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NA-0904 (#59)
Removal Site Evaluation Report

Final | September 28, 2018



Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

NA-0904 (#59) Removal Site Evaluation Report - Final

September 28, 2018

Prepared for:

Navajo Nation AUM Environmental Response Trust – First Phase

Prepared by:

Stantec Consulting Services Inc.

Title and Approval Sheet

Title: NA-0904 Removal Site Evaluation Report - Final

Approvals

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

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1	September 28, 2018	Submission of Final RSE report to Agencies

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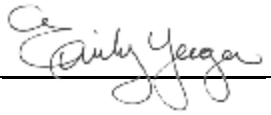
AUM Environmental Response Trust – First Phase

Sign-off Sheet

This document entitled *NA-0904 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 

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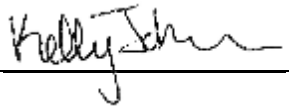
Reviewed by 

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LIST OF ATTACHMENTS – PROVIDED ELECTRONICALLY TO THE AGENCIES

- Site-specific geodatabase
- Tabular database files
- 2017 Cooper aerial survey orthophotographs and data files
- Historical documents referenced in this RSE Report (refer to Section 7 for complete citation)
    - Chenoweth and Malan, 1973 – The Uranium Deposits of Northeastern Arizona
    - Chenoweth, 1984 – Historical Review of Uranium-Vanadium Production in the Eastern Carrizo Mountains, San Juan County, New Mexico, and Apache County, Arizona
    - Chenoweth, 1985 – Historical Review Uranium-Vanadium Production in the Northern and Western Carrizo Mountains, Apache County, Arizona

- Hendricks, 2001 – An Aerial Radiological Survey of Abandoned Uranium Mines in the Navajo Nation
- NAML, 1992 – Field Activity Reports for 1992, NAML Division of Natural Resources
- NAML, 2000 – Memorandum from Melvin Yazzie, Reclamation Specialist III Navajo AML Reclamation Department. Re: Tse Tah AML site tour
- NAML, 2004 – Reclamation Status List prepared by Melvin Yazzie. Skey = S02190401
- USDOI, n.d. – Construction Grant Application issued to the Navajo Abandoned Mine Lands Reclamation Department
- USEPA, 2007a – Abandoned Uranium Mines and the Navajo Nation. Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data
- Weston Solutions, 2010 - NA-0904 AUM Site Navajo Abandoned Uranium Mine Site Screen Report

Executive Summary

Introduction

The NA-0904 site (the Site) is located within the Navajo Nation, Shiprock Bureau of Indian Affairs (BIA) Agency, Sweetwater Chapter in northeastern Arizona, near the border of Arizona and Utah. 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 July 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.

[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. The Site is located in-between Toh Atin Mesa and the Carrizo Mountain mining region. Bedrock on the Site consists of the Jurassic Morrison Formation. The Morrison Formation produced approximately 4.7 million pounds of uranium from areas of Arizona and New Mexico (USEPA, 2007a). The Site is also located within the San Juan River watershed, an area of approximately 24,600 square miles spanning Utah, Colorado, New Mexico, and Arizona. Topographically the Site is located on a mesa top, mesa sidewall, and plains with elevation ranges from 5,650 ft above mean sea level (amsl) to 5,850 ft amsl. On-site overland surface water flow, when present, is controlled by a decrease in elevation to the northwest from the mesa top to the surrounding plains.

Site-specific historical mining information is minimal and the only such information discovered was reported in the *2007 AUM Atlas* (USEPA, 2007a). The *2007 AUM Atlas* reported the Site was reclaimed. Ore production information pertaining to the Site was not identified. However, an important consideration is that even though ore production information pertaining to the Site was not identified, the *2007 AUM Atlas* reported that sometimes production from multiple mines was reported as a single combined value for one of the mines. In these cases, the mines were included on a single lease, and the ore production reported was inclusive of all of the mines on that single lease (USEPA, 2007a). It is unknown if the Site was part of a multi-mine lease but, it is possible that ore could have been mined from the Site, and combined with reports from other mine ore productions, for a combined reported production value.

Between 1991 and 1992, Navajo Abandoned Mine Lands Reclamation Program (NAML) reported the following reclamation activities were completed at one portal on-site:

- Blasting an area around the portal. The reason this area was blasted was not provided in the field notes.
- Backfilling the adit with waste material to within 3 ft of the portal and then filling the remaining 3 ft with "uncontaminated" material.
- Constructing a bulkhead in the portal.
- Reseeding the area disturbed during reclamation activities.

In 2004, the Site was listed as reclaimed (NAML, 2004). In 2010, Weston Solutions (Weston) performed site screening on behalf of the USEPA. The screening included: (1) recording site observations (i.e., number of homes, water sources, and sensitive environments[2] around the Site);

[2] 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) 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, and well water 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. The results of the well water analyses were used to evaluate mining impacts to well water.

Findings and Discussion

Surface and subsurface soil and sediment sampling results. Three background reference areas were selected to develop surface gamma, subsurface static gamma, Ra-226, and metals ILs for the Site. Arsenic, molybdenum, uranium, vanadium, and Ra-226 concentrations and gamma radiation measurements in soil/sediment exceeded their respective ILs and are confirmed constituents of potential concern (COPCs) for the Site. An IL for selenium was not identified because selenium sample results were non-detect in the background areas. However, because

selenium was detected in soil/sediment samples from the Survey Area (i.e., the full areal extent of the Site surface gamma survey), it is also confirmed as a COPC for the Site. Based on the data analyses performed for this report along with the multiple lines of evidence, approximately 9.2 acres, out of the 29.3 acres of the Survey Area (i.e., the full areal of the Site surface gamma survey), were estimated to contain TENORM. Of the 9.2 acres that contain TENORM, 5.6 acres contain TENORM exceeding the surface gamma ILs. The volume of TENORM in excess of ILs was estimated to be 11,144 yd^3 (8,520 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.

Water sampling results. Water samples were collected from one water well. Analytical results indicated the well water sample had total and dissolved arsenic concentrations which exceeded the arsenic IL. All other metals and radionuclides were below their respective ILs. Results of general chemistry parameters indicated that total dissolved solids (TDS) was also above its respective IL. All other general chemistry parameter results were below their respective ILs. Based on these results arsenic and TDS are confirmed COPCs for the water well. Because arsenic and TDS exceeded their respective ILs for the well water sample additional characterization may be considered in the future.

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

Acronyms/Abbreviations

°F	degrees Fahrenheit
e.g.	exempli gratia
etc.	et cetera
ft	feet
ft^2	square feet
i.e.	id est
mg/kg	milligram per kilogram
µg/L	micrograms per liter
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
cpm	counts per minute
Dinétahdóó	Dinétahdóó Cultural Resource Management
DMP	Data Management Plan
DQO	Data Quality Objective
ERG	Environmental Restoration Group, Inc.
ESA	Endangered Species Act
FSP	Field Sampling Plan
GIS	geographic information system
GPS	global positioning system
HASP	Health and Safety Plan
ICAL	initial calibration
ICB/CCB	initial/continuing calibration blank
ICV	initial calibration verification
IL	Investigation Level
LCS/LCSD	laboratory control sample/laboratory control sample duplicate

MARSSIM	Multi-agency Radiation Survey and Site Investigation Manual
MBTA	Migratory Bird Treaty Act
MCL	maximum contaminant level
MLR	Multivariate Linear Regression
MS/MSD	matrix spike/matrix spike duplicate
MWH	MWH, now part of Stantec Consulting Services Inc. (formerly MWH Americas, Inc.)
NaI	sodium iodide
NAML	Navajo Abandoned Mine Lands Reclamation Program
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NNDFW	Navajo Nation Department of Fish and Wildlife
NNDOJ	Navajo Nation Department of Justice
NNDNR	Navajo Nation Division of Natural Resources
NNDWR	Navajo Nation Department of Water Resources
NNEPA	Navajo Nation Environmental Protection Agency
NNESL	Navajo Nation Endangered Species List
NNHP	Navajo Natural Heritage Program
NNHPD	Navajo Nation Historic Preservation Department
NNPDWR	Navajo National Primary Drinking Water Regulation
NORM	Naturally Occurring Radioactive Material
NSDWR	National Secondary Drinking Water Regulation
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
R2	Pearson's Correlation Coefficient
Ra-226	Radium-226
Ra-228	Radium-228
Redente	Redente Ecological Consultants
RSE	Removal Site Evaluation
SOP	standard operating procedure
Stantec	Stantec Consulting Services Inc.
T&E	threatened and endangered
Th-230	thorium-230
Th-232	thorium-232
TDS	total dissolved solids
TENORM	Technologically Enhanced Naturally Occurring Radioactive 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
VCA	Vanadium Corporation of America
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.

Bulkhead – an engineered wall placed inside a mine portal/adit to close the portal/adit.

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.

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

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

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

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

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

Pan Evaporation – evaporative water losses from a standardized pan.

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

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

Radium-228 (Ra-228) – a radioactive isotope of radium that is produced by the natural decay of uranium.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1.0 INTRODUCTION

1.1 BACKGROUND

This report summarizes the purpose and objectives, field investigation activities, findings, and conclusions of Site Clearance and Removal Site Evaluation (RSE) activities conducted between July 2015 and September 2017 at the NA-0904 site (the Site) located in northeastern Arizona, near the border of Arizona and Utah, 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 #59 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 11.1 acres (483,516 square feet [ft^2]) and was provided as part of the *2007 AUM Atlas*. Per the *2007 AUM Atlas* this polygon and other factors represent the location and surface extent of the AUM.

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

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

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

The Site is one of 46 priority AUMs within the Navajo Nation selected by the USEPA in collaboration with the NNEPA for further evaluation based on radiation levels and potential for water contamination (USEPA, 2013). The 16 priority AUMs included in the *Trust Agreement* are located on Navajo Lands throughout southeastern Utah, northeastern Arizona, and western New Mexico, as shown in Figure 1-1. The 16 priority AUMs were selected by the US and Navajo Nation, as described in the *Trust Agreement*:

> "based on two primary criteria, specifically, demonstrated levels of Radium-226[3]: (a) at or in excess of 10 times the background levels and the existence of a potentially inhabited structure located within 0.25 miles of AUM features; or (b) at or in excess of two times background levels and the existence of a potentially inhabited structure located within 200 feet (ft)." *Trust Agreement*, Recitals.

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

1.2 OBJECTIVES AND PURPOSE OF THE REMOVAL SITE EVALUATION

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

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

An understanding of the extent and volume of TENORM that exceeds the ILs at the Site is key information for future Removal or Remedial Action evaluations, including whether, and to what extent, a Response Action is warranted under federal and Navajo law. Definitions presented in the glossary for "Removal", "Remedial Action", and "Response" are defined in 40 Code of Federal Regulations (CFR) Section 300.5 of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP; USEPA, 1992).

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

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

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

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

Site Clearance field activities – included the following:

- Site reconnaissance to evaluate in the field: access routes to the Site, location of site boundaries, and observations presented in the Weston Solutions (Weston)(2010) 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/sediment 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.
- Characterization of well water – well water sampling and laboratory analyses. Investigation of groundwater is not included in the scope of this RSE.

Details regarding the Site Clearance activities are provided in the *NA-0904 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 *NA-0904 Site Baseline Studies Field Report* (Stantec, 2017) and summarized in Section 3.3 of this report. Details regarding the Site Characterization Activities and Assessment are provided in Section 3.3 of this report. Findings are presented in Section 4.0 of this report.

1.3 REPORT ORGANIZATION

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

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

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

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

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

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

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

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

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

Tables Included at the end of this RSE report.

Figures Included at the end of this RSE report.

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

- **Appendix A** – Includes the radiological characterization report 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 near the border of Arizona and Utah and approximately 6 miles southeast of Red Mesa, Arizona, as shown in Figure 1-1 inset. Site-specific historical mining information is minimal and the only such information discovered was reported in the *2007 AUM Atlas*. The *2007 AUM Atlas* reported the Site was reclaimed. Ore production information pertaining to the Site was not identified. However, an important consideration is that even though ore production information pertaining to the Site was not identified, the *2007 AUM Atlas* reported that sometimes production from multiple mines was reported as a single combined value for one of the mines. In these cases, the mines were included on a single lease, and the ore production reported was inclusive of all of the mines on that single lease (USEPA, 2007a). It is unknown if the Site was part of a multi-mine lease but, it is possible that ore could have been mined from the Site, and combined with reports from other mine ore productions, for a combined reported production value[4].

The only other historical information found was for other AUMs located within the same mining region as the Site, in-between Toh Atin Mesa and the Carrizo Mountain mining region. Therefore, information regarding historical mining practices and background for the Site are presented on a regional level (i.e., the Toh Atin Mesa, within the Carrizo Mountain mining region). A summary of historical mining on the Carrizo Mountain region is presented below.

During the 1920s and 1930s, mining on the Navajo Nation primarily focused on vanadium mining. In November 1920, the first recorded shipment of uranium and vanadium ore was shipped from the Carrizo Mountain mining region (Chenoweth, 1984 and Chenoweth, 1985). Between 1942 and 1944, Vanadium Corporation of America (VCA) operated numerous vanadium mines in the Carrizo Mountain mining region. By 1945, mines in the Carrizo Mountain region became inactive due to the decreased market for vanadium.

After 1947, prospecting and mining for uranium increased in the Carrizo Mountains region. In light of new regulations, exploration drilling by both the US Atomic Energy Commission (USAEC) and uranium mining companies increased in 1953 and additional ore bodies were discovered. To fill the USAEC's need for uranium, VCA reopened its inactive vanadium mines in the Carrizo Mountain region and began mining them for uranium. During the mid-1950s, there were more mining operations in the northern and western Carrizo Mountains than at any other time, resulting in large mines, as well as numerous small mining operations throughout the Carrizo Mountain mining region. The final ore shipment from the Carrizo Mountain mining region was

[4] USEPA (2007a) noted that occasionally the ore mined from multiples sites within one lease were reported collectively. Thus it is possible, but less likely, that ore was mined from NA-0904 but reported for a different mine.

sent June 1968 (Chenoweth, 1984 and Chenoweth, 1985). Chenoweth and Malan (1973) reported that the total ore production from the northwestern Carrizo Mountain mining region was 27.4 tons (approximately 54,800 pounds) of ore containing 0.21 percent U_3O_8 (uranium oxide) and 1.54 percent V_2O_5 (vanadium oxide). The northwestern Carrizo Mountain mining region was inclusive of 36 properties located on the Toh Atin Mesa. The Site was not included in the report prepared by Chenoweth and Malan; however, four other historical AUMs surrounding the Site were included in the report: Plot 1, Plot 2, McKenzie 3, and Silentman 1 (refer to Figure 2-1) (Chenoweth and Malan, 1973).

2.1.2 Ownership and Surrounding Land Use

The Site is located within the Navajo Nation, Shiprock Bureau of Indian Affairs (BIA) Agency in Section 1 of Township 40 North, Range 28 East, Gila and Salt River Principal Meridian. Land ownership where the Site is located falls under Navajo Trust lands. The Site is located within the Sweetwater Chapter of the Navajo Nation, as shown in Figure 1-1, and is in Grazing Unit 9, as designated by the Navajo Nation Division of Natural Resources (NNDNR, 2006). The Site is currently uninhabited, and no home-sites are located within 0.25 miles of the Site, as shown in Figure 2-1. However, three home-sites are located northwest of and within 1.0 mile of the Site, as shown in Figure 2-1.

2.1.3 Site Access

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

2.1.4 Previous Work at the Site

2.1.4.1 1991 Construction Grant

Prior to 1991, the US Department of the Interior Office of Surface Mining issued a construction grant application to NAML for the 1991 fiscal year (USDOI, n.d.). The date the grant was issued is unknown. The purpose of the grant was to provide financial funding to NAML for the construction phase of reclamation activities at 176 historical mining features (e.g., portals, adits, incline shafts, etc.) related to historical uranium mining activities that occurred in the Tse Tah area. The grant divided the 176 historical mining features into nine project areas. The acreage inclusive of the Site was referred to as project area NC-0004 and included three mining features: two adits and one incline shaft (refer to maps included in NAML, 2000). The incline shaft was numbered as mining feature #164 and the two adits were numbered as mining features #165 and #166 (refer to maps included in NAML, 2000). The grant listed that the following reclamation activities were needed for the nine project areas (USDOI, n.d.):

- Close 55 adits/portals and two vertical openings. Any partially or completely backfilled adits/portals would be reopened and then properly sealed by backfilling the adits/portals with on-site waste material to a depth not to exceed the maximum reach of the construction machinery. Once the adit is backfilled, construct an 18-inch-thick concrete wall bulkhead to seal the portal using natural rock material. Backfill the exterior of the bulkhead, using uncontaminated material obtained from a predesignated borrow area, and contour the backfill to blend with the natural topography. Transport any excess waste material to a centralized disposal site.

- Consolidate scattered radiological material piles away from washes and drainages.

- Revegetate disturbed grazing lands.

- Remove or minimize the danger associated with 48 high-walls.

2.1.4.2 1992 Reclamation Progress

Between February and April 1992, NAML reported the reclamation progress in field notes (NAML, 1992). In the field notes the Site was referred to as NC-0004 and the individual mining features associated with the Site were referred to as #164, #165, and #166. The following activities were reported in the field notes, by date of NAML site visit:

- February 28, 1992 – "At NC-0004; inclined shaft #164 was backfilled and area prepared for bulkheading".

- March 19, 1992 – "NC-0004: Bulkhead and subsequent backfill is complete; but still need to establish diversion berms around site. Site #166 is ready for drilling and blasting activities".

- March 20, 1992 – "Drilling at area of NC-0004 site #166. Used 0.75 inch bit rock drill with maximum depth of 16 ft. Drilled 12 holes and used gel-max to shoot the back down-shot, real good collapse in place and shot one more time to break up boulder top highwall above portal. Site #166 closed."

- March 23, 1992 – Dump truck driver hauling "clean dirt" up to site #164 all day.

- April 27, 1992 – "The inclined shaft site #164 is completely backfilled and covered with clean material. Two berms has *(sic)* been emplaced to aid in erosion protection and to keep the surface drainage away from the reclaimed site. Site #165-166 portal opening have *(sic)* been blasted shut and slope with medium sized boulders. The access road leading to the site have *(sic)* one berm emplaced to discourage future use. The disturb *(sic)* area was grid to 20 ft intervals and followed with radiological reading at one meter and contact. Most of the readings does *(sic)* not exceed the recommended cleanup standard."

2.1.4.3 1994 through 1999 Aerial Radiological Surveys

Between 1994 and 1999, aerial radiological surveys were conducted at 41 geographical areas within the Navajo Nation, including the Tsetah Wash area, which included the location of the Site (Hendricks, 2001). The surveys were done at the request of the USEPA Region 9 and were performed by the Remote Sensing laboratory, a US Department of Energy facility, National

Nuclear Security Administration Nevada Operations Office. The intent of the surveys was to characterize the overall radioactivity levels and excess bismuth-214 activity (i.e., a radioisotope that is an indicator of uranium ore deposits and/or uranium mines) within the surveyed areas. Data collected from the surveys was used to assess the risks (i.e., average gross exposure rate) in mined areas and to determine what action, if any, was needed.

The aerial radiological survey for the Tsetah Wash area covered approximately 16.8 square miles and included the location of the Site. The aerial radiological survey results for the area within a 0.25 mile radius of the Site indicated a gross exposure rate range of 5 µR/hr to 12 µR/hr and excess bismuth (i.e., bismuth activity greater than approximately 3.5 µR/hr) present in approximately 0.0001 square miles (0.09 acres) of the area (*2007 AUM Atlas*). The aerial radiological survey results for the Tsetah Wash area indicated a gross exposure rate range of 3.54 µR/hr to 38.62 µR/hr and excess bismuth (i.e., bismuth activity greater than approximately 3.5 µR/hr) present in approximately 0.11 square miles of the 16.8 square miles of the Tsetah Wash flight area (Hendricks, 2001).

2.1.4.4 2004 Reclamation Status

In 2004, NAML provided a reclamation status list for sites located in the Tse Tah area (NAML, 2004). The Site was listed as reclaimed and was referred to as NA-0904 inclusive of #164, #165, and #165.

2.1.4.5 2010 Site Screening

In 2010, Weston performed site screening on behalf of the USEPA (Weston, 2010). The screening included: (1) recording site observations (i.e., number of homes, water sources, and sensitive environments[5] around the Site); (2) recording the type, number, and reclamation status of mine features; and (3) performing a surface gamma survey. Weston reported one home-site was within 0.25 miles of the Site, one windmill well within a one-mile radius of the Site and located 0.20 miles northeast of the Site, and no sensitive environments were identified. Weston also reported the Site was reclaimed and identified one un-reclaimed waste pile that measured 50 ft by 100 ft by 5 ft. Based on Weston's performance of a surface gamma survey, Weston determined that the highest gamma measurements were greater than 29 times the site-specific background level used for its gamma screening.

2.2 PHYSICAL CHARACTERISTICS

2.2.1 Regional and Site Physiography

The Site is located within the Colorado Plateau physiographic province, which is an area of approximately 240,000 square miles in the Four Corners region of Utah, Colorado, Arizona, and New Mexico. Figure 2-2 presents a current regional aerial photograph (NAIP, 2018) of the Site

[5] 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"

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 central 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. Figure 2-4 presents the Site topography (Cooper Aerial Surveys Company [Cooper; refer to Section 3.2.2.1]) within a portion of the Colorado Plateau. The Site is located on a mesa top, mesa sidewall, and plains with elevation ranges from 5,650 ft above mean sea level (amsl) to 5,850 ft amsl (refer to Figure 2-4).

2.2.2 Geologic Conditions

2.2.2.1 Regional Geology

Regionally the Site is located within the Colorado Plateau, which is a massive outcrop of generally flat-lying sedimentary rocks ranging in age from the Paleozoic Era to the Cenozoic Era (USGS, 2017). The plateau has very little regional structural deformation, compared with the mountainous basin-and-range region to the west, and the sedimentary beds range widely in thickness from less than one inch to hundreds of feet. Changes in paleoclimate and elevation produced alternating occurrences of deserts, streams, lakes, and shallow inland seas; and these changes contributed to the type of rock deposited in the region. The rock units of the plateau consist of shallow submarine or sub-aerially deposited rocks including sandstone, shale, limestone, mudstone, siltstone, and various other sedimentary rock subtypes.

Bedrock on-site consists of the Jurassic Summerville Formation and the Jurassic Salt Wash Member of the Morrison Formation. Regionally, the Summerville Formation is of marginal marine and tidal origin composed of reddish-brown, thinly bedded sandstone with interbedded gypsiferous siltstone, sandy siltstone, or mudstone and is known for its thin beds of rippled sandstones and mud cracks (University of Utah, 2018). Regionally, the Morrison Formation is composed of various rocks of lacustrine and fluvial continental origin, including mudstone, sandstone, limestone, and siltstone (USGS, 1967). Figure 2-5 depicts a regional geology map showing the Site in relation to the regional extent of the Morrison Formation. The sandstone strata of the Morrison Formation contains the majority of uranium ore reserves in the US. Deposition of the Morrison Formation may have coincided with uplift of the western basin-and-range region

and the beginning of the Nevadan orogeny. The Morrison Formation covers an area of approximately 600,000 square miles (USGS, 1967) and is centered in Wyoming and Colorado, with outcrops in Canada, Montana, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, Utah, Idaho, New Mexico, and Arizona (Turner and Peterson, 2004). Approximately 4.7 million pounds of uranium was mined from the Morrison Formation within areas of Arizona and New Mexico (USEPA, 2007a).

2.2.2.2 Site Geology

Bedrock outcrops on or adjacent to the Site consist of the Jurassic Salt Wash Member of the Morrison Formation and the Jurassic Summerville Formation, as shown in Figure 2-6a. The Salt Wash Member of the Morrison Formation consists of white and moderate-orange, very fine-to medium-grained sandstone, and grayish-red shale. The Summerville Formation consists of reddish-brown to light-orange very fine- to fine-grained flat bedded silty sandstone and thin-bedded silty sandstone, claystone, and siltstone. The transition between the Summerville Formation and the Quaternary deposits on-site is not a defined boundary and the Summerville Formation is often overlain by the Quaternary deposits. A geologic profile across the plains, mesa sidewall, and mesa top of the Site is shown in Figure 2-6a. Shallow or outcropping mineralized bedrock on-site is shown in Figure 2-6b.

Unconsolidated deposits on-site are alluvium, colluvium, and eolian deposits consisting of variable amounts of silt, sand, and gravel. During the Site Characterization field activities, boreholes were advanced through the unconsolidated deposits using a hand auger until termination within native material or termination due to refusal at bedrock (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 greater than 2.0 ft below ground surface (bgs).

According to the US Department of Agriculture (USDA) Soil Survey for Apache County, Arizona, soils on-site that have not been disturbed are classified as Shinume soil consisting of eolian soil derived from sandstone (USDA, 2011).

2.2.3 Regional Climate

The Colorado Plateau is located in a zone of arid temperate climates characterized by periods of drought and irregular precipitation, relatively warm to hot growing seasons, and winters with sustained periods of freezing temperatures (National Park Service, 2017). The average monthly high temperature at weather station 028468, Teec Nos Pos, Arizona (Western Regional Climate Center, 2017) located approximately 12 miles northeast of the Site, ranges between 41.5 degrees Fahrenheit (°F) in January to 93.1°F in July. Daily temperature extremes reach as high as 105°F in summer and as low as 18°F in winter. Teec Nos Pos receives an average annual precipitation of 8.1 inches, with August being the wettest month, averaging 1.16 inches, and June being the driest month, averaging 0.26 inches.

Potential evaporation in the area is greater than the area's average annual precipitation. The potential evaporation noted at the Many Farms School, Arizona weather station, located

approximately 41 miles southwest of the Site, averages 91 inches of pan evaporation annually (Western Regional Climate Center, 2017). Average wind speeds in the area are generally moderate, although relatively strong winds often accompany occasional frontal activity, especially during late winter and spring months. Blowing dust, soil erosion, and local sand-dune migration/formation are common during dry months. The Cortez, Colorado airport, located approximately 50 miles to the northeast of the Site, had the most complete record of wind conditions. A wind rose for the Cortez 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 east-northeast (refer to the wind rose on Figure 1-1). However, Stantec field personnel (field personnel) generally observed wind from the west when in the area of the Site.

2.2.4 Surface Water Hydrology

The Site is located within the San Juan River watershed, an area of approximately 24,600 square miles spanning Utah, Colorado, New Mexico, and Arizona, as shown in Figure 1-1. On-site surface water flow (i.e., overland flow), when present, is controlled by a decrease in elevation to the northwest from the mesa top to the surrounding plains (refer to Figures 2-4 and 2-7). Numerous sub-parallel patterned ephemeral drainages are present on-site that drain from the base of the mesa sidewall, to the north-northwest, and join together into an unnamed drainage that drains to the northeast, as shown in Figure 2-1.

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

2.2.5 Vegetation and Wildlife

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

Vegetation communities found within the physiographic transitional area described in Section 2.2.1 include shrublands with big sagebrush, rabbitbrush, winterfat, shadscale saltbush, and greasewood; and grasslands of blue grama, western wheatgrass, green needlegrass, and needle-and-thread grass. Higher elevations may support pinyon pine and juniper woodlands. The primary plant community on-site is pinyon-juniper (refer to Appendix E). During the surveys, Stantec and/or its subcontractors observed on-site wildlife including common raven, cottontail rabbit, coyote, mule deer, turkey vulture, and prairie falcon (refer to Appendix E).

2.2.6 Cultural Resources

In April 2016, as part of Site Clearance activities, Dinétahdóó Cultural Resource Management (Dinétahdóó), under contract to Stantec, conducted a cultural resource survey, as well as ethnographic and historical data reviews (Dinétahdóó, 2016). During the cultural resource survey Dinétahdóó identified one archaeological site and two isolated occurrences. Dinétahdóó did not identify any local residents to interview regarding the Site. Appendix E includes a copy of the *Cultural Resource Compliance Form,* and findings of the cultural resource survey are summarized in Section 3.2.2.4.

2.2.7 Observations of Potential Mining and Reclamation

During RSE activities, field personnel observed the following features indicative of potential mining or reclamation activities at the Site: a reclaimed portal location, potential haul roads, and waste piles. Details regarding these observations are presented in Section 3.2.2.1.

On July 28, 2017 a representative from NAML confirmed via email that the following reclamation activities had occurred:

- Sealed portal and inclined shaft (located potentially on top of the mesa were reopened and re-secured with 18 inch thick concrete bulkhead constructed at main portal using cinder blocks

In this email, NAML also confirmed that field notes mentioning a surface grade of 3 ft above the water table were incorrect, because the water table was not part of consideration for this Site.

On September 14, 2017 a representative from NAML met with field personnel on-site to verify what/where reclamation activities had occurred. NAML verified the following (refer to Figure 2-7 and Section 2.1.4):

- The portal location, along the portal access ramp, included two entrances that accessed one adit.
- The portal was blasted closed after a bulkhead was constructed.
- The location of the inclined shaft could not be identified. NAML personnel stated that a shaft was backfilled and closed, and that it was possible that the inclined shaft met up with the adit that was accessed by the portal on the ramp.
- The location of the portion of the haul road that was used to access the ramp and portal.

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

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

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

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

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

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

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

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

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

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

Sections 3.2 and 3.3 summarize the 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, Appendix C.2 includes borehole logs, and Appendix C.3 includes water sample field forms.

3.2 SUMMARY OF SITE CLEARANCE ACTIVITIES

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

3.2.1 Desktop Study

The desktop study included:

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

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

- Historical photographs (USGS, 2016) for the Site were selected from 1949, 1976, 1992, and 1997 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 1997 and the current 2017 image. There are only minor differences between the two images. The 1997 historical photograph was presented because it provided the best resolution of what the Site looked like after reclamation occurred on-site.

- The current aerial photograph review confirmed that the Site was uninhabited and no home-sites were located within 0.25 miles of the Site. However, three home-sites are located northwest of and within 1.0 mile of the Site, as shown in Figure 2-1. Numerous dirt roads were identified within 0.25 miles of the Site, refer to Figure 2-2. 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).

- Five potential water features were identified based on the review of information provided by the NNDWR and the *2007 AUM Atlas*, refer to Table 3-1a, Table 3-1b, and Figure 2-1.

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

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 2-7, were marked in the field with stakes and/or flagging and mapped with a global positioning system (GPS).

- Drainages – Numerous sub-parallel ephemeral drainages were mapped, as shown in Figures 2-1 and 2-7. The drainages originated from the base of the mesa sidewall and drained primarily to the north where they joined together into an unnamed drainage that drained to the northeast. Site drainages are shown in Appendix B-1 photograph numbers 2, 8, 10, and 11.

- Topographic features – The mapped area can be divided into three primary topographic areas, as shown in Figure 2-4: mesa top, mesa sidewall, and plains. Site topography is shown in Appendix B-1 photograph numbers 5, 6, 7.

- Portal – One reclaimed portal was mapped, as shown in Figure 2-7. The sealed portal was covered with rock of various sizes, as shown in Appendix B-1 photograph number 1.

- Waste pile – Three waste piles were mapped (Waste Pile 1 through Waste Pile 3), as shown in Figure 2-7. Waste Pile 1 was located downslope from the portal, along the base of the mesa sidewall, and into the plains and a drainage that drains north. Waste Piles 2 and 3 were located on the mesa top. Field personnel observed that Waste Pile 1 appeared to be around 0.5 to 3 ft deep, based on a visible color change between the gray waste rock material and the red material below the waste pile, and Waste Piles 2 and 3 were generally less than 1 ft deep and consisted of scattered waste rock. The three waste piles are also shown as earthworks in Figure 2-6b. Waste Pile 1 is shown in Appendix B-1 photograph numbers 4 and 11. Waste Pile 3 is shown in Appendix B-1 photograph number 9.

- Potential haul roads – Potential haul roads were mapped, as shown in Figures 2-1 and 2-7. The primary haul route to the portal, as identified during a site visit with NAML, is highlighted in Figures 2-1 and 2-7. The potential haul roads are also shown as earthworks in Figures 2-6a and 2-6b.

- Portal access ramp – A portal access ramp was mapped, as shown in Figure 2-7. The portal access ramp was located on the mesa sidewall and provided access to the historical portal from the mesa top. The portal access ramp is shown in Appendix B-1 photograph number 3. This feature is also shown as earthworks in Figure 2-6b.

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

- Water features – Field personnel assessed the five potential water features identified from the desktop study, as shown in Figure 2-1. The water features and field personnel observations are included in Table 3-1a. In addition, during site mapping activities field personnel identified an oil well feature, as described in Table 3-1a.

During site mapping, field personnel did not observe the un-reclaimed waste pile or the home-site located within 0.20 miles of the Site, as reported by Weston (2010). Also, during site mapping and site visits with NAML, field personnel did not observe the rim strip or potential incline shaft features identified in the *2007 AUM Atlas*. The *2007 AUM Atlas* locations of the rim strip and potential incline shaft features are shown in Figure 2-7.

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, 2016d), the Trustee notified the Agencies and obtained approval prior to commencement of the work. The Trust also consulted with Sweetwater 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 six potential background reference areas (BG-1 through BG-6) for the Site, as shown in Figure 3-2, and described in Appendix D.1. BG-2, BG-3, and BG-4 were selected as suitable background reference areas for the Site for the following reasons:

- BG-2 encompassed an area of 1,499 ft^2 (approximately 0.03 acres), was located 3,410 ft west of the claim boundary, and was 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 were within the Morrison Formation. The vegetation and ground cover at BG-2 were similar to the mesa portions of the Site and mesa sidewall portions of the site.

- BG-3 encompassed an area of 2,411 ft^2 (approximately 0.06 acres), was located 670 ft west of the claim boundary, and was cross-wind and hydrologically cross-gradient from the Site, and across a valley. The thicker soils deposits, colluvium-covered slopes, and bedrock outcrops represented the portions of the Survey Area that were within the Summerville Formation and the Quaternary deposits. The vegetation and ground cover at BG-3 were similar to the area where the mesa transitions into the plains portions of the Site.

- BG-4 encompassed an area of 463 ft^2 (approximately 0.01 acres), was located 520 ft west of the claim boundary, and was cross-wind and hydrologically cross-gradient from the Site, and across a drainage divide. The sediments represented the portions of the Survey Area that consisted of Quaternary deposits, including alluvium, in the drainages. The vegetation and ground cover at BG-4 were similar to the drainages that drain the Site to the north.

BG-1, BG-5, and BG-6 were not selected as background reference areas for the Site for the reasons described in Appendix D.1. The Agencies have suggested that additional study may be required to develop a background reference area for the mesa sidewall and mesa top (NNEPA, 2018).

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

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

The NNDFW listed two T&E plant species that may occur on-site; Parish's alkali grass (G4) and Zuni fleabane (G2). The USFWS did not list any T&E plant 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 wet areas and washes at elevations from 5,000 ft to 7,200 ft amsl. Zuni Fleabane is a native perennial forb that is found growing in fine textured clay hillsides primarily in pinyon juniper type and at elevations from 2,135 ft to 2,530 ft amsl. Its distribution is in Apache County in Arizona.

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

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

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 alkali seeps and fine-textured clay hillsides.

The Redente botanist did not identify either of the two T&E species at the Site, based on observations he made during the on-site survey. The botanist concluded he did not identify any of the T&E species at the Site because the Site was not a likely habitat for the T&E species. The primary plant community on-site is pinyon-juniper.

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

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

The wildlife evaluation was performed for species listed as NNESL, Federally Endangered, Federally Threatened, or Federal Candidate, and species protected under the Migratory Bird Treaty Act (MBTA) that have the potential to occur on-site. Prior to the start of the wildlife survey, Adkins submitted data requests to USFWS and NNDFW for animal species listed under the ESA. The NNESL species were further classified as G2, G3, or G4. The USFWS included seven ESA-species with the potential to occur in the area of the Site; two birds (Mexican spotted owl and western yellow-billed cuckoo), two fish (roundtail chub and Zuni bluehead sucker), two mammals (black-footed ferret and gray wolf), and one reptile (northern Mexican gartersnake). The NNDFW included: six birds (mountain plover [G4], golden eagle [G3], ferruginous hawk [G3], southwestern willow flycatcher [G2], American peregrine falcon [G4], and western burrowing owl [G4]), one fish (Colorado pikeminnow [G2]), one amphibian (northern leopard frog [G2]), and one mammal (banner tailed kangaroo rat [G4]). All species on the USFWS list and all species from the NNDFW list, with the exception of the golden eagle, ferruginous hawk, western burrowing owl, and banner tailed kangaroo rat, 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, three birds and one mammal remained as species of concern warranting further analysis during the Site survey: golden eagle, ferruginous hawk, western burrowing owl, and banner tailed kangaroo rat.

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"[8] 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 four NNESL species of concern that has the potential to occur within or near the Site based on habitat suitability or actual recorded observation: golden eagle, ferruginous hawk, western burrowing owl, and banner tailed kangaroo rat. 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 April 2016, Dinétahdóó conducted a cultural resource survey as part of the Site Clearance field investigations. Navajo Nation Historic Preservation Department (NNHPD) issued a Class B permit to Dinétahdóó on behalf of the Trust to conduct the cultural resource survey. Following the cultural resource survey, the NNHPD issued a Cultural Resources Compliance Form that included a "Notification to Proceed" with RSE field work. A copy of the Cultural Resources Compliance Form is included in Appendix E. According to NNHPD, this form is the equivalent of a "permit" to conduct the work (NNHPD, 2018[9]).

The survey included the areas within the claim boundary and the 100-ft claim boundary buffer, as shown in Figure 2-7. Dinétahdóó did not survey areas on steep terrain due to safety concerns. The survey identified one archaeological site and two isolated occurrences. For confidentiality reasons, details regarding the archaeological site and isolated occurrences are not provided herein. NNHPD can be contacted for additional information. NNHPD contact information is located on the *Cultural Resource Compliance Form* included in Appendix E.

Based on the survey findings, Dinétahdóó recommended during RSE activities that the boundaries of the archaeological site be flagged and that an archaeologist monitor all ground disturbing activities, including soil sampling, within 50 ft of the archaeological boundaries. Dinétahdóó also 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.

[8] 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.

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

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, and well water 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 Figure 3-3. Field personnel performed the Background Reference Area Study in accordance with the *RSE Work Plan,* Sections 4.2, 4.4, and 4.5.

The surface gamma surveys at BG-2 and BG-3 were completed in May 2016 and soil samples were collected in October 2016 (refer to Appendix D.1). Upon review of the surface gamma survey data and soil samples locations, it was determined that the surface gamma survey did not align spatially with the areal extent of the soil sample locations in BG-2. Supplemental gamma surveys for BG-2 were conducted in April 2017. Following review of data collected at the Site, it was determined that an additional potential background reference area may be required to characterize sediments in the drainage downgradient from the Site. BG-4 was identified and gamma surveys and sediment sampling were conducted in September 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 S059-SCX-001 (BG-2), S059-SCX-003 (BG-3), and S059-BG4-011 (BG-4). 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 3-2 and sample locations are shown in Figure 3-3. 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. Field personnel collected the following samples from the background reference areas:

- BG-2 – In October 2016, 10 surface soil grab samples were collected from 10 locations and one subsurface soil grab sample was collected from borehole S059-SCX-001

- BG-3 – In October 2016, 11 surface soil grab samples were collected from 11 locations and one subsurface soil grab sample was collected from borehole S059-SCX-003

- 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 S059-BG4-011

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 2 acres of the mesa sidewall 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 4.9. The potential haul road that was located nearest the mesa edge and ran from the southwest corner of the claim boundary was not surveyed, due to miscommunication with the field personnel. This is identified as a potential data gap in Section 4.9. The approximate centerline of the potential haul road exiting the main survey area on the mesa top was surveyed, but the shoulders were not. The approximate shoulders of the northeast/southwest trending potential haul road on the mesa top were surveyed, but the centerline was not. These were due to miscommunication with field personnel and are identified as potential data gaps in Section 4.9

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 and well water samples were also collected and used to evaluate mining-related impacts (refer to Section 3.3.2).

In September 2016, March 2017, and September 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. 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 29.3 acres and was subdivided into three 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 Salt Wash Member of the Morrison Formation (based on BG-2), Survey Area B is within the Summerville Formation (based on BG-3), and Survey Area C is within the Quaternary deposits (based on BG-4).

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/sediment 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 October 2016, field personnel identified five areas for the Gamma Correlation Study, as shown in Figure 3-5, by considering the results of the Site surface gamma survey (described in Section 3.3.1.2), field conditions (e.g., suitable terrain), and feasibility of sampling. To minimize variability when determining a correlation between gamma measurements (in cpm) and concentrations of Ra-226 in soil/sediment, the study area soils/sediments 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/sediment 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/sediment sample per area (refer to Table 3-2). Field personnel made a field modification from the *RSE Work Plan* by adjusting the size of the 900 ft^2 area smaller at 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/sediment 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/sediment 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 April 2017, samples were collected from the locations shown in Figure 3-6a and are summarized in Table 3-2. Sample locations and the locations of mining-related features are shown in Figure 3-6b. The numbers of surface samples collected within specific mine features are listed in Table 3-3. Thirty-two surface soil/sediment grab samples were collected from 31 locations in the Survey Area (two surface samples were collected from S059-SCX-007). Eight surface soil/sediment samples were collected from Survey Area A, four from Survey Area B, and 20 from Survey Area C.

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). 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.

Eighteen boreholes were advanced in the Survey Area (four in Survey Area A, one in Survey Area B, and 13 in Survey Area C). The boreholes were advanced through the unconsolidated deposits (from 0.5 ft to 2.0 ft bgs; refer to Table 3-2 and Appendix C.2) until: (1) refusal at bedrock; (2) subsurface static gamma measurements were below initial background levels; (3) or the termination reason was unknown at borehole S059-SCX-010 (field personnel neglected recording a reason for termination). 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 silt, sand, and gravel (refer to Appendix C.2 for borehole information). Subsurface sampling was limited in some areas on the mesa sidewall due to steep, unsafe terrain. A drill rig was not employed at the Site on the mesa side wall due to the steep unsafe terrain and on the mesa top because exposed bedrock was prevalent and soil/sediment depths were estimated to be shallow.

In April 2017, samples were collected from the locations shown in Figure 3-6a and are summarized in Table 3-2. Sample locations and the locations of mining-related features are shown in Figure 3-6b. The numbers of subsurface samples collected within specific mine features are listed in Table 3-3. Twenty-five subsurface soil/sediment samples were collected from 13 borehole locations in the Survey Area (multiple subsurface samples were collected from multiple boreholes). Three subsurface samples were collected from Survey Area A, two from Survey Area B, and 20 from Survey Area C.

Field personnel logged, classified, packaged, and shipped the samples in accordance with the *RSE Work Plan,* Sections 4.5, 4.9, 4.11, and Appendix E. Samples were shipped to ALS

Environmental Laboratories in Fort Collins, Colorado for analyses of Ra-226, uranium, arsenic, molybdenum, selenium, and vanadium, as described in the *RSE Work Plan,* Section 4.13.1. The subsurface analytical results are presented in Section 4.3. Field forms, including borehole logs showing static gamma measurements and Ra-226 analytical results, are provided in Appendix C.2. The laboratory analytical data, data validation reports, and Data Usability Report for the analyses are provided in Appendix F.

3.3.2.3 Water Sampling

Five potential water features were identified during the Site Clearance desktop study and one water feature was identified during site mapping, as shown in Figure 2-1 and Table 3-1a. Five of the six features were not sampled because four of the features were related to oil and gas wells and the remaining one feature was not observed by field personnel during site mapping. One water feature was sampled as described below.

On September 29, 2016, a well water sample (S059-WL-001) was collected from a water well identified in the NNDWR database and the *2007 AUM Atlas* as 09T-546/RV990317TNW002 (09T-546). Water well 09T-546 was completed in February 1960 to a total depth of 874 ft bgs (refer to Table 3-1b for additional well build specifications). The well was a windmill well located 0.25 miles northeast of the Site and the well water sample was collected from the valve at the trough associated with the water well, as shown in Appendix B-2 photograph number 12. Prior to shipment of the collected water sample, field personnel discovered that the bottle containing the mercury sample was broken. Therefore, on May 24, 2017 field personnel returned to water well 09T-546 and collected a water well sample for mercury analysis and general water quality field parameters.

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

Additional general water quality analyses or field measurements included: total dissolved solids (TDS), anions (carbonate, bicarbonate, chloride, and sulfate), cations (sodium and calcium), and field measurements (pH, conductivity, turbidity, temperature, salinity and oxidation reduction potential). Salinity was not collected as part of the May 24, 2017 specified field measurements because the water quality meter the field personnel were using could not measure salinity. This was identified as a data gap in Section 4.9. Table 3-4 provides a summary of the water analyses. Per the *RSE Work Plan*, if well water sample analyte concentrations are above the established ILs then those sample areas would be considered for additional

characterization in the future. Well water analytical results are presented in Section 4.8. Field forms are provided in Appendix C.3 and the laboratory analytical data and Data Usability Report for the analyses are provided in Appendix F. Investigation of groundwater is not included in the scope of this RSE.

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 (do not exist for this Site)
    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, 2002b) 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 and sample locations in the background reference areas BG-2, BG-3, and BG-4 are shown in Figure 4-1a. The surface gamma surveys in BG-2, BG-3, and BG-4 did not cover the areal extent of the soil/sediment sample locations with the background reference areas. However, the gamma survey measurements in BG-2, BG-3, and BG-4 were within approximately 3 ft of the soil/sediment sample locations that were not within the areal extent of the surface gamma survey area. Analytical results of the samples collected from BG-2, BG-3, and BG-4 are summarized in Table 4-1. The gamma measurements and surface soil sample analytical results collected from BG-2, BG-3, and BG-4 were evaluated statistically to calculate ILs (refer to Appendix D.2) for each corresponding Survey Area (i.e., Survey Area A, Survey Area B, and Survey Area C, respectively). As previously discussed in Section 3.3.1.2, the Site was subdivided into three separate Survey Areas based on the geologic formations on-site.

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, 2016c).

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

deviation from the *RSE Work Plan*. The subsurface static gamma measurements were excluded from the derivation of the surface gamma IL for two reasons: (1) they were collected using a different method (static one-minute measurements versus a walkover gamma survey); and (2) because of the downhole geometric effects that influence subsurface static gamma measurements (refer to the discussion of geometric effects below).

The ILs for Survey Area A (i.e., the Morrison Formation, refer to Figure 2-6a) were established using statistical analysis of background data collected from BG-2 (refer to Figures 3-3 and 4-1a) and are as follows:

- Arsenic – 4.38 milligrams per kilogram (mg/kg)
- Molybdenum – An IL for molybdenum was not identified because molybdenum sample results in BG-2 were all non-detect
- Selenium – An IL for selenium was not identified because selenium sample results in BG-2 were all non-detect
- Uranium – 3.28 mg/kg
- Vanadium – 18.7 mg/kg
- Ra-226 – 3.34 pCi/g
- Surface gamma measurements – 11,068 counts per minute (cpm)

The ILs for Survey Area B (i.e., the Summerville Formation; refer to Figure 2-6a) were established using statistical analysis of background data collected from BG-3 (refer to Figures 3-3 and 4-1a) and are as follows:

- Arsenic – 2.25 mg/kg
- Molybdenum – An IL for molybdenum was not identified because molybdenum sample results in BG-3 were non-detect in all but one sample
- Selenium – An IL for selenium was not identified because selenium sample results in BG-3 were all non-detect
- Uranium – 0.836 mg/kg
- Vanadium – 18.0 mg/kg
- Ra-226 – 1.06 pCi/g
- Surface gamma measurements – 10,447 cpm

The ILs for Survey Area C (i.e., Quaternary deposits; refer to Figure 2-6a) were established using statistical analysis of background data collected from BG-4 (refer to Figures 3-3 and 4-1a) and are as follows:

- Arsenic – 2.88 mg/kg
- Molybdenum – 0.334 mg/kg
- Selenium – An IL for selenium was not identified because selenium sample results in BG-4 were all non-detect
- Uranium – 0.948 mg/kg
- Vanadium – 8.65 mg/kg
- Ra-226 – 0.895 pCi/g
- Surface gamma measurements – 9,911 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 subsurface static gamma screening levels for Survey Areas A, B, and C. 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 for Survey Areas A, B and C, 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.

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

- BG-2 – One subsurface static gamma measurement (13,249 cpm) was collected at a down-hole depth of 0.5 ft bgs from BG-2 borehole S059-SCX-001, therefore 13,249 cpm was considered the subsurface static gamma IL for Survey Area A. This borehole was terminated at 0.6 ft bgs due to refusal on bedrock.

- BG-3 – Two subsurface static gamma measurements (11,880 and 13,159 cpm) were collected from borehole S059-SCX-003 at down-hole depths of 0.5 and 1.1 ft bgs, respectively. The reason the borehole was terminated was not provided on the field form. The lowest measurement collected at a depth of one or more ft bgs was 13,159 cpm, and because refusal was not confirmed to be on bedrock, it was selected as the Survey Area B subsurface static gamma IL.

- BG-4 – Three subsurface static gamma measurements (9,348, 10,141 and 11,166 cpm) were collected from BG-4 borehole S059-BG4-011at down-hole depths of 0.5, 1.0, and 1.5 ft bgs, respectively. The lowest measurement collected at a depth of 1.0 ft bgs or below was 10,141 cpm. Because this measurement was not on bedrock, 10,141 cpm was selected as the Survey Area C subsurface static gamma IL.

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 4-1b where the calculated surface gamma ILs for BG-2 and BG-4 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 bins ranges were based on the minimum site gamma measurement, the BG-2 and BG-4 ILs, and the maximum site gamma measurement. The maximum gamma survey measurement (202,616 cpm) was measured in a drainage channel approximately 300 ft southwest of the claim boundary and across a topographic divide from mining-related impacts observed at the Site (refer to Figures 2-4 and 2-7). Surface gamma measurements were generally highest in areas within or adjacent to Waste Pile 1 and the associated drainage channel. A description of these areas is provided in Section 3.2.2.1 and photographs in Appendix B-1 photograph numbers 4 and 6.

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

- Survey Area A (refer to Figure 4-1c) – Surface gamma IL exceedances (greater than 11,068 cpm) primarily occurred along the edge of the mesa, specifically in areas associated with or downgradient from the portal and portal access ramp. In addition, exceedances that were generally less than two times the IL were measured in Waste Pile 2, Waste Pile 3, and along portions of the potential haul road. The maximum measurement (100,860 cpm) was greater than nine times the IL and occurred in an area immediately downgradient of the portal.

- Survey Area B (refer Figure 4-1d) – Surface gamma IL exceedances (greater than 10,447 cpm) occurred primarily within and adjacent to Waste Pile 1. In addition, an area in the southwest portion of the Survey Area also had surface gamma IL exceedances on the mesa sidewall and extending into the plains to the north-northwest. The maximum measurement within Survey Area B and for the Site (202,616 cpm) was greater than 19 times the IL and was measured on a piece of talus in the drainage along the mesa sidewall in the southwestern portion of the Site (refer to Appendix B-1 photograph number 2). This drainage channel is cross-gradient from the mining-related disturbances (portal, portal access ramp) and there is a portion of the mesa sidewall that provides a topographic separation between the portal/Waste Pile 1 transport path and the drainage where the elevated gamma measurements were observed around talus pieces (refer to Figure 2-4). Additional information about the elevated gamma measurements in the southwest area of the Site is included in Section 4.6 below.

- Survey Area C (refer to Figure 4-1e) – Surface gamma IL exceedances (greater than 9,911 cpm) occurred in Survey Area C in areas within and adjacent to Waste Pile 1, within the drainage (refer to Appendix B-1 photograph number 10) located downgradient from

Waste Pile 1 (referred to hereafter as the Waste Pile 1 drainage), and extended to the northeast within the unnamed drainage. The maximum measurement (133,973 cpm) was greater than 13 times the IL and was measured in Waste Pile 1.

Figure 4-1c also compares Survey Area A to the surface gamma IL calculated for BG-1 (19,403 cpm; refer to Appendix D.1 and Table D.1-4). The higher IL calculated in BG-1 is an indication of the natural heterogeneity that is present in the Morrison Formation and consideration of this alternate screening level provides a valuable assessment tool for the Site. Figure 4-1c shows that a relatively large proportion of the measurements on the mesa top are greater than the BG-2 IL, but less than the BG-1 IL (green bin range) and Survey Area A surface gamma exceedances of the BG-1 IL (yellow and red bin ranges) occurred in a noticeably smaller portion of the Survey Area.

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

1. Approximately 2 acres of the mesa sidewall was not surveyed because field personnel were unable to safely access this area, as shown in Figure 3-4.

2. The potential haul road that was located nearest the mesa edge and ran from the southwest corner of the claim boundary was not surveyed due to a miscommunication with the field personnel. The unsurveyed potential haul road appears to be an access road between the NA-0904 site and the NA-0926 site approximately 0.45 miles to the southwest. Based on on-site discussions with NAML (refer to Section 2.2.7), this road was not the primary route used to haul materials to and from the Site (refer to Figure 2-7).

3. The survey was not extended laterally from the potential haul roads where the gamma measurements were greater than the IL due to a miscommunication with the field personnel. IL exceedances along the potential haul road were less than two-times the IL and they generally occurred in areas where bedrock was exposed within the roadway.

4. The survey was not extended laterally from the unnamed drainage where the gamma measurements were greater than the IL due to a miscommunication with the field personnel.

5. The survey was not extended to the south of the claim boundary on the mesa top, or to the northwest along the edge of the mesa until gamma measurements reached background levels. Mining-related impacts were not identified in these areas and the survey was not extended at the time due to professional judgement that the elevated gamma measurements were associated with natural mineralization present in bedrock exposed at the ground surface.

4.2.1.2 Subsurface Gamma Survey

Surface and subsurface static gamma measurements were collected at 18 borehole locations. Surface and subsurface static gamma measurement locations are shown in Figures 3-6a and 3-6b. Measurements and corresponding measurement depths are provided in Table 4-2 and are shown on the borehole logs in Appendix C.2. Surface and subsurface static gamma measurements from the boreholes are presented below by Survey Area:

- Survey Area A (refer to Figure 4-1c) – Four boreholes were completed in Survey Area A (S059-SCX-004 through -SCX-007) with refusal occurring between 0.25 and 1.0 ft bgs. The subsurface static gamma IL (13,249 cpm) was exceeded in three out of four boreholes and exceedances were observed at a maximum depth of 1.0 ft bgs. The one borehole (S059-SCX-007) that did not exceed the subsurface static gamma IL was located on the mesa top in the eastern portion of the claim and south of the potential haul road. The maximum subsurface measurement (75,735 cpm) was greater than five times the IL and occurred in borehole S059-SCX-004 at1.0 ft bgs, located on the portal access ramp and just west of the portal. Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements increased with depth in the two boreholes where more than one subsurface static gamma measurement was collected (notable increase in S059-SCX-004 and limited increase in S059-SCX-005). When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole (between 0.25 and 0.8 ft bgs), static gamma measurements increased with depth in all four boreholes. While downhole increases could be, in part, due to geometric effects, the relative increases in S059-SCX-004 and -SCX-006 were much greater than the increases that might be expected from geometric effects alone.

- Survey Area B (refer to Figure 4-1d) – One borehole was completed in Survey Area B (S260-SCX-019) and refusal occurred at a depth of 1.6 ft bgs. All three subsurface static gamma measurements exceeded the IL (13,159 cpm). The maximum measurement (21,191 cpm) was less than two times the IL and occurred at 1.0 ft bgs. Excluding the surface static gamma measurement (refer to Section 4.1), subsurface static gamma measurements fluctuated with depth, but generally remained relatively constant. When comparing the static gamma measurement collected at the surface to the first measurement collected down-hole (0.5 ft bgs), the static gamma measurement increased with depth (potentially due, in part, to geometric effects).

- Survey Area C (refer to Figure 4-1e) – Thirteen boreholes were completed in Survey Area C with refusal on rock or bedrock occurring in 11 boreholes at depths ranging from 0.5 to 2.0 ft bgs. Subsurface static gamma measurements exceeded the IL (10,141 cpm) in all 13 Survey Area C boreholes. Exceedances were observed at a maximum depth of 2.0 ft bgs. The maximum subsurface static gamma measurement of 324,081 cpm was greater than 31 times the IL and occurred at the refusal depth of 1.3 ft bgs in borehole S059-SCX-017, located within Waste Pile 1. Refusal in this borehole was on a large rock. Subsurface static gamma measurements greater than 10 times the IL were detected in five boreholes located either within Waste Pile 1 and/or the drainage that originates from Waste Pile 1(S059-SCX-011, -SCX-014, -SCX-016, -SCX-017 and -SCX-018). Excluding surface static gamma measurements (refer to Section 4.1), static gamma measurements generally increased with depth in three boreholes (S059-SCX-011, -SCX-016, and -SCX-020), decreased with depth for four boreholes (S059-SCX-010, -SCX-012, -SCX-013, and -SCX-015) and fluctuated with depth in three boreholes (S059-SCX-014, -SCX-017, and –SCX-021). When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole (0.5 ft bgs), the static gamma measurements increased with depth in all boreholes but one (S059-SCX-021).

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 0.95, 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:

$$\text{Gamma (cpm)} = 850 \times \text{Surface Soil Ra-226 (pCi/g)} + 16{,}582$$

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 (9,061) and greater than the maximum (107,374 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 -8.8 pCi/g and the concentration associated with the maximum mean gamma measurement is 106.8 pCi/g. Therefore, predicted Ra-226 concentrations less than -8.8 pCi/g and greater than 106.8 pCi/g should be limited to qualitative use only. Negative values for Ra-226 are a function of the linear regression equation and are not physically possible.

The correlation equation predicted Ra-226 concentrations that were less than zero for gamma survey measurements below 16,582 cpm. The predicted concentrations are shown in Figure 4-2a and the values less than zero are generally located across most of the Site with the exception of the mining-impacted areas around the portal, ramp, Waste Piles 1 and 3, the drainage downgradient from Waste Pile 1, and the area of NORM west of the Site. The elevated predicted Ra-226 concentrations shown in Figure 4-2a occur in the same areas where the elevated surface gamma measurements occur (refer to Section 4.2.1). 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 -12.6 to 218.9 pCi/g, with a mean of -3.5 pCi/g,

and a standard deviation of 15.2 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. The measured Ra-226 laboratory concentrations were within the applicable predicted Ra-226 bin ranges for 11 of the 22 sample locations. In 9 of the 11 sample locations where the predicted Ra-226 concentration and the Ra-226 concentration detected in the soil/sediment sample did not agree, the predicted concentration was lower than the reported laboratory concentration detected in the soil/sediment sample. Two soil sample locations had predicted Ra-226 concentrations that were higher than the laboratory Ra-226 concentration. The predicted Ra-226 concentration was noticeably different than the laboratory Ra-226 concentrations at three locations in the drainage downgradient from Waste Pile 3. Predicted Ra-226 concentrations in S059-SCX-010 and -SCX-012 were notably lower than laboratory Ra-226 concentrations, the predicted Ra-226 concentration at S059-SCX-011 was noticeably higher than the laboratory concentrations. The differences observed between the predicted and actual Ra-226 values are likely a function of the natural heterogeneity in Ra-226 concentrations and gamma radiation measurements, which affects the correlation based on the five Gamma Correlation Study areas, and the predicted values, based on the subsequent gamma measurements. However, the correlation may be useful as a screening tool as it provides a representative estimate of Ra-226 concentrations across the Site similar to the actual results.

The predicted Ra-226 concentrations were also compared to the Ra-226 ILs from each Survey Area, as shown in Figure 4-2c. The symbols for surface sample locations and boreholes where Ra-226 concentrations in surface soil/sediment samples exceeded the IL are highlighted with yellow halos. The predicted Ra-226 concentrations exceeded the Ra-226 ILs for the areas of the Site where mining-related impact was present (i.e., the portal, ramp, Waste Pile 1 and the drainage downgradient of Waste Pile 1) and Ra-226 ILs also exceeded in the undisturbed NORM area west of the Site. In addition, a majority of the sample locations where the Ra-226 concentration exceeded the IL was coincident with areas of the Site where the predicted Ra-226 concentrations exceeded the ILs. 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 32 surface soil/sediment grab samples (21 soil and 11 sediment) from 31 locations and 25 subsurface soil/sediment grab samples (13 soil and 12 sediment) from 13 borehole locations were collected at the Site (refer to Table 3-2). 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, and 4-4c. Figures 4-3 present the spatial patterns, both laterally and vertically, of metals and Ra-226 detections and IL exceedances in the soil/sediment samples. A subsurface sample was not collected from potentially buried waste material at Waste Pile 2; this has been identified as a data gap in Section 4.9.

Ra-226 and/or metals concentrations exceeded their respective ILs in all sample locations except for two Survey Area A surface sample locations (S059-CX-002, and -CX-003). In addition, 53 out of 57 surface or subsurface soil/sediment samples exceeded one or more IL. With the exception of molybdenum, the maximum Ra-226 and metals concentrations were detected in soil samples collected within Waste Pile 1 (Survey Area C). The maximum molybdenum detection occurred in a sediment sample that was collected from Waste Pile 1 drainage. Analyte concentrations in Waste Pile 1 drainage all initially decreased with distance downgradient from Waste Pile 1. However, concentrations of Ra-226, uranium and vanadium significantly increased (i.e., a concentration spike) in surface sediment samples from boreholes located approximately 600 to 800 hundred ft downgradient from Waste Pile1 (S059-SCX-010 or -SCX-012).

Concentrations of arsenic and molybdenum showed similar concentration spikes in the surface sediment sample from borehole S059-SCX-009, which was located approximately 300 ft downgradient from Waste Pile 1. Analytes returned to a pattern of decreasing concentrations with distance downgradient from the observed borehole location of each respective concentration spike. Surface and subsurface soil/sediment IL exceedances for each analyte with respect to the three Survey Areas are described below. Presented sample counts do not include duplicate samples.

- Ra-226
    - Survey Area A – The Ra-226 IL (3.34 pCi/g) was exceeded in three (out of seven) sample locations and included three (out of eight) surface samples and two (out of three) subsurface soil samples. Survey Area A Ra-226 concentrations ranged from 0.94 to 45.5 pCi/g. The maximum concentration (45.5 pCi/g) for Survey Area A was detected in surface soil sample located on the edge of the mesa top. Ra-226 decreased with depth in two borehole locations. Trends for discrete depths could not be evaluated in S059-SCX-005 and –SCX-006 due to overlap of the surface (0-0.5 ft bgs) and subsurface (0-0.8 ft bgs) samples at these locations.
    - Survey Area B – The Ra-226 IL (1.06 pCi/g) was exceeded in three (out of four) sample locations and included three (out of four) surface soil samples and two (out of two) subsurface soil samples. The one sample location that did not exceed the Ra-226 IL was located east of and cross-gradient from Waste Pile 1(S059-CX-008). Survey Area B Ra-226 concentrations ranged from 0.7 to 83.2 pCi/g. The maximum concentration (83.2 pCi/g) occurred in a surface soil sample collected from Waste Pile 1 (S059-CX-010). Ra-226 concentrations fluctuated with depth in borehole S059-SCX-019 but overall, the subsurface concentrations were higher than the surface soil concentration.
    - Survey Area C – The Ra-226 IL (0.895 pCi/g) was exceeded in 19 (out of 20) sample locations and included 18 (out of 20) surface soil/sediment samples and 19 (out of 20) subsurface soil/sediment samples. Survey Area C Ra-226 concentrations ranged from 0.75 to 146 pCi/g. The maximum detection (146 pCi/g) for Survey Area C and the Site was greater than 163 times the IL and occurred in a subsurface soil sample collected from Waste Pile 1(S059-SCX-017; 0.5-1.0 ft bgs). Ra-226 concentrations greater than ten times the IL were detected in: (1) surface and subsurface soil samples collected from all borehole locations within Waste Pile 1 (S059-SCX-015, -SCX-016, -SCX-017, and -SCX-018); (2) in surface and subsurface sediment samples within the Waste Pile 1 drainage (S059-SCX-009, -SCX-010, -SCX-011, -SCX-014); (3) in two sediment samples collected downgradient from the confluence (i.e., the point where two streams join together) of the Waste Pile 1 drainage and the unnamed drainage (S059-SCX-012); and (4) in two surface soil samples located in the southwest portion of the Site, cross-gradient from the portal and Waste Pile 1 (S059-CX-004 and -SCX-008). Ra-226 concentrations decreased with depth in three boreholes, increased with depth in one borehole, remained relatively constant in one borehole, and fluctuated with depth in four boreholes. No distinct spatial patterns were observed with respect to concentration changes with depth.

- Uranium

    - Survey Area A – The uranium IL (3.28 mg/kg) was exceeded in four (out of seven) sample locations and included three (out of eight) surface soil samples and all three subsurface soil samples. Survey Area A uranium concentrations ranged from 0.99 to 60 mg/kg. The maximum concentration for Survey Area A (60 mg/kg) was greater than 18 times the IL and occurred in a surface soil sample that was collected near the mesa edge (S059-CX-001). Uranium concentrations were unchanged with depth in one borehole location and decreased with the depth in the other borehole location.

    - Survey Area B – The uranium IL (0.836 mg/kg) was exceeded in three (out of four) sample locations and included three (out of four) surface soil samples and both subsurface soil samples. The one sample location that did not exceed the uranium IL was located east of and cross-gradient from Waste Pile 1(S059-CX-008). Survey Area B uranium concentrations ranged from 0.66 to 130 mg/kg. The maximum concentration (130 mg/kg) was greater than 155 times the IL and occurred in a surface soil sample collected from Waste Pile 1 (S059-CX-010). Uranium concentrations greater than ten times the IL were detected in both subsurface samples collected from Waste Pile 1 (S059-SCX-019). Uranium concentrations fluctuated with depth in borehole S059-SCX-019 but overall, the subsurface concentrations were higher than the surface soil concentration.

    - Survey Area C – The uranium IL (0.948 mg/kg) was exceeded in 17 (out of 20) sample locations and included 17 (out of 20) surface soil/sediment samples and 18 (out of 20) subsurface soil/sediment samples. The two sample locations where uranium did not exceed the IL were all located west-northwest of Waste Pile 1. Survey Area C uranium concentrations ranged from 0.55 to 650 mg/kg. The maximum concentration for Survey Area C and the Site (650 mg/kg) was greater than 685 times the IL and occurred in a subsurface soil sample that was collected from the Waste Pile 1 (S059-SCX-016; 0.5 to 1.0 ft bgs). Uranium concentrations greater than ten times the IL were detected in: (1) surface and subsurface soils samples collected from all borehole locations within Waste Pile 1 (S059-SCX-015, -SCX-016, -SCX-017 and -SCX-018); (2) in surface and subsurface sediment samples within the Waste Pile 1 drainage (S059-SCX-009, -SCX-010, -SCX-011, -SCX-014); and (3) in three surface and subsurface sediment samples collected downgradient from the confluence between the Waste Pile 1 drainage and the unnamed drainage at the S059-SCX-012 borehole. Uranium concentrations decreased with depth in four boreholes, increased with depth in two boreholes, and fluctuated with depth in three boreholes. No distinct spatial patterns were observed with respect to concentration changes with depth.

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 five (out of 11) Survey Area A soil samples, three (out of six) Survey Area B soil samples, and in 17 (out of 40) Survey Area C soil/sediment samples. With the exception of one surface soil sample in Survey Area C (S059-SCX-008) all samples that exceeded the maximum regional value were located within, adjacent to, or downgradient from Waste Piles 1, 2, or 3, or the portal.

- Arsenic

    - Survey Area A – The arsenic IL (4.38 mg/kg) was exceeded in four (out of seven) sample locations and included four (out of eight) surface soil samples and two (out of three) subsurface soil samples. Survey Area A arsenic concentrations ranged from 1.2 to 12 mg/kg. The maximum concentration (12 mg/kg) was less than three times the IL and occurred in a subsurface soil sample collected in Waste Pile 3 (S059-SCX-006). Arsenic concentrations decreased with depth in two boreholes.

    - Survey Area B – The arsenic IL (2.25 mg/kg) was exceeded in all four sample locations, and in all the surface and subsurface soil samples. Survey Area B arsenic concentrations ranged from 2.5 to 25 mg/kg. The maximum detection (25 mg/kg) was greater than 11 times the IL and measured in a surface soil sample collected from Waste Pile 1 (S059-CX-010). Arsenic concentrations fluctuated with depth in borehole S059-SCX-019 but overall, the subsurface concentrations were higher than the surface soil concentration.

    - Survey Area C – The arsenic IL (2.88 mg/kg) was exceeded in 13 (out of 20) sample locations and included 12 (out of 20) surface soil/sediment samples and nine (out of 20) subsurface soil/sediment samples. Survey Area C arsenic concentrations ranged from 0.97 to 76 mg/kg. The maximum detection (76 mg/kg) for Survey Area C and for the Site was greater than 26 times the IL and occurred in a surface soil sample collected from Waste Pile 1 (S059-SCX-017). Arsenic concentrations greater than ten times the IL were detected in surface and subsurface soils samples collected from boreholes S059-SCX-016 and -SCX-017, located within Waste Pile 1. Arsenic concentrations decreased with depth in three boreholes and fluctuated with depth in five boreholes. No distinct spatial patterns were observed with respect to concentration changes with depth.

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

- Molybdenum – ILs for molybdenum were not identified for Survey Areas A and B because molybdenum sample results in the background reference areas were either non-detect (BG-2) or there were not enough detections to establish an IL (BG-3).

    - Survey Area A – Molybdenum was detected in three (out of eight) sample locations and included two (out of seven) surface soil samples and two (out of three) subsurface samples. Measurable molybdenum concentrations ranged from 0.93 to 2.7 mg/kg. The maximum detection (2.7 mg/kg) occurred in a surface soil sample collected near the mesa edge (S059-CX-001). The molybdenum concentration increased with depth in the one borehole that had subsurface molybdenum detections.

    - Survey Area B – Molybdenum was detected in two (out of four) sample locations and included two (out of four) surface soil samples and both subsurface samples. Measurable molybdenum concentrations ranged from 0.3 to 45 mg/kg. The maximum detection (45 mg/kg) occurred in a surface soil collected from Waste Pile 1 (S059-CX-010). Molybdenum concentrations increased with depth in borehole S059-SCX-019.

- Survey Area C – The molybdenum IL (0.334 mg/kg) was exceeded in 17 (out of 20) sample locations and included 16 (out of 20) surface soil/sediment samples and in 14 (out of 20) subsurface soil/sediment samples. Molybdenum was not detected in three sample locations (S059-CX-005, -CX-006 and -SCX-021). Survey Area C molybdenum concentrations ranged from non-detect to 180 mg/kg. The maximum detection (180 mg/kg) for Survey Area C and for the Site was over 538 times the IL and occurred in a surface sediment sample collected from the Waste Pile 1 drainage, approximately 300 ft downgradient from Waste Pile 1 (S059-SCX-009). Molybdenum concentrations greater than ten times the IL were detected in: (1) surface and subsurface soil samples collected from all borehole locations within Waste Pile 1 (S059-SCX-015, -SCX-016, -SCX-017 and -SCX-018); (2) surface and subsurface sediment samples within the Waste Pile 1 drainage (S059-SCX-009, -SCX-010, and -SCX-014); and (3) in surface and/or subsurface sediment samples collected downgradient from the confluence between the Waste Pile 1 drainage and the unnamed drainage (S059-CX-012 and -SCX-12). Molybdenum concentrations decreased with depth in three boreholes, increased with depth in two boreholes, and fluctuated with depth in three boreholes. No distinct spatial patterns were observed with respect to concentrations changes with depth.

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 all Survey Area A soil samples but exceeded the maximum regional value in two (out of six) Survey Area B soil samples and 13 (out of 40) Survey Area C soil/sediment samples. All samples that exceeded the maximum regional value were located within or downgradient of Waste Pile 1.

- Selenium – ILs for selenium were not identified because selenium sample results in the background reference areas were all non-detect.

  - Survey Area A – Selenium was detected in one subsurface soil sample at a concentration of 1.6 mg/kg. The sample was collected from a borehole located in Waste Pile 3 (S059-SCX-006).

  - Survey Area B – Selenium was detected in one surface soil sample at a concentration of 1.6 mg/kg. The sample was collected from Waste Pile 1 (S059-CX-010).

  - Survey Area C – Selenium was detected in three (out of 20) sample locations and included two (out of 20) surface soil samples and four (out of 20) subsurface soil/sediment samples. All three sample locations with selenium detections were collected from Waste Pile 1 (S059-SCX-014, -SCX-016, and -SCX-017). Selenium concentrations ranged from 1 to 2.8 mg/kg and the maximum detections for Survey Area C and the Site occurred in two surface soil samples from boreholes S059-SCX-016 and -SCX-017. Selenium concentrations decreased with depth in two boreholes and fluctuated with depth in one borehole.

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). All selenium concentrations were within the typical range of regional values in all Survey Areas A, B, and C.

- Vanadium

    - Survey Area A – The vanadium IL (18.7 mg/kg) was exceeded in three (out of seven) sample locations and included three (out of eight) surface soil samples and two (out of three) subsurface soil samples. Survey Area A vanadium concentrations ranged from 6.3 to 290 mg/kg. The maximum vanadium concentration (290 mg/kg) was greater than 15 times the IL and occurred in a surface soil sample collected near the mesa edge (S059-CX-001). The remaining samples with IL exceedances had concentrations less than two times the IL. Vanadium concentrations decreased with depth in two boreholes.

    - Survey Area B – The vanadium IL (18 mg/kg) was exceeded in three (out of four) sample locations and included three (out of four) surface soil samples and both subsurface soils samples. The Survey Area B vanadium concentrations ranged from 11 to 690 mg/kg. The maximum vanadium concentration (690 mg/kg) was greater than 38 times the IL and occurred in a surface soil sample collected from Waste Pile 1 (S059-CX-010). The remaining samples with IL exceedances had concentrations that ranged from less than two times the IL to three times the IL. Vanadium concentrations increased with depth in borehole S059-SCX-019.

    - Survey Area C – The vanadium IL (8.65 mg/kg) was exceeded in all 20 sample locations and included all 20 surface soil/sediment samples and all 20 subsurface soil/sediment samples. The Survey Area C vanadium concentrations ranged from 9.2 to 1200 mg/kg. The maximum concentration (1200 mg/kg) for Survey Area C and the Site was greater than 138 times the IL and occurred in a subsurface soil sample collected from Waste Pile 1 (S059-SCX-016). Vanadium concentrations greater than ten times the IL were detected in: (1) surface and/or subsurface soil samples collected from all Survey Area C borehole locations within Waste Pile 1 (S059-SCX-015, -SCX-016, -SCX-017 and -SCX-018); (2) surface and/or subsurface sediment samples within the Waste Pile 1 drainage, located downgradient from Waste Pile 1 (S059-SCX-009, -SCX-010, -SCX-011, and -SCX-014); and (3) two surface and subsurface sediment samples collected downgradient from the confluence of the Waste Pile 1 drainage and the unnamed drainage in the S059-SCX-012 borehole. Vanadium concentrations increased with depth in one borehole location, decreased with depth in five borehole locations, and fluctuated with depth in three locations. No distinct spatial patterns were observed with respect to concentration changes with depth.

As a broader point of reference, a regional study of the Western US documented vanadium concentrations in soil that ranged from 7 to 500 mg/kg, with a mean value of 70 mg/kg (USGS, 1984). Vanadium concentrations were within the typical range of regional values in Survey Area A; however, one (out of six) Survey Area B soil samples, and eight (out of 40) Survey Area C soil/sediments samples exceeded the maximum regional value. Seven of the nine samples that exceeded the maximum value were surface and subsurface soil samples collected from Waste Pile 1. The other two samples were subsurface sediment samples collected from borehole S059-SCX-014 in the Waste Pile 1 drainage.

4.4 CONSTITUENTS OF POTENTIAL CONCERN

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

4.5 AREAS THAT EXCEED THE INVESTIGATION LEVELS

The approximate lateral extent of surface gamma IL exceedances in soil/sediment is 14.4 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 through 4-4d show larger scale views of each of the three Survey Areas to better display those areas with multiple, contiguous surface gamma IL exceedances. Two sample locations with IL exceedances were located in areas that were not included in the 14.4 acres, as follows:

- Borehole S059-SCX-007 had an arsenic concentration in the surface soil sample that was less than two times the IL. This borehole was within Survey Area A and located on the mesa top.
- Surface sample location S059-CX-005 had uranium and vanadium concentrations that were both less than two times their respective ILs. This surface sample location was in the drainage northwest of Waste Pile 1.

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

IL exceedances in metals and Ra-226 concentrations at surface and subsurface sample locations were 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. Predicted Ra-226 concentrations exceeded the Ra-226 IL in a much smaller area of the Site than the surface gamma IL exceedances. Approximate 20 percent of the surface gamma survey measurements collected within Survey Area A exceeded the surface gamma IL compared to

less than five percent of the predicted Ra-226 concentrations exceeding. Predicted Ra-226 concentrations exceed the IL in a much smaller area of Survey Areas B and C as well. The inconsistency between the predicted Ra-226 exceedances and the surface gamma exceedances may be the result of the surface gamma IL being relatively low when compared to the Ra-226 IL or because the predicted Ra-226 concentrations were lower than the actual concentration.

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, 9.2 acres, out of the 29.3 acres of the Survey Area, were estimated to contain TENORM at the Site. This estimate is inclusive of three areas: (1) Waste Pile 1 and surrounding areas; (2) the drainages located downgradient from Waste Pile 1; and (3) portions of the mesa top and sidewall, which included Waste Piles 2 and 3. The area containing TENORM is shown in relation to the lateral extent of IL exceedances in Figure 4-6 and in relation to the gamma measurements in Figure 4-7.

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

- Historical Data Review
    - Site-specific historical mining information was minimal. However, NAML reported that in some cases ore production from multiple mines was reported as a single value for one of the mines. In these cases, the mines were included on a single lease. It is unknown if the Site was part of a multi-mine lease or multi-mine production report.
    - Historical document review indicated that the Site had been reclaimed, and that one un-reclaimed waste pile was present on Site.
    - Historical document review indicated that the following reclamation activities were completed at one portal on-site: (1) blasting an area around the portal; (2) backfilling the adit with waste material to within 3 ft of the portal and then filling the remaining 3 ft with uncontaminated material; (3) constructing a bulkhead in the portal; and (4) reseeding areas disturbed during the reclamation activities.
- Geology/geomorphology
    - Bedrock at the Site consisted of two geologic units: the Summerville Formation and the Salt Wash Member of the Morrison Formation. The Morrison Formation is known to have natural enrichments of uranium. In addition, portions of the Site consisted of shallow or outcropping bedrock. Therefore, the geology and geomorphology of the Site was conducive to the presence of NORM at or below the ground surface.
    - Numerous sub-parallel patterned ephemeral drainages are present on-site that originated along the base of the mesa sidewall and drained primarily to the north where they joined together into an unnamed drainage that drained to the northeast. The drainages could transport NORM/TENORM to the north and northeast.

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

    - One reclaimed portal was observed on the mesa sidewall. The portal had been sealed and covered with rock of various sizes.

    - Three waste piles were observed that were assumed to be related to historical mining activities that occurred on-site. Waste Pile 1 was located downslope from the portal, along the base of the mesa sidewall and extended into the plains. Waste Piles 2 and 3 were located on the mesa top.

    - Several potential haul roads were observed along the mesa top. Additionally, there was a northeast/southwest trending linear feature approximately 225 feet northwest of the claim boundary. The feature does not intersect the Site. Because of the position of the ramp and potential haul roads on the mesa top, it is likely ore was hauled up the ramp from the portal and off the mesa. Therefore, this linear feature was not surveyed because it was not likely used as a haul road.

    - One portal access ramp was observed along the mesa sidewall. The portal access ramp provided access from the mesa top to the historical portal that was located on the mesa sidewall.

- Site Characterization

    - Waste Pile 1 and the areas surrounding it (referred to as the Waste Pile Area) is located downgradient from the portal and the portal access ramp. The Waste Pile Area extended from the mesa sidewall into the plains and includes portions of Survey Areas B and C. The highest surface and subsurface gamma measurements for the Site were located primarily in portions of Waste Pile 1 located on the mesa sidewall. In addition, one or more IL was exceeded in every sample location, with the highest concentrations and greatest IL exceedances detected in surface and subsurface soil samples from Waste Pile 1. TENORM in the western portion of the Waste Pile Area was extended to the point where overland water flow may transport impacted material. IL exceedances west of the TENORM boundary are assumed to be the result of NORM.

    - The drainages included in the TENORM area were located within Survey Area C and included the Waste Pile 1 drainage, and portions of the unnamed drainage located downgradient from the Waste Pile 1 drainage. This area was characterized by elevated surface gamma measurements within the drainage channels, as well as along the drainage banks (the area that borders the drainage). The width of the surface gamma exceedances along the drainage decreased with distance from Waste Pile 1. The highest surface and subsurface gamma measurements occurred in areas closest to Waste Pile 1. Ra-226 and metals concentrations exceeded four or more ILs in every sample collected within the drainage channels. Ra-226 and metals concentrations that were greater than ten times their respective ILs were detected in all but two sample locations, both of which were located in the most distal (northeast) portions of the drainage. In general, Ra-226 and metals concentrations decreased with depth. It is important to consider that the gamma survey in the unnamed drainage channel was limited to 0.25 miles from the claim boundary per the *RSE Work Plan* and gamma measurements exceeded the IL for the length of the surveyed drainage channel.

- The portion of the mesa top determined to be TENORM included Waste Piles 2 and 3, as well as the potential haul roads. Waste Piles 2 and 3 were generally less than 1 ft deep and consisted of scattered waste rock. The portion of the mesa sidewall considered TENORM was also within Survey Area A and included the portal access ramp, the portal, and the areas downgradient from the portal. These areas were characterized by elevated surface gamma measurements with the highest measurements occurring within Waste Pile 3, and in an area downgradient from the portal. In addition, one or more IL was exceeded in every sample location with the highest concentrations detected in a surface sample collected immediately downgradient from Waste Pile 2.

- An area along the southwest claim boundary that included a portion of the mesa sidewall and a drainage that extended to the northwest into the plains was not included in the TENORM boundary. This area had elevated surface gamma measurements (including the highest gamma measurement for the Site) and Ra-226 and metals concentrations that exceeded one or more IL. However, this area did not show signs of disturbance and it was located cross-gradient from and across a topographic divide from mining-related impacts observed at the Site. Limited amounts of the mesa sidewall were gamma surveyed in this area because of safety concerns due to the steep terrain. It was observed that elevated gamma measurements were generally associated with exposed bedrock higher on the mesa sidewall and talus material located downslope from the bedrock. The highest gamma survey measurements for the Site were associated with a large piece of talus in the drainage on the mesa sidewall. This area was assumed to be unimpacted and is considered to contain NORM. The TENORM boundary in this area was drawn based on gamma measurements and the evaluation of topographic features using a map with a 2- ft ground surface elevation contour interval (developed from the orthophotographs).

- Some areas along the edge of the mesa had elevated surface gamma measurements but were not included in the TENORM boundary. The surface gamma measurements in these areas were less than two times the IL, generally at or near exposed bedrock, and they showed no signs of mining-related disturbances. This suggests that these areas were unimpacted and are considered to contain NORM.

- Metals concentrations in samples collected outside the area of TENORM (six locations) were less than or within the regional concentration values.

- Mine waste was present in Waste Pile 1 downslope from the portal. Fine-grained gray sediment was mixed with brown and red sediment similar to that observed in areas outside of the waste pile. Additionally, samples from boreholes within the waste pile contained elevated COPC concentrations with notable uranium concentrations (greater than 200 mg/kg) measured in samples from S059-SCX-016 and S059-SCX-017. Waste Piles 2 and 3 consisted of shallow piles of loose rock and gravels. Mine waste was not observed in Waste Piles 2 and 3 and mine waste material was not observed in the borehole advanced in Waste Pile 3. With the exception of Waste Pile 1, no potential mine waste material was observed at the ground surface at the Site.

- It is important to consider that the subsurface static gamma ILs were not used as the only evidence to delineate the vertical extent of TENORM that exceeded the IL at the Site.

The area of the Site determined to contain TENORM (i.e., multiple lines of evidence indicated the presence of mining-related impacts) was 9.2 acres, as shown on Figure 4-8a. Portions of the TENORM exceeded one or more IL, where approximately 5.6 acres contained TENORM that exceeded the surface gamma IL and all sample locations where TENORM exceeded the ILs. TENORM that exceeded the ILs in Survey Areas A, B, and C is shown on Figures 4-8b through 4-8d, respectively, and is compared to mining-related features in Figure 4-8e.

The presence of an inclined shaft is listed in the *2007 AUM Atlas* and historical reclamation documentation, and NAML personnel discussed it during an on-site visit. The location of the potential inclined shaft could not be identified during disturbance mapping, on-site discussions with NAML personnel, or during Site Characterization (i.e., surface gamma exceedances were generally associated with mining disturbed areas and there were not areas of anomalously high surface gamma measurements).

4.7 TENORM VOLUME ESTIMATE

The volume estimate of TENORM that exceeded one or more ILs is approximately 11,144 cubic yards (yd^3) (8,520 cubic meters), as shown in Figure 4-9a. The volumes and areas of TENORM associated with specific mine features is listed in Table 3-3. This estimate was calculated using ESRI ArcGIS Desktop 10.3.1 Spatial Analyst Extension cut/fill tool (ESRI, 2017) 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 3-3. The assumptions that were used to calculate the volume of TENORM with IL exceedances were as follows:

General Assumptions

- It was assumed that subsurface bedrock encountered in boreholes was not previously modified by human activity and is therefore NORM.
- For areas of TENORM at the Site containing large cobble- or boulder-sized rocks at the surface whose heights exceeded the assumed depth of TENORM in that area (e.g., a 5-ft-tall boulder in an area where TENORM was assumed to extend 1 ft bgs), the additional volume was assumed to be accounted for by the TENORM depth estimates.

Group Assumptions

- Group 1 (5,299 yd^3) – Group 1 consists of Waste Pile 1 and the surrounding areas and is referred to as Waste Pile Area. The vertical extent (i.e., thickness) of TENORM exceeding ILs was variable throughout Group 1. Figure 4-9b provides contours of the Waste Pile Area that were created to support the volume calculation. The contours were developed based on: (1) surface and subsurface data collected in surface sample and borehole locations within and surrounding Waste Pile 1; (2) field observations (e.g., the visible contact between the gray-colored waste rock in Waste Pile 1 and the red soils beneath the waste rock); (3) elevation contours of the top surface of the Waste Pile Area that were generated from the orthophotographs (Cooper, 2017); (4) review of oblique aerial imagery of the Site (Google Earth, 2018); and (5) the assumption that all material within the footprint of the waste pile area exceeded the ILs. The maximum thickness of the Waste Pile Area was estimated to be 3 ft. Note that the surface extents of Group 1 depicted on Figure 4-9b differ from the Waste Pile 1 boundary. This is because the extent of Waste Pile 1 was based on field mapping alone, whereas the extent of Group 1 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 2 (3,612 yd^3) – Group 2 consists of the Waste Pile 1 drainage and the unnamed drainage. The volume of TENORM exceeding ILs in the drainages was estimated based on five borehole locations, three surface soil sample locations, and field observations of sediment thicknesses within the drainage. The width of the drainage containing TENORM above the ILs was estimated based on: (1) field mapping; (2) gamma survey results; and (3) review of aerial photographs of the Site. TENORM within the visible alluvial sediments in the drainage channel was estimated to extend to 2.0 ft bgs based on observed impacts. The TENORM between the visible alluvial sediments and the TENORM boundary was estimated to extend to 1.0 ft bgs.

- Group 3 (1,618 yd^3) – Group 3 consists of portions of the mesa top and sidewall that included Waste Piles 2 and 3 as well as the portal access ramp. A polygon was fit around the areas of the mesa top and portal access ramp where contiguous surface gamma IL exceedances were observed. TENORM exceeding ILs in the area was assumed to extend to 1.0 ft bgs over the area of the polygon based on bedrock being encountered at 0.8 to 1.0 ft bgs in boreholes S059-SCX-005 and -SCX-006, respectively, in the area, the presence of bedrock at ground surface, and the field observations that Waste Piles 2 and 3 are less than 1.0 ft deep.

- Group 4 (383 yd^3) – Group 4 consists of the Potential Haul Roads. The vertical extent of TENORM exceeding ILs was assumed to extend to 0.5 ft bgs in the Group 4 polygons based on field observations that the potential haul roads contained areas of exposed bedrock and followed existing topography (i.e., fill material was not used to create portions of the roads).

- Group 5 (232 yd^3) – Group 5 consists of an area on the mesa sidewall that could not be surveyed or sampled due to safety concerns because of steep or unsafe terrain (referred to as Colluvium on Sidewall). The lateral and vertical extent of potential TENORM exceeding ILs in this group was based on field observations from outside the area and review of aerial photographs of the Site. The vertical extent of TENORM was assumed to extend to 1.0 ft bgs in the Group 5 polygons.

4.8 WATER ANALYTICAL RESULTS

The well water samples collected as part of the Site Characterization activities were analyzed for the constituents listed in Section 3.3.2.3. Water well 09T-546 (sample S059-WL-001) located approximately 0.25 miles northeast of the Site, was sampled in September 2016 and an additional sample was collected in May 2017 and analyzed for mercury only (refer to Section 3.3.2.3). The location of this water feature is shown in Figure 2-1.

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

Analytical results indicated the well water sample (S059-WL-001) had total and dissolved arsenic concentrations of 15 micrograms per liter (µg/L), which exceeded the arsenic IL (10 µg/L). All other metals and radionuclides were below their respective ILs. Results of general chemistry parameters indicated that TDS was also above its respective IL. All other general chemistry parameter results were below their respective ILs. Based on these results arsenic and TDS are confirmed COPCs for water well 09T-546. Because arsenic and TDS exceeded their respective ILs for the well water sample, additional characterization may be considered at water well 09T-546 in the future. The laboratory analytical data and Data Usability Report are provided in Appendix F.

4.9 POTENTIAL DATA GAPS AND SUPPLEMENTAL STUDIES

4.9.1 Data Gaps

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

1. Approximately 2 acres of the mesa sidewall was not surveyed because field personnel were unable to safely access this area, as shown in Figure 3-4.

2. The potential haul road that was located nearest the mesa edge and ran from the southwest corner of the claim boundary was not surveyed due to a miscommunication with the field personnel. The unsurveyed potential haul road appears to be an access road between the NA-0904 site and the NA-0926 site approximately 0.45 miles to the southwest. Per on-site discussions with NAML, this road was not the primary route used to haul materials to and from the Site (refer to Figure 2-7).

