 7,130 feet. Global Positioning System coordinates are 35°30'11” N by 108°39'0” W NAD 83. The legal description of the project surface location is as follows: Section 28, Township 15 North, Range 17 West, New Mexico Principal Meridian. Project area maps are provided in Appendix A.

2.2. Estimated Disturbance

MWH proposes a phased approach to scientific investigations at the Eunice Becenti AUM. The study area encompasses the claim boundary and a 100-foot perimeter buffer zone for a total of approximately 4.7 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 Eunice Becenti includes the mine boundary and a 100-foot perimeter buffer zone for a total of approximately 4.7 acres. The affected environment or action area includes any area that may be directly or indirectly impacted by the proposed activities. Project area maps are provided in Appendix A.

3.1.1. Environmental Setting

Project activities would occur in northwestern New Mexico 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.

The Eunice Becenti site is situated on top of a narrow northwest-southeast trending ridge known as The Hogback. Terrain is steep on both sides with numerous cliff faces, ledges, crevices and fallen boulders.

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 Eunice Becenti site consists of steep sandstone with scattered shrubs and numerous piñon-juniper trees.

Fauna

Wildlife or evidence of wildlife observed within or near the PPA included turkey vulture (*Cathartes aura*), common raven (*Corvus corax*), coyote (*Canis latrans*), mule deer (*Odocoileus hemionus*), and cottontail rabbit (S*ylvilagus* sp.). 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 would drain to the east or west of The Hogback. This drainage collects in the town of Gallup and follows the Rio Puerco generally to the west. Rio Puerco continues west for 100 miles and joins the Little Colorado River in Holbrook, AZ. There are no wetlands, seeps, springs, or riparian areas within the proposed project area. The proposed project activities would contribute to a negligible increase in sedimentation down gradient of the project area. This increase is not anticipated to be a factor due to the distance from perennial waters. There is no suitable habitat for ESA-listed fish, nor critical habitats thereof, within 100 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 (02ENNM00-2016-SLI-0444) on April 20, 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 and visibility was good.

Follow up surveys were conducted at the site specifically targeting Golden eagle (*Aquila chrysaetos*), and American peregrine falcon (*Falco peregrinus*) following Navajo Natural Heritage Program (NNHP) guidelines. All wildlife species observed in the action area were recorded, and digital photos were taken (Appendix B). Follow up survey details including date, site conditions and methods can be found on summary sheets attached as Appendix E.

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 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 IPaC Official Species List for the Eunice Becenti 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.
Southwestern willow flycatcher (*Empidonax traillii extimus)*	Endangered with Final Critical habitat	Possible rare summer/breeding occurrences.[2]	Breeds in dense riparian habitat.[2]	No potential. Action area does not provide suitable habitat for species to occur.
FISHES				

Table 1: USFWS IPaC Official Species List for the Eunice Becenti 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.
PLANTS				
Zuni Fleabane (*Erigeron rhizomatus*)	Threatened	Chuska Mts from Lukachukai and west of Red Valley, Apache Co., AZ south to Navajo in McKinley County, NM.	Typically only found on fine textured clay hillsides of mid to high elevation between ca. 7000 and 8300ft. It is known from clays derived from the Chinle Formation in the Zuni and Chuska Mountains, and to similar clays of the Baca Formation in the Datil and Sawtooth ranges in New Mexico.[2]	No individuals found during the 2016 Redente site surveys.[4]

[1]USFWS; [2]NatureServe Explorer; [3]Navajo Endangered Species List, Species Accounts 2008; [4]Redente 2016

4.2.2. ESA-Listed Species Eliminated From Further Consideration

Table 1 includes five (5) ESA-listed species that have the potential to occur in the project area based on the USFWS IPaC Official Species List. All of the species in Table 1 have been eliminated from further discussion in this report. There would be no direct, indirect or cumulative impacts to the species in Table 1.

4.3. NESL Species Analysis and Results

4.3.1. Navajo Endangered Species List (NESL) and Species of Concern

Table 2.a lists species of concern with potential to occur on the 7.5-minute quadrangle(s) containing the project boundaries. According to the NESL information letter received from the NNFWD found in Appendix D, no sensitive species are known to occur within three miles of project site. . Biologists evaluated the potential for species of concern listed in the table below to occur within the project area.

Additionally, the NESL information letter requested that the potential for black-footed ferret (*Mustela nigripes*) be evaluated if prairie dog towns of sufficient size (per NFWD guidelines) occur in the project area, and that potential for Parish's alkali grass (*Puccinellia parishii*) be evaluated if wetland conditions exist that contain white alkaline crusts. Species listed by the USFWS in Table 1 are not reiterated here.

Table 2.a: Navajo Endangered Species List (NESL) and Species of Concern

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area
ANIMALS			
Black-footed ferret (*Mustela nigripes*)	USFWS Endangered	Open habitat, including grasslands, steppe, and shrub steppe. Closely associated with prairie dog colonies. At least 40 hectares of prairie dog colony required to support one ferret.[1]	No potential. Action area does not provide suitable habitat for species to occur. Action area does not provide prairie dog colonies of sufficient size
Western burrowing owl (*Athene cunicularia hypugaea*)	NESL G4	Open grasslands and sometimes other open areas (such as vacant lots). Nests in abandoned burrows, such as those dug by prairie dogs. [1,3]	No potential. Action area does not provide suitable 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 marginal habitat for species to occur.
Golden eagle (*Aquila chrysaetos*)	NESL G3	In the west, mostly open habitats in mountainous, canyon terrain. Nests primarily on cliffs. [3]	Action area provides potential foraging and nesting habitat for species to occur.
PLANTS			
Parish's alkali grass (*Puccinellia parishii*)	NESL G4 NM-E	Alkaline springs, seeps, and seasonally wet areas that occur at the heads of drainages or on gentle slopes. Elevation: 2600-7200 feet.[2,3]	No individuals found during the 2016 Redente site surveys.[5]
Navajo bladderpod (*Lesquerella navajoensis*)	NESL G3	Mostly windward, windswept mesa rims and nearby habitat with little vegetative cover and high insolation. Also found at the base and slopes of small hills of the Chinle Formation. Typically only found in a combination of Todilto Limestone overlaying Entrada Sandstone or Chinle outcrops in pinon-juniper communities. [3]	No individuals found during the 2016 Redente site surveys.[5]
Sivinski's fleabane (*Erigeron sivinskii*)	NESL G4	Steep, barren, shale slopes of the Chinle Formation, in pinon-juniper woodland and Great Basin Desert Scrub communities. Known populations occur at 6100 to 7400ft elevation. [3]	No individuals found during the 2016 Redente site surveys.[5]
Acoma fleabane (*Erigeron acomanus*)	NESL G3	Sandy slopes beneath sandstone cliffs of the Entrada Sandstone Formation in pinion-juniper woodland communities. Populations are known from ca. 7000ft elevation.[3]	No individuals found during the 2016 Redente site surveys.[5]

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area

Species are listed by the NESL as; Group 2: Endangered (survival or recruitment in jeopardy); Group 3: Endangered (survival or recruitment in jeopardy in foreseeable future); and Group 4: Species of Consideration. NESL Species with New Mexico State Endangered or Threatened status are labeled as NM-T or NM-E.

Sources: 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 eight (8) NESL and Navajo Species of Concern that have the potential to occur in the project area based on the 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: black-footed ferret (*Mustela nigripes*), burrowing owl (*Athene cunicularia*), Parish's alkali grass (*Puccinellia parishii*), Navajo bladderpod *(Lesquerella navajoensis),* Sivinski's fleabane *(Erigeron sivinskii),* and Acoma fleabane *(Erigeron acomanus).* None of these species were observed during surveys of the proposed project area or immediate surroundings. There would be no direct, indirect or cumulative impacts to these species.

Habitat potential was assessed for the American peregrine falcon (*Falco peregrinus*) within the action area. ACI biologists determined the cliffs within and surrounding the site to be marginal potential nesting habitat for this species and conducted follow up surveys to closely examine the cliff faces for any signs of use. Sixteen hours of observation following Navajo Natural Heritage Program (NNHP) protocol were conducted during April 2016. ACI biologists saw no sign of use by this species and concluded the habitat was not likely to be used by American peregrine falcon based on this detailed study. Survey results were discussed with Chad Smith, NNDFW zoologist, and with his concurrence, no further surveys were conducted. The project site was eliminated as potential nesting habitat for the following reason: cliff walls are approximately 100 feet in height but are sloped and ledged instead of sheer as is typical for American peregrine falcon on Navajo lands (Chad Smith--NNDFW zoologist, personal communication, May 9th, 2016).