3. Due to miscommunication with the field personnel, the approximate center of the potential haul road exiting the Survey Area was surveyed, but the shoulders were not; and the

approximate shoulders of the northeast/southwest trending potential haul road on the mesa top was surveyed, but the center was not.

4. The survey was not extended laterally from the potential haul roads where the gamma measurements were greater than the IL due to a miscommunication with the field personnel. This is not considered a significant data gap because IL exceedances along the potential haul road were less than two-times the IL, and generally occurred in areas where bedrock was exposed within the roadway.

5. The survey was not extended laterally from the unnamed drainage where the gamma measurements were greater than the IL due to a miscommunication with the field personnel.

6. The survey was not extended to the south of the claim boundary on the mesa top, or to the northwest along the edge of the mesa until gamma measurements reached background levels. Mining-related impacts were not identified in these areas and the survey was not extended at the time due to professional judgement that the elevated gamma measurements were associated with natural mineralization present in bedrock exposed at the ground surface.

7. Salinity was not collected as part of the May 24, 2017 specified field measurements because the water quality meter the field personnel were using could not measure salinity.

8. A subsurface sample was not collected from Waste Pile 2.

4.9.2 Supplemental Studies

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

1. The Agencies have suggested that additional study may be required to develop a background reference area for the mesa sidewall and mesa top (NNEPA, 2018).

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

3. The Agencies suggested that additional investigation may be warranted in Waste Pile 1 (NNEPA, 2018).

4. Additional surface and subsurface sampling of the potential haul roads may be warranted.

5. Additional evaluation of the drainage channel downgradient of Waste Pile 1 is warranted. The gamma survey in the drainage channel was limited to 0.25 miles from the claim boundary per the RSE Work Plan and gamma measurements exceeded the IL for the length of the surveyed drainage channel.

6. The USEPA identified that there were potential discrepancies between the NNDWR database used for this study (received from NNDWR in 2016) and a 2018 version of the NNDWR database that the USEPA reviewed. It is recommended that the two databases be

compared (with additional field work, if necessary) to confirm the locations of water features.

5.0 SUMMARY AND CONCLUSIONS

This report details the purpose and objectives, field investigation activities, findings, and conclusions of the Site Clearance and RSE activities conducted for the Site between July 2015 and September 2017. The Site is known as the NA-0904 site and is also identified by the USEPA as AUM identification #59 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. A well water sample was also collected as part of the RSE to evaluate potential mining-related impacts. The correlation between gamma measurements (in cpm) and concentrations of Ra-226 in surface soils (pCi/g) was developed as a potential field screening tool for future Removal or Remedial Action evaluations. The gamma correlation was not used for the Site Characterization, which relied instead on the actual gamma radiation measurements and soil/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.

Site-specific historical mining information is minimal and the only such information discovered was reported in the *2007 AUM Atlas*. The *2007 AUM Atlas* reported the Site was reclaimed. Ore production information pertaining to the Site was not identified. However, an important consideration is that even though ore production information pertaining to the Site was not identified, the *2007 AUM Atlas* reported that sometimes production from multiple mines was reported as a single combined value for one of the mines. In these cases, the mines were included on a single lease, and the ore production reported was inclusive of all of the mines on that single lease (USEPA, 2007a). It is unknown if the Site was part of a multi-mine lease but, it is possible that ore could have been mined from the Site, and combined with reports from other mine ore productions, for a combined reported production value.

Between 1991 and 1992 NAML reported the following reclamation activities were completed at one portal on-site:

- Blasting an area around the portal. The reason this area was blasted was not provided in the field notes.

- Backfilling the adit with waste material to within 3 ft of the portal and then filling the remaining 3 ft with "uncontaminated" material.
- Constructing a bulkhead in the portal.
- Reseeding the area disturbed during reclamation activities.

Six potential background reference areas were considered. Three background reference areas (BG-2, BG-3, and BG-4) were selected to develop surface gamma, subsurface gamma, Ra-226, and metals ILs for the three Survey Areas (Survey Area A, Survey Area B, and Survey Area C) at the Site.

Arsenic, molybdenum, uranium, vanadium, and Ra-226 concentrations and gamma radiation measurements exceeded their respective ILs and were confirmed as COPCs for the Site. In addition, selenium was also confirmed as a COPC because it was detected in soil samples from Survey Areas A, B and C, but was non-detect in all background reference area samples.

Surface gamma measurements and Ra-226 and metals concentrations were generally highest in areas coincident with Waste Pile 1 or the drainage channel located downgradient from Waste Pile 1. The maximum gamma survey measurement (202,616 cpm) was greater than 18 times the maximum IL (i.e. BG-2 IL of 11,068 cpm) and occurred in Survey Area B approximately 300 ft southwest of and cross-gradient from Waste Pile 1. The highest Ra-226 and metals concentrations and subsurface static gamma measurements were also detected in surface/subsurface soil/sediment samples collected from Waste Pile 1 or in the Waste Pile 1 drainage.

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

Based on the data analysis performed for this RSE report and the multiple lines of evidence, approximately 9.2 acres out of the 29.3 acres of the Survey Area were estimated to contain TENORM. This estimate was inclusive of three areas: (1) Waste Pile 1 and surrounding areas; (2) the Waste Pile 1 drainage and the unnamed drainage downgradient from the Waste Pile 1 drainage; and (3) portions of the mesa top and sidewall, which included Waste Piles 2 and 3. The areas outside of the TENORM boundary show no signs of disturbance related to mining and, therefore, are considered NORM (i.e., naturally occurring). Of the 9.2 acres that contain TENORM, 5.6 acres contain TENORM exceeding the surface gamma ILs and TENORM that exceeded the ILs at all of the soil/sediment sample locations. The volume of TENORM in excess of ILs is estimated to be 11,144 yd^3 (8,520 cubic meters). It should be noted that there are areas of NORM outside the TENORM boundary (e.g., the area southwest of the claim boundary) where surface gamma measurements were similar to measurements in some areas of TENORM.

An analytical well water sample and field parameter measurements were collected as part of the Site Characterization activities. Analytical results indicated the well water sample

(S059-WL-001) had total and dissolved arsenic concentrations of 15 µg/L, which exceeded the arsenic IL (10 µg/L). All other metals and radionuclides were below their respective ILs. Results of general chemistry parameters indicated that TDS was also above its respective IL. All other general chemistry parameter results were below their respective ILs. Based on these results arsenic and TDS are confirmed COPCs for water well 09T-546. Because arsenic and TDS exceeded their respective ILs for the well water sample, additional characterization may be considered at water well 09T-546 in the future.

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

6.0 ESTIMATE OF REMOVAL SITE EVALUATION COSTS

The NA-0904 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 NA-0904 RSE were $472,553. Stantec's costs associated with interim actions (sign installation) were $4,000. In addition, Administrative costs provided by the Trust were estimated currently at $191,500[10,11]. Administrative costs will change due to continued community outreach and close out activities.

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

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TABLES

Table 3-1a
Identified Potential Water Features
NA-0904
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Identified Water Feature	Source of Identified Water Feature	Water Feature Identification	Field Sample Identification	Field Personnel Observations
No Feature	2007 AUM Atlas[1], NNDWR	09T-563	NA	No surface water or water well observed at this location.
Windmill Well	2007 AUM Atlas[1], NNDWR	09T-546 /RV990317TNW002	S059-WL-001	Windmill well, water tank, and water trough were observed at this location. Water sample ID S059-WL-001 was collected from the valve at the trough on September 29, 2016. Due to a broken mercury sample bottle from the September 29, 2016 sampling event, a second visit was made on May 24, 2017 to collect a water well sample for mercury analysis and field parameters.
Oil Well or Equipment	Stantec	S059-Gas Well-3	NA	No surface water or windmill well observed at this location during RSE activities. Equipment for oil well observed in area of this location.
Oil Well or Equipment	2007 AUM Atlas[1], NNDWR	NAVAJO 138#3	NA	No surface water or windmill well observed at this location during RSE activities. Equipment for oil well observed in area of this location.
Oil Well or Equipment	2007 AUM Atlas[1], NNDWR	TEX PACF 1	NA	No surface water or windmill well observed at this location during RSE activities. Equipment for oil well observed in area of this location.
Oil Well or Equipment	2007 AUM Atlas[1], NNDWR	TEX PACF 2	NA	No surface water or windmill well observed at this location during RSE activities. Equipment for oil well observed in area of this location.

Notes
NA - Water feature not sampled
ID - identification
NNDWR - Navajo Nation Department of Water Resources
RSE - Removal Site Evaluation
[1] USEPA, 2007a

Table 3-1b
Water Well Specifications for 09T-546
NA-0904
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Description	Water Well Information
Tribal Well Number	09T-546
Easting[1]	651977.00
Northing[1]	4085357.00
Operator	Tribe Operations and Maintenance
Well Completed Date	2/26/1960
Elevation (ft amsl)	5,860
Well Depth (ft bgs)	874
Well Type	Water Well
Well Status	Active
Well Use	Livestock
Well Borehole Diameter (inches)	8.0
Well Casing Diameter (inches)	4.0
Top of Well Casing (ft ags)	0
Bottom of Well Casing (ft bgs)	unknown
Well Build Material	unknown
Top of Well Screen Perforation (ft bgs)	unknown
Bottom of Well Screen Perforation (ft bgs)	unknown

Notes
ft - feet
ft ags - feet above ground surface
ft amsl - feet above mean sea level
ft bgs - feet below ground surface
[1] Coordinate System: NAD 1983 UTM Zone 12N

Table 3-2
Soil and Sediment Sampling Summary
NA-0904
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 2											
S059-BG2-001	0 - 0.5	soil	SF	grab	NA	10/5/2016	650513.41	4084635.51	N;FD	N;FD	--
S059-BG2-002	0 - 0.5	soil	SF	grab	NA	10/5/2016	650510.96	4084633.92	N	N	--
S059-BG2-003	0 - 0.5	soil	SF	grab	NA	10/5/2016	650511.44	4084631.57	N	N	--
S059-BG2-004	0 - 0.5	soil	SF	grab	NA	10/5/2016	650513.19	4084630.23	N	N	--
S059-BG2-005	0 - 0.5	soil	SF	grab	NA	10/5/2016	650516.29	4084634.25	N	N	--
S059-BG2-006	0 - 0.5	soil	SF	grab	NA	10/5/2016	650515.81	4084631.17	N	N	--
S059-BG2-007	0 - 0.5	soil	SF	grab	NA	10/5/2016	650518.59	4084629.54	N	N	--
S059-BG2-008	0 - 0.5	soil	SF	grab	NA	10/5/2016	650518.56	4084626.43	N	N	--
S059-BG2-009	0 - 0.5	soil	SF	grab	NA	10/5/2016	650513.06	4084625.85	N	N	--
S059-BG2-010	0 - 0.5	soil	SF	grab	NA	10/5/2016	650516.93	4084624.85	N;FD	N;FD	--
S059-SCX-001	0 - 0.6	soil	SF	grab	NA	10/11/2016	650513.05	4084630.51	N	N	--
Background Reference Area Study - Background Area 3											
S059-BG3-001	0 - 0.5	soil	SF	grab	NA	10/6/2016	651139.20	4085183.03	N	N	--
S059-BG3-002	0 - 0.5	soil	SF	grab	NA	10/6/2016	651142.96	4085181.59	N	N	--
S059-BG3-003	0 - 0.5	soil	SF	grab	NA	10/6/2016	651145.92	4085184.25	N	N	--
S059-BG3-004	0 - 0.5	soil	SF	grab	NA	10/6/2016	651143.92	4085177.81	N;MS;MSD	N	--
S059-BG3-005	0 - 0.5	soil	SF	grab	NA	10/6/2016	651146.45	4085176.00	N	N	--
S059-BG3-006	0 - 0.5	soil	SF	grab	NA	10/6/2016	651149.62	4085178.17	N	N	--
S059-BG3-007	0 - 0.5	soil	SF	grab	NA	10/6/2016	651146.08	4085172.25	N	N	--
S059-BG3-008	0 - 0.5	soil	SF	grab	NA	10/6/2016	651149.88	4085170.76	N	N	--
S059-BG3-009	0 - 0.5	soil	SF	grab	NA	10/6/2016	651150.91	4085167.27	N	N	--
S059-BG3-010	0 - 0.5	soil	SF	grab	NA	10/6/2016	651153.79	4085166.11	N;FD	N;FD	--
S059-SCX-003	0 - 0.5	soil	SF	grab	NA	10/11/2016	651152.99	4085166.31	N	N	--
S059-SCX-003	0.5 - 1.2	soil	SB	grab	NA	10/11/2016	651152.99	4085166.31	N	N	--
Background Reference Area Study - Background Area 4											
S059-BG4-001	0 - 0.5	sediment	SF	grab	NA	9/14/2017	651140.63	4085261.30	N	N	--
S059-BG4-002	0 - 0.5	sediment	SF	grab	NA	9/14/2017	651141.30	4085262.68	N;FD	N;FD	--
S059-BG4-003	0 - 0.5	sediment	SF	grab	NA	9/14/2017	651141.30	4085265.84	N	N	--
S059-BG4-004	0 - 0.5	sediment	SF	grab	NA	9/14/2017	651141.36	4085268.74	N;FD	N;FD	--
S059-BG4-005	0 - 0.5	sediment	SF	grab	NA	9/14/2017	651143.27	4085270.56	N	N	--
S059-BG4-006	0 - 0.5	sediment	SF	grab	NA	9/14/2017	651143.44	4085271.66	N;FD	N;FD	--
S059-BG4-007	0 - 0.5	sediment	SF	grab	NA	9/14/2017	651145.58	4085272.25	N	N	--
S059-BG4-008	0 - 0.5	sediment	SF	grab	NA	9/14/2017	651146.59	4085274.17	N;FD	N;FD	--
S059-BG4-009	0 - 0.5	sediment	SF	grab	NA	9/14/2017	651149.95	4085276.61	N	N	--
S059-BG4-010	0 - 0.5	sediment	SF	grab	NA	9/14/2017	651151.11	4085277.83	N	N	--
S059-BG4-011	0 - 0.5	sediment	SF	grab	NA	9/14/2017	651151.68	4085277.53	N	N	--
S059-BG4-011	0.5 - 1.5	sediment	SB	grab	NA	9/14/2017	651151.68	4085277.53	N	N	--
Correlation											
S059-C01-001	0 - 0.5	soil	SF	5-point composite	NA	10/11/2016	651462.38	4085494.11	--	N	N
S059-C02-001	0 - 0.5	soil	SF	5-point composite	NA	10/11/2016	651364.16	4085325.70	--	N	N
S059-C03-001	0 - 0.5	soil	SF	5-point composite	NA	10/11/2016	651361.42	4085309.28	--	N	N
S059-C04-001	0 - 0.5	sediment	SF	5-point composite	NA	10/11/2016	651345.77	4085435.32	--	N	N
S059-C05-001	0 - 0.5	soil	SF	5-point composite	NA	10/11/2016	651413.67	4085257.16	--	N	N
Characterization											
S059-CX-001	0 - 0.5	soil	SF	grab	A	4/11/2017	651431.20	4085256.21	N	N	--
S059-CX-002	0 - 0.5	soil	SF	grab	A	4/11/2017	651394.53	4085217.27	N	N	--
S059-CX-003	0 - 0.5	soil	SF	grab	A	4/11/2017	651546.87	4085252.58	N	N	--
S059-CX-004	0 - 0.5	soil	SF	grab	C	4/12/2017	651265.62	4085278.15	N	N	--
S059-CX-005	0 - 0.5	sediment	SF	grab	C	4/12/2017	651229.85	4085335.64	N;FD	N;FD	--
S059-CX-006	0 - 0.5	soil	SF	grab	C	4/12/2017	651341.32	4085344.28	N;MS;MSD	N	--
S059-CX-007	0 - 0.5	soil	SF	grab	C	4/12/2017	651368.56	4085345.66	N	N	--
S059-CX-008	0 - 0.5	soil	SF	grab	B	4/12/2017	651386.77	4085310.65	N	N	--
S059-CX-009	0 - 0.5	soil	SF	grab	B	4/12/2017	651392.98	4085294.61	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

Stantec | NAVAJO NATION AUM Environmental Response Trust - First Phase

Table 3-2
Soil and Sediment Sampling Summary
NA-0904
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Sample Location	Sample Depth (ft bgs)	Sample Media	Sample Category	Sample Collection Method	Survey Area	Sample Date	Easting [1]	Northing [1]	Sample Types: Metals, Total	Sample Types: Ra-226	Sample Types: Thorium
Characterization continued											
S059-CX-010	0 - 0.5	soil	SF	grab	B	4/12/2017	651383.52	4085272.87	N	N	--
S059-CX-011	0 - 0.5	sediment	SF	grab	C	4/12/2017	651336.55	4085489.35	N	N	--
S059-CX-012	0 - 0.5	sediment	SF	grab	C	4/12/2017	651508.67	4085726.64	N	N	--
S059-CX-013	0 - 0.5	sediment	SF	grab	C	4/13/2017	651501.99	4085724.27	N;FD;MS;MSD	N;FD	--
S059-SCX-004	0 - 0.5	soil	SF	grab	A	4/11/2017	651399.64	4085246.03	N	N	--
S059-SCX-004	0.5 - 1.0	soil	SB	grab	A	4/11/2017	651399.64	4085246.03	N	N	--
S059-SCX-005	0 - 0.5	soil	SF	grab	A	4/11/2017	651447.42	4085277.06	N	N	--
S059-SCX-005	0 - 0.8	soil	SB	grab	A	4/11/2017	651447.42	4085277.06	N	N	--
S059-SCX-006	0 - 0.5	soil	SF	grab	A	4/11/2017	651478.39	4085282.98	N	N	--
S059-SCX-006	0 - 0.8	soil	SB	grab	A	4/11/2017	651478.39	4085282.98	N	N	--
S059-SCX-007	0 - 0.1	soil	SF	grab	A	4/11/2017	651547.05	4085288.76	N	N	--
S059-SCX-007	0.1 - 0.25	soil	SF	grab	A	4/11/2017	651547.05	4085288.76	N	N	--
S059-SCX-008	0 - 0.5	soil	SF	grab	C	4/12/2017	651273.92	4085282.20	N	N	--
S059-SCX-009	0 - 0.5	sediment	SF	grab	C	4/12/2017	651344.99	4085435.15	N;MS;MSD	N	--
S059-SCX-010	0 - 0.5	sediment	SF	grab	C	4/12/2017	651350.56	4085532.31	N	N	--
S059-SCX-010	0.5 - 1.0	sediment	SB	grab	C	4/12/2017	651350.56	4085532.31	N	N	--
S059-SCX-010	1.0 - 1.5	sediment	SB	grab	C	4/12/2017	651350.56	4085532.31	N	N	--
S059-SCX-010	1.5 - 2.0	sediment	SB	grab	C	4/12/2017	651350.56	4085532.31	N	N	--
S059-SCX-011	0 - 0.5	sediment	SF	grab	C	4/12/2017	651320.35	4085572.33	N	N	--
S059-SCX-012	0 - 0.5	sediment	SF	grab	C	4/12/2017	651345.75	4085585.89	N	N	--
S059-SCX-012	0.5 - 1.0	sediment	SB	grab	C	4/12/2017	651345.75	4085585.89	N	N	--
S059-SCX-012	1.0 - 1.5	sediment	SB	grab	C	4/12/2017	651345.75	4085585.89	N	N	--
S059-SCX-012	1.5 - 2.0	sediment	SB	grab	C	4/12/2017	651345.75	4085585.89	N	N	--
S059-SCX-013	0 - 0.5	sediment	SF	grab	C	4/12/2017	651411.40	4085687.10	N	N	--
S059-SCX-013	0.5 - 1.0	sediment	SB	grab	C	4/12/2017	651411.40	4085687.10	N;MS;MSD	N	--
S059-SCX-014	0 - 0.5	sediment	SF	grab	C	4/13/2017	651348.42	4085387.07	N	N	--
S059-SCX-014	0.5 - 1.0	sediment	SB	grab	C	4/13/2017	651348.42	4085387.07	N	N	--
S059-SCX-014	1.0 - 1.8	sediment	SB	grab	C	4/13/2017	651348.42	4085387.07	N	N	--
S059-SCX-015	0 - 0.5	sediment	SF	grab	C	4/13/2017	651360.20	4085335.70	N	N	--
S059-SCX-015	0.5 - 1.0	sediment	SB	grab	C	4/13/2017	651360.20	4085335.70	N	N	--
S059-SCX-015	1.0 - 1.5	sediment	SB	grab	C	4/13/2017	651360.20	4085335.70	N	N	--
S059-SCX-015	1.5 - 2.0	sediment	SB	grab	C	4/13/2017	651360.20	4085335.70	N	N	--
S059-SCX-016	0 - 0.5	soil	SF	grab	C	4/13/2017	651359.79	4085306.57	N	N	--
S059-SCX-016	0.5 - 1.0	soil	SB	grab	C	4/13/2017	651359.79	4085306.57	N	N	--
S059-SCX-016	1.0 - 1.8	soil	SB	grab	C	4/13/2017	651359.79	4085306.57	N;MS;MSD	N	--
S059-SCX-017	0 - 0.5	soil	SF	grab	C	4/13/2017	651354.84	4085290.05	N;FD	N;FD	--
S059-SCX-017	0.5 - 1.0	soil	SB	grab	C	4/13/2017	651354.84	4085290.05	N	N	--
S059-SCX-018	0 - 0.5	soil	SF	grab	C	4/13/2017	651363.42	4085290.30	N	N	--
S059-SCX-019	0 - 0.5	soil	SF	grab	B	4/13/2017	651391.92	4085291.35	N	N	--
S059-SCX-019	0.5 - 1.0	soil	SB	grab	B	4/13/2017	651391.92	4085291.35	N	N	--
S059-SCX-019	1.0 - 1.5	soil	SB	grab	B	4/13/2017	651391.92	4085291.35	N	N	--
S059-SCX-020	0 - 0.5	soil	SF	grab	C	4/13/2017	651338.35	4085312.16	N	N	--
S059-SCX-020	0.5 - 1.0	soil	SB	grab	C	4/13/2017	651338.35	4085312.16	N	N	--
S059-SCX-020	1.0 - 1.5	soil	SB	grab	C	4/13/2017	651338.35	4085312.16	N	N	--
S059-SCX-020	1.5 - 2.0	soil	SB	grab	C	4/13/2017	651338.35	4085312.16	N	N	--
S059-SCX-021	0 - 0.5	soil	SF	grab	C	4/13/2017	651336.84	4085288.73	N	N	--
S059-SCX-021	0.5 - 1.0	soil	SB	grab	C	4/13/2017	651336.84	4085288.73	N	N	--
S059-SCX-021	1.0 - 1.3	soil	SB	grab	C	4/13/2017	651336.84	4085288.73	N	N	--

Notes

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

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

Table 3-3
Mine Feature Samples and Area
NA-0904
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Mine Feature	Surface Samples	Subsurface Samples	Area (sq. ft)	Volume of TENORM exceeding ILs (yd^3)
Waste Pile 1	7	8	22,285	2284
Waste Pile 2	0	0	880	33
Waste Pile 3	1	1	4,004	148
Potential Haul Roads	3	3	*	383
Drainages	11	12	**	3612

Notes

sq.ft - square feet

yd^3 - cubic yards

ILs - investigation levels

TENORM - technologically enhanced naturally occurring radioactive material

* Area not determined because the width of the potential haul roads vary throughout the Site

** Area not determined because the width of the drainages vary throughout the Site

Table 3-4
Water Sampling Summary
NA-0904
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Field Sample Identification	Water Feature Identification	Sample Date	Easting [1]	Northing [1]	Sample Types							
					Ra-226	Ra-228	Gross Alpha	Metals, Dissolved	Metals, Total	TDS	Anions	Cations
Well Water												
S059-WL-001	09T-546 /RV990317TNW002	9/29/2016	651904.10	4085529.22	N	N	N	N	N;MS;MSD	N	N;MS;MSD	N
S059-WL-001[2]	09T-546 /RV990317TNW002	5/24/2017	651904.10	4085529.22	--	--	--	N	N;MS;MSD	--	--	--

Notes
-- Not Sampled
N Normal
MS Matrix Spike
MSD Matrix Spike Duplicate
Ra-226 Radium 226
Ra-228 Radium 228
TDS Total Dissolved Solids
[1] Coordinate System: NAD 1983 UTM Zone 12N
[2] Metals total mercury analysis also included laboratory MS/MSD, all other metals analyses did not include laboratory MS/MDS

Table 4-1
Background Reference Area Soil and Sediment Sample Analytical Results
NA-0904
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Location Identification	S059-BG2-001	S059-BG2-001 Dup	S059-BG2-002	S059-BG2-003	S059-BG2-004	S059-BG2-005	S059-BG2-006	S059-BG2-007	S059-BG2-008	S059-BG2-009	S059-BG2-010
Date Collected	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Analyte (Units)											
Metals[1] (mg/kg)											
Arsenic	1.4	1.2	2	1.5	1.4	1.7	4.2	1.7	2.1	2.1	1.6
Molybdenum	<0.18	<0.19	<0.21	<0.2	<0.2	<0.19	<0.18	<0.2	<0.18	<0.18	<0.18
Selenium	<0.92	<0.93	<1	<0.98	<0.99	<0.95	<0.92	<1	<0.9	<0.9	<0.92
Uranium	2.3	2.3	1.2	1.6	1.2	2	2.4	1.8	1.3	1.2	2.5
Vanadium	6.8	6.6	15	7.9	8.2	13	14	9.3	9.1	12	10
Radionuclides (pCi/g)											
Radium-226	1.58 ± 0.31	1.27 ± 0.28	1.79 ± 0.33	1.23 ± 0.27	1.18 ± 0.27	1.98 ± 0.33	2.94 ± 0.49	1.26 ± 0.28	0.92 ± 0.23	1.57 ± 0.31	2.04 ± 0.37

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 and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Table 4-1
Background Reference Area Soil and Sediment Sample Analytical Results
NA-0904
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Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification	S059-BG2-010 Dup	S059-SCX-001	S059-BG3-001	S059-BG3-002	S059-BG3-003	S059-BG3-004	S059-BG3-005	S059-BG3-006	S059-BG3-007	S059-BG3-008	S059-BG3-009	S059-BG3-010
Date Collected	10/5/2016	10/11/2016	10/6/2016	10/6/2016	10/6/2016	10/6/2016	10/6/2016	10/6/2016	10/6/2016	10/6/2016	10/6/2016	10/6/2016
Depth (feet)	0 - 0.5	0 - 0.6	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	1.5	2.2	1.4	1.3	1.5	1.3 J+	1.4	1.4	1.4	1.5	1.7	2
Molybdenum	<0.2	<0.19	<0.17	<0.18	0.24	<0.18	<0.19	<0.2	<0.2	<0.19	<0.18	<0.19
Selenium	<0.99	<0.96	<0.85	<0.89	<0.95	<0.88	<0.95	<0.98	<1	<0.94	<0.91	<0.95
Uranium	2.6	1.5	0.4	0.45	0.59	0.6 J+	0.61	0.51	0.78	0.56	0.58	0.56
Vanadium	10	12	6.3	6.9	7.3	7.8 J+	8.2	9.5	9.3	11	17	12
Radionuclides (pCi/g)												
Radium-226	1.62 ± 0.3	1.26 ± 0.29	0.5 ± 0.23	0.43 ± 0.19	0.84 ± 0.23	0.86 ± 0.24	0.68 ± 0.2	0.49 ± 0.2	0.58 ± 0.21	0.61 ± 0.27	0.44 ± 0.17	0.79 ± 0.24 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 and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data

Table 4-1
Background Reference Area Soil and Sediment Sample Analytical Results
NA-0904
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Location Identification	S059-BG3-010 Dup	S059-SCX-003	S059-SCX-003	S059-BG4-001	S059-BG4-002	S059-BG4-002 Dup	S059-BG4-003	S059-BG4-004	S059-BG4-004 Dup	S059-BG4-005	S059-BG4-006
Date Collected	10/6/2016	10/11/2016	10/11/2016	9/14/2017	9/14/2017	9/14/2017	9/14/2017	9/14/2017	9/14/2017	9/14/2017	9/14/2017
Depth (feet)	0 - 0.5	0 - 0.5	0.5 - 1.2	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	2	2	1.9	1.5	1.5	5.1	2.2	2.4	2	1.6	1.8
Molybdenum	<0.19	<0.2	<0.21	0.27	<0.2	<0.19	0.28	<0.19	<0.2	<0.2	<0.2
Selenium	<0.93	<0.98	<1	<0.98	<1	<0.97	<1	<0.95	<1	<0.99	<0.99
Uranium	0.56	0.55	0.48	0.69	0.67	1	0.66	0.85	0.72	0.69	0.71
Vanadium	12	9.4	7.8	5.9	6.5	7.8	6.6	8.2	7.4	6.9	6
Radionuclides (pCi/g)											
Radium-226	0.61 ± 0.2 J-	0.62 ± 0.19	0.6 ± 0.2	0.81 ± 0.22	0.61 ± 0.17 J-	0.52 ± 0.18 J-	0.56 ± 0.17	0.75 ± 0.19	0.8 ± 0.21	0.67 ± 0.19 J-	0.7 ± 0.19

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

Table 4-1
Background Reference Area Soil and Sediment Sample Analytical Results
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Location Identification	S059-BG4-006 Dup	S059-BG4-007	S059-BG4-008	S059-BG4-008 Dup	S059-BG4-009	S059-BG4-010	S059-BG4-011	S059-BG4-011
Date Collected	9/14/2017	9/14/2017	9/14/2017	9/14/2017	9/14/2017	9/14/2017	9/14/2017	9/14/2017
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.5
Analyte (Units)								
Metals[1] (mg/kg)								
Arsenic	3.9	1.5	1.8	1.8	2.5	1.5	1.7	1.8
Molybdenum	0.61	<0.2	<0.19	0.21	0.3	<0.19	<0.2	<0.21
Selenium	<1	<1	<0.96	<0.95	<0.99	<0.96	<0.99	<1.1
Uranium	0.77	0.59	0.7	0.71	0.87	0.66	0.76	0.76
Vanadium	6.9	5.9	6	6.2	7	7.2	7	6.8
Radionuclides (pCi/g)								
Radium-226	0.76 ± 0.22	0.77 ± 0.21	0.67 ± 0.24	0.91 ± 0.21	0.62 ± 0.17 J-	0.7 ± 0.2	0.71 ± 0.2 J-	0.7 ± 0.22

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

Table 4-2
Static Gamma Measurement Summary
NA-0904
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Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S059-SCX-001	Background Area 2	*	0.0	soil	8,379
S059-SCX-001	Background Area 2	*	0.5	soil	13,249**
S059-SCX-003	Background Area 3	*	0.5	soil	11,880
S059-SCX-003	Background Area 3	*	1.1	soil	13,159
S059-BG4-011	Background Area 4	*	0.0	sediment	8,051
S059-BG4-011	Background Area 4	*	0.5	sediment	9,348
S059-BG4-011	Background Area 4	*	1.0	sediment	10,141
S059-BG4-011	Background Area 4	*	1.5	sediment	11,166**
S059-SCX-004	A	--	0.0	soil	32,064
S059-SCX-004	A	13,249	0.5	soil	50,742
S059-SCX-004	A	13,249	1.0	soil	75,735**
S059-SCX-005	A	--	0.0	soil	12,041
S059-SCX-005	A	13,249	0.5	soil	15,283
S059-SCX-005	A	13,249	0.8	soil	16,433**
S059-SCX-006	A	--	0.0	soil	20,381
S059-SCX-006	A	13,249	0.8	soil	70,016**
S059-SCX-007	A	--	0.0	soil	9,343
S059-SCX-007	A	13,249	0.3	soil	9,756**
S059-SCX-019	B	--	0.0	soil	19,182
S059-SCX-019	B	13,159	0.5	soil	20,581
S059-SCX-019	B	13,159	1.0	soil	21,191
S059-SCX-019	B	13,159	1.5	soil	20,863**
S059-SCX-008	C	--	0.0	soil	18,445
S059-SCX-008	C	10,141	0.5	soil	29,852**
S059-SCX-009	C	--	0.0	sediment	25,334
S059-SCX-009	C	10,141	0.5	sediment	58,154**
S059-SCX-010	C	--	0.0	sediment	34,657
S059-SCX-010	C	10,141	0.5	sediment	37,271
S059-SCX-010	C	10,141	1.0	sediment	18,167
S059-SCX-010	C	10,141	1.5	sediment	14,897
S059-SCX-010	C	10,141	1.8	sediment	14,125
S059-SCX-011	C	--	0.0	sediment	27,121
S059-SCX-011	C	10,141	0.5	sediment	121,478
S059-SCX-011	C	10,141	0.6	sediment	147,979**
S059-SCX-012	C	--	0.0	sediment	24,887
S059-SCX-012	C	10,141	0.5	sediment	40,419
S059-SCX-012	C	10,141	1.0	sediment	38,250
S059-SCX-012	C	10,141	1.5	sediment	24,910
S059-SCX-012	C	10,141	2.0	sediment	17,865**
S059-SCX-013	C	--	0.0	sediment	11,165
S059-SCX-013	C	10,141	0.5	sediment	12,259
S059-SCX-013	C	10,141	1.0	sediment	11,911
S059-SCX-013	C	10,141	1.3	sediment	11,694**

Notes

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

Table 4-2
Static Gamma Measurement Summary
NA-0904
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Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S059-SCX-014	C	--	0.0	sediment	72,691
S059-SCX-014	C	10,141	0.5	sediment	142,792
S059-SCX-014	C	10,141	1.0	sediment	162,633
S059-SCX-014	C	10,141	1.5	sediment	153,633
S059-SCX-014	C	10,141	1.8	sediment	100,184**
S059-SCX-015	C	--	0.0	sediment	49,050
S059-SCX-015	C	10,141	0.5	sediment	57,600
S059-SCX-015	C	10,141	1.0	sediment	28,069
S059-SCX-015	C	10,141	1.5	sediment	19,532
S059-SCX-015	C	10,141	2.0	sediment	16,974
S059-SCX-016	C	--	0.0	soil	137,018
S059-SCX-016	C	10,141	0.5	soil	178,207
S059-SCX-016	C	10,141	1.0	soil	200,184
S059-SCX-016	C	10,141	1.5	soil	216,806
S059-SCX-016	C	10,141	1.8	soil	267,183**
S059-SCX-017	C	--	0.0	soil	135,194
S059-SCX-017	C	10,141	0.5	soil	315,825
S059-SCX-017	C	10,141	1.0	soil	310,826
S059-SCX-017	C	10,141	1.3	soil	324,081**
S059-SCX-018	C	--	0.0	soil	133,040
S059-SCX-018	C	10,141	0.5	soil	200,633**
S059-SCX-020	C	--	0.0	soil	15,385
S059-SCX-020	C	10,141	0.5	soil	15,462
S059-SCX-020	C	10,141	1.0	soil	27,810
S059-SCX-020	C	10,141	1.5	soil	27,351
S059-SCX-020	C	10,141	2.0	soil	28,452**
S059-SCX-021	C	--	0.0	soil	13,611
S059-SCX-021	C	10,141	0.5	soil	10,201
S059-SCX-021	C	10,141	1.0	soil	10,404
S059-SCX-021	C	10,141	1.3	soil	10,284**

Notes

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

Table 4-3
Gamma Correlation Study Soil and Sediment Sample Analytical Results
NA-0904
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Location Identification	S059-C01-001	S059-C02-001	S059-C03-001	S059-C04-001	S059-C05-001
Date Collected	10/11/2016	10/11/2016	10/11/2016	10/11/2016	10/11/2016
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Analyte (Units)					
Radionuclides (pCi/g)					
Radium-226	0.97 ± 0.25	31.3 ± 3.8	110 ± 13	9.4 ± 1.2	4.04 ± 0.6
Thorium-228	0.43 ± 0.086	0.52 ± 0.1	0.59 ± 0.11	0.376 ± 0.082	0.57 ± 0.11
Thorium-230	0.76 ± 0.14	25.1 ± 3.9	175 ± 27	6.4 ± 1	3.17 ± 0.51
Thorium-232	0.377 ± 0.076	0.477 ± 0.093	0.73 ± 0.13	0.388 ± 0.08	0.65 ± 0.12

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
NA-0904
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Location Identification		S059-CX-001	S059-CX-002	S059-CX-003	S059-SCX-004	S059-SCX-004	S059-SCX-005	S059-SCX-005	S059-SCX-006	S059-SCX-006	S059-SCX-007	S059-SCX-007
Date Collected		4/11/2017	4/11/2017	4/11/2017	4/11/2017	4/11/2017	4/11/2017	4/11/2017	4/11/2017	4/11/2017	4/11/2017	4/11/2017
Depth (feet)		0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.0	0 - 0.5	0 - 0.8	0 - 0.5	0 - 0.8	0 - 0.1	0.1 - 0.25
Sample Category		surface	surface	surface	surface	subsurface	surface	subsurface	surface	subsurface	surface	surface
Sample Collection Method		grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
Media		soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)	Investigation Level											
Metals[1] (mg/kg)												
Arsenic	4.38	6.1	1.8	1.2	9.7	7.1	2.4	2.2	4.8	12	4.7	4.1
Molybdenum	NA	2.7	<0.2	<0.2	0.96	1.2	<0.2	<0.21	<0.21	0.93	<0.2	<0.22
Selenium	NA	<1.1	<0.99	<0.98	<1.1	<1	<1	<1	<1.1	1.6	<1	<1.1
Uranium	3.28	60	1.9	0.99	10	10	3.2	3.4	8.1	16	2.4	2.3
Vanadium	18.7	290	6.3	8.3	35	28	16	14	22	23	16	13
Radionuclides (pCi/g)												
Radium-226	3.34	45.5 ± 5.4	0.94 ± 0.25	0.98 ± 0.23	10.2 ± 1.3	6.84 ± 0.92 J+	1.72 ± 0.33	2.8 ± 0.49	5.6 ± 0.81	22 ± 2.7	1.8 ± 0.36	1.09 ± 0.28

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 and molybdenum sample results in BG-2 were all non-detect
[1]	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit
J+	Data are estimated and are potentially biased high due to associated quality control data.

Table 4-4b
Site Characterization Soil Sample Analytical Results for Survey Area B
NA-0904
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Analyte (Units)	Location Identification	Investigation Level	S059-CX-008	S059-CX-009	S059-CX-010	S059-SCX-019	S059-SCX-019	S059-SCX-019
	Date Collected		4/12/2017	4/12/2017	4/12/2017	4/13/2017	4/13/2017	4/13/2017
	Depth (feet)		0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.0	1.0 - 1.5
	Sample Category		surface	surface	surface	surface	subsurface	subsurface
	Sample Collection Method		grab	grab	grab	grab	grab	grab
	Media		soil	soil	soil	soil	soil	soil
Metals[1] (mg/kg)								
Arsenic		2.25	4.2	2.5	25	3.7	5	5.1
Molybdenum		NA	<0.21	<0.2	45	0.3	0.73	22
Selenium		NA	<1.1	<0.99	1.6	<1	<1	<1
Uranium		0.836	0.66	2.8	130 D	6.2	9.9	9.7
Vanadium		18	11	54	690	27	43	54
Radionuclides (pCi/g)								
Radium-226		1.06	0.7 ± 0.22	2.76 ± 0.42	83.2 ± 9.8	5.65 ± 0.77	7.6 ± 1	7.12 ± 0.97

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 in BG-3 molybdenum sample results were all non-detect and selenium had only one detection
[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

Table 4-4c
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area C
NA-0904
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Location Identification		S059-CX-004	S059-CX-005	S059-CX-005 Dup	S059-CX-006	S059-CX-007	S059-CX-011	S059-CX-012	S059-CX-013	S059-CX-013 Dup	S059-SCX-008	S059-SCX-009	S059-SCX-010
Date Collected		4/12/2017	4/12/2017	4/12/2017	4/12/2017	4/12/2017	4/12/2017	4/12/2017	4/13/2017	4/13/2017	4/12/2017	4/12/2017	4/12/2017
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
Sample Category		surface	surface	surface	surface	surface	surface	surface	surface	surface	surface	surface	surface
Sample Collection Method		grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
Media		soil	sediment	sediment	soil	soil	sediment	sediment	sediment	sediment	soil	sediment	sediment
Analyte (Units)	Investigation Level												
Metals[1] (mg/kg)													
Arsenic	2.88	4.1	1.9	1.7	1.2	1.8	1.8	3.2	2.1 J	0.85	7.9	27 J-	12
Molybdenum	0.334	0.79	<0.21	<0.21	<0.2	0.68	0.86	30	0.37	<0.2	1.8	180 J	46
Selenium	NA	<0.98	<1	<1	<1	<1	<1	<0.95	<0.97	<1	<1	<1	<1
Uranium	0.948	2.2	0.99	0.69	0.71	3.3	4.5	2.4	1.9 J	1.1	8.2	20 J	17
Vanadium	8.65	70	12	13	9.2 J+	33	35	19	35 J	7	84	100 J	110
Radionuclides (pCi/g)													
Radium-226	0.895	10.3 ± 1.3	0.77 ± 0.24	0.91 ± 0.22	1.05 ± 0.29	2.52 ± 0.4	2.33 ± 0.38	2.88 ± 0.43 J-	0.91 ± 0.2 J-	1.02 ± 0.24 J-	15.7 ± 1.9	15.3 ± 2 J+	30 ± 3.6

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-4 were all non-detect
[1]	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit
D	Sample dilution required for analysis; reported values reflect the dilution
J	Data are estimated due to associated quality control data
J-	Data are estimated and are potentially biased low due to associated quality control data
J+	Data are estimated and are potentially biased high due to associated quality control data

Table 4-4c
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area C
NA-0904
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification		S059-SCX-010	S059-SCX-010	S059-SCX-010	S059-SCX-011	S059-SCX-012	S059-SCX-012	S059-SCX-012	S059-SCX-012	S059-SCX-013	S059-SCX-013	S059-SCX-014	S059-SCX-014
Date Collected		4/12/2017	4/12/2017	4/12/2017	4/12/2017	4/12/2017	4/12/2017	4/12/2017	4/12/2017	4/12/2017	4/12/2017	4/13/2017	4/13/2017
Depth (feet)		0.5 - 1.0	1.0 - 1.5	1.5 - 2.0	0 - 0.5	0 - 0.5	0.5 - 1.0	1.0 - 1.5	1.5 - 2.0	0 - 0.5	0.5 - 1.0	0 - 0.5	0.5 - 1.0
Sample Category		subsurface	subsurface	subsurface	surface	surface	subsurface	subsurface	subsurface	surface	subsurface	surface	subsurface
Sample Collection Method		grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
Media		sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment
Analyte (Units)	Investigation Level												
Metals[1] (mg/kg)													
Arsenic	2.88	2.1	2.3	1.9	3.6	4.1	7.3	3.1	3.6	2.5	1.7	9.4	12
Molybdenum	0.334	0.6	0.41	0.23	1.9	3	1.8	1.8	5.3	3.2	0.3	11	38
Selenium	NA	<0.98	<1	<0.99	<0.96	<1	<0.97	<0.99	<1	<1	<1	<1	1
Uranium	0.948	3.7	2.6	1.7	41	160 D	44	38	2.3	2	1.3 J+	41	59
Vanadium	8.65	28	26	17	160	240	120	97	19	29	21 J+	270	530
Radionuclides (pCi/g)													
Radium-226	0.895	1.45 ± 0.3	5.3 ± 0.81 J+	2.09 ± 0.37	11.3 ± 1.4	22.1 ± 2.7	16.5 ± 2.1	8.9 ± 1.2	1.95 ± 0.39	3.1 ± 0.52	0.9 ± 0.23	40.6 ± 4.8	77.2 ± 9.1

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-4 were all non-detect
1	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit
D	Sample dilution required for analysis; reported values reflect the dilution
J	Data are estimated due to associated quality control data
J-	Data are estimated and are potentially biased low due to associated quality control data
J+	Data are estimated and are potentially biased high due to associated quality control data

Table 4-4c
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area C
NA-0904
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Location Identification		S059-SCX-014	S059-SCX-015	S059-SCX-015	S059-SCX-015	S059-SCX-015	S059-SCX-016	S059-SCX-016	S059-SCX-016	S059-SCX-017	S059-SCX-017	S059-SCX-017 Dup	S059-SCX-018
Date Collected		4/13/2017	4/13/2017	4/13/2017	4/13/2017	4/13/2017	4/13/2017	4/13/2017	4/13/2017	4/13/2017	4/13/2017	4/13/2017	4/13/2017
Depth (feet)		1.0 - 1.8	0 - 0.5	0.5 - 1.0	1.0 - 1.5	1.5 - 2.0	0 - 0.5	0.5 - 1.0	1.0 - 1.8	0 - 0.5	0.5 - 1.0	0 - 0.5	0 - 0.5
Sample Category		subsurface	surface	subsurface	subsurface	subsurface	surface	subsurface	subsurface	surface	subsurface	surface	surface
Sample Collection Method		grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
Media		sediment	sediment	sediment	sediment	sediment	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)	Investigation Level												
Metals[1] (mg/kg)													
Arsenic	2.88	13	18	2.6	1.6	1.5	63	51	44 J	76	53	38	13
Molybdenum	0.334	13	19	1.1	0.25	0.3	47	49	38 J	51	56	28	10
Selenium	NA	<1.1	<1.1	<0.99	<1.1	<1.1	2.8	2.2	2 J	2.8	2.6	2.2	<1
Uranium	0.948	160 D	89	6.4	2.7	2.4	120 D	650 D	160 DJ	160 D	170 D	210 D	150 D
Vanadium	8.65	660	470	31	16	12	700	1200 D	970 DJ	1100 D	970 D	1200 D	510 D
Radionuclides (pCi/g)													
Radium-226	0.895	36.1 ± 4.4	48.3 ± 5.8	5.95 ± 0.81	1.64 ± 0.34	1.1 ± 0.28	127 ± 15	127 ± 15	125 ± 15	103 ± 12	146 ± 17	110 ± 13	101 ± 12

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-4 were all non-detect
[1]	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit
D	Sample dilution required for analysis; reported values reflect the dilution
J	Data are estimated due to associated quality control data
J-	Data are estimated and are potentially biased low due to associated quality control data
J+	Data are estimated and are potentially biased high due to associated quality control data

Table 4-4c
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area C
NA-0904
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Analyte (Units)		Location Identification	S059-SCX-020	S059-SCX-020	S059-SCX-020	S059-SCX-020	S059-SCX-021	S059-SCX-021	S059-SCX-021
		Date Collected	4/13/2017	4/13/2017	4/13/2017	4/13/2017	4/13/2017	4/13/2017	4/13/2017
		Depth (feet)	0 - 0.5	0.5 - 1.0	1.0 - 1.5	1.5 - 2.0	0 - 0.5	0.5 - 1.0	1.0 - 1.3
		Sample Category	surface	subsurface	subsurface	subsurface	surface	subsurface	subsurface
		Sample Collection Method	grab	grab	grab	grab	grab	grab	grab
		Media	soil	soil	soil	soil	soil	soil	soil
Metals[1] (mg/kg)	Investigation Level								
Arsenic	2.88		1.5	2.5	3	2.3	0.97	1.3	1
Molybdenum	0.334		0.22	0.53	0.57	0.6	<0.22	<0.2	<0.21
Selenium	NA		<0.99	<1	<1	<1.1	<1.1	<1	<1
Uranium	0.948		0.78	2.2	4.6	2.3	0.55	0.71	0.56
Vanadium	8.65		10	28	46	30	27	52	23
Radionuclides (pCi/g)									
Radium-226	0.895		1.12 ± 0.27	3.42 ± 0.51	8.2 ± 1.1	4.56 ± 0.65	0.75 ± 0.21	1.01 ± 0.27	0.86 ± 0.26

Notes

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

Table 4-5
Summary of Investigation Level Exceedances in Soil at Borehole Locations
NA-0904
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Sample Location	Survey Area	Investigation Level Exceedances
S059-SCX-004[1]	A	As, Mo, U, V, Ra-226, Static Gamma
S059-SCX-005	A	U, Static Gamma
S059-SCX-006[1,2]	A	As, Mo, Se, U, V, Ra-226, Static Gamma
S059-SCX-007	A	As
S059-SCX-008	C	As, Mo, U, V, Ra-226, Static Gamma
S059-SCX-009	C	As, Mo, U, V, Ra-226, Static Gamma
S059-SCX-010	C	As, Mo, U, V, Ra-226, Static Gamma
S059-SCX-011	C	As, Mo, U, V, Ra-226, Static Gamma
S059-SCX-012	C	As, Mo, U, V, Ra-226, Static Gamma
S059-SCX-013	C	Mo, U, V, Ra-226, Static Gamma
S059-SCX-014[2]	C	As, Mo, Se, U, V, Ra-226, Static Gamma
S059-SCX-015	C	As, Mo, U, V, Ra-226, Static Gamma
S059-SCX-016[2]	C	As, Mo, Se, U, V, Ra-226, Static Gamma
S059-SCX-017[2]	C	As, Mo, Se, U, V, Ra-226, Static Gamma
S059-SCX-018	C	As, Mo, U, V, Ra-226, Static Gamma
S059-SCX-019[1]	B	As, Mo, U, V, Ra-226, Static Gamma
S059-SCX-020	C	As, Mo, U, V, Ra-226, Static Gamma
S059-SCX-021	C	V, Ra-226, Static Gamma

Notes

[1] Detections of Mo included for reference, no IL was established for Mo for Survey Area A and Survey Area B

[2] Detections of Se included for reference, no IL was established for Se

IL - Investigation Level
As - Arsenic
Mo - Molybdenum
Ra-226 - Radium 226
Se - Selenium
U - Uranium
V - Vanadium

Table 4-6a
Water Sampling Investigation Level Derivation
NA-0904
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Analyte (Units)	USEPA		Navajo Nation		Investigation Level
	MCL [a]	Secondary Standard [b]	Surface Water Quality Standards [c]	Primary Drinking Water MCL[d]	
Radionuclides (pCi/L)					
Ra-226 [e]	5	*	5	5	5
Ra-228 [e]	5	*	5	5	5
Gross Alpha	15	*	15	15	15
Metals (ng/L)					
Mercury	2000	*	2000	2000	2000
Metals (µg/L)					
Antimony	6	*	5.6	6	5.6
Arsenic	10	*	10	10	10
Barium	2000	*	2000	2000	2000
Beryllium	4	*	4	4	4
Cadmium	5	*	5	5	5
Chromium, Total	100	*	100	100	100
Cobalt	*	*	*	*	*
Copper	1300	*	1300	*	1300
Lead	15	*	15	15	15
Molybdenum	*	*	*	*	*
Nickel	*	*	610	*	610
Selenium	50	*	50	50	50
Silver	*	100	35	*	35
Thallium	2	*	2	2	2
Uranium	30	*	30	30	30
Vanadium	*	*	*	*	*
Zinc	*	5000	2100	*	2100
General Chemistry Parameters (mg/L) [f]					
Bicarbonate	*	*	*	*	*
Calcium	*	*	*	*	*
Carbonate	*	*	*	*	*
Chloride	*	250	*	*	250
Sodium	*	*	*	*	*
Sulfate	*	250	*	*	250
TDS	*	500	*	*	500

Notes

Bold – indicates the most conservative value to be used for comparison.

[a] "Table of Regulated Drinking Water Contaminants", Groundwater and Drinking Water (USEPA, 2016a).

[b] "Table of Secondary Drinking Water Standards", Secondary Drinking Water Standards: Guidance for Nuisance Chemicals (USEPA, 2016b).

[c] Navajo Nation Surface Water Quality Standards (NNEPA, 2015)

[d] Maximum Contaminant Levels Navajo Nation Primary Drinking Water Regulations (NNPDWR, 2015)

[e] The MCL for Ra-226 and Ra-228 have a combined limit of 5 pCi/L, and are not individually 5pCi/L

[f] Collected data will be used for water quality analysis purposes

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

MCL - maximum contaminant level

µg/L - micrograms per liter

mg/L - milligrams per liter

ng/L - nanograms per liter

pCi/L - picocuries per liter

TDS - Total Dissolved Solids

Ra-226 - Radium 226

Ra-228 - Radium 228

USEPA - Unites States Environmental Protection Agency

Table 4-6b
Water Sampling Analytical Results
NA-0904
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Analyte (Units)		Water Feature Identification	09T-546 /RV990317TNW002	09T-546 /RV990317TNW002	09T-546 /RV990317TNW002	09T-546 /RV990317TNW002
		Field Sample Identification	S059-WL-001	S059-WL-001	S059-WL-001	S059-WL-001
		Date Collected	9/29/2016	9/29/2016	5/24/2017	5/24/2017
		Matrix	Water Well	Water Well	Water Well	Water Well
		Preparation	Dissolved	Total	Dissolved	Total
Radionuclides (pCi/L)	Investigation Level					
Ra-226	5 [1]		NS	0 ± 0.074	NS	NS
Ra-228	5 [1]		NS	0 ± 0.33	NS	NS
Gross Alpha	--		NS	13.4 ± 2.7	NS	NS
Adjusted Gross Alpha [2]	15		NS	8.1	NS	NS
Gross Beta	--		NS	0 ± 1.4	NS	NS
Mercury (ng/L)						
Mercury	2000		NS	NS	0.6	1.6
Metals [3] (µg/L)						
Antimony	5.6		<0.3	<0.3	NS	NS
Arsenic	10		15	15	NS	NS
Barium	2000		7.9	8.2	NS	NS
Beryllium	4		<0.5	<0.5	NS	NS
Cadmium	5		<0.3	0.34	NS	NS
Chromium, Total	100		<10	<10	NS	NS
Cobalt	--		<1	<1	NS	NS
Copper	1300		11	22	NS	NS
Lead	15		0.63	1.6	NS	NS
Molybdenum	--		4.5	4.5	NS	NS
Nickel	610		<5	<5	NS	NS
Selenium	50		<1	<1	NS	NS
Silver	35		<0.1	<0.1	NS	NS
Thallium	2		<0.2	<0.2	NS	NS
Uranium	30		7.3	7.9	NS	NS
Vanadium	--		13	14	NS	NS
Zinc	2100		520	960	NS	NS
General Chemistry Parameters (mg/L)						
TDS	500		--	620	NS	NS
Carbonate	--		--	20	NS	NS
Bicarbonate	--		--	240	NS	NS
Chloride	250		--	11	NS	NS
Sulfate	250		--	40	NS	NS
Calcium	--		1400	1700	NS	NS
Sodium	--		140000	150000	NS	NS
Field Parameters						
Oxidation Reduction Potential(millivolts)	--		NS	105.9	NS	138.6
pH(pH units)	--		NS	8.79	NS	8.99
Salinity(PPTV)	--		NS	0.3	NS	--
Specific Conductivity(µS/cm)	--		NS	1215	NS	589
Temperature(°C)	--		NS	18.2	NS	17.2
Turbidity(NTU)	--		NS	13.3	NS	3.16

Notes

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result or reporting limit greater than or equal to the investigation level
°C	Degrees Celsius
µg/L	micrograms per liter
µS/cm	microSiemens per centimeter
mg/L	milligrams per liter
ng/L	nanograms per liter
NTU	nephelometric turbidity unit
pCi/L	picocuries per liter
PPTV	parts per trillion volume
--	Not established
NS	Not scheduled
Ra-226	Radium 226
Ra-228	Radium 228
TDS	Total Dissolved Solids
<	Result not detected above associated laboratory reporting limit
1	The Investigation Level for Ra-226 and Ra-228 have a combined limit of 5 pCi/L, and are not individually 5pCi/L
2	Adjusted Gross Alpha = Gross alpha concentration - uranium concentration, using the conversion factor of 0.6757 to convert uranium µg/L to pCi/L (U.S. Department of Energy, 2011)
3	Analysis required sample dilution of 10 times; reported values have been converted to non-diluted value

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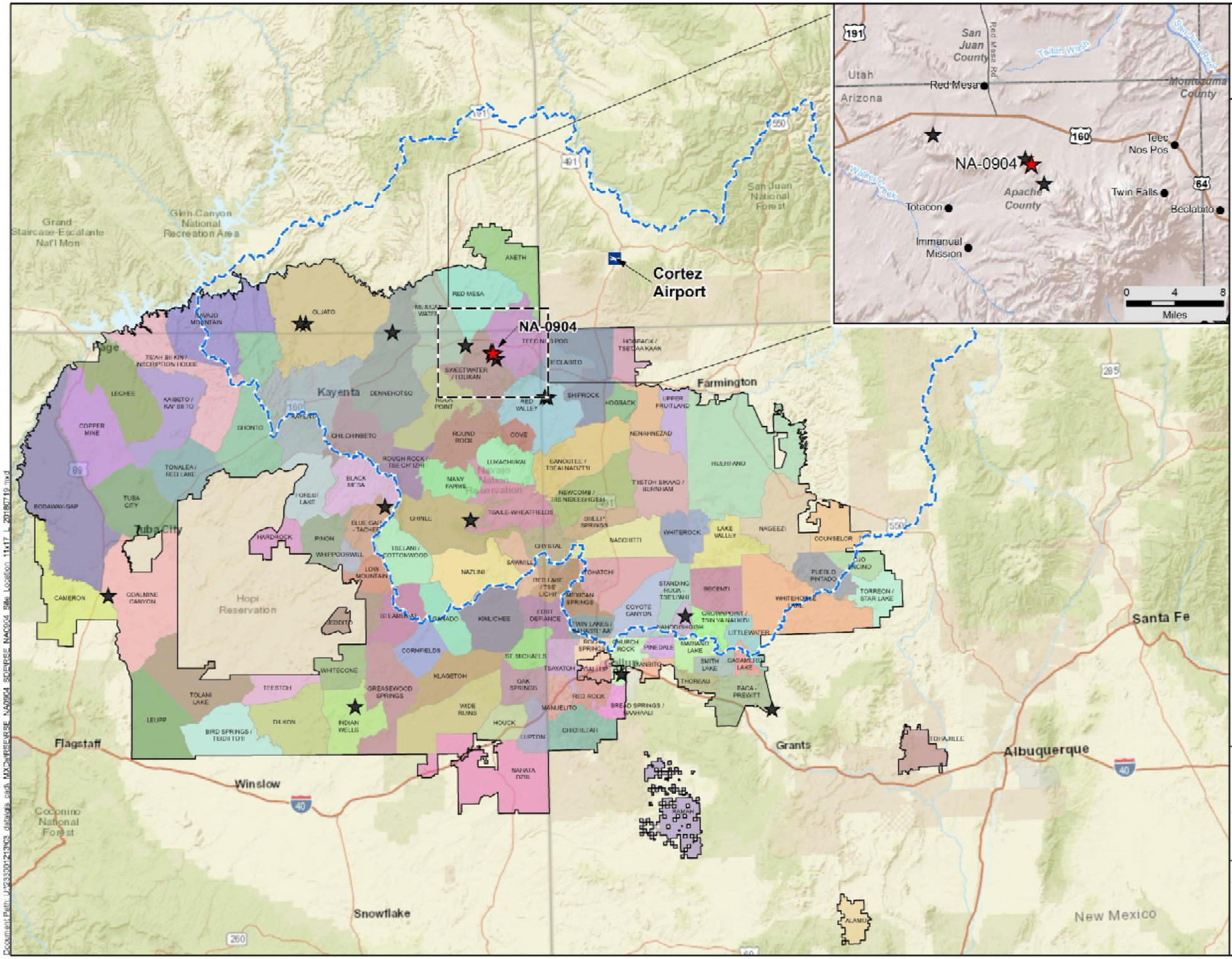
NAVAJO NATION
AUM Environmental Response Trust - First Phase

FIGURES

FIGURE ACRONYMS/ABBREVIATIONS

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

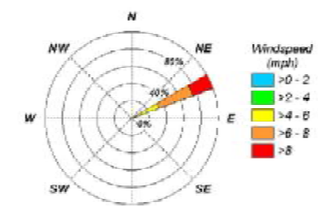


NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- NA-0904 Mine Site
- Priority Abandoned Uranium Mine (AUM) Site
- Populated Place
- US Highway
- State Highway
- Major Road
- Stream
- Intermittent Stream
- San Juan Watershed
- Navajo Nation Boundary
- Navajo Nation Chapter

Cortez Airport, Colorado Wind Rose (KCEZ), 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

0 25 50
Miles

TITLE: Site Location

PROJECT: Removal Site Evaluation NA-0904 Mine Site

DATE: 7/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 1-1

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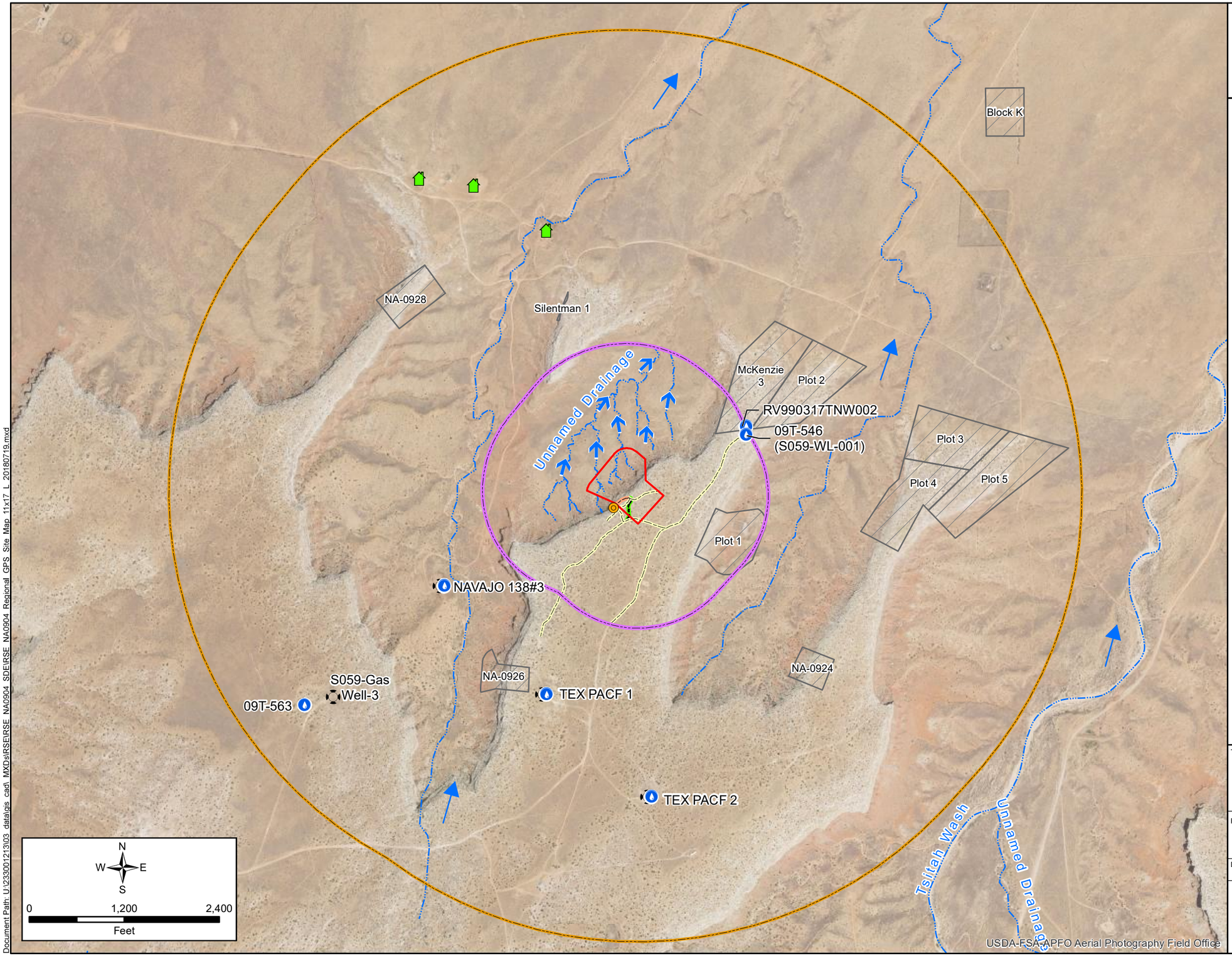


NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Site Clearance Identified Potential Water Feature[1]
- Habitable Building
- Portal
- Oil / Gas Well[2]
- Flow Direction
- Intermittent Stream/River
- Potential Haul Road
- Primary Haul Route[3]
- Portal Access Ramp
- Claim Boundary
- 1/4-Mile Claim Boundary Buffer
- 1-Mile Claim Boundary Buffer
- Other Claim Boundary

NOTES:

1. Potential water features and identification names identified in 2007 AUM Atlas and/or in database provided by the Navajo Nation Department of Water Resources.

2. S059-Gas Well-3 identified during site mapping.

3. Primary haul route identified by NAML during site visit on September 14, 2017.

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 7/19/2018

TITLE:

Site Features

PROJECT:

Removal Site Evaluation
NA-0904 Mine Site

DATE: 7/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

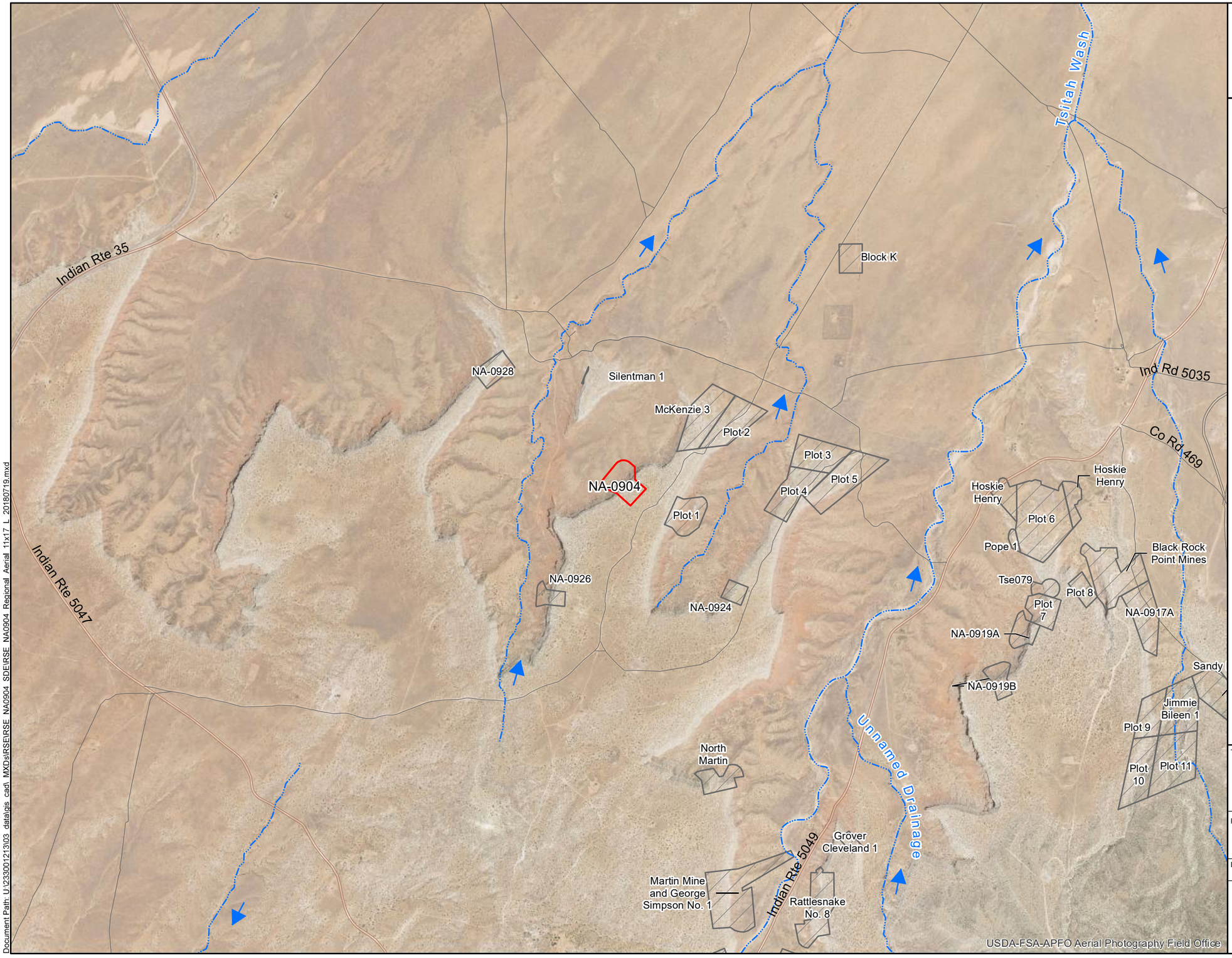
AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 2-1

Stantec

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\RSE NA0904 Regional GPS Site Map 11x17 L 20180719.mxd



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NAVAJO NATION

AUM Environmental Response Trust-First Phase

LEGEND

- Flow Direction
- Intermittent Stream/River
- Tribal Road
- County Road
- Local Road
- Claim Boundary
- Other 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 7/19/2018

N W E S

0 2,000 4,000

Feet

TITLE:

Regional Aerial Photograph

PROJECT:

Removal Site Evaluation
NA-0904 Mine Site

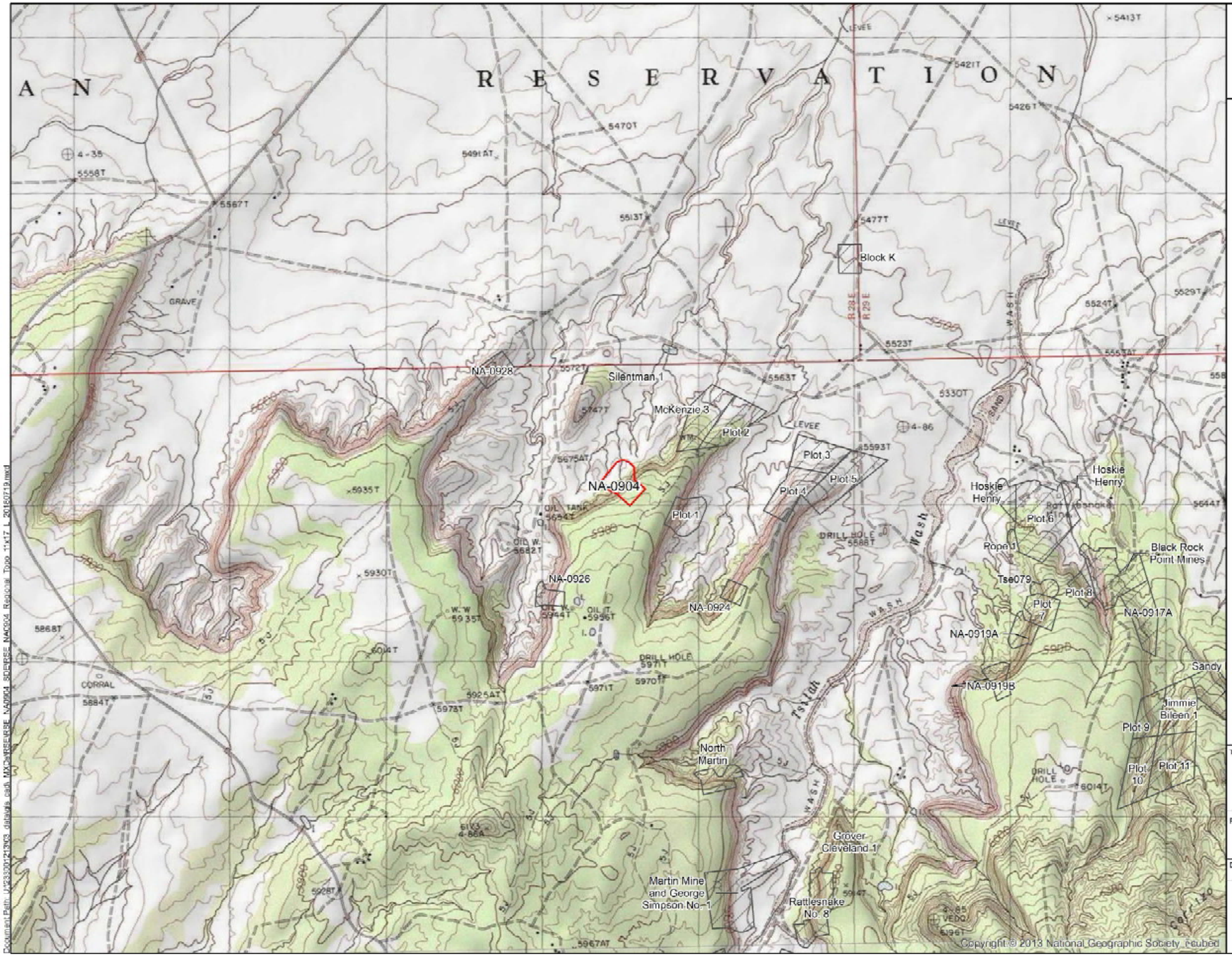
DATE: 7/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB | REVIEWER: EDZ

FIGURE: 2-2



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:

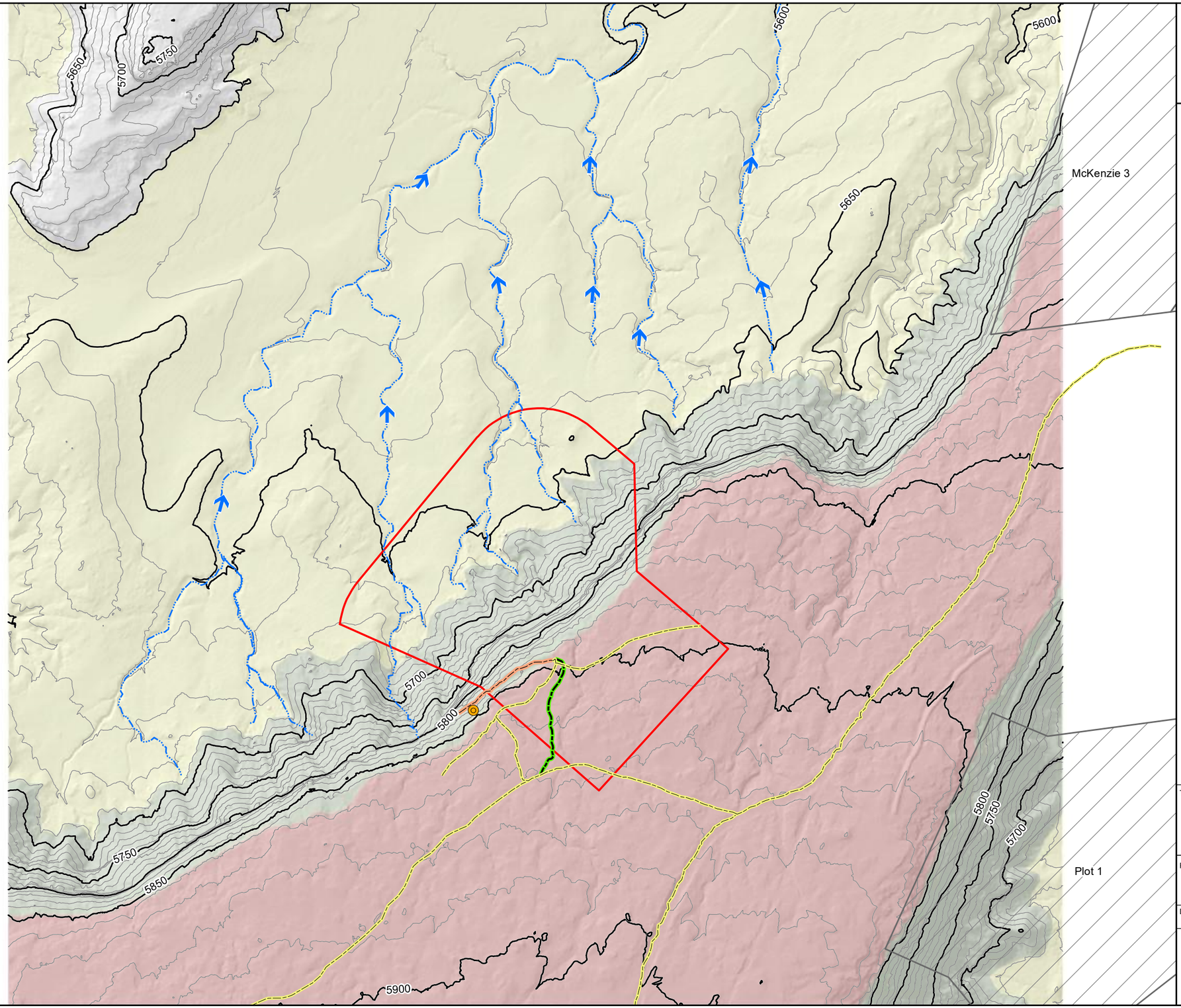
Regional Topographic Map

PROJECT:

Removal Site Evaluation
NA-0904 Mine Site

DATE: 7/19/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EDZ
	FIGURE: 2-3	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_NA0904_SDE\RSE_NA0904_Regional_Topo_11x17_L_20180719.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Portal
- Flow Direction
- Drainage
- Potential Haul Road
- Primary Haul Route
- Portal Access
- Index Contour (50 ft Inverval)
- Intermediate Contour (10 ft Interval)
- Claim Boundary
- Other Claim Boundary

Geomorphology Features

- Mesa Top
- Mesa Sidewall
- Plains

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

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

0 250 500
Feet

TITLE:
Site Topography

PROJECT:
Removal Site Evaluation
NA0904 Mine Site

DATE: 7/19/2018

DOCUMENT NAME:
Removal Site Evaluation Report

AUTHOR: EDZ
REVIEWER: CBB

Stantec

FIGURE:
2-4

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_NA0904_SDE\RSE_NA0904_Site_Topo_11x17_L_20180719.mxd

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
U.S. ATOMIC ENERGY COMMISSION

MISCELLANEOUS GEOLOGIC INVESTIGATIONS
MAP I-345 (SHEET 1-GEOLOGY)

NA-0904

Base from Army Map Service Shiprock sheet, 1954

Geology compiled in 1958

SCALE 1:250 000

CONTOUR INTERVAL 200 FEET
DATUM IS MEAN SEA LEVEL

EXPLANATION

QUATERNARY

- **Qa** — Alluvium. Unconsolidated surficial deposits of valley fill, mainly stream-deposited silt, sand, and gravel, but includes some eolian sand, talus, and rock-glacier material, and in valleys of low-level terrace gravels. In the Monument Valley area may include unconsolidated gravel in a matrix of fine- to medium-grained sand.
- **Qal** — Landslide debris. Unconsolidated surficial masses of broken rock mainly of the Chuska sandstone and Chuska Mountains above conspicuous posthistoric cliffs of Chuska sandstone, on large landslides in the Hova Verde area, and on parts of the Monument Valley area mesas. Includes unconsolidated gravel in a matrix of fine- to medium-grained sand.
- **Qtt** — Tertiary gravel. Scattered remnants of unconsolidated gravel and sand on high mesas and terrace deposits along and near the San Juan River.
- **Qpd** — Pediment gravel. Scattered remnants of unconsolidated gravel and boulder debris on pediment surfaces around the Carrizo Mountains, near Mexican Water, and at the Chuska Mountains, and around Barker Dome.

TERTIARY

- **Tt** — Trachybasalt. Intrusive and extrusive basaltic rock composed of clinopyroxene, basaltic plagioclase, sanidine, and accessory minerals, including olivine, and glass.
- **Ts** — Serpentine-bearing breccia. Includes large and small fragments of sedimentary and ultramafic rocks cemented by a matrix of serpentinized serpentine and accessory chromite, mica, and garnets of uncertain origin.
- **Tm** — Minette. Intrusive basaltic rock composed of diopside, sanidine, plagioclase, and accessory and secondary minerals.
- **Tma** — Monchiquite. Intrusive basaltic rock composed of augite, sanidine, and accessory minerals.
- **Tbx** — Tuff-breccia. Predaybreak tuff and agglomerate, breccia, and subordinate sedimentary rocks, mainly basaltic to andesitic clastic rocks and irregular bodies of intrusive rock similar to intrusive igneous rocks and basaltic to andesitic rocks.
- **Tc** — Chuska sandstone. Light-brown, yellowish-gray to white cross-bedded sandstone and tuffaceous sandstone and red, reticulated, reddish-brown siltstone and shale.
- **Tsj** — San Jose formation of Simpson (1948). Fluvial tuffaceous sandstone and conglomeratic sandstone and reticulated gray and red shale.
- **Tn** — Nacimiento formation. Gray and brown shale and tan, medium-grained and conglomeratic sandstone.
- **Tbr** — Breccia and rocks. Unsorted unbedded deposits of angular fragments of Paleozoic and Mesozoic rocks in a matrix of clay, sand, and silt, probably of Tertiary age.
- **Tdp** — Diorite porphyry. Dikelike porphyry in rock formations and flows of the Carrizo Mountains area; consists of phenocrysts of feldspar and quartz, commonly clouded by hydrothermal alteration products, in a groundmass of granular feldspar, quartz, and ferromagnesian minerals.

CRETACEOUS

- **Kjo** — Ojo Alamo sandstone. Thicker-bedded gray and conglomeratic sandstone.
- **Kk** — Animas formation. Purple and grayish shale, montmorillonite and light-gray sandstone and conglomerate. Along the La Plata River only the lower part of the Animas formation is present.
- **Kkl** — Kirtland shale. Gray, upper shale member; green-gray to dark Fruitland formation; medium-gray, fine- to medium-grained, sandstone member; and dark-gray, fissile shale member, at base.
- **Kf** — Fruitland formation.* Gray, brown, and black shale, siltstone strata and ten crossbedded sandstone and coal.
- **Kpc** — Pictured Cliffs sandstone.* Two crossbedded sandstone to massive-bedded, fine- to medium-grained sandstone. In a small area approximately eight miles east of Shiprock where the Lewis shale is absent, the Pictured Cliffs sandstone cannot be separated from the underlying Cliff House sandstone and is mapped with the Cliff House sandstone.
- **Kl** — Lewis shale.* Light- to dark-gray shale, commonly lacks of fissurelike, and, especially in the upper and least fossiliferous part, dark-gray beds of sandstone.
- **Kch** — Cliff House sandstone.* Tan and gray crossbedded fine- to medium-grained sandstone with carrying amounts of interbedded gray shale. Locally Cliff House sandstone includes tongues of the Menefee formation.
- **Kmf** — Menefee formation.* Alternating beds of tan and brown sandstone, gray and brown clayey to sandy shale, coal, and scattered layers of carbonaceous and limestone concretions.
- **Kp** — Point Lookout sandstone.* Tan and brown sandstone with lesser amounts of gray shale. In the Toadlena-Crystal area, the Mesa Rompe, Kph, is separated from the main body of the Point Lookout by the Satan tongue of the Mancos shale.
- **Kmv** — Mancos shale and Dakota sandstone, undifferentiated. On Mesa Rompe and in the Carrizo Mountains the Dakota sandstone is ragged locally within the Mancos shale.
- **Kwp** — Wepo formation. Interbedded light-gray and olive-drab shaly siltstone, yellowish-gray carbonaceous shale and coal.
- **Kt** — Toreva formation. Light-brown to red pinkish-gray, fine- to medium-grained sandstone and gray to red siltstone and carbonaceous shale.
- **Kmv** — Mancos shale. Predominantly light- to dark-gray marine shale with subordinate thin, fine-grained sandstone and siltstone and lenticular or concretionary limestone. North of the San Juan River includes the strong members of Sears, Hunt, and Hendricks (1941). South of the San Juan River the Mancos rests, Kch, is divided by the Gallup sandstone into upper, Kmu, and lower, Kml, parts. Kmu, the upper part, includes the Juana Lopez member, a calcareous zone south of the Mesaverde to form the Satan tongue, Kms, and the Niobrara tongue, Kmn. In a small area a wider exposure of Crystal the Niobrara tongue is mapped with the Cretaceous Cliffhouse formation. On Mesa Rompe the Mancos shale, Kmr, is not divided.
- **Kd** — Dakota sandstone. Tan, brown, and gray sandstone, conglomeratic sandstone, brownish-gray shale, and lenses of coal.

UNCONFORMITY

JURASSIC

- **Jm** — Morrison formation. Jma, Brushy Basin member, variegated gray shale and siltstone, gray and tan sandstone and conglomerate, sandstone may locally include the Recapture Creek sandstone. The Brushy Basin member may be present at Tufa Point but not elsewhere on Black Mesa. Jmw, Westwater Canyon member, yellow-ledge-forming sandstone with conglomeratic lenses, and green-to-gray shale. Jmr, Recapture member, which may include fine- to medium-grained sandstone, gray shale, and red shale. Jmb, Bluff Sand member, which may include sandstone, gray shale to mudstone, and gray-to-red shale. In some areas the members of the Morrison formation are not shown separately; Jm, in other areas it is divided into upper, Jmu, and lower, Jml, parts. Jointly in the Carrizo Mountains and along the east side of the Chuska Mountains north of the head of deposition of the Bluff Sand member, Westwater Canyon, and Recapture members are mapped together, Jmwr.
- **Jn** — Summerville formation. Moderate reddish-brown, fine- to medium-grained sandstone and argillaceous siltstone. In the Carrizo Mountains area the Bluff sandstone is a medium-grained and friable, very pale orange to pink sandstone that is mapped with the Bluff sandstone member of the Morrison formation, Jm. In the Four Mile Point area a tongue of the Zia Springs sandstone is mapped with the Summerville. Southeast of Lybrook Point No. 2 the Summerville formation grades laterally into the Zia Springs sandstone.
- **Jmt** — Summerville and Entrada formations undifferentiated.
- **Jte** — Todilto and Entrada formations undifferentiated. In the Hogback Monocline area and in the southeastern part of Hubbell area.
- **Jt** — Todilto limestone. Gray thin-bedded limestone and reddish-brown sandy shale and siltstone.
- **Je** — Entrada sandstone. Reddish-brown, fine-grained sandstone and siltstone.
- **Jc** — Carmel formation. Dark grayish-red siltstone, sandstone, and interbedded reddish-orange sandstone.
- **JTRn** — Navajo sandstone. Light-brown and pale-orange, fine- to medium-grained crossbedded sandstone.
- **Jk** — Kayenta formation. Lenticular pale-red to reddish-brown conglomeratic sandstone, grit, conglomerate, and minor siltstone.
- **Jw** — Wingate sandstone. Jwck of Lupton, Colo.) includes the upper, Lukachukai member, pale reddish-brown, fine- to medium-grained crossbedded sandstone, and a lower, Rock Point member, pale reddish-brown silty sandstone and siltstone. North of Lupton Creek the Lukachukai member constitutes the entire Wingate sandstone and the Rock Point member is included in the Chinle Basal member of the Chinle formation.
- **Jc** — Chinle formation. In most of the area from the Chinle to Arizona Basin, Owl Rock member, interbedded limestone and reddish-brown siltstone; Jcp, Petrified Forest member, blue to white bentonitic claystone and minor amounts of siltstone and sandstone. Jcr, the red member, dark reddish-brown bentonitic siltstone, sandstone, and conglomerate. Jcs, Shinarump conglomerate member, massive-bedded crossbedded conglomeratic sandstone, siltstone, conglomeratic, and scaly shale. In the Monument Valley area the Chinle formation is divided into an upper unit, Ru, which consists in descending order of the Owl Rock member, Owl Rock member, Petrified Forest member, and Agathla Butte member; and the Shinarump member, Ru, or Shinarump conglomerate, Rs. In the southeastern part of the Chinle formation as mapped in the southwestern part of the Carrizo Mountains area and along the east side of the Chuska Mountains.

UNCONFORMITY

- **Jmr** — Morrekopi formation. Upper part, Jmu, in the Tohatchi-Chuska area, consists of gray to reddish-brown, ripple-marked shaly siltstone, overlying the Zia Springs sandstone member, cross-bedded sandstone and minor interbedded siltstone; the Morrekopi pinches out eastward approximately under Ojitos Flats. In Monument Valley the Morrekopi formation is mapped mainly with the underlying De Chelly sandstone member of the Cutler formation, Pcd.
- **Pcc** — Cutler formation. In Monument Valley the Cutler is divided into, Pcd, De Chelly sandstone member, buff massive crossbedded sandstone.
- **Pcs** — Cutler formation. Pcs, Organ Rock tongue, reddish-brown cross-bedded sandstone, siltstone, and shale.
- **Pcr** — Cutler formation. Pcr, Cedar Mesa sandstone member, orange-brown crossbedded sandstone with thin localizations interbeds of light-gray clayey siltstone.
- **Pch** — Halgaito tongue, reddish-brown shaly siltstone and silty sandstone with thin localizations beds of light-gray limestone.
- **Pc** — Cutler formation. In the Carrizo Mountains area; Pcd, De Chelly sandstone member, reddish to grayish-orange and crossbedded.
- **Pdc** — De Chelly sandstone. Reddish-orange and pale-orange cross-bedded sandstone; in De Chelly quarry.
- **PPs** — Supai formation. Red crossbedded sandstone, fine-grained sandstone, and siltstone; south of the Hogback Monocline.

PERMIAN

PENNSYLVANIAN AND PERMIAN

Contact
Dashed where approximately located

Fault, showing downthrown side
Dashed where approximately located

Jcs / Jc

Limit of deposition of a formation or member, in this case the limit of the Todilto limestone. In the Lukachukai Mountains, the erosional truncation of the Recapture member of the Morrison formation is shown by this symbol

Jr

Uranium-bearing formation or member

*See schematic diagram

REFERENCES CITED IN EXPLANATION

Baars, J. L., Hunt, C. B., and Hendricks, T. A., 1941, Tectonic and regional features of the Colorado-New Mexico border: Am. Assoc. Petroleum Geologists Bull., v. 25, no. 9, p. 1717-1742.

Gregory, H. E., 1917, Geology of the Navajo country: U.S. Geol. Survey Prof. Paper 93, 161 p.

Harshbarger, J. W., Repenning, C. A., and Irwin, J. H., 1957, Stratigraphy of the uppermost Triassic and the Jurassic rocks of the Navajo country: U.S. Geol. Survey Prof. Paper 291, 74 p.

O'Sullivan, R. B., 1961, The Entrada of the San Juan Basin, New Mexico: Am. Assoc. Petroleum Geologists Bull., v. 45, no. 9, p. 1571-1582.

INDEX MAP SHOWING SOURCES OF GEOLOGIC DATA

GEOLOGIC SOURCES

Numbers correspond to those given on key map (* indicates unpublished maps)

1. Winkler, L. J., and others, U. S. Geol. Survey Mineral Inv. Field Studies Maps MF-32, 99, 95.
2. O'Sullivan, R. B., U. S. Geol. Survey detailed mapping (*).
3. Strobell, J. D., Jr., U.S. Geol. Survey detailed and photogeology mapping (*).
4. Strobell, J. D., Jr., U.S. Geol. Survey Oil and Gas Inv. Map OM-160 (supplemented by unpublished data in the central and southern part of the area).
5. O'Sullivan, R. B., and Beaumont, E. C., U. S. Geol. Survey Oil and Gas Inv. Map OM-196.
6. Hayes, P. T., and Zapp, A. D., U.S. Geol. Survey Oil and Gas Inv. Map OM-144.
7. Baltz, E. H., Heikkinen, H. M., and O'Sullivan, R. B., U. S. Geol. Survey photogeology and detailed geologic mapping (*).
8. Repenning, C. A., U. S. Geol. Survey detailed mapping (*).
9. Repenning, C. A., U. S. Geol. Survey open-file maps (modified in part by reconnaissance mapping by R. B. O'Sullivan).
10. Cooley, M. E., Irwin, J. H., Repenning, C. A., and Stevens, P. R., U. S. Geol. Survey open-file maps (modified in part by reconnaissance mapping by R.B. O'Sullivan).
11. O'Sullivan, R. B., U. S. Geol. Survey reconnaissance mapping (*).

INDEX MAP SHOWING AREA OF SHIPROCK QUADRANGLE

SCHEMATIC DIAGRAM SHOWING STRATIGRAPHIC RELATIONS OF MESAVERDE GROUP, EQUIVALENT FORMATIONS, AND THE MANCOS SHALE

GEOLOGY, STRUCTURE, AND URANIUM DEPOSITS OF THE SHIPROCK QUADRANGLE, NEW MEXICO AND ARIZONA

Compiled by
Robert B. O'Sullivan and Helen M. Beikman
1963

(GOS)M
MISCELLANEOUS GEOLOGIC INVESTIGATIONS
MAP I-345 (SHEET 1-GEOLOGY)

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

TITLE: Regional Geology

PROJECT: Removal Site Evaluation
NA-0904 Mine Site

DATE: 7/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: 2-5

SEP 26 1963
U.S. GEOLOGICAL SURVEY
LIBRARY

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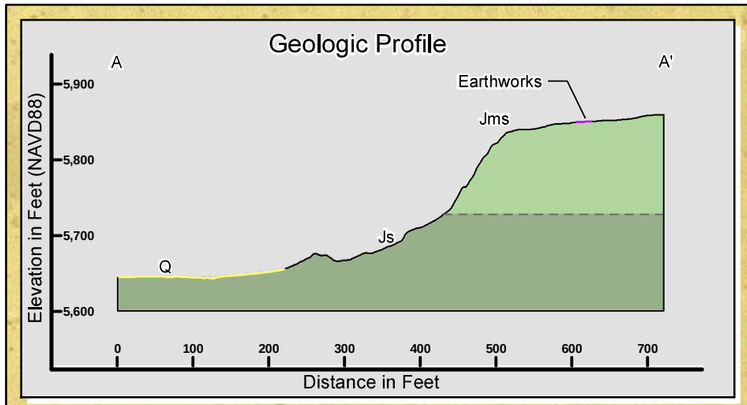
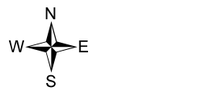


NOTE:
Based on field observations at the Site, bedrock units shown are near surface (typically within 1 foot), but do not necessarily outcrop and may be overlain by minor Q deposits

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 08/2018.

Geology adapted from O'Sullivan, R.B., and Beikman, H.M (1963): O'Sullivan, R.B., and Beikman, H.M, 1963, Geology, structure and uranium deposits of the Shiprock quadrangle, New Mexico and Arizona: U.S. Geological Survey I-345, scale 1:250,000.



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

Site Geology

HOLOCENE / PLEISTOCENE

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

JURASSIC

- Jms: Salt Wash Member of the Morrison Formation (Upper Jurassic) – white and moderate-orange, very fine- to medium-grained sandstone, and grayish-red shale.
- Js: Summerville Formation (Upper Jurassic) – Reddish-brown to light-orange very fine- to fine-grained flat bedded silty sandstone and reddish brown thin-bedded silty sandstone, siltstone, and claystone; forms banded steep slopes and cliffs.

TITLE: Site Geology

PROJECT: Removal Site Evaluation
NA-0904 Mine Site

DATE: 8/29/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 2-6a

Stantec

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\RSE NA0904 Site Geology 11x17 L 20180719.mxd

NOTES:

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

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

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

Geology adapted from O'Sullivan, R.B., and Beikman, H.M (1963): O'Sullivan, R.B., and Beikman, H.M, 1963, Geology, structure and uranium deposits of the Shiprock quadrangle, New Mexico and Arizona: U.S. Geological Survey I-345, scale 1:250,000.

N
W E
S

0 150 300
Feet

Q

Js

Jms

Jms

Jms

Js

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

Site Geology

HOLOCENE / PLEISTOCENE

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

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

JURASSIC

Jms: Salt Wash Member of the Morrison Formation (Upper Jurassic) – white and moderate-orange, very fine- to medium-grained sandstone, and grayish-red shale.

Js: Summerville Formation (Upper Jurassic) – Reddish-brown to light-orange very fine- to fine-grained flat bedded silty sandstone and reddish brown thin-bedded silty sandstone, siltstone, and claystone; forms banded steep slopes and cliffs.

TITLE:
Site Exposed Bedrock

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 7/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

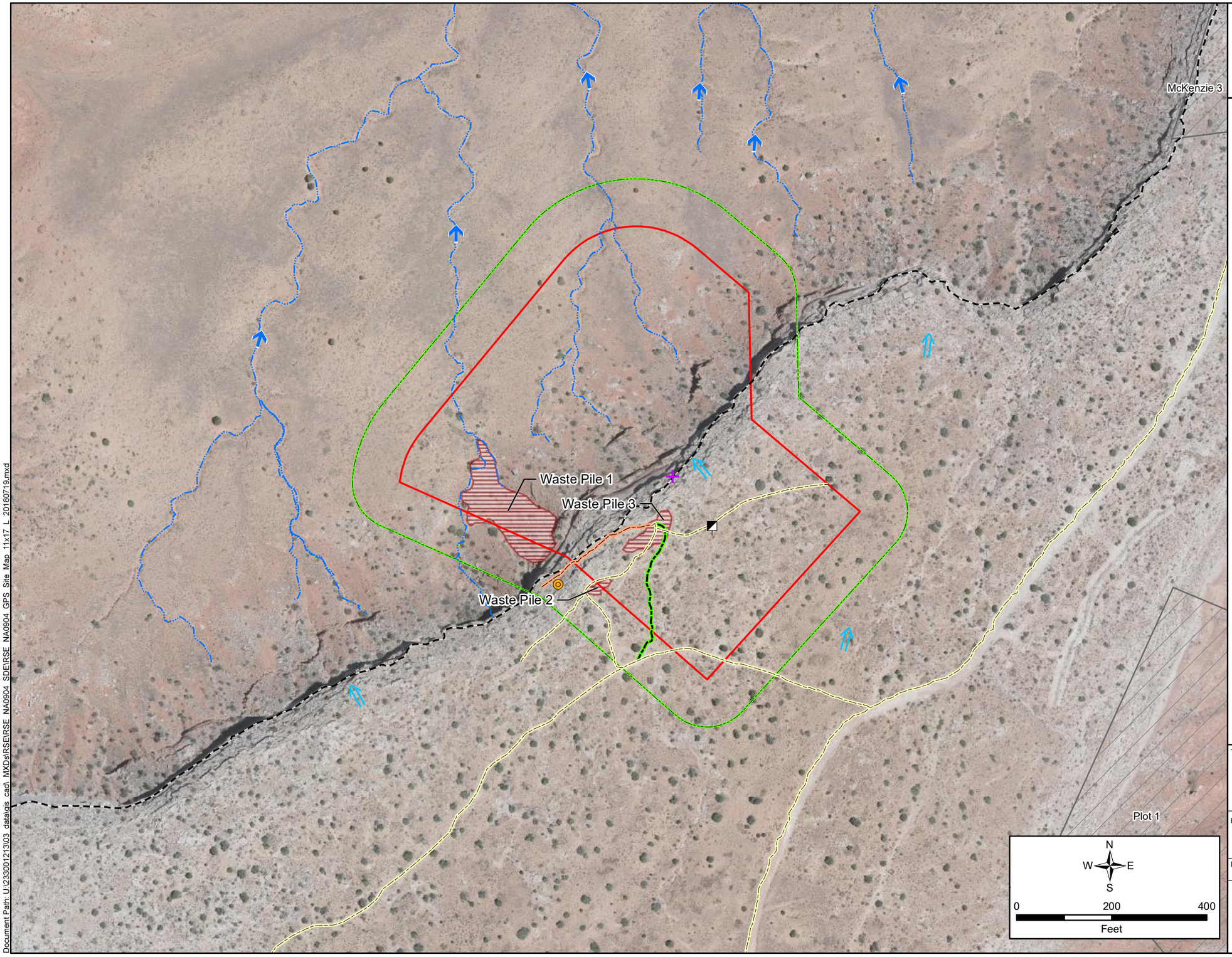
AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 2-6b

Stantec

Document Path: U:\233001213\03 data\gis cad\ MXD\sl\RSE\RSE NA0904_SDE\RSE NA0904 Site Geology Bedrock11x17 L 20180719.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Potential Incline Shaft[1]
- Potential Rim Strip[1]
- Portal
- Flow Direction
- Approximate Overland Water Flow Direction
- Drainage
- Potential Haul Road
- Primary Haul Route[2]
- Portal Access Ramp
- Approximate Edge of Mesa
- Waste Pile
- Claim Boundary
- 100-Foot Claim Buffer
- Other Claim Boundary

NOTES:

1. Potential incline shaft and potential rim strip as shown in the 2007 AUM Atlas (USEPA, 2007a) were not observed during field mapping or site visit with NAML.

2. Primary haul route identified by NAML during site visit on September 14, 2017.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

TITLE:

Site Map

PROJECT:

Removal Site Evaluation
NA-0904 Mine Site

DATE: 7/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

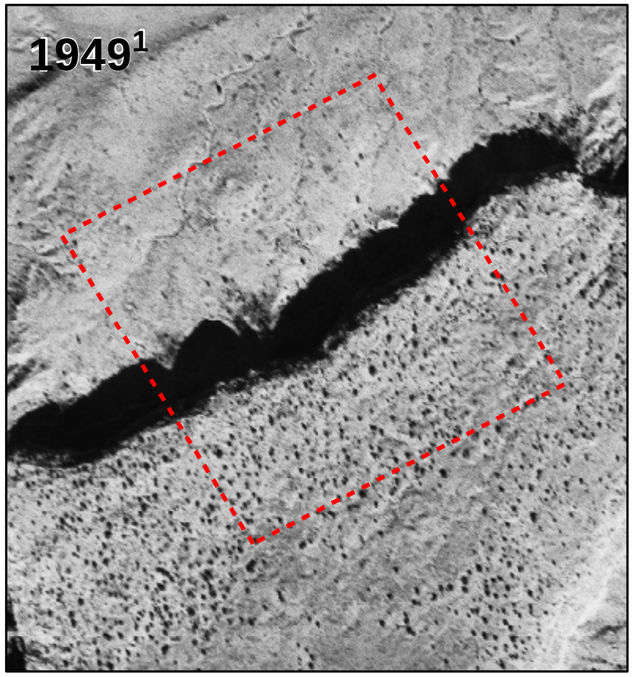
AUTHOR: CBB

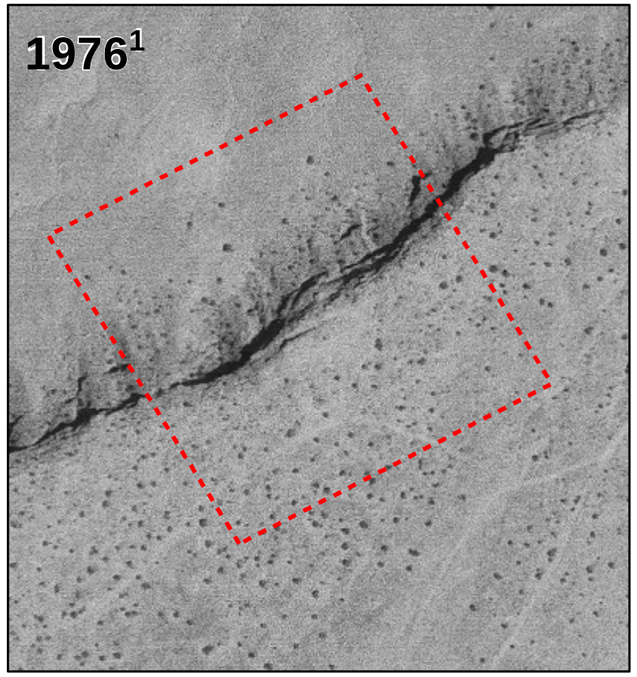
REVIEWER: EDZ

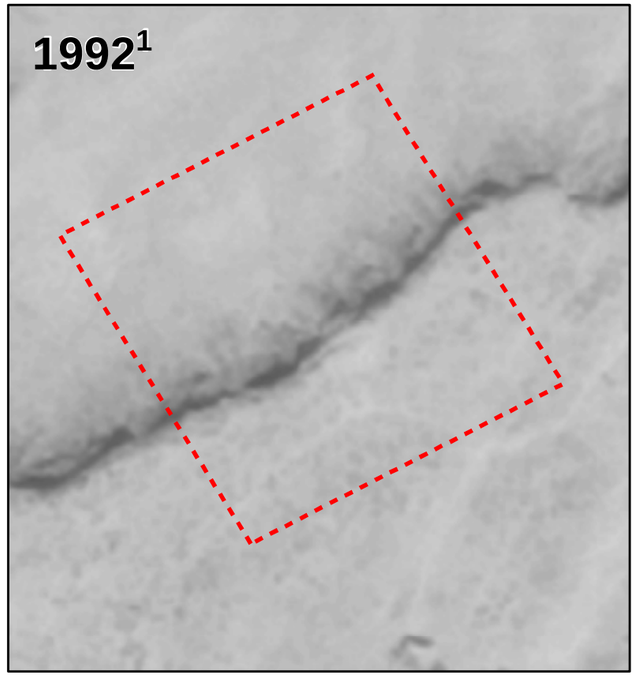
FIGURE: 2-7

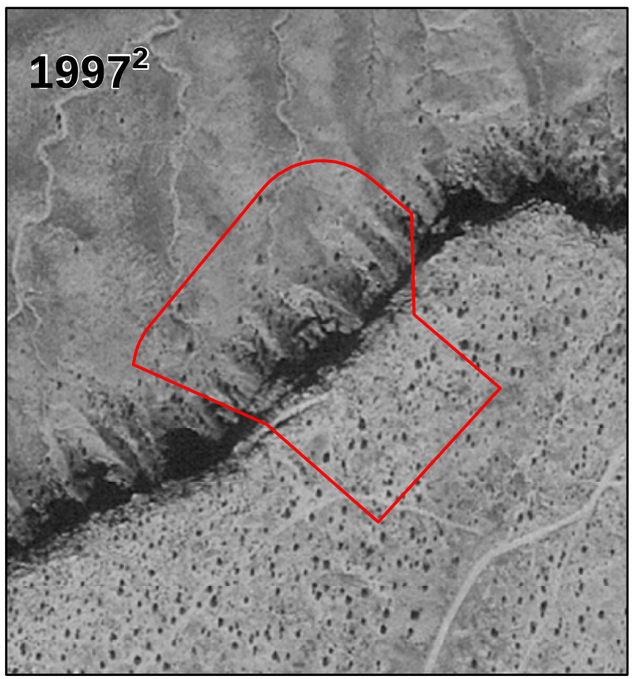
Stantec

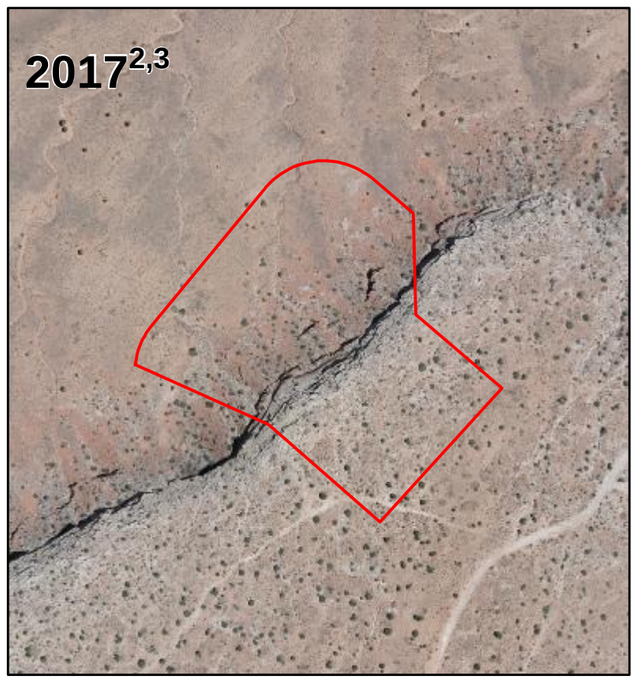
Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\RSE NA0904 GPS Site Map 11x17 L 20180719.mxd











NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

NA-0904 Claim Boundary

Approximate Site Location, not georeferenced

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

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

3. Site-specific imagery flown by Cooper 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

0 400 800
Feet

TITLE:
Historical Aerial Photograph Comparison

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 7/19/2018

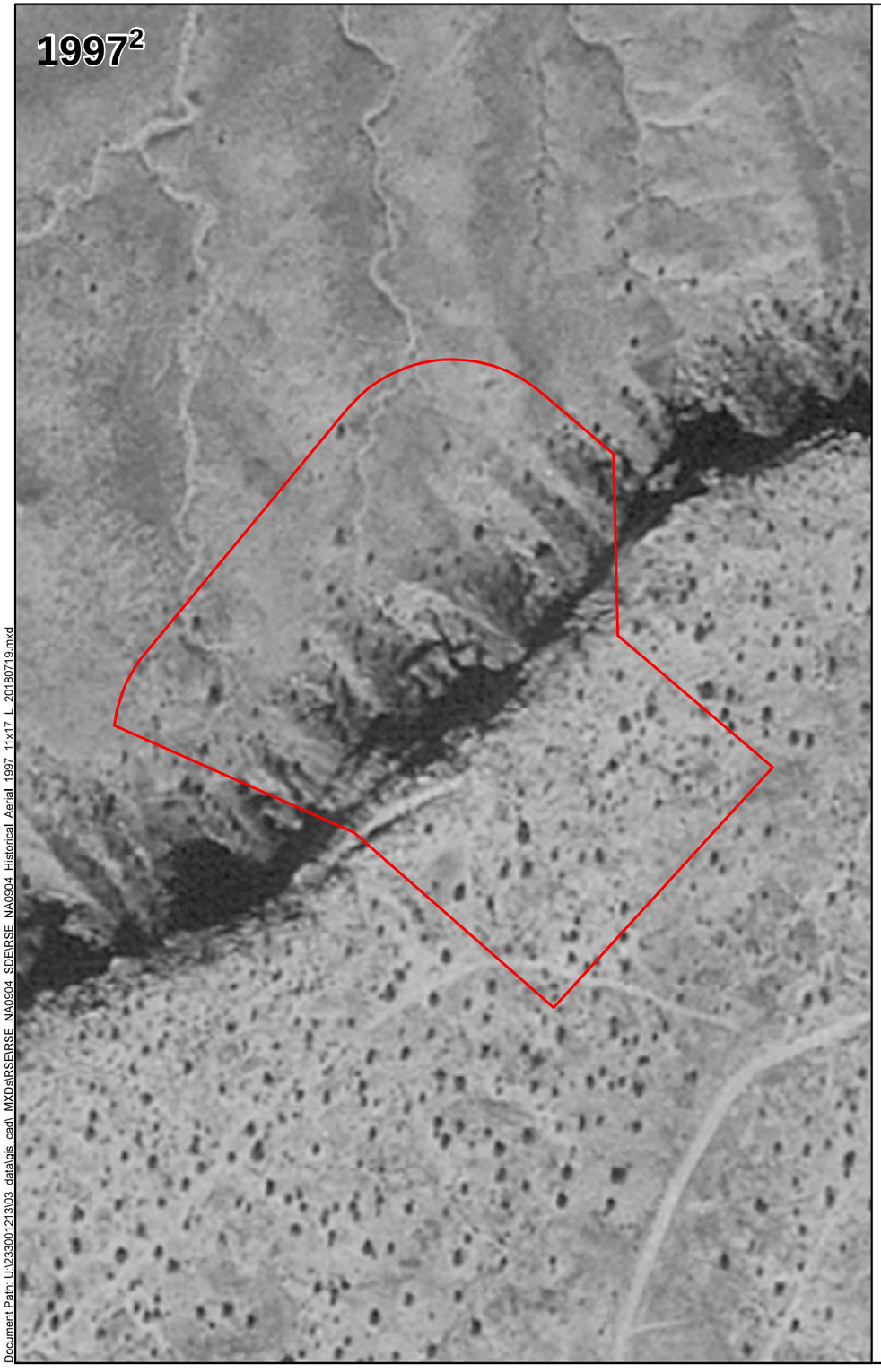
DOCUMENT NAME: Removal Site Evaluation Report

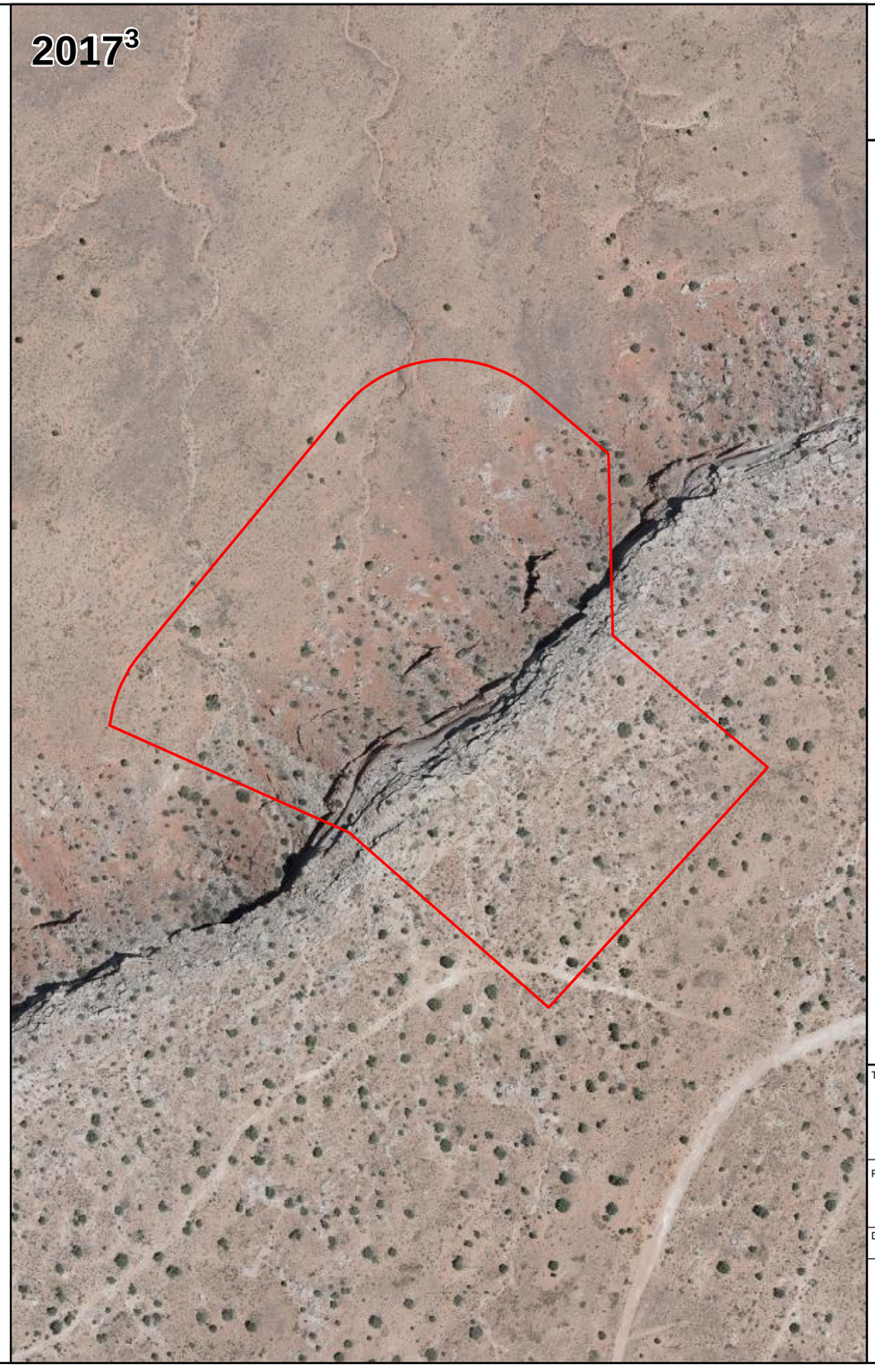
AUTHOR: EDZ | REVIEWER: CBB

Stantec

FIGURE: 3-1a

Document Path: U:\233001213\03 data\gis_cad\ MXDs\RSE\ERSE_NA0904_SDE\RSE_NA0904 Historical Aerial Compilation_11x17_L_20180719.mxd





NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Claim Boundary

REFERENCES:

1. Coordinate System: NAD 1983 UTM Zone 12N

2. 1997 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

0 200 400
Feet

TITLE:
1997 Historical Aerial Photograph Comparison

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 7/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 3-1b

Stantec

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\RSE NA0904 Historical Aerial 1997 11x17 L 20180719.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 08/2018.

N
W E
S

0 300 600
Feet

TITLE:
Potential Background Reference Areas

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 8/29/2018

DOCUMENT NAME: Removal Site Evaluation Report

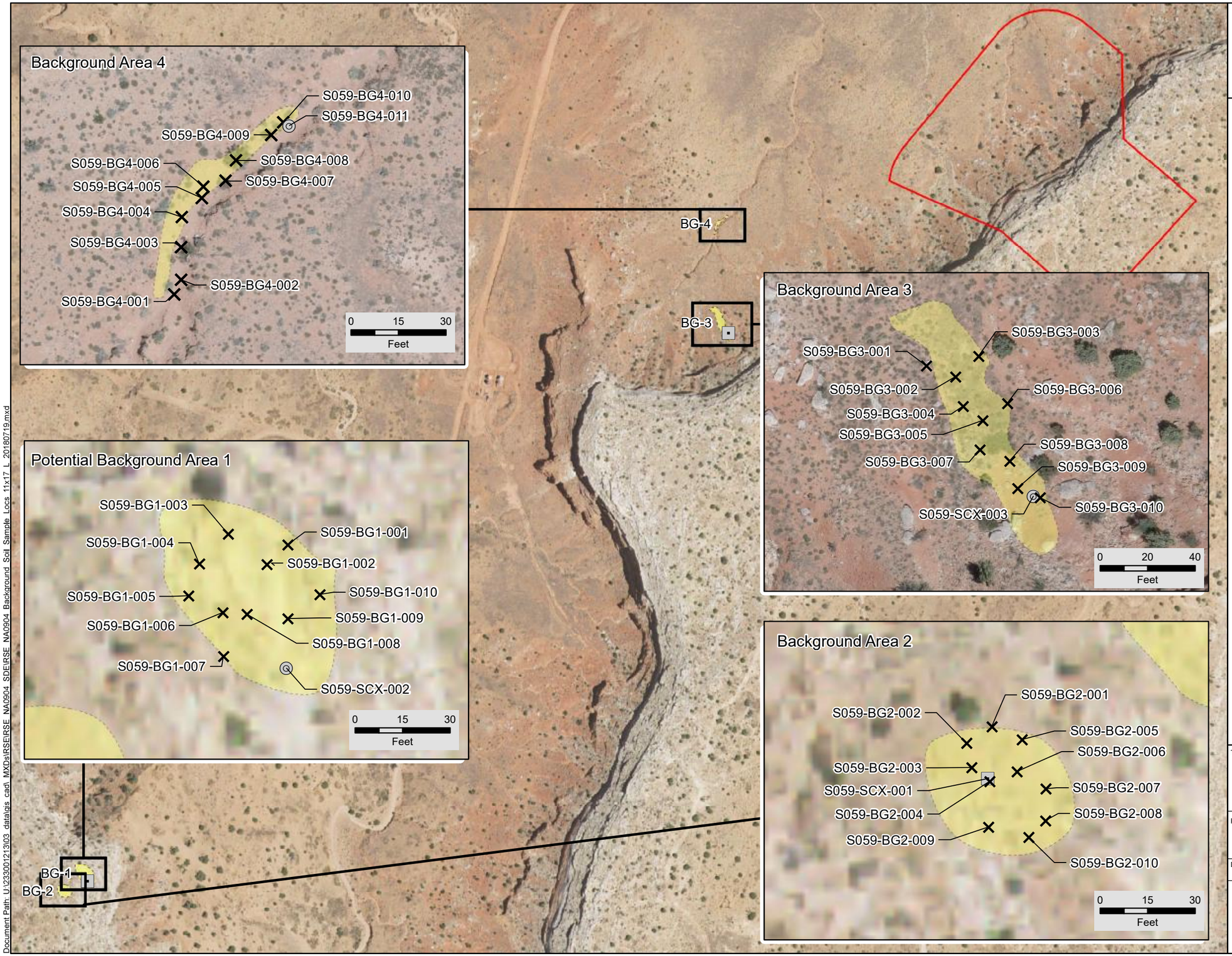
AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: 3-2

Document Path: U:\23300121303_data\gis_cad_MXDs\RSE\RSE_NA0904_SDE\RSE_NA0904_BackgroundAreas_11x17_L_20180719.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Main display and Background Areas 1 and 2 basemap image insets accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 08/2018.

Background Areas 3 and 4 basemap image insets flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 300 600
Feet

TITLE:
Background Reference Areas - Sample Locations

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 8/29/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: 3-3

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_NA0904_SDE\RSE_NA0904_Background_Soil_Sample_Locs_11x17_L_20180719.mxd

Background Reference Area Associated with Survey Area	
Survey Area	Background Reference Area
A	BG-2
B	BG-3
C	BG-4

BG-4

BG-3

BG-2

NA-0926

NA-0924

Plot 1

Plot 2

McKenzie 3

USDA-FSA-APFO Aerial Photography Field Office

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

NOTE:

1. Areas within Survey Areas that were not surveyed (2.0 acres) due to steep/unsafe terrain.

2. Gamma survey area is approximately 29.3 acres.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 08/2018.

N
W E
S

0 450 900
Feet

TITLE:

Gamma Radiation Survey Areas

PROJECT:

Removal Site Evaluation
NA-0904 Mine Site

DATE: 8/29/2018

DOCUMENT NAME: Removal Site Evaluation Report

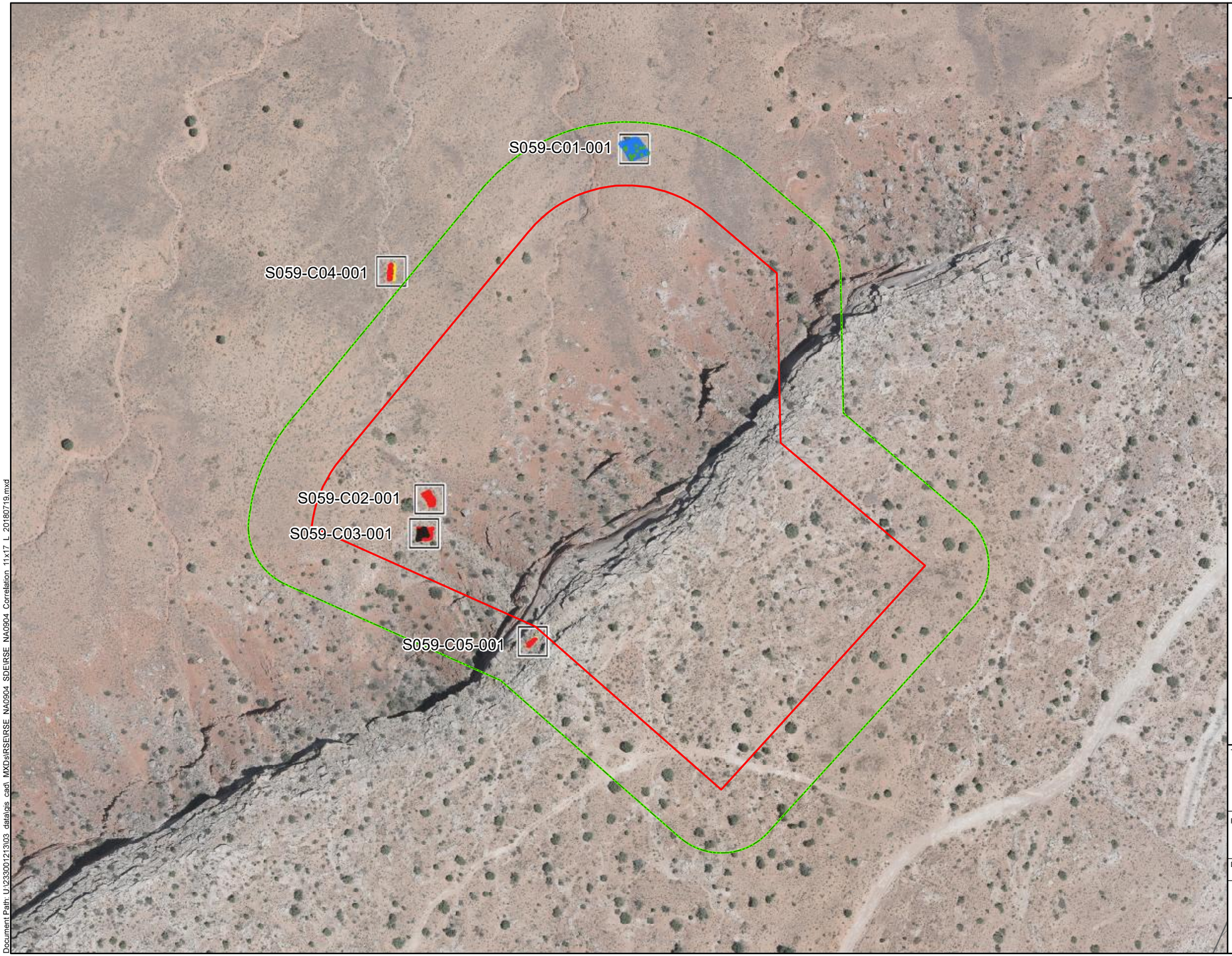
AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 3-4

Stantec

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSEVRSE NA0904 SDEIRSE NA0904 Gamma Survey Area 11x17 L 20180719.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- S059-C01-001 Correlation Location (30' x 30')
- Claim Boundary
- 100-Foot Claim Buffer
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 8,035 - 9,911 (Minimum to BG-4 UTL)
- 9,912 - 11,068 (>BG-4 UTL to BG-2 UTL)
- 11,069 - 19,822 (>BG-2 UTL to 2x BG-4 UTL)
- 19,823 - 110,680 (>2x BG-4 UTL to 10x BG-2 UTL)
- 110,681 - 122,582 (>10x BG-2 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

0 150 300

Feet

TITLE:

Gamma Correlation Study Locations

PROJECT:

Removal Site Evaluation
NA-0904 Mine Site

DATE: 7/19/2018

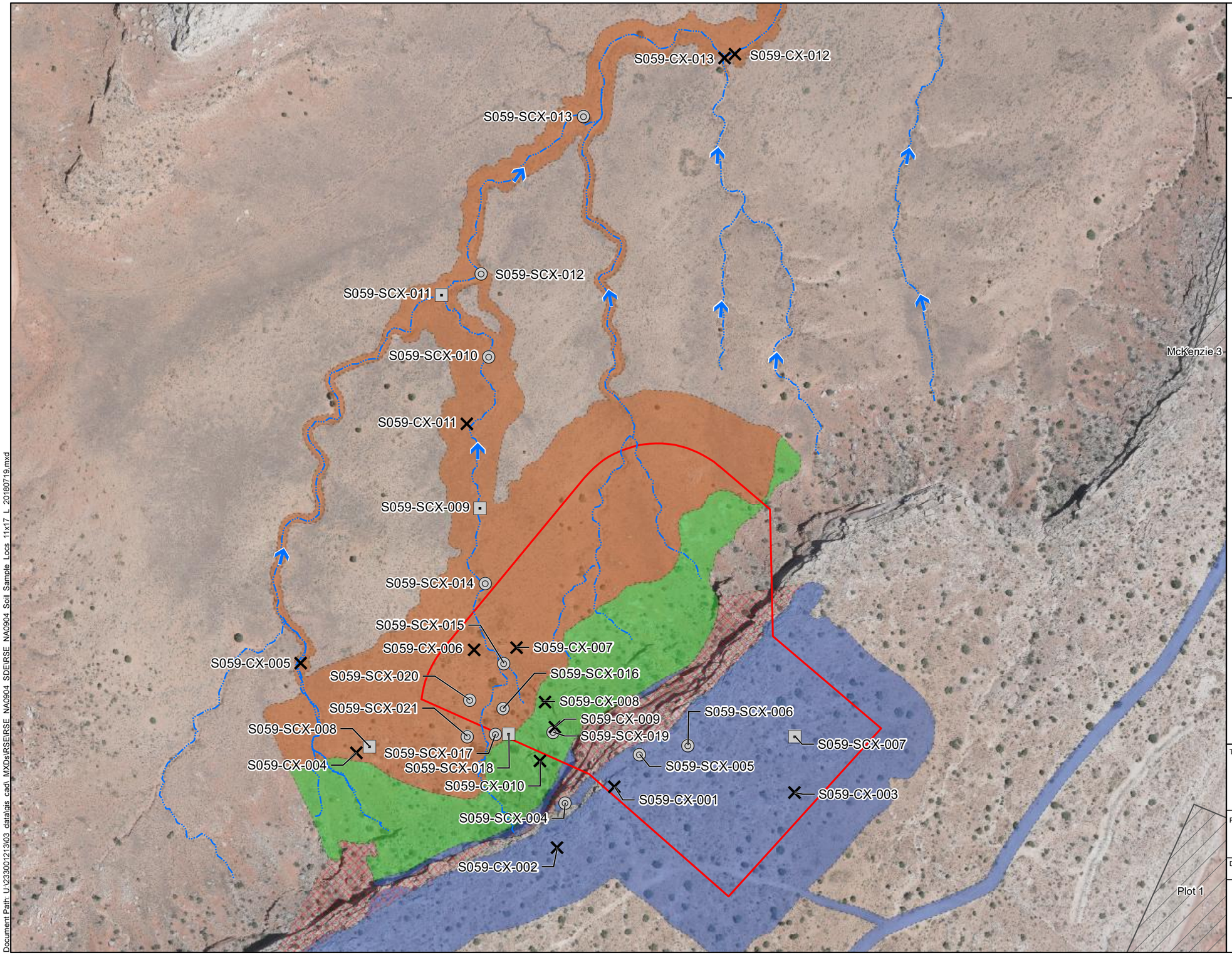
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB | REVIEWER: EDZ

FIGURE: 3-5

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\RSE NA0904 Correlation 11x17 L 20180719.mxd



Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\RSE NA0904 Soil Sample Locs 11x17 L 20180719.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
- Unsurveyed Area
- Claim Boundary
- Other Claim Boundary

NOTES:

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

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

Subsurface soil samples range from 0.5 - 2.0 ft bgs

Static gamma measurements range from 0.0 - 2.0 ft bgs

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

N W E S

0 200 400

Feet

TITLE:

Site Characterization Surface and Subsurface Sample Locations

PROJECT:

Removal Site Evaluation
NA-0904 Mine Site

DATE: 8/29/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 3-6a

Stantec

NOTES:

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

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

Subsurface soil samples range from 0.5 - 2.0 ft bgs

Static gamma measurements range from 0.0 - 2.0 ft bgs

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

S059-CX-013
S059-CX-012
S059-SCX-013
S059-SCX-012
S059-SCX-011
S059-SCX-010
S059-CX-011
S059-SCX-009
S059-SCX-014
S059-SCX-015
S059-CX-006
S059-CX-007
S059-CX-005
S059-SCX-020
S059-SCX-016
S059-CX-008
S059-SCX-021
S059-CX-009
S059-SCX-019
S059-SCX-006
S059-SCX-008
S059-SCX-017
S059-SCX-018
S059-CX-004
S059-CX-010
S059-SCX-005
S059-SCX-007
S059-CX-001
S059-CX-003
S059-SCX-004
S059-CX-002
McKenzie 3
Plot 1

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Potential Incline Shaft
- Potential Rim Strip
- Portal
- Flow Direction
- Drainage
- Potential Haul Road
- Primary Haul Route
- Portal Access Ramp
- Waste Pile
- Claim Boundary
- Other Claim Boundary

N
W E
S

0 200 400
Feet

TITLE:
Sample Locations Compared to Mining-Related Features

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 8/29/2018

DOCUMENT NAME: Removal Site Evaluation Report

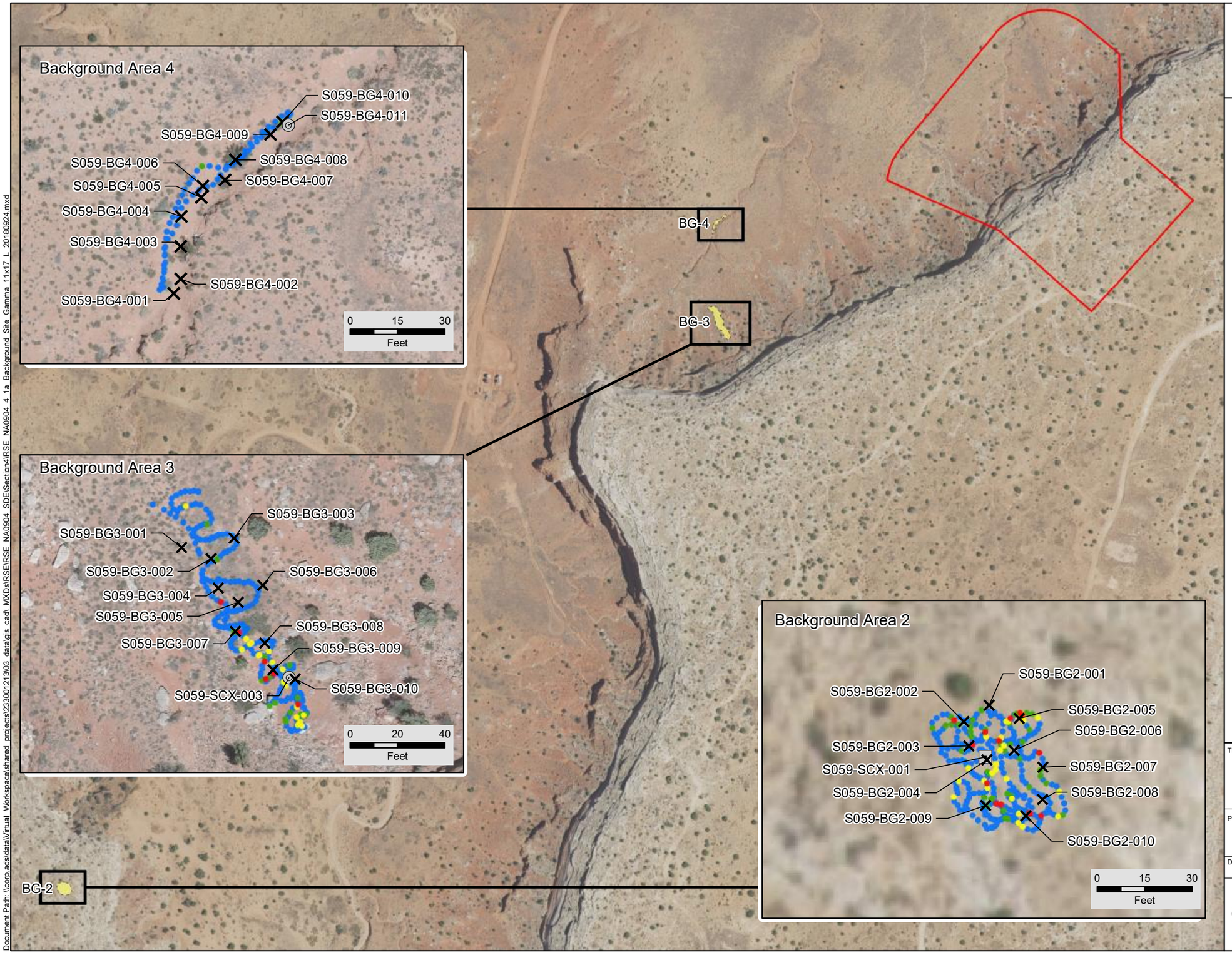
AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 3-6b

Stantec

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\RSE NA0904 Soil Sample Locs MineFeatures 11x17 L 20180719.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

Gamma Survey

Counts per Minute (CPM)

- 5,599 - 9,911 (Minimum to BG-4 IL)
- 9,912 - 10,447 (>BG-4 IL to BG-3 IL)
- 10,448 - 11,068 (>BG-3 IL to BG-2 IL)
- 11,069 - 13,471 (>BG-2 IL to Maximum)

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Main display and Background Area 2 basemap image inset accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

Background Areas 3 and 4 basemap image insets flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 300 600
Feet

TITLE:

Background Reference Areas Gamma Radiation Survey Results

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

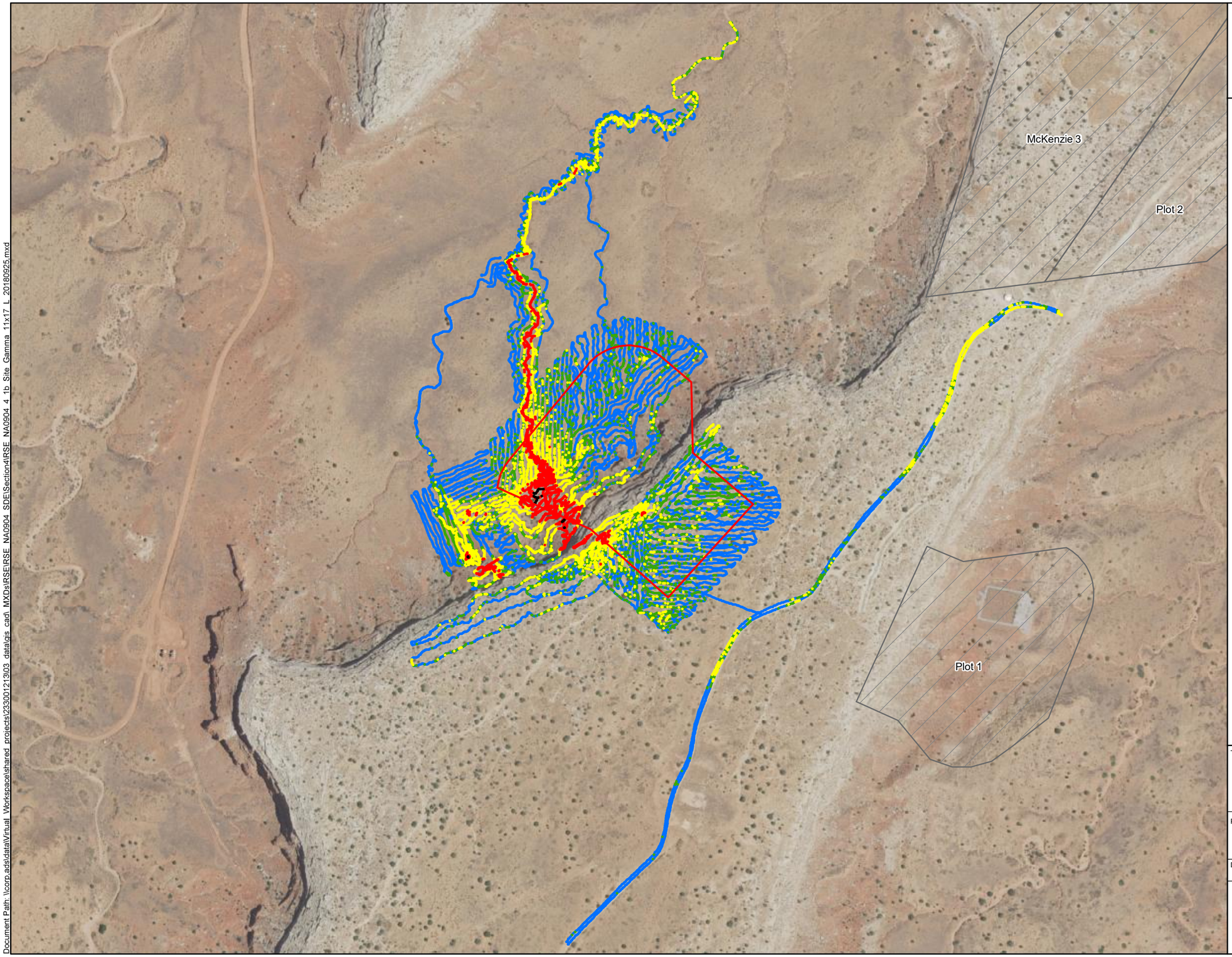
AUTHOR: JSB

REVIEWER: CBB

FIGURE: 4-1a

Stantec

Document Path: \\corp.ads\data\Virtual Workspace\shared projects\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\Section4\RSE_NA0904_4_1a Background Site Gamma 11x17 L 20180924.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Claim Boundary

Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 5,835 - 9,911 (Minimum to BG-4 IL)
- 9,912 - 11,068 (>BG-4 IL to BG-2 IL)
- 11,069 - 19,822 (>BG-2 IL to 2x BG-4 IL)
- 19,823 - 110,680 (>2x BG-4 IL to 10x BG-2 IL)
- 110,681 - 202,616 (>10x BG-2 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 (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

N
W E
S

0 360 720
Feet

TITLE:
Gamma Radiation Survey Results for Site

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

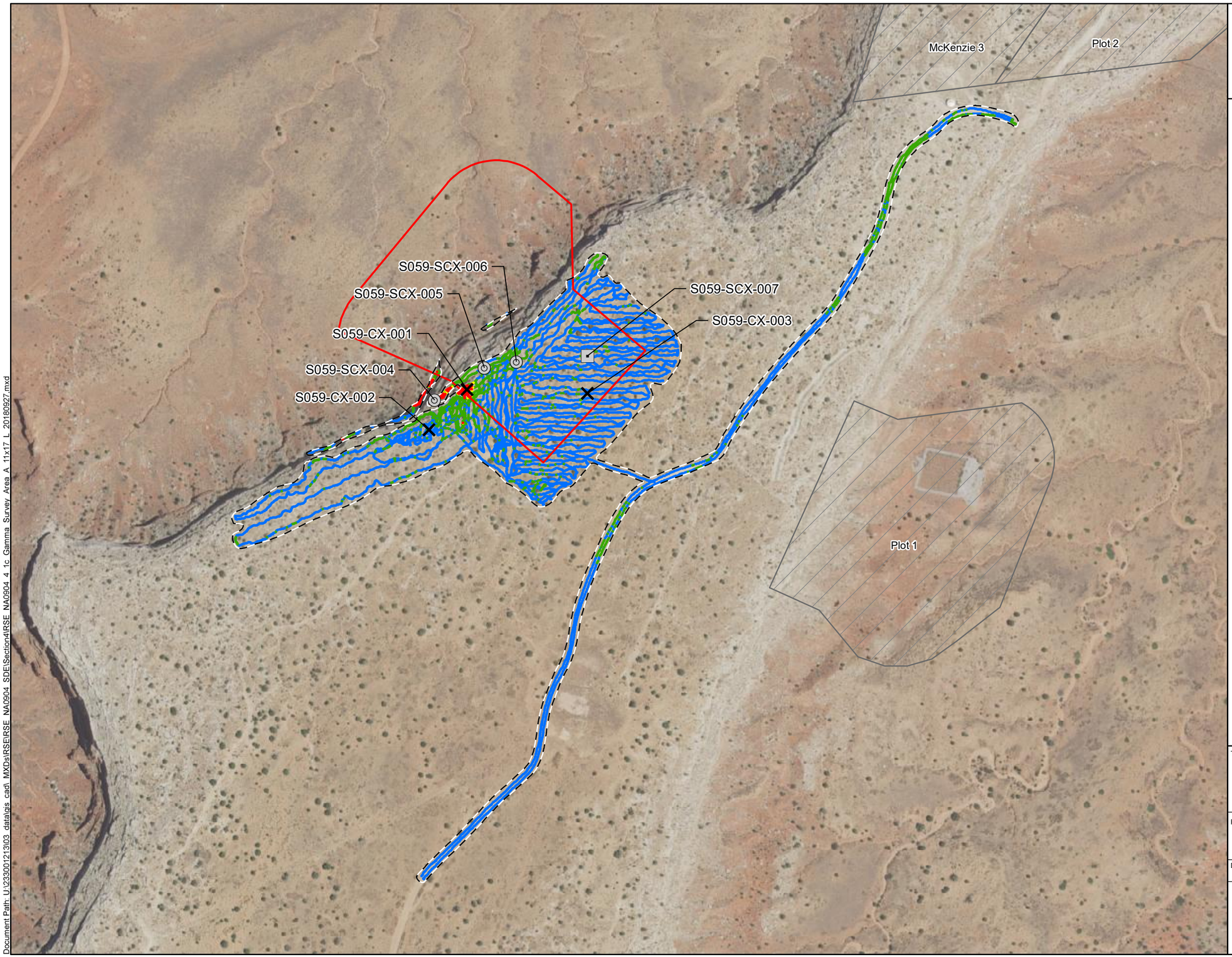
AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-1b

Stantec

Document Path: \\corp.ad\data\Virtual Workspaces\shared projects\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 4 1b Site Gamma 11x17 L 20180925.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
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 6,110 - 11,068 (Minimum to BG-2 IL)
- 11,069 - 19,403 (>BG-2 IL to BG-1 IL)
- 19,404 - 22,136 (>BG-1 IL to 2x BG-2 IL)
- 22,137 - 55,340 (>2x BG-2 IL to 5x BG-2 IL)
- 55,341 - 100,860 (>5x BG-2 IL to Maximum)

NOTE:
BG-1 IL incorporated for comparison purposes.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

N W E S

0 300 600
Feet

TITLE:
Gamma Radiation Survey Results for Survey Area A

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/28/2018

DOCUMENT NAME: Removal Site Evaluation Report

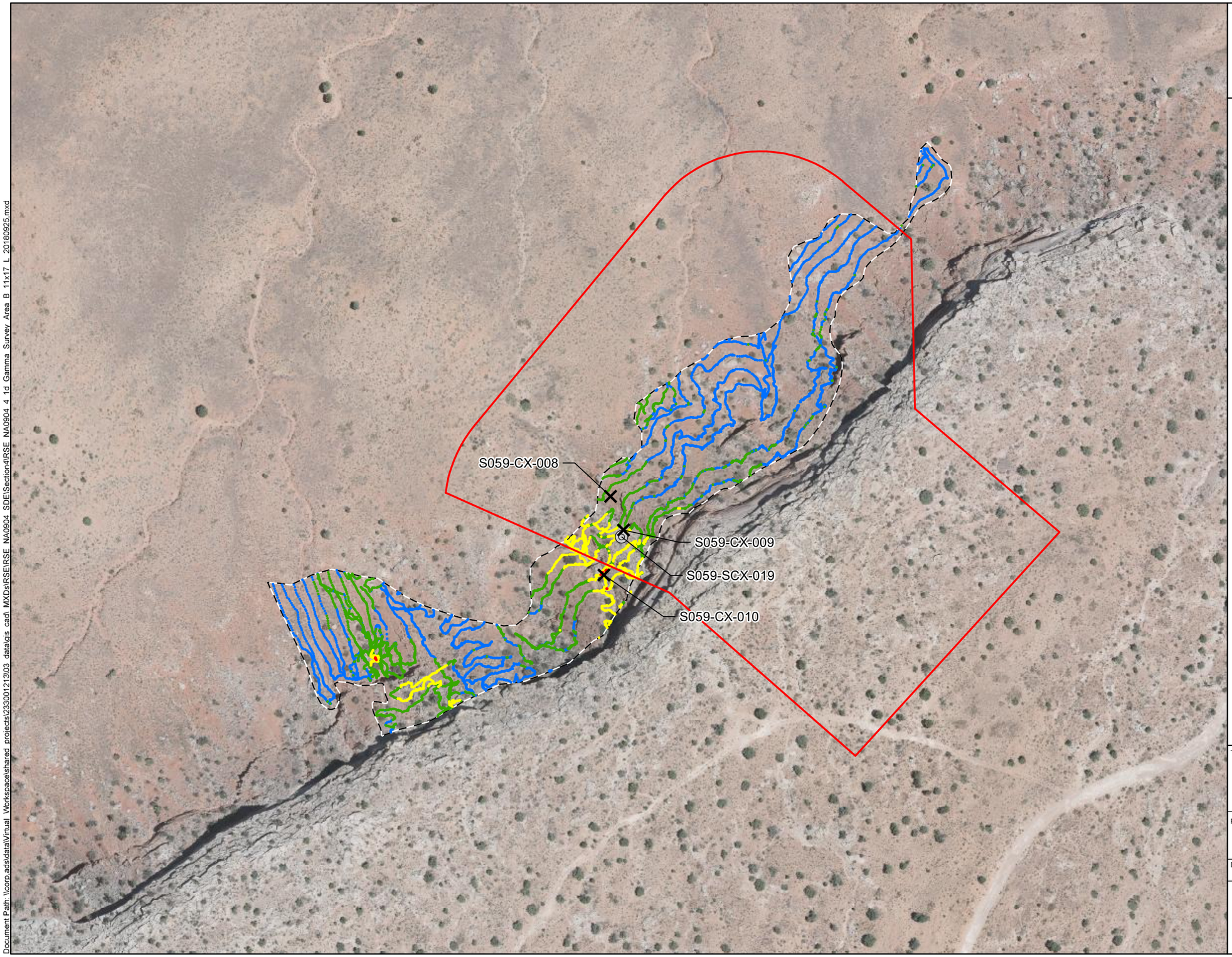
AUTHOR: JSB

REVIEWER: CBB

FIGURE: 4-1c

Stantec

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\Section4\RSE NA0904 4 1c Gamma Survey Area A 11x17 L 20180927.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

Gamma Survey

Counts per Minute (CPM)

- 5,921 - 10,447 (Minimum to BG-3 IL)
- 10,448 - 20,894 (>BG-3 IL to 2x BG-3 IL)
- 20,895 - 104,470 (>2x BG-3 IL to 10x BG-3 IL)
- 104,471 - 202,616 (>10x 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

0 150 300

Feet

TITLE:

Gamma Radiation Survey Results for Survey Area B

PROJECT:

Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

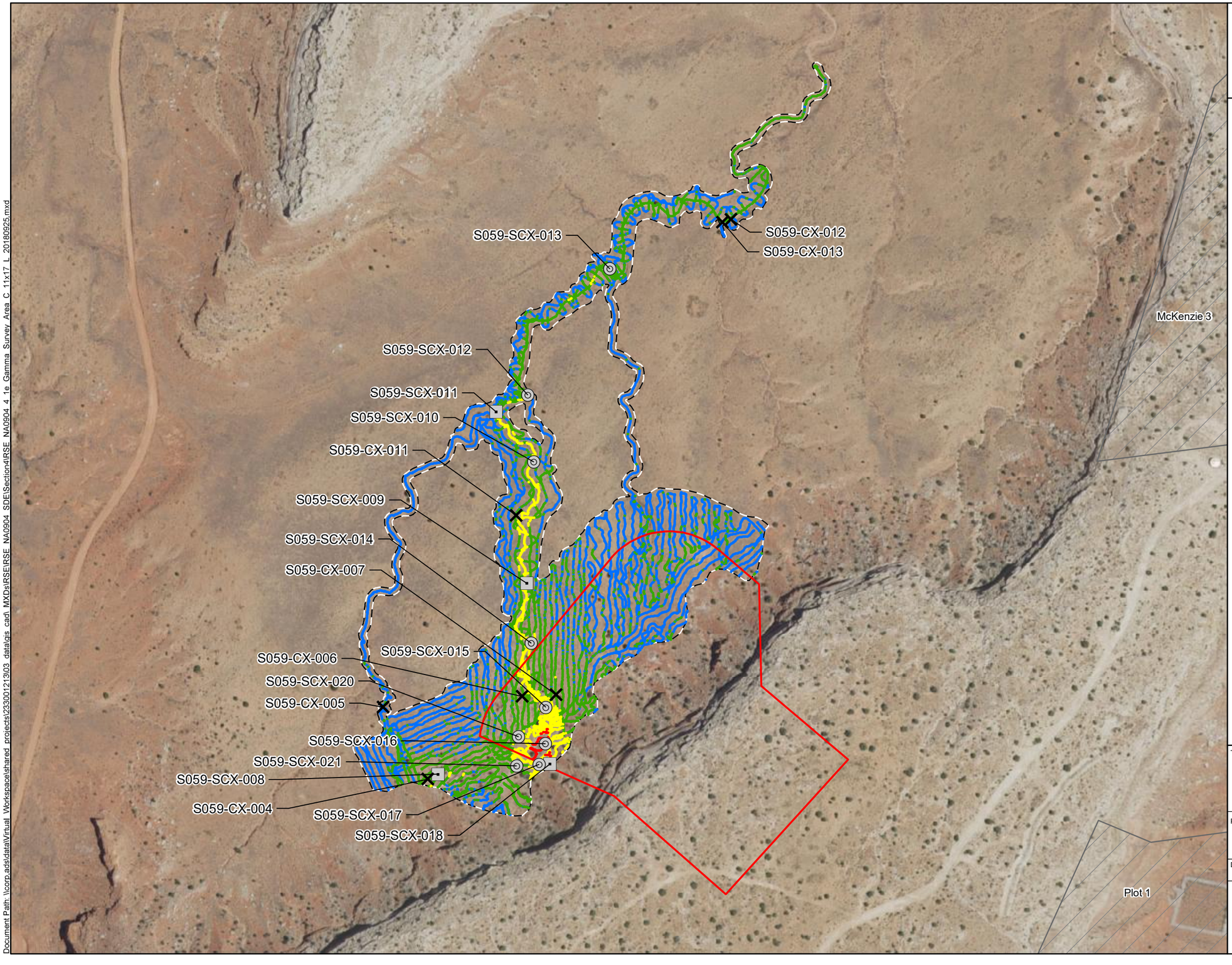
AUTHOR: JSB

REVIEWER: CBB

FIGURE: 4-1d

Stantec

Document Path: \\corp.adst\data\Virtual Workspace\shared projects\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\Section4\RSE NA0904 4 1d Gamma Survey Area B 11x17 L 20180925.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
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 5,835 - 9,911 (Minimum to BG-4 IL)
- 9,912 - 19,822 (>BG-4 IL to 2x BG-4 IL)
- 19,823 - 99,110 (>2x BG-4 IL to 10x BG-4 IL)
- 99,111 - 133,973 (>10x BG-4 IL to Maximum)

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

N W E S

0 250 500

Feet

TITLE:

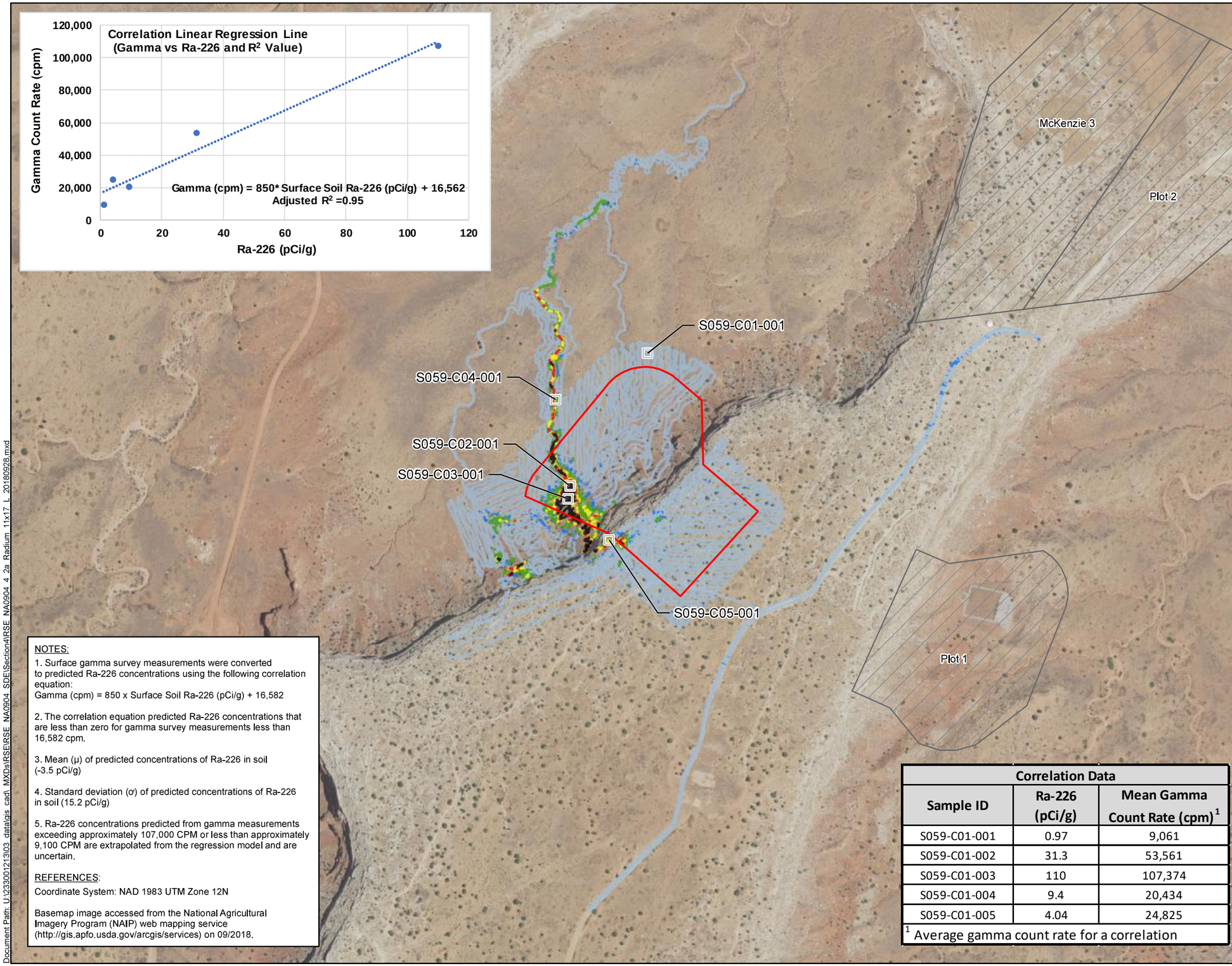
Gamma Radiation Survey Results for Survey Area C

PROJECT:

Removal Site Evaluation
NA-0904 Mine Site

DATE:	DOCUMENT NAME:
9/26/2018	Removal Site Evaluation Report
	AUTHOR: JSB / REVIEWER: EDZ
Stantec	FIGURE: 4-1e

Document Path: \\corp.ads\data\Virtual Workspace\shared projects\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\Section4\RSE_NA0904_4-1e_Gamma_Survey_Area_C_11x17_L_20180925.mxd



NOTES:

1. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
Gamma (cpm) = 850 x Surface Soil Ra-226 (pCi/g) + 16,582

2. The correlation equation predicted Ra-226 concentrations that are less than zero for gamma survey measurements less than 16,582 cpm.

3. Mean (μ) of predicted concentrations of Ra-226 in soil (-3.5 pCi/g)

4. Standard deviation (σ) of predicted concentrations of Ra-226 in soil (15.2 pCi/g)

5. Ra-226 concentrations predicted from gamma measurements exceeding approximately 107,000 CPM or less than approximately 9,100 CPM are extrapolated from the regression model and are uncertain.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agricultural Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

Correlation Data

Sample ID	Ra-226 (pCi/g)	Mean Gamma Count Rate (cpm)[1]
S059-C01-001	0.97	9,061
S059-C01-002	31.3	53,561
S059-C01-003	110	107,374
S059-C01-004	9.4	20,434
S059-C01-005	4.04	24,825

[1] Average gamma count rate for a correlation

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

S059-C01-001 Correlation Location (30' x 30')

Claim Boundary

Other Claim Boundary

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

- -12.6 - -3.5 (μ)[2,3]
- -3.4 - 0[2]
- 0 - 11.7 (μ + 1σ[4])
- 11.8 - 26.9 (μ + 2σ)
- 27.0 - 42.1 (μ + 3σ)
- 42.2 - 218.9

N W E S

0 400 800
Feet

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

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/28/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: JSB

REVIEWER: CBB

FIGURE: 4-2a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_NA0904_SDE\Section4\RSE_NA0904_4_2a_Radium_11x17_L_20180928.mxd

NOTES:

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

2. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
Gamma (cpm) = 850 x Surface Soil Ra-226 (pCi/g) + 16,582

3. The correlation equation predicted Ra-226 concentrations that are less than zero for gamma survey measurements less than 16,582 cpm.

4. Mean (μ) of predicted concentrations of Ra-226 in soil (-3.5 pCi/g)

5. Standard deviation (σ) of predicted concentrations of Ra-226 in soil (15.2 pCi/g)

6. Ra-226 concentrations predicted from gamma measurements xceeding approximately 107,000 CPM or less than approximately 9,100 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.

S059-CX-012 (2.88)
S059-CX-013 (0.91)
S059-SCX-013 (3.1)
McKenzie 3
S059-SCX-012 (22.1)
S059-SCX-011 (11.3)
S059-SCX-010 (30)
S059-CX-011 (2.33)
S059-SCX-009 (15.3)
S059-SCX-014 (40.6)
S059-SCX-016 (127)
S059-SCX-020 (1.12)
S059-CX-005 (0.77)
S059-SCX-017 (103)
S059-SCX-008 (15.7)
S059-CX-004 (10.3)
S059-SCX-021 (0.75)
S059-SCX-018 (101)
S059-CX-010 (83.2)
S059-CX-006 (1.05)
S059-CX-007 (2.52)
S059-SCX-015 (48.3)
S059-CX-008 (0.7)
S059-CX-009 (2.76)
S059-SCX-019 (5.65)
S059-SCX-007 (1.09 and 1.8)
S059-CX-003 (0.98)
S059-SCX-006 (5.6)
S059-SCX-005 (1.72)
S059-CX-001 (45.5)
S059-SCX-004 (10.2)
S059-CX-002 (0.94)

N
W E
S
0 250 500
Feet

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

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

- -12.6 - -3.5 $(\mu)^{3,4}$
- -3.4 - 0[3]
- 0 - 11.7 $(\mu + 1\sigma^{5})$
- 11.8 - 26.9 $(\mu + 2\sigma)$
- 27.0 - 42.1 $(\mu + 3\sigma)$
- 42.2 - 218.9

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

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/28/2018

DOCUMENT NAME: Removal Site Evaluation Report

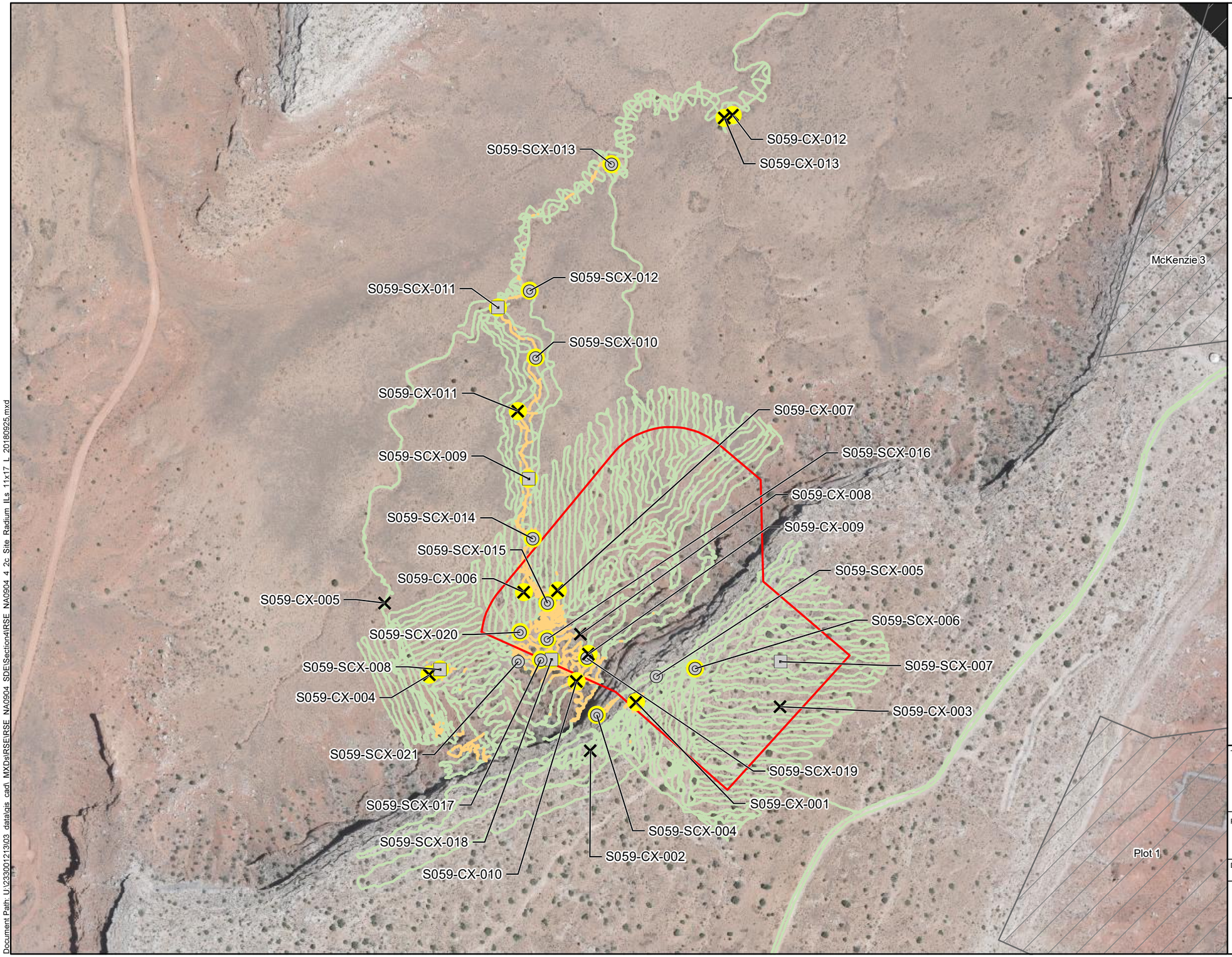
AUTHOR: JSB

REVIEWER: CBB

FIGURE: 4-2b

Stantec

Document Path: U:\233901213\03_data\gis_cad_MXDs\RSE\RSE_NA0904_SDE\Section4\RSE_NA0904_4_2b_Radium_SoilConc_11x17_L_20180925.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Ra-226 IL Exceedance in Surface Soil
- Claim Boundary
- Other Claim Boundary

Predicted Ra-226 Concentrations (pCi/g)

IL Not Exceeded
Survey Area A: -12.3 - 3.34
Survey Area B: -12.5 - 1.06
Survey Area C: -12.6 - 0.895

IL Exceeded
Survey Area A: 3.35 - 99.2
Survey Area B: 1.07 - 218.9
Survey Area C: 0.896 - 138.1

NOTES:

1. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
Gamma (cpm) = 850 x Surface Soil Ra-226 (pCi/g) + 16,582

2. 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.

N W E S

0 250 500
Feet

TITLE:

Predicted Ra-226 Concentrations in Surface Soil Compared to Ra-226 ILs

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/25/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: JSB

REVIEWER: CBB

Stantec

FIGURE: 4-2c

Document Path: U:\23300121303_data\gis_cad_MXDs\RSE\RSE_NA0904_SDE\Section4\RSE_NA0904_4_2c_Site_Radium_ILs_11x17_L_20180925.mxd

Soil and Sediment Investigation Levels			
	Investigation Level		
Analyte (Units)	**Survey Area A**	**Survey Area B**	**Survey Area C**
Metals (mg/kg)			
Arsenic	4.38	2.25	2.88
Molybdenum	NA[1]	NA[2]	0.334
Selenium	NA[3]	NA[3]	NA[3]
Uranium	3.28	0.836	0.948
Vanadium	18.7	18	8.65
Radionuclides (pCi/g)			
Radium-226	3.34	1.06	0.895
Gamma (CPM)			
Subsurface Static Gamma	13,249	13,159	10,141

[1] No IL was established for Mo in Survey Area A because Mo was not detected in background reference area 2.

[2] No IL was established for Mo in Survey Area B because there were not enough detections in background reference area 3 (one detection) to establish an IL.

[3] No IL was established for Se because Se was not detected in the background reference areas.

S059-CX-012						
As	Mo	Se	U	V	Ra	

S059-CX-013						
As	Mo	Se	U	V	Ra	

S059-SCX-012							
0 - 0.5	As	Mo	Se	U	V	Ra	
0.5 - 1.0	As	Mo	Se	U	V	Ra	
1.0 - 1.5	As	Mo	Se	U	V	Ra	
1.5 - 2.0	As	Mo	Se	U	V	Ra	

S059-SCX-013							
0 - 0.5	As	Mo	Se	U	V	Ra	
0.5 - 1.0	As	Mo	Se	U	V	Ra	

S059-SCX-010							
0 - 0.5	As	Mo	Se	U	V	Ra	
0.5 - 1.0	As	Mo	Se	U	V	Ra	
1.0 - 1.5	As	Mo	Se	U	V	Ra	
1.5 - 2.0	As	Mo	Se	U	V	Ra	

S059-SCX-011							
0 - 0.5	As	Mo	Se	U	V	Ra	

S059-CX-006						
As	Mo	Se	U	V	Ra	

S059-CX-011						
As	Mo	Se	U	V	Ra	

S059-CX-007						
As	Mo	Se	U	V	Ra	

S059-SCX-016							
0 - 0.5	As	Mo	Se	U	U	Ra	
0.5 - 1.0	As	Mo	Se	U	V	Ra	
1.0 - 1.8	As	Mo	Se	U	V	Ra	

S059-CX-008						
As	Mo	Se	U	V	Ra	

S059-SCX-009							
0 - 0.5	As	Mo	Se	U	V	Ra	

S059-CX-009						
As	Mo	Se	U	V	Ra	

S059-SCX-014							
0 - 0.5	As	Mo	Se	U	U	Ra	
0.5 - 1.0	As	Mo	Se	U	V	Ra	
1.0 - 1.8	As	Mo	Se	U	V	Ra	

S059-SCX-007							
0 - 0.1	As	Mo	Se	U	V	Ra	
0.1 - 0.25	As	Mo	Se	U	V	Ra	

S059-SCX-015							
0 - 0.5	As	Mo	Se	U	V	Ra	
0.5 - 1.0	As	Mo	Se	U	V	Ra	
1.0 - 1.5	As	Mo	Se	U	V	Ra	
1.5 - 2.0	As	Mo	Se	U	V	Ra	

S059-CX-003						
As	Mo	Se	U	V	Ra	

S059-SCX-006							
0 - 0.5	As	Mo	Se	U	V	Ra	
0.0 - 0.8	As	Mo	Se	U	V	Ra	

S059-CX-004						
As	Mo	Se	U	V	Ra	

S059-SCX-005							
0 - 0.5	As	Mo	Se	U	V	Ra	
0.5 - 1.0	As	Mo	Se	U	V	Ra	

S059-SCX-008							
0 - 0.5	As	Mo	Se	U	V	Ra	

S059-CX-001						
As	Mo	Se	U	V	Ra	

S059-SCX-020							
0 - 0.5	As	Mo	Se	U	V	Ra	
0.5 - 1.0	As	Mo	Se	U	V	Ra	
1.0 - 1.5	As	Mo	Se	U	V	Ra	
1.5 - 2.0	As	Mo	Se	U	V	Ra	

S059-SCX-019							
0 - 0.5	As	Mo	Se	U	U	Ra	
0.5 - 1.0	As	Mo	Se	U	V	Ra	
1.0 - 1.5	As	Mo	Se	U	V	Ra	

S059-SCX-017							
0 - 0.5	As	Mo	Se	U	V	Ra	
0.5 - 1.0	As	Mo	Se	U	V	Ra	

S059-SCX-004							
0 - 0.5	As	Mo	Se	U	V	Ra	
0.5 - 1.0	As	Mo	Se	U	V	Ra	

S059-SCX-021							
0 - 0.5	As	Mo	Se	U	U	Ra	
0.5 - 1.0	As	Mo	Se	U	V	Ra	
1.0 - 1.3	As	Mo	Se	U	V	Ra	

S059-SCX-018						
0 - 0.5	As	Mo	Se	U	V	Ra

S059-CX-010						
As	Mo	Se	U	V	Ra	

S059-CX-002						
As	Mo	Se	U	V	Ra	

McKenzie 3

Plot 2

NA-0926

Investigation Level Not Exceeded

Investigation Level Exceeded

Analyte Detected - No Investigation Level[1]

Non-detect - No Investigation Level[1]

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

NOTES:
1. No Investigation Level - Selenium or molybdenum was not detected in corresponding background reference area.

2. Sample intervals (e.g. 0 - 0.5) are in ft bgs.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

N W E S

0 400 800

Feet

TITLE:

Surface and Subsurface Metals and Ra-226 Analytical Results

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: JSB | REVIEWER: CBB

Stantec

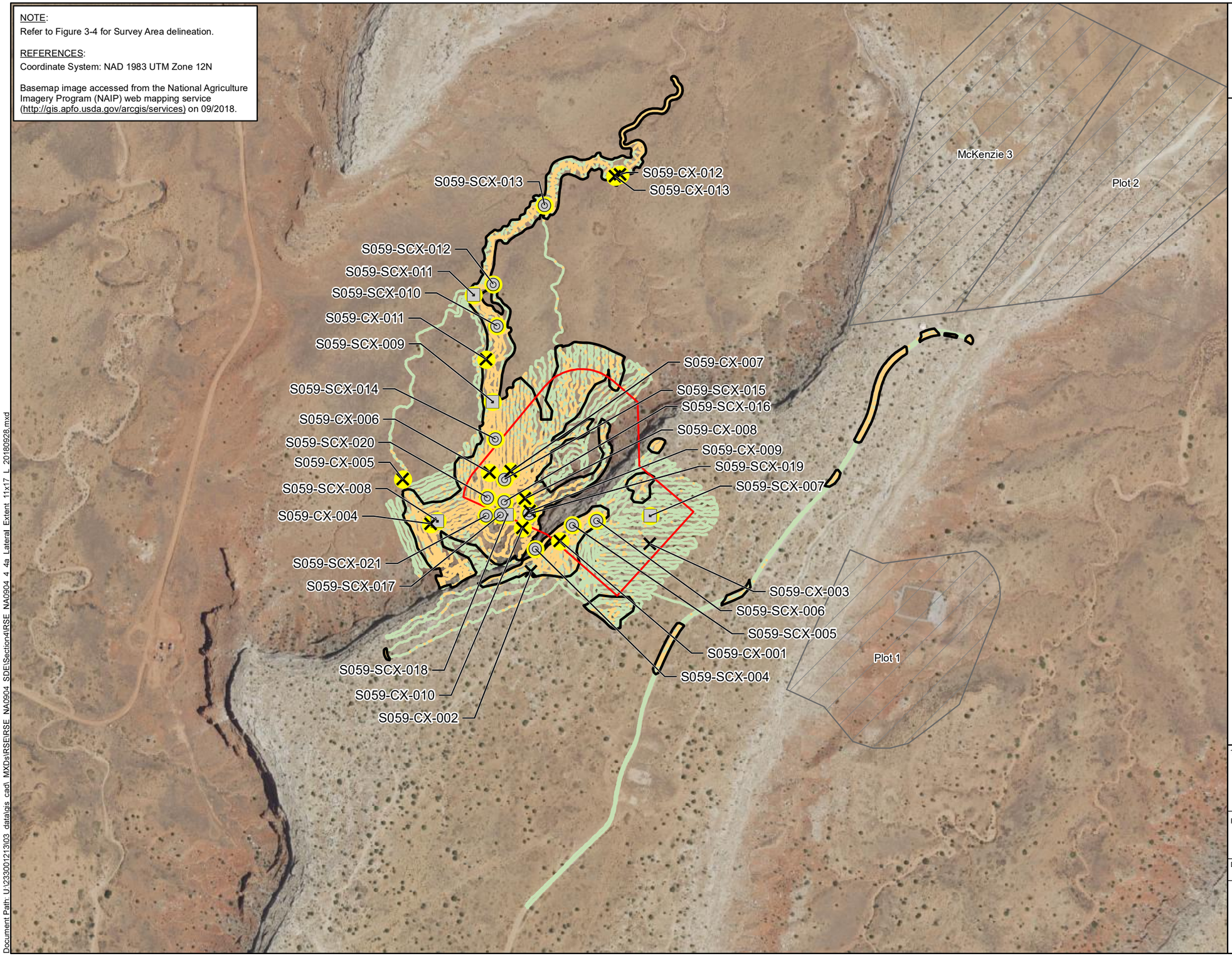
FIGURE: 4-3

Document Path: \\corp.ads\data\Virtual Workspaces\shared_projects\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDEISection4\RSE NA0904 4 3 Analytical Results 11x17 L 20180925.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 (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma ILs are Exceeded (14.4 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

IL Not Exceeded
Survey Area A: 6,110 - 11,068
Survey Area B: 5,921 - 10,447
Survey Area C: 5,835 - 9,911

IL Exceeded
Survey Area A: 11,069 - 100,860
Survey Area B: 10,448 - 202,616
Survey Area C: 9,912 - 133,973

N
W E
S

0 400 800
Feet

TITLE:
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/28/2018

DOCUMENT NAME: Removal Site Evaluation Report

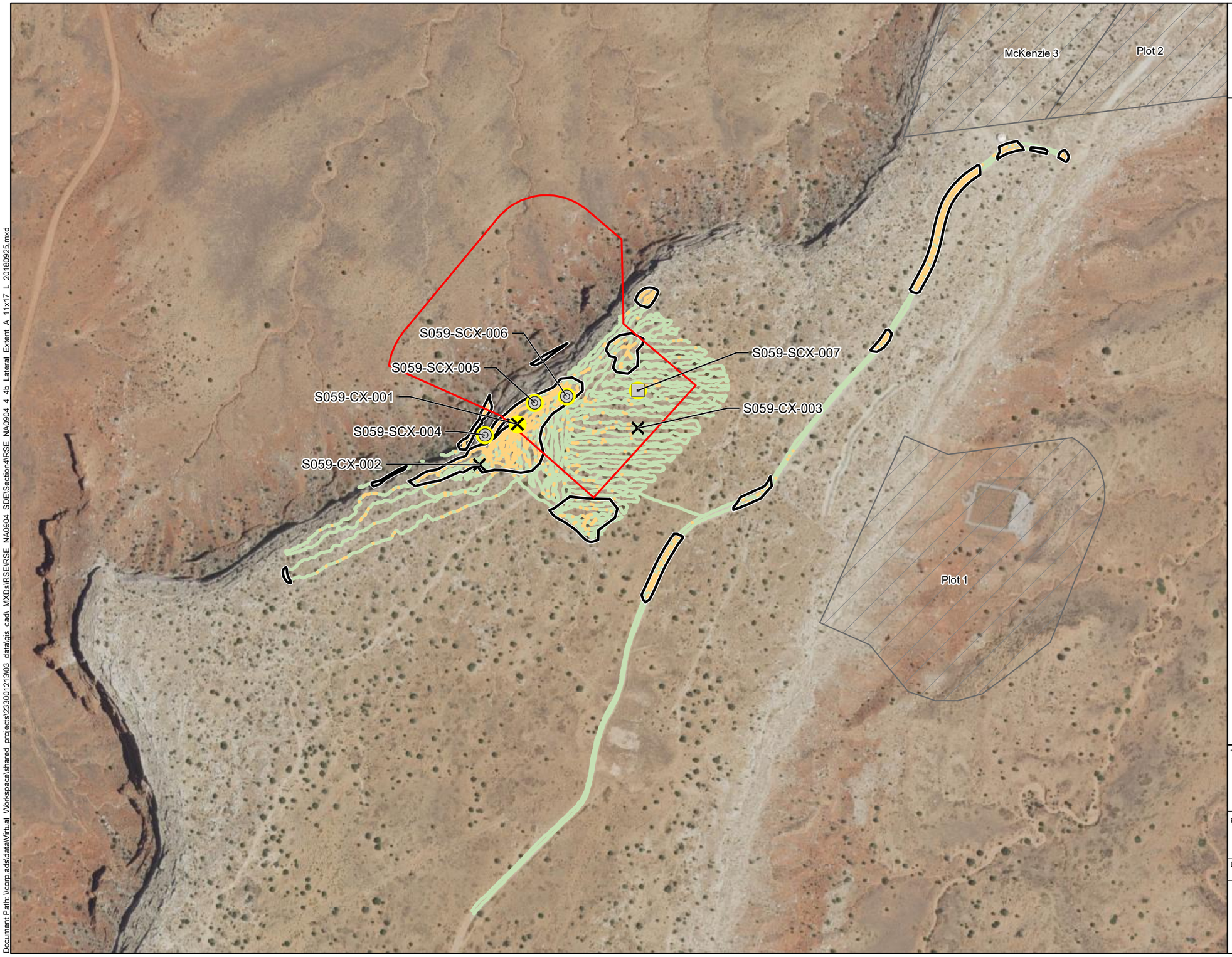
AUTHOR: JSB

REVIEWER: CBB

FIGURE: 4-4a

Stantec

Document Path: U:\233001213\03 data\gis_cad\ MXDs\RSE\RSE NA0904 SDE\Section4\RSE NA0904 4 4a Lateral Extent 11x17 L 20180928.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma IL is Exceeded (2.8 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 6,110 - 11,068 (IL Not Exceeded)
- 11,069 - 100,860 (IL Exceeded)

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

N
W E
S

0 300 600
Feet

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

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

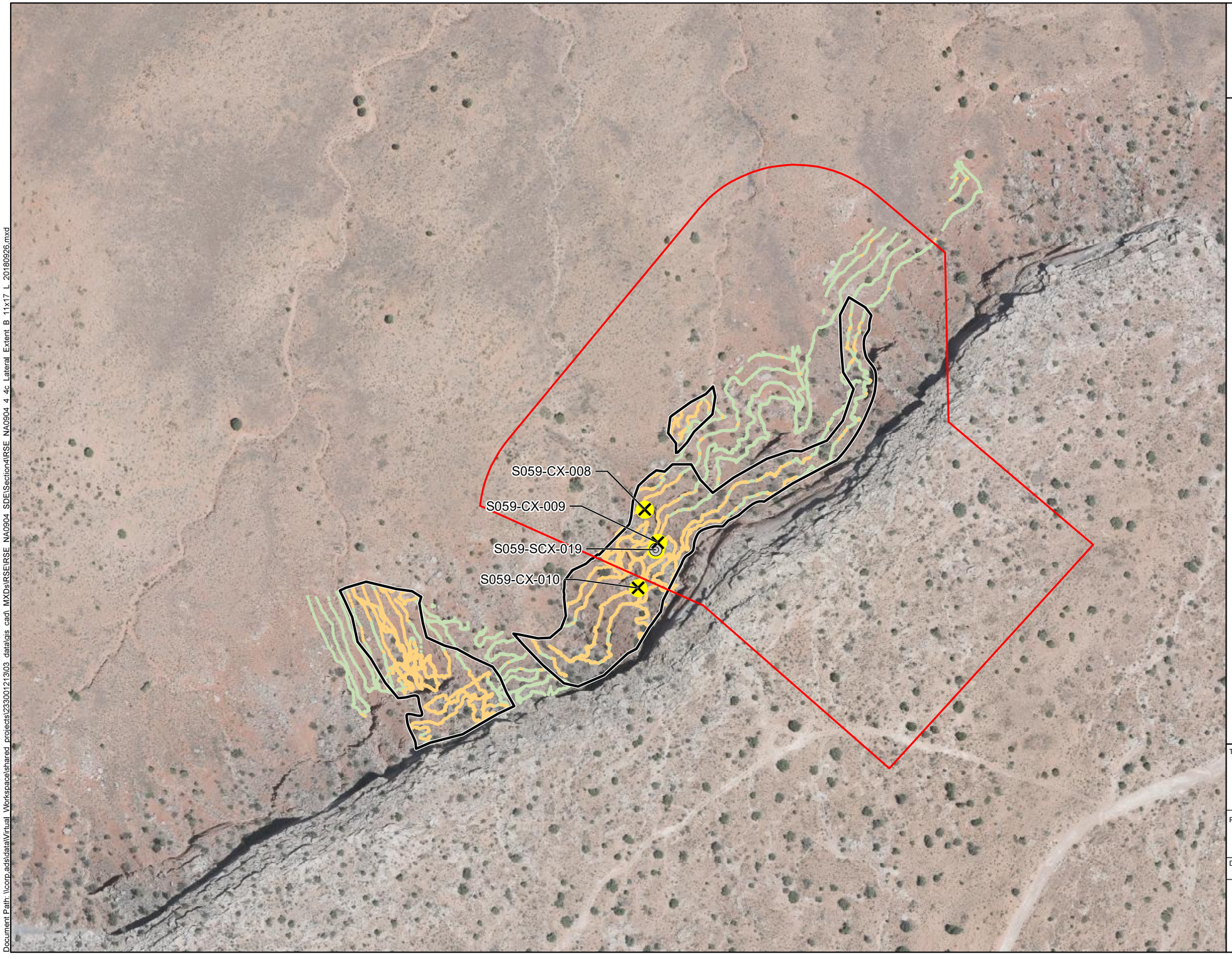
AUTHOR: JSB

REVIEWER: CBB

FIGURE: 4-4b

Stantec

Document Path: \\corp.adsldata\Virtual Workspaces\shared projects\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\Section4\RSE NA0904 4 4b Lateral Extent A 11x17 L 20180925.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma IL is Exceeded (2.3 acres)
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 5,921 - 10,447 (IL Not Exceeded)
- 10,448 - 202,616 (IL Exceeded)

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

N W E S

0 150 300

Feet

TITLE:

Survey Area B Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT:

Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

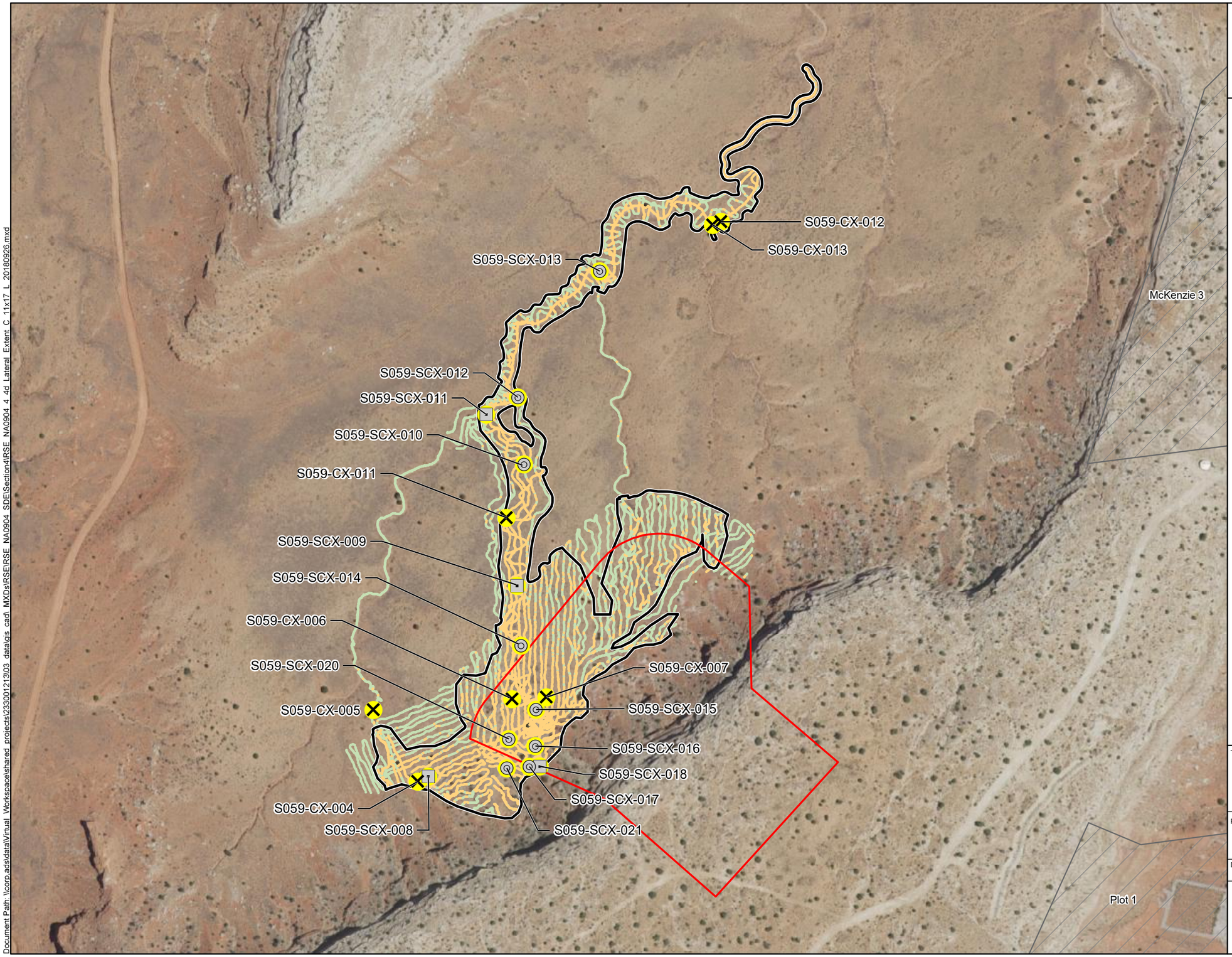
AUTHOR: JSB

REVIEWER: CBB

FIGURE: 4-4c

Stantec

Document Path: \\corp.ads\data\Virtual Workspaces\shared projects\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\Section4\RSE NA0904 4 4c- Lateral Extent B 11x17 L 20180926.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 (9.3 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 5,835 - 9,911 (IL Not Exceeded)
- 9,912 - 133,973 (IL Exceeded)

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

N
W E
S

0 250 500
Feet

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

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: JSB | REVIEWER: CBB

FIGURE: 4-4d

Stantec

Document Path: \\corp.ads\data\Virtual Workspace\shared projects\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\Section4\RSE_NA0904_4_4d_Lateral Extent_C_11x17_L_20180926.mxd

NOTES:

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

2. Range of Investigation Level (IL) Exceedance in Unconsolidated Material selected based on Unconsolidated Material analytical results, subsurface gamma measurements, and subsurface observations.