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. [3]	Action area provides potential foraging and nesting habitat for species to occur.

Species are listed by the NESL as; Group 2: Endangered (survival or recruitment in jeopardy); Group 3: Endangered (survival or recruitment in jeopardy in foreseeable future); and Group 4: Species of Consideration. NESL Species with New Mexico State Endangered or Threatened status are labeled as NM-T or NM-E.

Sources: [1]New Mexico Natural Heritage Program 2010, [2]NatureServe Explorer; [3]Navajo Endangered Species List, Species Accounts 2008, [4] IUCN Red List, [5]Redente 2016, [6] Hammerson et al 2004.

4.4. Migratory Bird Species

The Migratory Bird Treaty Act (MBTA) implements various treaties and conventions between the U.S. and Canada, Japan, Mexico and the former Soviet Union for the protection of migratory birds. Under the Act, taking, killing or possessing migratory birds is unlawful.

The bald eagle (*Haliaeetus leucocephalus*) was delisted under the ESA on August 9, 2007. Both the bald eagle and golden eagle (*Aquila chrysaetos*) are still protected under the MBTA and Bald and Golden Eagle Protection Act (BGEPA). The BGEPA affords both eagles protection in addition to that provided by the MBTA, in particular, by making it unlawful to "disturb" eagles.

In preparation for conducting the migratory bird survey, information from the New Mexico Partners In Flight website (http://www.hawksaloft.org/pif.shtml), the New Mexico PIF highest priority list of species of concern by vegetation type, the USFWS's Division of Migratory Bird Management website (http://www.fws.gov/migratorybirds/), and the 2002 Birds of Conservation Concern Report for the Southern Rockies/Colorado Plateau Bird Conservation Region (BCR) No. 16, were used to develop a list of high priority migratory bird species with potential to occur in the area of the proposed action. Species addressed previously will not be reiterated here.

Table 3: Priority Birds of Conservation Concern with Potential to Occur in the Project Area

Species Name	Habitat Associations	Potential to Occur in the Project Area
Black-throated sparrow (*Amphispiza bilineata*)	Xeric habitats dominated by open shrubs with areas of bare ground.	No 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.	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.	No suitable habitat is present within the action area for species to occur.
Mountain bluebird (*Sialia currucoides*)	Open piñon-juniper woodlands, mountain meadows, and sagebrush shrublands; requires larger trees and snags for cavity nesting.	Suitable habitat is present within the action area for species to occur.
Mourning dove (*Zenaida macroura*)	Open country, scattered trees, and woodland edges. Feeds on ground in grasslands and agricultural fields. Roost in woodlands in the winter. Nests in trees or on ground.	No 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.	No suitable habitat is present within the action area for species to occur.

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.
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 AZ, central & western portions of NM; most common in southwest NM.	No 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.	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.	Suitable habitat is 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 at Eunice Becenti includes the mine boundary and a 100-foot perimeter buffer zone for a total of approximately 4.7 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

Habitat potential was assessed for the golden eagle and ferruginous hawk within the action area. ACI biologists determined the sandstone cliffs surrounding the site to be potential nesting habitat for this species and conducted follow up surveys to closely examine the cliff faces for any signs of use. Observations following Navajo Natural Heritage Program (NNHP) protocol were conducted during April 2016. No active or old nests for this species were observed.

<u>Phase I:</u>
Noise and surface disturbance will be low and short term during pedestrian survey activity. Adult raptors would not be directly impacted by Phase I because of their mobility and ability to avoid areas of human activity. The area is not currently occupied as a nest territory; Phase I activities that may occur within the breeding season are unlikely to discourage adults from selecting the area as a new nest territory. Direct and indirect effects from Phase I are expected to be short term and negligible.

<u>Phase II:</u>
During Phase II, noise may be moderate for a short duration, and surface disturbance will be light to moderate within a minimal footprint at the study area. No permanent structures will be left on site. Adult raptors would not be directly harmed by Phase II activities because of their mobility and ability to avoid areas of human activity. Phase II activities that may occur within the breeding season may disrupt potential nesting in the area. Nest initiation or nesting activity within the PPA is not expected to be directly impacted if activities occur outside of the raptor breeding season for the region: for golden eagle, 15 January to 15 July (Navajo Nation Division of Natural Resources, Department of Fish and Wildlife 2008b).

5.1.2. Migratory Birds

The PPA encompasses approximately 4.7 acres of potential migratory bird habitat in the form of mainly cliffs and ledges with pinon-juniper trees. No trees would be removed as a result of the proposed project.

<u>Phase I:</u>
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 minor.

<u>Phase II:</u>
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

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 varying degrees of noise and surface disturbance within approximately 4.7 acres of potential migratory bird habitat in the form of mainly cliffs and ledges with pinon-juniper trees. During Phase I, noise and surface disturbance will be low during pedestrian survey activity. Direct and indirect effects are expected to be short term and negligible. For Phase II, the total surface disturbance is unknown at this point; however equipment movement would be confined to only a few temporary travel corridors (likely less than one acre). 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 100 miles of the PPA.

Navajo Endangered Species List (NESL) and Species of Concern

One (1) NESL and Navajo species of concern has potential to occur within of near the PPA based on habitat suitability or actual record of observation. Based on site surveys, ACI determined the PPA contains potential foraging habitat for golden eagle.

Potential effects to this species are discussed in detail in Section 5 above. The short term increased human activity and ground disturbance associated with Phase II of the project may have some impact; however, with the implementation of recommendations discussed in Section 7 below, it is unlikely that the proposed action would result in detriment this species.