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

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

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

S059-SCX-013 (1, 1, 0-1)

S059-SCX-012 (2, 2, 0-2)

S059-SCX-011 (uk, 0.6, 0-0.6)

S059-SCX-010 (uk, 2, 0-2)

S059-SCX-009 (uk, 0.5, 0-0.5)

S059-SCX-014 (1.8, 1.8, 0-1.8)

S059-SCX-015 (uk, 2, 0-2)

S059-SCX-020 (2, 2, 0-2)

S059-SCX-016 (uk, 1.8, 0-1.8)

S059-SCX-008 (0.5, 0.5, 0-0.5)

S059-SCX-021 (1.3, 1.3, 0-1.3)

S059-SCX-017 (uk, 1.3, 0-1.3)

S059-SCX-018 (uk, 0.5, 0-0.5)

S059-SCX-019 (1.6, 1.6, 0-1.6)

S059-SCX-004 (1, 1, 0-1)

S059-SCX-007 (0.25, 0.25, 0-0.1)

S059-SCX-006 (0.8, 0.8, 0-0.8)

S059-SCX-005 (0.8, 0.8, 0-0.8)

Plot 1

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

Gamma Survey

Counts per Minute (CPM)

IL Not Exceeded
Survey Area A: 6,110 - 11,068
Survey Area B: 5,921 - 10,447
Survey Area C: 5,835 - 9,911

IL Exceeded
Survey Area A: 11,069 - 100,860
Survey Area B: 10,448 - 202,616
Survey Area C: 9,912 - 133,973

N
W E
S

0 200 400
Feet

TITLE: Vertical Extent of IL Exceedances in Unconsolidated Material

PROJECT: Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

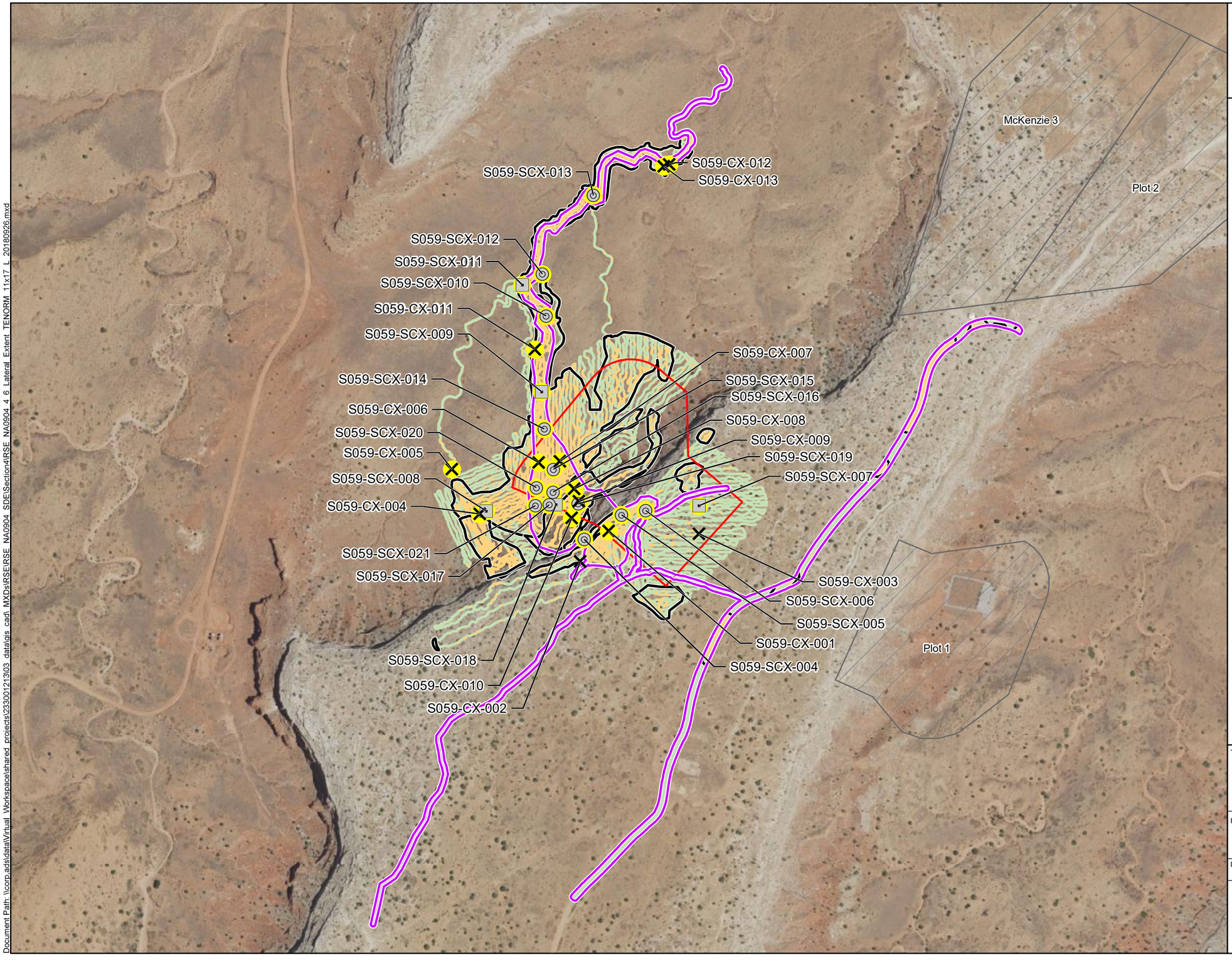
AUTHOR: JSB

REVIEWER: CBB

FIGURE: 4-5

Stantec

Document Path: \\corp.ad\data\Virtual Workspace\shared projects\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\Section4\RSE NA0904 4 5 Vertical Extent 11x17 L 20180925.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
- TENORM (9.2 acres)
- Approximate Area where Surface Gamma ILs are Exceeded (14.4 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

IL Not Exceeded
Survey Area A: 6,110 - 11,068
Survey Area B: 5,921 - 10,447
Survey Area C: 5,835 - 9,911

IL Exceeded
Survey Area A: 11,069 - 100,860
Survey Area B: 10,448 - 202,616
Survey Area C: 9,912 - 133,973

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 (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

N W E S

0 400 800
Feet

TITLE:
TENORM Compared to Lateral Extent of IL Exceedances

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

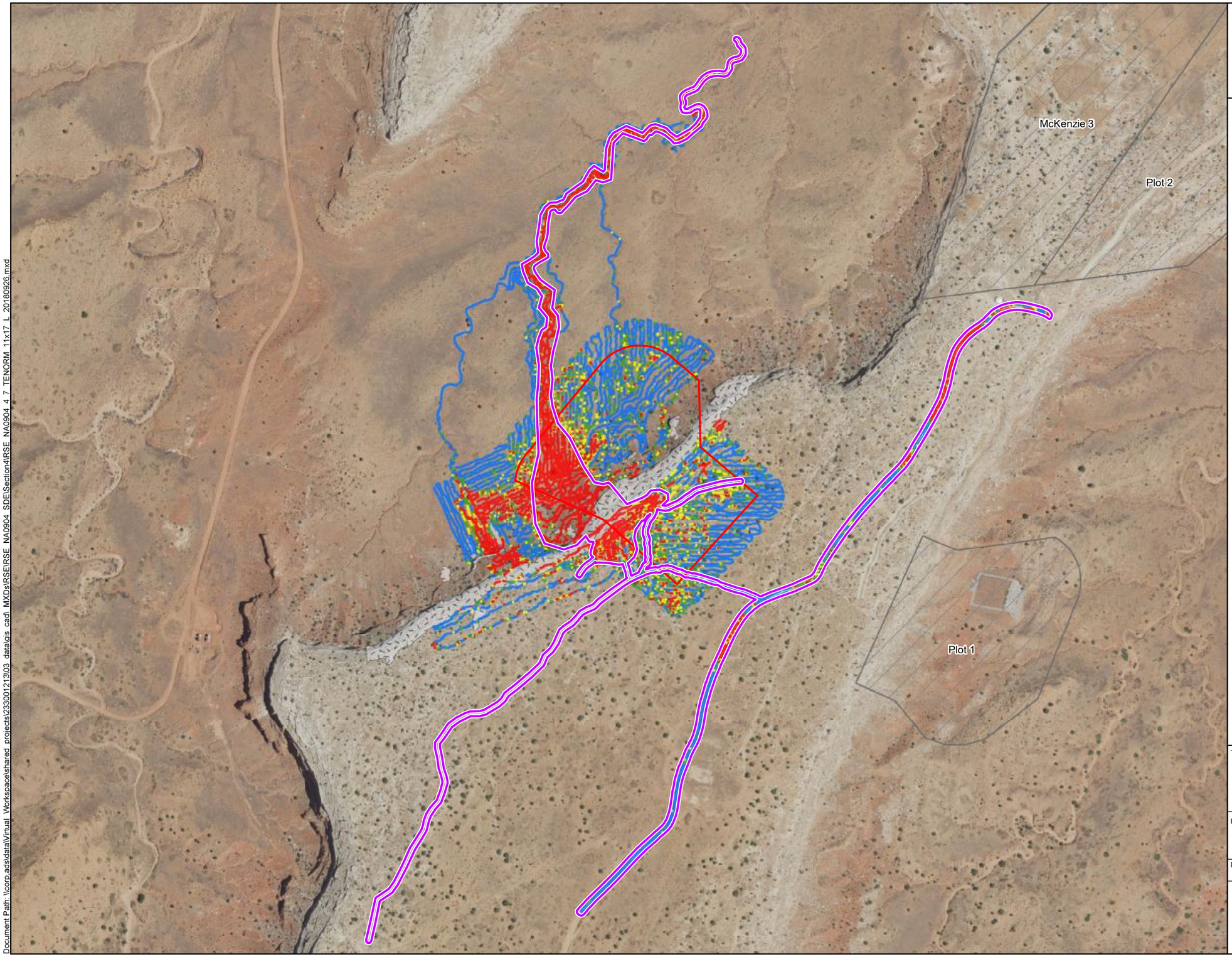
AUTHOR: JSB

REVIEWER: CBB

FIGURE: 4-6

Stantec

Document Path: \\corp.ads\data\Virtual Workspace\shared projects\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\Section4\RSE NA0904 4 6 Lateral Extent TENORM 11x17 L 20180926.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- TENORM (9.2 acres)
- Exposed Bedrock[1]
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 5,835 - 9,911 (Minimum to BG-4 IL)
- 9,912 - 10,447 (>BG-4 IL to BG-3 IL)
- 10,448 - 11,068 (>BG-3 IL to BG-2 IL)
- 11,069 - 202,616 (>BG-2 IL to Maximum)

NOTE:

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

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

N
W E
S

0 380 760
Feet

TITLE:
TENORM Compared to Gamma Radiation Survey Results

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

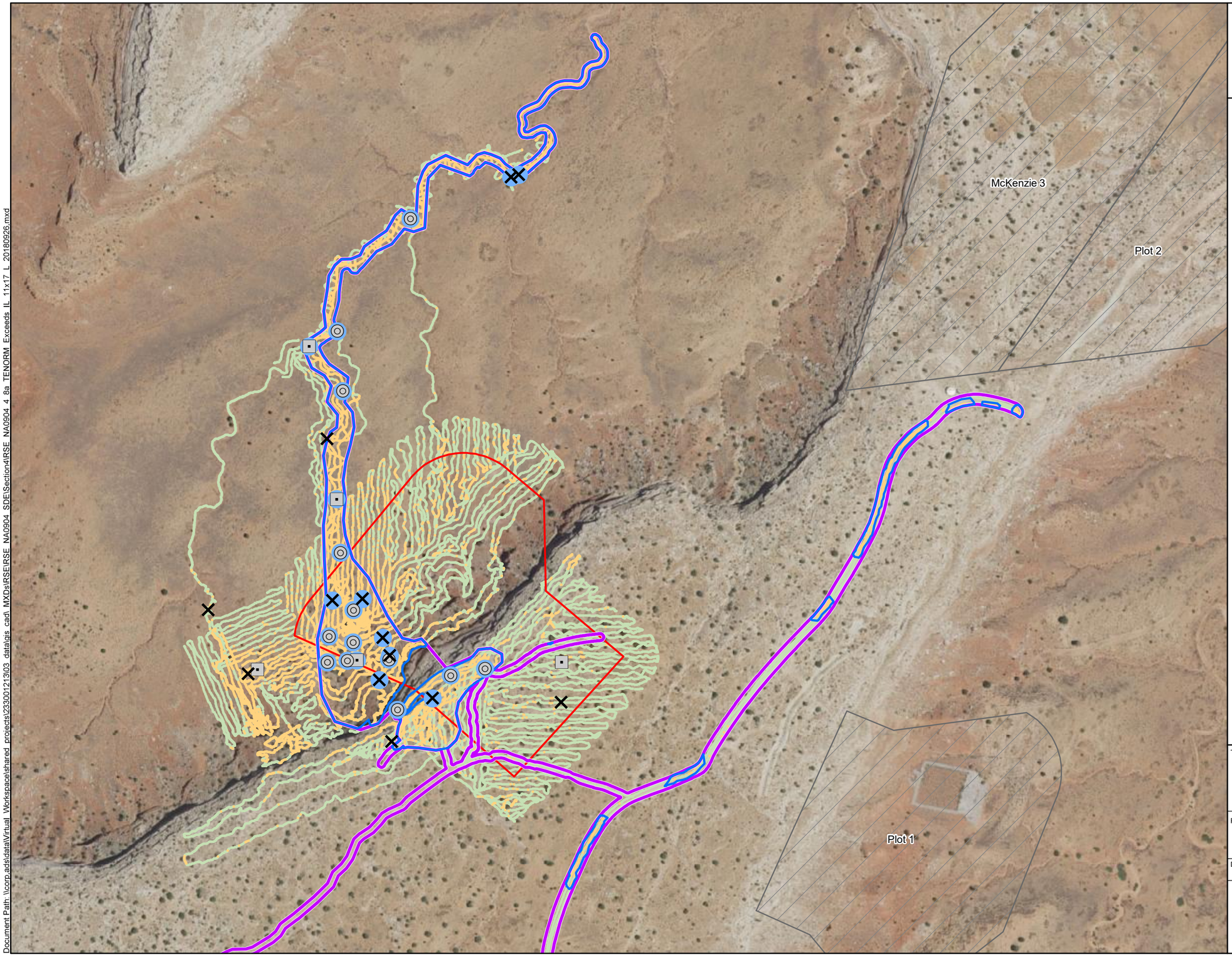
AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-7

Stantec

Document Path: \\corp.adst\data\Virtual Workspace\shared projects\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDEIS\Section4\RSE_NA0904_4_7_TENORM_11x17_L_20180926.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 (5.6 acres)
- TENORM (9.2 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

IL Not Exceeded
Survey Area A: 6,110 - 11,068
Survey Area B: 5,921 - 10,447
Survey Area C: 5,835 - 9,911

IL Exceeded
Survey Area A: 11,069 - 100,860
Survey Area B: 10,448 - 202,616
Survey Area C: 9,912 - 133,973

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 (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

N
W E
S

0 280 560
Feet

TITLE:
TENORM that Exceeds ILs

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

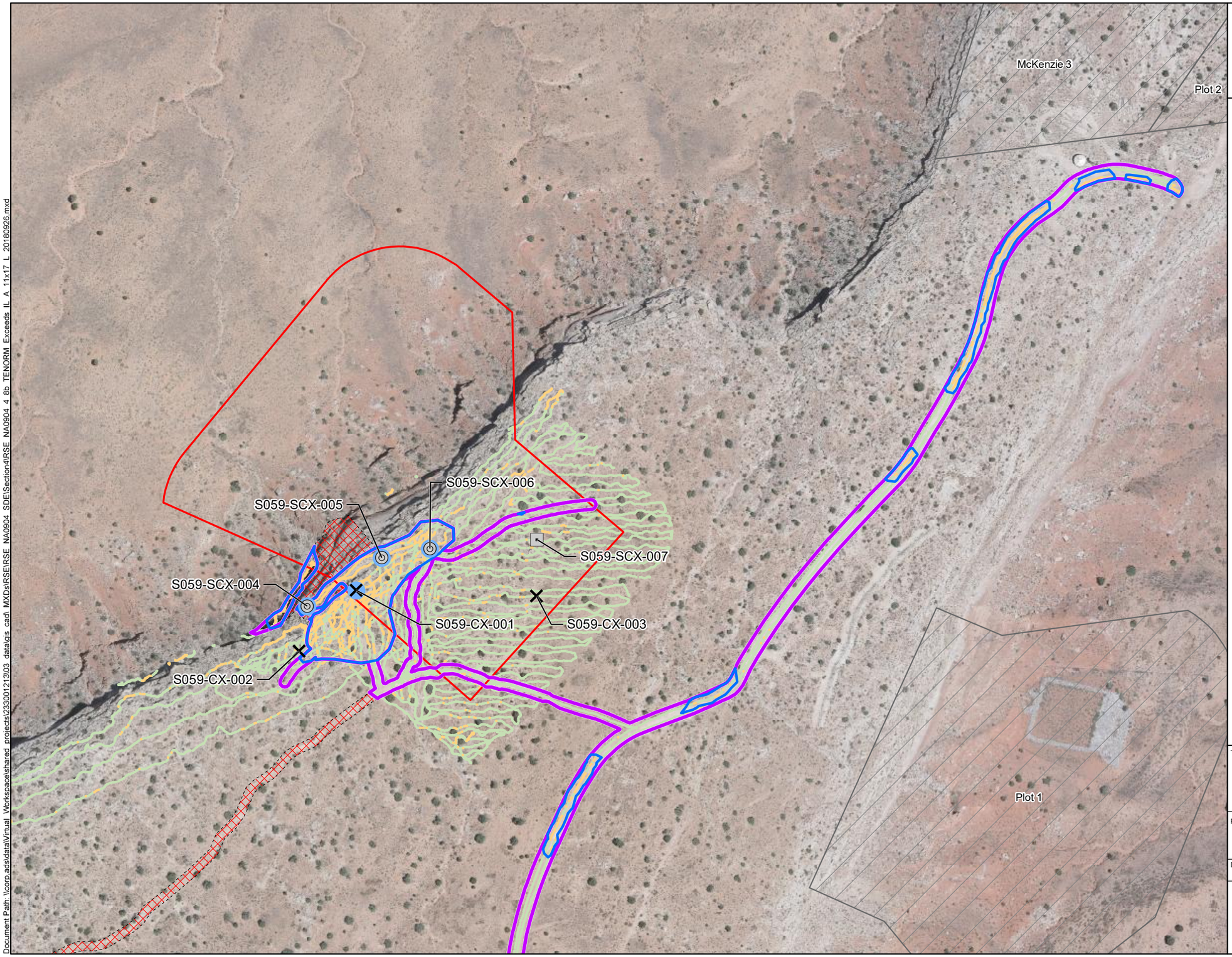
AUTHOR: JSB

REVIEWER: CBB

FIGURE: 4-8a

Stantec

Document Path: \\corp.ads\data\Virtual Workspaces\shared projects\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 4 8a TENORM Exceeds IL 11x17 L 20180926.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 (1.5 acres)
- TENORM (3.9 acres)
- TENORM Unsurveyed(1.2 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey[1]

Counts per Minute (CPM)

- 6,110 - 11,068 (IL Not Exceeded)
- 11,069 - 100,860 (IL Exceeded)

NOTE:

1. Gamma Survey Area A is approximately 12.5 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

0 200 400

Feet

TITLE:

Survey Area A TENORM that Exceeds ILs

PROJECT:

Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: JSB

REVIEWER: CBB

FIGURE: 4-8b

Stantec

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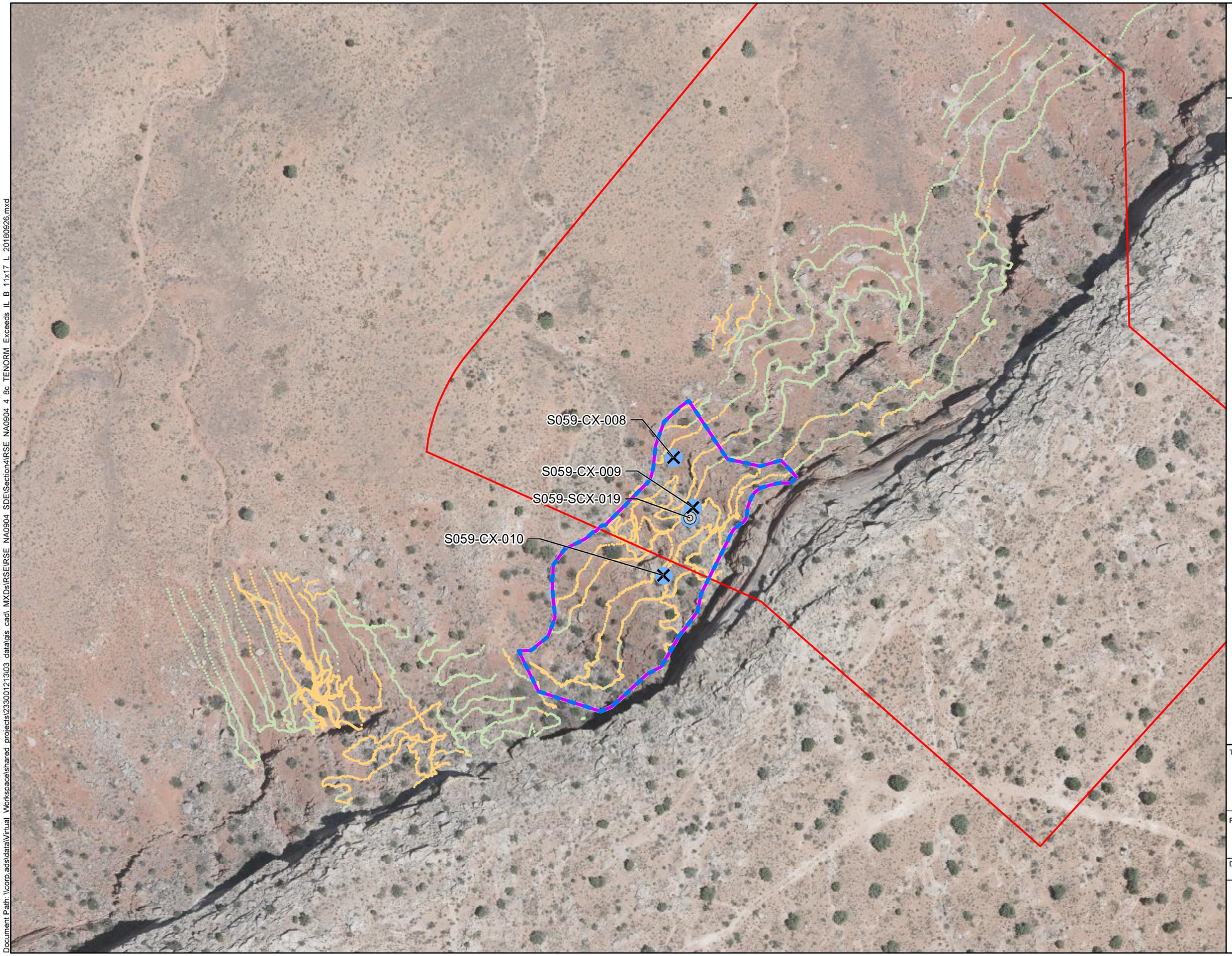


NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- TENORM Exceeding IL in Unconsolidated Material at Location
- TENORM Area Exceeding Surface Gamma ILs (0.9 acres)
- TENORM (0.9 acres)
- Claim Boundary

Gamma Survey[1]

Counts per Minute (CPM)

- 5,921 - 10,447 (IL Not Exceeded)
- 10,448 - 202,616 (IL Exceeded)

NOTE:
1. Gamma Survey Area B is approximately 4.2 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

0 100 200
Feet

TITLE:
Survey Area B
TENORM that Exceeds ILs

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/26/2018

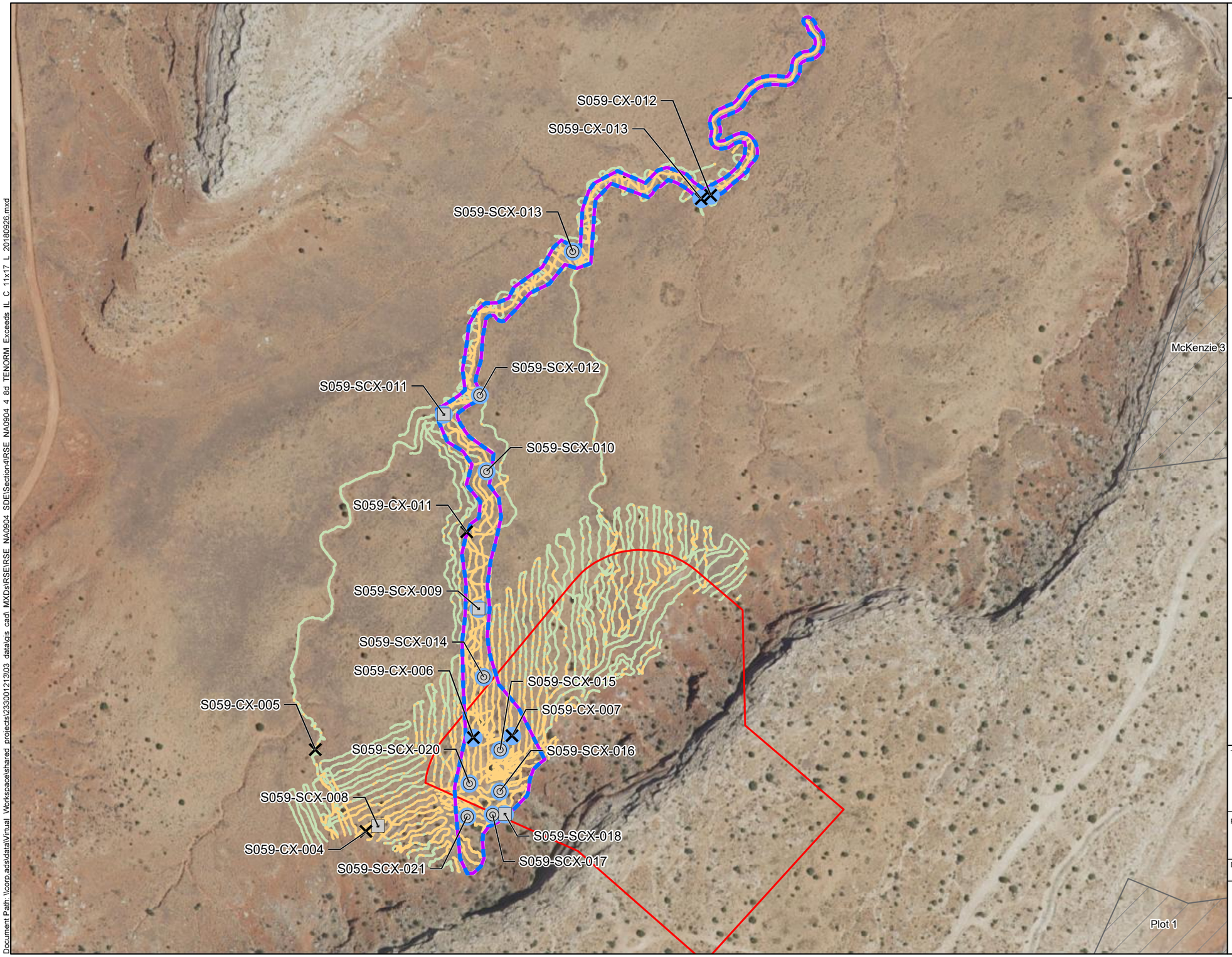
DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: JSB | REVIEWER: CBB

FIGURE: 4-8c

Stantec

Document Path: \\corp.ads\data\Virtual Workspace\shared projects\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\Section4\RSE NA0904 4 8c TENORM Exceeds IL B 11x17 L 20180926.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 (3.2 acres)
- TENORM (3.2 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey[1]

Counts per Minute (CPM)

- 5,835 - 9,911 (IL Not Exceeded)
- 9,912 - 133,973 (IL Exceeded)

NOTE:

1. Gamma Survey Area C is approximately 12.6 acres

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

N W E S

0 200 400

Feet

TITLE:

Survey Area C TENORM that Exceeds ILs

PROJECT:

Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

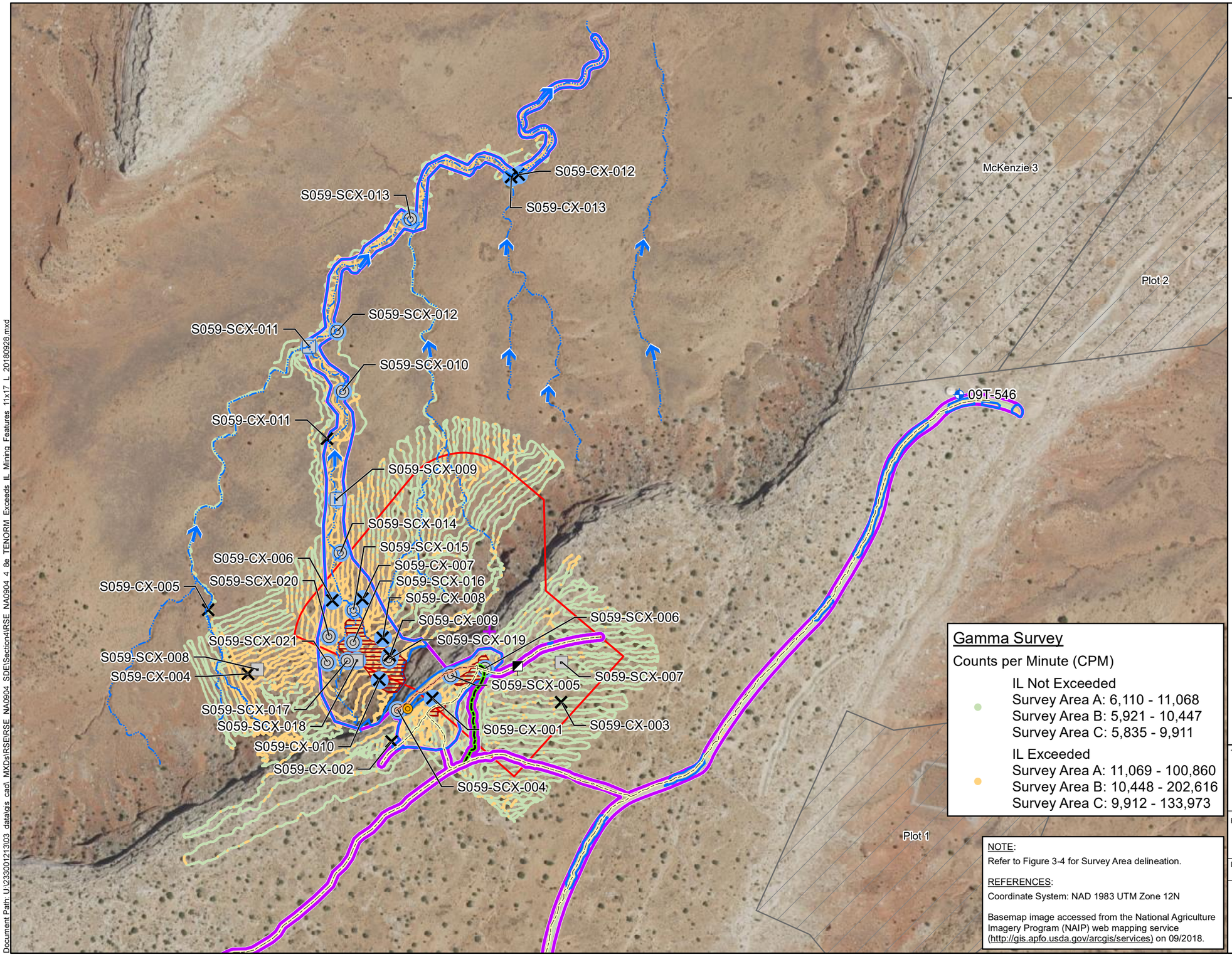
AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-8d

Stantec

Document Path: \\corp.ads\data\Virtual Workspace\shared projects\233001213\03 data\gis cad\ MXDs\RSE\RSE NA0904 SDE\Section4\RSE NA0904 4 8d TENORM Exceeds IL C 11x17 L 20180926.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
- Potential Incline Shaft
- Potential Rim Strip
- Portal
- Well
- Flow Direction
- Drainage
- Potential Haul Road
- Primary Haul Route
- Portal Access *Portal Access Ramp*
- Waste Pile
- TENORM Area Exceeding Surface Gamma ILs (5.6 acres)
- TENORM (9.2 acres)
- Claim Boundary
- Other Claim Boundary

N
W E
S

0 280 560
Feet

Gamma Survey

Counts per Minute (CPM)

IL Not Exceeded
Survey Area A: 6,110 - 11,068
Survey Area B: 5,921 - 10,447
Survey Area C: 5,835 - 9,911

IL Exceeded
Survey Area A: 11,069 - 100,860
Survey Area B: 10,448 - 202,616
Survey Area C: 9,912 - 133,973

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 (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

TITLE:
TENORM that Exceeds ILs Compared to Mining-Related Features

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/28/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: JSB

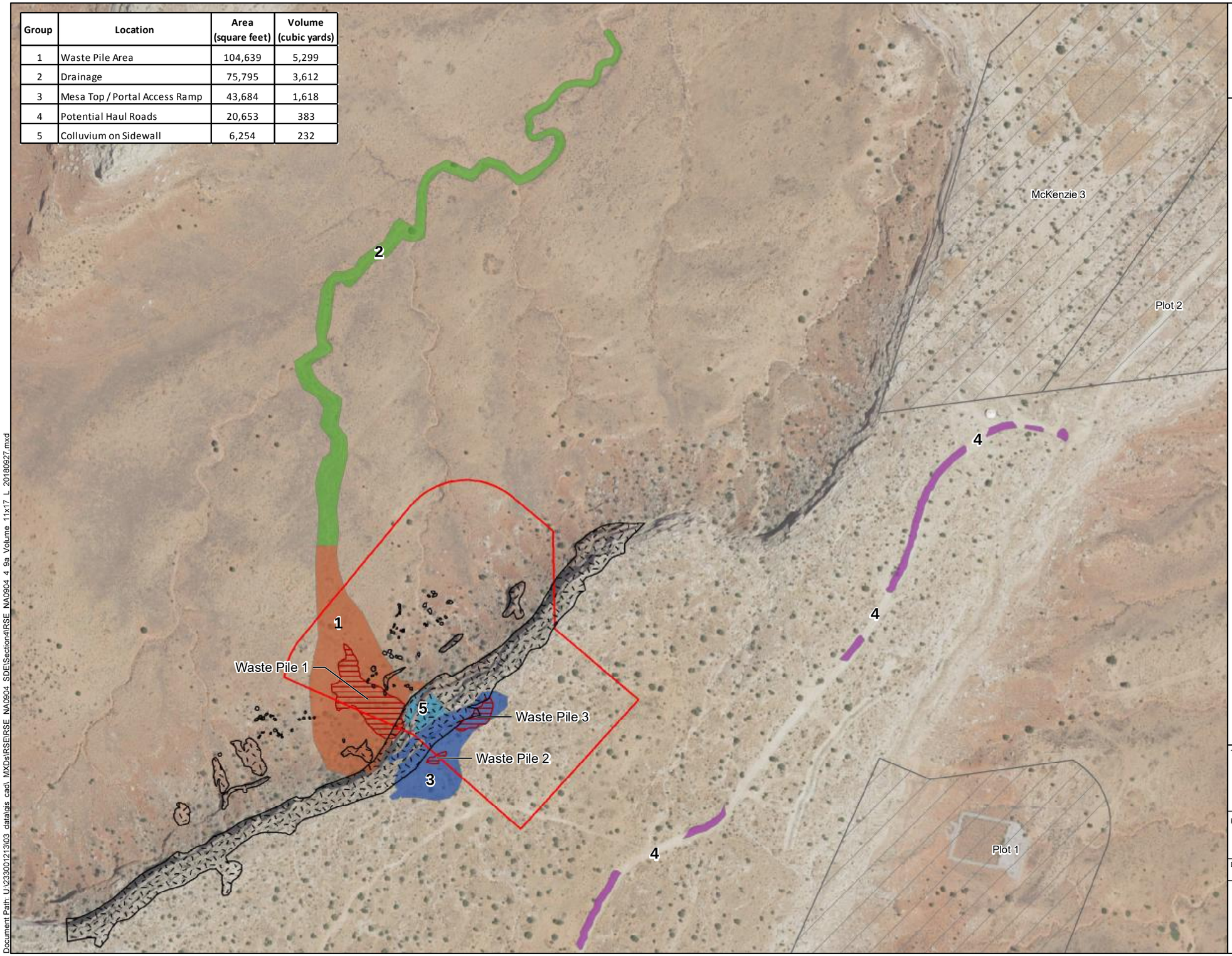
REVIEWER: CBB

Stantec

FIGURE: 4-8e

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_NA0904_SDE\Section4\RSE_NA0904_4_8e_TENORM_Exceeds_IL_Mining_Features_11x17_L_20180928.mxd

Group	Location	Area (square feet)	Volume (cubic yards)
1	Waste Pile Area	104,639	5,299
2	Drainage	75,795	3,612
3	Mesa Top / Portal Access Ramp	43,684	1,618
4	Potential Haul Roads	20,653	383
5	Colluvium on Sidewall	6,254	232



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Exposed Bedrock[1]
- Waste Pile
- Claim Boundary
- Other Claim Boundary

Average Depth by Group (feet below ground surface)

- Group 1 - Variable[2]
- Group 2 - Variable
- Group 3 - 1.0 ft
- Group 4 - 0.5 ft
- Group 5 - 1.0 ft

NOTES:

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

2. See Figure 4-9b

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

N W E S

0 260 520

Feet

TITLE:

Volume Estimate of TENORM that Exceeds IL

PROJECT:

Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/27/2018

DOCUMENT NAME: Removal Site Evaluation Report

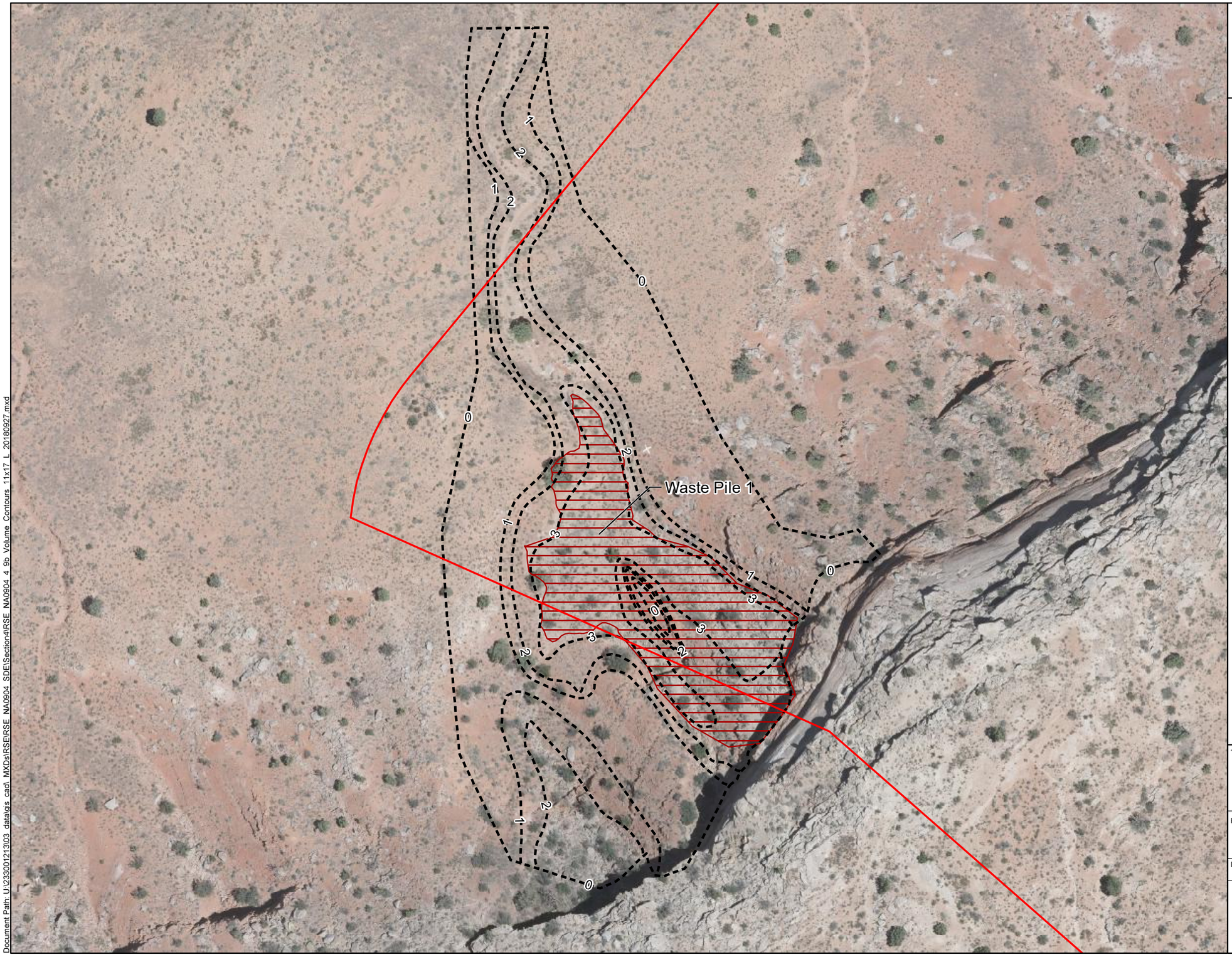
AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: 4-9a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_NA0904_SDE\Section4\RSE_NA0904_4_9a_Volume_11x17_L_20180927.mxd



NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

- Contours (thickness in feet) of TENORM Area Exceeding IL
- Waste Pile
- Claim Boundary
- Other Claim Boundary

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N
W E
S

0 70 140
Feet

TITLE:
Waste Pile Area Contours for Volume Estimate

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/27/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-9b

Stantec

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_NA0904_SDE\Section4\RSE_NA0904_4_9b_Volume_Contours_11x17_L_20180927.mxd

APPENDICES

Appendix A Radiological Characterization of the NA-0904 Abandoned Uranium Mine

Radiological Characterization of the NA-0904 Abandoned Uranium Mine

September 18, 2018

prepared for:

Stantec Consulting Services, Inc.

2130 Resort Drive, Suite 350
Steamboat Springs, CO 80487

prepared by:



Environmental Restoration Group, Inc.

8809 Washington St. NE
Suite 150
Albuquerque, NM 87113

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Appendix B	Exposure Rate Measurements
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"
Appendix D	Preliminary Report "NA-0904 Abandoned Uranium Mine"

Acronyms

ANSI	American National Standards Institute
AUM	abandoned uranium mine
BG1	Background Reference Area 1
BG2	Background Reference Area 2
bgs	below ground surface
cpm	counts per minute
EPA	U.S. Environmental Protection Agency
ERG	Environmental Restoration Group, Inc.
ft	foot
GPS	global positioning system
MDC	minimum detectable concentration
µg/kg	micrograms per kilogram
µR/h	microRoentgens per hour
pCi/g	picocuries per gram
R2	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 NA-0904 abandoned uranium mine (AUM) located in the Sweetwater Chapter of the Navajo Nation near Red Mesa, Arizona. 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, 2016a). The work was performed by Environmental Restoration Group, Inc (ERG) of Albuquerque, New Mexico and MWH, now part of Stantec Consulting Services, Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase.

This report provides the results of a 1) Global Positioning System (GPS)-based gamma radiation (gamma) survey and 2) comparisons of the gamma count rates at this AUM to exposure rates and concentrations of radium-226 in surface soils. The field activities addressed in this report were conducted on May 3, 2016; September 27, 28, and 30, 2016; and October 11, 2016. They included a GPS-based radiological survey of land surfaces over a Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer; and roads and drainages within a 0.25-mile radius of the 100-ft buffer; and correlation studies. The Survey Area was extended beyond the 100-ft buffer where elevated gamma count rates were observed.

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in the "NA-0904 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.

- Three potential Background Reference Areas were established.

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

  Gamma Count Rate (cpm) = 850 x [radium-226 (pCi/g)] + 16582

- The distribution of concentrations of radium-226 in surface soils predicted using this model are rightward tailed. The values in the Survey Area range from -12.6 to 218.9 pCi/g, with a central tendency (median) of -8.0 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 of equilibrium, but not secular equilibrium, among the uranium decay series radionuclides.

- The relationship between gamma count rates and exposure rates is described by a linear regression model: Exposure Rate (µR/h) = Gamma Count Rate (cpm) x $5x10^{-4}$ + 6.7233

- The distribution of exposure rates predicted using this model are rightward tailed. The values in the Survey Area range from 9.6 to 108, with a central tendency (median) of 11.6 µR/h.

1.0 Introduction

This report, addresses the radiological characterization of the NA-0904 abandoned uranium mine (AUM) located in the Sweetwater Chapter of the Navajo Nation near Red Mesa, Arizona. 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, 2016a). The work was performed by Environmental Restoration Group, Inc (ERG) of Albuquerque, New Mexico and MWH, now part of Stantec Consulting Services, Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase.

The activities described here focus on the characterization of gamma radiation (gamma) emitted by uranium series radionuclides in surface soils at the AUM. This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of 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 were conducted on May 3; September 27, 28, and 30, 2016; and October 11, 2016 in accordance with the methods described in the RSE Work Plan. They included a GPS-based radiological survey of land surfaces over an approximately 29-acre Survey Area that included the mine claim area out to a 100-foot buffer; and roads and drainages within a 0.25-mile radius of the buffer; gamma count rate and exposure rate measurements at fixed points; and gamma count rate measurements and soil sampling for radionuclides and metals in areas centered on these fixed points. The Survey Area was extended beyond the 100-ft buffer where elevated gamma count rates were observed. Section 3.0 of the RSE Work Plan provides the data quality objectives (DQOs) for the project.

The discussion here of the results of soil sampling is limited to a comparison of gamma count rates to concentrations of radium-226 in 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 "NA-0904 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 "NA-0904 Removal Site Evaluation Report" (Stantec 2018).

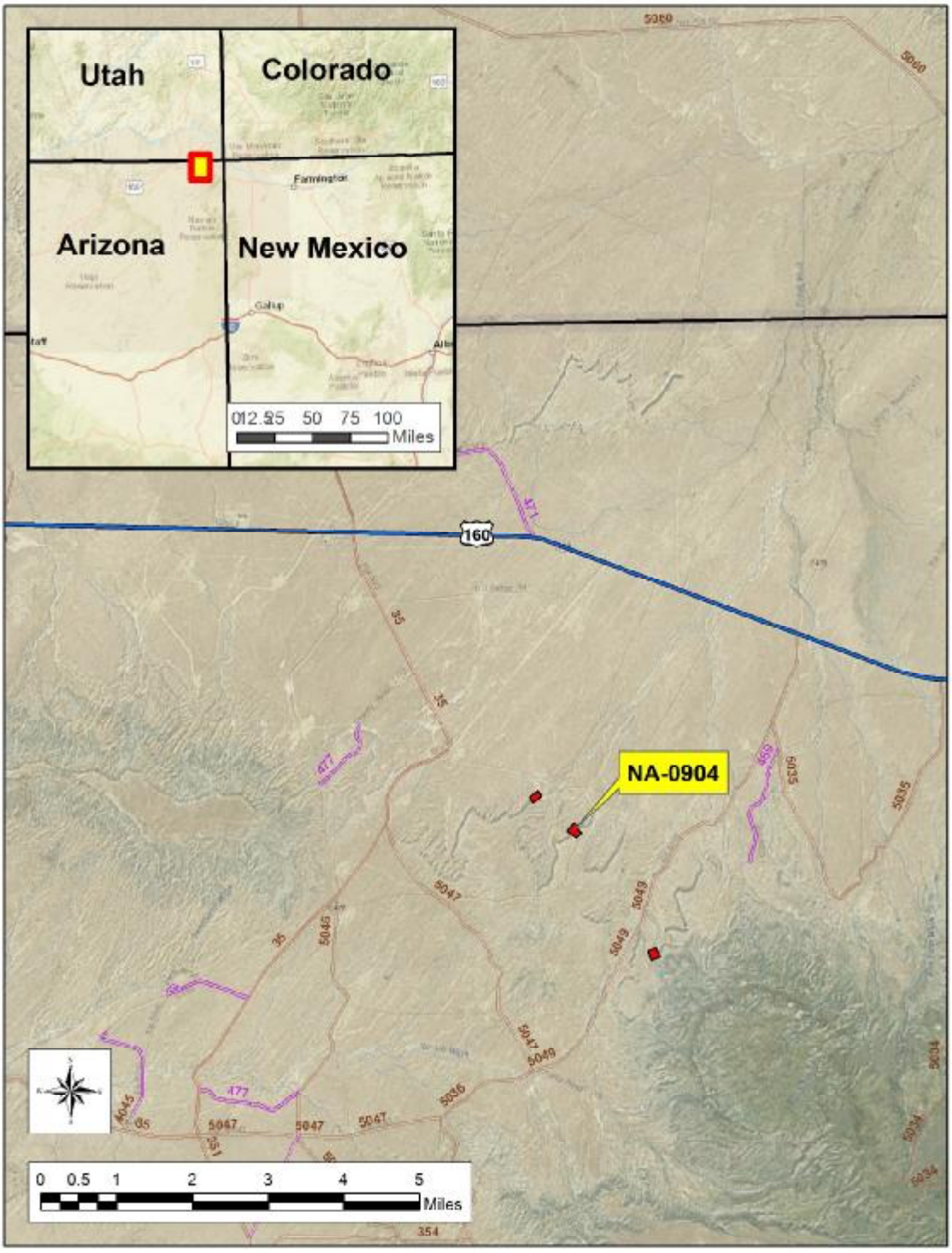


Figure 1. Location of the NA-0904 Abandoned Uranium Mine

2.0 GPS-Based Gamma Surveys

This section addresses the GPS-based surveys conducted in three 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 Work Plan.

The 2x2 sodium iodide (NaI) detectors used in this investigation are sensitive to sub-surface radium-226 decay products and other gamma emitting radionuclides. The purpose of the gamma correlation was to estimate radium-226 concentrations in the upper 15 cm of soil. ERG selected correlation plots based on the range of gamma radiation levels observed. If subsurface soil concentrations of gamma emitting radionuclides were variable between correlation locations, this variability would be included in the regression model, and if the magnitude of the effect were sufficiently large, it would result in failure of the DQOs related to the regression analysis.

Table 1. Detection systems used in the GPS-Based gamma surveys.

Survey Area	Ludlum Model 44-10	Ludlum Model 2221 Ratemeter/Scaler
Potential Background Reference Areas	PR303727[a]	254772 [a]
	PR355763	138368
Survey Area	PR295014	196086
	PR295017	271435
	PR303727[a]	254772 [a]
	PR355763	138368

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

2.1 Background Reference Areas

Three potential Background Reference Areas were surveyed, the locations and results of which are depicted on Figure 2. BG2, BG3, and BG4 in the figure are Background Reference Areas 2, 3, and 4, respectively. These potential Background Reference Areas are the same as those used for AUM NA-0928, which is shown in the figure for its proximity to NA-0904. Table 2 lists a summary of the gamma count rates, which in:

- BG2 ranged from 7,118 to 13,741 counts per minute (cpm), with a mean and median of 9,369 and 9,310 cpm, respectively.
- BG3 ranged from 5,599 to 12,226 cpm, with a mean and median of 8,668 and 8,490 cpm, respectively.
- BG4 ranged from 7,158 to 10,204 cpm, with a mean and median of 8,463 and 8,430 cpm, respectively.

Figure 3 depicts histograms of the gamma count rates in the Background Reference Areas. The red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could be expected if the distributions were normal or lognormal.

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

	Gamma Count Rate (cpm)					
Potential Background Reference Area	**n**	**Minimum**	**Maximum**	**Mean**	**Median**	**Standard Deviation**
2	328	7,118	13,741	9,369	9,310	948
3	378	5,599	12,226	8,668	8,490	999
4	70	7,158	10,204	8,463	8,430	729

Notes:
cpm = counts per minute

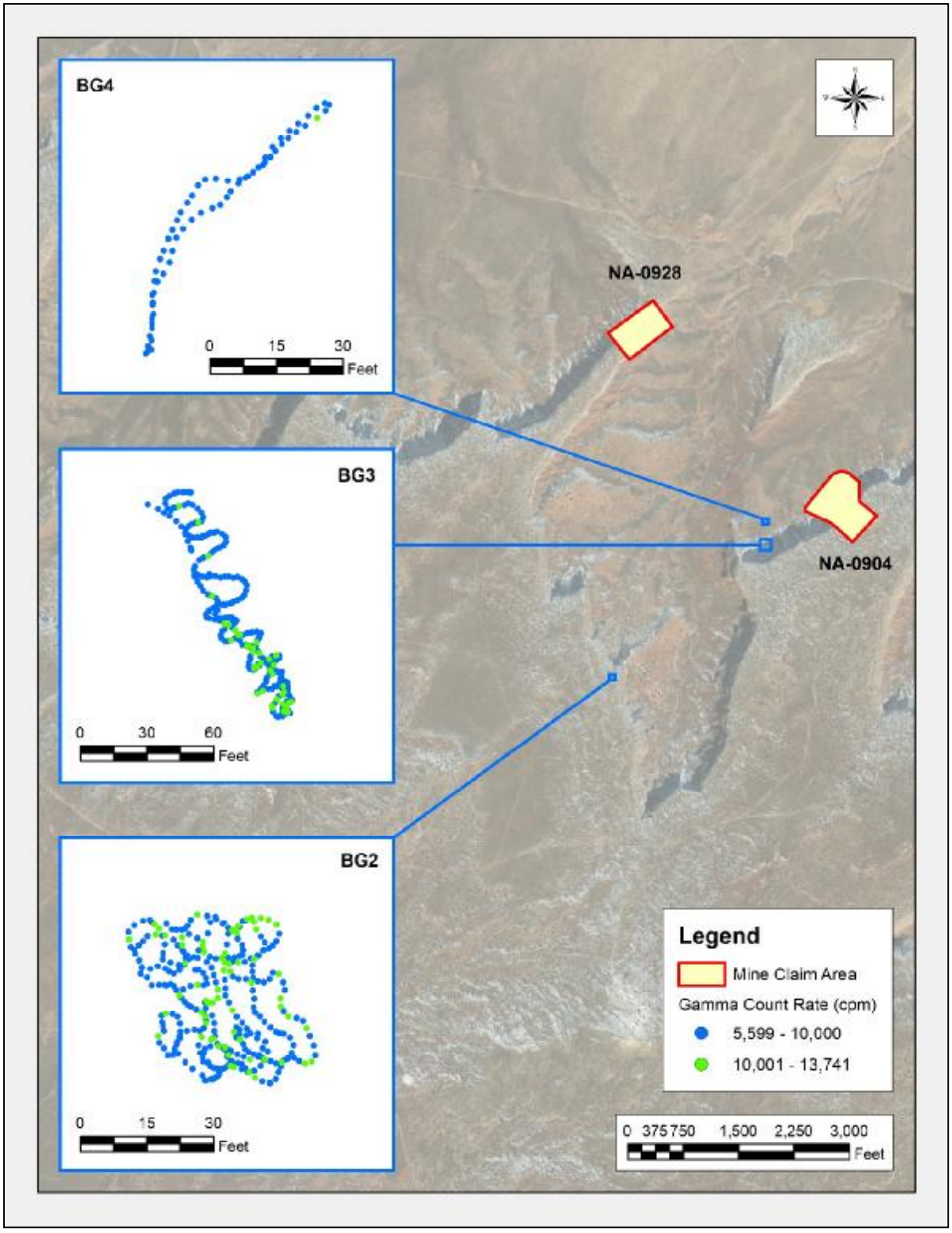
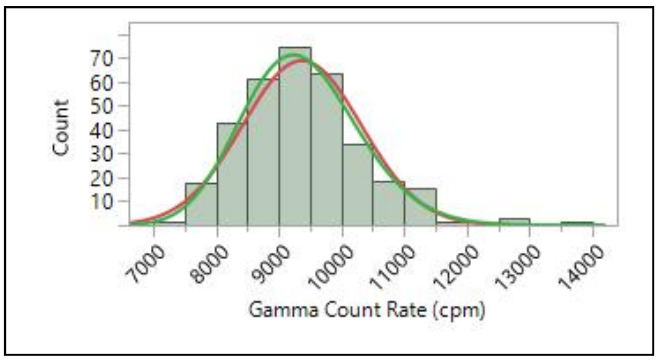
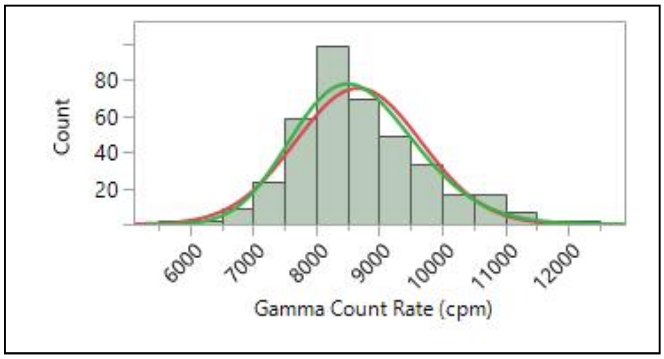


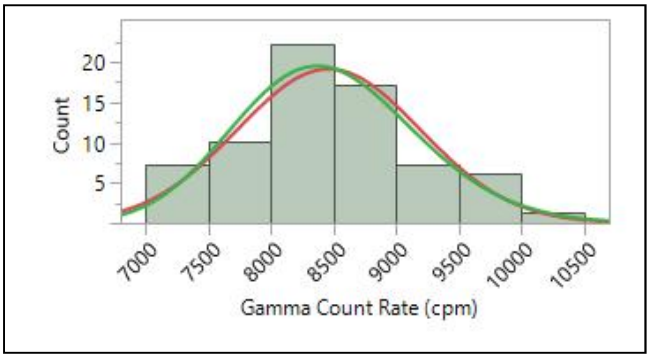
Figure 2. Gamma count rates in the potential Background Reference Areas.



a. Background Reference Area 2



b. Background Reference Area 3



a. Background Reference Area 4

Figure 3. Histograms of gamma count rates in the Background Reference Areas.

2.2 Survey Area

The gamma count rates observed in the Survey Area are depicted in Figure 4. Elevated count rates were observed largely on waste rock situated at the western edge of the mine claim and in a drainage extending from that area.

Figure 5 is a histogram of the gamma count rate measurements made in the Survey Area, including the area surveyed outside the 100-ft buffer. As stated in Section 2.1, the red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could be expected if the distributions were normal or lognormal. The distribution of the right-tailed set of measurements, evaluated using U.S. Environmental Protection Agency software ProUCL (version 5.1.002), is not defined. The box plot in Figure 6 depicts cutoffs as horizontal bars, from bottom to top, for the following values or percentiles: minimum, 0.5, 2.5, 10, 25, 50, 75, 90, 97.5, 99.5, and maximum. The 25th, 50th, and 75th percentiles (the three horizontal lines of the box inside the box plot) are 8,930, 9,822, and 11,740 cpm, respectively.

Table 3 is a statistical summary of the measurements, which range from 5,835 to 202,616 cpm and have a central tendency (median) of 9,822 cpm.

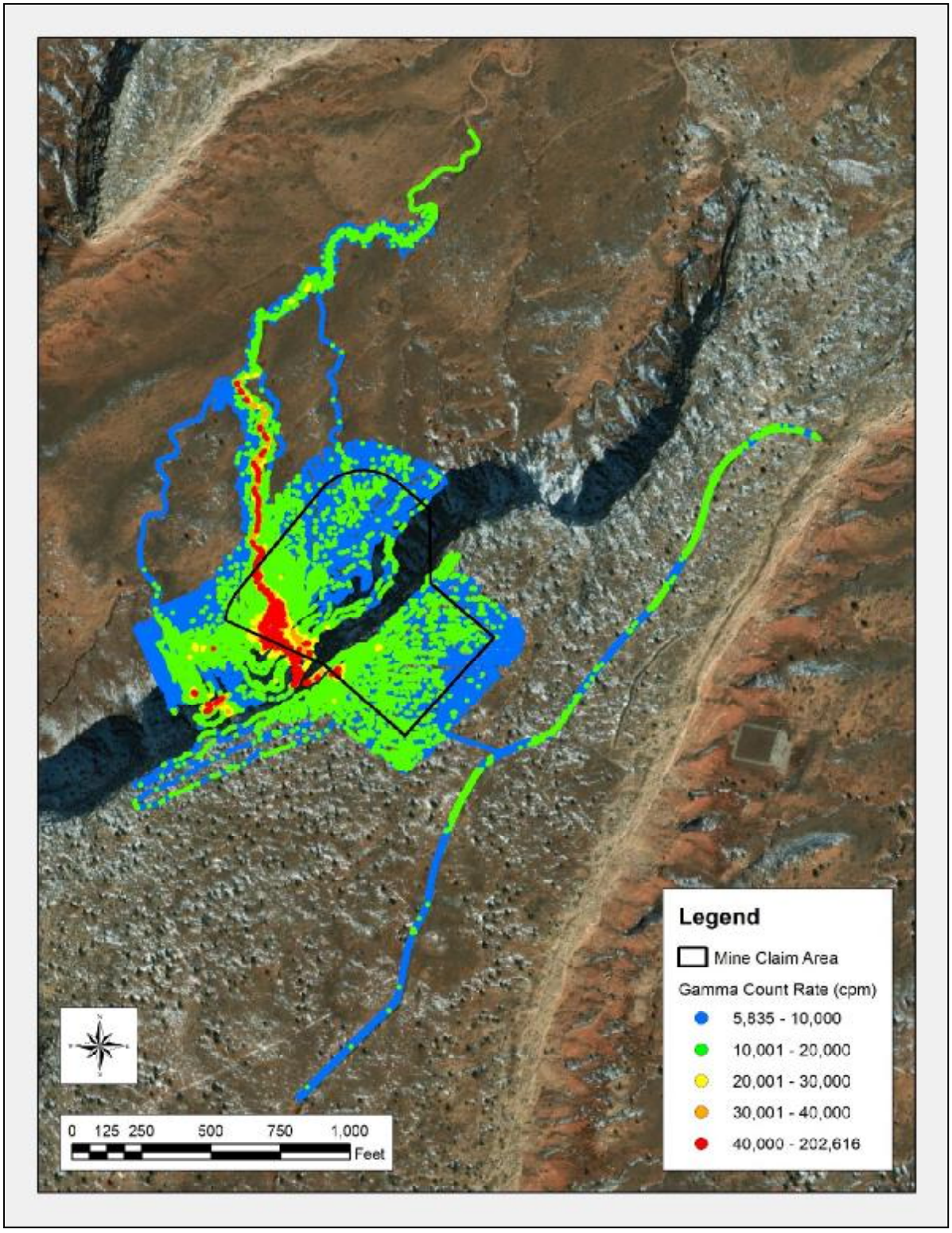


Figure 4. Gamma count rates in the Survey Area.

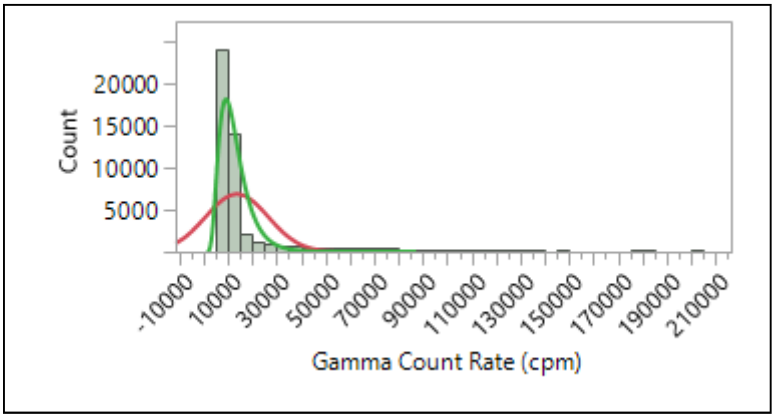


Figure 5. Histogram of gamma count rates in the Survey Area.

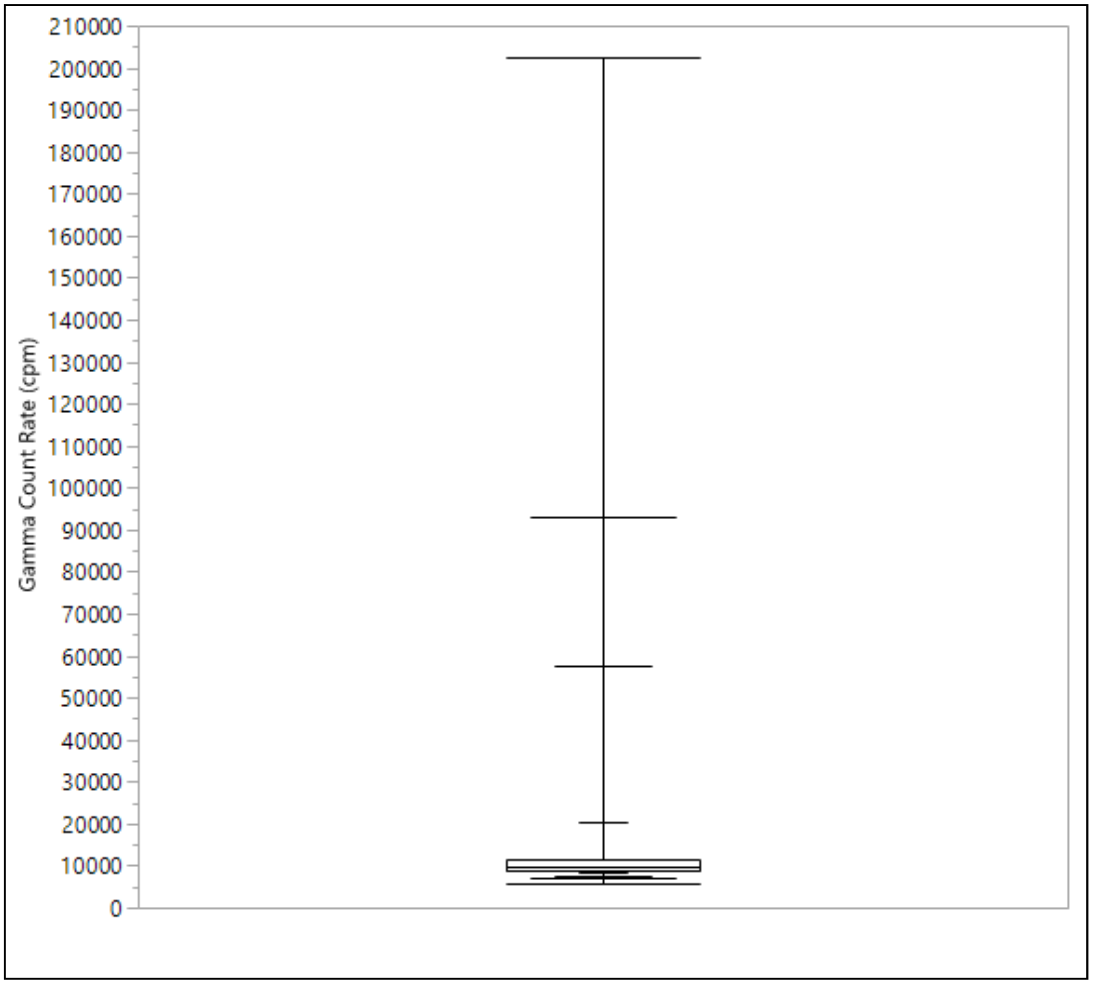


Figure 6. Box plot of gamma count rates in the Survey Area.

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

Parameter	Gamma Count Rate (cpm)
n	44,138
Minimum	5,835
Maximum	202,616
Mean	13,644
Median	9,822
Standard Deviation	12,891

Notes:
cpm = counts per minute

3.0 Correlation Studies

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

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

On October 11, 2016 field personnel made GPS-based gamma count rates measurements and collected five-point composite samples of surface soils in each of five areas at the AUM. These areas were selected using criteria established in the RSE Work Plan. No DQO was established for homogeneity of the correlation plots and as described in Section 4.3 and Appendix E of the RSE Work Plan, homogeneity of the correlation plots was evaluated qualitatively. Sub-samples were collected from the correlation plot centroid and at each corner of the plot. The activities were performed contemporaneously, by area and all on the same day, such that the two could be compared. Figure 7 shows the GPS-based gamma count rate measurements in the five areas (labeled with location identifiers).

The soil samples were analyzed by ALS Laboratories in 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. Table 4 lists the results of the measurements and radium-226 concentrations in the soil samples. The means of the gamma count rate measurements range from 9,061 to 107,374 cpm. The concentrations of radium-226 range from 0.97 to 110 picocuries per gram (pCi/g).

Table 5 lists the concentrations of isotopes of thorium (thorium-228, -230, and -232) in the same soil samples.

Laboratory analyses are presented in Appendix F.2, Laboratory Analytical Data and Data Validation Report, in the “NA-0904 Removal Site Evaluation Report” (Stantec, 2018).

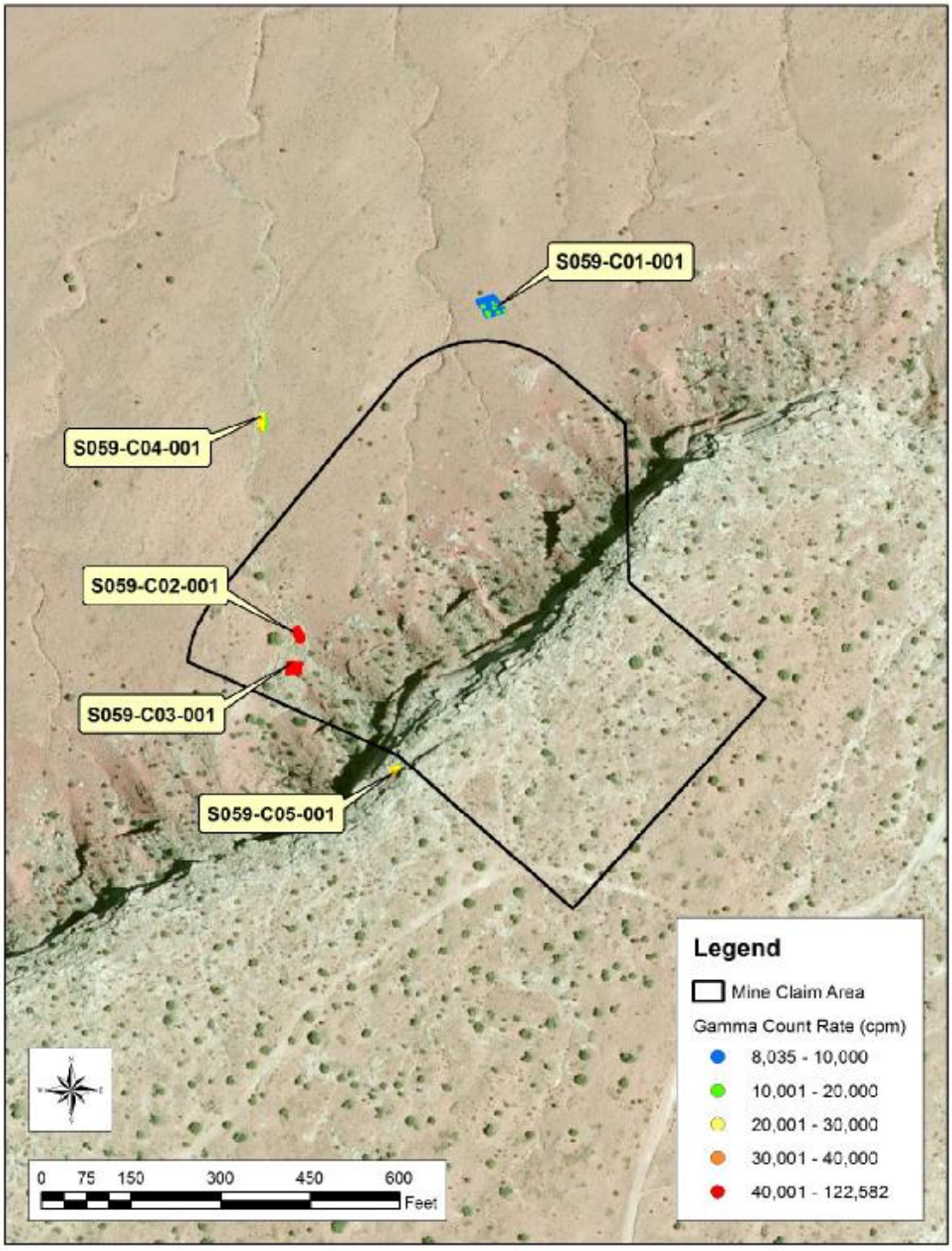


Figure 7. GPS-based gamma count rate measurements made for the correlation study.

Table 4. Gamma count rates and associated concentrations of radium-226 in samples of surface soils obtained in the correlation study.

		Gamma Count Rate (cpm)				Ra-226 (pCi/g)		
Location	Area (m^2)	Mean	Minimum	Maximum	σ	Result	Error ±2σ	MDC
S059-C01-001	122.7	9,061	8,035	11,004	509	0.97	0.25	0.41
S059-C02-001	35.3	53,561	30,842	77,719	9,894	31.3	3.8	1
S059-C03-001	30.2	107,374	82,023	122,582	9,194	110	13	1
S059-C04-001	49.7	20,434	13,753	30,386	4,026	9.4	1.2	0.5
S059-C05-001	12.2	24,825	17,507	33,467	4,623	4.04	0.6	0.48

Notes:
cpm = counts per minute
MDC = minimum detectable concentration
m^2 =square meters
pCi/g = picocuries per gram
σ = standard deviation

Table 5. Concentrations of isotopes of thorium in samples of surface soils obtained in the correlation study.

	Thorium-228			Thorium-230			Thorium-232		
Sample ID	Result	Error ± 2 σ	MDC	Result	Error ± 2 σ	MDL	Result	Error ± 2 σ	MDC
S059-C01-001	0.43	0.086	0.029	0.76	0.14	0.07	0.377	0.076	0.015
S059-C02-001	0.52	0.1	0.03	25.1	3.9	0.1	0.477	0.093	0.013
S059-C03-001	0.59	0.11	0.04	175	27	0	0.73	0.13	0.03
S059-C04-001	0.376	0.082	0.046	6.4	1	0.1	0.388	0.08	0.026
S059-C05-001	0.57	0.11	0.05	3.17	0.51	0.07	0.65	0.12	0.02

Notes:
MDC = minimum detectable concentration
pCi/g = picocuries per gram
σ = standard deviation

A model was made of the results in Table 4, predicting the concentrations of radium-226 in surface soils from the mean gamma count rate in each area. The mean relationship between the measurements, shown in Figure 8, is a linear function with an adjusted Pearson's Correlation Coefficient (adjusted R^2) of 0.95, as expressed in the equation:

$$\text{Gamma Count Rate (cpm)} = 850 \times [\text{radium-226 (pCi/g)}] + 16582$$

The root mean square error and p-value for the model are 8.7×10^3 and 0.003, 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 -12.6 to 218.9 pCi/g, with a mean and median of -3.5 and -8.0 pCi/g, respectively. While the gamma correlation equation can be used to convert gamma count rates to

concentrations of Ra-226 in soil, the resulting radium concentrations are highly uncertain estimates, as the wide prediction interval bands illustrated in Figure 8 demonstrate. Users of the regression equation should be aware of the limitations of the dataset and be cautious when estimating radium-226 concentrations.

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

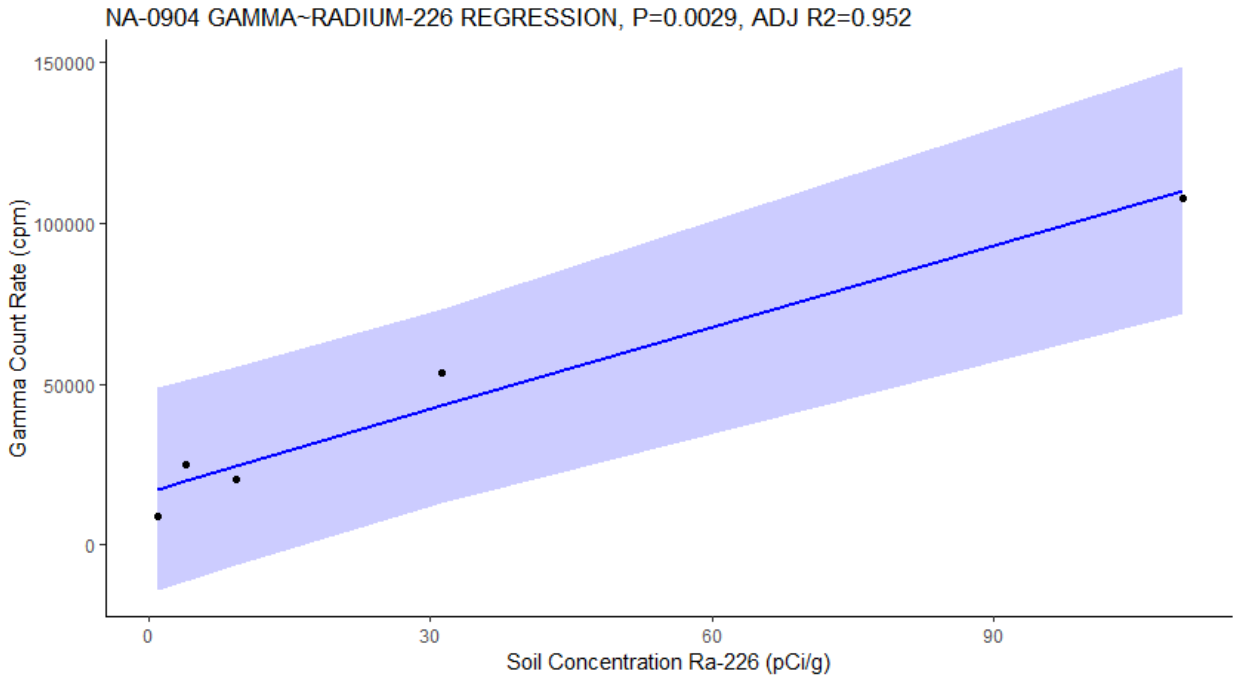


Figure 8. Correlation of gamma count rates and concentrations of radium-226 in surface soils (blue line) and 95% prediction intervals plotted (shaded area).

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

Parameter	Radium-226 (pCi/g)
n	44,138
Minimum	-12.6
Maximum	218.9
Mean	-3.5
Median	-8.0
Standard Deviation	15.2

Notes:
pCi/g = picocuries per gram

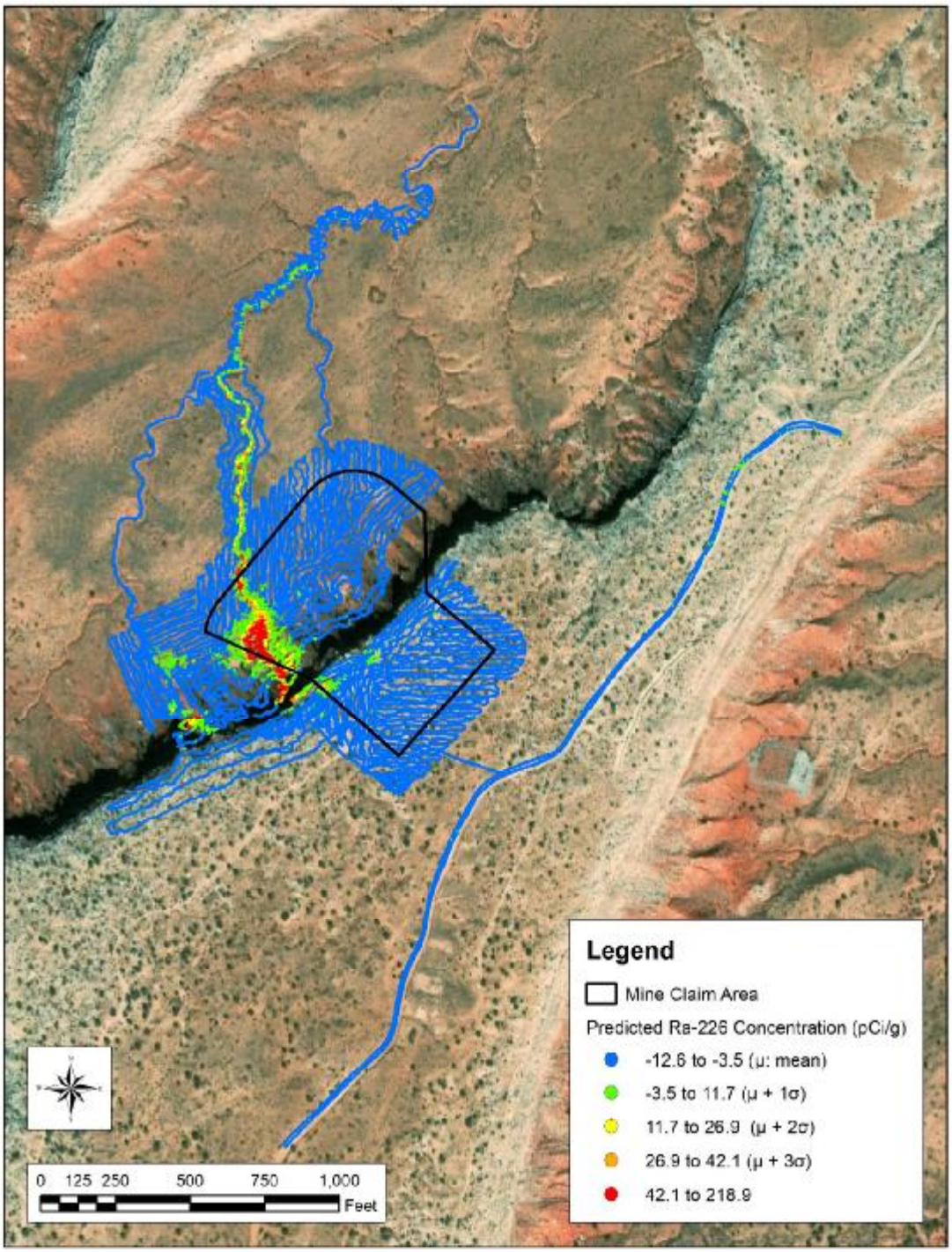


Figure 9. Predicted concentrations of radium-226 in the Survey Area.

Soil concentrations of potassium-40 (K-40) were not expected to be spatially variable within the site, and therefore this radionuclide was not separately accounted for in the RSE Work Plan. If K-40 concentrations did vary, this variability would be included in the regression model and, if the magnitude of the effect were sufficiently large, would result in failure of DQOs related to the regression analysis.

A multivariate linear regression (MLR) was used to evaluate the influence of thorium-232 and thorium-228, isotopes in the thorium series, on the average gamma count rate in the correlation locations. The MLR model was first run using radium-226, thorium-232, and thorium-228 as predictors of gamma count rate. The model failed to produce results because thorium-232 and thorium-228 are colinear. The MLR model was subsequently run without thorium-228. For the second model, the p-value for radium-226 (0.03) met the significance criterion of $p < 0.05$, while thorium-232 was non-significant at 0.6. 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 0.15 with an adjusted R^2 of 0.4. 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 ($p = 0.003$), as described above, and the adjusted R^2 value (0.95) met the applicable project DQO ($R^2 > 0.8$).

The depletion of radon-222 in surface soil due to environmental factors is assumed to be relatively constant across the correlation locations (i.e., the loss is a fixed fraction of the available source). Provided this is the case, any loss of radon-222 in surface soil is unimportant and accounted for within the statistical model. If the loss is not a consistent fraction at each correlation location, it is one of many potential correlation confounders that are all linked to spatial heterogeneity of the environmental conditions, and especially spatial heterogeneity of the soil matrix.

The presence of heterogeneous concentrations of gamma emitting radionuclides in sub-surface soil can affect the gamma correlation model. If subsurface soil concentrations of gamma emitting radionuclides were variable between correlation locations, this variability would be included in the regression model, and if the magnitude of the effect were sufficiently large, it would result in failure of the DQOs related to the regression analysis.

3.2 Equilibrium in the uranium series

Secular equilibrium is a condition that occurs when the half-life of a decay-product nuclide is significantly shorter than that of its parent nuclide. After a period of ingrowth equal to approximately seven times the half-life of the decay product, the two nuclides effectively decay with the half-life of the parent. When two radionuclides are in secular equilibrium, their activities are equal.

Equilibrium, for the purpose of this report, is defined as a condition whereby a parent nuclide and its decay product are present in the environment at a fixed ratio, but this ratio – for whatever reason – is not a one-to-one relationship indicative of secular equilibrium. Most commonly, an equilibrium condition results from an environmental process which chemically selects for and transports one nuclide (parent or decay product) away from the other nuclide. Because a consistent fraction of one nuclide has been removed, the two nuclides are present at a fixed ratio other than one-to-one.

Determination of secular equilibrium for an AUM can be an important part of the risk assessment process, as the assumed fraction of radium-226 decay products present in the environment greatly influences a hypothetical receptor's radiation dose and mortality risk. However, it is also acceptable and conservative to assume secular equilibrium between radium-226 and its decay products for the purpose of risk assessment, and therefore to avoid the need to conclusively determine the secular equilibrium status of an AUM. Thus, an inconclusive result regarding secular equilibrium is not a study data gap, as the risk assessment phase may still proceed, provided that conservative assumptions are included regarding equilibrium concentrations of radium-226 decay products.

Regardless, the RSE Work Plan specified that an evaluation of secular equilibrium would be made at each of the 16 Trust AUMs, and so a robust statistical examination of secular equilibrium status for thorium-230 and radium-226 was conducted. The RSE Work Plan did not require an evaluation of equilibrium condition of uranium-238 and uranium-234 because the natural activity abundance for these isotopes is expected and therefore assumed. Likewise, thorium-234 and protactinium-234m were not evaluated since their half-lives are sufficiently short that secular equilibrium can be assumed. Uranium-235 is not in the uranium-238 decay series therefore it 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.
3. The line y=x is added to the figure generated in step 2 (this line represents a perfect 1:1 ratio between Th-230 to Ra-226, indicative of secular equilibrium).
4. An examination of the model and the figure is made sequentially:
    a. If the p-value for the regression slope is insignificant (i.e., $p > 0.05$) or the adjusted R^2 does not meet the study's data quality objective (Adjusted $R^2 > 0.8$), ERG concludes that there is insufficient evidence to conclude that Ra-226 and Th-230 are in equilibrium (secular or otherwise).
    b. If the p-value for the regression slope is significant (i.e., $p < 0.05$) and the adjusted R^2 meets the DQO (Adjusted $R^2 > 0.8$) there are two possible conditions, which are evaluated via visual examination of the figure generated in step 3.

i. If the y=x line falls fully within the bounds of the 95% UCL bands on the regression, ERG concludes that there is evidence that Ra-226 and Th-230 are in secular equilibrium at the site.

ii. If the y=x line falls partially or completely outside the bounds of the 95% UCL bands on the regression, ERG concludes that there is evidence that Ra-226 and Th-230 are in equilibrium, but not secular equilibrium at the site.

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

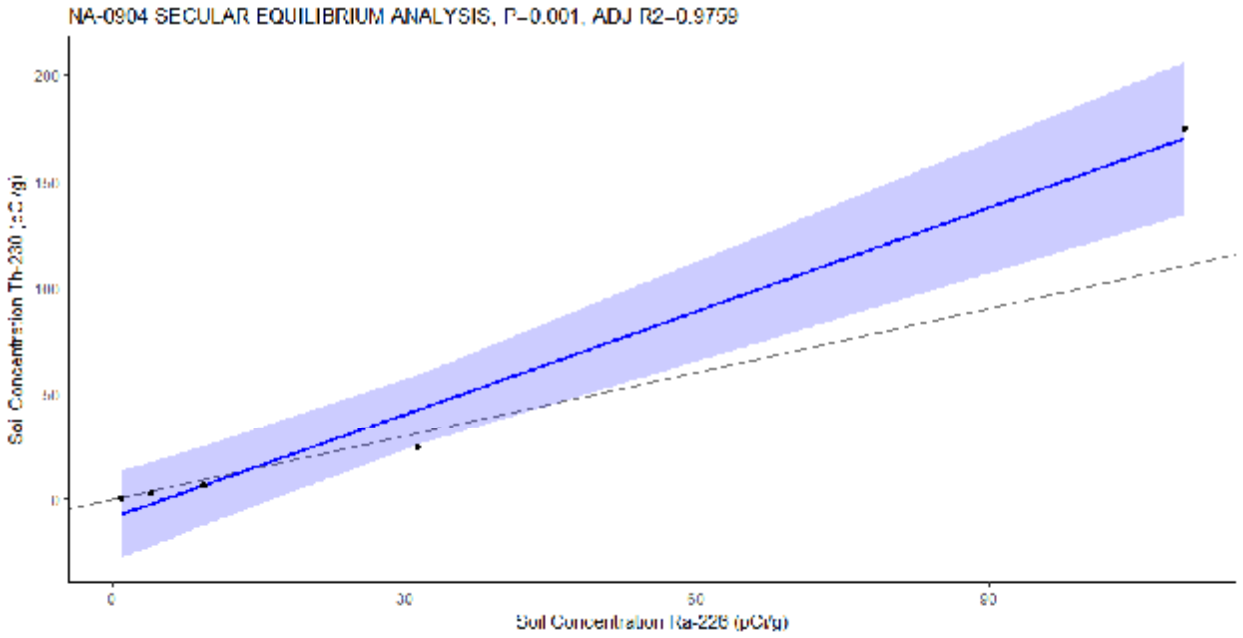


Figure 10. Evaluation of secular equilibrium in the uranium decay series.

3.2 Exposure rates and gamma count rates

On October 11, 2016 field personnel made co-located one-minute static count rate and exposure rate measurements at the five locations within the Survey Area, representing the range of gamma count rates obtained in the GPS-based gamma survey. Figure 7 shows the locations of the co-located measurements, which were made in the centers of the areas.

The gamma count rate and exposure rate measurements were made at 0.5 m and 1 m above the ground surface, respectively. The gamma count rate measurements were made using one of the sodium iodide detection systems used in the GPS-based gamma survey of the AUM (Serial Number PR303727/254772). The exposure rate measurements were made using a Reuter Stokes Model RSS-131 (Serial Number 07J00KM1) high pressure ionization chamber (HPIC) at six-second intervals for about 10 minutes. The exposure rates used in the comparison was the mean of these measurements, less those occurring in

initial instrument spikes. The HPIC was in current calibration and function checked before and after use. A correction factor of 1.02 was applied to the measured value per the manufacturer's recommendation by the software of the unit. Calibration forms for the HPIC are provided in Appendix A.

Table 7 presents the results for the two types of measurements made at each of the five locations. Appendix B presents the individual (one second) exposure rate measurements.

The best predictive relationship between the measurements is linear with an R^2 of 0.9998 indicating a strong, positive correlation. The root mean square error and p-value for the model are 0.363327 and less than 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 (microRoentgens per hour [µR/h]) = $5x10^{-4}$ x Gamma Count Rate (cpm) + 6.7233

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 three Background Reference Areas and AUM, respectively.

The range of predicted exposure rates at:

- BG2 is 10.3 to 13.6 µR/h, with a mean and median of 11.4 µR/h
- BG3 is 9.5 to 12.8 µR/h, with a mean and median of 11.1 and 11.0 µR/h, respectively
- BG4 is 10.3 to 11.8 µR/h, with a mean and median of 11.0 and 10.9 µR/h, respectively

The range of predicted exposure rates at the AUM is 9.6 to 108.0 µR/h, with a mean and median of 13.5 and 11.6 µR/h, respectively.

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

Location	Gamma Count Rate (cpm)	Exposure Rate (µR/h)
S059-C01-001	9,095	11.4
S059-C02-001	58,078	36.3
S059-C03-001	115,596	66.3
S059-C04-001	20,089	17.5
S059-C05-001	29,337	21.5

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

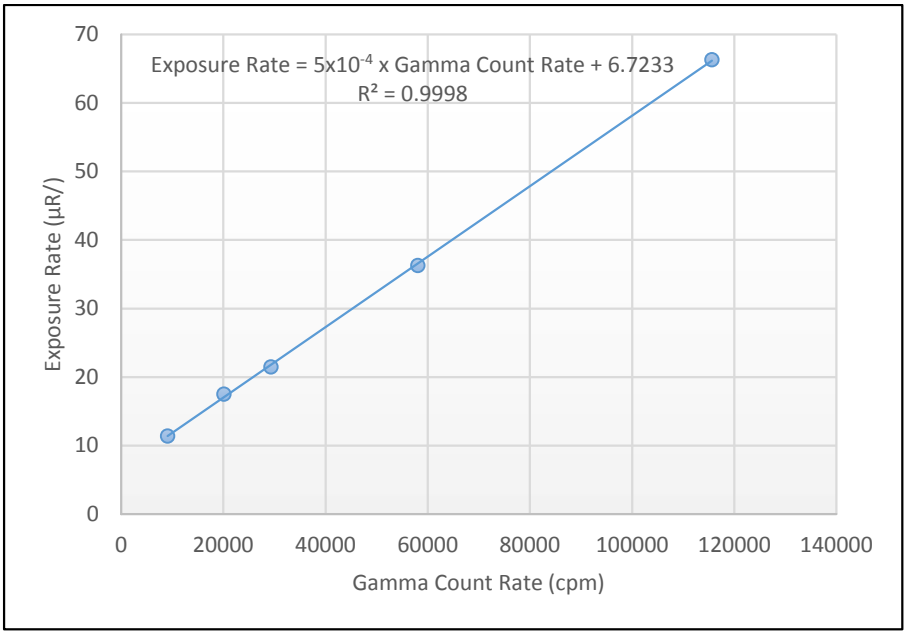


Figure 11. Correlation of gamma count rates and exposure rates.

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

Potential Background Reference Area	BG2	BG3	BG4
Parameter	Exposure Rate (µR/h)		
n	328	378	70
Minimum	10.3	9.5	10.3
Maximum	13.6	12.8	11.8
Mean	11.4	11.1	11.0
Median	11.4	11.0	10.9
Standard Deviation	0.5	0.5	0.4

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

Table 9. Predicted exposure rates in the Survey Area.

Parameter	Exposure Rate (µR/h)
n	44,138
Minimum	9.6
Maximum	108.0
Mean	13.5
Median	11.6
Standard Deviation	13.5

Notes:
µR/h = microRoentgens per hour

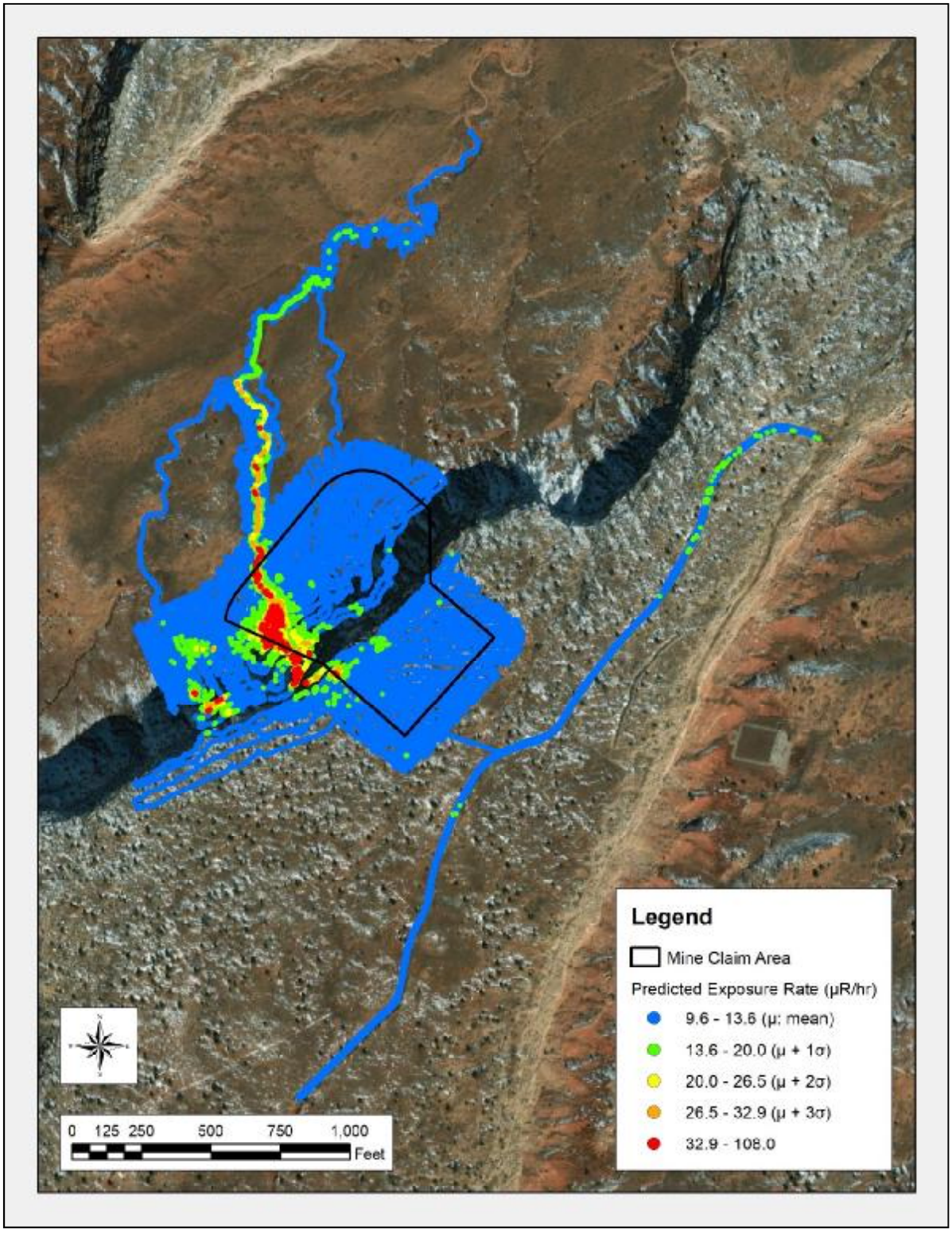


Figure 12. Predicted exposure rates in the Survey Area.

4.0 Deviations to RSE Workplan

The RSE Workplan 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.
- Three potential Background Reference Areas were established.
- The relationship between mean gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface [bgs]) is described by a linear regression model:

  Gamma Count Rate (cpm) = 850 x [radium-226 (pCi/g)] + 16582

- The distribution of concentrations of radium-226 in surface soils predicted using this model are rightward tailed. The values in the Survey Area range from -12.6 to 218.9 pCi/g, with a central tendency (median) of -8.0 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 of equilibrium, but not secular equilibrium, among the uranium decay series radionuclides.
- The relationship between gamma count rates and exposure rates is described by a linear regression model:

  Exposure Rate (µR/h) = Gamma Count Rate (cpm) x $5x10^{-4}$ + 6.7233

- The distribution of exposure rates predicted using this model are rightward tailed. The values in the Survey Area range from 9.6 to 108, with a central tendency (median) of 11.6 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. NA-0904 Removal Site Evaluation Report, September 2018.

Appendix A Instrument calibration and completed function check forms

Certificate of Calibration

Calibration and Voltage Plateau

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

Meter: Manufacturer: Ludlum Model Number: 2221r Serial Number: 254772

Detector: Manufacturer: Ludlum Model Number: 44-10 Serial Number: PR303727

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

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

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

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

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

Threshold: 10 mV

Window:

Barometric Pressure: 24.6 inches Hg

Temperature: 73 °F

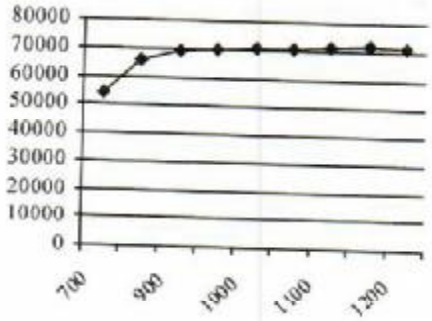
Relative Humidity: 20 %

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

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	398773	400
x 1000	100	100	100		100
x 100	400	400	400	39887	400
x 100	100	100	100		100
x 10	400	400	400	3988	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	53957	
800	65946	
900	69049	
950	69687	
1000	70240	9925
1050	70288	
1100	71224	
1150	71563	
1200	71161	

Voltage Plateau



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

Reference Instruments and/or Sources:

Ludlum pulser serial number: [ ] 97743 [x] 201932

[ ] Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03

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

Fluke multimeter serial number: [ ] 8749012

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

[ ] Other Source:

Calibrated By:

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

Reviewed By:

Date: 1/20/16

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
- ✔ 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: 24.78 inches Hg

Temperature: 74 °F

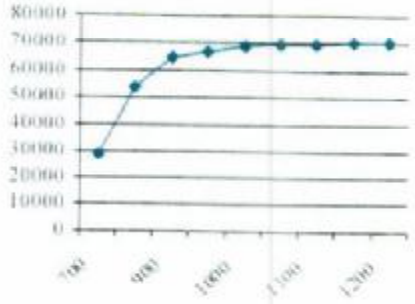
Relative Humidity: 20 %

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:

Calibration Date: 7/20/16 Calibration Due: 7/20/17

Reviewed By:

Date: 7/20/16

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

Certificate of Calibration

Calibration and Voltage Plateau

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

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

- ✔ 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: 24.24 inches Hg

Temperature: 78 °F

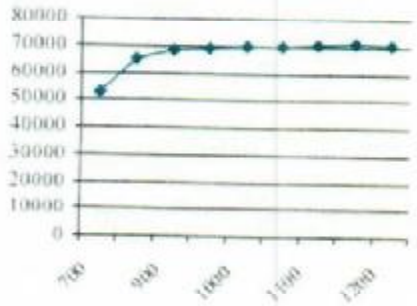
Relative Humidity: 20 %

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]

Reviewed By: [signature]

Calibration Date: ~~2 March 17~~ 2/28/17 ASH

Calibration Due: ~~2 March 18~~ 2/28/18 ASH

Date: 3-1-17

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

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
- ✔ 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: 24.27 inches Hg

Temperature: 78 °F

Relative Humidity: 20 %

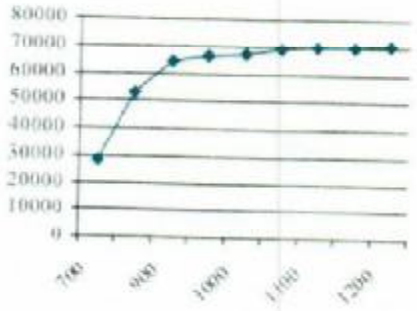
Instrument found within tolerance: ✔ Yes ☐ No

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
700	28235
800	52834
900	64481
950	66468
1000	67321
1050	69009
1100	69981
1150	69564
1200	70538

Background: 9079

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1100

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932

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

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

Fluke multimeter serial number: ☐ 87490128

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

☐ Other Source:

Calibrated By:

Reviewed By:

Calibration Date: ~~3 March 17~~ 2/28/17 BLH

Calibration Due: ~~3 March 18~~ 2/28/18 BLH

Date: 3-1-17

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

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

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

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

Barometric Pressure: 24.66 inches Hg

Source Distance: ☐ Contact ✔ 6 inches ☐ Other: Threshold: 10 mV Temperature: 76 °F

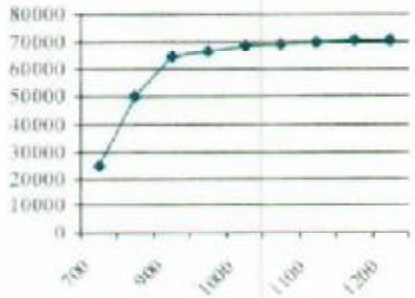
Source Geometry: ✔ Side ☐ Below ☐ Other: Window: Relative Humidity: 20 %

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
- ☐ Beta Source: Tc-99 sn: 4099-03 @ 17,700dpm/11,100cpm (1/4/12
- ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
- ☐ Other Source:

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

Reviewed By: [signature] Date: 14 March 2017

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:	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: 24.81 inches Hg

Temperature: 76 °F

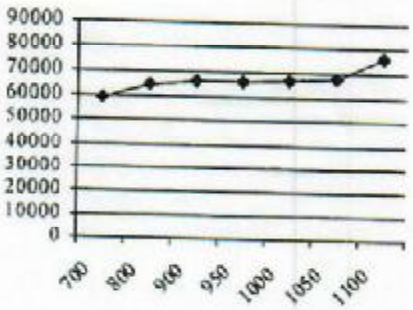
Relative Humidity: 20 %

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	400154	400
x 1000	100	100	100		100
x 100	400	400	400	40018	400
x 100	100	100	100		100
x 10	400	400	400	4002	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	59737	
800	64927	
900	66145	
950	66534	
1000	66864	10073
1050	67810	
1100	76513	

Voltage Plateau



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

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932

Fluke multimeter serial number: 87490128

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

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

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

☐ Other Source:

Calibrated By: [signature]

Calibration Date: 7-6-17

Calibration Due: 7-6-18

Reviewed By: [signature]

Date: 07/06/17

ERG Form ITC. 101.A

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

K&S Associates, Inc.
1926 Elm Tree Drive
Nashville, Tennessee 37210-3716
Phone 800-522-2325 Fax 615-871-0856

ACCREDITED
CALIBRATION CERT #1866.01

CALIBRATION REPORT

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

INSTRUMENT: Reuter Stokes RSS-131, #07J00KM1

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

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

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

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

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

ACCREDITED

CALIBRATION CERTIFICATE

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

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

Sensor Type: 100 mR/h

Serial Number: 07J00KM1

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

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

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

Found RAC: 2.169e-8

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

Calibrated By: Richard Hardison Reviewed By: Angela Roper

Richard Hardison

Title: Calibration Technician Title: Calibration Physicist

Log: M-53 Page: 73

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

ACCREDITED

AS FOUND DATA

Reuter-Stokes Chamber Calibration

June 27, 2016 *Test Number M161588*

CHAMBER:

Mfgr: Reuter Stokes

Model: RSS-131

Serial: 07J00KM1

SUBMITTED BY:

ERG

Albuquerque, NM

ORIENTATION/CONDITIONS: Serial number away from source

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

ATMOSPHERIC COMMUNICATION: SEALED

POLARIZING POTENTIAL 401V

LEAKAGE: negligible

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

Comments Batt: 6.1V, Temp: 24.6 deg C, K&S Environment: Temp:21 deg C , RH 59%, Press: 752 mmHg; Report Number: 161866

Refer to Appendix I of this report for details on PIC ionization chamber calibrations. Procedure: SI 25

RAC Found: 2.169e-8

Calibrated By Richard Hardison **Reviewed By:**

Title: Calibration Technician **Title:** Calibration Specialist

Checked By: **Prepared By:**

Form RSS

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:	7-19-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	7-19-17

Comments:
NNEAT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-16-94 Distance to Source: 6 inches

Serial No.: 331-94 Emission Rate: ND cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project Reference Point,
9-27-16	1126	6.1	1002	99	45988	6844	39144	NW	NA-0904
9-27-16	1617	5.9	999	99	44136	6788	37348	NW	NA-0904
9-28-16	1022	5.9	1001	99	44612	6242	38370	NW	Comfort Suites, Parking lot
9-28-16	1754	5.9	1000	99	43583	6742	36841	NW	NA-0928
9-29-16	0936	5.9	1001	100	44695	5574	39121	NW	Comfort Suites, Parking Lot
9-29-16	1600	5.8	1002	99	46024	6760	39264	NW	NA-0928
9-30-16	0920	5.8	1002	99	44958	5748	39210	NW	NA-0904
9-30-16	1436	5.7	998	99	44138	6240	37898	NW	NA-0504
10-1-16	0913	5.7	1002	100	43656	5047	38609	NW	Oak 124/125
10-1-16	1605	5.6	995	99	43105	6275	36830	NW	Alonso
10-3-16	0950	5.7	1001	99	44914	5611	39303	NW	Berton 3
10-3-16	1220	5.6	996	99	45923	5670	40105	NW	Berton 3

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

(2

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8800 Washington S. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	196086
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	PR295014
Cal. Due Date:	7-9-17

Comments:
NNGRT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-16-94 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
9-27-16	1121	5.7	1100	100	45851	6762	39089	NW	NA-0904
9-27-16	1619	5.6	1094	99	45492	6313	39179	NW	NA-0904
9-28-16	1026	5.7	1100	100	44929	6287	38642	NW	NA-0904
9-29-16	1754	5.6	1098	100	44643	6434	38209	NW	Comfort Suites Parking Lot
9-29-16	0940	5.6	1100	99	43453	5654	37799	NW	NA-0928
9-30-16	1603	5.5	1101	100	44546	6525	38061	NW	Comfort Suites Parking Lot
9-30-16	0915	5.5	1102	100	44975	5236	39739	NW	NA-0928
10-1-16	1433	5.4	1096	100	44003	5827	38176	NW	NA-0904
10-1-16	0925	5.5	1102	100	42929	5140	37789	NW	Dock 124/125
10-3-16	1605	5.3	1092	100	44650	6271	38379	NW	Mango
10-3-16	0946	5.5	1100	100	43675	4995	38684	NW	Berlin 3
10-3-16	1225	5.4	1099	100	45921	5361	40560	NW	Berlin 3

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

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:	7-19-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	7-19-17

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):
10-4-16	0925	5.7	1003	99	45635	6378	39254	NW	Project reference point,
10-4-16	1720	5.6	1008	99	46987	6720	40267	NW	Tsosie 1
10-5-16	0610	5.7	1007	99	47335	6804	40531	NW	Comfort Suites Parking Lot
10-5-16	1542	5.5	999	99	45375	6342	39033	NW	Comfort Suites Parking Lot
10-6-16	0900	5.5	1003	99	43705	6264	37341	NW	Tsosie 1
10-6-16	1713	5.5	1000	99	44279	6053	38226	NW	Tsosie,
10-7-16	0902	5.5	1006	99	44457	6003	38404	NW	Comfort Suites Parking Lot
10-7-16	1627	5.5	999	99	46107	6751	39352	NW	Oak 124/125
10-8-16	0903	5.6	1003	99	45434	6365	39069	NW	Comfort Suites Parking Lot
10-8-16	1653	5.5	999	99	45185	6467	38718	NW	Red Valley Intersection
10-10-16	0858	5.5	1004	100	42755	5579	37176	NW	Comfort Suites Parking Lot
10-10-16	1919	5.5	999	99	51651	6930	44721	NW	Oak 124/125

Reviewed by: MP 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:	44-10
Serial No.:	196086
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	PR 285014
Cal. Due Date:	7-9-17

Comments:
NNERS

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-16-94 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):
10-4-16	0934	5.5	1102	100	46804	6042	40762	NW	Project Reference Points
10-4-16	1720	5.4	1106	100	46032	6898	39134	NW	Comfort Suites Parking Lot
10-5-16	0622	5.4	1109	101	45794	6834	38960	NW	Comfort Suites Parking Lot
10-5-16	1348	5.3	1097	99	46608	6021	40587	NW	Tijosie 1
10-6-16	0904	5.4	1103	100	44521	6273	38248	NW	Comfort Suites Parking Lot
10-6-16	1718	5.3	1099	100	45178	6311	38867	NW	Comfort Suites Parking Lot
10-7-16	0859	5.4	1104	100	44101	5226	38875	NW	Oak 124/125
10-7-16	1633	5.4	1098	99	44930	6832	38098	NW	Comfort Suites Parking Lot
10-8-16	0908	5.4	1104	100	45110	6201	38909	NW	Red Valley Intersection
10-8-16	1658	5.3	1098	99	45810	6196	39614	NW	Comfort Suites Parking Lot
10-12-16	1331	5.4	1099	99	46496	6519	39977	NW	Barton 3
10-12-16	1614	5.4	1097	100	44509	6060	38449	NW	Comfort Suites Parking Lot

Reviewed by: MW 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:
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

4-2-17

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

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 296-4224

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:
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	Chink lot
3-21-17	0641	5.7	1004	101	37904	5597	32307	NW	Chink 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
3-29-17	0810	5.5	1007	101	35608	4282	31326	NW	Eunice Becenti
3-29-17	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: MW Review Date: 10/19/17

(4)

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:
NNSA

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	5.9	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: 10/9/17

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:	2-28-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	2-28-17

Comments:
NVRAT

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):
4-11-17	0920	5.7	1000	101	36807	5626	31181	NV	NA-0928
4-11-17	1607	5.1	994	100	35724	5073	30651	NV	NA-0904 upper
4-14-17	0910	5.3	999	100	37554	5361	32193	NV	NA-0928
4-14-17	1050	5.3	997	108	37119	5165	31954	NV	NA-0928
4-17-17	0926	5.6	1000	101	37381	5937	31444	NV	NA-0928
4-17-17	1314	5.5	993	100	37712	5579	32133	NV	Berton 3
4-18-17	1400	5.6	997	100	40901	8541	32360	NV	Claim 28
4-18-17	1633	5.5	996	100	38299	8808	29491	NV	Claim 28
					4-19-17				

Reviewed by: Michael Baker Review Date: 11/08/17

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:
NNSA

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

Serial No.: 544-96 Emission Rate: N4 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	Berton 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	Alonzo
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 Benati
9-15-17	1729	5.3	957	109	35937	5261	30676	NW	Eunice Benati
9-19-17	0831	5.4	958	105	36967	6034	30433	NW	Section 26 @ trailer
9-16-17	1453	5.3	946	98	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: MW Review Date: 10/4/17

Single-Channel Function Check Log

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

METER	
Manufacturer:	GE
Model:	RSS-131
Serial No.:	07300km1
Cal. Due Date:	6-29-17

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

Comments:
NNERT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-16-94 Distance to Source: Contact - housing

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

Date	Time	Battery	High Voltage	Threshhold	Source Counts (µR/h)	BKG Counts	Net Counts	Initials	Note(s): Project reference point)
10-7-16	0545	~6.16	~400	~NA~	~26.7	~9.5	~17.2	NW	Comfort Suites Room - Farmington
10-7-16	2040	~6.16	~400	NA	~26.5	~8.7	~17.8	NW	Comfort Suites Room - Farmington
10-11-16	0634	~6.2	~406	NA	~25	~10.5	~14.5	NW	Comfort Suites Room - Farmington
10-11-16	1801	~6.3	~400	NA	~25.5	~10.1	~14.4	NW	Comfort Suites Room - Farmington
10-12-16	0548	~6.3	~400	NA	~26.5	~10	~16.5	NW	Comfort Suites Room - Farmington
10-12-16	1640	~6.3	~400	NA	~26.4	~10	~16.4	NW	Comfort Suites Room - Farmington
10-13-16	0606	~6.3	~400	NA	~27	~9.8	~17.2	NW	Comfort Suites Room - Farmington
10-13-16	1950	~6.3	~400	NA	~26.3	~9.5	~16.8	NW	Comfort Suites Room - Farmington
10-14-16	0630	~6.4	~406	NA	~26.4	~9.5	~16.9	NW	Comfort Suites Room - Farmington
10-14-16	1549	~6.2	~400	NA	~30	~12	~18	NW	Comfort Suites Room - Farmington
10-25-16	0539	~6.3	~400	NA	~29	~11	~18	NW	Best Western Room - Flagstaff
10-25-16	1755				D10	NOT USE			

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

Appendix B Exposure Rate Measurements

Date and Time	Exposure Rate (mR/h)	Location
10/11/2016 10:27	0.0536	Correlation Location 1
10/11/2016 10:28	0.0931	Correlation Location 1
10/11/2016 10:28	0.0806	Correlation Location 1
10/11/2016 10:28	0.0548	Correlation Location 1
10/11/2016 10:28	0.0355	Correlation Location 1
10/11/2016 10:28	0.024	Correlation Location 1
10/11/2016 10:28	0.017	Correlation Location 1
10/11/2016 10:28	0.0139	Correlation Location 1
10/11/2016 10:28	0.0127	Correlation Location 1
10/11/2016 10:28	0.0121	Correlation Location 1
10/11/2016 10:28	0.0117	Correlation Location 1
10/11/2016 10:29	0.0116	Correlation Location 1
10/11/2016 10:29	0.0115	Correlation Location 1
10/11/2016 10:29	0.0116	Correlation Location 1
10/11/2016 10:29	0.0117	Correlation Location 1
10/11/2016 10:29	0.0116	Correlation Location 1
10/11/2016 10:29	0.0116	Correlation Location 1
10/11/2016 10:29	0.0111	Correlation Location 1
10/11/2016 10:29	0.0109	Correlation Location 1
10/11/2016 10:29	0.0111	Correlation Location 1
10/11/2016 10:29	0.0111	Correlation Location 1
10/11/2016 10:30	0.0112	Correlation Location 1
10/11/2016 10:30	0.0114	Correlation Location 1
10/11/2016 10:30	0.0114	Correlation Location 1
10/11/2016 10:30	0.0115	Correlation Location 1
10/11/2016 10:30	0.0116	Correlation Location 1
10/11/2016 10:30	0.0115	Correlation Location 1
10/11/2016 10:30	0.0116	Correlation Location 1
10/11/2016 10:30	0.0111	Correlation Location 1
10/11/2016 10:30	0.0109	Correlation Location 1
10/11/2016 10:30	0.0111	Correlation Location 1
10/11/2016 10:31	0.0115	Correlation Location 1
10/11/2016 10:31	0.0115	Correlation Location 1
10/11/2016 10:31	0.0112	Correlation Location 1
10/11/2016 10:31	0.0111	Correlation Location 1
10/11/2016 10:31	0.0111	Correlation Location 1
10/11/2016 10:31	0.0111	Correlation Location 1
10/11/2016 10:31	0.0112	Correlation Location 1
10/11/2016 10:31	0.0111	Correlation Location 1
10/11/2016 10:31	0.0114	Correlation Location 1
10/11/2016 10:31	0.0117	Correlation Location 1
10/11/2016 10:32	0.0114	Correlation Location 1
10/11/2016 10:32	0.0111	Correlation Location 1
10/11/2016 10:32	0.0111	Correlation Location 1
10/11/2016 10:32	0.0111	Correlation Location 1
10/11/2016 10:32	0.0112	Correlation Location 1
10/11/2016 10:32	0.0115	Correlation Location 1
10/11/2016 10:32	0.0117	Correlation Location 1
10/11/2016 10:32	0.0117	Correlation Location 1
10/11/2016 10:32	0.0116	Correlation Location 1
10/11/2016 10:32	0.0114	Correlation Location 1
10/11/2016 10:33	0.0115	Correlation Location 1
10/11/2016 10:33	0.0117	Correlation Location 1
10/11/2016 10:33	0.0116	Correlation Location 1
10/11/2016 10:33	0.0111	Correlation Location 1
10/11/2016 10:33	0.0111	Correlation Location 1
10/11/2016 10:33	0.0115	Correlation Location 1
10/11/2016 10:33	0.0114	Correlation Location 1
10/11/2016 10:33	0.0112	Correlation Location 1
10/11/2016 10:33	0.011	Correlation Location 1
10/11/2016 10:33	0.0109	Correlation Location 1
10/11/2016 10:34	0.0111	Correlation Location 1
10/11/2016 10:34	0.0116	Correlation Location 1
10/11/2016 10:34	0.0117	Correlation Location 1
10/11/2016 10:34	0.0116	Correlation Location 1
10/11/2016 10:34	0.0114	Correlation Location 1
10/11/2016 10:34	0.0112	Correlation Location 1
10/11/2016 10:34	0.0114	Correlation Location 1
10/11/2016 10:34	0.0117	Correlation Location 1
10/11/2016 10:34	0.0117	Correlation Location 1
10/11/2016 10:34	0.0116	Correlation Location 1
10/11/2016 10:35	0.0111	Correlation Location 1
10/11/2016 10:35	0.011	Correlation Location 1
10/11/2016 10:35	0.0111	Correlation Location 1
10/11/2016 10:35	0.0114	Correlation Location 1
10/11/2016 10:35	0.0115	Correlation Location 1
10/11/2016 10:35	0.0116	Correlation Location 1
10/11/2016 10:35	0.0116	Correlation Location 1
10/11/2016 10:35	0.0115	Correlation Location 1
10/11/2016 10:35	0.0117	Correlation Location 1
10/11/2016 10:35	0.012	Correlation Location 1
10/11/2016 10:36	0.0117	Correlation Location 1
10/11/2016 10:36	0.0115	Correlation Location 1
10/11/2016 10:36	0.0118	Correlation Location 1
10/11/2016 10:36	0.012	Correlation Location 1
10/11/2016 10:36	0.012	Correlation Location 1
10/11/2016 10:36	0.0117	Correlation Location 1
10/11/2016 10:36	0.0116	Correlation Location 1
10/11/2016 10:36	0.0114	Correlation Location 1
10/11/2016 10:36	0.0116	Correlation Location 1
10/11/2016 10:36	0.0121	Correlation Location 1
10/11/2016 10:37	0.0121	Correlation Location 1
10/11/2016 10:37	0.012	Correlation Location 1
10/11/2016 10:37	0.0118	Correlation Location 1
10/11/2016 10:37	0.0117	Correlation Location 1
10/11/2016 10:37	0.0116	Correlation Location 1
10/11/2016 10:37	0.0117	Correlation Location 1
10/11/2016 10:37	0.0117	Correlation Location 1
10/11/2016 10:37	0.0116	Correlation Location 1
10/11/2016 10:37	0.0115	Correlation Location 1
10/11/2016 10:37	0.0116	Correlation Location 1
10/11/2016 10:38	0.0111	Correlation Location 1
10/11/2016 10:38	0.0106	Correlation Location 1
10/11/2016 10:38	0.0105	Correlation Location 1
10/11/2016 10:38	0.0106	Correlation Location 1
10/11/2016 10:38	0.0106	Correlation Location 1
10/11/2016 10:38	0.0108	Correlation Location 1
10/11/2016 10:38	0.0105	Correlation Location 1
10/11/2016 10:38	0.0108	Correlation Location 1
10/11/2016 10:38	0.0112	Correlation Location 1
10/11/2016 10:38	0.0118	Correlation Location 1
10/11/2016 11:09	0.0584	Correlation Location 2

NA-0904 Exposure Rate Measurements for Correlation

Date and Time	Exposure Rate (mR/h)	Location
10/11/2016 11:09	0.1057	Correlation Location 2
10/11/2016 11:09	0.0775	Correlation Location 2
10/11/2016 11:10	0.0594	Correlation Location 2
10/11/2016 11:10	0.0489	Correlation Location 2
10/11/2016 11:10	0.043	Correlation Location 2
10/11/2016 11:10	0.0394	Correlation Location 2
10/11/2016 11:10	0.0383	Correlation Location 2
10/11/2016 11:10	0.0378	Correlation Location 2
10/11/2016 11:10	0.037	Correlation Location 2
10/11/2016 11:10	0.0367	Correlation Location 2
10/11/2016 11:10	0.0365	Correlation Location 2
10/11/2016 11:10	0.0369	Correlation Location 2
10/11/2016 11:11	0.0375	Correlation Location 2
10/11/2016 11:11	0.0374	Correlation Location 2
10/11/2016 11:11	0.0372	Correlation Location 2
10/11/2016 11:11	0.0365	Correlation Location 2
10/11/2016 11:11	0.0359	Correlation Location 2
10/11/2016 11:11	0.0357	Correlation Location 2
10/11/2016 11:11	0.0361	Correlation Location 2
10/11/2016 11:11	0.0365	Correlation Location 2
10/11/2016 11:11	0.0369	Correlation Location 2
10/11/2016 11:11	0.037	Correlation Location 2
10/11/2016 11:12	0.0374	Correlation Location 2
10/11/2016 11:12	0.0376	Correlation Location 2
10/11/2016 11:12	0.0375	Correlation Location 2
10/11/2016 11:12	0.0368	Correlation Location 2
10/11/2016 11:12	0.0365	Correlation Location 2
10/11/2016 11:12	0.0361	Correlation Location 2
10/11/2016 11:12	0.0359	Correlation Location 2
10/11/2016 11:12	0.0357	Correlation Location 2
10/11/2016 11:12	0.0357	Correlation Location 2
10/11/2016 11:12	0.0359	Correlation Location 2
10/11/2016 11:13	0.0361	Correlation Location 2
10/11/2016 11:13	0.0365	Correlation Location 2
10/11/2016 11:13	0.0361	Correlation Location 2
10/11/2016 11:13	0.0361	Correlation Location 2
10/11/2016 11:13	0.0359	Correlation Location 2
10/11/2016 11:13	0.036	Correlation Location 2
10/11/2016 11:13	0.0365	Correlation Location 2
10/11/2016 11:13	0.0367	Correlation Location 2
10/11/2016 11:13	0.0365	Correlation Location 2
10/11/2016 11:13	0.0365	Correlation Location 2
10/11/2016 11:14	0.0363	Correlation Location 2
10/11/2016 11:14	0.0363	Correlation Location 2
10/11/2016 11:14	0.0361	Correlation Location 2
10/11/2016 11:14	0.0361	Correlation Location 2
10/11/2016 11:14	0.0361	Correlation Location 2
10/11/2016 11:14	0.0365	Correlation Location 2
10/11/2016 11:14	0.0368	Correlation Location 2
10/11/2016 11:14	0.037	Correlation Location 2
10/11/2016 11:14	0.0369	Correlation Location 2
10/11/2016 11:14	0.0368	Correlation Location 2
10/11/2016 11:15	0.0365	Correlation Location 2
10/11/2016 11:15	0.036	Correlation Location 2
10/11/2016 11:15	0.0361	Correlation Location 2
10/11/2016 11:15	0.0364	Correlation Location 2
10/11/2016 11:15	0.0364	Correlation Location 2
10/11/2016 11:15	0.0357	Correlation Location 2
10/11/2016 11:15	0.0361	Correlation Location 2
10/11/2016 11:15	0.0361	Correlation Location 2
10/11/2016 11:15	0.0363	Correlation Location 2
10/11/2016 11:15	0.0361	Correlation Location 2
10/11/2016 11:16	0.0357	Correlation Location 2
10/11/2016 11:16	0.0352	Correlation Location 2
10/11/2016 11:16	0.0348	Correlation Location 2
10/11/2016 11:16	0.0346	Correlation Location 2
10/11/2016 11:16	0.0344	Correlation Location 2
10/11/2016 11:16	0.0346	Correlation Location 2
10/11/2016 11:16	0.0357	Correlation Location 2
10/11/2016 11:16	0.0364	Correlation Location 2
10/11/2016 11:16	0.0361	Correlation Location 2
10/11/2016 11:16	0.0365	Correlation Location 2
10/11/2016 11:17	0.0365	Correlation Location 2
10/11/2016 11:17	0.037	Correlation Location 2
10/11/2016 11:17	0.037	Correlation Location 2
10/11/2016 11:17	0.0367	Correlation Location 2
10/11/2016 11:17	0.0361	Correlation Location 2
10/11/2016 11:17	0.0359	Correlation Location 2
10/11/2016 11:17	0.0359	Correlation Location 2
10/11/2016 11:17	0.0361	Correlation Location 2
10/11/2016 11:17	0.0368	Correlation Location 2
10/11/2016 11:17	0.0369	Correlation Location 2
10/11/2016 11:18	0.037	Correlation Location 2
10/11/2016 11:18	0.0369	Correlation Location 2
10/11/2016 11:18	0.0361	Correlation Location 2
10/11/2016 11:18	0.0357	Correlation Location 2
10/11/2016 11:18	0.0357	Correlation Location 2
10/11/2016 11:18	0.0354	Correlation Location 2
10/11/2016 11:18	0.0357	Correlation Location 2
10/11/2016 11:18	0.0361	Correlation Location 2
10/11/2016 11:18	0.0363	Correlation Location 2
10/11/2016 11:18	0.0368	Correlation Location 2
10/11/2016 11:19	0.0374	Correlation Location 2
10/11/2016 11:19	0.0376	Correlation Location 2
10/11/2016 11:19	0.037	Correlation Location 2
10/11/2016 11:19	0.0365	Correlation Location 2
10/11/2016 11:19	0.0363	Correlation Location 2
10/11/2016 11:19	0.0364	Correlation Location 2
10/11/2016 11:19	0.0364	Correlation Location 2
10/11/2016 11:19	0.0363	Correlation Location 2
10/11/2016 11:19	0.0361	Correlation Location 2
10/11/2016 11:19	0.0363	Correlation Location 2
10/11/2016 11:20	0.0361	Correlation Location 2
10/11/2016 11:20	0.0361	Correlation Location 2
10/11/2016 11:20	0.0365	Correlation Location 2
10/11/2016 11:20	0.037	Correlation Location 2
10/11/2016 11:20	0.0372	Correlation Location 2
10/11/2016 11:20	0.0367	Correlation Location 2
10/11/2016 11:20	0.0361	Correlation Location 2
10/11/2016 11:20	0.0357	Correlation Location 2
10/11/2016 11:20	0.0352	Correlation Location 2
10/11/2016 11:20	0.0352	Correlation Location 2
10/11/2016 11:21	0.0354	Correlation Location 2
10/11/2016 11:21	0.0361	Correlation Location 2

Date and Time	Exposure Rate (mR/h)	Location
10/11/2016 11:21	0.0365	Correlation Location 2
10/11/2016 11:21	0.0364	Correlation Location 2
10/11/2016 11:21	0.0361	Correlation Location 2
10/11/2016 11:21	0.0354	Correlation Location 2
10/11/2016 11:21	0.0352	Correlation Location 2
10/11/2016 11:21	0.0357	Correlation Location 2
10/11/2016 11:21	0.0365	Correlation Location 2
10/11/2016 11:21	0.0364	Correlation Location 2
10/11/2016 11:22	0.0361	Correlation Location 2
10/11/2016 11:22	0.0359	Correlation Location 2
10/11/2016 11:22	0.0359	Correlation Location 2
10/11/2016 11:22	0.0355	Correlation Location 2
10/11/2016 11:22	0.0357	Correlation Location 2
10/11/2016 11:22	0.0357	Correlation Location 2
10/11/2016 11:22	0.0359	Correlation Location 2
10/11/2016 11:22	0.0357	Correlation Location 2
10/11/2016 11:22	0.0352	Correlation Location 2
10/11/2016 11:22	0.0354	Correlation Location 2
10/11/2016 11:23	0.0359	Correlation Location 2
10/11/2016 11:23	0.036	Correlation Location 2
10/11/2016 11:23	0.0357	Correlation Location 2
10/11/2016 11:23	0.0357	Correlation Location 2
10/11/2016 11:23	0.0361	Correlation Location 2
10/11/2016 11:23	0.0367	Correlation Location 2
10/11/2016 11:23	0.0367	Correlation Location 2
10/11/2016 11:23	0.0363	Correlation Location 2
10/11/2016 11:23	0.036	Correlation Location 2
10/11/2016 11:23	0.0359	Correlation Location 2
10/11/2016 11:24	0.036	Correlation Location 2
10/11/2016 11:24	0.0361	Correlation Location 2
10/11/2016 11:24	0.036	Correlation Location 2
10/11/2016 11:24	0.036	Correlation Location 2
10/11/2016 11:24	0.0364	Correlation Location 2
10/11/2016 11:24	0.0363	Correlation Location 2
10/11/2016 11:24	0.0365	Correlation Location 2
10/11/2016 11:24	0.0369	Correlation Location 2
10/11/2016 11:24	0.037	Correlation Location 2
10/11/2016 11:24	0.0365	Correlation Location 2
10/11/2016 11:25	0.0365	Correlation Location 2
10/11/2016 11:25	0.0361	Correlation Location 2
10/11/2016 11:25	0.0357	Correlation Location 2
10/11/2016 11:25	0.0361	Correlation Location 2
10/11/2016 11:25	0.0364	Correlation Location 2
10/11/2016 11:25	0.0363	Correlation Location 2
10/11/2016 11:25	0.0364	Correlation Location 2
10/11/2016 11:25	0.036	Correlation Location 2
10/11/2016 11:25	0.036	Correlation Location 2
10/11/2016 11:25	0.0361	Correlation Location 2
10/11/2016 11:26	0.0365	Correlation Location 2
10/11/2016 11:26	0.0365	Correlation Location 2
10/11/2016 11:26	0.0363	Correlation Location 2
10/11/2016 11:26	0.0368	Correlation Location 2
10/11/2016 11:26	0.0369	Correlation Location 2
10/11/2016 11:26	0.0365	Correlation Location 2
10/11/2016 11:26	0.0363	Correlation Location 2
10/11/2016 11:26	0.0368	Correlation Location 2
10/11/2016 11:26	0.0374	Correlation Location 2
10/11/2016 11:26	0.037	Correlation Location 2
10/11/2016 11:27	0.0369	Correlation Location 2
10/11/2016 11:27	0.0368	Correlation Location 2
10/11/2016 11:27	0.0365	Correlation Location 2
10/11/2016 11:27	0.0363	Correlation Location 2
10/11/2016 11:27	0.0363	Correlation Location 2
10/11/2016 11:27	0.0361	Correlation Location 2
10/11/2016 11:43	0.0639	Correlation Location 3
10/11/2016 11:43	0.12	Correlation Location 3
10/11/2016 11:43	0.1216	Correlation Location 3
10/11/2016 11:43	0.1029	Correlation Location 3
10/11/2016 11:43	0.0869	Correlation Location 3
10/11/2016 11:43	0.0767	Correlation Location 3
10/11/2016 11:43	0.0712	Correlation Location 3
10/11/2016 11:43	0.0687	Correlation Location 3
10/11/2016 11:43	0.0675	Correlation Location 3
10/11/2016 11:44	0.0674	Correlation Location 3
10/11/2016 11:44	0.067	Correlation Location 3
10/11/2016 11:44	0.0668	Correlation Location 3
10/11/2016 11:44	0.0664	Correlation Location 3
10/11/2016 11:44	0.0663	Correlation Location 3
10/11/2016 11:44	0.0672	Correlation Location 3
10/11/2016 11:44	0.0674	Correlation Location 3
10/11/2016 11:44	0.0672	Correlation Location 3
10/11/2016 11:44	0.0674	Correlation Location 3
10/11/2016 11:44	0.0677	Correlation Location 3
10/11/2016 11:45	0.0677	Correlation Location 3
10/11/2016 11:45	0.0678	Correlation Location 3
10/11/2016 11:45	0.0673	Correlation Location 3
10/11/2016 11:45	0.0671	Correlation Location 3
10/11/2016 11:45	0.0665	Correlation Location 3
10/11/2016 11:45	0.0663	Correlation Location 3
10/11/2016 11:45	0.0663	Correlation Location 3
10/11/2016 11:45	0.0663	Correlation Location 3
10/11/2016 11:45	0.0661	Correlation Location 3
10/11/2016 11:45	0.0662	Correlation Location 3
10/11/2016 11:46	0.0665	Correlation Location 3
10/11/2016 11:46	0.0665	Correlation Location 3
10/11/2016 11:46	0.0662	Correlation Location 3
10/11/2016 11:46	0.0663	Correlation Location 3
10/11/2016 11:46	0.0663	Correlation Location 3
10/11/2016 11:46	0.0657	Correlation Location 3
10/11/2016 11:46	0.0658	Correlation Location 3
10/11/2016 11:46	0.0669	Correlation Location 3
10/11/2016 11:46	0.0672	Correlation Location 3
10/11/2016 11:46	0.0668	Correlation Location 3
10/11/2016 11:47	0.0656	Correlation Location 3
10/11/2016 11:47	0.0639	Correlation Location 3
10/11/2016 11:47	0.0629	Correlation Location 3
10/11/2016 11:47	0.0633	Correlation Location 3
10/11/2016 11:47	0.0636	Correlation Location 3
10/11/2016 11:47	0.0642	Correlation Location 3
10/11/2016 11:47	0.0653	Correlation Location 3
10/11/2016 11:47	0.0658	Correlation Location 3
10/11/2016 11:47	0.0662	Correlation Location 3
10/11/2016 11:47	0.067	Correlation Location 3
10/11/2016 11:48	0.0678	Correlation Location 3

Date and Time	Exposure Rate (mR/h)	Location
10/11/2016 11:48	0.0681	Correlation Location 3
10/11/2016 11:48	0.0673	Correlation Location 3
10/11/2016 11:48	0.0665	Correlation Location 3
10/11/2016 11:48	0.0658	Correlation Location 3
10/11/2016 11:48	0.0657	Correlation Location 3
10/11/2016 11:48	0.0658	Correlation Location 3
10/11/2016 11:48	0.0663	Correlation Location 3
10/11/2016 11:48	0.0665	Correlation Location 3
10/11/2016 11:48	0.0665	Correlation Location 3
10/11/2016 11:49	0.0666	Correlation Location 3
10/11/2016 11:49	0.0665	Correlation Location 3
10/11/2016 11:49	0.0662	Correlation Location 3
10/11/2016 11:49	0.0657	Correlation Location 3
10/11/2016 11:49	0.0658	Correlation Location 3
10/11/2016 11:49	0.0658	Correlation Location 3
10/11/2016 11:49	0.0655	Correlation Location 3
10/11/2016 11:49	0.066	Correlation Location 3
10/11/2016 11:49	0.0656	Correlation Location 3
10/11/2016 11:49	0.0655	Correlation Location 3
10/11/2016 11:50	0.0656	Correlation Location 3
10/11/2016 11:50	0.0657	Correlation Location 3
10/11/2016 11:50	0.0658	Correlation Location 3
10/11/2016 11:50	0.0662	Correlation Location 3
10/11/2016 11:50	0.0666	Correlation Location 3
10/11/2016 11:50	0.0663	Correlation Location 3
10/11/2016 11:50	0.0661	Correlation Location 3
10/11/2016 11:50	0.0657	Correlation Location 3
10/11/2016 11:50	0.0656	Correlation Location 3
10/11/2016 11:50	0.0649	Correlation Location 3
10/11/2016 11:51	0.0652	Correlation Location 3
10/11/2016 11:51	0.0656	Correlation Location 3
10/11/2016 11:51	0.0658	Correlation Location 3
10/11/2016 11:51	0.0661	Correlation Location 3
10/11/2016 11:51	0.0662	Correlation Location 3
10/11/2016 11:51	0.066	Correlation Location 3
10/11/2016 11:51	0.066	Correlation Location 3
10/11/2016 11:51	0.0662	Correlation Location 3
10/11/2016 11:51	0.0665	Correlation Location 3
10/11/2016 11:51	0.0672	Correlation Location 3
10/11/2016 11:52	0.0674	Correlation Location 3
10/11/2016 11:52	0.067	Correlation Location 3
10/11/2016 11:52	0.0668	Correlation Location 3
10/11/2016 11:52	0.067	Correlation Location 3
10/11/2016 11:52	0.0673	Correlation Location 3
10/11/2016 11:52	0.0671	Correlation Location 3
10/11/2016 11:52	0.0668	Correlation Location 3
10/11/2016 11:52	0.0666	Correlation Location 3
10/11/2016 11:52	0.0668	Correlation Location 3
10/11/2016 11:52	0.0666	Correlation Location 3
10/11/2016 11:53	0.0668	Correlation Location 3
10/11/2016 11:53	0.067	Correlation Location 3
10/11/2016 11:53	0.0671	Correlation Location 3
10/11/2016 11:53	0.0673	Correlation Location 3
10/11/2016 11:53	0.0668	Correlation Location 3
10/11/2016 11:53	0.0665	Correlation Location 3
10/11/2016 11:53	0.0662	Correlation Location 3
10/11/2016 11:53	0.0662	Correlation Location 3
10/11/2016 11:53	0.0664	Correlation Location 3
10/11/2016 11:53	0.0668	Correlation Location 3
10/11/2016 11:54	0.0665	Correlation Location 3
10/11/2016 11:54	0.0665	Correlation Location 3
10/11/2016 11:54	0.0656	Correlation Location 3
10/11/2016 12:34	0.0544	Correlation Location 4
10/11/2016 12:35	0.0956	Correlation Location 4
10/11/2016 12:35	0.085	Correlation Location 4
10/11/2016 12:35	0.0601	Correlation Location 4
10/11/2016 12:35	0.0412	Correlation Location 4
10/11/2016 12:35	0.0299	Correlation Location 4
10/11/2016 12:35	0.0235	Correlation Location 4
10/11/2016 12:35	0.0198	Correlation Location 4
10/11/2016 12:35	0.0182	Correlation Location 4
10/11/2016 12:35	0.0177	Correlation Location 4
10/11/2016 12:35	0.0179	Correlation Location 4
10/11/2016 12:36	0.018	Correlation Location 4
10/11/2016 12:36	0.018	Correlation Location 4
10/11/2016 12:36	0.0179	Correlation Location 4
10/11/2016 12:36	0.0175	Correlation Location 4
10/11/2016 12:36	0.017	Correlation Location 4
10/11/2016 12:36	0.017	Correlation Location 4
10/11/2016 12:36	0.0173	Correlation Location 4
10/11/2016 12:36	0.0174	Correlation Location 4
10/11/2016 12:36	0.0172	Correlation Location 4
10/11/2016 12:36	0.0172	Correlation Location 4
10/11/2016 12:37	0.0172	Correlation Location 4
10/11/2016 12:37	0.0174	Correlation Location 4
10/11/2016 12:37	0.0174	Correlation Location 4
10/11/2016 12:37	0.0173	Correlation Location 4
10/11/2016 12:37	0.0173	Correlation Location 4
10/11/2016 12:37	0.017	Correlation Location 4
10/11/2016 12:37	0.0175	Correlation Location 4
10/11/2016 12:37	0.018	Correlation Location 4
10/11/2016 12:37	0.0179	Correlation Location 4
10/11/2016 12:37	0.018	Correlation Location 4
10/11/2016 12:38	0.0178	Correlation Location 4
10/11/2016 12:38	0.0176	Correlation Location 4
10/11/2016 12:38	0.0174	Correlation Location 4
10/11/2016 12:38	0.0173	Correlation Location 4
10/11/2016 12:38	0.0172	Correlation Location 4
10/11/2016 12:38	0.0173	Correlation Location 4
10/11/2016 12:38	0.017	Correlation Location 4
10/11/2016 12:38	0.0169	Correlation Location 4
10/11/2016 12:38	0.0169	Correlation Location 4
10/11/2016 12:38	0.0169	Correlation Location 4
10/11/2016 12:39	0.0169	Correlation Location 4
10/11/2016 12:39	0.0169	Correlation Location 4
10/11/2016 12:39	0.017	Correlation Location 4
10/11/2016 12:39	0.0172	Correlation Location 4
10/11/2016 12:39	0.0169	Correlation Location 4
10/11/2016 12:39	0.017	Correlation Location 4
10/11/2016 12:39	0.017	Correlation Location 4
10/11/2016 12:39	0.0173	Correlation Location 4
10/11/2016 12:39	0.0176	Correlation Location 4
10/11/2016 12:39	0.0174	Correlation Location 4
10/11/2016 12:40	0.0174	Correlation Location 4

Date and Time	Exposure Rate (mR/h)	Location
10/11/2016 12:40	0.0178	Correlation Location 4
10/11/2016 12:40	0.0178	Correlation Location 4
10/11/2016 12:40	0.0175	Correlation Location 4
10/11/2016 12:40	0.0175	Correlation Location 4
10/11/2016 12:40	0.0175	Correlation Location 4
10/11/2016 12:40	0.0174	Correlation Location 4
10/11/2016 12:40	0.0168	Correlation Location 4
10/11/2016 12:40	0.017	Correlation Location 4
10/11/2016 12:40	0.0174	Correlation Location 4
10/11/2016 12:41	0.0175	Correlation Location 4
10/11/2016 12:41	0.0176	Correlation Location 4
10/11/2016 12:41	0.0179	Correlation Location 4
10/11/2016 12:41	0.0178	Correlation Location 4
10/11/2016 12:41	0.017	Correlation Location 4
10/11/2016 12:41	0.017	Correlation Location 4
10/11/2016 12:41	0.0174	Correlation Location 4
10/11/2016 12:41	0.0182	Correlation Location 4
10/11/2016 12:41	0.0182	Correlation Location 4
10/11/2016 12:41	0.0179	Correlation Location 4
10/11/2016 12:42	0.0178	Correlation Location 4
10/11/2016 12:42	0.0177	Correlation Location 4
10/11/2016 12:42	0.0176	Correlation Location 4
10/11/2016 12:42	0.0178	Correlation Location 4
10/11/2016 12:42	0.0178	Correlation Location 4
10/11/2016 12:42	0.0174	Correlation Location 4
10/11/2016 12:42	0.0173	Correlation Location 4
10/11/2016 12:42	0.0176	Correlation Location 4
10/11/2016 12:42	0.0178	Correlation Location 4
10/11/2016 12:42	0.0172	Correlation Location 4
10/11/2016 12:43	0.0168	Correlation Location 4
10/11/2016 12:43	0.017	Correlation Location 4
10/11/2016 12:43	0.0179	Correlation Location 4
10/11/2016 12:43	0.0182	Correlation Location 4
10/11/2016 12:43	0.018	Correlation Location 4
10/11/2016 12:43	0.0176	Correlation Location 4
10/11/2016 12:43	0.0175	Correlation Location 4
10/11/2016 12:43	0.0176	Correlation Location 4
10/11/2016 12:43	0.0177	Correlation Location 4
10/11/2016 12:43	0.0179	Correlation Location 4
10/11/2016 12:44	0.0178	Correlation Location 4
10/11/2016 12:44	0.0176	Correlation Location 4
10/11/2016 12:44	0.0173	Correlation Location 4
10/11/2016 12:44	0.0174	Correlation Location 4
10/11/2016 12:44	0.0177	Correlation Location 4
10/11/2016 12:44	0.0175	Correlation Location 4
10/11/2016 12:44	0.0178	Correlation Location 4
10/11/2016 12:44	0.018	Correlation Location 4
10/11/2016 12:44	0.018	Correlation Location 4
10/11/2016 12:44	0.018	Correlation Location 4
10/11/2016 12:45	0.0177	Correlation Location 4
10/11/2016 12:45	0.0172	Correlation Location 4
10/11/2016 12:45	0.017	Correlation Location 4
10/11/2016 12:45	0.0169	Correlation Location 4
10/11/2016 12:45	0.017	Correlation Location 4
10/11/2016 12:45	0.017	Correlation Location 4
10/11/2016 12:45	0.0172	Correlation Location 4
10/11/2016 12:45	0.0175	Correlation Location 4
10/11/2016 12:45	0.0178	Correlation Location 4
10/11/2016 15:02	0.0551	Correlation Location 5
10/11/2016 15:02	0.0977	Correlation Location 5
10/11/2016 15:02	0.0877	Correlation Location 5
10/11/2016 15:02	0.0632	Correlation Location 5
10/11/2016 15:02	0.0446	Correlation Location 5
10/11/2016 15:02	0.0334	Correlation Location 5
10/11/2016 15:02	0.0274	Correlation Location 5
10/11/2016 15:02	0.0242	Correlation Location 5
10/11/2016 15:03	0.0223	Correlation Location 5
10/11/2016 15:03	0.0218	Correlation Location 5
10/11/2016 15:03	0.0216	Correlation Location 5
10/11/2016 15:03	0.0216	Correlation Location 5
10/11/2016 15:03	0.0216	Correlation Location 5
10/11/2016 15:03	0.0213	Correlation Location 5
10/11/2016 15:03	0.0209	Correlation Location 5
10/11/2016 15:03	0.021	Correlation Location 5
10/11/2016 15:03	0.0215	Correlation Location 5
10/11/2016 15:03	0.0215	Correlation Location 5
10/11/2016 15:04	0.0213	Correlation Location 5
10/11/2016 15:04	0.0215	Correlation Location 5
10/11/2016 15:04	0.0216	Correlation Location 5
10/11/2016 15:04	0.022	Correlation Location 5
10/11/2016 15:04	0.0221	Correlation Location 5
10/11/2016 15:04	0.0221	Correlation Location 5
10/11/2016 15:04	0.0223	Correlation Location 5
10/11/2016 15:04	0.0225	Correlation Location 5
10/11/2016 15:04	0.0223	Correlation Location 5
10/11/2016 15:04	0.0219	Correlation Location 5
10/11/2016 15:05	0.0218	Correlation Location 5
10/11/2016 15:05	0.0219	Correlation Location 5
10/11/2016 15:05	0.0225	Correlation Location 5
10/11/2016 15:05	0.0225	Correlation Location 5
10/11/2016 15:05	0.0221	Correlation Location 5
10/11/2016 15:05	0.0216	Correlation Location 5
10/11/2016 15:05	0.0213	Correlation Location 5
10/11/2016 15:05	0.0213	Correlation Location 5
10/11/2016 15:05	0.0216	Correlation Location 5
10/11/2016 15:05	0.0216	Correlation Location 5
10/11/2016 15:06	0.0219	Correlation Location 5
10/11/2016 15:06	0.022	Correlation Location 5
10/11/2016 15:06	0.0216	Correlation Location 5
10/11/2016 15:06	0.0211	Correlation Location 5
10/11/2016 15:06	0.0211	Correlation Location 5
10/11/2016 15:06	0.0215	Correlation Location 5
10/11/2016 15:06	0.0218	Correlation Location 5
10/11/2016 15:06	0.0219	Correlation Location 5
10/11/2016 15:06	0.022	Correlation Location 5
10/11/2016 15:06	0.0218	Correlation Location 5
10/11/2016 15:07	0.0213	Correlation Location 5
10/11/2016 15:07	0.0211	Correlation Location 5
10/11/2016 15:07	0.0213	Correlation Location 5
10/11/2016 15:07	0.0213	Correlation Location 5
10/11/2016 15:07	0.0213	Correlation Location 5
10/11/2016 15:07	0.0211	Correlation Location 5
10/11/2016 15:07	0.0211	Correlation Location 5
10/11/2016 15:07	0.0211	Correlation Location 5

Date and Time	Exposure Rate (mR/h)	Location
10/11/2016 15:07	0.0211	Correlation Location 5
10/11/2016 15:07	0.0211	Correlation Location 5
10/11/2016 15:08	0.021	Correlation Location 5
10/11/2016 15:08	0.0208	Correlation Location 5
10/11/2016 15:08	0.0207	Correlation Location 5
10/11/2016 15:08	0.0209	Correlation Location 5
10/11/2016 15:08	0.0213	Correlation Location 5
10/11/2016 15:08	0.0213	Correlation Location 5
10/11/2016 15:08	0.0211	Correlation Location 5
10/11/2016 15:08	0.0213	Correlation Location 5
10/11/2016 15:08	0.0216	Correlation Location 5
10/11/2016 15:08	0.0213	Correlation Location 5
10/11/2016 15:09	0.0211	Correlation Location 5
10/11/2016 15:09	0.0217	Correlation Location 5
10/11/2016 15:09	0.0219	Correlation Location 5
10/11/2016 15:09	0.0218	Correlation Location 5
10/11/2016 15:09	0.0217	Correlation Location 5
10/11/2016 15:09	0.0218	Correlation Location 5
10/11/2016 15:09	0.0221	Correlation Location 5
10/11/2016 15:09	0.0221	Correlation Location 5
10/11/2016 15:09	0.0217	Correlation Location 5
10/11/2016 15:09	0.0217	Correlation Location 5
10/11/2016 15:10	0.0216	Correlation Location 5
10/11/2016 15:10	0.0218	Correlation Location 5
10/11/2016 15:10	0.0213	Correlation Location 5
10/11/2016 15:10	0.021	Correlation Location 5
10/11/2016 15:10	0.0209	Correlation Location 5
10/11/2016 15:10	0.0211	Correlation Location 5
10/11/2016 15:10	0.0213	Correlation Location 5
10/11/2016 15:10	0.0217	Correlation Location 5
10/11/2016 15:10	0.0217	Correlation Location 5
10/11/2016 15:10	0.0217	Correlation Location 5
10/11/2016 15:11	0.0219	Correlation Location 5
10/11/2016 15:11	0.0215	Correlation Location 5
10/11/2016 15:11	0.021	Correlation Location 5
10/11/2016 15:11	0.0213	Correlation Location 5
10/11/2016 15:11	0.0216	Correlation Location 5
10/11/2016 15:11	0.0211	Correlation Location 5
10/11/2016 15:11	0.0209	Correlation Location 5
10/11/2016 15:11	0.0208	Correlation Location 5
10/11/2016 15:11	0.0206	Correlation Location 5
10/11/2016 15:11	0.0202	Correlation Location 5
10/11/2016 15:12	0.0204	Correlation Location 5
10/11/2016 15:12	0.0207	Correlation Location 5
10/11/2016 15:12	0.0208	Correlation Location 5
10/11/2016 15:12	0.0211	Correlation Location 5
10/11/2016 15:12	0.0216	Correlation Location 5
10/11/2016 15:12	0.0217	Correlation Location 5
10/11/2016 15:12	0.0218	Correlation Location 5
10/11/2016 15:12	0.0219	Correlation Location 5
10/11/2016 15:12	0.0216	Correlation Location 5
10/11/2016 15:12	0.0213	Correlation Location 5
10/11/2016 15:13	0.0213	Correlation Location 5

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

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Memo

To: Kirsty Woods, Program Director, Stantec

From: Liz Ruedig, PhD, CHP, and Mike Schierman, CHP, Environmental Restoration Group

Date: 7/31/2018

Re: Statistical Analysis of the Navajo Trustee Mines Dataset: Multivariate Linear Regression for Evaluation of Gamma Correlation with Ra-226 and Evaluation of Secular Equilibrium Between Ra-226 and Th-230

Multivariate Linear Regression for Evaluation of Gamma Count Rate with Ra-226 Concentrations in Surface Soil

Due to a large number of reviewer comments at the sixteen Navajo Trust Abandoned Uranium Mines (AUMs) concerning the influence of gamma-emitting radionuclides not within the uranium-238 decay series on the correlation between dynamic gamma count rate and soil concentration of radium-226, Environmental Restoration Group has performed multivariate linear regression (MLR), relating gamma count rate to multiple soil radionuclides simultaneously. MLR models the influence of a set of predictor variables (in this case, soil concentrations of several gamma-emitting radionuclides, or surrogates for these radionuclides) on a single response variable (in this case, dynamic gamma count rate), accounting for the influence of each predictor variable upon the response variable independently of the other predictor variables within the set.

In a MLR, it is possible to distinguish from a large set of variables the subset that significantly predicts a response variable. This is done by evaluating potential models on a number of criteria:

1. **The multi-collinearity of predictor variables.**

   Predictor variables that are linearly related to each other (i.e., variables y and x, where y may also be mathematically expressed as some multiple of x) produce a condition known as multicollinearity, where the matrix math used to solve the multivariate linear regression becomes irreducible. A physical example of multicollinearity occurs when modelling the influence of two radionuclides in equilibrium with each other (e.g., Th-230 and Ra-226) on a single response variable (e.g., gamma count rate). In order to compute a mathematical solution to the regression model, one of the multicollinear variables must be removed from the regression matrix. The multicollinear variables are identifiable by a large variance inflation factor (VIF), typically greater than 7, but in cases of near-perfect multicollinearity, often much greater than this value (e.g., > 100).

   It is also possible to identify multicollinear predictor variables by regressing two suspect variables upon each other. A high degree of correlation (i.e., $p < 0.05$ and high adjusted R^2) between the two variables suggests that the predictor variables are multicollinear, and that one variable should be eliminated from the multivariate regression prior to analysis.

2. **The p-value of predictor variables**

   For a variable to be considered a significant predictor of the response variable, the p-value of its slope (as calculated in an ANOVA table) must be significant (i.e., $p < 0.05$). In a MLR, the adjusted R^2 value for individual predictor variables is not indicative of overall model quality.

For the Navajo Trust AUMs there are three potential gamma-contributing radionuclides (defined as radionuclides that emit gamma radiation, or whose short-lived decay products emit gamma radiation) present in soil: thorium-232, radium-226 and, thorium-228. Thorium-230, which does not emit gamma radiation, was excluded as a potentially significant gamma-contributing radionuclide.

A MLR model: gamma = radium-226 + thorium-228 + thorium-232 was run for each AUM. For 15 of the 16 mines, thorium-232 and thorium-228 were multicollinear. On this basis, thorium-228 was excluded from the MLR. No multicollinearity was detected at Barton 3. However, none of the predictor variables was a significant predictor of gamma count rate ($p > 0.05$) for the complete model. As such, analysis for all 16 AUMs proceeded by removing thorium-228 from the set of predictor variables and running a new MLR model: gamma = radium-226 + thorium-232. None of the 16 models exhibited multicollinearity with the reduced model. After accounting for the effect of radium-226, thorium-232 was not a significant predictor of gamma count rate at any of the 16 AUMs. Radium-226 was a significant predictor ($p < 0.05$) of gamma count rate (after accounting for the influence of thorium-232 and thorium-228) at some of the AUMs (six of 16 AUMs).

Since neither predictor variable (thorium-232 or radium-226) was unambiguously a predictor in the MLR, two univariate regression models were performed as a final step: gamma = radium-226 and gamma = thorium-232. Thorium-232 was a significant predictor of gamma count rate ($p < 0.05$) only at Standing Rock, which is not unexpected given the geological conditions at this AUM. At all other sites, thorium-232 (and thorium-228 by association) were not significant predictors of gamma count rate ($p > 0.05$). By way of contrast, radium-226 was a significant predictor of the gamma count rate ($p < 0.05$) at 13 of the 16 AUMs. At three AUMs (Mitten, NA-0928, and Tsosie 1) none of the measured radionuclides significantly predicted the gamma count rate. Additionally, the adjusted R^2 values for the correlation models at the three AUMs, plus Claim 28, fail to meet the specified data quality objective (DQO) of greater than 0.8.

The failure to construct statistically defensible correlation models at four AUMs has been identified as a data gap in the relevant AUM report. The unsatisfactory correlation result at these locations is likely due to the small number of correlation locations, or environmental conditions at the AUMs (e.g., spatial heterogeneity in radionuclide concentration in soil, topographic features influencing gamma count rate, etc.), or some combination thereof.

Note that while the statistical measures (i.e., conformance with the study DQO of $R^2 > 0.8$) associated with these regressions can be improved by fitting a power curve to the data, and reporting unadjusted R^2 values, with only five data points at each AUM, ERG does not believe that any statistical correlation model is sufficiently robust to make meaningful inferences concerning soil radium-226 concentration from the gamma scanning data. ERG believes that linear functions – not power curves – best mimic the conceptual model for the physical processes governing the observed data. Fitting any other function in an effort to achieve the study DQO for R^2 is not a statistically rigorous approach, and improving R^2 does not commensurately improve a statistical model's predictive ability. Figure *1* compares the result of fitting a linear versus a power function to the available correlation data for one AUM (Hoskie Tso); the other AUM results are similar.

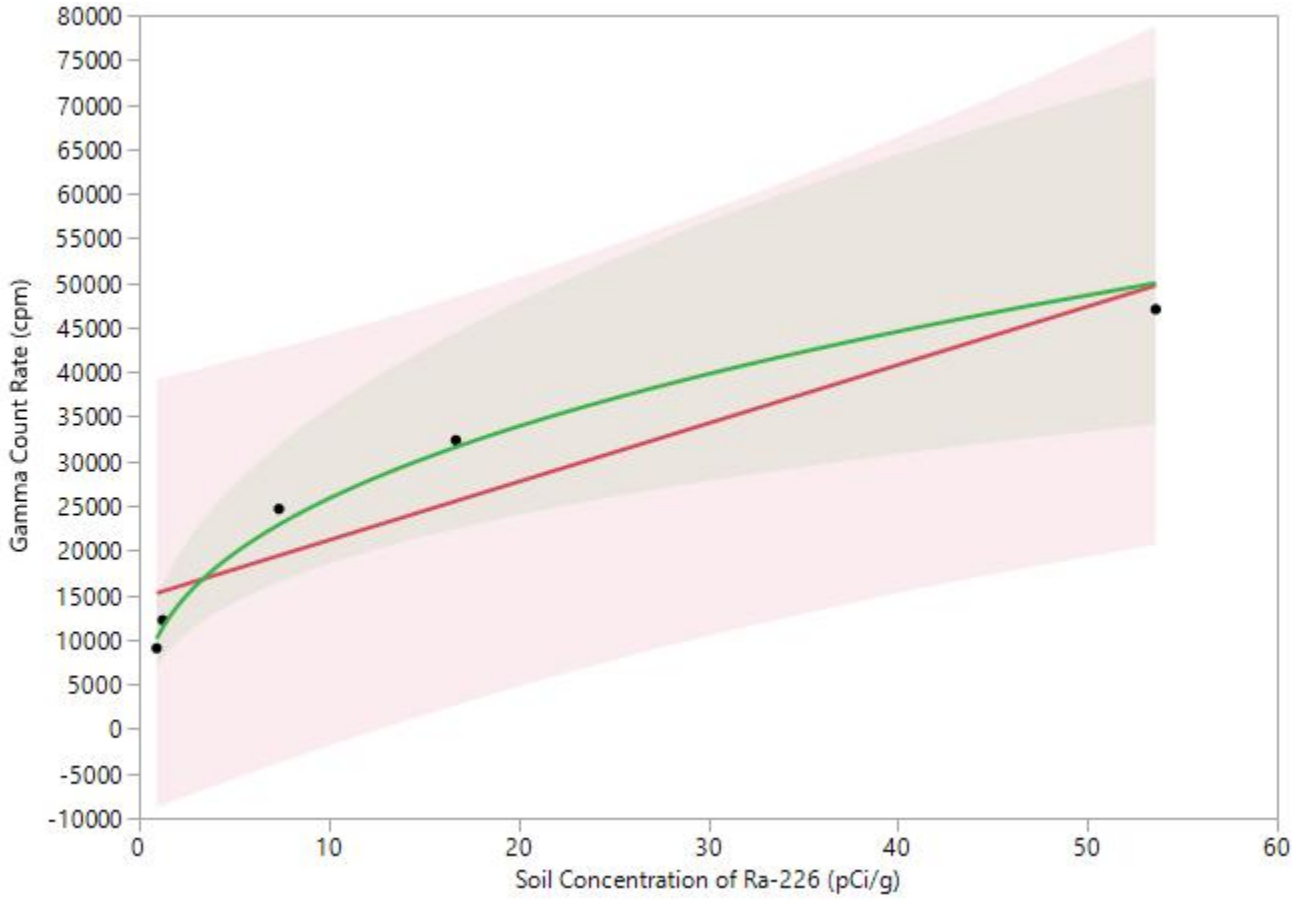

Figure 1. Regression models (linear versus power curve) for gamma count rate regressed on radium-226 showing 95% UPLs (upper prediction limits). Both models meet the study DQO for adjusted R^2 (greater than 0.8). Gamma count rate is not an especially strong predictor of soil concentration of radium-226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

ERG has updated the individual AUM reports with linear correlation functions and reported the more robust measures of statistical performance described in this memo.

Evaluation of Secular Equilibrium Between Ra-226 and Th-230

Secular equilibrium is a condition that occurs when the half-life of a decay-product nuclide is significantly shorter than that of its parent nuclide. After a period of ingrowth equal to approximately seven times the half-life of the decay product, the two nuclides effectively decay with the half-life of the parent. When two radionuclides are in secular equilibrium, their activities are equal.

Equilibrium, for the purpose of this report, is defined as a condition whereby a parent nuclide and its decay product are present in the environment at a fixed ratio, but this ratio – for whatever reason – is not a one-to-one relationship indicative of secular equilibrium. Most commonly, an equilibrium condition results from an environmental process which chemically selects for and

transports one nuclide (parent or decay product) away from the other nuclide. Because a consistent fraction of one nuclide has been removed, the two nuclides are present at a fixed ratio other than one-to-one.

Determination of secular equilibrium for an AUM can be an important part of the risk assessment process, as the assumed fraction of radium-226 decay products present in the environment greatly influences a hypothetical receptor's radiation dose and mortality risk. However, it is also acceptable and conservative to assume secular equilibrium between radium-226 and its decay products for the purpose of risk assessment, and therefore to avoid the need to conclusively determine the secular equilibrium status of an AUM. Thus, an inconclusive result regarding secular equilibrium is not a study data gap, as the risk assessment phase may still proceed, provided that conservative assumptions are included regarding equilibrium concentrations of radium-226 decay products.

Regardless, the Navajo Nation AUM Environmental Response Trust RSE workplan specified that an evaluation of secular equilibrium would be made at each of the 16 Trust AUMs, and so a robust statistical examination of secular equilibrium status for radium-226 and its decay products at each AUM was conducted. One method of evaluating equilibrium between Ra-226 and Th-230 is to calculate the ratio (φ) between the two nuclides for each soil sample location, i.e.,

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

When φ is unity, the two nuclides may be said to be in secular equilibrium. Sometimes, φ is averaged over a number of locations, and if the average is unity, the population of measurement locations is said to be in secular equilibrium. Similarly, if φ is consistently some number other than one, it may be concluded that the measured population is in equilibrium. This approach does not account for the statistical uncertainty associated with making inferences across a population, nor the bias introduced into the measurement by averaging a potentially large number of ratios. It is also difficult to establish defensible cutoffs for whether Ra-226 and Th-230 are in secular equilibrium at a particular site using a ratio approach, as there is no objective basis for concluding, e.g., that φ must be between 0.8 and 1.2 (versus any other range of values for φ) for secular equilibrium to occur.

Due to a large number of reviewer comments concerning secular equilibrium within the RSE reports, Environmental Restoration Group opted to re-evaluate equilibrium at each mine site using a more robust statistical method: simple linear regression. This was done after confirming the methods to analyze Ra-226 (EPA Method 901.1) and Th-230 (alpha spectroscopy following sample digestion with hydrofluoric acid) are both total-activity methods with comparable results (L. Steere, ALS personal email communication, July 25, 2018). Evaluation of secular equilibrium for each mine site proceeded as follows:

1. Construction of a figure that depicts soil concentrations of Th-230 plotted against soil concentrations of Ra-226.

2. Simple linear regression is performed on the dataset; the p-value and the adjusted R^2 are recorded. The resulting linear model and the 95% UCL (upper confidence limit) bands are plotted on the figure generated in step 1.

3. The line y=x is added to the figure generated in step 2 (this line represents a perfect 1:1 ratio between Th-230 to Ra-226, indicative of secular equilibrium).

4. An examination of the model and the figure is made sequentially:

    a. If the p-value for the regression slope is insignificant (i.e., $p > 0.05$) or the adjusted R^2 does not meet the study's data quality objective (Adjusted $R^2 > 0.8$), ERG concludes that there is insufficient evidence to conclude that Ra-226 and Th-230 are in equilibrium (secular or otherwise) therefore, it is listed as inconclusive (no equilibrium). Figure *2* depicts the regression result for an AUM (Mitten) that failed to meet the p-value and adjusted R^2 criteria.

    b. If the p-value for the regression slope is significant (i.e., $p < 0.05$) and the adjusted R^2 meets the DQO (Adjusted $R^2 > 0.8$) there are two possible conditions, which are evaluated via visual examination of the figure generated in step 3.

        i. If the y=x line falls fully within the bounds of the 95% UCL bands on the regression, ERG concludes that there is evidence that Ra-226 and Th-230 are in secular equilibrium at the site. Figure *3* depicts the regression result for an AUM (Harvey Blackwater) where there is evidence that Ra-226 and Th-230 are in secular equilibrium.

        ii. If the y=x line falls partially or completely outside the bounds of the 95% UCL bands on the regression, ERG concludes that there is evidence that Ra-226 and Th-230 are in equilibrium, but not secular equilibrium at the site. Figure *4* depicts the regression result for an AUM (Alongo Mines) where there is evidence that Ra-226 and Th-230 are in equilibrium, but not secular equilibrium.

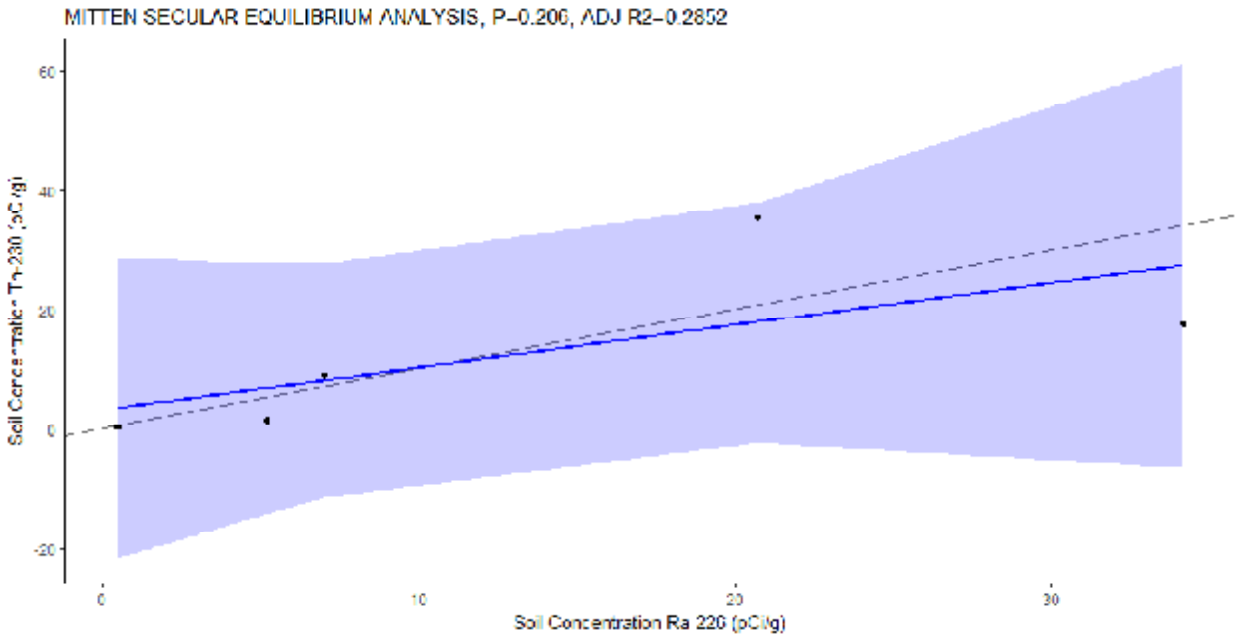

Figure 2. Result for Mitten secular equilibrium analysis, showing failure to meet p-value and adjusted R^2 criteria, i.e., the data are poorly correlated.

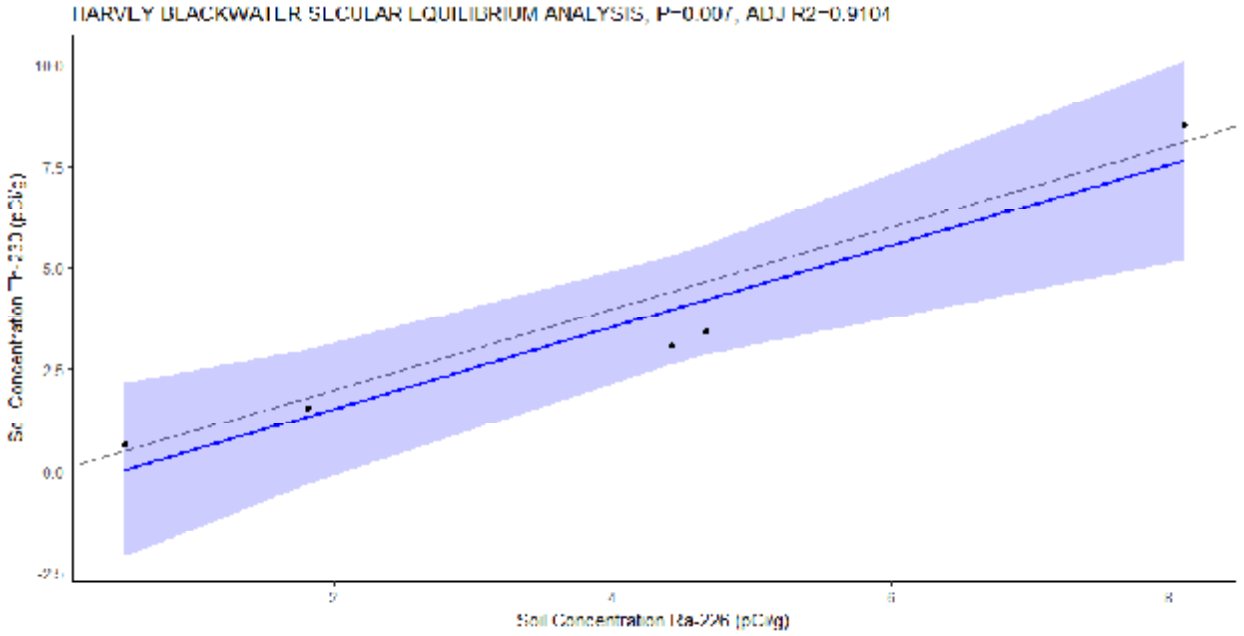

Figure 3. Result for Harvey Blackwater secular equilibrium analysis, showing excellent correlation between the data and the y=x line, i.e., Th-230 and Ra-226 are in secular equilibrium.