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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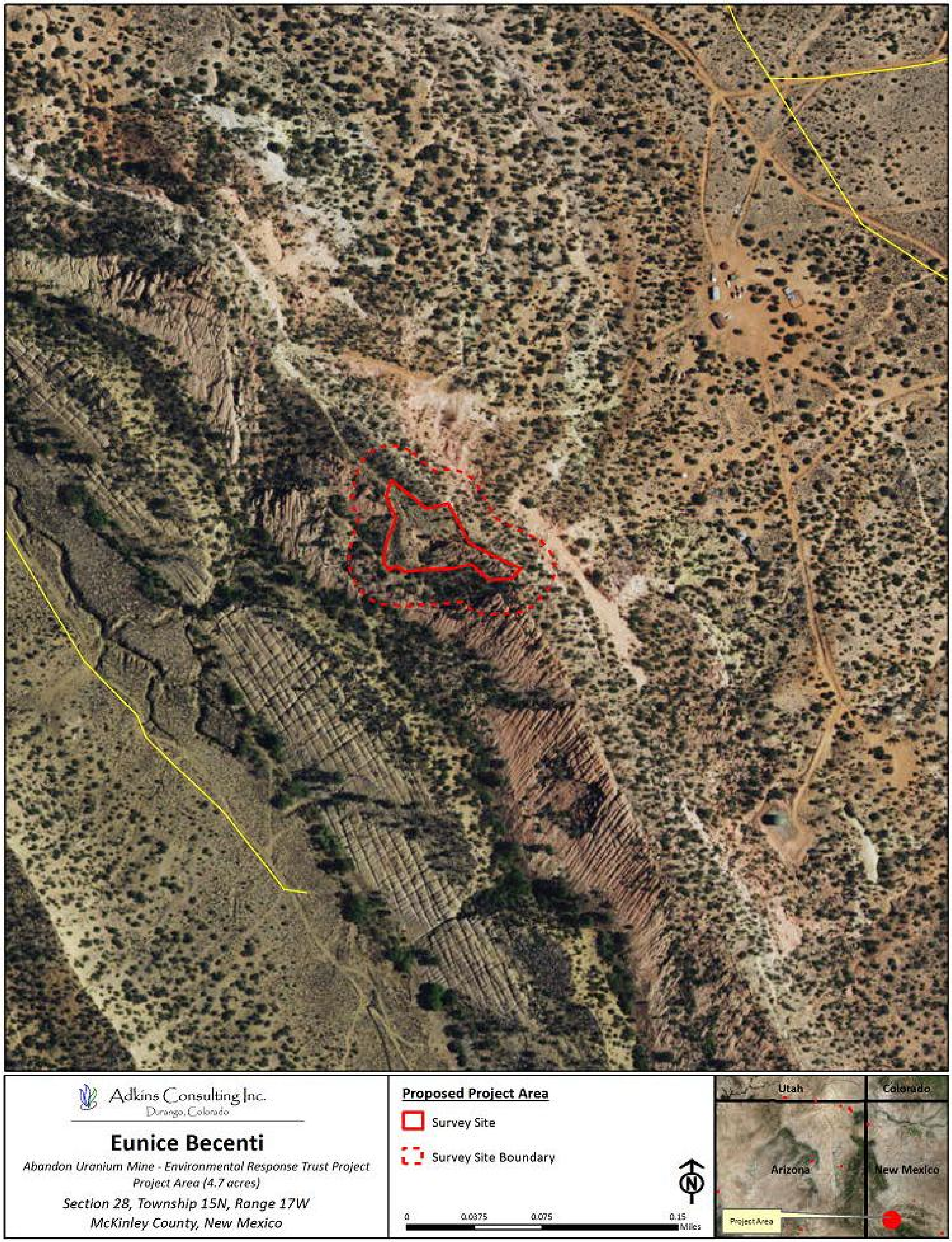
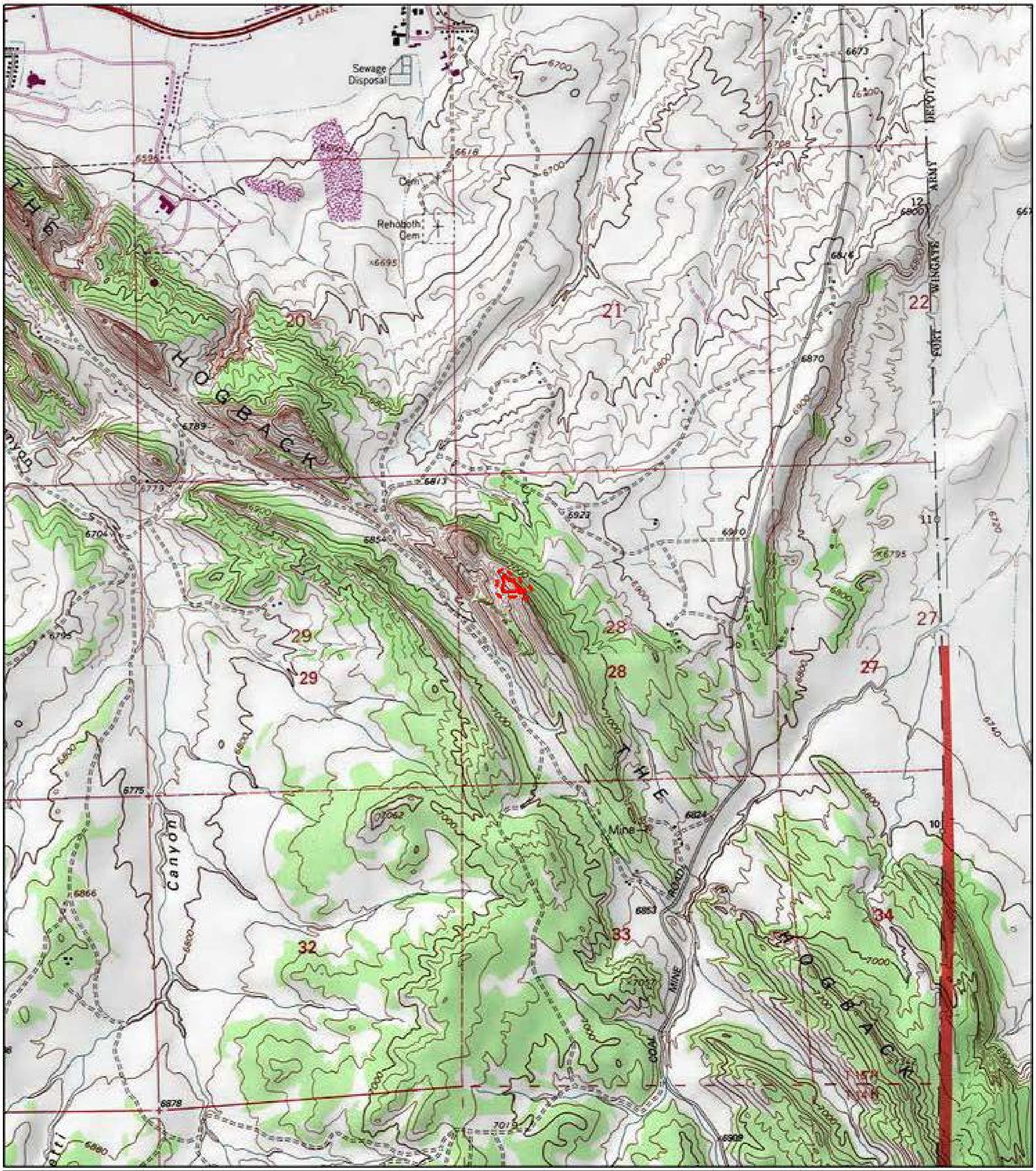
APPENDIX A. MAPS





Adkins Consulting Inc.
Durango, Colorado

Eunice Becenti

Abandon Uranium Mine - Environmental Response Trust Project
Project Area (4.7 acres)

Section 28, Township 15N, Range 17W
McKinley County, New Mexico

Proposed Project Area

Survey Site

Survey Site Boundary

N

0 0.25 0.5 1 Miles

APPENDIX B. PHOTOGRAPHS

General habitat in PPA

APPENDIX C. REDENTE PLANT SURVEY REPORT

Navajo Nation AUM Environmental Response Trust

Plant Survey Report for Species of Concern At Eunice Becenti Project Site McKinley County, New Mexico August 2016

Prepared by:
Redente Ecological Consultants
1322 Alene Circle
Fort Collins, CO 80525

TABLE OF CONTENTS

INTRODUCTION

Purpose of Report

A biological survey was conducted at the Eunice Becenti site as part of the Navajo Nation AUM Environmental Response Trust. The purpose of the survey is to determine if plant species of concern are present within the claim boundary and extending 100 feet around the site. Biological clearance is required at each site prior to any site investigation to determine if the project may affect potential species-of-concern or potential federal threatened and endangered (T&Es) species and/or critical habitat.

Site Location

Eunice Becenti is located in McKinley County New Mexico, approximately 10 km (6.2 miles) east of Gallup, New Mexico at an elevation of approximately 2,134 m (7,001 ft). Global Positioning System coordinates are 35^{o} 30'22" N by 108^{o} 39' 14" W (North American Datum of 1983). The site is documented to be an allotment.

Environmental Setting

Climate

The climate of the Eunice Becenti site is classified as semi-arid. The average annual precipitation at the closest official weather station in Gallup, New Mexico is 292 mm (11.5 in), with the greatest precipitation months occurring in July and August. Average annual temperature is 9.4^{o} C (49^{o} F).

Soils

The U.S. Department of Agriculture (USDA) Soil Survey for McKinley County was published in 2005 and covers most of the county, including the portion where Eunice Becenti is located. This area of McKinley County has rock outcrops consisting of barren or nearly barren areas of exposed sandstone. Slopes range from about 5 to 15% on structural benches to vertical cliffs on escarpment faces. The general mapping unit for the site is Rock Outcrop-Eagleye-Atchee Complex and the soil type is Atchee, which is derived from sandstone (USDA 2005). Typical features include escarpments and benches on cuestas (which are hills or ridges with a gentle slope on one site and a steep slope on the other side).

Plant Community Type

The plant community type on the Eunice Becenti site is upland woodland. The most common species on the site include pinyon pine (*Pinus edulis*), oneseeded juniper (*Juniperus monosperma*), mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush (*Purshia tridentata*), serviceberry (*Amelanchier alnifolia*), broom snakeweed (*Gutierrizia sarathrae*), blue grama (*Bouteloua gracilis*), alkali sacaton (*Sporobolus airoides*), galleta (*Pleuraphis jamesii*), and Indian ricegrass (*Achnatherum hymenoides*).

Land Use

The land type on the Eunice Becenti site is rangeland and the principal land use is wildlife habitat.