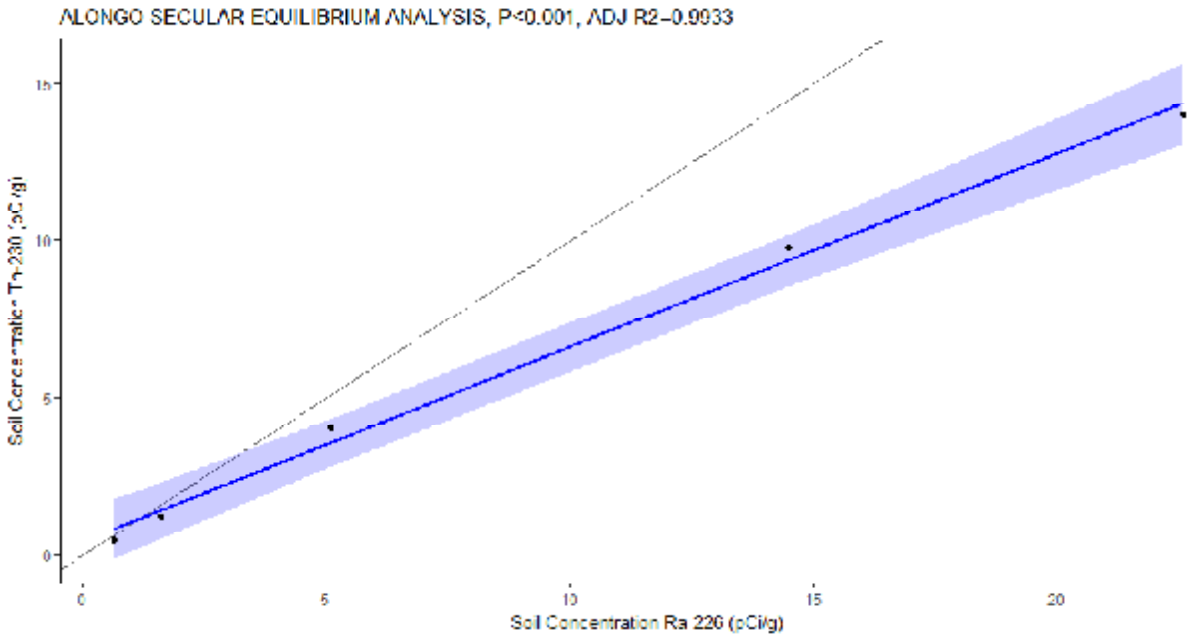

Figure 4. Result for Alongo Mines secular equilibrium analysis, showing excellent correlation between the data, but poor agreement with the y=x line, i.e., Th-230 and Ra-226 are in equilibrium, but not secular equilibrium.

ERG tested for secular equilibrium at each of the 16 Navajo AUMs using the process described above. The results are summarized in Table 1 and in the RSE report for each AUM, respectively. ERG concluded that the data provide evidence that that Ra-226 and Th-230 are in secular equilibrium in soils at two mines (Harvey Blackwater and NA-0928). At one mine (Mitten) there was insufficient evidence to draw any conclusions regarding equilibrium. At the remaining sites, there is evidence that Ra-226 and Th-230 are in equilibrium.

Table 1. Results of secular equilibrium analysis for each of the 16 Navajo Trust AUMs.

Mine	p-value	Adjusted R^2	Conclusion
Alongo Mine	<0.001	0.99	Equilibrium
Barton 3	<0.001	0.98	Equilibrium
Boyd Tisi	<0.001	0.99	Equilibrium
Charles Keith	<0.001	0.99	Equilibrium
Claim 28	<0.001	0.99	Equilibrium
Eunice Becenti	<0.001	0.99	Equilibrium
Harvey Blackwater	0.008	0.91	Secular Equilibrium
Hoskie Tso	<0.001	0.99	Equilibrium
Mitten	0.2	0.29	No Equilibrium
NA-0904	0.001	0.98	Equilibrium
NA-0928	0.002	0.97	Secular Equilibrium
Oak 124-125	<0.001	0.99	Equilibrium
Occurrence B	<0.001	0.98	Equilibrium
Section 26	0.002	0.96	Equilibrium
Standing Rock	0.008	0.91	Equilibrium
Tsosie 1	0.02	0.86	Equilibrium

Appendix D Preliminary Report “NA-0904 Abandoned Uranium Mine”

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

Radiological Characterization of the NA-0904 Abandoned Uranium Mine

Preliminary

January 22, 2018

prepared for:

Stantec Consulting Services Inc.

2130 Resort Drive, Suite 350
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Appendix B	Exposure Rate Measurements

Acronyms

ANSI	American National Standards Institute
AUM	abandoned uranium mine
BG2	Background Reference Area 2
BG3	Background Reference Area 3
BG4	Background Reference Area 4
cpm	counts per minute
DQOs	data quality objectives
ERG	Environmental Restoration Group, Inc.
ft	foot
GPS	global positioning system
MDL	method detection limit
µR/h	microRoentgens per hour
pCi/g	picocuries per gram
R^2	Pearson's Correlation Coefficient
RSE	removal site evaluation
σ	standard deviation
Stantec	Stantec Consulting Services Inc.

Executive Summary

This report addresses the radiological characterization of the NA-0904 abandoned uranium mine (AUM) located in the Sweetwater Chapter of the Navajo Nation near Red Mesa, Arizona. 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 3, September 27, 28, and 30, and October 4 and 11, 2016; and March 23, April 11, and September 12 and 14, 2017. They included a GPS-based radiological survey of land surfaces over a Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, areas where the survey was extended; and correlation studies.

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in "NA-0904 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 waste rock situated at the western edge of the mine claim and in a drainage extending from that area.

- Three potential Background Reference Areas were established.

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

  Radium-226 Concentration (picocuries per gram [pCi/g]) = 8×10^{-9} (Gamma Count Rate^2 in counts per minute [cpm]) + 1×10^{-4} (Gamma Count Rate)- 0.6825

- 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 348.0, with a central tendency (median) of 1.1 pCi/g.

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

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

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

  Exposure Rate (microRoentgens per hour [µR/h]) = Gamma Count Rate (cpm) x $5x10^{-4}$ + 6.7233

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 9.6 to 108.0, with a central tendency (median) of 11.6 µR/h.

1.0 Introduction

This report addresses the radiological characterization of the NA-0904 abandoned uranium mine (AUM) located in the Sweetwater Chapter of the Navajo Nation near Red Mesa, Arizona. 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 3, September 27, 28, and 30, and October 4 and 11, 2016; and March 23, April 11, and September 12 and 14, 2017. They included a GPS-based radiological survey of land surfaces over an approximately 26-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 "NA-0904 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 "NA-0904 Removal Site Evaluation Report" (Stantec, 2018).

2.0 GPS-Based Gamma Surveys

This section addresses the GPS-based surveys conducted in three potential Background Reference Areas and the Survey Area. The survey was extended to bound areas in which elevated count rates were observed. Table 1 lists the detection systems used in the survey, which were function-checked before and after each day of use and within calibration, in accordance with American National Standards Institute (ANSI) Standard N232A (ANSI, 1997). Appendix A presents the completed function check forms and calibration certificates for the instruments.

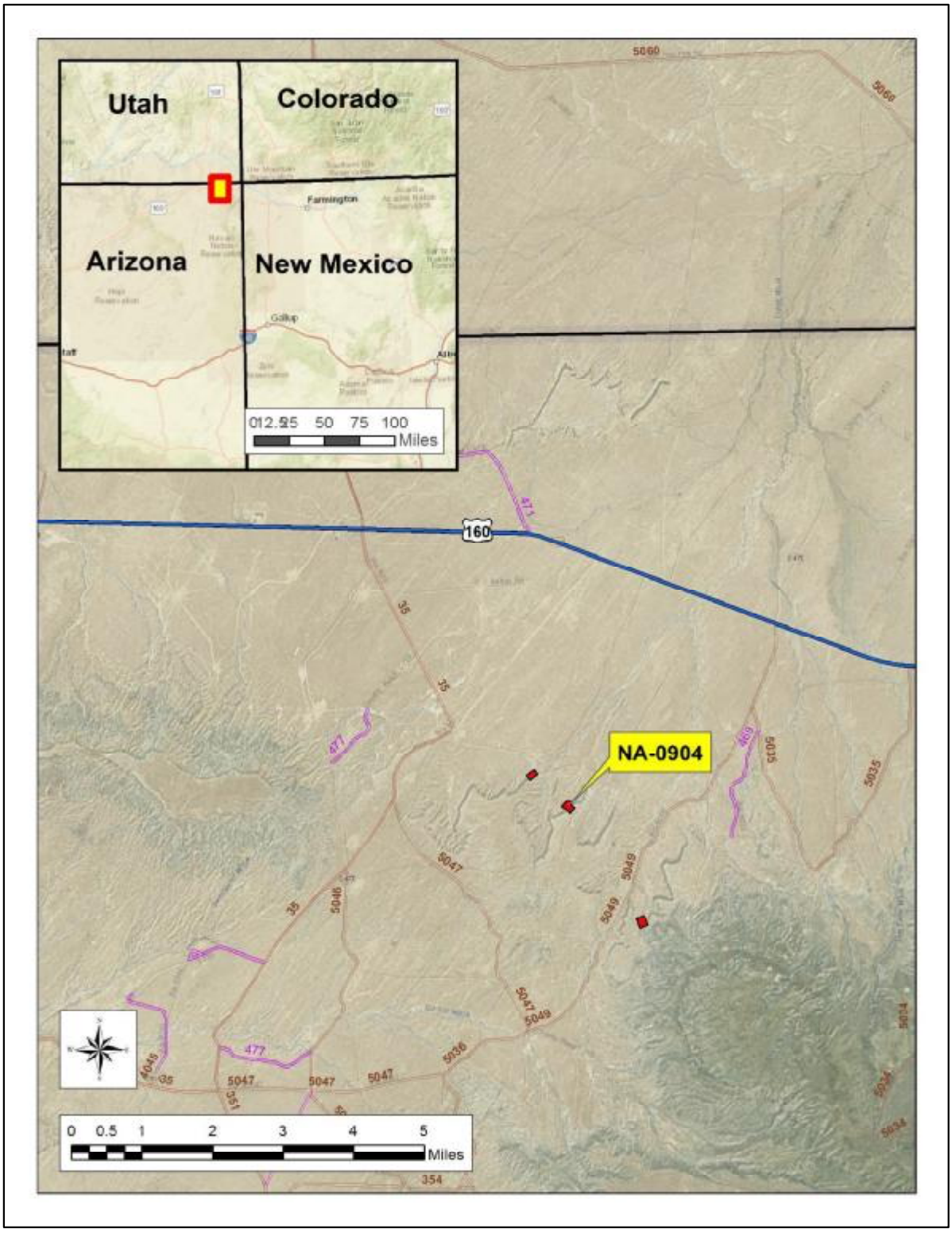


Figure 1. Location of the NA-0904 Abandoned Uranium Mine

Table 1. Detection systems used in the GPS-Based gamma surveys.

Survey Area	Ludlum Model 44-10	Ludlum Model 2221 Ratemeter/Scaler
Potential Background Reference Areas	PR303727[a]	254772 [a]
	PR355763	138368
Survey Area	PR295014	196086
	PR295017	271435
	PR303727[a]	254772 [a]
	PR355763	138368

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

2.1 Potential Background Reference Areas

Three potential Background Reference Areas were surveyed, the locations and results of which are depicted on Figure 2. BG2, BG3, and BG4 in the figure are Background Reference Areas 2, 3, and 4, respectively. These potential Background Reference Areas are the same as those used for AUM NA-0928, which is shown in the figure for its proximity to NA-0904. Table 2 lists a summary of the gamma count rates, which in:

- BG2 ranged from 7,118 to 13,741 counts per minute (cpm), with a mean and median of 9,369 and 9,310 cpm, respectively.
- BG3 ranged from 5,599 to 12,226 cpm, with a mean and median of 8,668 and 8,490 cpm, respectively.
- BG4 ranged from 7,158 to 10,204 cpm, with a mean and median of 8,463 and 8,430 cpm, respectively.

Figure 3 depicts histograms of the gamma count rates in in the Background Reference Areas. The red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could be expected if the distributions were normal or lognormal.

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

	Gamma Count Rate (cpm)					
Potential Background Reference Area	**n**	**Minimum**	**Maximum**	**Mean**	**Median**	**Standard Deviation**
2	328	7,118	13,741	9,369	9,310	948
3	378	5,599	12,226	8,668	8,490	999
4	70	7,158	10,204	8,463	8,430	729

Notes:
cpm = counts per minute

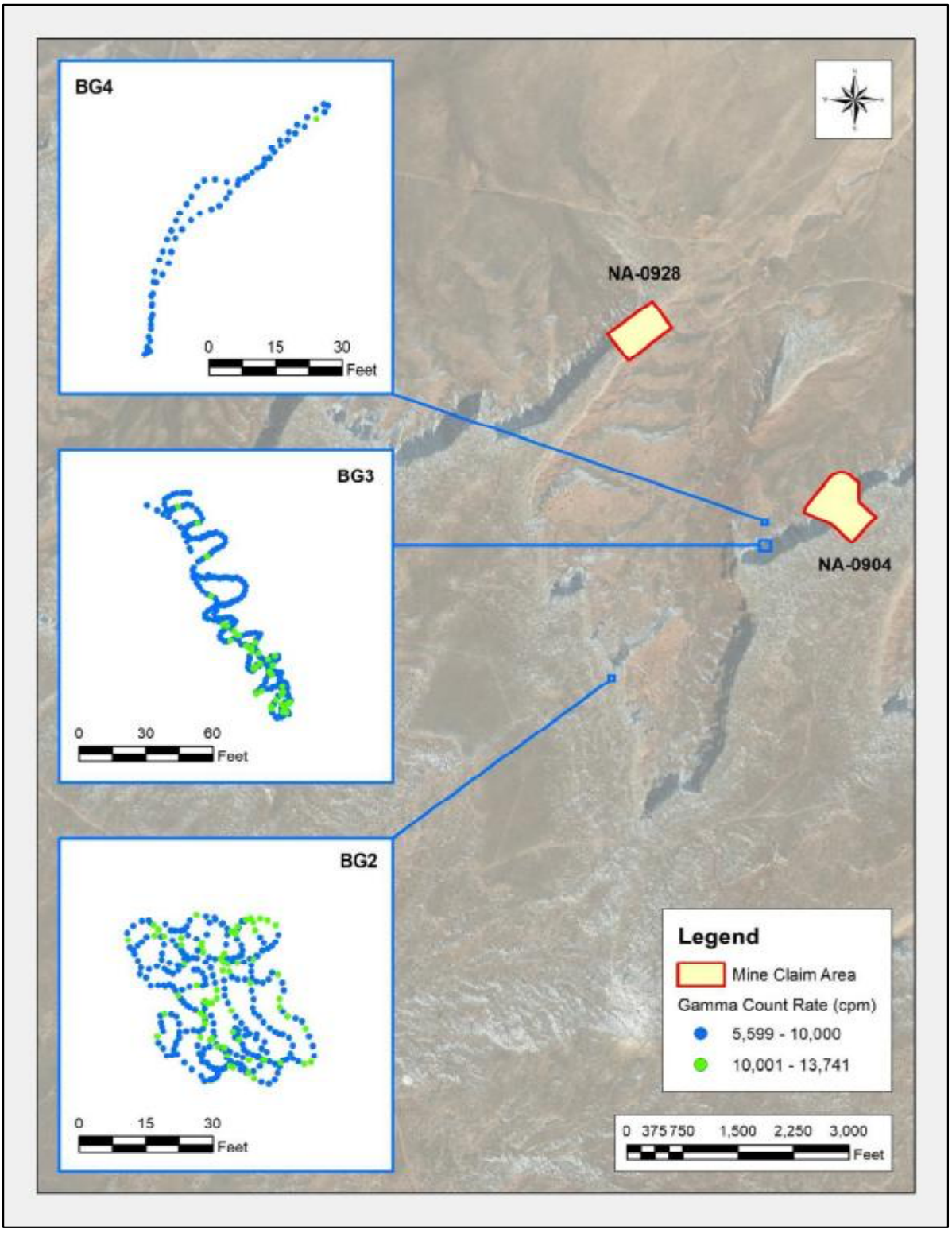
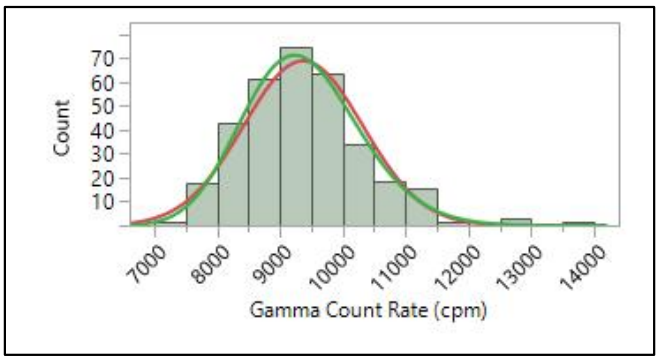
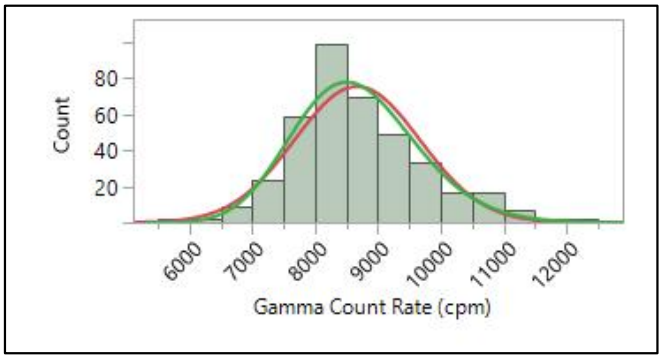


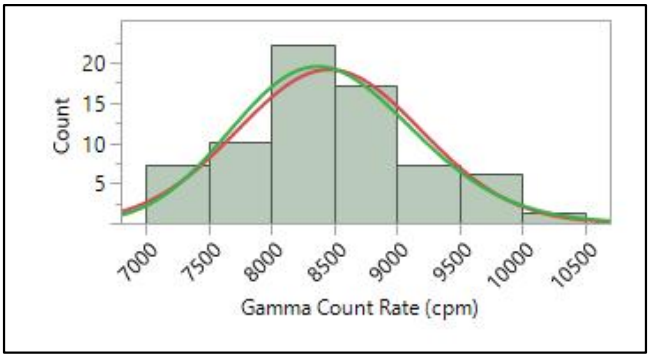
Figure 2. Gamma count rates in the potential Background Reference Areas.



a. Background Reference Area 2



b. Background Reference Area 3



a. Background Reference Area 4

Figure 3. Histograms of gamma count rates in the Background Reference Areas.

2.2 Survey Area

The gamma count rates observed in the Survey Area are depicted in Figure 4. Elevated count rates were observed largely on waste rock situated at the western edge of the mine claim and in a drainage extending from that area.

Figure 5 is a histogram of the gamma count rate measurements made in the Survey Area, including the area surveyed outside the 100-ft buffer. As stated in Section 2.1, the red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could be expected if the distributions were normal or lognormal. The distribution of the right-tailed set of measurements, evaluated using U.S. Environmental Protection Agency software ProUCL (version 5.1.002), is not defined; i.e., neither normal or logarithmic. The box plot in Figure 6 depicts cutoffs as horizontal bars, from bottom to top, for the following values or percentiles: minimum, 0.5, 2.5, 10, 25, 50, 75, 90, 97.5, 99.5, and maximum. The 25th, 50th, and 75th percentiles (the three horizontal lines of the box inside the box plot) are 8,930, 9,822, and 11,740 cpm, respectively.

Table 3 is a statistical summary of the measurements, which range from 5,835 to 202,616 cpm and have a central tendency (median) of 9,822 cpm.

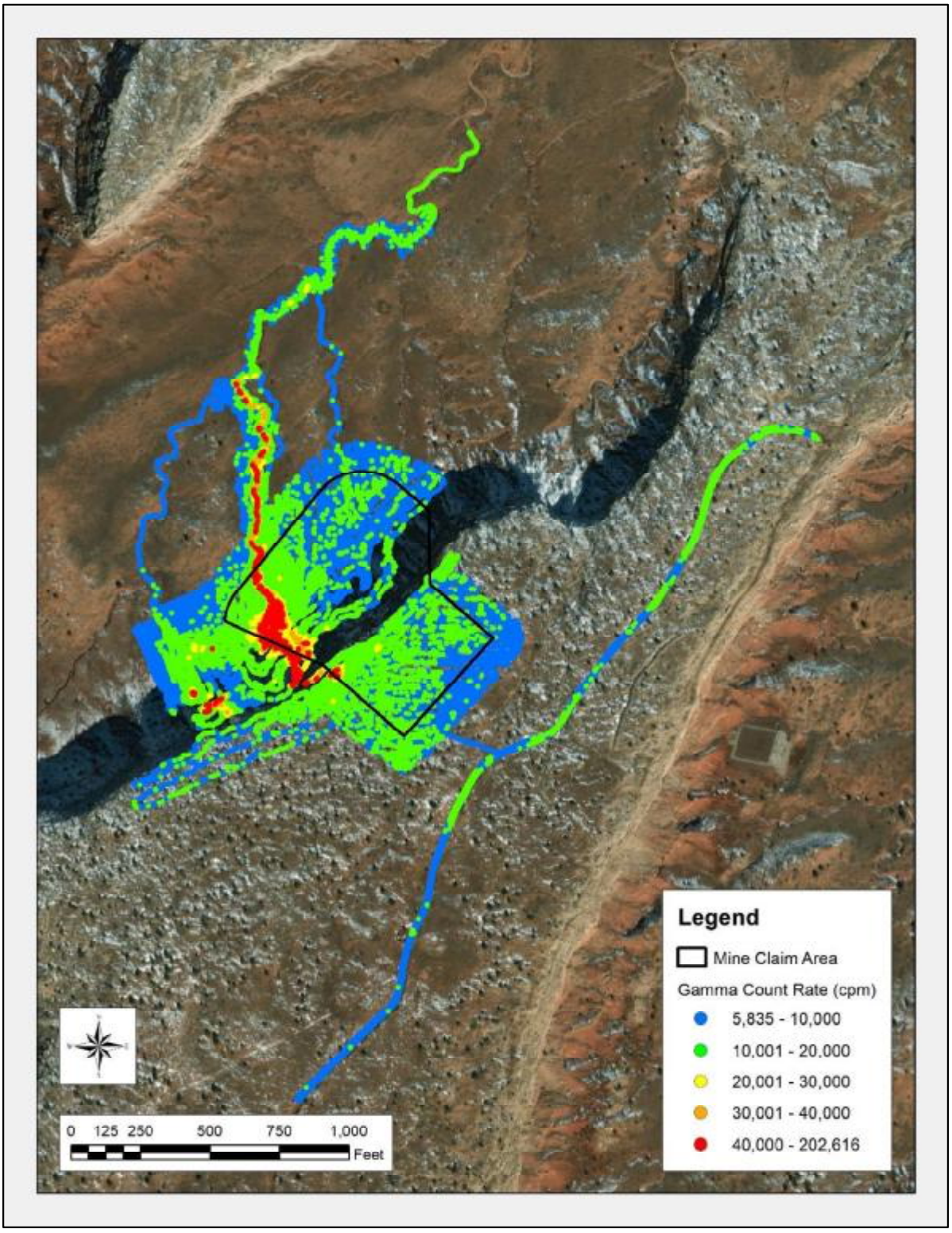


Figure 4. Gamma count rates in the Survey Area.

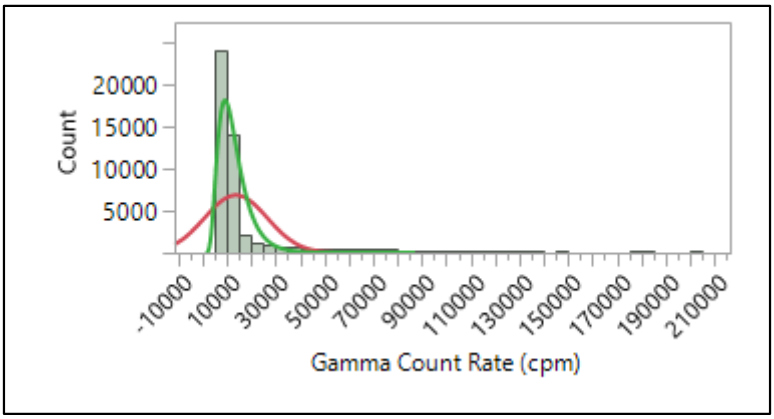


Figure 5. Histogram of gamma count rates in the Survey Area.

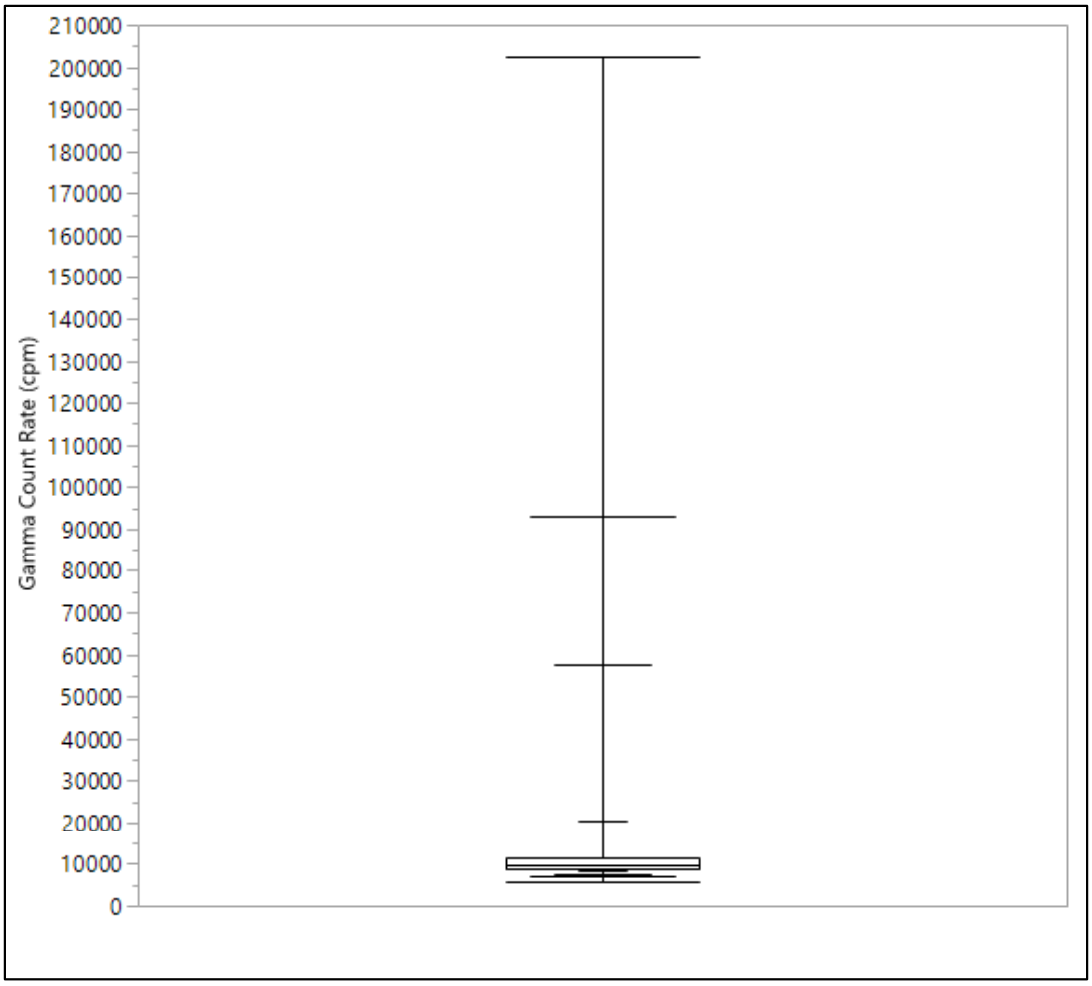


Figure 6. Box plot of gamma count rates in the Survey Area.

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

Parameter	Gamma Count Rate (cpm)
n	44,138
Minimum	5,835
Maximum	202,616
Mean	13,644
Median	9,822
Standard Deviation	12,891

Notes:
cpm = counts per minute

3.0 Correlation Studies

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

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

On October 11, 2016 field personnel made GPS-based gamma count rates measurements and collected five-point composite samples of surface soils in each of five areas at the AUM. The activities were performed contemporaneously, by area and all on the same day, such that 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 9,061 to 107,374 cpm. The concentrations of radium-226 in the soil samples range from 0.97 to 110 picocuries per gram (pCi/g).

Table 5 lists the concentrations of isotopes of thorium (thorium-228, -230, and -232) in the same soil samples.

Laboratory analyses are presented in Appendix D, Laboratory Analytical Data and Data Usability Report, in “NA-0904 Removal Site Evaluation Report” (Stantec, 2018).

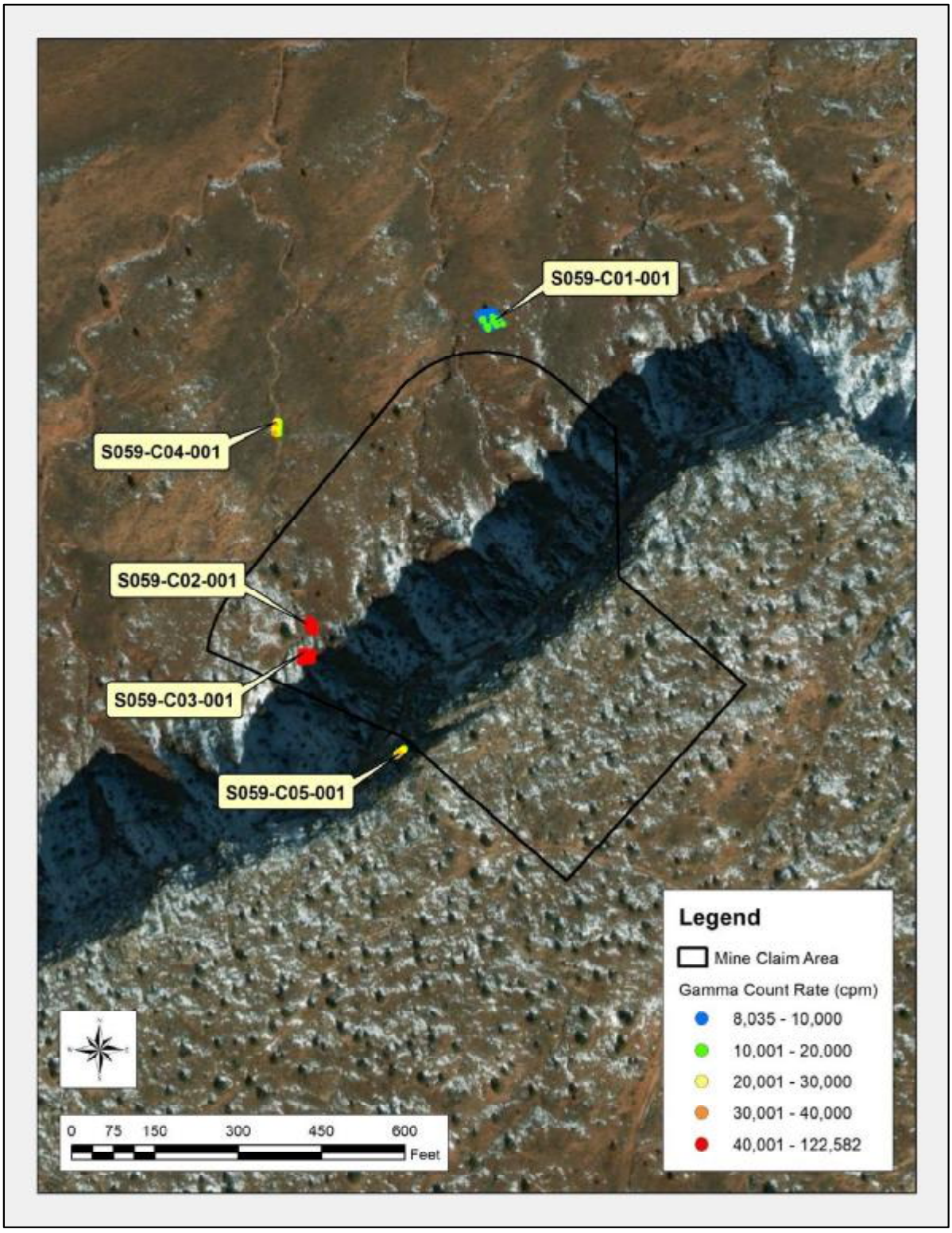


Figure 7. GPS-based gamma count rate measurements made for the correlation study.

Table 4. Gamma count rates and associated concentrations of radium-226 in samples of surface soils obtained in the correlation study.

	Gamma Count Rate (cpm)				Ra-226 (pCi/g)		
Location	Mean	Minimum	Maximum	σ	Result	Error ±1σ	MDL
S059-C01-001	9,061	8,035	11,004	509	0.97	0.25	0.41
S059-C02-001	53,561	30,842	77,719	9,894	31.3	3.8	1
S059-C03-001	107,374	82,023	122,582	9,194	110	13	1
S059-C04-001	20,434	13,753	30,386	4,026	9.4	1.2	0.5
S059-C05-001	24,825	17,507	33,467	4,623	4.04	0.6	0.48

Notes:
cpm = counts per minute
MDL = method detection limit
pCi/g = picocuries per gram
σ = standard deviation

Table 5. Concentrations of isotopes of thorium in samples of surface soils obtained in the correlation study.

	Thorium-228 (pCi/g)			Thorium-230 (pCi/g)			Thorium-232 (pCi/g)		
Sample ID	Result	Error ± 1 σ	MDL	Result	Error ± 1 σ	MDL	Result	Error ± 1 σ	MDL
S059-C01-001	0.43	0.086	0.029	0.76	0.14	0.07	0.377	0.076	0.015
S059-C02-001	0.52	0.1	0.03	25.1	3.9	0.1	0.477	0.093	0.013
S059-C03-001	0.59	0.11	0.04	175	27	0	0.73	0.13	0.03
S059-C04-001	0.376	0.082	0.046	6.4	1	0.1	0.388	0.08	0.026
S059-C05-001	0.57	0.11	0.05	3.17	0.51	0.07	0.65	0.12	0.02

Notes:
MDL = method detection limit
pCi/g = picocuries per gram
σ = standard deviation

A model was made of the results in Table 4, predicting the concentrations of radium-226 in surface soils from the mean gamma count rate in each area. The best predictive relationship between the measurements, shown in Figure 8, is a strong, polynomial function with a Pearson's Correlation Coefficient (R^2) of 0.9964, as expressed in the equation:

$$\text{Radium-226 Concentration (pCi/g)} = 8\text{x}10^{-9}\,(\text{Gamma Count Rate}^2\,\text{in cpm}) + 1 \text{ x } 10^{-4}\,(\text{Gamma Count Rate}) - 0.6825$$

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 0.992898 and 0.0036, respectively; these parameters are not data quality objectives (DQOs) and are included only as information.

The concentrations of thorium-232 and thorium-228, isotopes in the thorium series, in the correlation samples are similar and at most 0.73 pCi/g. Given these low concentrations and the high R^2 of the polynomial 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 348.0 pCi/g, with a mean and median of 3.5 and 1.1 pCi/g, respectively. Note that the radium-226 concentrations predicted from gamma count rate measurements exceeding approximately 108,000 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.

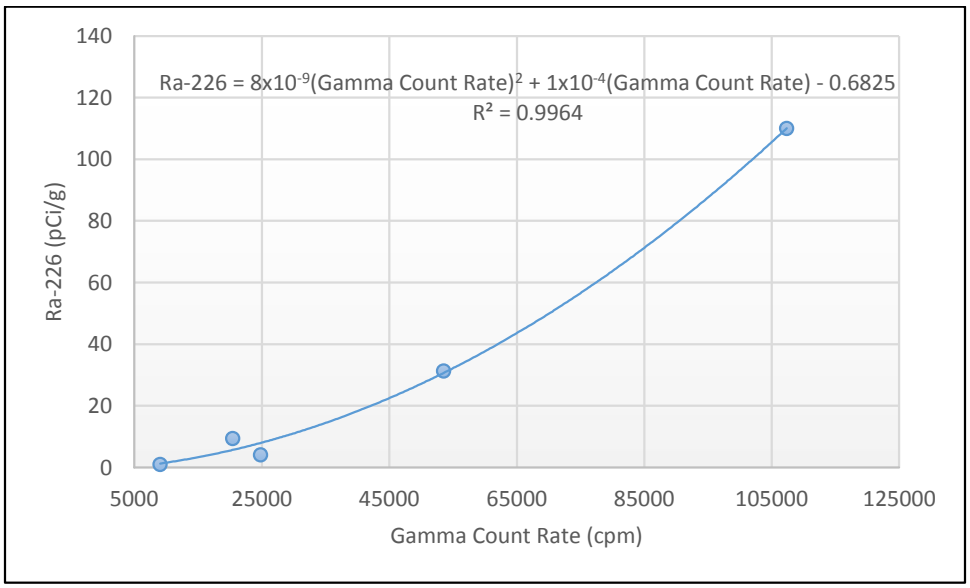


Figure 8. Correlation of gamma count rates and concentrations of radium-226 in surface soils.

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

Parameter	Radium-226 (pCi/g)
n	44,138
Minimum	0.2
Maximum	348.0
Mean	3.5
Median	1.1
Standard Deviation	10.7

Notes:
pCi/g = picocuries per gram

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 S059-C01-001), 1.2 (Sample S059-C02-001), 0.6 (Sample S059-C03-001), 1.5 (Sample S059-C04-001), and 1.3 (Sample S059-C05-001) indicating that in four of the five samples 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.

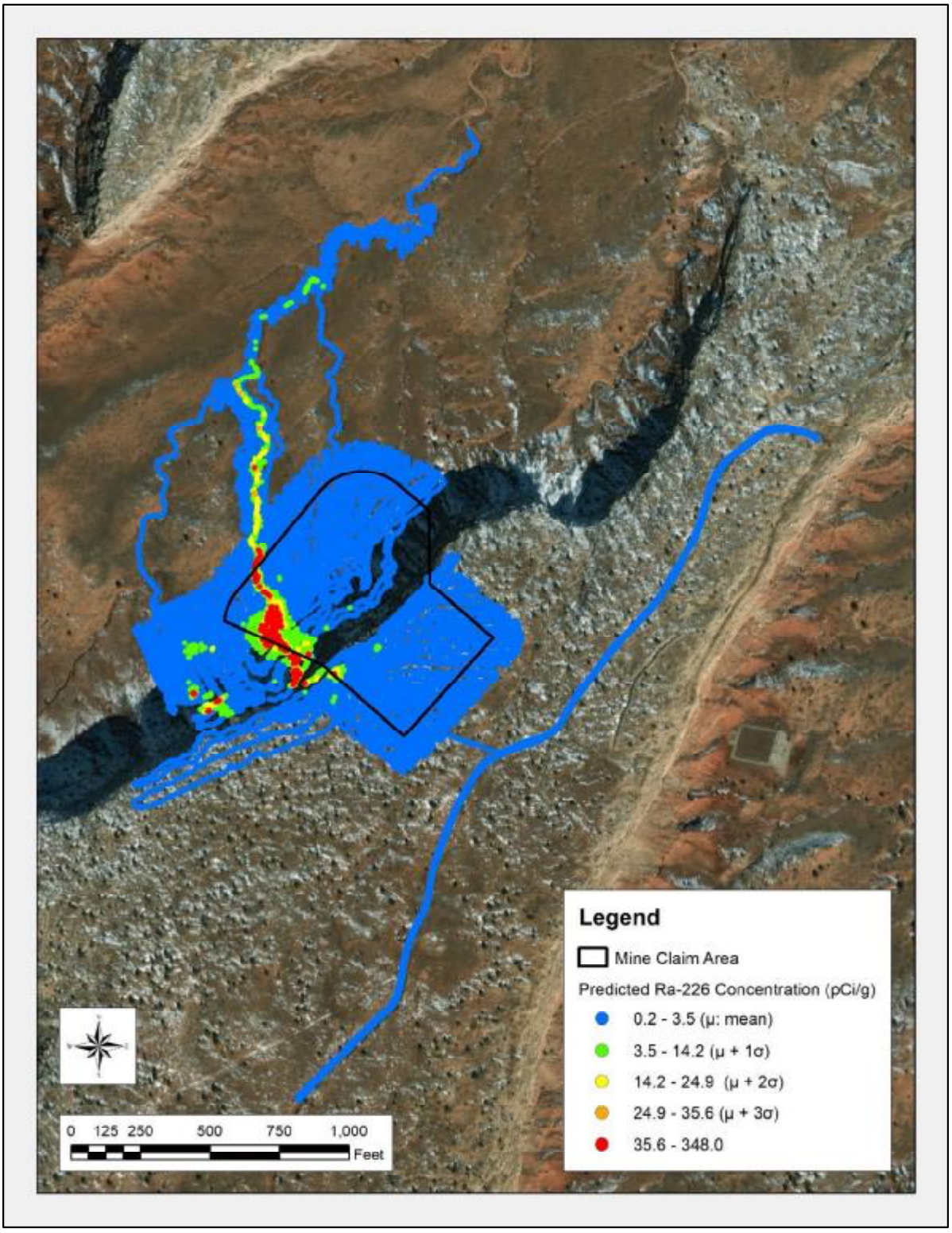


Figure 9. Predicted concentrations of radium-226 in the Survey Area.

3.3 Exposure rates and gamma count rates

On October 11, 2016 field personnel made co-located one-minute static count rate and exposure rate measurements at the five locations within the Survey Area, representing the range of gamma count rates obtained in the GPS-based gamma survey. Figure 7 shows the locations of the co-located measurements, which were made in the centers of the areas.

The gamma count rate and exposure rate measurements were made at 0.5 m and 1 m above the ground surface, respectively. The gamma count rate measurements were made using one of the sodium iodide detection systems used in the GPS-based gamma survey of the AUM (Serial Number PR303727/254772). The exposure rate measurements were made using a Reuter Stokes Model RSS-131 (Serial Number 07J00KM1) high pressure ionization chamber (HPIC) at six-second intervals for about 10 minutes. The exposure rates used in the comparison was the mean of these measurements, less those occurring in initial instrument spikes. The HPIC was in current calibration and function checked before and after use. Calibration forms for the HPIC are provided in Appendix A. Table 7 presents the results for the two types of measurements made at each of the five locations. Appendix B presents the individual (one second) exposure rate measurements.

The best predictive relationship between the measurements is linear with an R^2 of 0.9998 indicating a strong, positive correlation. The root mean square error and p-value for the model are 0.363327 and less than 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:

$$\text{Exposure Rate (microRoentgens per hour [µR/h])} = 5\text{x}10^{-4} \text{ x Gamma Count Rate (cpm)} + 6.7233$$

Figure 11presents 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 three Background Reference Areas and AUM, respectively.

The range of predicted exposure rates at:

- BG2 is 10.3 to 13.6 µR/h, with a mean and median of 11.4 µR/h
- BG3 is 9.5 to 12.8 µR/h, with a mean and median of 11.1 and 11.0 µR/h, respectively
- BG4 is 10.3 to 11.8 µR/h, with a mean and median of 11.0 and 10.9 µR/h, respectively

The range of predicted exposure rates at the AUM is 9.6 to 108.0 µR/h, with a mean and median of 13.5 and 11.6 µR/h, respectively.

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

Location	Gamma Count Rate (cpm)	Exposure Rate (µR/h)
S059-C01-001	9,095	11.4
S059-C02-001	58,078	36.3
S059-C03-001	115,596	66.3
S059-C04-001	20,089	17.5
S059-C05-001	29,337	21.5

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

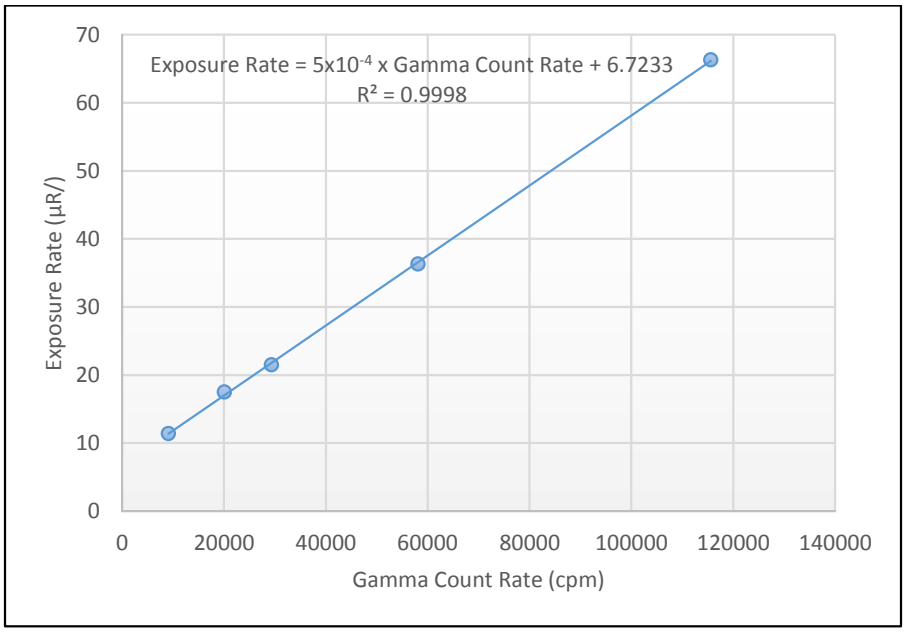


Figure 10. Correlation of gamma count rates and exposure rates.

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

Potential Background Reference Area	BG2	BG3	BG4
Parameter	Exposure Rate (µR/h)		
n	328	378	70
Minimum	10.3	9.5	10.3
Maximum	13.6	12.8	11.8
Mean	11.4	11.1	11.0
Median	11.4	11.0	10.9
Standard Deviation	0.5	0.5	0.4

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

Table 9. Predicted exposure rates in the Survey Area.

Parameter	Exposure Rate (µR/h)
n	44,138
Minimum	9.6
Maximum	108.0
Mean	13.5
Median	11.6
Standard Deviation	13.5

Notes:
µR/h = microRoentgens per hour

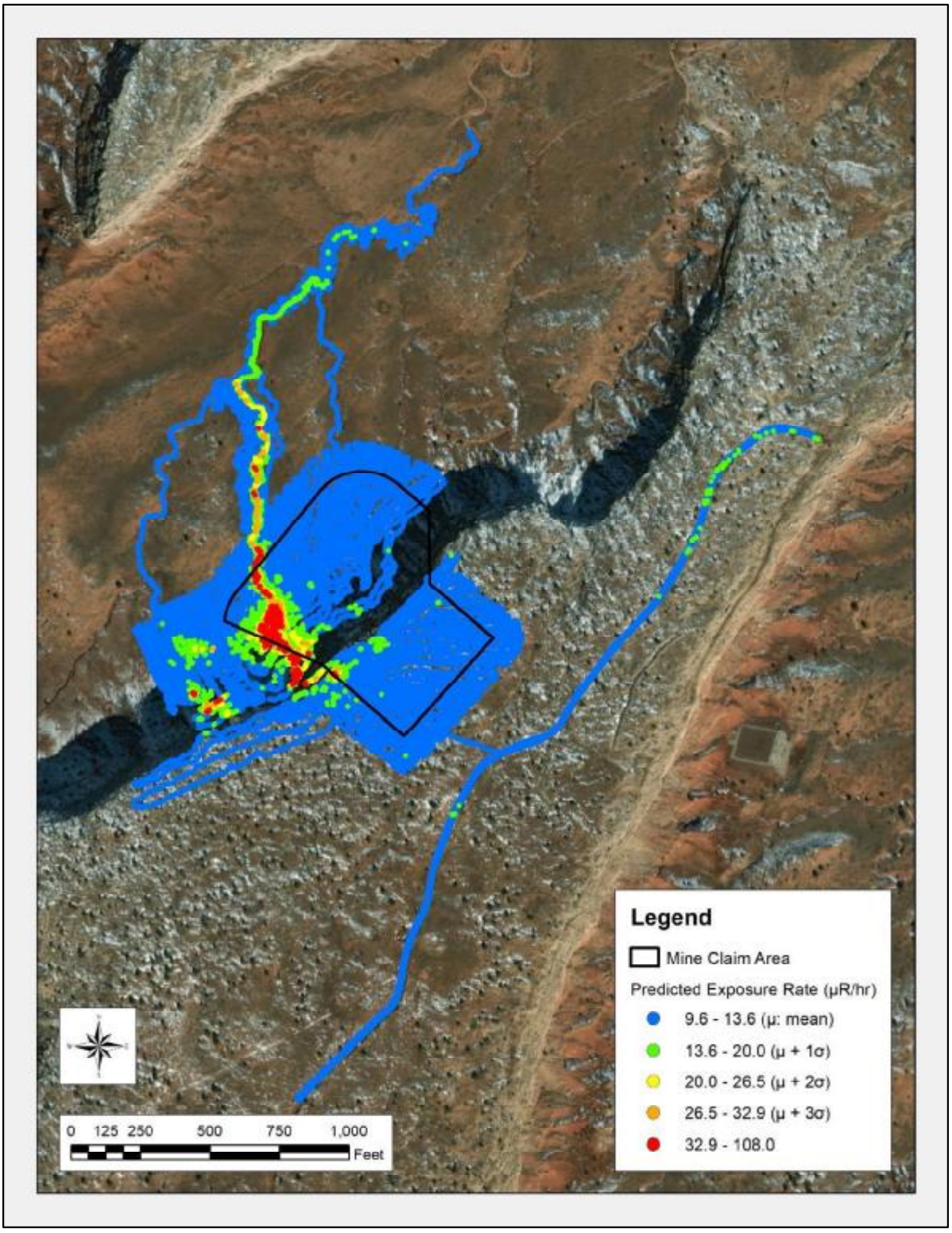


Figure 11. Predicted exposure rates in the Survey Area.

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 waste rock situated at the western edge of the mine claim and in a drainage extending from that area.

- Three potential Background Reference Areas were established.

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

  $$\text{Radium-226 Concentration (pCi/g)} = 8\text{x}10^{-9}\,(\text{Gamma Count Rate}^2 \text{ in cpm}) + 1 \text{ x } 10^{-4}\,(\text{Gamma Count Rate}) - 0.6825$$

- 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 348.0, with a central tendency (median) of 1.1 pCi/g.

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

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

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

  $$\text{Exposure Rate (µR/h)} = \text{Gamma Count Rate (cpm)} \times 5\text{x}10^{-4} + 6.7233$$

  The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 9.6 to 108.0, with a central tendency (median) of 11.6 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. NA-0904 Removal Site Evaluation Report, January 2018.

Appendix A Instrument calibration and completed function check forms

Certificate of Calibration

Calibration and Voltage Plateau

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

Meter: Manufacturer: Ludlum Model Number: 2221r Serial Number: 254772

Detector: Manufacturer: Ludlum Model Number: 44-10 Serial Number: PR303727

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

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

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

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

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

Threshold: 10 mV

Window:

Barometric Pressure: 24.6 inches Hg

Temperature: 73 °F

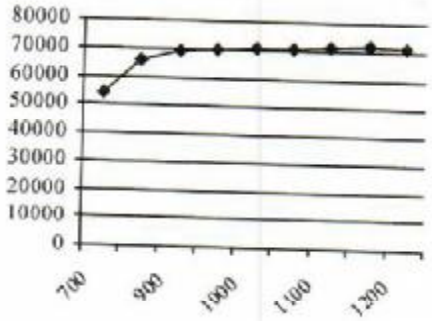
Relative Humidity: 20 %

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

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	398773	400
x 1000	100	100	100		100
x 100	400	400	400	39887	400
x 100	100	100	100		100
x 10	400	400	400	3988	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	53957	
800	65946	
900	69049	
950	69687	
1000	70240	9925
1050	70288	
1100	71224	
1150	71563	
1200	71161	

Voltage Plateau



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

Reference Instruments and/or Sources:

Ludlum pulser serial number: [ ] 97743 [x] 201932

[ ] Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03

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

Fluke multimeter serial number: [ ] 8749012

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

[ ] Other Source:

Calibrated By:

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

Reviewed By:

Date: 1/20/16

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
- ✔ 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: 24.78 inches Hg

Temperature: 74 °F

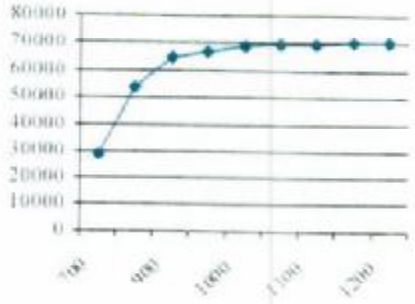
Relative Humidity: 20 %

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:

Calibration Date: 7/20/16 Calibration Due: 7/20/17

Reviewed By:

Date: 7/20/16

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

Certificate of Calibration

Calibration and Voltage Plateau

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

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

- ✔ 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: 24.24 inches Hg

Temperature: 78 °F

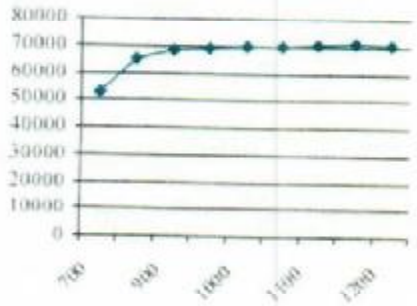
Relative Humidity: 20 %

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]

Reviewed By: [signature]

Calibration Date: ~~2 March 17~~ 2/28/17 ASH

Calibration Due: ~~2 March 18~~ 2/28/18 ASH

Date: 3-1-17

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

Environmental Restoration Group Inc.
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Meter: Manufacturer: Ludlum Model Number: 2221r Serial Number: 196086

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

- ✔ 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: 24.27 inches Hg

Temperature: 78 °F

Relative Humidity: 20 %

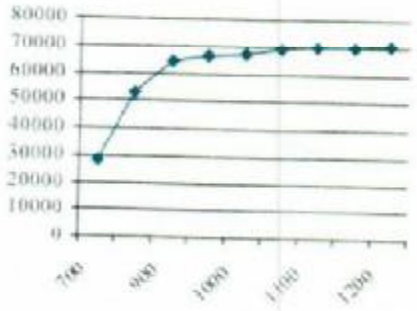
Instrument found within tolerance: ✔ Yes ☐ No

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
700	28235
800	52834
900	64481
950	66468
1000	67321
1050	69009
1100	69981
1150	69564
1200	70538

Background: 9079

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: ~~1 March 17~~ 2/28/17 BLH

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

Date: 3-1-17

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

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

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

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

Barometric Pressure: 24.66 inches Hg

Source Distance: ☐ Contact ✔ 6 inches ☐ Other: Threshold: 10 mV Temperature: 76 °F

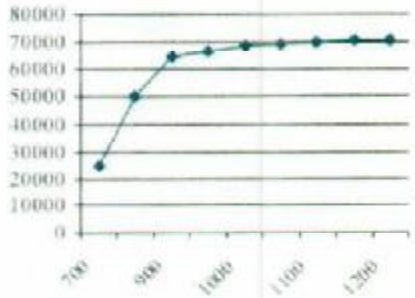
Source Geometry: ✔ Side ☐ Below ☐ Other: Window: Relative Humidity: 20 %

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
- ☐ Beta Source: Tc-99 sn: 4099-03 @ 17,700dpm/11,100cpm (1/4/12
- ✔ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
- ☐ Other Source:

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

Reviewed By: [signature] Date: 14 March 2017

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:	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: 24.81 inches Hg

Temperature: 76 °F

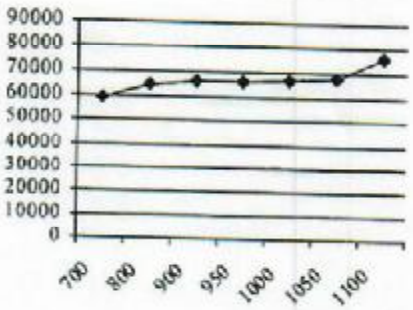
Relative Humidity: 20 %

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	400154	400
x 1000	100	100	100		100
x 100	400	400	400	40018	400
x 100	100	100	100		100
x 10	400	400	400	4002	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	59737	
800	64927	
900	66145	
950	66534	
1000	66864	10073
1050	67810	
1100	76513	

Voltage Plateau



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

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✔ 201932

Fluke multimeter serial number: 87490128

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

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

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

☐ Other Source:

Calibrated By: [signature]

Calibration Date: 7-6-17

Calibration Due: 7-6-18

Reviewed By: [signature]

Date: 07/06/17

ERG Form ITC. 101.A

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

K&S Associates, Inc.
1926 Elm Tree Drive
Nashville, Tennessee 37210-3716
Phone 800-522-2325 Fax 615-871-0856

ACCREDITED
CALIBRATION CERT #1866.01

CALIBRATION REPORT

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

INSTRUMENT: Reuter Stokes RSS-131, #07J00KM1

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

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

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

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

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

ACCREDITED

CALIBRATION CERTIFICATE

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

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

Sensor Type: 100 mR/h

Serial Number: 07J00KM1

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

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

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

Found RAC: 2.169e-8

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

Calibrated By: Richard Hardison Reviewed By: Angela Roper

Richard Hardison

Title: Calibration Technician Title: Calibration Physicist

Log: M-53 Page: 73

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

ACCREDITED

AS FOUND DATA

Reuter-Stokes Chamber Calibration

June 27, 2016 *Test Number M161588*

CHAMBER:

Mfgr: Reuter Stokes

Model: RSS-131

Serial: 07J00KM1

SUBMITTED BY:

ERG

Albuquerque, NM

ORIENTATION/CONDITIONS: Serial number away from source

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

ATMOSPHERIC COMMUNICATION: SEALED

POLARIZING POTENTIAL 401V

LEAKAGE: negligible

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

Comments Batt: 6.1V, Temp: 24.6 deg C, K&S Environment: Temp:21 deg C , RH 59%, Press: 752 mmHg; Report Number: 161866

Refer to Appendix I of this report for details on PIC ionization chamber calibrations. Procedure: SI 25

RAC Found: 2.169e-8

Calibrated By Richard Hardison **Reviewed By:**

Title: Calibration Technician **Title:** Calibration Specialist

Checked By: **Prepared By:**

Form RSS

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:	7-19-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	7-19-17

Comments:
NNEAT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-16-94 Distance to Source: 6 inches

Serial No.: 331-94 Emission Rate: ND cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project Reference Point,
9-27-16	1126	6.1	1002	99	45988	6844	39144	NW	NA-0904
9-27-16	1617	5.9	999	99	44136	6788	37348	NW	NA-0904
9-28-16	1022	5.9	1001	99	44612	6242	38370	NW	Comfort Suites, Parking lot
9-28-16	1754	5.9	1000	99	43583	6742	36841	NW	NA-0928
9-29-16	0936	5.9	1001	100	44695	5574	39121	NW	Comfort Suites, Parking Lot
9-29-16	1600	5.8	1002	99	46024	6760	39264	NW	NA-0928
9-30-16	0920	5.8	1002	99	44958	5748	39210	NW	NA-0904
9-30-16	1436	5.7	998	99	44138	6240	37898	NW	NA-0504
10-1-16	0913	5.7	1002	100	43656	5047	38609	NW	Oak 124/125
10-1-16	1605	5.6	995	99	43105	6275	36830	NW	Alonso
10-3-16	0950	5.7	1001	99	44914	5611	39303	NW	Berton 3
10-3-16	1220	5.6	996	99	45923	5670	40105	NW	Berton 3

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

(2

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8800 Washington S. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	196086
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	PR295014
Cal. Due Date:	7-9-17

Comments:
NNGRT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-16-94 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
9-27-16	1121	5.7	1100	100	45851	6762	39089	NW	NA-0904
9-27-16	1619	5.6	1094	99	45492	6313	39179	NW	NA-0904
9-28-16	1026	5.7	1100	100	44929	6287	38642	NW	NA-0904
9-29-16	1754	5.6	1098	100	44643	6434	38209	NW	Comfort Suites Parking Lot
9-29-16	0940	5.6	1100	99	43453	5654	37799	NW	NA-0928
9-30-16	1603	5.5	1101	100	44546	6525	38061	NW	Comfort Suites Parking Lot
9-30-16	0915	5.5	1102	100	44975	5236	39739	NW	NA-0928
10-1-16	1433	5.4	1096	100	44003	5827	38176	NW	NA-0904
10-1-16	0925	5.5	1102	100	42929	5140	37789	NW	Dock 124/125
10-3-16	1605	5.3	1092	100	44650	6271	38379	NW	Mango
10-3-16	0946	5.5	1100	100	43675	4995	38684	NW	Berlin 3
10-3-16	1225	5.4	1099	100	45921	5361	40560	NW	Berlin 3

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

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:	7-19-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	7-19-17

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):
10-4-16	0925	5.7	1003	99	45635	6378	39254	NW	Project reference point,
10-4-16	1720	5.6	1008	99	46987	6720	40267	NW	Tsosie 1
10-5-16	0610	5.7	1007	99	47335	6804	40531	NW	Comfort Suites Parking Lot
10-5-16	1542	5.5	999	99	45375	6342	39033	NW	Comfort Suites Parking Lot
10-6-16	0900	5.5	1003	99	43705	6264	37341	NW	Tsosie 1
10-6-16	1713	5.5	1000	99	44279	6053	38226	NW	Tsosie,
10-7-16	0902	5.5	1006	99	44457	6003	38404	NW	Comfort Suites Parking Lot
10-7-16	1627	5.5	999	99	46107	6751	39352	NW	Oak 124/125
10-8-16	0903	5.6	1003	99	45434	6365	39069	NW	Comfort Suites Parking Lot
10-8-16	1653	5.5	999	99	45185	6467	38718	NW	Red Valley Intersection
10-10-16	0858	5.5	1004	100	42755	5579	37176	NW	Comfort Suites Parking Lot
10-10-16	1919	5.5	999	99	51651	6930	44721	NW	Oak 124/125

Reviewed by: MP 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:	44-10
Serial No.:	196086
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	PR 285014
Cal. Due Date:	7-9-17

Comments:
NNERS

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-16-94 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):
10-4-16	0934	5.5	1102	100	46804	6042	40762	NW	Project Reference Points
10-4-16	1720	5.4	1106	100	46032	6898	39134	NW	Comfort Suites Parking Lot
10-5-16	0622	5.4	1109	101	45794	6834	38960	NW	Comfort Suites Parking Lot
10-5-16	1348	5.3	1097	99	46608	6021	40587	NW	Tijosie 1
10-6-16	0904	5.4	1103	100	44521	6273	38248	NW	Comfort Suites Parking Lot
10-6-16	1718	5.3	1099	100	45178	6311	38867	NW	Comfort Suites Parking Lot
10-7-16	0859	5.4	1104	100	44101	5226	38875	NW	Oak 124/125
10-7-16	1633	5.4	1098	99	44930	6832	38098	NW	Comfort Suites Parking Lot
10-8-16	0908	5.4	1104	100	45110	6201	38909	NW	Red Valley Intersection
10-8-16	1658	5.3	1098	99	45810	6196	39614	NW	Comfort Suites Parking Lot
10-12-16	1331	5.4	1099	99	46496	6519	39977	NW	Barton 3
10-12-16	1614	5.4	1097	100	44509	6060	38449	NW	Comfort Suites Parking Lot

Reviewed by: MW 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:
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

4-2-17

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

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 296-4224

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:
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	Chink lot
3-21-17	0641	5.7	1004	101	37904	5597	32307	NW	Chink 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
3-29-17	0810	5.5	1007	101	35608	4282	31326	NW	Eunice Becenti
3-29-17	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: MW Review Date: 10/19/17

(4)

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:
NNSA

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	5.9	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: 10/9/17

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:	2-28-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	2-28-17

Comments:
NVRAT

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):
4-11-17	0920	5.7	1000	101	36807	5626	31181	NV	NA-0928
4-11-17	1607	5.1	994	100	35724	5073	30651	NV	NA-0904 upper
4-14-17	0910	5.3	999	100	37554	5361	32193	NV	NA-0928
4-14-17	1050	5.3	997	108	37119	5165	31954	NV	NA-0928
4-17-17	0926	5.6	1000	101	37381	5937	31444	NV	NA-0928
4-17-17	1314	5.5	993	100	37712	5579	32133	NV	Berton 3
4-18-17	1400	5.6	997	100	40901	8541	32360	NV	Claim 28
4-18-17	1633	5.5	996	100	38299	8808	29491	NV	Claim 28
					4-19-17				

Reviewed by: Michael Baker Review Date: 11/08/17

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:
NNSA

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

Serial No.: 544-96 Emission Rate: N4 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	Berton 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	Alonzo
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 Benati
9-15-17	1729	5.3	957	109	35937	5261	30676	NW	Eunice Benati
9-19-17	0831	5.4	958	105	36967	6034	30433	NW	Section 26 @ trailer
9-16-17	1453	5.3	946	98	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: MW Review Date: 10/4/17

Single-Channel Function Check Log

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

METER	
Manufacturer:	GE
Model:	RSS-131
Serial No.:	07300km1
Cal. Due Date:	6-29-17

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

Comments:
NNERT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-16-94 Distance to Source: Contact - housing

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

Date	Time	Battery	High Voltage	Threshhold	Source Counts (µR/h)	BKG Counts	Net Counts	Initials	Note(s): Project reference point)
10-7-16	0545	~6.16	~400	~NA~	~26.7	~9.5	~17.2	NW	Comfort Suites Room - Farmington
10-7-16	2040	~6.16	~400	NA	~26.5	~8.7	~17.8	NW	Comfort Suites Room - Farmington
10-11-16	0634	~6.2	~406	NA	~25	~10.5	~14.5	NW	Comfort Suites Room - Farmington
10-11-16	1801	~6.3	~400	NA	~25.5	~10.1	~14.4	NW	Comfort Suites Room - Farmington
10-12-16	0548	~6.3	~400	NA	~26.5	~10	~16.5	NW	Comfort Suites Room - Farmington
10-12-16	1640	~6.3	~400	NA	~26.4	~10	~16.4	NW	Comfort Suites Room - Farmington
10-13-16	0606	~6.3	~400	NA	~27	~9.8	~17.2	NW	Comfort Suites Room - Farmington
10-13-16	1950	~6.3	~400	NA	~26.3	~9.5	~16.8	NW	Comfort Suites Room - Farmington
10-14-16	0630	~6.4	~406	NA	~26.4	~9.5	~16.9	NW	Comfort Suites Room - Farmington
10-14-16	1549	~6.2	~400	NA	~30	~12	~18	NW	Comfort Suites Room - Farmington
10-25-16	0539	~6.3	~400	NA	~29	~11	~18	NW	Best Western Room - Flagstaff
10-25-16	1755				D10	NOT USE			

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

Appendix B Exposure Rate Measurements

Date and Time	Exposure Rate (mR/h)	Location
10/11/2016 10:27	0.0536	Correlation Location 1
10/11/2016 10:28	0.0931	Correlation Location 1
10/11/2016 10:28	0.0806	Correlation Location 1
10/11/2016 10:28	0.0548	Correlation Location 1
10/11/2016 10:28	0.0355	Correlation Location 1
10/11/2016 10:28	0.024	Correlation Location 1
10/11/2016 10:28	0.017	Correlation Location 1
10/11/2016 10:28	0.0139	Correlation Location 1
10/11/2016 10:28	0.0127	Correlation Location 1
10/11/2016 10:28	0.0121	Correlation Location 1
10/11/2016 10:28	0.0117	Correlation Location 1
10/11/2016 10:29	0.0116	Correlation Location 1
10/11/2016 10:29	0.0115	Correlation Location 1
10/11/2016 10:29	0.0116	Correlation Location 1
10/11/2016 10:29	0.0117	Correlation Location 1
10/11/2016 10:29	0.0116	Correlation Location 1
10/11/2016 10:29	0.0116	Correlation Location 1
10/11/2016 10:29	0.0111	Correlation Location 1
10/11/2016 10:29	0.0109	Correlation Location 1
10/11/2016 10:29	0.0111	Correlation Location 1
10/11/2016 10:29	0.0111	Correlation Location 1
10/11/2016 10:30	0.0112	Correlation Location 1
10/11/2016 10:30	0.0114	Correlation Location 1
10/11/2016 10:30	0.0114	Correlation Location 1
10/11/2016 10:30	0.0115	Correlation Location 1
10/11/2016 10:30	0.0116	Correlation Location 1
10/11/2016 10:30	0.0115	Correlation Location 1
10/11/2016 10:30	0.0116	Correlation Location 1
10/11/2016 10:30	0.0111	Correlation Location 1
10/11/2016 10:30	0.0109	Correlation Location 1
10/11/2016 10:30	0.0111	Correlation Location 1
10/11/2016 10:31	0.0115	Correlation Location 1
10/11/2016 10:31	0.0115	Correlation Location 1
10/11/2016 10:31	0.0112	Correlation Location 1
10/11/2016 10:31	0.0111	Correlation Location 1
10/11/2016 10:31	0.0111	Correlation Location 1
10/11/2016 10:31	0.0111	Correlation Location 1
10/11/2016 10:31	0.0112	Correlation Location 1
10/11/2016 10:31	0.0111	Correlation Location 1
10/11/2016 10:31	0.0114	Correlation Location 1
10/11/2016 10:31	0.0117	Correlation Location 1
10/11/2016 10:32	0.0114	Correlation Location 1
10/11/2016 10:32	0.0111	Correlation Location 1
10/11/2016 10:32	0.0111	Correlation Location 1
10/11/2016 10:32	0.0111	Correlation Location 1
10/11/2016 10:32	0.0112	Correlation Location 1
10/11/2016 10:32	0.0115	Correlation Location 1
10/11/2016 10:32	0.0117	Correlation Location 1
10/11/2016 10:32	0.0117	Correlation Location 1
10/11/2016 10:32	0.0116	Correlation Location 1
10/11/2016 10:32	0.0114	Correlation Location 1
10/11/2016 10:33	0.0115	Correlation Location 1
10/11/2016 10:33	0.0117	Correlation Location 1
10/11/2016 10:33	0.0116	Correlation Location 1
10/11/2016 10:33	0.0111	Correlation Location 1
10/11/2016 10:33	0.0111	Correlation Location 1
10/11/2016 10:33	0.0115	Correlation Location 1
10/11/2016 10:33	0.0114	Correlation Location 1
10/11/2016 10:33	0.0112	Correlation Location 1
10/11/2016 10:33	0.011	Correlation Location 1
10/11/2016 10:33	0.0109	Correlation Location 1
10/11/2016 10:34	0.0111	Correlation Location 1
10/11/2016 10:34	0.0116	Correlation Location 1
10/11/2016 10:34	0.0117	Correlation Location 1
10/11/2016 10:34	0.0116	Correlation Location 1
10/11/2016 10:34	0.0114	Correlation Location 1
10/11/2016 10:34	0.0112	Correlation Location 1
10/11/2016 10:34	0.0114	Correlation Location 1
10/11/2016 10:34	0.0117	Correlation Location 1
10/11/2016 10:34	0.0117	Correlation Location 1
10/11/2016 10:34	0.0116	Correlation Location 1
10/11/2016 10:35	0.0111	Correlation Location 1
10/11/2016 10:35	0.011	Correlation Location 1
10/11/2016 10:35	0.0111	Correlation Location 1
10/11/2016 10:35	0.0114	Correlation Location 1
10/11/2016 10:35	0.0115	Correlation Location 1
10/11/2016 10:35	0.0116	Correlation Location 1
10/11/2016 10:35	0.0116	Correlation Location 1
10/11/2016 10:35	0.0115	Correlation Location 1
10/11/2016 10:35	0.0117	Correlation Location 1
10/11/2016 10:35	0.012	Correlation Location 1
10/11/2016 10:36	0.0117	Correlation Location 1
10/11/2016 10:36	0.0115	Correlation Location 1
10/11/2016 10:36	0.0118	Correlation Location 1
10/11/2016 10:36	0.012	Correlation Location 1
10/11/2016 10:36	0.012	Correlation Location 1
10/11/2016 10:36	0.0117	Correlation Location 1
10/11/2016 10:36	0.0116	Correlation Location 1
10/11/2016 10:36	0.0114	Correlation Location 1
10/11/2016 10:36	0.0116	Correlation Location 1
10/11/2016 10:36	0.0121	Correlation Location 1
10/11/2016 10:37	0.0121	Correlation Location 1
10/11/2016 10:37	0.012	Correlation Location 1
10/11/2016 10:37	0.0118	Correlation Location 1
10/11/2016 10:37	0.0117	Correlation Location 1
10/11/2016 10:37	0.0116	Correlation Location 1
10/11/2016 10:37	0.0117	Correlation Location 1
10/11/2016 10:37	0.0117	Correlation Location 1
10/11/2016 10:37	0.0116	Correlation Location 1
10/11/2016 10:37	0.0115	Correlation Location 1
10/11/2016 10:37	0.0116	Correlation Location 1
10/11/2016 10:38	0.0111	Correlation Location 1
10/11/2016 10:38	0.0106	Correlation Location 1
10/11/2016 10:38	0.0105	Correlation Location 1
10/11/2016 10:38	0.0106	Correlation Location 1
10/11/2016 10:38	0.0106	Correlation Location 1
10/11/2016 10:38	0.0108	Correlation Location 1
10/11/2016 10:38	0.0105	Correlation Location 1
10/11/2016 10:38	0.0108	Correlation Location 1
10/11/2016 10:38	0.0112	Correlation Location 1
10/11/2016 10:38	0.0118	Correlation Location 1
10/11/2016 11:09	0.0584	Correlation Location 2

NA-0904 Exposure Rate Measurements for Correlation

Date and Time	Exposure Rate (mR/h)	Location
10/11/2016 11:09	0.1057	Correlation Location 2
10/11/2016 11:09	0.0775	Correlation Location 2
10/11/2016 11:10	0.0594	Correlation Location 2
10/11/2016 11:10	0.0489	Correlation Location 2
10/11/2016 11:10	0.043	Correlation Location 2
10/11/2016 11:10	0.0394	Correlation Location 2
10/11/2016 11:10	0.0383	Correlation Location 2
10/11/2016 11:10	0.0378	Correlation Location 2
10/11/2016 11:10	0.037	Correlation Location 2
10/11/2016 11:10	0.0367	Correlation Location 2
10/11/2016 11:10	0.0365	Correlation Location 2
10/11/2016 11:10	0.0369	Correlation Location 2
10/11/2016 11:11	0.0375	Correlation Location 2
10/11/2016 11:11	0.0374	Correlation Location 2
10/11/2016 11:11	0.0372	Correlation Location 2
10/11/2016 11:11	0.0365	Correlation Location 2
10/11/2016 11:11	0.0359	Correlation Location 2
10/11/2016 11:11	0.0357	Correlation Location 2
10/11/2016 11:11	0.0361	Correlation Location 2
10/11/2016 11:11	0.0365	Correlation Location 2
10/11/2016 11:11	0.0369	Correlation Location 2
10/11/2016 11:11	0.037	Correlation Location 2
10/11/2016 11:12	0.0374	Correlation Location 2
10/11/2016 11:12	0.0376	Correlation Location 2
10/11/2016 11:12	0.0375	Correlation Location 2
10/11/2016 11:12	0.0368	Correlation Location 2
10/11/2016 11:12	0.0365	Correlation Location 2
10/11/2016 11:12	0.0361	Correlation Location 2
10/11/2016 11:12	0.0359	Correlation Location 2
10/11/2016 11:12	0.0357	Correlation Location 2
10/11/2016 11:12	0.0357	Correlation Location 2
10/11/2016 11:12	0.0359	Correlation Location 2
10/11/2016 11:13	0.0361	Correlation Location 2
10/11/2016 11:13	0.0365	Correlation Location 2
10/11/2016 11:13	0.0361	Correlation Location 2
10/11/2016 11:13	0.0361	Correlation Location 2
10/11/2016 11:13	0.0359	Correlation Location 2
10/11/2016 11:13	0.036	Correlation Location 2
10/11/2016 11:13	0.0365	Correlation Location 2
10/11/2016 11:13	0.0367	Correlation Location 2
10/11/2016 11:13	0.0365	Correlation Location 2
10/11/2016 11:13	0.0365	Correlation Location 2
10/11/2016 11:14	0.0363	Correlation Location 2
10/11/2016 11:14	0.0363	Correlation Location 2
10/11/2016 11:14	0.0361	Correlation Location 2
10/11/2016 11:14	0.0361	Correlation Location 2
10/11/2016 11:14	0.0361	Correlation Location 2
10/11/2016 11:14	0.0365	Correlation Location 2
10/11/2016 11:14	0.0368	Correlation Location 2
10/11/2016 11:14	0.037	Correlation Location 2
10/11/2016 11:14	0.0369	Correlation Location 2
10/11/2016 11:14	0.0368	Correlation Location 2
10/11/2016 11:15	0.0365	Correlation Location 2
10/11/2016 11:15	0.036	Correlation Location 2
10/11/2016 11:15	0.0361	Correlation Location 2
10/11/2016 11:15	0.0364	Correlation Location 2
10/11/2016 11:15	0.0364	Correlation Location 2
10/11/2016 11:15	0.0357	Correlation Location 2
10/11/2016 11:15	0.0361	Correlation Location 2
10/11/2016 11:15	0.0361	Correlation Location 2
10/11/2016 11:15	0.0363	Correlation Location 2
10/11/2016 11:15	0.0361	Correlation Location 2
10/11/2016 11:16	0.0357	Correlation Location 2
10/11/2016 11:16	0.0352	Correlation Location 2
10/11/2016 11:16	0.0348	Correlation Location 2
10/11/2016 11:16	0.0346	Correlation Location 2
10/11/2016 11:16	0.0344	Correlation Location 2
10/11/2016 11:16	0.0346	Correlation Location 2
10/11/2016 11:16	0.0357	Correlation Location 2
10/11/2016 11:16	0.0364	Correlation Location 2
10/11/2016 11:16	0.0361	Correlation Location 2
10/11/2016 11:16	0.0365	Correlation Location 2
10/11/2016 11:17	0.0365	Correlation Location 2
10/11/2016 11:17	0.037	Correlation Location 2
10/11/2016 11:17	0.037	Correlation Location 2
10/11/2016 11:17	0.0367	Correlation Location 2
10/11/2016 11:17	0.0361	Correlation Location 2
10/11/2016 11:17	0.0359	Correlation Location 2
10/11/2016 11:17	0.0359	Correlation Location 2
10/11/2016 11:17	0.0361	Correlation Location 2
10/11/2016 11:17	0.0368	Correlation Location 2
10/11/2016 11:17	0.0369	Correlation Location 2
10/11/2016 11:18	0.037	Correlation Location 2
10/11/2016 11:18	0.0369	Correlation Location 2
10/11/2016 11:18	0.0361	Correlation Location 2
10/11/2016 11:18	0.0357	Correlation Location 2
10/11/2016 11:18	0.0357	Correlation Location 2
10/11/2016 11:18	0.0354	Correlation Location 2
10/11/2016 11:18	0.0357	Correlation Location 2
10/11/2016 11:18	0.0361	Correlation Location 2
10/11/2016 11:18	0.0363	Correlation Location 2
10/11/2016 11:18	0.0368	Correlation Location 2
10/11/2016 11:19	0.0374	Correlation Location 2
10/11/2016 11:19	0.0376	Correlation Location 2
10/11/2016 11:19	0.037	Correlation Location 2
10/11/2016 11:19	0.0365	Correlation Location 2
10/11/2016 11:19	0.0363	Correlation Location 2
10/11/2016 11:19	0.0364	Correlation Location 2
10/11/2016 11:19	0.0364	Correlation Location 2
10/11/2016 11:19	0.0363	Correlation Location 2
10/11/2016 11:19	0.0361	Correlation Location 2
10/11/2016 11:19	0.0363	Correlation Location 2
10/11/2016 11:20	0.0361	Correlation Location 2
10/11/2016 11:20	0.0361	Correlation Location 2
10/11/2016 11:20	0.0365	Correlation Location 2
10/11/2016 11:20	0.037	Correlation Location 2
10/11/2016 11:20	0.0372	Correlation Location 2
10/11/2016 11:20	0.0367	Correlation Location 2
10/11/2016 11:20	0.0361	Correlation Location 2
10/11/2016 11:20	0.0357	Correlation Location 2
10/11/2016 11:20	0.0352	Correlation Location 2
10/11/2016 11:20	0.0352	Correlation Location 2
10/11/2016 11:21	0.0354	Correlation Location 2
10/11/2016 11:21	0.0361	Correlation Location 2

Date and Time	Exposure Rate (mR/h)	Location
10/11/2016 11:21	0.0365	Correlation Location 2
10/11/2016 11:21	0.0364	Correlation Location 2
10/11/2016 11:21	0.0361	Correlation Location 2
10/11/2016 11:21	0.0354	Correlation Location 2
10/11/2016 11:21	0.0352	Correlation Location 2
10/11/2016 11:21	0.0357	Correlation Location 2
10/11/2016 11:21	0.0365	Correlation Location 2
10/11/2016 11:21	0.0364	Correlation Location 2
10/11/2016 11:22	0.0361	Correlation Location 2
10/11/2016 11:22	0.0359	Correlation Location 2
10/11/2016 11:22	0.0359	Correlation Location 2
10/11/2016 11:22	0.0355	Correlation Location 2
10/11/2016 11:22	0.0357	Correlation Location 2
10/11/2016 11:22	0.0357	Correlation Location 2
10/11/2016 11:22	0.0359	Correlation Location 2
10/11/2016 11:22	0.0357	Correlation Location 2
10/11/2016 11:22	0.0352	Correlation Location 2
10/11/2016 11:22	0.0354	Correlation Location 2
10/11/2016 11:23	0.0359	Correlation Location 2
10/11/2016 11:23	0.036	Correlation Location 2
10/11/2016 11:23	0.0357	Correlation Location 2
10/11/2016 11:23	0.0357	Correlation Location 2
10/11/2016 11:23	0.0361	Correlation Location 2
10/11/2016 11:23	0.0367	Correlation Location 2
10/11/2016 11:23	0.0367	Correlation Location 2
10/11/2016 11:23	0.0363	Correlation Location 2
10/11/2016 11:23	0.036	Correlation Location 2
10/11/2016 11:23	0.0359	Correlation Location 2
10/11/2016 11:24	0.036	Correlation Location 2
10/11/2016 11:24	0.0361	Correlation Location 2
10/11/2016 11:24	0.036	Correlation Location 2
10/11/2016 11:24	0.036	Correlation Location 2
10/11/2016 11:24	0.0364	Correlation Location 2
10/11/2016 11:24	0.0363	Correlation Location 2
10/11/2016 11:24	0.0365	Correlation Location 2
10/11/2016 11:24	0.0369	Correlation Location 2
10/11/2016 11:24	0.037	Correlation Location 2
10/11/2016 11:24	0.0365	Correlation Location 2
10/11/2016 11:25	0.0365	Correlation Location 2
10/11/2016 11:25	0.0361	Correlation Location 2
10/11/2016 11:25	0.0357	Correlation Location 2
10/11/2016 11:25	0.0361	Correlation Location 2
10/11/2016 11:25	0.0364	Correlation Location 2
10/11/2016 11:25	0.0363	Correlation Location 2
10/11/2016 11:25	0.0364	Correlation Location 2
10/11/2016 11:25	0.036	Correlation Location 2
10/11/2016 11:25	0.036	Correlation Location 2
10/11/2016 11:25	0.0361	Correlation Location 2
10/11/2016 11:26	0.0365	Correlation Location 2
10/11/2016 11:26	0.0365	Correlation Location 2
10/11/2016 11:26	0.0363	Correlation Location 2
10/11/2016 11:26	0.0368	Correlation Location 2
10/11/2016 11:26	0.0369	Correlation Location 2
10/11/2016 11:26	0.0365	Correlation Location 2
10/11/2016 11:26	0.0363	Correlation Location 2
10/11/2016 11:26	0.0368	Correlation Location 2
10/11/2016 11:26	0.0374	Correlation Location 2
10/11/2016 11:26	0.037	Correlation Location 2
10/11/2016 11:27	0.0369	Correlation Location 2
10/11/2016 11:27	0.0368	Correlation Location 2
10/11/2016 11:27	0.0365	Correlation Location 2
10/11/2016 11:27	0.0363	Correlation Location 2
10/11/2016 11:27	0.0363	Correlation Location 2
10/11/2016 11:27	0.0361	Correlation Location 2
10/11/2016 11:43	0.0639	Correlation Location 3
10/11/2016 11:43	0.12	Correlation Location 3
10/11/2016 11:43	0.1216	Correlation Location 3
10/11/2016 11:43	0.1029	Correlation Location 3
10/11/2016 11:43	0.0869	Correlation Location 3
10/11/2016 11:43	0.0767	Correlation Location 3
10/11/2016 11:43	0.0712	Correlation Location 3
10/11/2016 11:43	0.0687	Correlation Location 3
10/11/2016 11:43	0.0675	Correlation Location 3
10/11/2016 11:44	0.0674	Correlation Location 3
10/11/2016 11:44	0.067	Correlation Location 3
10/11/2016 11:44	0.0668	Correlation Location 3
10/11/2016 11:44	0.0664	Correlation Location 3
10/11/2016 11:44	0.0663	Correlation Location 3
10/11/2016 11:44	0.0672	Correlation Location 3
10/11/2016 11:44	0.0674	Correlation Location 3
10/11/2016 11:44	0.0672	Correlation Location 3
10/11/2016 11:44	0.0674	Correlation Location 3
10/11/2016 11:44	0.0677	Correlation Location 3
10/11/2016 11:45	0.0677	Correlation Location 3
10/11/2016 11:45	0.0678	Correlation Location 3
10/11/2016 11:45	0.0673	Correlation Location 3
10/11/2016 11:45	0.0671	Correlation Location 3
10/11/2016 11:45	0.0665	Correlation Location 3
10/11/2016 11:45	0.0663	Correlation Location 3
10/11/2016 11:45	0.0663	Correlation Location 3
10/11/2016 11:45	0.0663	Correlation Location 3
10/11/2016 11:45	0.0661	Correlation Location 3
10/11/2016 11:45	0.0662	Correlation Location 3
10/11/2016 11:46	0.0665	Correlation Location 3
10/11/2016 11:46	0.0665	Correlation Location 3
10/11/2016 11:46	0.0662	Correlation Location 3
10/11/2016 11:46	0.0663	Correlation Location 3
10/11/2016 11:46	0.0663	Correlation Location 3
10/11/2016 11:46	0.0657	Correlation Location 3
10/11/2016 11:46	0.0658	Correlation Location 3
10/11/2016 11:46	0.0669	Correlation Location 3
10/11/2016 11:46	0.0672	Correlation Location 3
10/11/2016 11:46	0.0668	Correlation Location 3
10/11/2016 11:47	0.0656	Correlation Location 3
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10/11/2016 11:47	0.0636	Correlation Location 3
10/11/2016 11:47	0.0642	Correlation Location 3
10/11/2016 11:47	0.0653	Correlation Location 3
10/11/2016 11:47	0.0658	Correlation Location 3
10/11/2016 11:47	0.0662	Correlation Location 3
10/11/2016 11:47	0.067	Correlation Location 3
10/11/2016 11:48	0.0678	Correlation Location 3

Date and Time	Exposure Rate (mR/h)	Location
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10/11/2016 11:48	0.0665	Correlation Location 3
10/11/2016 11:48	0.0658	Correlation Location 3
10/11/2016 11:48	0.0657	Correlation Location 3
10/11/2016 11:48	0.0658	Correlation Location 3
10/11/2016 11:48	0.0663	Correlation Location 3
10/11/2016 11:48	0.0665	Correlation Location 3
10/11/2016 11:48	0.0665	Correlation Location 3
10/11/2016 11:49	0.0666	Correlation Location 3
10/11/2016 11:49	0.0665	Correlation Location 3
10/11/2016 11:49	0.0662	Correlation Location 3
10/11/2016 11:49	0.0657	Correlation Location 3
10/11/2016 11:49	0.0658	Correlation Location 3
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10/11/2016 11:50	0.0656	Correlation Location 3
10/11/2016 11:50	0.0657	Correlation Location 3
10/11/2016 11:50	0.0658	Correlation Location 3
10/11/2016 11:50	0.0662	Correlation Location 3
10/11/2016 11:50	0.0666	Correlation Location 3
10/11/2016 11:50	0.0663	Correlation Location 3
10/11/2016 11:50	0.0661	Correlation Location 3
10/11/2016 11:50	0.0657	Correlation Location 3
10/11/2016 11:50	0.0656	Correlation Location 3
10/11/2016 11:50	0.0649	Correlation Location 3
10/11/2016 11:51	0.0652	Correlation Location 3
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10/11/2016 11:51	0.0658	Correlation Location 3
10/11/2016 11:51	0.0661	Correlation Location 3
10/11/2016 11:51	0.0662	Correlation Location 3
10/11/2016 11:51	0.066	Correlation Location 3
10/11/2016 11:51	0.066	Correlation Location 3
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10/11/2016 11:52	0.067	Correlation Location 3
10/11/2016 11:52	0.0673	Correlation Location 3
10/11/2016 11:52	0.0671	Correlation Location 3
10/11/2016 11:52	0.0668	Correlation Location 3
10/11/2016 11:52	0.0666	Correlation Location 3
10/11/2016 11:52	0.0668	Correlation Location 3
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10/11/2016 11:53	0.0668	Correlation Location 3
10/11/2016 11:53	0.067	Correlation Location 3
10/11/2016 11:53	0.0671	Correlation Location 3
10/11/2016 11:53	0.0673	Correlation Location 3
10/11/2016 11:53	0.0668	Correlation Location 3
10/11/2016 11:53	0.0665	Correlation Location 3
10/11/2016 11:53	0.0662	Correlation Location 3
10/11/2016 11:53	0.0662	Correlation Location 3
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10/11/2016 11:53	0.0668	Correlation Location 3
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10/11/2016 12:35	0.0299	Correlation Location 4
10/11/2016 12:35	0.0235	Correlation Location 4
10/11/2016 12:35	0.0198	Correlation Location 4
10/11/2016 12:35	0.0182	Correlation Location 4
10/11/2016 12:35	0.0177	Correlation Location 4
10/11/2016 12:35	0.0179	Correlation Location 4
10/11/2016 12:36	0.018	Correlation Location 4
10/11/2016 12:36	0.018	Correlation Location 4
10/11/2016 12:36	0.0179	Correlation Location 4
10/11/2016 12:36	0.0175	Correlation Location 4
10/11/2016 12:36	0.017	Correlation Location 4
10/11/2016 12:36	0.017	Correlation Location 4
10/11/2016 12:36	0.0173	Correlation Location 4
10/11/2016 12:36	0.0174	Correlation Location 4
10/11/2016 12:36	0.0172	Correlation Location 4
10/11/2016 12:36	0.0172	Correlation Location 4
10/11/2016 12:37	0.0172	Correlation Location 4
10/11/2016 12:37	0.0174	Correlation Location 4
10/11/2016 12:37	0.0174	Correlation Location 4
10/11/2016 12:37	0.0173	Correlation Location 4
10/11/2016 12:37	0.0173	Correlation Location 4
10/11/2016 12:37	0.017	Correlation Location 4
10/11/2016 12:37	0.0175	Correlation Location 4
10/11/2016 12:37	0.018	Correlation Location 4
10/11/2016 12:37	0.0179	Correlation Location 4
10/11/2016 12:37	0.018	Correlation Location 4
10/11/2016 12:38	0.0178	Correlation Location 4
10/11/2016 12:38	0.0176	Correlation Location 4
10/11/2016 12:38	0.0174	Correlation Location 4
10/11/2016 12:38	0.0173	Correlation Location 4
10/11/2016 12:38	0.0172	Correlation Location 4
10/11/2016 12:38	0.0173	Correlation Location 4
10/11/2016 12:38	0.017	Correlation Location 4
10/11/2016 12:38	0.0169	Correlation Location 4
10/11/2016 12:38	0.0169	Correlation Location 4
10/11/2016 12:38	0.0169	Correlation Location 4
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10/11/2016 12:39	0.0169	Correlation Location 4
10/11/2016 12:39	0.017	Correlation Location 4
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10/11/2016 12:39	0.0169	Correlation Location 4
10/11/2016 12:39	0.017	Correlation Location 4
10/11/2016 12:39	0.017	Correlation Location 4
10/11/2016 12:39	0.0173	Correlation Location 4
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10/11/2016 12:39	0.0174	Correlation Location 4
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Date and Time	Exposure Rate (mR/h)	Location
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10/11/2016 12:40	0.0178	Correlation Location 4
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10/11/2016 12:40	0.0175	Correlation Location 4
10/11/2016 12:40	0.0175	Correlation Location 4
10/11/2016 12:40	0.0174	Correlation Location 4
10/11/2016 12:40	0.0168	Correlation Location 4
10/11/2016 12:40	0.017	Correlation Location 4
10/11/2016 12:40	0.0174	Correlation Location 4
10/11/2016 12:41	0.0175	Correlation Location 4
10/11/2016 12:41	0.0176	Correlation Location 4
10/11/2016 12:41	0.0179	Correlation Location 4
10/11/2016 12:41	0.0178	Correlation Location 4
10/11/2016 12:41	0.017	Correlation Location 4
10/11/2016 12:41	0.017	Correlation Location 4
10/11/2016 12:41	0.0174	Correlation Location 4
10/11/2016 12:41	0.0182	Correlation Location 4
10/11/2016 12:41	0.0182	Correlation Location 4
10/11/2016 12:41	0.0179	Correlation Location 4
10/11/2016 12:42	0.0178	Correlation Location 4
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10/11/2016 12:42	0.0178	Correlation Location 4
10/11/2016 12:42	0.0178	Correlation Location 4
10/11/2016 12:42	0.0174	Correlation Location 4
10/11/2016 12:42	0.0173	Correlation Location 4
10/11/2016 12:42	0.0176	Correlation Location 4
10/11/2016 12:42	0.0178	Correlation Location 4
10/11/2016 12:42	0.0172	Correlation Location 4
10/11/2016 12:43	0.0168	Correlation Location 4
10/11/2016 12:43	0.017	Correlation Location 4
10/11/2016 12:43	0.0179	Correlation Location 4
10/11/2016 12:43	0.0182	Correlation Location 4
10/11/2016 12:43	0.018	Correlation Location 4
10/11/2016 12:43	0.0176	Correlation Location 4
10/11/2016 12:43	0.0175	Correlation Location 4
10/11/2016 12:43	0.0176	Correlation Location 4
10/11/2016 12:43	0.0177	Correlation Location 4
10/11/2016 12:43	0.0179	Correlation Location 4
10/11/2016 12:44	0.0178	Correlation Location 4
10/11/2016 12:44	0.0176	Correlation Location 4
10/11/2016 12:44	0.0173	Correlation Location 4
10/11/2016 12:44	0.0174	Correlation Location 4
10/11/2016 12:44	0.0177	Correlation Location 4
10/11/2016 12:44	0.0175	Correlation Location 4
10/11/2016 12:44	0.0178	Correlation Location 4
10/11/2016 12:44	0.018	Correlation Location 4
10/11/2016 12:44	0.018	Correlation Location 4
10/11/2016 12:44	0.018	Correlation Location 4
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10/11/2016 12:45	0.017	Correlation Location 4
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10/11/2016 12:45	0.017	Correlation Location 4
10/11/2016 12:45	0.017	Correlation Location 4
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10/11/2016 15:02	0.0446	Correlation Location 5
10/11/2016 15:02	0.0334	Correlation Location 5
10/11/2016 15:02	0.0274	Correlation Location 5
10/11/2016 15:02	0.0242	Correlation Location 5
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10/11/2016 15:03	0.0216	Correlation Location 5
10/11/2016 15:03	0.0216	Correlation Location 5
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10/11/2016 15:03	0.0215	Correlation Location 5
10/11/2016 15:03	0.0215	Correlation Location 5
10/11/2016 15:04	0.0213	Correlation Location 5
10/11/2016 15:04	0.0215	Correlation Location 5
10/11/2016 15:04	0.0216	Correlation Location 5
10/11/2016 15:04	0.022	Correlation Location 5
10/11/2016 15:04	0.0221	Correlation Location 5
10/11/2016 15:04	0.0221	Correlation Location 5
10/11/2016 15:04	0.0223	Correlation Location 5
10/11/2016 15:04	0.0225	Correlation Location 5
10/11/2016 15:04	0.0223	Correlation Location 5
10/11/2016 15:04	0.0219	Correlation Location 5
10/11/2016 15:05	0.0218	Correlation Location 5
10/11/2016 15:05	0.0219	Correlation Location 5
10/11/2016 15:05	0.0225	Correlation Location 5
10/11/2016 15:05	0.0225	Correlation Location 5
10/11/2016 15:05	0.0221	Correlation Location 5
10/11/2016 15:05	0.0216	Correlation Location 5
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10/11/2016 15:06	0.022	Correlation Location 5
10/11/2016 15:06	0.0216	Correlation Location 5
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10/11/2016 15:06	0.0215	Correlation Location 5
10/11/2016 15:06	0.0218	Correlation Location 5
10/11/2016 15:06	0.0219	Correlation Location 5
10/11/2016 15:06	0.022	Correlation Location 5
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Date and Time	Exposure Rate (mR/h)	Location
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10/11/2016 15:08	0.0208	Correlation Location 5
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10/11/2016 15:08	0.0209	Correlation Location 5
10/11/2016 15:08	0.0213	Correlation Location 5
10/11/2016 15:08	0.0213	Correlation Location 5
10/11/2016 15:08	0.0211	Correlation Location 5
10/11/2016 15:08	0.0213	Correlation Location 5
10/11/2016 15:08	0.0216	Correlation Location 5
10/11/2016 15:08	0.0213	Correlation Location 5
10/11/2016 15:09	0.0211	Correlation Location 5
10/11/2016 15:09	0.0217	Correlation Location 5
10/11/2016 15:09	0.0219	Correlation Location 5
10/11/2016 15:09	0.0218	Correlation Location 5
10/11/2016 15:09	0.0217	Correlation Location 5
10/11/2016 15:09	0.0218	Correlation Location 5
10/11/2016 15:09	0.0221	Correlation Location 5
10/11/2016 15:09	0.0221	Correlation Location 5
10/11/2016 15:09	0.0217	Correlation Location 5
10/11/2016 15:09	0.0217	Correlation Location 5
10/11/2016 15:10	0.0216	Correlation Location 5
10/11/2016 15:10	0.0218	Correlation Location 5
10/11/2016 15:10	0.0213	Correlation Location 5
10/11/2016 15:10	0.021	Correlation Location 5
10/11/2016 15:10	0.0209	Correlation Location 5
10/11/2016 15:10	0.0211	Correlation Location 5
10/11/2016 15:10	0.0213	Correlation Location 5
10/11/2016 15:10	0.0217	Correlation Location 5
10/11/2016 15:10	0.0217	Correlation Location 5
10/11/2016 15:10	0.0217	Correlation Location 5
10/11/2016 15:11	0.0219	Correlation Location 5
10/11/2016 15:11	0.0215	Correlation Location 5
10/11/2016 15:11	0.021	Correlation Location 5
10/11/2016 15:11	0.0213	Correlation Location 5
10/11/2016 15:11	0.0216	Correlation Location 5
10/11/2016 15:11	0.0211	Correlation Location 5
10/11/2016 15:11	0.0209	Correlation Location 5
10/11/2016 15:11	0.0208	Correlation Location 5
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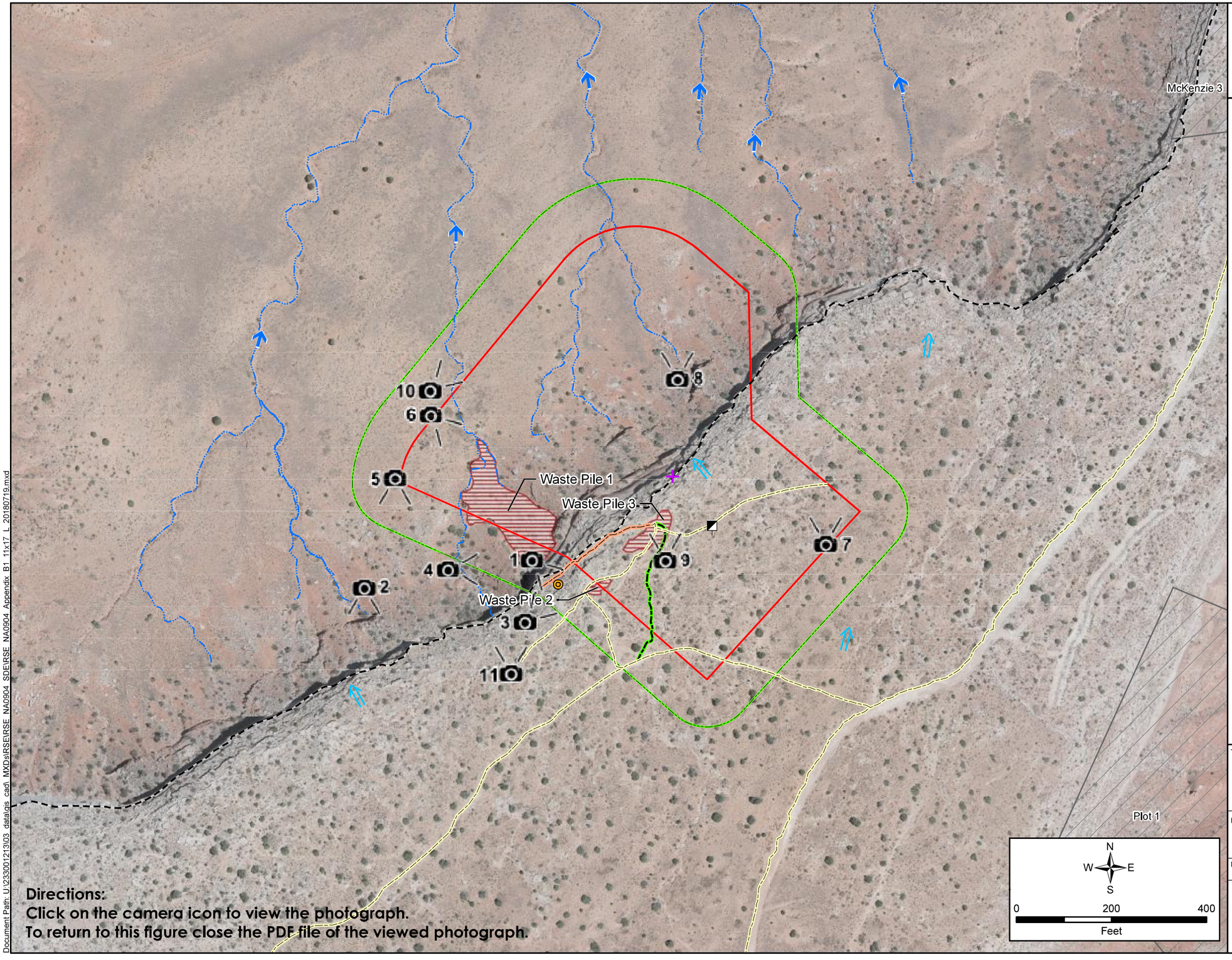
10/11/2016 15:11	0.0202	Correlation Location 5
10/11/2016 15:12	0.0204	Correlation Location 5
10/11/2016 15:12	0.0207	Correlation Location 5
10/11/2016 15:12	0.0208	Correlation Location 5
10/11/2016 15:12	0.0211	Correlation Location 5
10/11/2016 15:12	0.0216	Correlation Location 5
10/11/2016 15:12	0.0217	Correlation Location 5
10/11/2016 15:12	0.0218	Correlation Location 5
10/11/2016 15:12	0.0219	Correlation Location 5
10/11/2016 15:12	0.0216	Correlation Location 5
10/11/2016 15:12	0.0213	Correlation Location 5
10/11/2016 15:13	0.0213	Correlation Location 5

Appendix B Photographs

B.1 Site Photographs

B.2 Regional Site Photographs



Directions:
Click on the camera icon to view the photograph.
To return to this figure close the PDF file of the viewed photograph.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Photograph Indicating Direction Taken
- Potential Incline Shaft[1]
- Potential Rim Strip[1]
- Portal
- Flow Direction
- Approximate Overland Water Flow Direction
- Drainage
- Potential Haul Road
- Primary Haul Route[2]
- Portal Access Ramp
- Approximate Edge of Mesa
- Waste Pile
- Claim Boundary
- 100-Foot Claim Buffer
- Other Claim Boundary

NOTES:

1. Potential incline shaft and potential rim strip as shown in the 2007 AUM Atlas (USEPA, 2007a) were not observed during field mapping or site visit with NAML.

2. Primary haul route identified by NAML during site visit on September 14, 2017.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

TITLE:

Site Photographs

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 7/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

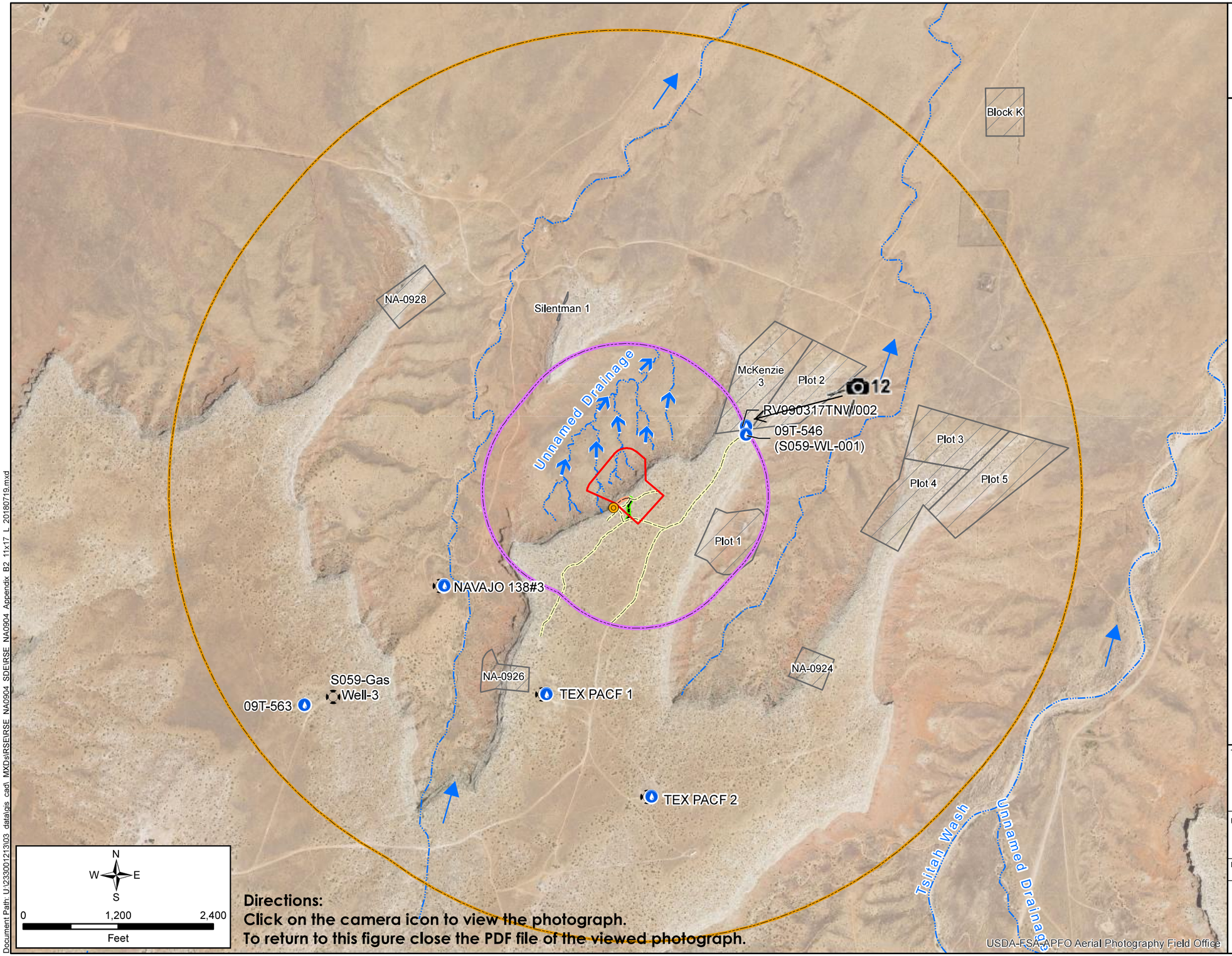
AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: B-1

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSEVRSE NA0904 SDEIRSE NA0904 Appendix B1 11x17 L 20180719.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Photograph Indicating Direction Taken
- Site Clearance Identified Potential Water Feature[1]
- Portal
- Oil / Gas Well[2]
- Flow Direction
- Intermittent Stream/River
- Potential Haul Road
- Primary Haul Route[3]
- Portal Access Ramp
- Claim Boundary
- 1/4-Mile Claim Boundary Buffer
- 1-Mile Claim Boundary Buffer
- Other Claim Boundary

NOTES:

1. Potential water features and identification names identified in 2007 AUM Atlas and/or in database provided by the Navajo Nation Department of Water Resources.

2. S059-Gas Well-3 identified during site mapping.

3. Primary haul route identified by NAML during site visit on September 14, 2017.

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 7/19/2018

TITLE:

Regional Site Photographs

PROJECT:

Removal Site Evaluation
NA-0904 Mine Site

DATE:	DOCUMENT NAME:
7/19/2018	Removal Site Evaluation Report
	AUTHOR: CBB / REVIEWER: EDZ

Stantec

FIGURE: B-2

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_NA0904_SDE\RSE_NA0904_Appendix_B2_11x17_L_20180719.mxd

Appendix C Field Activity Forms

C.1 Soil Sample Field Forms

C.2 Hand Auger Borehole Logs

C.3 Water Sample Field Forms

C.1 Soil Sample Field Forms

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5059 (AA-0904)

SAMPLE I.D. 5059-BG1-001 (201, dup)

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1210

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS silty sand

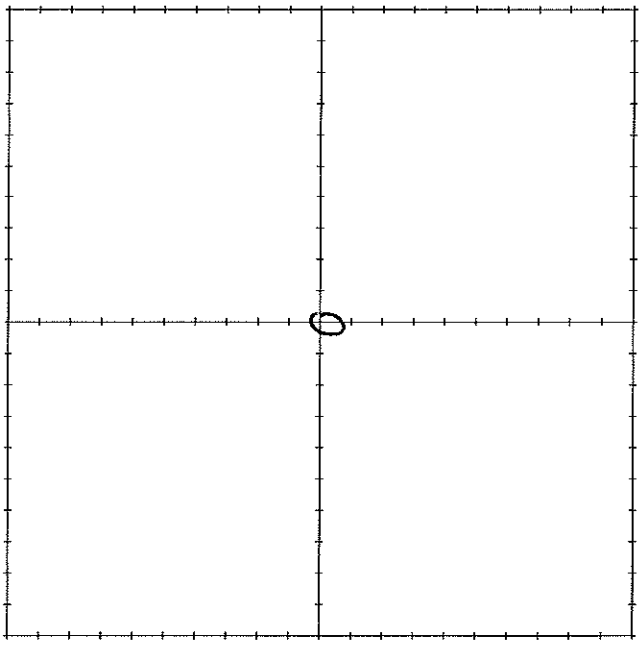
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 3059 (MA-0904

SAMPLE I.D. 3059-BG1-002 (MS, MSD)

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1225

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS silty sand

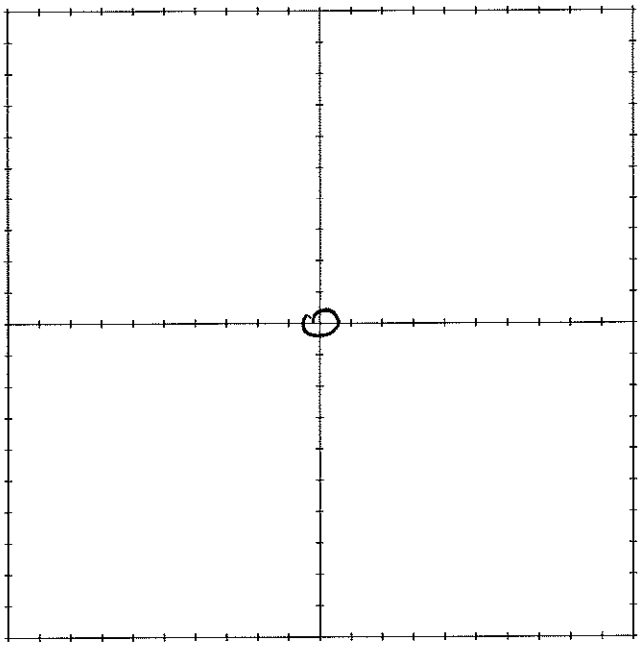
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, zip loc

ANALYSES: Ra226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S059 (NA-0904)

SAMPLE I.D. S059-BG1-003

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1245

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS silt & sand, minor weather shale frags

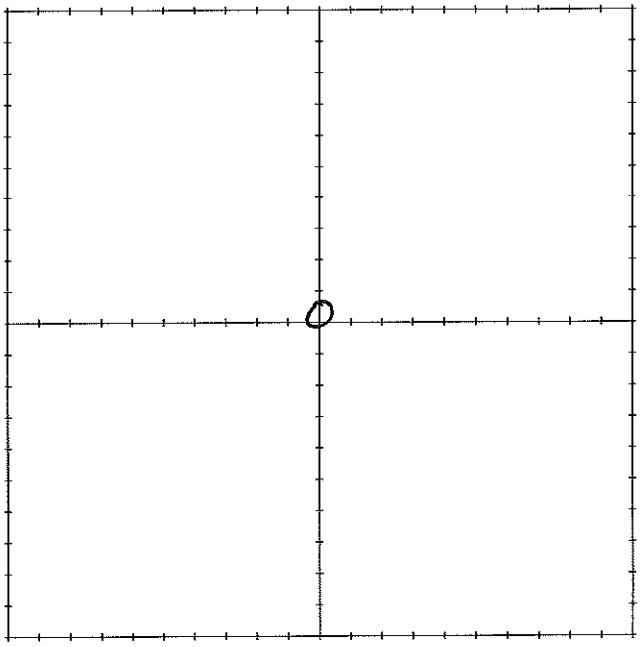
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 3059 (NA-0704)

SAMPLE I.D. 3059-361-004

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1259

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS Silt & Sand

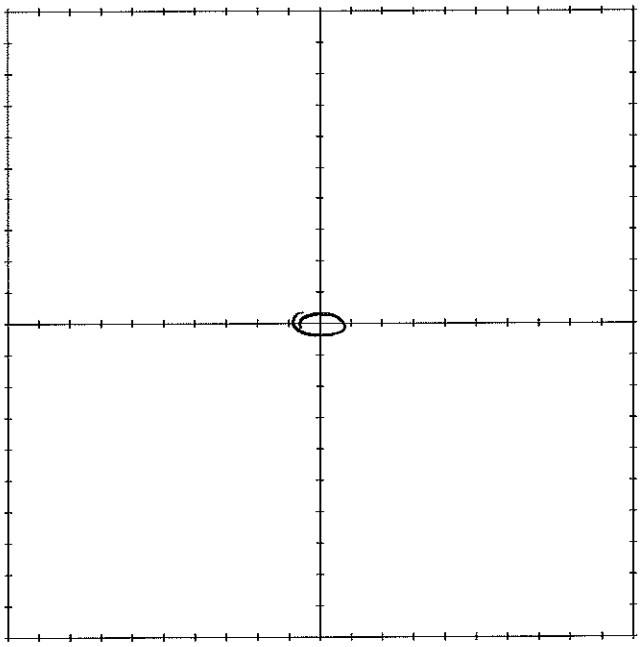
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplocs

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5059 (MA-0904)

SAMPLE I.D. 5059-BG1-005

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1259

SAMPLE COLLECTED BY RJJ

WEATHER CONDITIONS 50's, Clear

FIELD USCS DESCRIPTIONS Silty sand

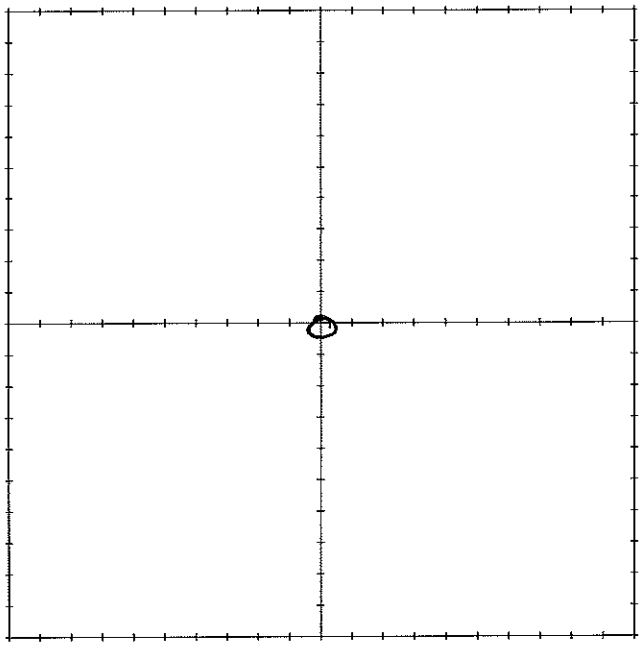
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5059 (HA-090Y)

SAMPLE I.D. 5059-BG1-006

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1306

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 50's, Clear

FIELD USCS DESCRIPTIONS Silty sand, trace weathered sandstone frags

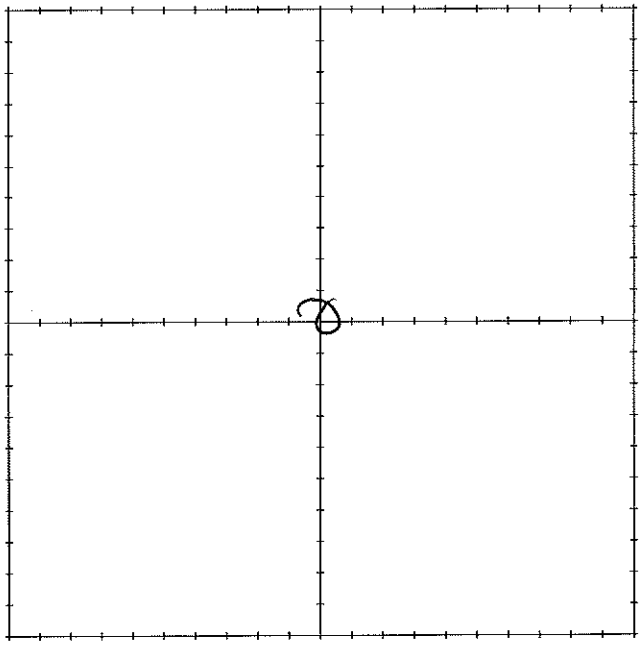
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziplox

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5059 (NA-0904)

SAMPLE I.D. 5059-B91-007

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME ~~1412~~ 1312

SAMPLE COLLECTED BY KJS

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS Silty Sand, some organic material

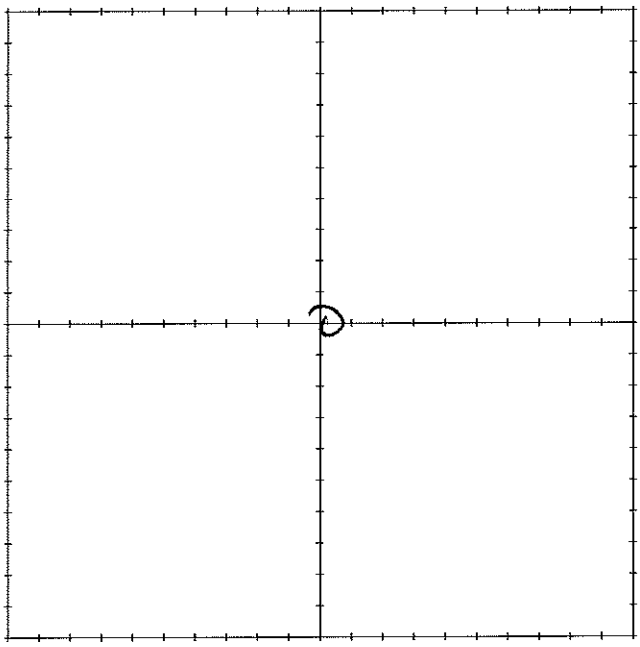
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 5059 (NA-0904)

SAMPLE I.D. 5059-BGI-008

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1322

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS silty sand, trace organic matter

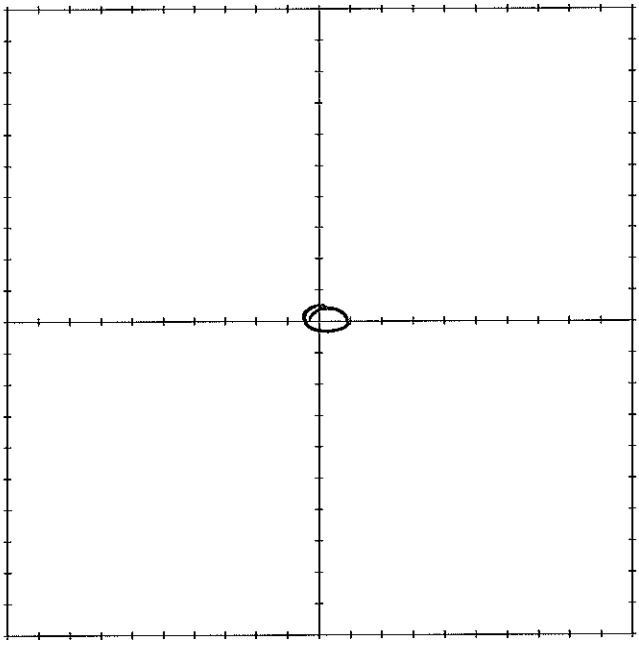
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziplocs

ANALYSES: Ra-226, Metals.



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5059 CHA-0904

SAMPLE I.D. 5059-BG1-009

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1330

SAMPLE COLLECTED BY KJS

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS silty sand

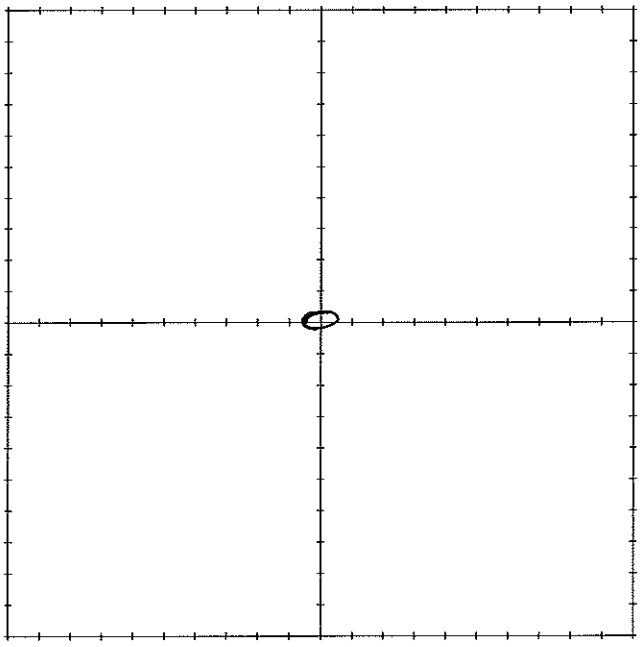
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziploc

ANALYSES: Perchlorate, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 3059 (MA-0904)

SAMPLE I.D. 3059-BG1-010

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1337

SAMPLE COLLECTED BY KJS

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS silty sand

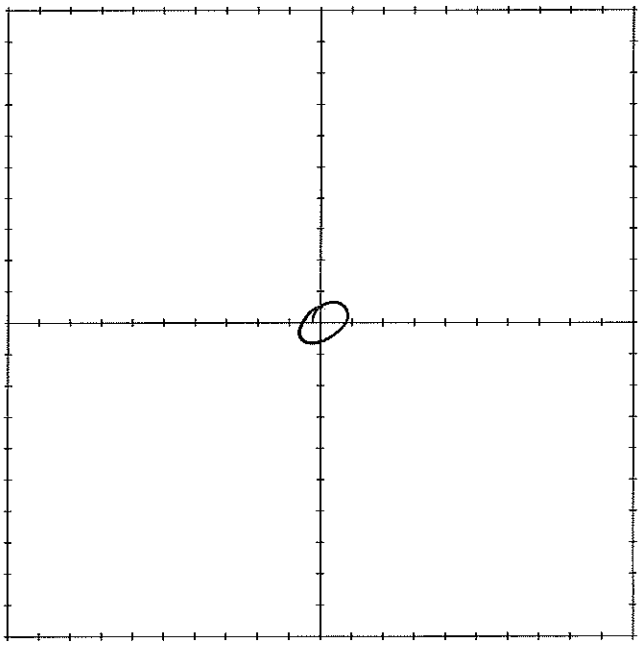
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5059 (NA-09041)

SAMPLE I.D. 5059-BG2-001 (201, dup)

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1352

SAMPLE COLLECTED BY KJS

WEATHER CONDITIONS 50s, Clear

FIELD USCS DESCRIPTIONS Silty Sand

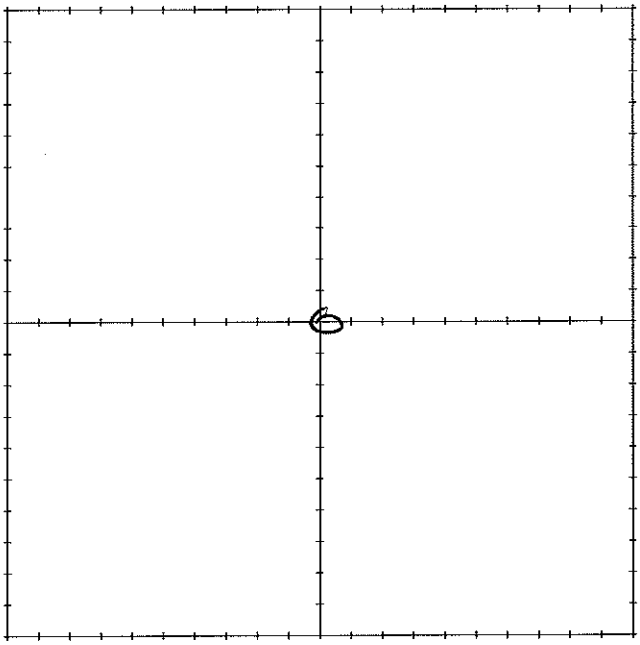
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, zplus

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 8059 (NA-09041)

SAMPLE I.D. 8059-BG2-002

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1401

SAMPLE COLLECTED BY KJS

WEATHER CONDITIONS 50's, Clear

FIELD USCS DESCRIPTIONS Silty sand, minor weathered slate

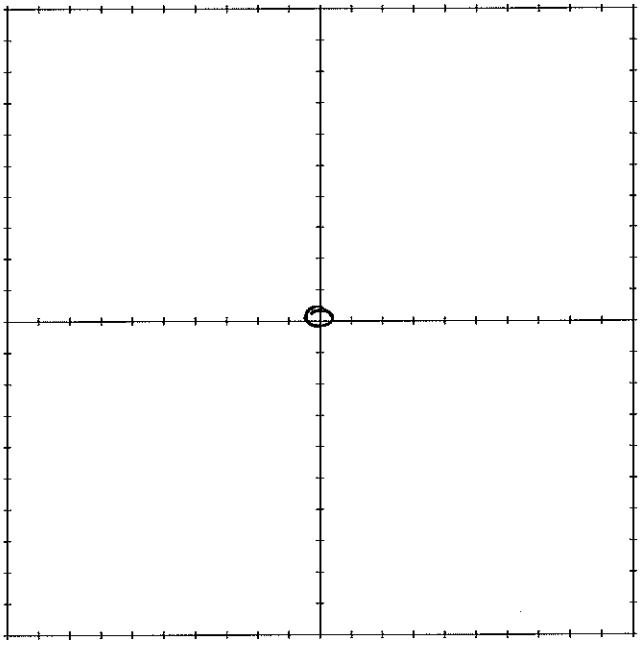
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 5059 (HA-0904)

SAMPLE I.D. 5059-BG2-0013

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1408

SAMPLE COLLECTED BY KJS

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS Silty sand

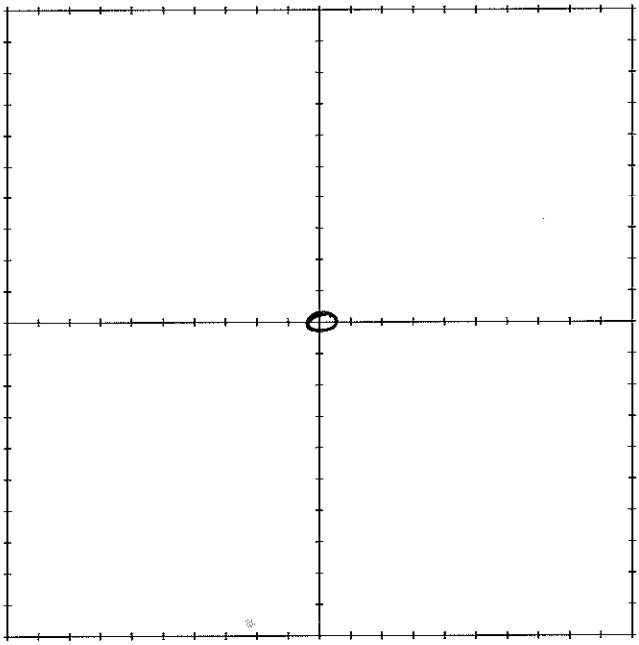
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5059 (NA-0904)

SAMPLE I.D. 5059-BG2-0041

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1416

SAMPLE COLLECTED BY KJS

WEATHER CONDITIONS 50's, Clear

FIELD USCS DESCRIPTIONS Silty sand, dk grey SB trace

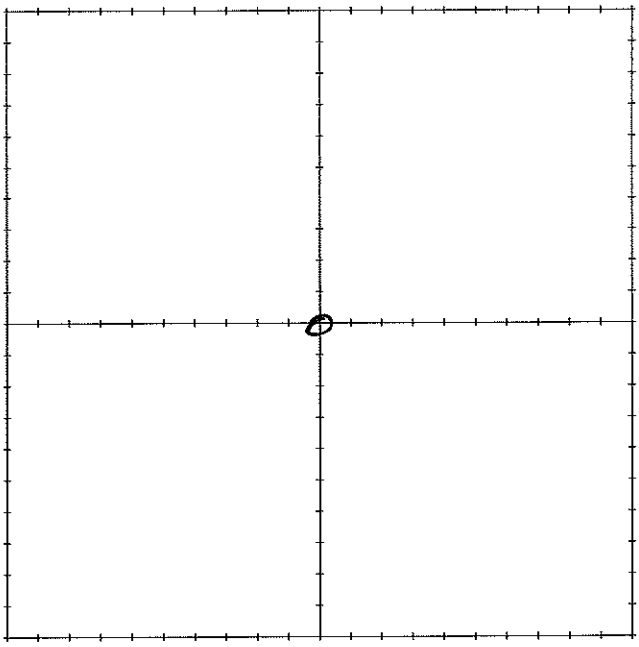
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziplc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 3059 (MA-0904)

SAMPLE I.D. 3059-BG2-005

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1424

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 50's, Clear

FIELD USCS DESCRIPTIONS Fine sand, minor decomposed SS

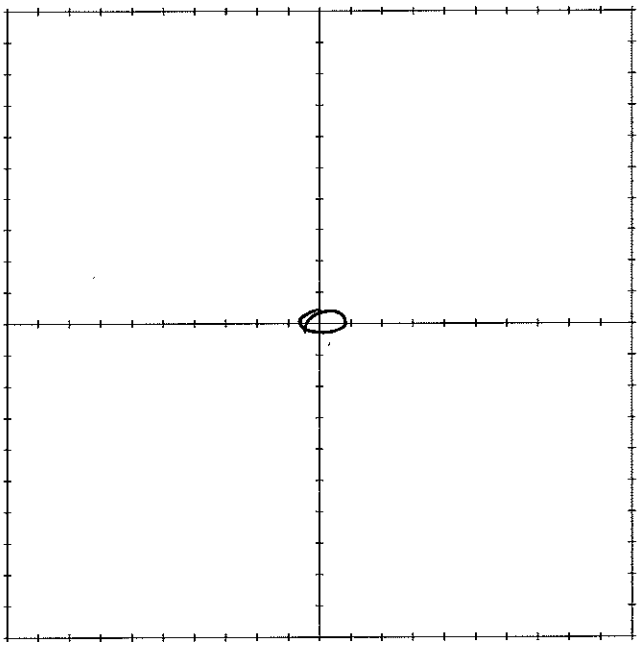
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 S059 (MA-0904)

SAMPLE I.D. S059-BG2-0006

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1430

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS Silty sand, decomposed SS minor

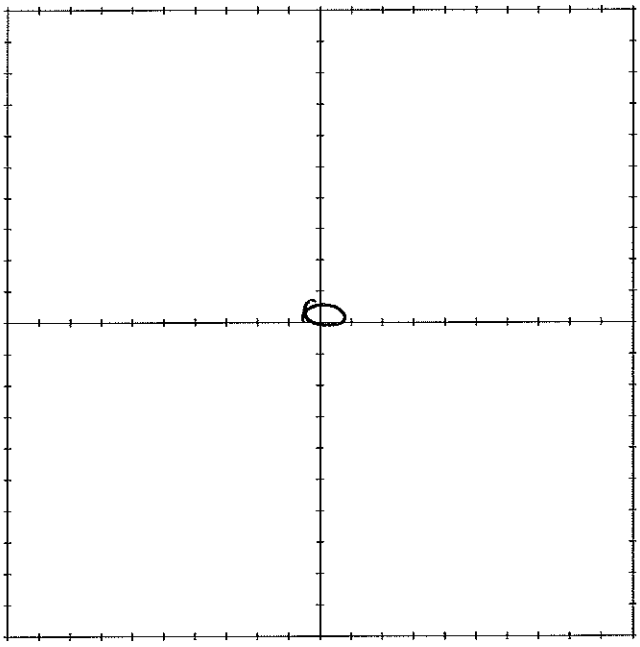
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziplocs

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 3059 (HA-0904)

SAMPLE I.D. 3059-BG2-007

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1436

SAMPLE COLLECTED BY KJS

WEATHER CONDITIONS 50's, Clear

FIELD USCS DESCRIPTIONS Silty Sand

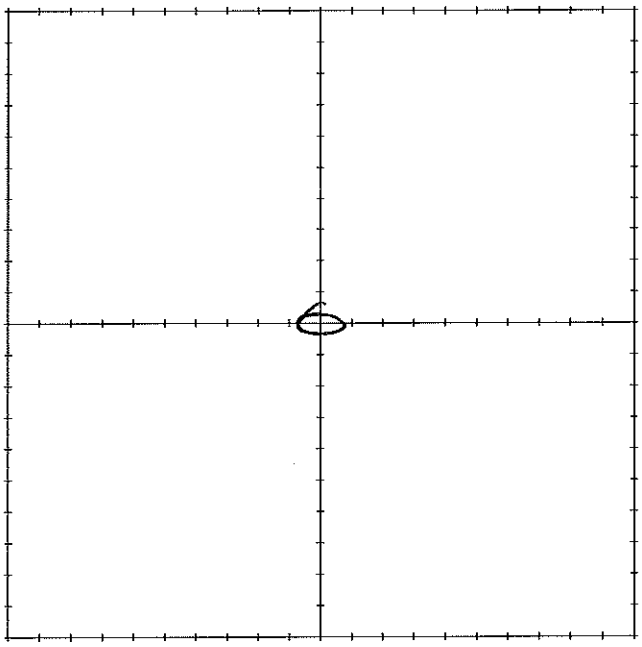
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplac

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: SD59 (MA-090-4)

SAMPLE I.D.: SD59-BG2-0008

SAMPLE COLLECTION DATE: 10/5/16

SAMPLE COLLECTION TIME: 1443

SAMPLE COLLECTED BY: KJJ

WEATHER CONDITIONS: 50's, clear

FIELD USCS DESCRIPTIONS: Silty Sand

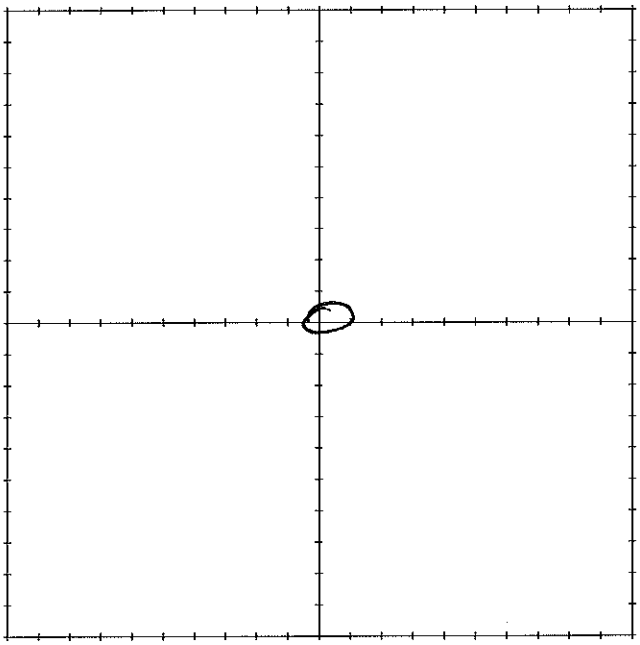
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE): 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5059 (HA-0904)

SAMPLE I.D. 5059-BG2-009

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1450

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS silty sand

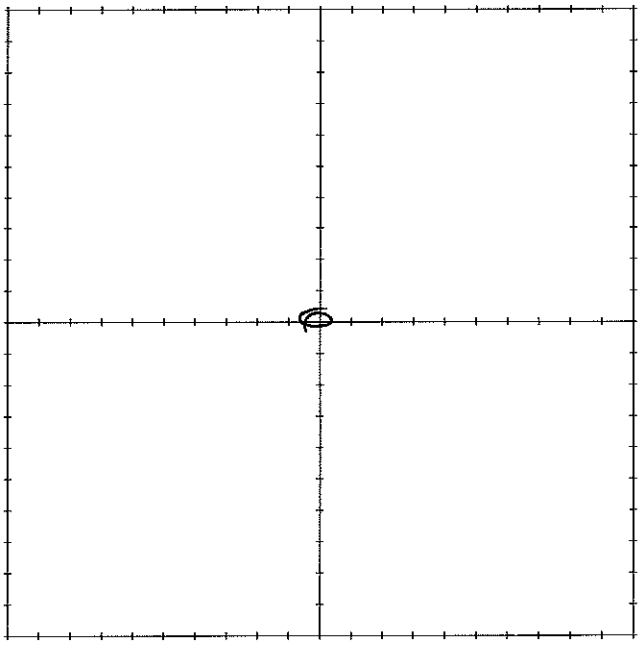
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5059 (HA-0904)

SAMPLE I.D. 5059 - BG2- 010 (210, dup)

SAMPLE COLLECTION DATE 10/5/16

SAMPLE COLLECTION TIME 1458

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS Silty Sand

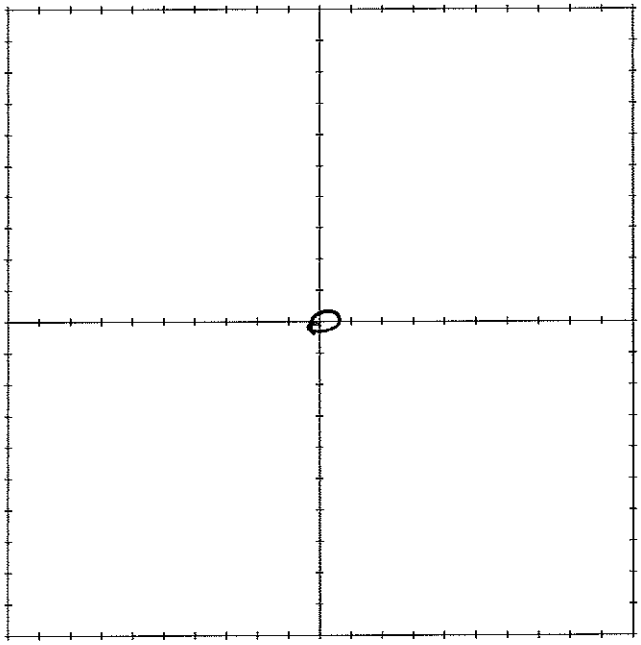
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: SD59 (MA-0904)

SAMPLE I.D.: SD59-BG3-001

SAMPLE COLLECTION DATE: 10/6/16

SAMPLE COLLECTION TIME: 1205

SAMPLE COLLECTED BY: C. Lee

WEATHER CONDITIONS: 50's, clear

FIELD USCS DESCRIPTIONS: Clean sand

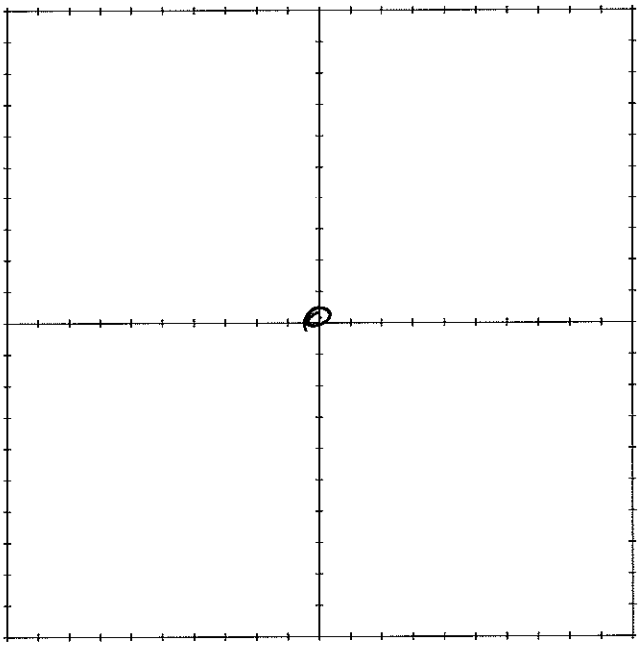
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE): 2 ziplocs

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5059 (MA-0904)

SAMPLE I.D. 5059-BG3-002

SAMPLE COLLECTION DATE 10/6/16

SAMPLE COLLECTION TIME 1212

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 50's, Clear

FIELD USCS DESCRIPTIONS Well sorted fine sand

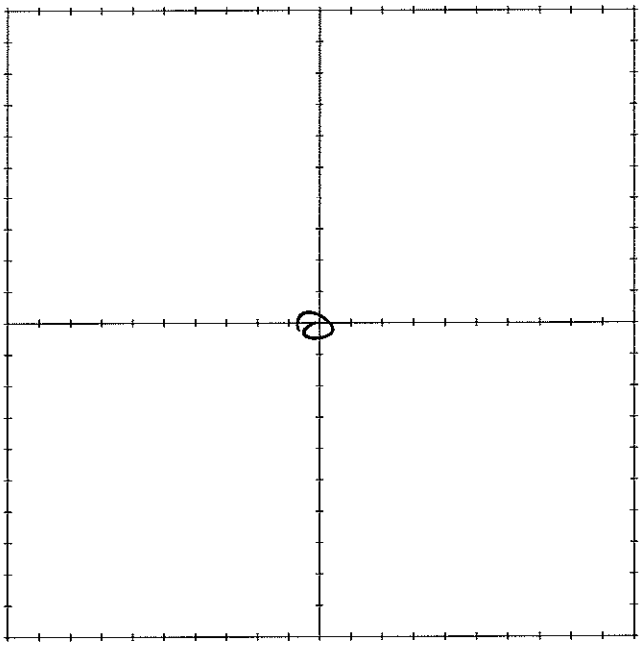
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplocs

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5059 (HA-0904)

SAMPLE I.D. 5059-BG3-003

SAMPLE COLLECTION DATE 10/6/16

SAMPLE COLLECTION TIME 1216

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 50's, Clear

FIELD USCS DESCRIPTIONS well-sorted fine sand

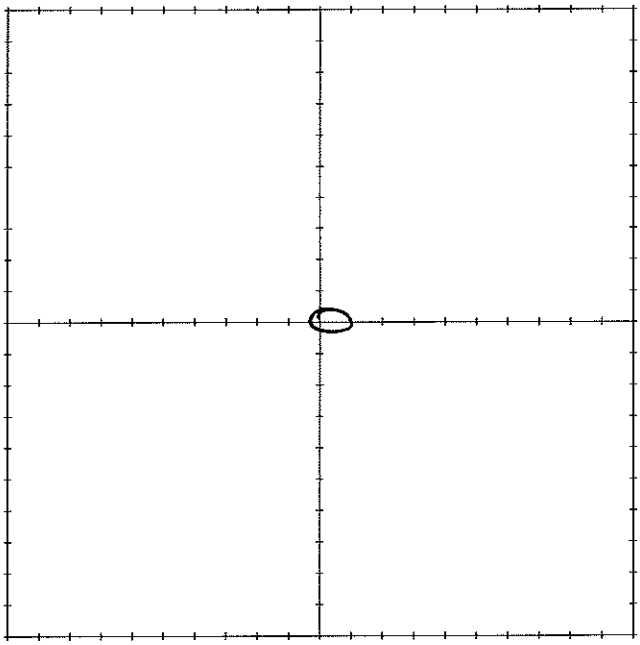
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziplox

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: S059 (MA-0904)

SAMPLE I.D.: S059-BG3-004 (MS, MSD)

SAMPLE COLLECTION DATE: 10/6/16

SAMPLE COLLECTION TIME: 1222

SAMPLE COLLECTED BY: C. Lee

WEATHER CONDITIONS: 50's, Clear

FIELD USCS DESCRIPTIONS: Well-sorted fine sand

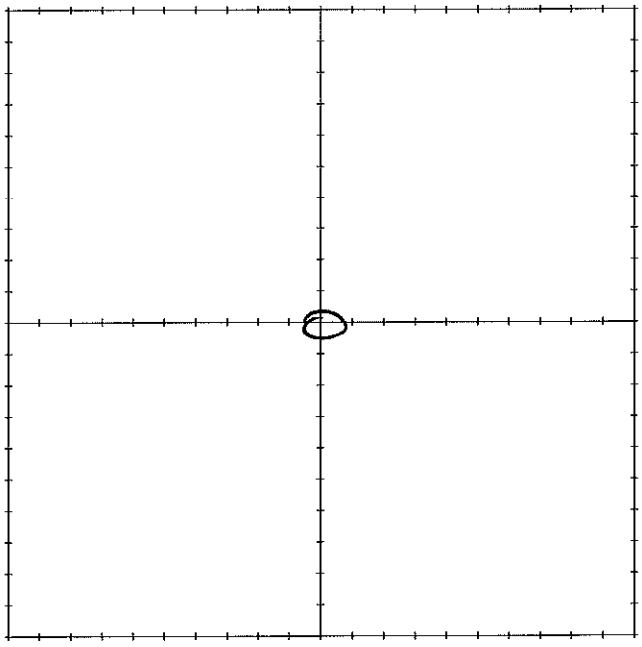
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE): 2, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5059 (NA-09041)

SAMPLE I.D. 5059-BG3-005

SAMPLE COLLECTION DATE 10/6/16

SAMPLE COLLECTION TIME 1238

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS Sands, decomposed SS trace

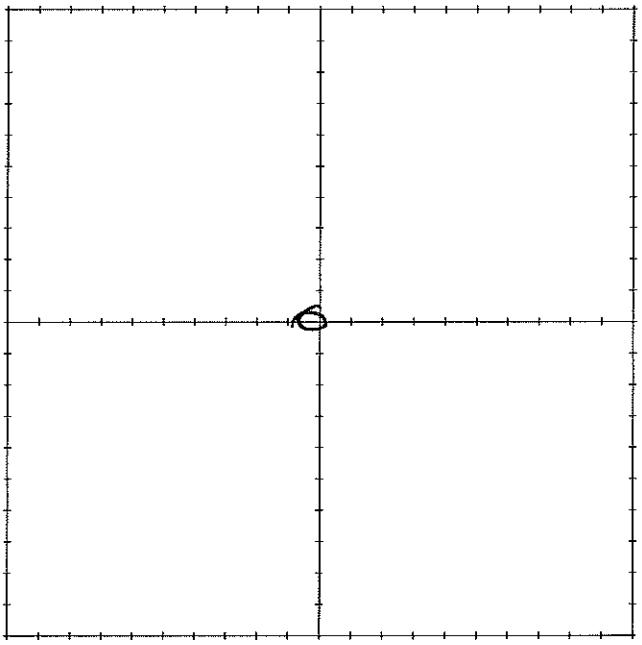
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, zip loc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 3059 (MA-0904)

SAMPLE I.D. 3059-BG3-006

SAMPLE COLLECTION DATE 10/6/16

SAMPLE COLLECTION TIME 1243

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 50', clear

FIELD USCS DESCRIPTIONS Well-sorted sand

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

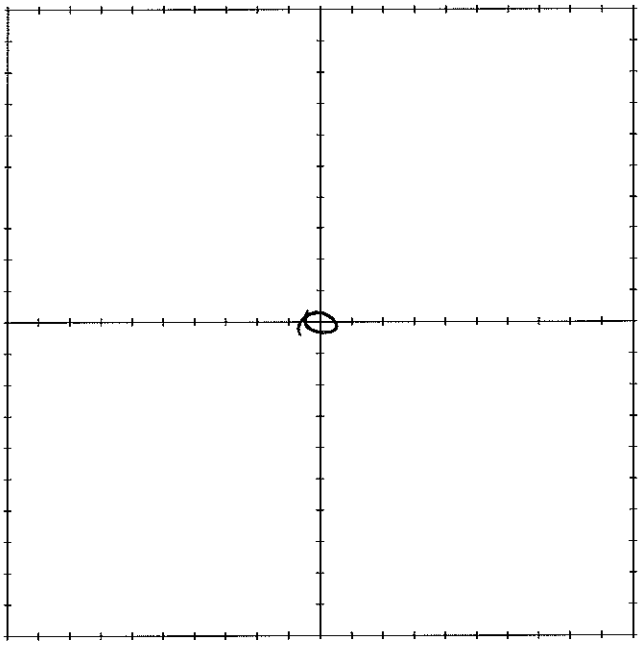
No Trace

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, 2-pint

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5059 (MA-0904)

SAMPLE I.D. 5059-BG3-007

SAMPLE COLLECTION DATE 10/6/16

SAMPLE COLLECTION TIME 1249

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 50's, Clear

FIELD USCS DESCRIPTIONS Well sorted Sand

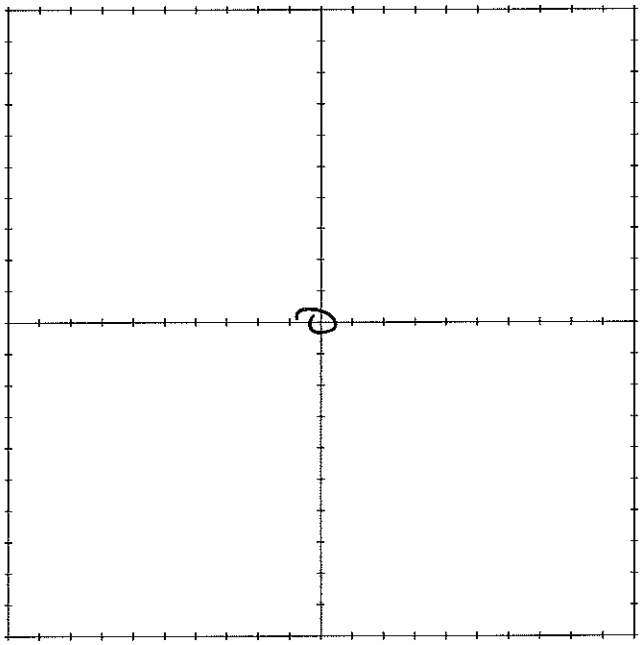
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziplox

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 3059 (HA-0904)

SAMPLE I.D. 3059-BG3-008

SAMPLE COLLECTION DATE 10/6/16

SAMPLE COLLECTION TIME 1255

SAMPLE COLLECTED BY L. Lee

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS Well-sorted sand

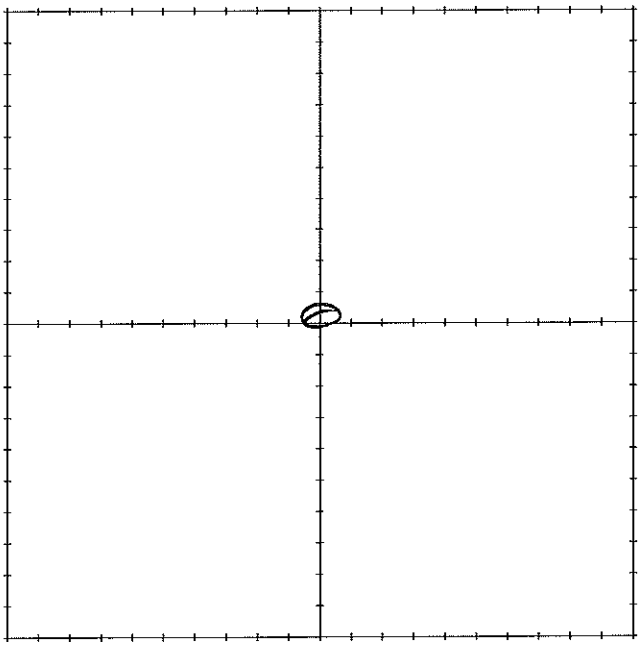
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S059 (MA-0904)

SAMPLE I.D. S059-BG3-009

SAMPLE COLLECTION DATE 10/6/16

SAMPLE COLLECTION TIME 1303

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS Weathd fine-grained SS particles, Minor sand

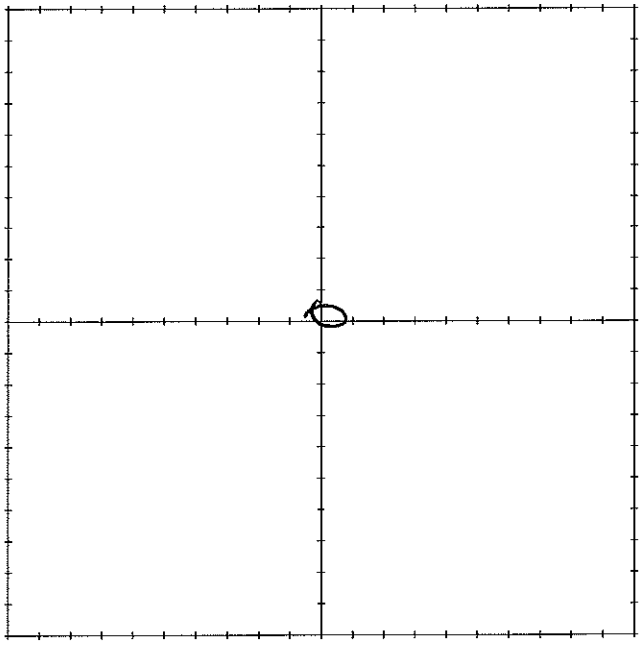
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☑ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: S059 (MA-0904)

SAMPLE I.D.: S059-BG3-010 (210, dup)

SAMPLE COLLECTION DATE: 10/6/16

SAMPLE COLLECTION TIME: 1310

SAMPLE COLLECTED BY: C. Lee

WEATHER CONDITIONS: 50's, clear

FIELD USCS DESCRIPTIONS: well sorted sand

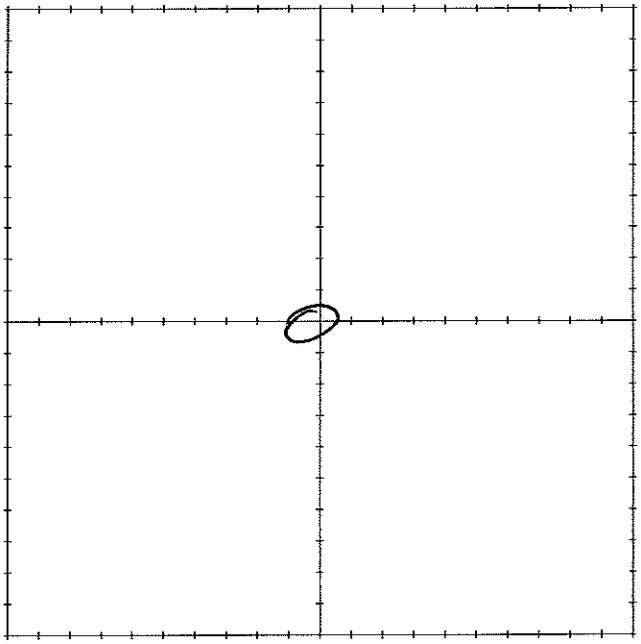
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE): 2 ziploc

ANALYSES: Ra-226, Metals.



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME NA-0904

SAMPLE I.D. 5059-BG-4-001

SAMPLE COLLECTION DATE 9/14/17

SAMPLE COLLECTION TIME 1018

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny, 75°F

FIELD USCS DESCRIPTIONS Poorly graded Sand (SP), light reddish brown (5YR 6/4), fine to coarse grained sand, dry, loose.

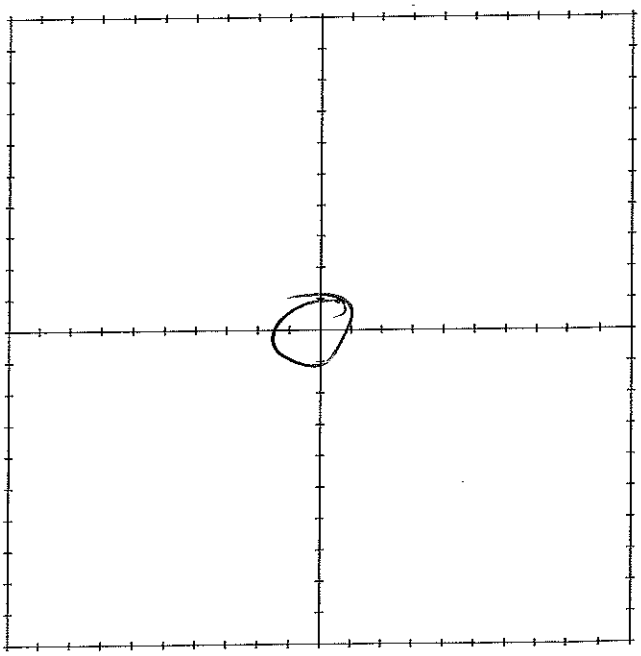
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplocks

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME NA-0904

SAMPLE I.D. 5059-804-002

SAMPLE COLLECTION DATE 9/14/17

SAMPLE COLLECTION TIME 1030

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded Sand (SP), light reddish-brown (5 YR 6/4), fine to coarse sand, dry, loose

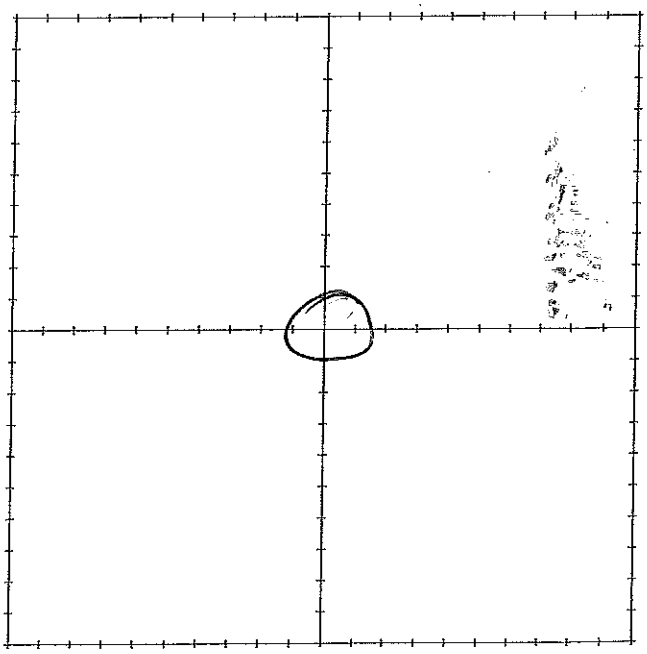
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 NA - 0904

SAMPLE I.D. SO59 - BG-4-003

SAMPLE COLLECTION DATE 9/14/17

SAMPLE COLLECTION TIME 1041

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded Sand (SP), light reddish brown (5YR 6/4), fine to coarse sand, trace gravels, loose, dry.

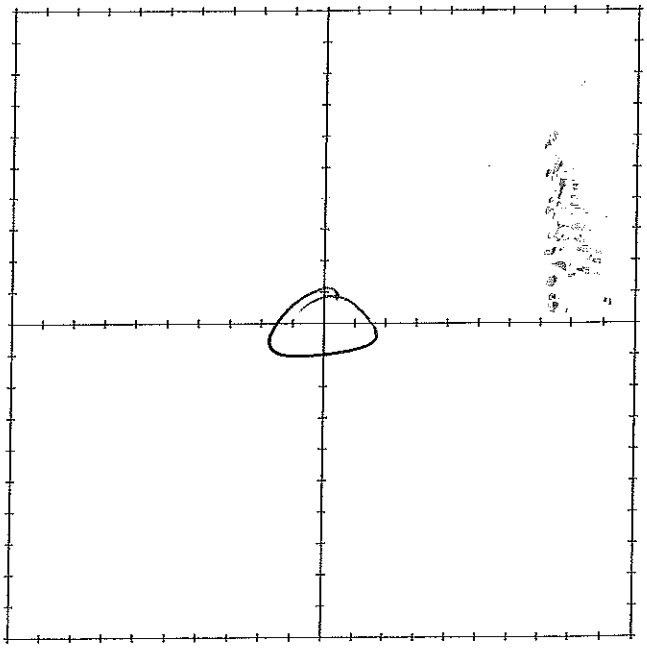
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags

ANALYSES: RA - 226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME NA-0904

SAMPLE I.D. S059-BG4-004

SAMPLE COLLECTION DATE 9/14/17

SAMPLE COLLECTION TIME 1047

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP) light reddish brown (5YR 6/4), fine to coarse sand, dry, loose

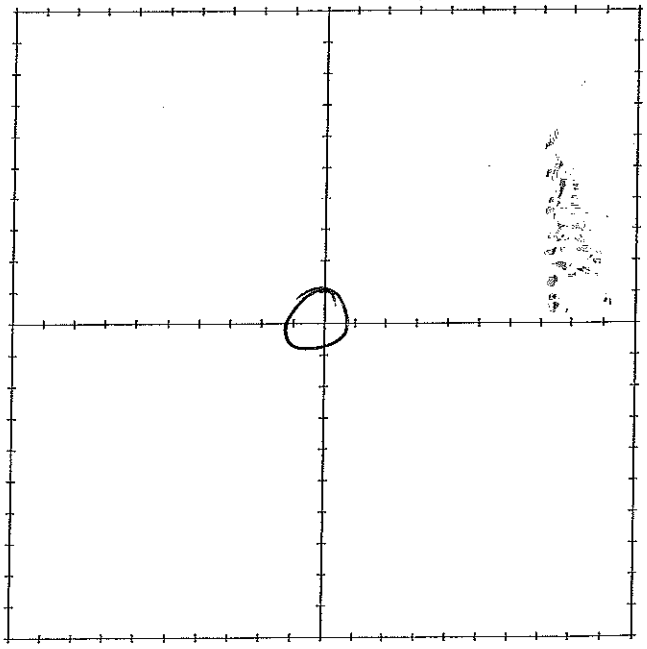
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 NA-0904

SAMPLE I.D. 5059-B64-005

SAMPLE COLLECTION DATE 9/14/17

SAMPLE COLLECTION TIME 1057

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny, 75°F

FIELD USCS DESCRIPTIONS Poorly graded sand (SP), light reddish-brown (5YR 6/4) fine to coarse sand, dry, loose, trace white.

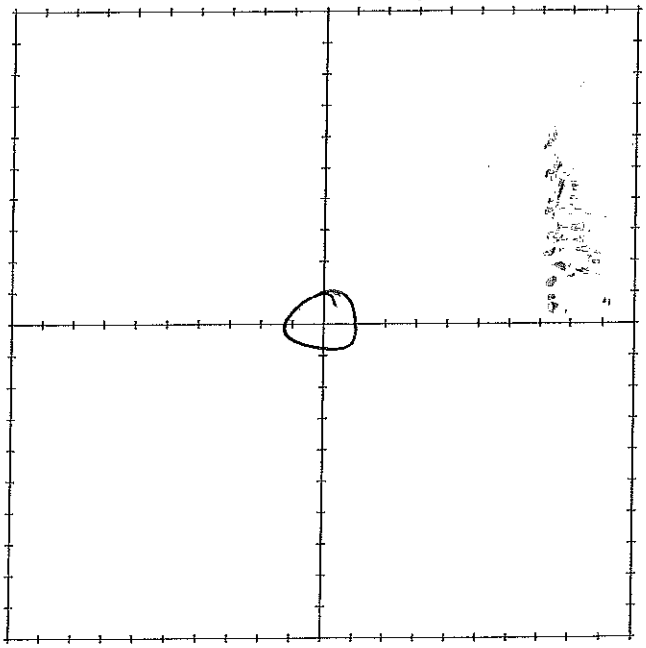
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 NA-0904

SAMPLE I.D. SO59-BG-4-006

SAMPLE COLLECTION DATE 9/14/17

SAMPLE COLLECTION TIME 1103

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded Sand (SP), light reddish brown (5YR 6/4), fine to medium grained Sand, dry, loose

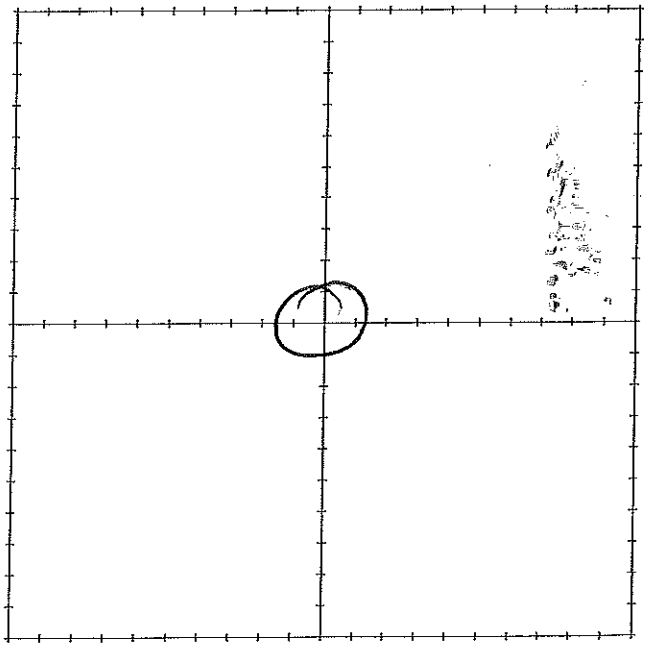
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 NA-0904

SAMPLE I.D. 5059-BG4-007

SAMPLE COLLECTION DATE 9/14/17

SAMPLE COLLECTION TIME 1107

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded Sand (SP) light reddish brown (5 YR 6/4), fine to medium grained sand, dry, loose.

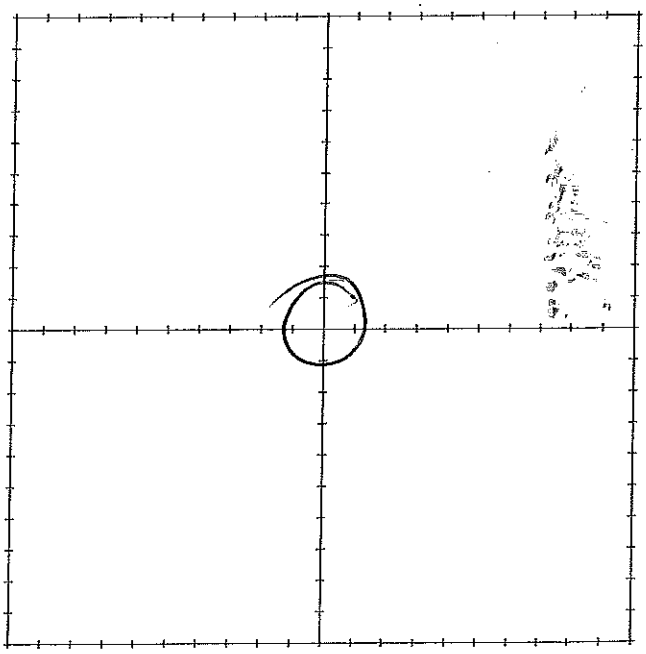
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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: NA - 0904

SAMPLE I.D.: 5059-864-008

SAMPLE COLLECTION DATE: 9/14/17

SAMPLE COLLECTION TIME: 1113

SAMPLE COLLECTED BY: JR

WEATHER CONDITIONS: Sunny 75°F

FIELD USCS DESCRIPTIONS: Poorly graded Sand (SP), light reddish brown (5YR 6/4), fine to medium grained Sand, dry, loose

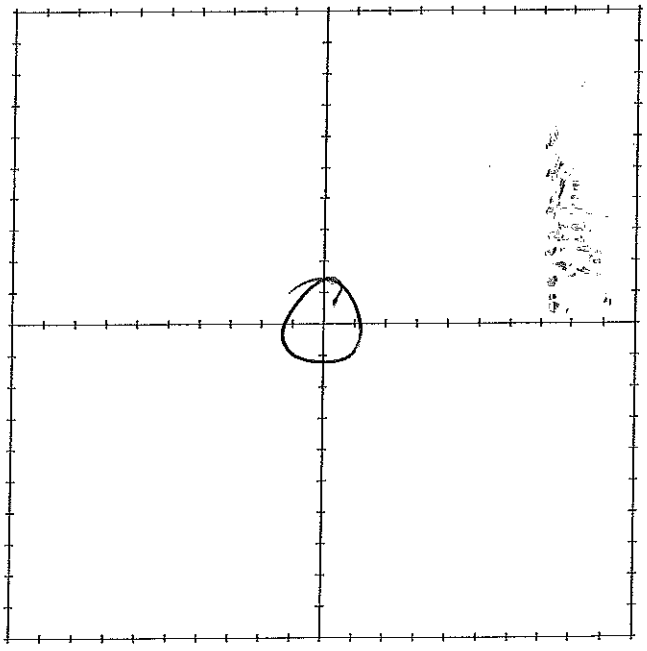
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 NA-0904

SAMPLE I.D. 5059-864-009

SAMPLE COLLECTION DATE 9/14/17

SAMPLE COLLECTION TIME 1120

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny 75°F

FIELD USCS DESCRIPTIONS Poorly graded Sand (SP) Light reddish brown (5 YR 6/4) Fine to Coarse Sand, dry, loose.