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 four plant species of concern that may occur in the project area. These species included Sivinski's fleabane (*Erigeron sivinskii*), Zuni fleabane (*Erigeron rhizomatus*), Acoma fleabane (*Erigeron acomanus), and Navajo bladderpod (Lesquerella navajoensis)*. The USFWS also listed Zuni fleabane 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 spring (May) and summer (July) of 2016 during the appropriate season to observe the phenological characteristics of the special status plant species that were necessary for identification (Table 1).

Table 1. Species of Concern and Survey Period

Species of Concern	Survey Period
Navajo bladderpod (*Lesquerella navajoensis*)	May
Sivinski's fleabane (*Erigeron sivinskii*)	May
Zuni fleabane (*Erigeron rhizomatus*)	May
Acoma fleabane (*Erigeron acomanus*)	July

The botanical survey team was assisted during the survey by GIS trained staff from MWH with training specifically in the use of the Trimble GeoExplorer 6000 Series and the Garmin Montana 600. The GPS operator was also instructed in sight identification of species of concern to help delineate points or polygons and other data collection and data management tasks. GPS units were preloaded for the plant team with background and data files that showed the aerial photographic base map, the site boundaries, and the study area, so team members could clearly identify their exact location in the field at all times.

2016 Field Survey

The project site was surveyed by a field botanist. The botanist walked meandering "transect" lines through each area and looked for suitable habitat for these species, such as steep barren slopes, windward, windswept mesa rims, clay hillsides, and sandy slopes below sandstone cliffs. 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 4 plant species of concern were identified as potentially occurring within the proximity of the project area. These species included *Erigeron sivinskii*, *Erigeron rhizomatus, Erigeron acomanus, and Lesquerella navajoensis*. *Erigeron sivinskii* is a native perennial forb that has a general distribution in Apache and McKinley Counties and inhabits steep barren shale slopes in Desert Shrub and Pinyon-Juniper communities at elevations between 1,860 and 2,250 m (6,102 and 7,382 ft). *Erigeron rhizomatus* is native perennial forb found in McKinley, San Juan and Catron Counties. It is found growing on fine textured clay hillsides primarily in Pinyon-Juniper type. It occurs at elevation ranges between 2,135 and 2,530 m (7,005 and 8,301 ft). *Erigeron acomanus* is a native perennial forb found in McKinley County. It inhabits sandy slopes, primarily beneath sandstone cliffs in Pinyon-Juniper communities. Populations are known to occur at elevations around 2,135 m (7,005 ft). *Lesquerella navajoensis* is a native perennial forb that has a general distribution in Apache and McKinley Counties and occurs mostly on windward, windswept mesa rims and nearby habitat with little vegetation cover and high solar radiation. Populations are known to occur at elevations between 2,200 and 2,400 m (7,218 and 7,874 ft).

The surveys at Eunice Becenti on May 5 and July 19, 2016 did not identify any of the four species that have been listed as potential species of concern for this site. The habitat at Eunice Becenti is conducive to the establishment of all four species of concern, but it does not appear that its distribution includes the site where Eunice Becenti is located.

Photo #1—Overview of general landscape and plant community at Eunice Becenti.

Photo #2—Overview of general landscape and plant community at Eunice Becenti.

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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-0928	None	None	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, ATCU, AQCH, PUPA	Area 3
Oak124, Oak125	AQCH	AQCH	Horse Mesa (36109-F1) / AZ, NM	None	LIPI, FAPE, EMTREX, CHMO, BURE, AQCH, ZIVA, PUPA, PLZO, CIRY, CASP	Area 3
Occurrence B	None	AQCH, CASP	Del Muerto (36109-B4) / AZ	None	LIPI, FAPE, EMTREX, CIME, AQCH, ZIVA, PLZO, CYUT, CIRY, CASP, ALGO	Area 3
Section 26 (Desiddero Group)	None	None	Dos Lomas (35107-C7) / NM	None	FAPE, CHMO, ATCU, AQCH	Area 3
Standing Rock	None	None	Dalton Pass (35108-F3) / NM	None	VUMA, MUNI, FAPE, CHMO, BURE, ATCU, AQCH, ERSI, ASNA	Area 3

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
Tsosie 1	AQCH	AQCH	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, AQCH, PUPA	Area 1, Area 3

5. Conditional Criteria Notes *(Recent revisions made please read thoroughly. For certain species, and/or circumstances, please read and comply)*

A. **Biological Resource Land Use Clearance Policies and Procedures (RCP)** - The purpose of the RCP is to assist the Navajo Nation government and chapters ensure compliance with federal and Navajo laws which protect, wildlife resources, including plants, and their habitat resulting in an expedited land use clearance process. After years of research and study, the NNDFW has identified and mapped wildlife habitat and sensitive areas that cover the entire Navajo Nation.
The following is a brief summary of six (6) wildlife areas:
1.***Highly Sensitive Area*** – recommended no development with few exceptions.
2.***Moderately Sensitive Area*** – moderate restrictions on development to avoid sensitive species/habitats.
3.***Less Sensitive Area*** – fewest restrictions on development.
4.*Community Development Area* – areas in and around towns with few or no restrictions on development.
5.***Biological Preserve*** – no development unless compatible with the purpose of this area.
6.*Recreation Area* – no development unless compatible with the purpose of this area.
None - outside the boundaries of the Navajo Nation
This is not intended to be a full description of the RCP please refer to the our website for additional information at http://www.nndfw.org/clup.htm.

B. **Raptors** – If raptors are known to occur within 1 mile of project location: Contact Chad Smith at 871-7070 regarding your evaluation of potential impacts and mitigation.
   - **Golden and Bald Eagles**- If Golden or Bald Eagle are known to occur within 1 mile of the project, decision makers need to ensure that they are not in violation of the Golden and Bald Eagle Nest Protection Regulations found at http://nnhp.nndfw.org/docs_reps/gben.pdf.
   - **Ferruginous Hawks** – Refer to "Navajo Nation Department of Fish and Wildlife's Ferruginous Hawk Management Guidelines for Nest Protection" http://nnhp.nndfw.org/docs_reps.htm for relevant information on avoiding impacts to Ferruginous Hawks within 1 mile of project location.
   - **Mexican Spotted Owl** - Please refer to the Navajo Nation Mexican Spotted Owl Management Plan http://nnhp.nndfw.org/docs_reps.htm for relevant information on proper project planning near/within spotted owl protected activity centers and habitat.

C. **Surveys** – Biological surveys need to be conducted during the appropriate season to ensure they are complete and accurate please refer to NN Species Accounts http://nnhp.nndfw.org/sp_account.htm. Surveyors on the Navajo Nation must be permitted by the Director, NNDFW. Contact Jeff Cole at (928) 871-7068 for permitting procedures. Questions pertaining to surveys should be directed to the NNDFW Zoologist (Chad Smith) for animals at 871-7070, and Botanist (Andrea Hazelton) for plants at (928)523-3221. Questions regarding biological evaluation should be directed to Jeff Cole at 871-7068.

D. **Oil/Gas Lease Sales** – Any settling or evaporation pits that could hold contaminants should be lined and covered. Covering pits, with a net or other material, will deter waterfowl and other migratory bird use. Lining pits will protect ground water quality.

E. **Power line Projects** – These projects need to ensure that they do not violate the regulations set forth in the Navajo Nation Raptor Electrocution Prevention Regulations found at http://nnhp.nndfw.org/docs_reps/repr.pdf.

F. **Guy Wires** – Does the project design include guy wires for structural support? If so, and if bird species may occur in relatively high concentrations in the project area, then guy wires should be equipped with highly visual markers to reduce the potential mortality due to bird-guy wire collisions. Examples of visual markers include aviation balls and bird flight diverters. Birds can be expected to occur in relatively high concentrations along migration routes (e.g., rivers, ridges or other distinctive linear topographic features) or where important habitat for breeding, feeding, roosting, etc. occurs. The U.S. Fish and Wildlife Service recommends marking guy wires with at least one marker per 100 meters of wire.

G. **San Juan River** – On 21 March 1994 (Federal Register, Vol. 59, No. 54), the U.S. Fish and Wildlife Service designated portions of the San Juan River (SJR) as critical habitat for Ptychocheilus lucius (Colorado pikeminnow) and Xyrauchen texanus (Razorback sucker). Colorado pikeminnow critical habitat includes the SJR and its 100-year floodplain from the State Route 371 Bridge in T29N, R13W, sec. 17 (New Mexico Meridian) to Neskahai Canyon in the San Juan arm of Lake Powell in T41S, R11E, sec. 26 (Salt Lake Meridian) up to the full pool elevation. Razorback sucker critical habitat includes the SJR and its 100-year floodplain from the Hogback Diversion in T29N, R16W, sec. 9 (New Mexico Meridian) to the full pool elevation at the mouth of Neskahai Canyon on the San Juan arm of Lake Powell in T41S, R11E, sec. 26 (Salt Lake Meridian). All actions carried out, funded or authorized by a federal agency which may alter the constituent elements of critical habitat must undergo section 7 consultation under the Endangered Species Act of 1973, as amended. Constituent elements are those physical and biological attributes essential to a species conservation and include, but are not limited to, water, physical habitat, and biological environment as required for each particular life stage of a species.

H. **Little Colorado River** - On 21 March 1994 (Federal Register, Vol. 59, No. 54) the U.S. Fish and Wildlife Service designated Critical Habitat along portions of the Colorado and Little Colorado Rivers (LCR) for Gila cypha (humpback chub). Within or adjacent to the Navajo Nation this critical habitat includes the LCR and its 100-year floodplain from river mile 8 in T32N R6E, sec. 12 (Salt and Gila River Meridian) to its confluence with the Colorado River in T32N R5E sec. 1 (S&GRM) and the Colorado River and 100-year floodplain from Nautuloid Canyon (River Mile 34) T36N R5E sec. 35 (S&GRM) to its confluence with the LCR. All actions carried out, funded or authorized by a federal agency which may alter the constituent elements of Critical Habitat must undergo section 7 consultation under the Endangered Species Act of 1973, as amended. Constituent elements are those physical and biological attributes essential to a species conservation and include, but are not limited to, water, physical habitat, and biological environment as required for each particular life stage of a species.

I. **Wetlands** – In Arizona and New Mexico, potential impacts to wetlands should also be evaluated. The U.S. Fish & Wildlife Service's National Wetlands Inventory (NWI) maps should be examined to determine whether areas classified as wetlands are located close enough to the project site(s) to be impacted. In cases where the maps are inconclusive (e.g., due to their small scale), field surveys must be completed. For field surveys, wetlands identification and delineation methodology contained in the "Corps of Engineers Wetlands Delineation Manual" (Technical Report Y-87-1) should be used. When wetlands are present, potential impacts must be addressed in an environmental assessment and the Army Corps of Engineers, Phoenix office, must be contacted. NWI maps are available for examination at the Navajo Natural Heritage Program (NNHP) office, or may be purchased through the U.S. Geological Survey (order forms are available through the NNHP). The NNHP has complete coverage of the Navajo Nation, excluding Utah, at 1:100,000 scale; and coverage at 1:24,000 scale in the southwestern portion of the Navajo Nation. In Utah, the U.S. Fish & Wildlife Service's National Wetlands Inventory maps are not yet available for the Utah portion of the Navajo Nation, therefore, field surveys should be completed to determine whether wetlands are located close enough to the project site(s) to be impacted. For field surveys, wetlands identification and delineation methodology contained in the "Corps of Engineers Wetlands Delineation Manual" (Technical Report Y-87-1) should be used. When wetlands are present, potential impacts must be addressed in an environmental assessment and the Army Corps of Engineers, Phoenix office, must be contacted. For more information contact the Navajo Environmental Protection Agency's Water Quality Program.

J. **Life Length of Data Request** – The information in this report was identified by the NNHP and NNDFW's biologists and computerized database, and is based on data available at the time of this response. If project planning takes more than two (02) years from the date of this response, verification of the information provided herein is necessary. It should not be regarded as the final statement on the occurrence of any species, nor should it substitute for on-site surveys. Also, because the NNDFW information is continually updated, any given information response is only wholly appropriate for its respective request.

K. **Ground Water Pumping** - Projects involving the ground water pumping for mining operations, agricultural projects or commercial wells (including municipal wells) will have to provide an analysis on the effects to surface water and address potential impacts on all aquatic and/or wetlands species listed below. NESL Species potentially impacted by ground water pumping: Carex specuicola (Navajo Sedge), Cirsium rydbergii (Rydberg's Thistle), Primula specuicola (Cave Primrose), Platanthera zothecina (Alcove Bog Orchid), Puccinellia parishii (Parish Alkali Grass), Zigadenus vaginatus (Alcove Death Camas), Perityle specuicola (Alcove Rock Daisy), Symphyotrichum welshii (Welsh's American-aster), Coccyzus americanus (Yellow-billed Cuckoo), Empidonax traillii extimus (Southwestern Willow Flycatcher), Rana pipiens (Northern Leopard Frog), Gila cypha (Humpback Chub), Gila robusta (Roundtail Chub), Ptychocheilus lucius (Colorado Pikeminnow), Xyrauchen texanus (Razorback Sucker), Cinclus mexicanus (American Dipper), Speyeria nokomis (Western Seep Fritillary), Aechmophorus clarkia (Clark's Grebe), Ceryle alcyon (Belted Kingfisher), Dendroica petechia (Yellow Warbler), Porzana carolina (Sora), Catostomus discobolus (Bluehead Sucker), Cottus bairdi (Mottled Sculpin), Oxyloma kanabense (Kanab Ambersnail)

6. Personnel Contacts

Wildlife Manager
Sam Diswood
928.871.7062
sdiswood@nndfw.org

Zoologist
Chad Smith
928.871.7070
csmith@nndfw.org

Botanist
Vacant

Biological Reviewer
Pamela Kyselka
928.871.7065
pkyselka@nndfw.org

GIS Supervisor
Dexter D Prall
928.645.2898
prall@nndfw.org

Wildlife Tech
Sonja Detsoi
928.871.6472
sdetsoi@nndfw.org

7. Resources

National Environmental Policy Act

Navajo Endangered Species List:
http://nnhp.nndfw.org/endangered.htm

Species Accounts:
http://nnhp.nndfw.org/sp_account.htm

Biological Investigation Permit Application
http://nnhp.nndfw.org/study_permit.htm

Navajo Nation Sensitive Species List
http://nnhp.nndfw.org/study_permit.htm

Various Species Management and/or Document and Reports
http://nnhp.nndfw.org/docs_reps.htm

Consultant List
(Coming Soon)

Dexter D Prall

Digitally signed by Dexter D Prall
DN: cn=Dexter D Prall, o=Navajo Nation Department of Fish and Wildlife, ou=Navajo Natural Heritage Program, email=prall@nndfw.org, c=US
Date: 2015.11.19 15:56:30 -07'00'

Dexter D Prall, GIS Supervisor - Natural Heritage Program
Navajo Nation Department of Fish and Wildlife

MWH

BUILDING A BETTER WORLD

November 18, 2015

TO: Navajo Natural Heritage Program
Navajo Nation Dept. of Fish and Wildlife
ATTN: Sonja Detsoi and Dexter Prall
P.O. Box 1480
Window Rock, AZ 86515

FROM: MWH Americas
ATTN: Eileen Dornfest, Project Manager
3665 John F Kennedy Parkway
Bldg 1, Suite 206
Ft. Collins, CO 80525
Phone: (970) 377-9410
Fax: (970) 377-9406
E-mail: Eileen.Dornfest@mwhglobal.com

SUBJECT: Request for T and E Information for 16 Abandoned Uranium Mine (AUM) Sites

PROJECT NAME:
Navajo Nation AUM Environmental Response Trust (ERT) Project

LOCATION:
16 AUM Sites (attached in GIS shape files and USGS topographic maps)

SUMMARY DESCRIPTION OF PROJECT:
The work is to be conducted at 16 Abandoned Uranium Mines (AUMs) and includes Removal Site Evaluations (RSEs) according to CERCLA at each of the Sites. The RSEs are site investigations that include the following activities:

- conducting background soil studies
- conducting gamma radiation scans of surface soils
- sampling surface and subsurface soils and sediments related to historic mining operations
- assessing radiation exposure inside mine operations buildings, homes, or other nearby structures (if present at the Sites)
- sampling existing and accessible groundwater wells
- mitigating physical hazards and other interim response actions
- preparing a final written report documenting the work performed and information obtained for each of the Sites

3665 John F Kennedy Pkwy
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Ft. Collins CO 80525
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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.

APPENDIX E. NOTES FROM SPECIES SPECIFIC SURVEYS

Adkins Consulting Inc. Environmental Permitting Services 180 East 12 Street Suite #5 Durango, CO 81301 Phone: 505-793-1140	DAILY REPORT Field Surveys

PROJECT NAME: NN AUM SITE: Eunice Becenti

DATE: 4/27/16

WEATHER: Cloudy, light winds, temps low 50's

PERSONNEL ONSITE: Maria Adkins (Principal Biologist), Sarah Cowley (Field Assistant)

==

CONTRACTORS ONSITE NOTES:

Background: During the previous habitat assessment survey habitat was documented for Peregrine Falcons. The site is located partially on top of a steep ridge and partially within the valley below and between a number of deep canyons on both the east and west side. Surveys will be split between the east and west sides (pm survey on west side, am survey on east side) in order to increase chance of detection and minimize travel time during survey hours.

Purpose: In areas where suitable habitat occurs, a formal survey of the species is to be performed following Navajo Nation survey protocols[1] outlined below:

Peregrine Falcons - Two 8 hours surveys (4 hours before sunset and 4 hours after sunrise the following day) during each period: 1 FEB-30 APR (surveys during egg-laying/incubation discouraged) & 1 MAY-31 JUL (2 survey preferably prior to JUL). Productivity surveys require >=1 additional visits.

Methods: Surveys were performed for Peregrine Falcon along the west side of the project area. Surveyors arrived at the project site at 4:00 p.m. and conducted a thorough survey of the project area. Surveys included establishing appropriate vantage points, remaining at those points for 20 to 30 minutes listening for calls and using high powered binoculars to examine cliff faces for signs of nesting (ex. whitewash, nests, single or pairs of adults remaining in the area, etc.) until dark. Surveyors left the site at 8:00 p.m.

Findings: A turkey vulture was seen flying over the project area and was not seen or heard again.

[1] Navajo Natural Heritage Program – Navajo Nation Endangered Species List- Species Accounts. 2008. http://www.nndfw.org/nnhp/species_acct.pdf

Adkins Consulting Inc.
Environmental Permitting Services

180 East 12 Street Suite #5
Durango, CO 81301
Phone: 505-793-1140

DAILY REPORT
Field Surveys

PROJECT NAME: NN AUM SITE: Eunice Becenti

DATE: 4/28/16

WEATHER: Party cloudy, calm for most of the survey, with gusts up to 5-10 mph, temps low 50's

PERSONNEL ONSITE: Maria Adkins (Principal Biologist), Sarah Cowley (Field Assistant)

==

CONTRACTORS ONSITE NOTES:

Background: During the previous habitat assessment survey habitat was documented for Peregrine Falcons. The site is located partially on top of a steep ridge and partially within the valley below and between a number of deep canyons on both the east and west sides. Surveys will be split between the east and west sides of the site (pm survey on west side, am survey on east side) in order to increase chance of detection and minimize travel time during survey hours.

Purpose: In areas where suitable habitat occurs, a formal survey of the species is to be performed following Navajo Nation survey protocols[1] outlined below:

Peregrine Falcons - Two 8 hours surveys (4 hours before sunset and 4 hours after sunrise the following day) during each period: 1 FEB-30 APR (surveys during egg-laying/incubation discouraged) & 1 MAY-31 JUL (2 survey preferably prior to JUL). Productivity surveys require >=1 additional visits.

Methods: Surveyors arrived at the eastern portion of the project site at 6:00 a.m. and conducted a thorough survey of the project area. Surveys included establishing appropriate vantage points, remaining at those points for 20 to 30 minutes listening for calls and using high powered binoculars to examine cliff faces for signs of nesting (ex. whitewash, nests, single or pairs of adults remaining in the area, etc.) and continued until 10:00 a.m.

Additional Information: This completes the first of two required surveys before April 30th. Surveyors determined more suitable habitat exists on the east side and concentration their survey efforts along the eastern portion of the site tonight for the pm portion of the second survey.

Findings: No species of concern or note were seen or heard during the survey.

[1] Navajo Natural Heritage Program – Navajo Nation Endangered Species List- Species Accounts. 2008. http://www.nndfw.org/nnhp/species_acct.pdf

Adkins Consulting Inc.
Environmental Permitting Services

180 East 12 Street Suite #5
Durango, CO 81301
Phone: 505-793-1140

DAILY REPORT

Field Surveys

PROJECT NAME: NN AUM SITE: Eunice Becenti

DATE: 4/28/16

WEATHER: Party cloudy, gusty, winds up to 15-20 mph, temps low 50's

PERSONNEL ONSITE: Maria Adkins (Principal Biologist), Sarah Cowley (Field Assistant)

==

CONTRACTORS ONSITE NOTES:

Background: During the previous habitat assessment survey habitat was documented for Peregrine Falcons. The site is located partially on top of a steep ridge and partially within the valley below and between a number of deep canyons on both the east and west sides. Surveyors determined more suitable habitat exists on the east side and concentration their survey efforts along the eastern portion of the site.

Purpose: In areas where suitable habitat occurs, a formal survey of the species is to be performed following Navajo Nation survey protocols[1] outlined below:

Peregrine Falcons - Two 8 hours surveys (4 hours before sunset and 4 hours after sunrise the following day) during each period: 1 FEB-30 APR (surveys during egg-laying/incubation discouraged) & 1 MAY-31 JUL (2 survey preferably prior to JUL). Productivity surveys require >=1 additional visits.

Methods: Surveyors arrived at the eastern portion of the project site at 4:00 p.m. and conducted a thorough survey of the project area. Surveys included establishing appropriate vantage points, remaining at those points for 20 to 30 minutes listening for calls and using high powered binoculars to examine cliff faces for signs of nesting (ex. whitewash, nests, single or pairs of adults remaining in the area, etc.) and continued until approximately 8:00 p.m.

Additional Information: Tomorrow morning's survey will complete the second of two surveys required before April 30th.

Findings: No species of concern or note were seen or heard during the survey.

[1] Navajo Natural Heritage Program – Navajo Nation Endangered Species List- Species Accounts. 2008. http://www.nndfw.org/nnhp/species_acct.pdf

Adkins Consulting Inc.
Environmental Permitting Services

180 East 12 Street Suite #5
Durango, CO 81301
Phone: 505-793-1140

DAILY REPORT
Field Surveys

PROJECT NAME: NN AUM SITE: Eunice Becenti

DATE: 4/29/16

WEATHER: Cloudy, light snow, calm with winds at 0-3 mph, temps mid 30's

PERSONNEL ONSITE: Maria Adkins (Principal Biologist), Sarah Cowley (Field Assistant)

==

CONTRACTORS ONSITE NOTES:

Background: During the previous habitat assessment survey habitat was documented for Peregrine Falcons. The site is located partially on top of a steep ridge and partially within the valley below and between a number of deep canyons on both the east and west sides. Surveyors determined more suitable habitat exists on the east side and concentration their survey efforts along the eastern portion of the site.

Purpose: In areas where suitable habitat occurs, a formal survey of the species is to be performed following Navajo Nation survey protocols[1] outlined below:

Peregrine Falcons - Two 8 hours surveys (4 hours before sunset and 4 hours after sunrise the following day) during each period: 1 FEB-30 APR (surveys during egg-laying/incubation discouraged) & 1 MAY-31 JUL (2 survey preferably prior to JUL). Productivity surveys require >=1 additional visits.

Methods: Surveyors arrived at the eastern portion of the project site at 6:00 a.m. and conducted a thorough survey of the project area. Surveys included establishing appropriate vantage points, remaining at those points for 20 to 30 minutes listening for calls and using high powered binoculars to examine cliff faces for signs of nesting (ex. whitewash, nests, single or pairs of adults remaining in the area, etc.) and continued until approximately 9:50 a.m.

Additional Information: This completes the second of two required surveys before April 30th. Another set of two complete surveys (evening and following morning) are required before July 31st.

Findings: No species of concern or note were seen or heard during the survey.

[1] Navajo Natural Heritage Program – Navajo Nation Endangered Species List- Species Accounts. 2008. http://www.nndfw.org/nnhp/species_acct.pdf

THE NAVAJO NATION
HISTORIC PRESERVATION DEPARTMENT
PO Box 4950, Window Rock, Arizona 86515
TEL: (928) 871-7198 FAX: (928) 871-7886

CULTURAL RESOURCES COMPLIANCE FORM

ROUTE COPIES TO:	NNHPD NO.: HPD-16-565 - *REVISED*
☑ DCRM	OTHER PROJECT NO.: DCRM 2016-09

PROJECT TITLE: A Cultural Resource Inventory of Three Abandoned Uranium Mines for MWH Global, Inc.: (Eunice Becenti, Standing Rock, and Section 26 Desidero Group) in Church Rock, Nahodishgish, and Baca/Prewitt Chapters, Navajo Nation

LEAD AGENCY: BIA/NR

SPONSOR: Sadie Hoskie, Trustee, Navajo Nation AUM, Environmental Response Trust, PO Box 3330, Window Rock, Arizona 86515

PROJECT DESCRIPTION: The proposed undertaking will involve the removal site evaluations to define the horizontal extent of contamination in surface soil and sediments a three former uranium mine areas. The area of potential effect is 51.8-acres. Ground disturbing activities will be intensive and extensive with the use of heavy equipment.

LAND STATUS:	Navajo Tribal Trust													
CHAPTER:	Church Rock, Nahodishgish, Baca/Prewitt													
LOCATION:	*T.*	15	*N.,*	*R.*	17	*W*	*Sec.*	28;	Gallup East	Quadrangle,	McKinley	County	New Mexico	NMPM
	T.	18	*N.,*	*R.*	14	*W-*	*Sec.*	34/35;	Dalton Pass	Quadrangle,	McKinley	County	New Mexico	NMPM
	T.	13	*N.,*	*R.*	10	*W-*	*Sec.*	26;	Don Lomas	Quadrangle,	McKinley	County	New Mexico	NMPM

PROJECT ARCHAEOLOGIST:	Clifford Werito, Tristin Moone, Rena Martin, Arlo Werito with Klara Kelley and Harris Francis
NAVAJO ANTIQUITIES PERMIT NO.:	B16161
DATE INSPECTED:	5/2/2016 - 5/16/2016
DATE OF REPORT:	7/5/2016
TOTAL ACREAGE INSPECTED:	87.6 – ac
METHOD OF INVESTIGATION:	Class III pedestrian inventory with transects spaced 15 m apart.
LIST OF CULTURAL RESOURCES FOUND:	**(1) Site (NM-R-47-01); (4) Isolated Occurrences (IO), (2) In-Use Sites (IUS); (1) Traditional Cultural Property (TCP)**
LIST OF ELIGIBLE PROPERTIES:	**(1) TCP**
LIST OF NON-ELIGIBLE PROPERTIES:	**(1) Site (NM-R-47-01); (4) IO; (2) IUS**
LIST OF ARCHAEOLOGICAL RESOURCES:	**None**

:FFECT/CONDITIONS OF COMPLIANCE: No adverse effect with the following conditions:

;ite NM-R-47-01:
lo further work is warranted.

TCP:

1. TCP boundary will be marked/flagged by qualified archaeologist prior to remediation activities.
2. TCP will be avoided by all mining activities & a qualified archaeologist will monitor all activities within 100-at of the TCP.

If TCP cannot be avoided:

Mitigation measures will be initiated by the sponsor in consultation with NNHPD and with the Chee Bob Thompson family.

In the event of a discovery [*"discovery"* means any previously unidentified or incorrectly identified cultural resources including but not limited to archaeological deposits, human remains, or locations reportedly associated with Native American religious/traditional beliefs or practices], all operations in the immediate vicinity of the discovery must cease, and the Navajo Nation Historic Preservation Department must be notified at (928) 871-7198.

FORM PREPARED BY: **Tamara Billie**
FINALIZED: September 9, 2016

Notification to Proceed ☑ Yes ☐ No
Recommended
Conditions: ☑ Yes ☐ No

Tamara Billie · 9/9/16
The Navajo Nation Historic Preservation Office — Date

Navajo Region Approval ☒ Yes ☐ No

SEP 28 2016
BIA – Navajo Regional Office — Date
Acting

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.: Eunice Becenti - 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 4.7 acres.

LOCATION: 35°30'11"N 108°39'00"W, Church Rock Chapter, McKinley County, New Mexico

REPRESENTATIVE: Lori Gregory, Adkins Consulting, Inc. for MWH Global/Stantec

ACTION AGENCY: U.S. Environmental Protection Agency and Navajo Nation

B.R. REPORT TITLE / DATE / PREPARER: BE-Eunice Becenti Abandoned Uranium Mine Project/AUG 2016/Lori Gregory, Plant Survey Report for Species of Concern At Eunice Becenti Project Site/AUG 2016/Redente Ecological Consultants

SIGNIFICANT BIOLOGICAL RESOURCES FOUND: Area 3. Suitable nesting habitat is present in the project area for Migratory Birds not listed under the NESL or ESA. Migratory Birds and their habitats are protected under the Migratory Bird Treaty Act (16 USC §703-712) and Executive Order 13186. Under the EO, all federal agencies are required to consider management impacts to protect migratory non-game birds.

<u>POTENTIAL IMPACTS</u>

NESL SPECIES POTENTIALLY IMPACTED: NA

FEDERALLY-LISTED SPECIES AFFECTED: NA

OTHER SIGNIFICANT IMPACTS TO BIOLOGICAL RESOURCES: NA

AVOIDANCE / MITIGATION MEASURES: Mitigation measures will be implemented to ensure that there are no impacts to migratory birds that could potentially nest in the project area.

CONDITIONS OF COMPLIANCE*: NA

FORM PREPARED BY / DATE: Pamela A. Kyselka/10 NOV 2016

COPIES TO: (add categories as necessary)

☐ ____________________ ☐ ____________________

2 NTC § 164 Recommendation:	Signature	Date
☒Approval ☐Conditional Approval (with memo) ☐Disapproval (with memo) ☐Categorical Exclusion (with request letter) ☐None (with memo)	Gloria M. Tom, Director, Navajo Nation Department of Fish and Wildlife	11/16/16

*I understand and accept the conditions of compliance, and acknowledge that lack of signature may be grounds for the Department not recommending the above described project for approval to the Tribal Decision-maker.

Representative's signature Date

From:	Nystedt, John
To:	Justin Peterson
Cc:	Lori Gregory; Pam Kyselka; tbillie@navajo-nsn.gov; Harrilene Yazzie; Melissa Mata
Subject:	Navajo Nation AUM Environmental Response Trust - -First Phase
Date:	Monday, November 07, 2016 4:08:30 PM
Attachments:	image001.png

Justin,

Thank you for your November 6, 2016, email. This email documents our response regarding the subject project, in compliance with section 7 of the Endangered Species Act of 1973 (ESA) as amended (16 U.S.C. 1531 et seq.). Based on the information you provided, we believe no endangered or threatened species or critical habitat will be affected by this project; nor is this project likely to jeopardize the continued existence of any proposed species or adversely modify any proposed critical habitat. No further review is required for this project at this time. Should project plans change or if new information on the distribution of listed or proposed species becomes available, this determination may need to be reconsidered. In all future communication on this project, please refer to consultation numbers given below.

In keeping with our trust responsibilities to American Indian Tribes, by copy of this email, we will notify the Navajo Nation, which may be affected by the proposed action and encourage you to invite the Bureau of Indian Affairs to participate in the review of your proposed action.

Should you require further assistance or if you have any questions, please contact me as indicated below, or my supervisor, Brenda Smith, at 556-2157. Thank you for your continued efforts to conserve endangered species.

Claim 28	02EAAZ00-2016-SLI-0358
Section 26 (Desiddero Group)	02ENNM00-2016-SLI-0447
Mitten #3	06E23000-2016-SLI-0210
NA-0904	02EAAZ00-2016-SLI-0363
Occurrence B	02EAAZ00-2016-SLI-0361
Standing Rock	02ENNM00-2016-SLI-0448
Alongo Mines	02ENNM00-2016-SLI-0465
Tsosie 1*	02EAAZ00-2016-SLI-0364
Boyd Tisi No. 2 Western	02EAAZ00-2016-SLI-0355
Harvey Blackwater #3	02EAAZ00-2016-SLI-0356 / 06E23000-2016-SLI-0207
Oak 124/125	02ENNM00-2016-SLI-0466
NA-0928	02EAAZ00-2016-SLI-0360
Hoskie Tso #1	02EAAZ00-2016-SLI-0362
Charles Keith	06E23000-2016-SLI-0208
Barton 3	02EAAZ00-2016-SLI-0354
Eunice Becenti	02ENNM00-2016-SLI-0444

* It is our understanding that the Tsosie No. 1 site has been put on hold indefinitely due to access issues. However, provided the results of the survey were negative (i.e., no potential for

any ESA-listed species) then we would come to the same conclusion, above, as for the other 15 projects.

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Fish and Wildlife Biologist/AESO Tribal Coordinator
USFWS AZ Ecological Services Office - Flagstaff Suboffice
Southwest Forest Science Complex, 2500 S Pine Knoll Dr, Rm 232
Flagstaff, AZ 86001-6381 (928) 556-2160 Fax-2121 Cell:(602) 478-3797
http://www.fws.gov/southwest/es/arizona/

Appendix F Data Usability Report, Laboratory Analytical Data, and Data Validation Reports

F.1 Data Usability Report

F.2 Laboratory Analytical Data and Data Validation Reports

(provided in a separate electronic file due to its file size and length)

F.1 Data Usability Report

DATA USABILITY REPORT

1.0 INTRODUCTION

This data usability report presents a summary of the validation results for the sample data collected from the Eunice Becenti abandoned uranium mine (AUM) as part of the Removal Site Evaluation (RSE) performed for the Navajo Nation AUM Environmental Response Trust. The purpose of validation was to ascertain the data usability measured against the data quality objectives and confirm that results obtained are scientifically defensible.

Samples were collected between November 19, 2016 and September 16, 2017 and were analyzed by ALS Environmental of Ft. Collins, Colorado, for all methods. Samples were analyzed for one or more of the following:

- Radium-226 in soil by United States Environmental Protection Agency (USEPA) Method 901.1
- Metals in soil by USEPA Method SW6020
- Isotopic thorium in soil by USDOEAS-06/EMSL/LV

Samples were collected and analyzed according to the procedures and specific criteria presented in the *Quality Assurance Project Plan, Navajo Nation AUM Environmental Response Trust (QAPP),* (MWH 2016).

Project data were validated as follows:

- Laboratory Data Consultants, Inc. (LDC) of Carlsbad, California, performed validation of all radiological data, plus ten percent of the non-radiological data (Level IV only)
- All non-radiological data were validated by 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 data quality objects 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. Therefore, not all of the requested reporting limits can be met using the laboratory's routine protocol. The dilution is narrated by the laboratory merely as a matter of transparency, as well as for the validator's information. The dilution should have no impact on the project's sensitivity goals.

Sample Preservation Evaluation. All samples were preserved as specified in the QAPP.

Holding Time Evaluation. All analytical holding times were met.

Initial Calibration, Initial Calibration Verification, and Continuing Calibration Verification Evaluation. All ICAL, ICV, and CCV results were within acceptance criteria.

Method Blank Evaluation. No sample data were qualified due to method blank results.

Initial and Continuing Calibration Blank Evaluation. No sample data were qualified due to ICB/CCB data.

Matrix Spike/Matrix Spike Duplicate Samples Evaluation. All MS/MSD recoveries were within acceptance criteria with the exception of one metal. Table F.1-1 lists the analyte where an MS percent recovery was outside the acceptance criteria. The sample result was qualified with a "J-" flag to indicate the result is estimated and potentially biased low. 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 if not otherwise qualified 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, with the exception of results for five metals and three radium-226. The sample IDs, sample results, and RPDs for those results that did not meet the guidance RPD are listed in Table F.1-2. Sample results were not qualified due to RPDs exceeding the guidance criteria as described in the QAPP.

Minimum Detectable Concentration Evaluation. All minimum detectable concentrations met reporting limits with the exception of thirteen samples for the analysis of radium-226. However, the reported activity for each of these samples was greater than the achieved minimum detectable concentration and no qualification was needed.

Reporting Limit Evaluation. All sample data were reported to the reporting limit established in the QAPP, with the exception of the metals, as discussed at the beginning of this section related to dilution.

Sample Result Verification. All sample result verifications were acceptable with the exception of sixteen samples analyzed for radium-226. 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 qualified.

Representativeness. Based on the results of the sample preservation and holding time evaluation, the method and ICB/CCB blank sample results, the field duplicate sample evaluation, and the RL evaluation, the data are considered representative of the Site as reported.

Completeness. All media and QC sample results were valid and collected as scheduled; therefore, completeness for this RSE is 100 percent.

Comparability. Standard methods of sample collection and standard units of measure were used during this project. The analysis performed by the laboratory was in accordance with current EPA 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
Eunice Becenti
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
S313-BG1-008	11/19/16	E901.1	Radium-226	8.7	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S313-SCX-004-1	5/17/17	SW6020	Uranium	2.9	mg/kg	MS LR	8% 21%	75% - 125% 20%	J-	Result is estimated, potentially biased low. MS recovery below acceptance criteria. LR RPD outside acceptance criteria.
S313-SCX-004-3	5/17/17	E901.1	Radium-226	0.86	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S313-SCX-016-3	5/17/17	E901.1	Radium-226	6.32	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S313-SCX-001-1	5/16/17	E901.1	Radium-226	2.58	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S313-SCX-001-2	5/16/17	E901.1	Radium-226	9.3	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S313-SCX-001-3	5/16/17	E901.1	Radium-226	11.1	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S313-BG2-002	9/15/17	SW6020	Molybdenum	3.2	mg/kg	LR	54%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S313-BG2-002	9/15/17	SW6020	Arsenic	6.8	mg/kg	LR	53%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S313-BG2-002	9/15/17	SW6020	Uranium	1.6	mg/kg	LR	54%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S313-BG2-002	9/15/17	SW6020	Vanadium	23	mg/kg	LR	50%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S313-BG2-011-02	9/15/17	E901.1	Radium-226	2.94	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
LCS laboratory control sample
LR laboratory replicate (duplicate)
MS matrix spike
RPD relative percent difference

Table F.1-1
Summary of Qualified Data
Eunice Becenti
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
S313-BG3-001	9/15/17	E901.1	Radium-226	1.28	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S313-BG3-010	9/15/17	E901.1	Radium-226	0.89	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S313-BG3-204	9/15/17	E901.1	Radium-226	1.38	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S313-BG3-004	9/15/17	E901.1	Radium-226	1.17	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S313-BG3-005	9/15/17	E901.1	Radium-226	1.84	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S313-BG3-008	9/15/17	E901.1	Radium-226	1.12	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S313-BG3-009	9/15/17	E901.1	Radium-226	0.71	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S313-BG4-011-02	9/15/17	E901.1	Radium-226	1.38	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S313-BG4-007	9/15/17	E901.1	Radium-226	1.25	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
LCS laboratory control sample
LR laboratory replicate (duplicate)
MS matrix spike
RPD relative percent difference

Table F.1-2
Results that did not Meet the Relative Percent Difference Guidance
Eunice Becenti
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Primary Sample / Duplicate Indentification	Sample Date	Parameter	Primary Result	Duplicate Result	Units	RPD (%)
S313-SCX-003-1/S313-SCX-203-1	5/16/2017	Radium-226	2.49	3.98	pCi/g	46
S313-SCX-012-1/S313-SCX-212-1	5/17/2017	Selenium	2.9	2.0	mg/kg	37
S313-SCX-020-1/S313-SCX-220-01	9/16/2017	Radium-226	3.71	2.01	pCi/g	59
S313-BG2-004/S313-BG2-204	9/15/2017	Radium-226	1.03	1.58	pCi/g	42
S313-BG3-004/S313-BG3-204	9/15/2017	Molybdenum	1	0.73	mg/kg	31
S313-BG5-002/S313-BG5-202	9/16/2017	Arsenic	3.2	4.50	mg/kg	34
S313-BG5-002/S313-BG5-202	9/16/2017	Molybdenum	0.4	0.57	mg/kg	35
S313-BG5-002/S313-BG5-202	9/16/2017	Vanadium	16	34	mg/kg	72

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
RPD relative percent difference