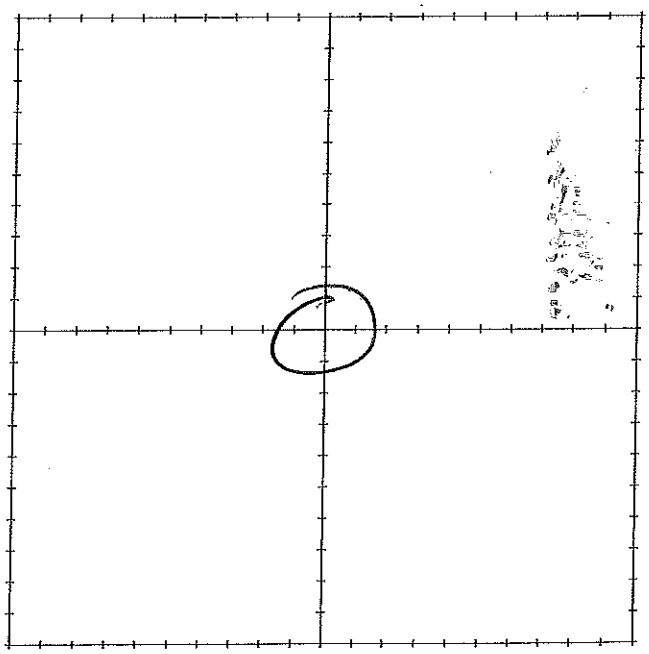
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 NA - 0904

SAMPLE I.D. 5059 - BG4 - 010

SAMPLE COLLECTION DATE 9/14/17

SAMPLE COLLECTION TIME 1125

SAMPLE COLLECTED BY JR

WEATHER CONDITIONS Sunny, 75°F

FIELD USCS DESCRIPTIONS Poorly graded Sand (SP) light reddish brown (5YR 6/4), fine to medium grained sand, dry, loose,

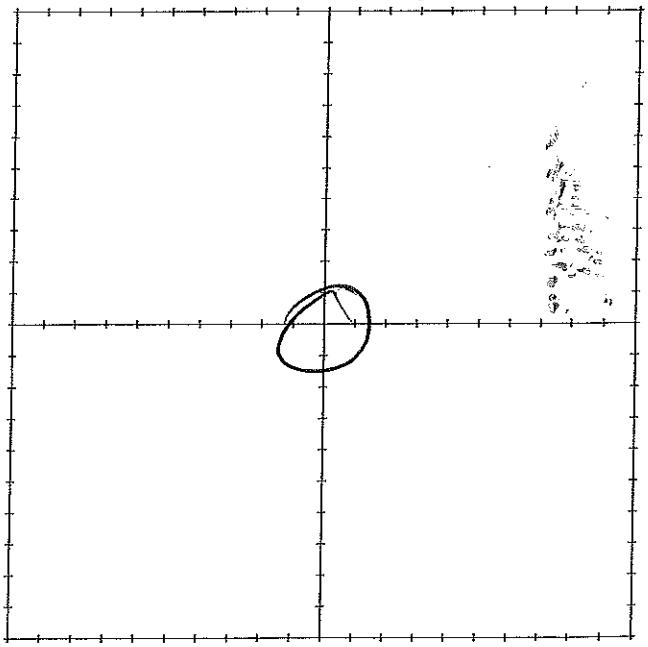
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 3059-601-001 (HA-0904)

SAMPLE I.D. 3059-601-001

SAMPLE COLLECTION DATE 10/11/16

SAMPLE COLLECTION TIME 1030

SAMPLE COLLECTED BY L. Lee

WEATHER CONDITIONS 60's, sunny

FIELD USCS DESCRIPTIONS Brown silt

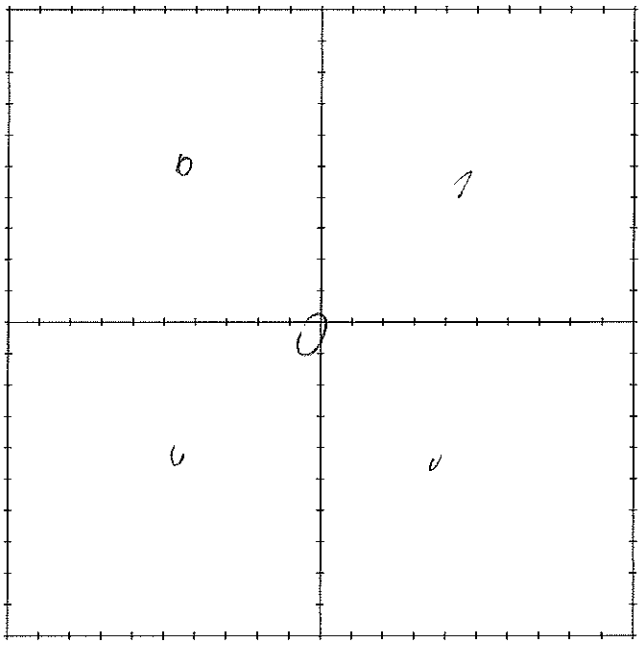
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziplock

ANALYSES: Ra-226, Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S059-C02-001 (HA-0964)

SAMPLE I.D. S059-C02-001

SAMPLE COLLECTION DATE 10/11/16

SAMPLE COLLECTION TIME 1110

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 60's Sunny

FIELD USCS DESCRIPTIONS Brown silt

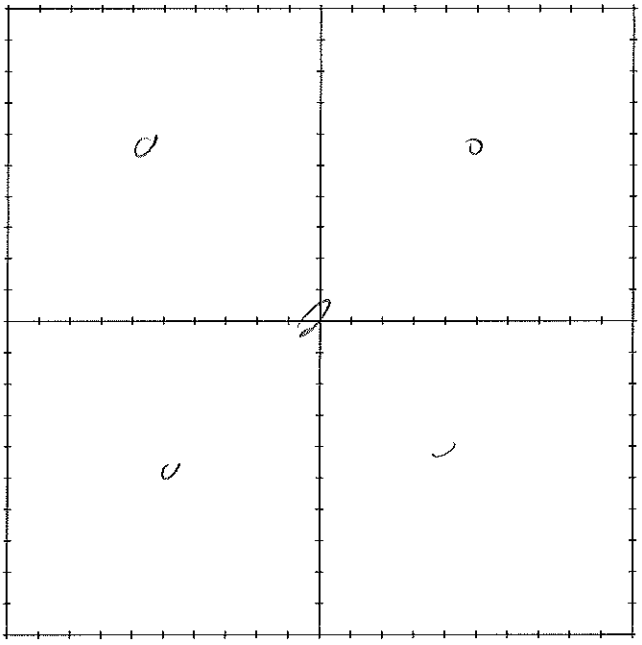
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziplock

ANALYSES: Ra-226, Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME SO59-603-601 (NA-0704)

SAMPLE I.D. SO59-(03-001)

SAMPLE COLLECTION DATE 10/11/16

SAMPLE COLLECTION TIME 1142

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 60's sunny

FIELD USCS DESCRIPTIONS Brown silt

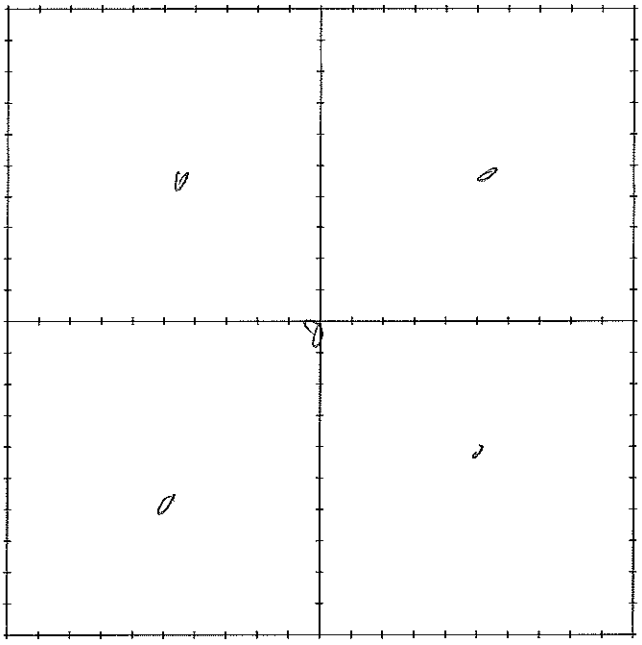
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziplock

ANALYSES: Ra-226, Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5059-C04-601 (HA-0904)

SAMPLE I.D. 5059-C04-601

SAMPLE COLLECTION DATE 10/19/16

SAMPLE COLLECTION TIME 1230

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 40's sunny

FIELD USCS DESCRIPTIONS Brown Silt

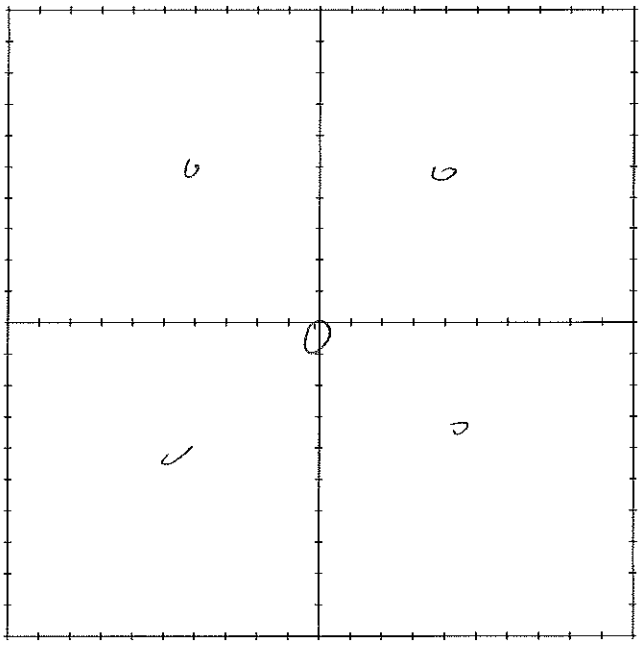
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 - 2 ziploch

ANALYSES: Ra-226, Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: 5059-C05-001 (NA-0904)

SAMPLE I.D.: 5059-C05-001

SAMPLE COLLECTION DATE: 10/11/16

SAMPLE COLLECTION TIME: 1505

SAMPLE COLLECTED BY: C. Lee

WEATHER CONDITIONS: 60's, Sunny

FIELD USCS DESCRIPTIONS: Brown silt

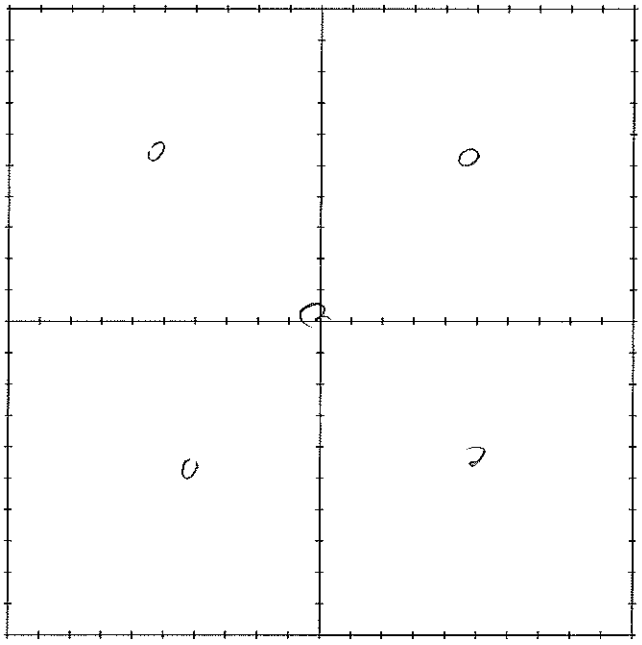
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE): 1, Ziplock

ANALYSES: Ra-226, Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME NA-904

SAMPLE I.D. S059-cx-001

SAMPLE COLLECTION DATE 4/11/17

SAMPLE COLLECTION TIME 1400

SAMPLE COLLECTED BY L. Rod

WEATHER CONDITIONS Sunny

FIELD USCS DESCRIPTIONS Fine light red sands and silts minor clay

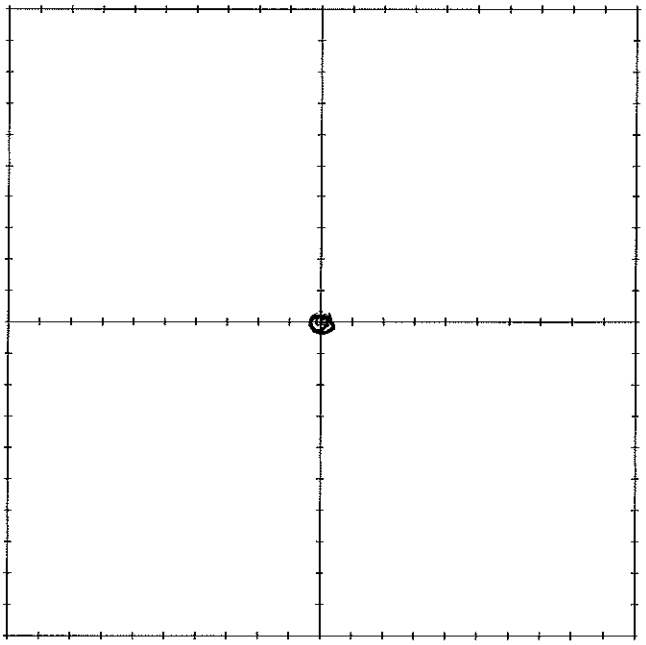
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☑ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☐ DRY ☑ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 zip lock

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME NA-904

SAMPLE I.D. S059-CX-002

SAMPLE COLLECTION DATE 4/11/17

SAMPLE COLLECTION TIME 1500

SAMPLE COLLECTED BY L. Rodd

WEATHER CONDITIONS Sunny

FIELD USCS DESCRIPTIONS Fine light red sand, moist, gravels ½" - 1"

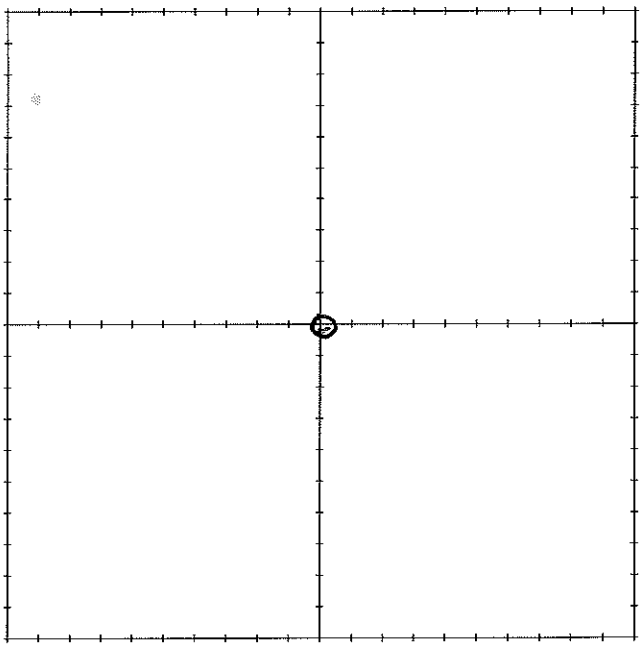
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☐ DRY ☒ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Zip locks

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME NA-904

SAMPLE I.D. SO59-EX-003

SAMPLE COLLECTION DATE 4/11/17

SAMPLE COLLECTION TIME 1530

SAMPLE COLLECTED BY L. Rad

WEATHER CONDITIONS Sunny

FIELD USCS DESCRIPTIONS Fine poorly graded sand with silt

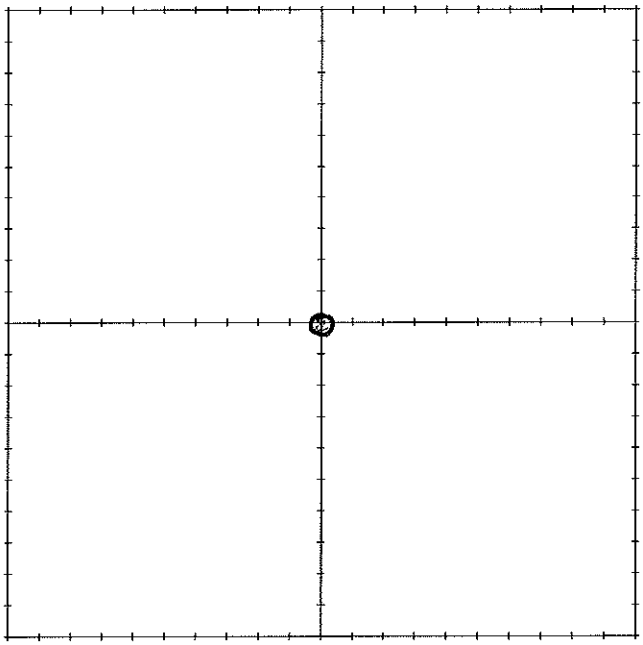
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☐ DRY ☑ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Zip locks

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME NA-904

SAMPLE I.D. SO59-CX-004

SAMPLE COLLECTION DATE 4/12/17

SAMPLE COLLECTION TIME 1123

SAMPLE COLLECTED BY TO, LR

WEATHER CONDITIONS Sunny

FIELD USCS DESCRIPTIONS Fine red sand, poorly graded, few gravels, subrounded to rounded, organic matter increased with depth

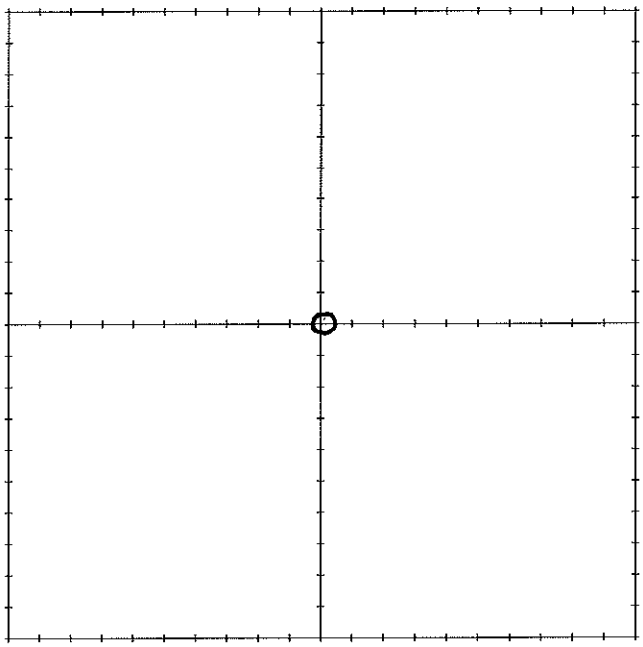
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☐ DRY ☑ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 zip locks

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME NA-904

SAMPLE I.D. SO59-CX-005

SAMPLE COLLECTION DATE 4/12/17

SAMPLE COLLECTION TIME 1145

SAMPLE COLLECTED BY TO, LR

WEATHER CONDITIONS SUNNY

FIELD USCS DESCRIPTIONS well sorted fine sand

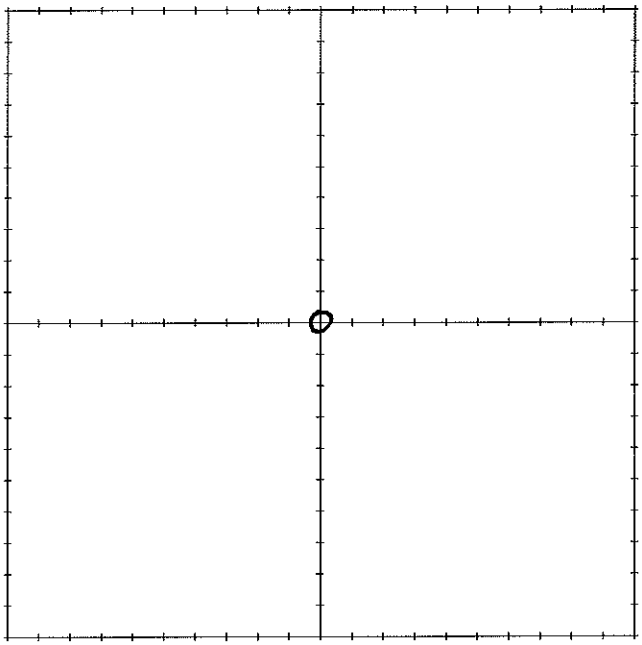
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 zip locks

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME NA-904

SAMPLE I.D. S054-CX-006

SAMPLE COLLECTION DATE 4/12/17

SAMPLE COLLECTION TIME 1202

SAMPLE COLLECTED BY TO, LR

WEATHER CONDITIONS Sunny

FIELD USCS DESCRIPTIONS Well sorted fine sand, slightly moist

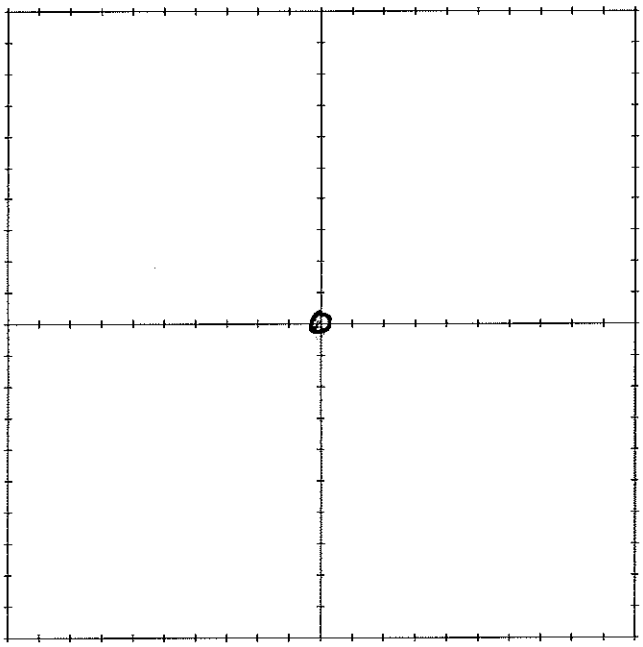
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☐ DRY ☑ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 zip locks

ANALYSES: Ra-226, Mytals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME NA-0904

SAMPLE I.D. SO59-CX-0007

SAMPLE COLLECTION DATE 4/12/17

SAMPLE COLLECTION TIME 1221

SAMPLE COLLECTED BY LR TO

WEATHER CONDITIONS SUNNY

FIELD USCS DESCRIPTIONS well graded fine sand

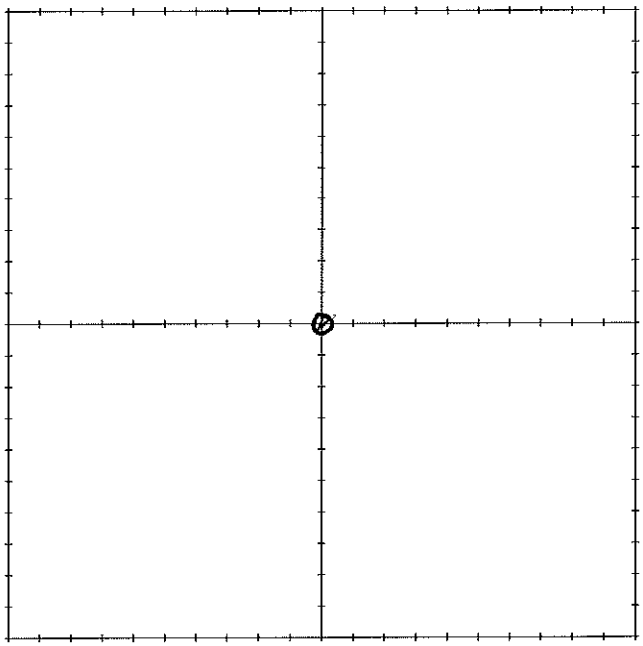
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☑ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☐ DRY ☑ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Zip locks

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME NA-0904

SAMPLE I.D. SOSG-CX-008

SAMPLE COLLECTION DATE 4/12/17

SAMPLE COLLECTION TIME 1236

SAMPLE COLLECTED BY LR, TO

WEATHER CONDITIONS Sunny

FIELD USCS DESCRIPTIONS fine sand, well developed biological soil 0-2" trace gravels

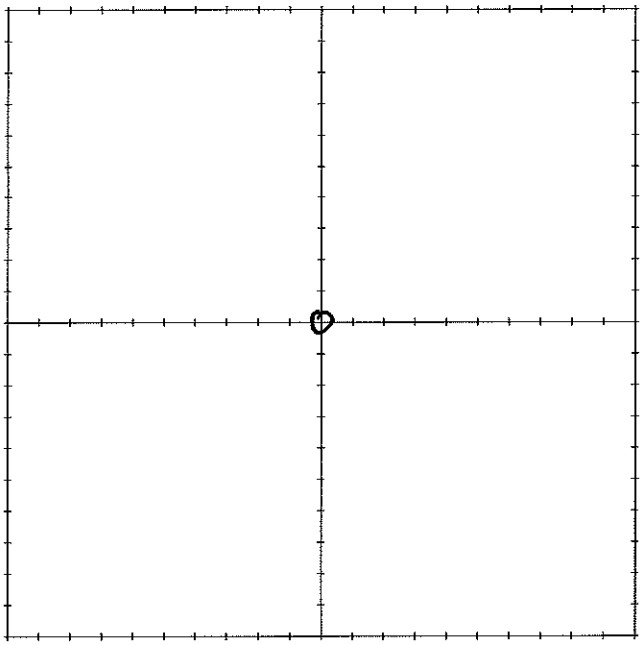
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 2:8 locks

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME NA-0904

SAMPLE I.D. S059-CX-0009

SAMPLE COLLECTION DATE 4/12/17

SAMPLE COLLECTION TIME 1315

SAMPLE COLLECTED BY L.R. & T.O.

WEATHER CONDITIONS Sunny

FIELD USCS DESCRIPTIONS fine brown/red sand, angular gravels to cobbles

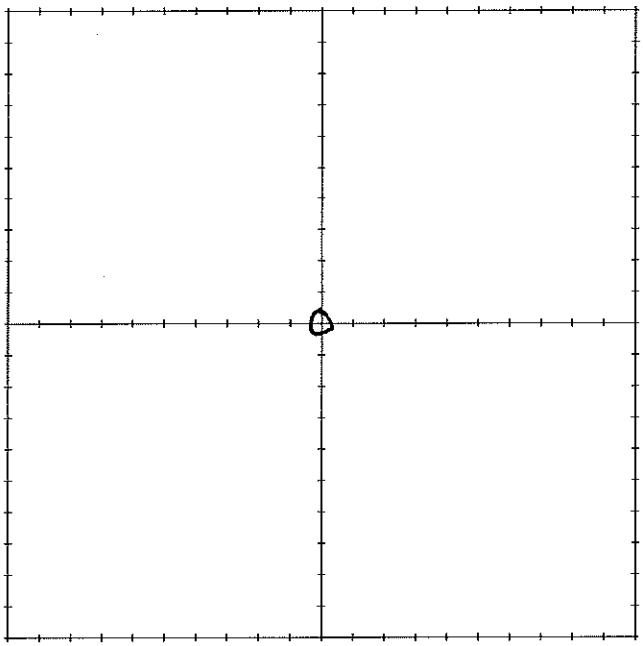
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☑ GP ☐ GW

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

MOISTURE: ☐ DRY ☑ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: Ra226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME NA-0904

SAMPLE I.D. S059-CX-010

SAMPLE COLLECTION DATE 4/12/17

SAMPLE COLLECTION TIME 1341

SAMPLE COLLECTED BY L.R. AND T.O.

WEATHER CONDITIONS Sunny

FIELD USCS DESCRIPTIONS fine tan/light brown sand w/ gravel, subangular ½"-3" max cobbles

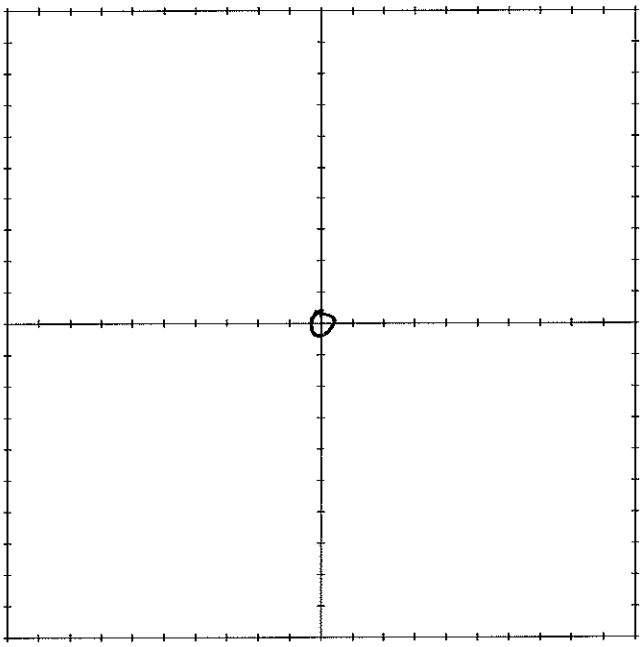
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☑ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: RA226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME NA-0904

SAMPLE I.D. S059-CX-011

SAMPLE COLLECTION DATE 9/12/17

SAMPLE COLLECTION TIME 1422

SAMPLE COLLECTED BY TO, LR

WEATHER CONDITIONS Sunny

FIELD USCS DESCRIPTIONS Fine sand light brown/red, well sorted, slightly moist

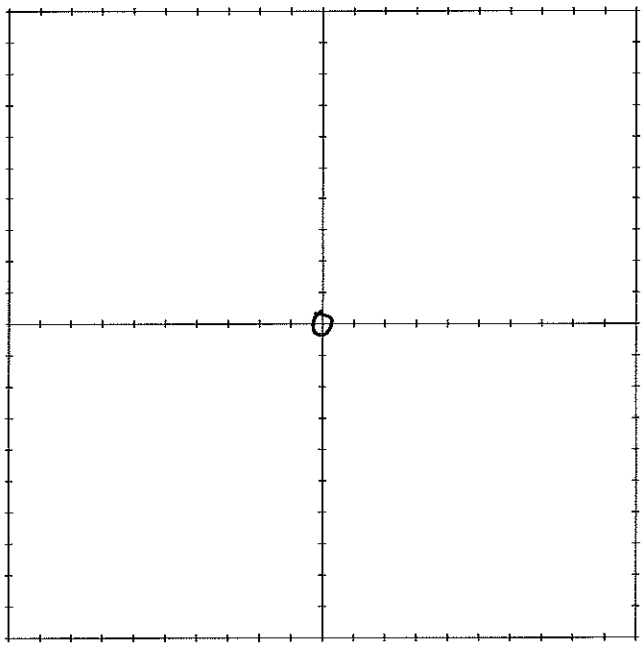
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☐ DRY ☑ MOIST ☐ WET

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 NA-0904

SAMPLE I.D. SO59-CX-012

SAMPLE COLLECTION DATE 4/12/17

SAMPLE COLLECTION TIME 1448

SAMPLE COLLECTED BY TO, LR

WEATHER CONDITIONS SUNNY

FIELD USCS DESCRIPTIONS well graded sands and gravels round to subangular, fine sand to 2", moist, no organics

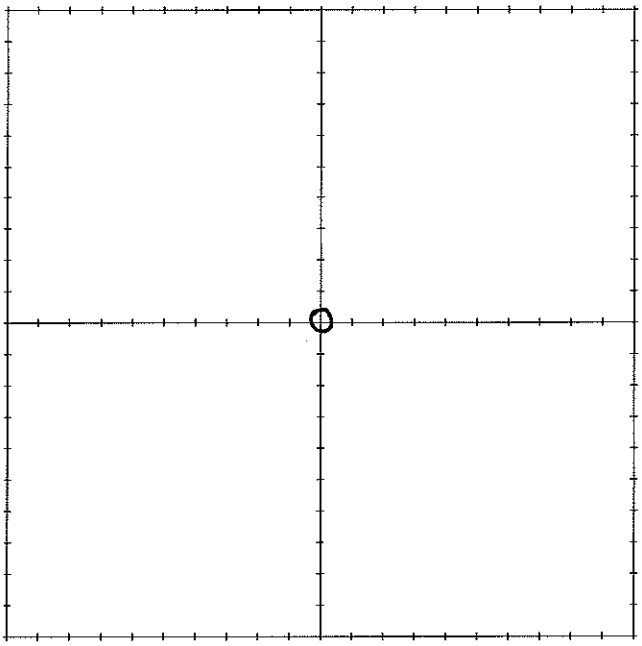
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☑ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☐ DRY ☑ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: Ra226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME NA-0904

SAMPLE I.D. SOSA-CX-013

SAMPLE COLLECTION DATE 4/13/17

SAMPLE COLLECTION TIME 1620

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS Sunny

FIELD USCS DESCRIPTIONS red/Brown poorly graded fine sand with minor coarse sand and gravel

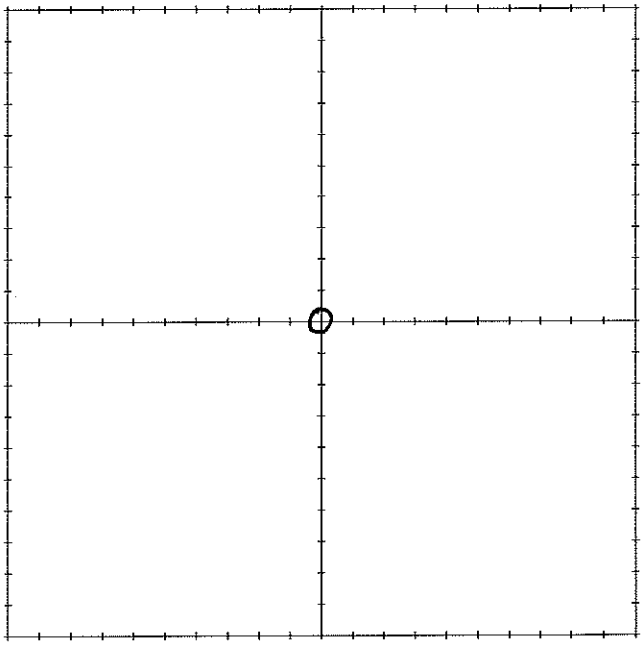
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplock bags

ANALYSES: RA226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

C.2 Hand Auger Borehole Logs

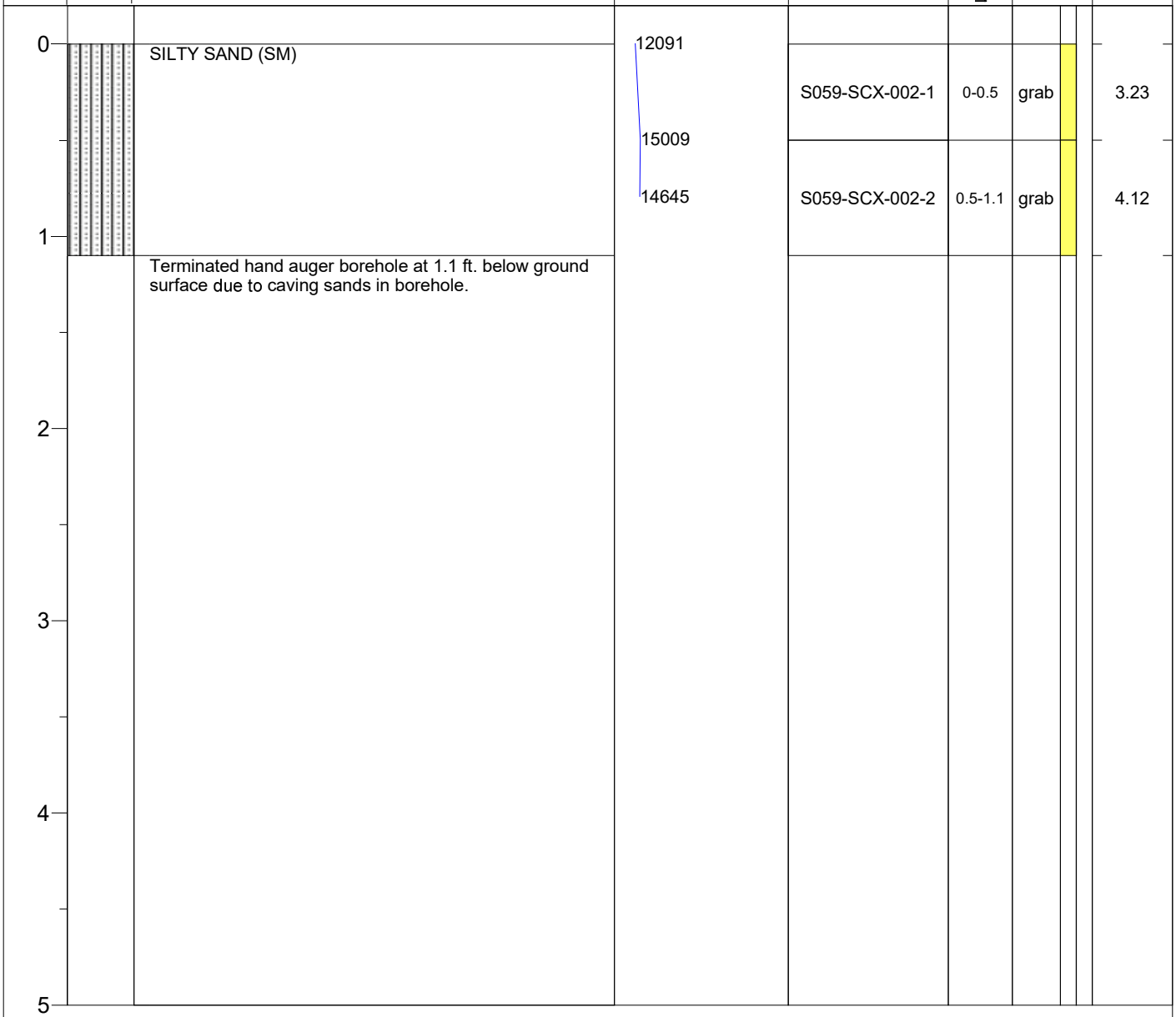
Stantec

NAVAJO NATION
AUM Environmental Response Trust - First Phase

BOREHOLE ID: **S059-SCX-002 (BG-1)**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 650536.5 NORTHING: 4084639.09
DATE STARTED: 10/11/2016 DATE STARTED: 10/11/2016
TOTAL DEPTH (ft.): 1.1 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez



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

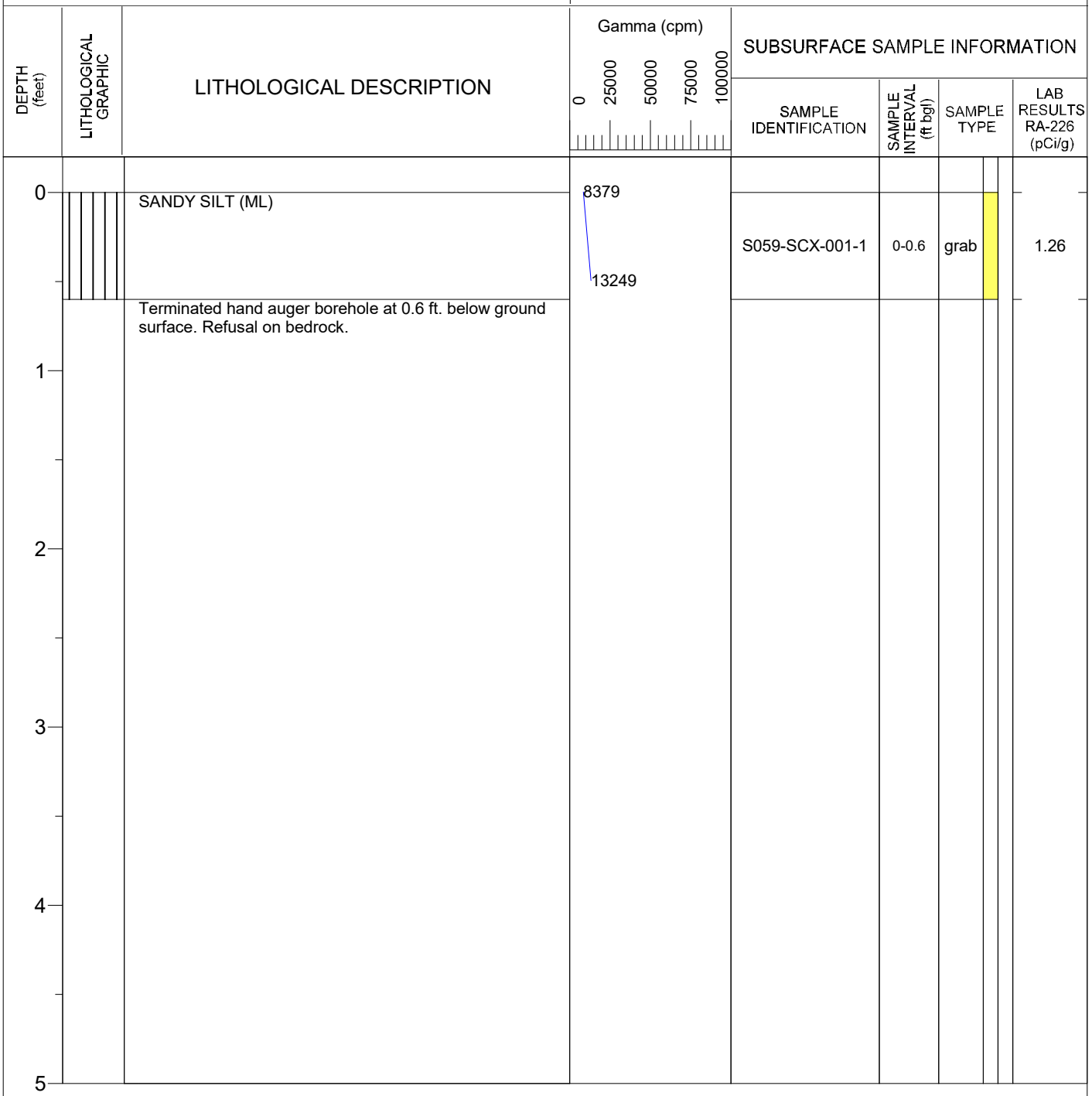
Stantec

NAVAJO NATION
AUM Environmental Response Trust - First Phase

BOREHOLE ID: **S059-SCX-001 (BG-2)**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 650513.05 NORTHING: 4084630.51
DATE STARTED: 10/11/2016 DATE STARTED: 10/11/2016
TOTAL DEPTH (ft.): 0.6 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez



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: **S059-SCX-003 (BG-3)**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651152.99 NORTHING: 4085166.31
DATE STARTED: 10/11/2016 DATE STARTED: 10/11/2016
TOTAL DEPTH (ft.): 1.1 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez

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): red, dry.	11880	S059-SCX-003-1	0-0.5	grab	0.62
1			13159	S059-SCX-003-2	0.5-1.1	grab	0.60
		Terminated hand auger borehole at 1.1 ft. below ground surface. Reason for termination unknown.					
2							
3							
4							
5							

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

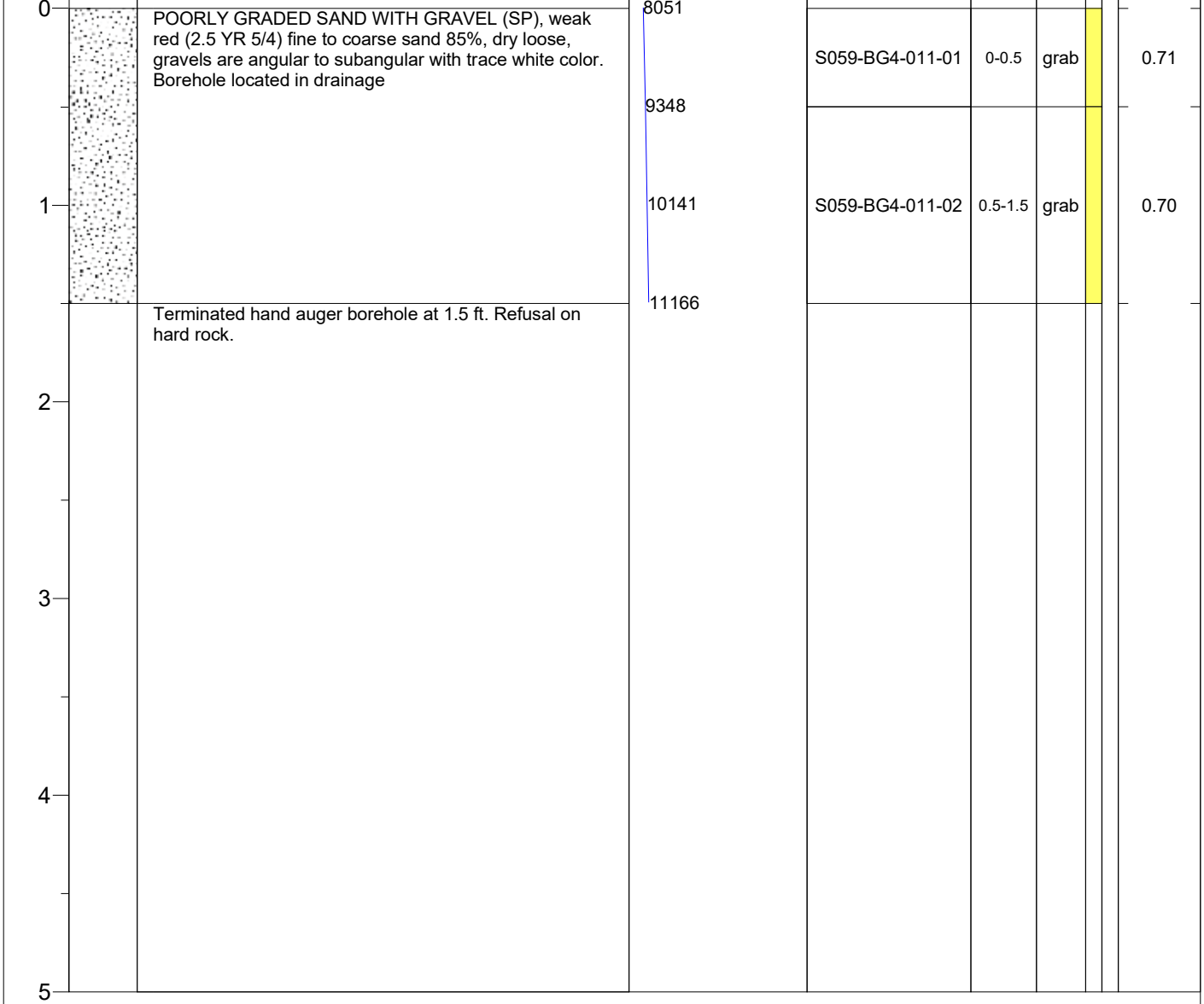
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S059-BG4-011**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651150.09 NORTHING: 4085278.11
DATE STARTED: 9/14/2017 DATE STARTED: 9/14/2017
TOTAL DEPTH (ft.): 1.5 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Michael Ward



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

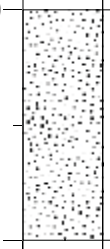
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S059-SCX-004**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651399.63 NORTHING: 4085246.02
DATE STARTED: 4/11/2017 DATE STARTED: 4/11/2017
TOTAL DEPTH (ft.): 1 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn



DEPTH (feet)	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SUBSURFACE SAMPLE INFORMATION			
			SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	POORLY GRADED SAND (SP): green, red, tan, fine to medium sand	32064				
			S059-SCX-004-1	0-0.5	grab	10.20
		50742				
			S059-SCX-004-3	0.5-1	grab	6.84
1	Terminated hand auger borehole at 1 ft. below ground surface. Refusal on rock.	75735				
2						
3						
4						
5						

Gamma (cpm) scale: 0, 50000, 100000, 150000, 200000

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

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S059-SCX-005**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651447.42 NORTHING: 4085277.06
DATE STARTED: 4/11/2017 DATE STARTED: 4/11/2017
TOTAL DEPTH (ft.): 0.8 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 / 25000 / 50000 / 75000 / 100000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): tan, fine sand, trace round gravel.	12041	S059-SCX-005-1	0-0.5	grab	1.72
			15283	S059-SCX-005-2	0-0.8	grab	2.80
		Terminated hand auger borehole at 0.8 ft. below ground surface. Refusal on rock.	16433				
1							
2							
3							
4							
5							

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

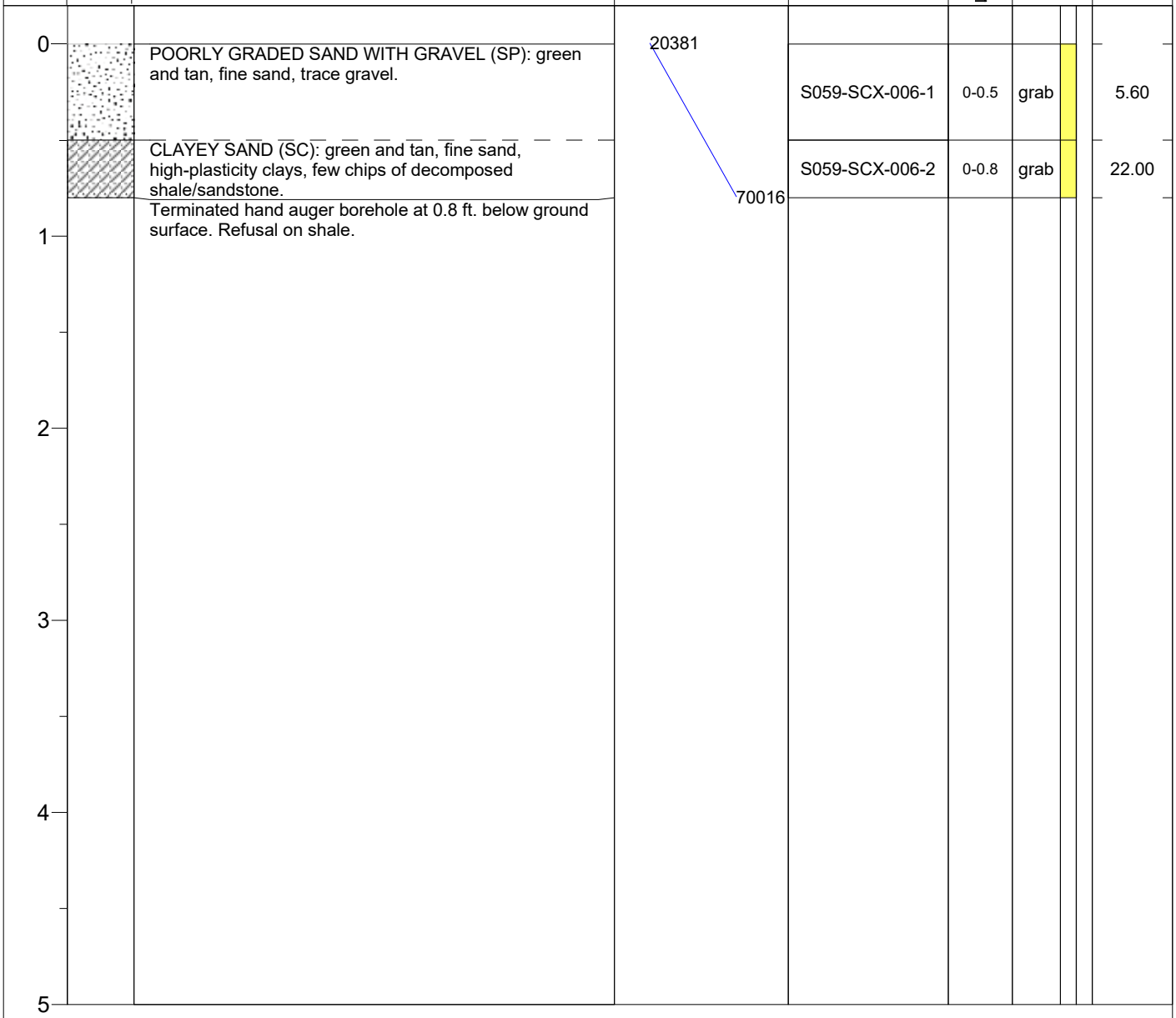
Stantec

NAVAJO NATION
AUM Environmental Response Trust - First Phase

BOREHOLE ID: **S059-SCX-006**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651478.38 NORTHING: 4085282.97
DATE STARTED: 4/11/2017 DATE STARTED: 4/11/2017
TOTAL DEPTH (ft.): 0.8 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn



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: **S059-SCX-007**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651547.04 NORTHING: 4085288.76
DATE STARTED: 4/11/2017 DATE STARTED: 4/11/2017
TOTAL DEPTH (ft.): 0.25 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 / 25000 / 50000 / 75000 / 100000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): red, fine sand with trace angular gravels.	9343	S059-SCX-007-1	0-0.1	grab	1.80
			9756	S059-SCX-007-2	0.1-0.25	grab	1.09
		Terminated hand auger borehole at 0.25 ft. below ground surface. Refusal on bedrock.					
1							
2							
3							
4							
5							

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

Stantec

NAVAJO NATION
AUM Environmental Response Trust - First Phase

BOREHOLE ID: **S059-SCX-008**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651273.92 NORTHING: 4085282.2
DATE STARTED: 4/12/2017 DATE STARTED: 4/12/2017
TOTAL DEPTH (ft.): 0.5 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): brown, fine sand, trace angular coarse sand.	18445	S059-SCX-008-1	0-0.5	grab	15.70
		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on bedrock.	29852				
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: **S059-SCX-009**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651344.99 NORTHING: 4085435.14
DATE STARTED: 4/12/2017 DATE STARTED: 4/12/2017
TOTAL DEPTH (ft.): 0.5 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): red to light brown, fine sand.	25334	S059-SCX-009-1	0-0.5	grab	15.30
		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on weathered bedrock.	58154				
1							
2							
3							
4							
5							

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

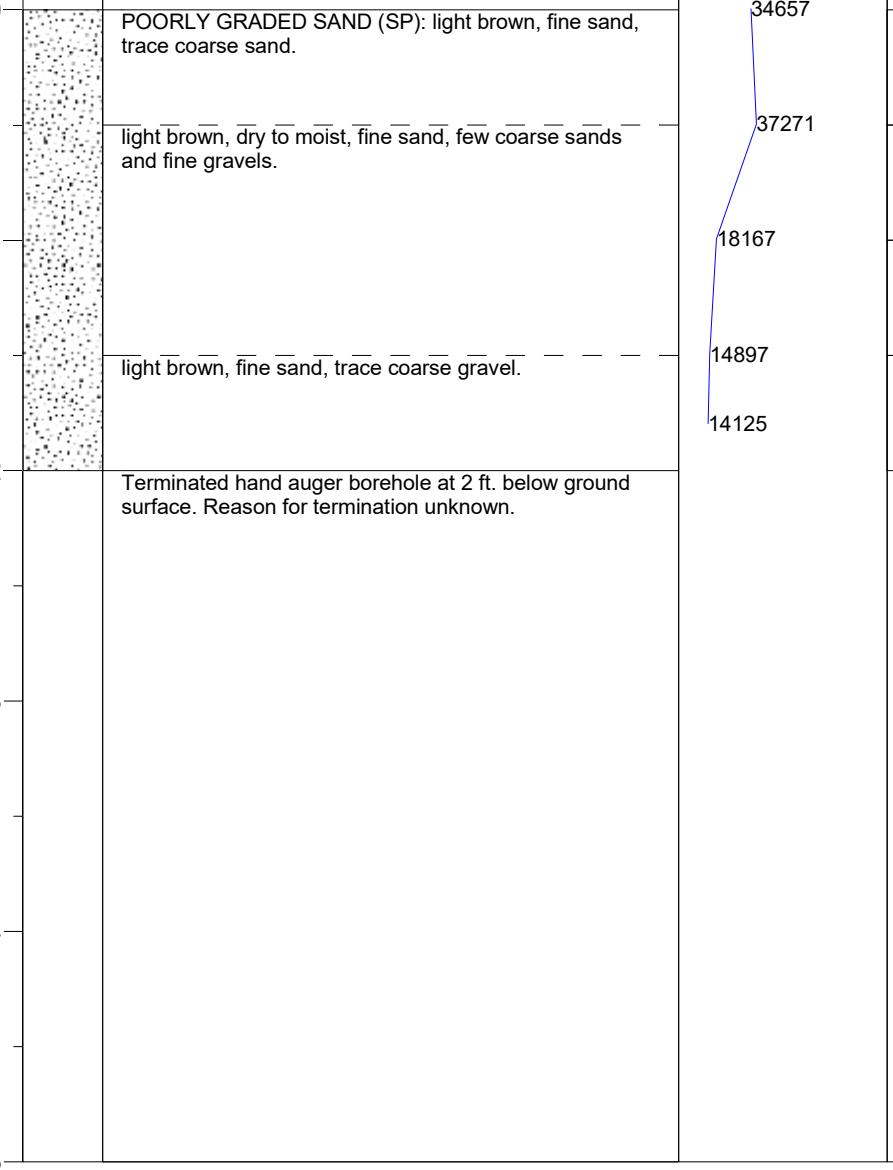
Stantec

NAVAJO NATION
AUM Environmental Response Trust - First Phase

BOREHOLE ID: **S059-SCX-010**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651350.56 NORTHING: 4085532.3
DATE STARTED: 4/12/2017 DATE STARTED: 4/12/2017
TOTAL DEPTH (ft.): 2 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn



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: **S059-SCX-011**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651320.35 NORTHING: 4085572.32
DATE STARTED: 4/12/2017 DATE STARTED: 4/12/2017
TOTAL DEPTH (ft.): 0.6 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 / 100000 / 200000 / 300000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): light brown, fine sand, few coarse sand.	27121	S059-SCX-011-1	0-0.5	grab	11.30
		Terminated hand auger borehole at 0.6 ft. below ground surface. Refusal on rock.	121478 147979				
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: **S059-SCX-012**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651345.74 NORTHING: 4085585.89
DATE STARTED: 4/12/2017 DATE STARTED: 4/12/2017
TOTAL DEPTH (ft.): 2 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): light brown, fine sand, angular to subangular coarse sand and fine gravel (25%).	24887				
				S059-SCX-012-1	0-0.5	grab	22.10
		grades finer with depth, with decreasing coarse sand and fine gravel (20%).	40419				
				S059-SCX-012-2	0.5-1	grab	16.50
1		grades finer with depth, with decreasing coarse sand and fine gravel (10%).	38250				
				S059-SCX-012-3	1-1.5	grab	8.90
			24910				
				S059-SCX-012-4	1.5-2	grab	1.95
2		Terminated hand auger borehole at 2 ft. below ground surface. Refusal on bedrock.	17865				
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: **S059-SCX-013**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651411.39 NORTHING: 4085687.1
DATE STARTED: 4/12/2017 DATE STARTED: 4/12/2017
TOTAL DEPTH (ft.): 1 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): light brown, fine sand.	11165				
				S059-SCX-013-1	0-0.5	grab	3.10
			12259				
				S059-SCX-013-2	0.5-1	grab	0.90
1		Terminated hand auger borehole at 1 ft. below ground surface. Refusal on bedrock.	11911				
2							
3							
4							
5							

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

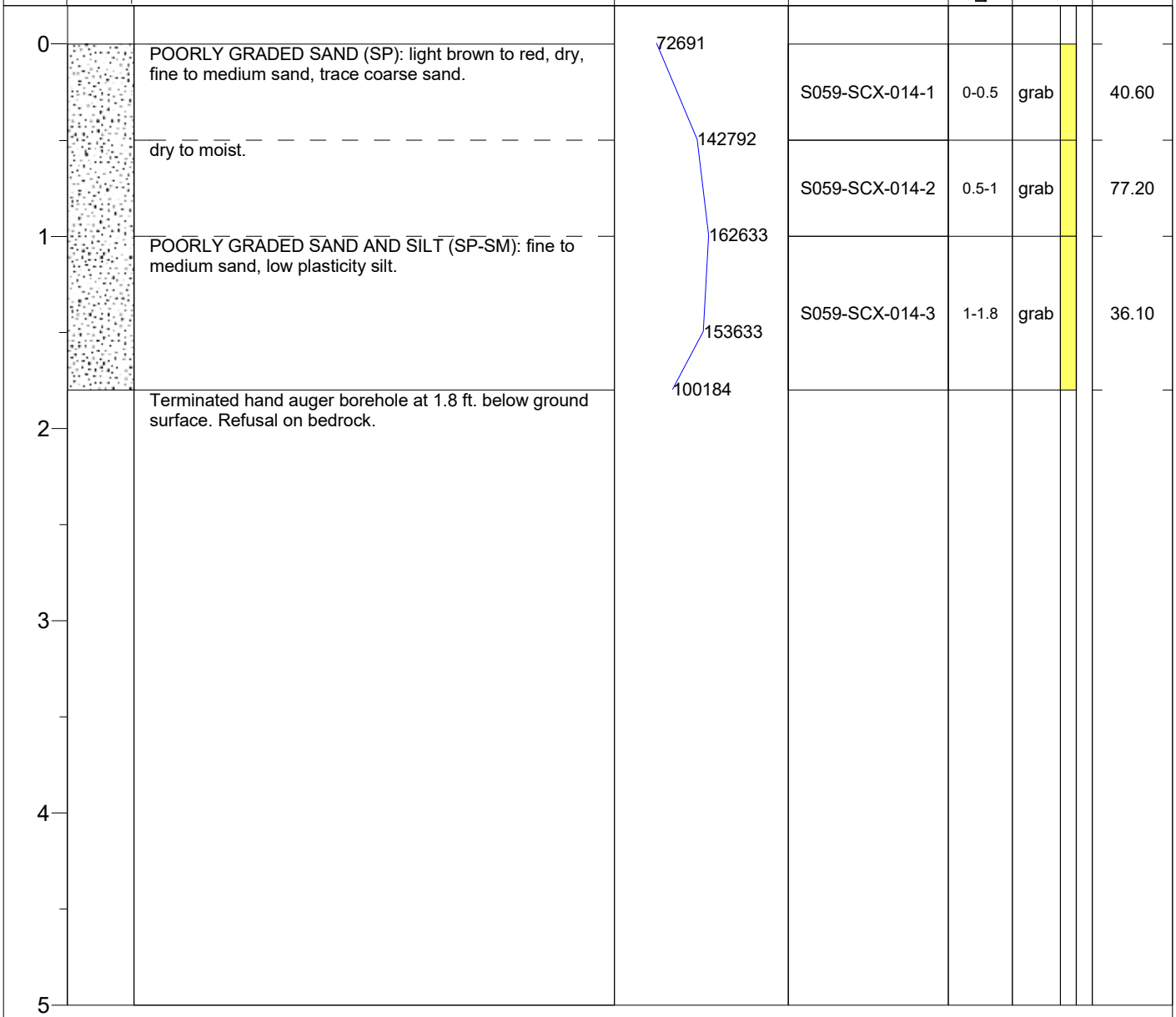
Stantec

NAVAJO NATION
AUM Environmental Response Trust - First Phase

BOREHOLE ID: **S059-SCX-014**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651348.41 NORTHING: 4085387.06
DATE STARTED: 4/13/2017 DATE STARTED: 4/13/2017
TOTAL DEPTH (ft.): 1.8 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn



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

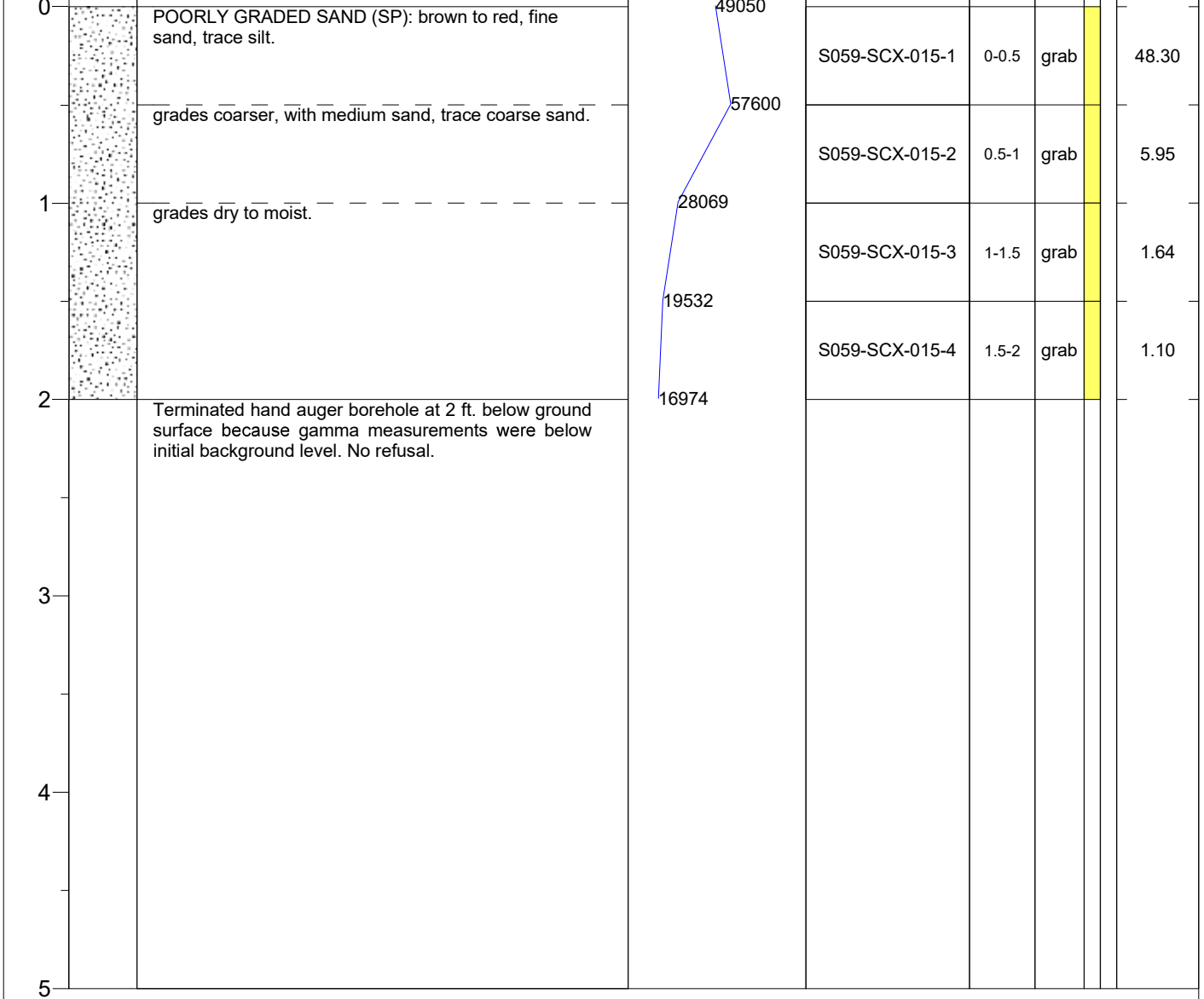
Stantec

NAVAJO NATION
AUM Environmental Response Trust - First Phase

BOREHOLE ID: **S059-SCX-015**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651360.2 NORTHING: 4085335.69
DATE STARTED: 4/13/2017 DATE STARTED: 4/13/2017
TOTAL DEPTH (ft.): 2 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn



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

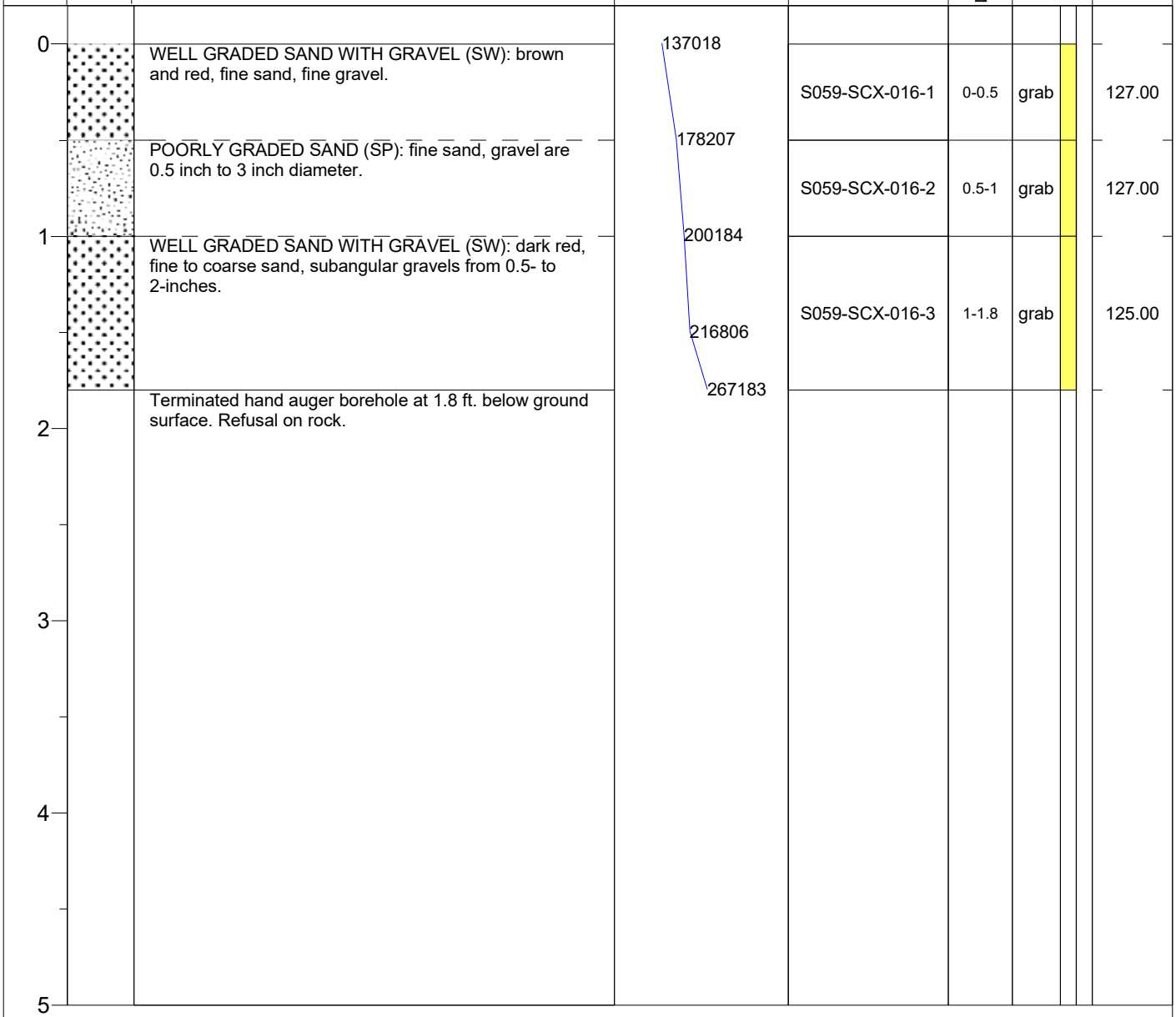
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S059-SCX-016**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651359.78 NORTHING: 4085306.56
DATE STARTED: 4/13/2017 DATE STARTED: 4/13/2017
TOTAL DEPTH (ft.): 1.8 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn



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

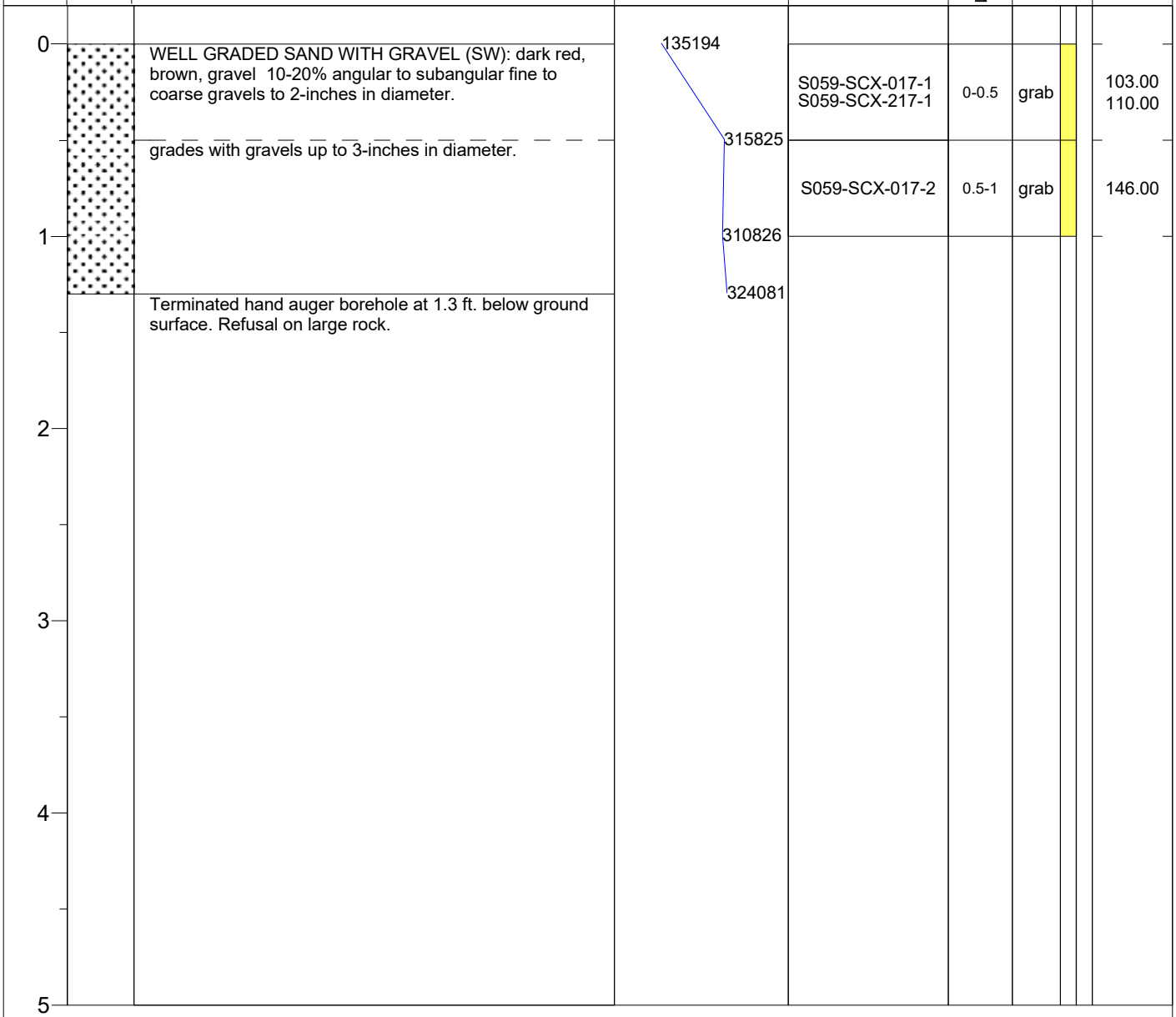
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S059-SCX-017**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651354.84 NORTHING: 4085290.05
DATE STARTED: 4/13/2017 DATE STARTED: 4/13/2017
TOTAL DEPTH (ft.): 1.3 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn



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: **S059-SCX-018**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651363.42 NORTHING: 4085290.29
DATE STARTED: 4/13/2017 DATE STARTED: 4/13/2017
TOTAL DEPTH (ft.): 0.5 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 / 200000 / 400000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0			133040				
		WELL GRADED SAND (SW): brown and red, fine to coarse grained sand.		S059-SCX-018-1	0-0.5	grab	101.00
			200633				
		Terminated hand auger borehole at 0.5 ft. below ground surface on hard rock. Refusal on rock.					
1							
2							
3							
4							
5							

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

Stantec

NAVAJO NATION
AUM Environmental Response Trust - First Phase

BOREHOLE ID: **S059-SCX-019**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651391.91 NORTHING: 4085291.35
DATE STARTED: 4/13/2017 DATE STARTED: 4/13/2017
TOTAL DEPTH (ft.): 1.6 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 / 25000 / 50000 / 75000 / 100000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0			19182				
		POORLY GRADED SAND (SP): brown, dry, fine to medium sand, trace coarse sand.		S059-SCX-019-1	0-0.5	grab	5.65
			20581				
				S059-SCX-019-2	0.5-1	grab	7.60
1		trace gravels.	21191				
				S059-SCX-019-3	1-1.5	grab	7.12
			20863				
		Terminated hand auger borehole at 1.6 ft. below ground surface on hard rock. Refusal on bedrock.					
2							
3							
4							
5							

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

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NAVAJO NATION
AUM Environmental Response Trust - First Phase

BOREHOLE ID: **S059-SCX-020**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651338.34 NORTHING: 4085312.15
DATE STARTED: 4/13/2017 DATE STARTED: 4/13/2017
TOTAL DEPTH (ft.): 2 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 / 25000 / 50000 / 75000 / 100000	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0			15385				
		POORLY GRADED SAND (SP): red, fine sand.		S059-SCX-020-1	0-0.5	grab	1.12
			15462				
				S059-SCX-020-2	0.5-1	grab	3.42
1			27810				
				S059-SCX-020-3	1-1.5	grab	8.20
			27351				
				S059-SCX-020-4	1.5-2	grab	4.56
2		Terminated hand auger borehole at 2 ft. below ground surface. Refusal on bedrock.	28452				
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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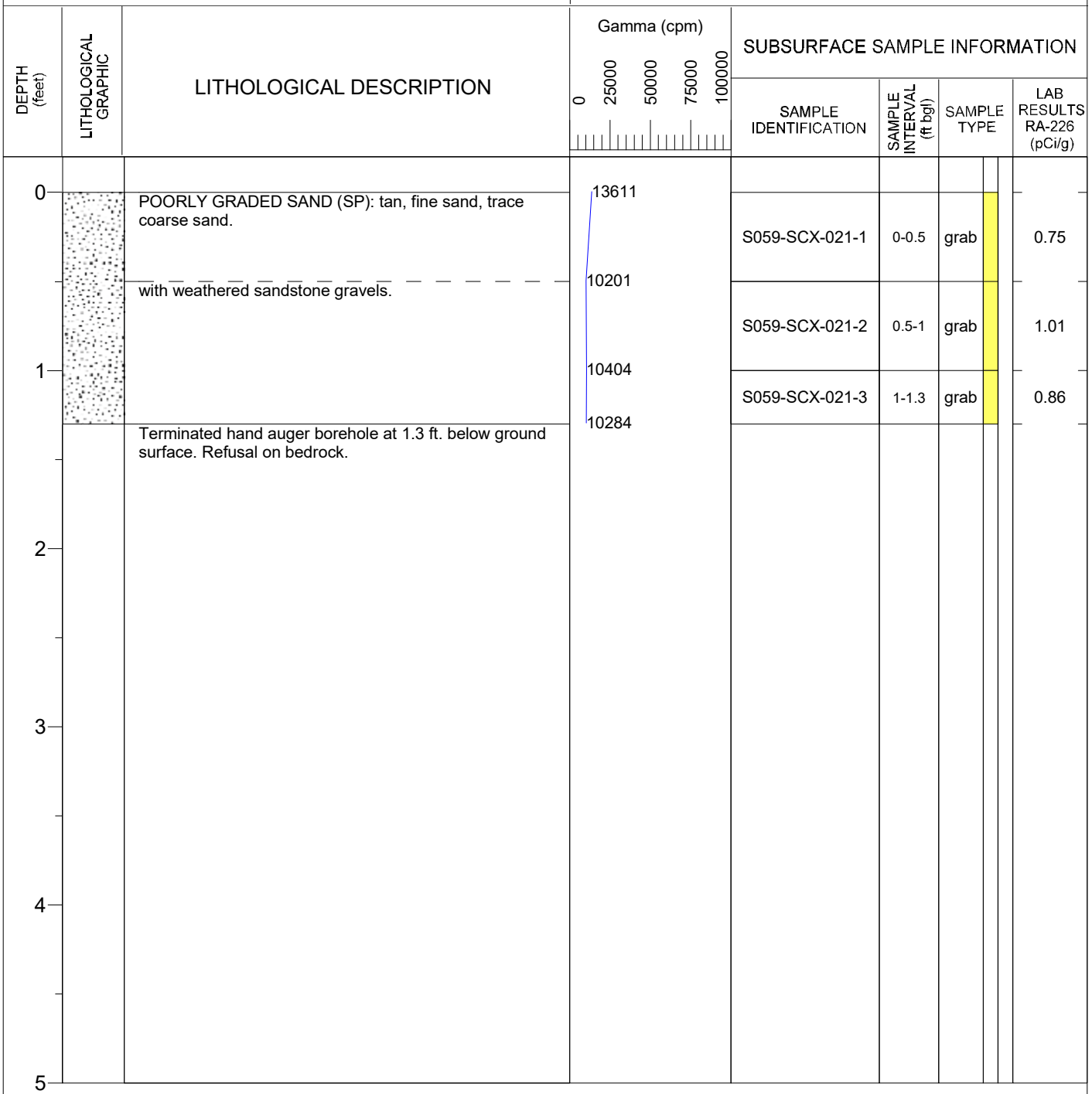
NAVAJO NATION
AUM Environmental Response Trust - First Phase

BOREHOLE ID: **S059-SCX-021**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: NA-0904

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: 651336.83 NORTHING: 4085288.72
DATE STARTED: 4/13/2017 DATE STARTED: 4/13/2017
TOTAL DEPTH (ft.): 1.3 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn



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

C.3 Water Sample Field Forms

WATER SAMPLE COLLECTION FORM

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

Date 09/29/2016 **Arrival Time** 1445

Field Personnel

Chris Lee, Kelly Johnson, Linda Reeves (USEPA)

SITE DESCRIPTION

Entered 12/20/2016

Surface Water ☐ **Well Water** ☒

Loc ID

Station Name NA-0904 **Station Number** 09T-5416

Site Description Windmill well, sampling at valve at water tank

Water Characteristics (color, odor, appearance): Clear, limited sulfur smell

SAMPLE COLLECTION

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

Sample ID: SO59-WL-001 **Sample Time:** ~~1445~~ 1456

Field Measurements			
Parameter	**Sample 1 (normal sample)**	**Sample 2 (field dup or MS)**	**Sample 3 (MSD)**
Time	~~1535~~ 1456		
pH	8.79		
Conductivity (µS/cm)	1215		
Turbidity (NTU)	13.3	09/29/16	
Water Temperature (°C)	19.2		
Salinity	0.30		
Oxidation Reduction Potential (mV)	105.9		

SURFACE WATER FLOW MEASUREMENT FORM

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

Date 09 29 / 2016 **Time** 1445 **Station Number** NA-0904

Field Personnel: K. Johnson C. Lee 09T-549

Flow by Capture Method

Measurement Number	Time (sec)	Volume (L)

No Flow Measurement At Spigot & Trough

WATER SAMPLE COLLECTION FORM

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

Date 5 / 24 / 17 **Arrival Time** 1141

Field Personnel

J. Kester K. Johnson

SITE DESCRIPTION

Surface Water ☐ **Well Water** ☒

Station Name NA-0904 windmill well **Station Number** ~~09-16~~ S059-WL-001 ~~09-6-14~~

Site Description ~~Collect~~ Trough associated with windmill well, 09T-546

Dry on arrival

Water Characteristics (color, odor, appearance): Clear, odorless,

SAMPLE COLLECTION

Entered 6/16/2017

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

Sample ID: S059-WL-001 **Sample Time:** 1148

LOC ID S059-WL-001

Field Measurements			
Parameter	Sample 1 (normal sample)	Sample 2 (field dup or MS)	Sample 3 (MSD)
Time	1148		
pH	8.99		
Conductivity (µS/cm)	589		
Turbidity (NTU)	3.16		
Water Temperature (°C)	17.2		
Salinity	—		
Oxidation Reduction Potential (mV)	138.6		

SURFACE WATER FLOW MEASUREMENT FORM

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

Date 5/24/17 **Time** 1141 **Station Number**_____

Field Personnel: K. Johnson T. Kesler

NA-8904 windmill

Flow by Capture Method

Measurement Number	Time (sec)	Volume (L)

Entered 6/16/2017

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 NA-0904 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, three potential background reference areas (BG-1, BG-2, and BG-3) were identified to represent the geologic formations at the Site where mining-impacted material was assumed to be present. These formations include: (1) the Salt Wash Member of the Morrison Formation (Morrison Formation) on the mesa top and upper mesa sidewall (BG-1 and BG-2); (2) the Summerville Formation on the lower mesa sidewall and extending into the plains (BG-3); and (3) Quaternary deposits on the plains (BG-3). The surface gamma surveys at BG-1, BG-2, and BG-3 were completed in May 2016 and soil samples were collected in October 2016.

Upon review of the surface gamma survey data and soil samples locations, it was determined that the surface gamma survey did not align spatially with the areal extent of the soil sample locations in BG-1 and BG-2. Supplemental gamma surveys for BG-1 and BG-2 were conducted in April 2017. Following review of data collected at the Site, it was determined that an additional potential background reference area may be required to characterize sediments in the drainage downgradient from the Site. Three additional potential background reference areas were identified and gamma surveys were conducted in September 2017. Three areas were surveyed within the same drainage and all three areas (BG-4, BG-5, and BG-6) represent Quaternary deposits, including alluvium, in the drainage. Multiple areas were surveyed in the drainage because the gamma survey data could not be reviewed in the field in real-time and needed to be downloaded from the data logger first. Multiple areas were surveyed in the drainage to allow the field team to review the data from different areas after completion of the survey to select the most representative area. During further review of the Baseline Studies data, it was determined that BG-1, BG-5, and BG-6 would not be used to represent the Site, as described in Section 3.0 below. Soil samples were collected at BG-4 in September 2017.

The locations of the six potential background reference areas (BG-1 through BG-6) are shown along with the site geology and predominant wind direction in Figure D.1-1. The wind rose on Figure D.1-1 depicts regional wind data from the Cortez, CO airport, approximately 50 miles northeast of the Site, and it shows the predominant wind direction is from the northeast. However, field personnel generally observed wind from the west at the Site and the background descriptions below are based on the wind direction being from the west. The potential background reference areas are described below:

- BG-1 encompasses an area of 2,448 ft^2 (approximately 0.06 acres), is located 3,330 ft west of the claim boundary, and is cross-wind and hydrologically cross-gradient from the Site, and across a valley. The thin soils, colluvium-covered slopes, and bedrock outcrops represent the portions of the survey area that are within the Morrison Formation. The vegetation and ground cover at BG-1 are similar to the mesa sidewall portions of the Site.

- BG-2 encompasses an area of 1,499 ft^2 (approximately 0.03 acres), is located 3,410 ft west of the claim boundary, and is cross-wind and hydrologically cross-gradient from the Site, and across a valley. The thin soils, colluvium-covered slopes, and bedrock outcrops represent the portions of the survey area that are within the Morrison Formation. The vegetation and ground cover at BG-2 are similar to the mesa top and mesa sidewall portions of the Site.

- BG-3 encompasses an area of 2,411 ft^2 (approximately 0.06 acres), is located 670 ft west of the claim boundary, and is upwind and hydrologically cross-gradient from the Site, and across a drainage divide. The thicker soils deposits, colluvium-covered slopes, and bedrock outcrops represent the portions of the survey areas that are within the Summerville Formation and the Quaternary deposits. The vegetation and ground cover at BG-3 are similar to the area where the mesa sidewall transitions into the plains portions of the Site.

- BG-4 encompasses an area of 463 ft^2 (approximately 0.01 acres), is located 520 ft west of the claim boundary, and is upwind and hydrologically cross-gradient from the Site, and across a drainage divide. The sediments represent the portions of the survey area that consists of Quaternary deposits, including alluvium, in the drainages. The vegetation and ground cover at BG-4 are similar to the drainages that drain the Site to the north.

- BG-5 encompasses an area of 1,351ft^2 (approximately 0.03 acres), is located 430 ft west of the claim boundary, and is upwind and hydrologically cross-gradient from the Site, and across a drainage divide. The sediments represent the portions of the survey area that consist of Quaternary deposits, including alluvium, in the drainages. The vegetation and ground cover at BG-5 are similar to the drainages that drain the Site to the north.

- BG-6 encompasses an area of 583 ft^2 (approximately 0.01 acres), is located 570 ft west of the claim boundary, and is upwind and hydrologically cross-gradient from the Site, and across a valley. The sediments represent the portions of the survey area that consist of Quaternary deposits, including alluvium, in the drainages. The vegetation and ground cover at BG-6 are similar to the drainages that drain the Site to the north.

The potential background reference area evaluation included surface gamma surveys, surface and subsurface static gamma measurements, and collection of surface soil samples and subsurface soil samples as described below:

- BG-1 – 11 surface soil grab samples were collected from 11 locations; one subsurface soil grab sample, and surface and subsurface static gamma measurements, were collected from borehole location S059-SCX-002
- BG-2 – 10 surface soil grab samples were collected from 10 locations; one subsurface soil grab sample was collected from borehole location S059-SCX-001 where the depth ranged from 0.0-0.6 feet below ground surface (ft bgs); surface and subsurface static gamma measurements were also collected from borehole location S059-SCX-001
- BG-3 – 11 surface soil grab samples were collected from 11 locations; one subsurface soil grab sample, and subsurface static gamma measurements, were collected from borehole location S059-SCX-003
- 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 borehole location S059-BG4-011
- BG-5 – surface gamma survey only
- BG-6 – surface gamma survey only

The sample locations and surface gamma survey data for BG-1, BG-2, and BG-3 are shown in Figure D.1-2. The sample locations for BG-4 and the surface gamma survey data for BG-4, BG-5, and BG-6 are shown in Figure D.1-3. Samples were categorized as surface soil/sediment samples where sample depths were up to 0.5 ft bgs, and as subsurface samples where sample depths were greater than 0.5 ft bgs. Static gamma measurements were categorized as surface where static gamma was measured at the ground surface, and as subsurface where static gamma was measured at or greater than 0.1 ft bgs. Table D.1-1 provides a summary of the samples collected and Table D.1-2 includes the results of the sample analyses. It is important to note that sample analyses for BG-1 are included in this appendix and not in the tables in the RSE Report. Tables D.1-3 and D.1-4 provide descriptive statistics for the metals/Ra-226 concentrations and the surface gamma measurements, respectively. Field forms, including borehole logs, are provided in Appendix C of the RSE Report.

The equipment used for the surface gamma survey were also used for static one-minute gamma measurements at the ground surface and for subsurface gamma measurements at the borehole location. Soil/sediment samples and gamma measurements were collected according to the methods described in the *Removal Site Evaluation Work Plan* (MWH, 2016).

3.0 SELECTION OF BACKGROUND REFERENCE AREAS

Background reference areas were needed to represent the three geologic units present at or near the Site where mining-related impacts may have occurred: BG-1 and BG-2 were identified

to represent portions of the survey area within the Morrison Formation; BG-3 was selected to represent portions of the survey area within the Summerville Formation and Quaternary deposits; and BG-4, BG-5, and BG-6 were identified to represent portions of the survey area within Quaternary deposits, including alluvium. Upon review of the gamma survey and soil sample data collected for BG-1 and BG-2 (refer to Figure D.1-2 and Tables D.1-3 and D.1-4), BG-2 was selected over BG-1 to represent areas of the Site within the Morrison Formation because BG-1 contained elevated gamma measurements that were not representative of some areas of the Site (e.g., the mesa top). However, BG-1 does provide a valuable comparison to BG-2 regarding the variation in gamma measurements that may occur in background areas and the heterogeneity present within the Morrison Formation. As a result, BG-1 is included in the RSE Report for discussion purposes. BG-3 was selected to represent the areas of the Site within the Summerville Formation, specifically the area of the Site where the mesa sidewall transitions to the plains. BG-4 was selected over BG-5 and BG-6 to represent the areas of the Site within the drainages that contain Quaternary deposits, including alluvium. BG-4 was selected because it was the middle of the three potential background reference areas, and the magnitude of the gamma survey measurements for BG-4 were between those for BG-5 and BG-6. BG-4 was also selected to represent the portions of the survey area within the Quaternary deposits that are outside the drainage channel (e.g., the northern portion of the Site). Both BG-3 and BG-4 were considered for this area because the Summerville formation is generally covered by limited Quaternary deposits. Comparing the BG-3 and BG-4 statistical values, the sediments in BG-4 had lower gamma measurements and Ra-226 values than BG-3 (refer to Tables D.1-3 and D.1-4).

Gamma survey measurements, soil/sediment sample results and subsurface static gamma measurements collected from BG-2, BG-3, and BG-4 were used for the remainder of the Removal Site Evaluation for 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
Potential Background Reference Area Soil and Sediment Sampling Summary
NA-0904
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	Sample Date	Easting [1]	Northing [1]	Sample Types Metals, Total	Sample Types Ra-226
Potential Background Reference Area Study - Background Area 1 - Morrison Formation									
S059-BG1-001	0 - 0.5	soil	SF	grab	10/5/2016	650536.63	4084650.95	N;FD	N;FD
S059-BG1-002	0 - 0.5	soil	SF	grab	10/5/2016	650534.60	4084649.06	N;MS;MSD	N
S059-BG1-003	0 - 0.5	soil	SF	grab	10/5/2016	650530.89	4084652.00	N	N
S059-BG1-004	0 - 0.5	soil	SF	grab	10/5/2016	650528.11	4084649.12	N	N
S059-BG1-005	0 - 0.5	soil	SF	grab	10/5/2016	650527.05	4084646.03	N	N
S059-BG1-006	0 - 0.5	soil	SF	grab	10/5/2016	650530.38	4084644.41	N	N
S059-BG1-007	0 - 0.5	soil	SF	grab	10/5/2016	650530.43	4084640.20	N	N
S059-BG1-008	0 - 0.5	soil	SF	grab	10/5/2016	650532.69	4084644.27	N	N
S059-BG1-009	0 - 0.5	soil	SF	grab	10/5/2016	650536.63	4084643.84	N;MS;MSD	N
S059-BG1-010	0 - 0.5	soil	SF	grab	10/5/2016	650539.69	4084646.17	N	N
S059-SCX-002	0 - 0.5	soil	SF	grab	10/11/2016	650536.50	4084639.09	N	N
S059-SCX-002	0.5 - 1.1	soil	SB	grab	10/11/2016	650536.50	4084639.09	N	N
Potential Background Reference Area Study - Background Area 2 - Morrison Formation									
S059-BG2-001	0 - 0.5	soil	SF	grab	10/5/2016	650513.41	4084635.51	N;FD	N;FD
S059-BG2-002	0 - 0.5	soil	SF	grab	10/5/2016	650510.96	4084633.92	N	N
S059-BG2-003	0 - 0.5	soil	SF	grab	10/5/2016	650511.44	4084631.57	N	N
S059-BG2-004	0 - 0.5	soil	SF	grab	10/5/2016	650513.19	4084630.23	N	N
S059-BG2-005	0 - 0.5	soil	SF	grab	10/5/2016	650516.29	4084634.25	N	N
S059-BG2-006	0 - 0.5	soil	SF	grab	10/5/2016	650515.81	4084631.17	N	N
S059-BG2-007	0 - 0.5	soil	SF	grab	10/5/2016	650518.59	4084629.54	N	N
S059-BG2-008	0 - 0.5	soil	SF	grab	10/5/2016	650518.56	4084626.43	N	N
S059-BG2-009	0 - 0.5	soil	SF	grab	10/5/2016	650513.06	4084625.85	N	N
S059-BG2-010	0 - 0.5	soil	SF	grab	10/5/2016	650516.93	4084624.85	N;FD	N;FD
S059-SCX-001	0 - 0.6	soil	SF	grab	10/11/2016	650513.05	4084630.51	N	N
Potential Background Reference Area Study - Background Area 3 - Summerville Formation and Quaternary Deposits									
S059-BG3-001	0 - 0.5	soil	SF	grab	10/6/2016	651139.20	4085183.03	N	N
S059-BG3-002	0 - 0.5	soil	SF	grab	10/6/2016	651142.96	4085181.59	N	N
S059-BG3-003	0 - 0.5	soil	SF	grab	10/6/2016	651145.92	4085184.25	N	N
S059-BG3-004	0 - 0.5	soil	SF	grab	10/6/2016	651143.92	4085177.81	N;MS;MSD	N
S059-BG3-005	0 - 0.5	soil	SF	grab	10/6/2016	651146.45	4085176.00	N	N
S059-BG3-006	0 - 0.5	soil	SF	grab	10/6/2016	651149.62	4085178.17	N	N
S059-BG3-007	0 - 0.5	soil	SF	grab	10/6/2016	651146.08	4085172.25	N	N
S059-BG3-008	0 - 0.5	soil	SF	grab	10/6/2016	651149.88	4085170.76	N	N
S059-BG3-009	0 - 0.5	soil	SF	grab	10/6/2016	651150.91	4085167.27	N	N
S059-BG3-010	0 - 0.5	soil	SF	grab	10/6/2016	651153.79	4085166.11	N;FD	N;FD
S059-SCX-003	0 - 0.5	soil	SF	grab	10/11/2016	651152.99	4085166.31	N	N
S059-SCX-003	0.5 - 1.2	soil	SB	grab	10/11/2016	651152.99	4085166.31	N	N
Potential Background Reference Area Study - Background Area 4 - Quaternary Deposits									
S059-BG4-001	0 - 0.5	sediment	SF	grab	9/14/2017	651140.63	4085261.30	N	N
S059-BG4-002	0 - 0.5	sediment	SF	grab	9/14/2017	651141.30	4085262.68	N;FD	N;FD
S059-BG4-003	0 - 0.5	sediment	SF	grab	9/14/2017	651141.30	4085265.84	N	N
S059-BG4-004	0 - 0.5	sediment	SF	grab	9/14/2017	651141.36	4085268.74	N;FD	N;FD
S059-BG4-005	0 - 0.5	sediment	SF	grab	9/14/2017	651143.27	4085270.56	N	N
S059-BG4-006	0 - 0.5	sediment	SF	grab	9/14/2017	651143.44	4085271.66	N;FD	N;FD
S059-BG4-007	0 - 0.5	sediment	SF	grab	9/14/2017	651145.58	4085272.25	N	N
S059-BG4-008	0 - 0.5	sediment	SF	grab	9/14/2017	651146.59	4085274.17	N;FD	N;FD
S059-BG4-009	0 - 0.5	sediment	SF	grab	9/14/2017	651149.95	4085276.61	N	N
S059-BG4-010	0 - 0.5	sediment	SF	grab	9/14/2017	651151.11	4085277.83	N	N
S059-BG4-011	0 - 0.5	sediment	SF	grab	9/14/2017	651151.68	4085277.53	N	N
S059-BG4-011	0.5 - 1.5	sediment	SB	grab	9/14/2017	651151.68	4085277.53	N	N

Notes

N	Normal
FD	Field Duplicate
MS	Matrix Spike
MSD	Matrix Spike Duplicate
Ra-226	Radium 226
SB	Subsurface Sample
SF	Surface Sample
ft bgs	feet below ground surface

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

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NAVAJO NATION
AUM Environmental Response Trust - First Phase

Table D.1-2
Potential Background Reference Area Soil and Sediment Sample Analytical Results
NA-0904
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification	S059-BG1-001 Dup	S059-BG1-001	S059-BG1-002	S059-BG1-003	S059-BG1-004	S059-BG1-005	S059-BG1-006	S059-BG1-007	S059-BG1-008	S059-BG1-009	S059-BG1-010	S059-SCX-002	S059-SCX-002
Date Collected	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/11/2016	10/11/2016
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.1
Analyte (Units)													
Metals[1] (mg/kg)													
Arsenic	<0.19	14	19 J+	23	2	2.1	2.1	8.4	12	6.5	10	23	35
Molybdenum	<0.19	1.3	1.7	2.2	<0.19	<0.2	<0.19	<0.19	0.61	0.37	1.1	0.75	1.1
Selenium	<0.94	<0.99	1.1	1.5	<0.93	<0.98	<0.96	<0.96	<0.89	<0.96	<0.96	<0.98	<0.93
Uranium	<0.0094	7.6	9.3 J-	13	2.8	2.3	3.9	3.5	2.5	3.3 J+	6	4.4	5.4
Vanadium	<0.47	9.8	12 J	18	7.5	10	6.7	17	9.5	7.4	10	7.7	9.7
Radionuclides (pCi/g)													
Radium-226	4.94 ± 0.67	5.13 ± 0.72 J-	6.26 ± 0.86	5.95 ± 0.8	2.15 ± 0.38	1.99 ± 0.36	2.41 ± 0.38	4.24 ± 0.62	2.44 ± 0.42	2.93 ± 0.46	4.36 ± 0.61	3.23 ± 0.51	4.12 ± 0.58

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data
[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

Table D.1-2
Potential Background Reference Area Soil and Sediment Sample Analytical Results
NA-0904
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification	S059-BG2-001	S059-BG2-001 Dup	S059-BG2-002	S059-BG2-003	S059-BG2-004	S059-BG2-005	S059-BG2-006	S059-BG2-007	S059-BG2-008	S059-BG2-009	S059-BG2-010	S059-BG2-010 Dup	S059-SCX-001
Date Collected	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/5/2016	10/11/2016
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.6
Analyte (Units)													
Metals[1] (mg/kg)													
Arsenic	1.4	1.2	2	1.5	1.4	1.7	4.2	1.7	2.1	2.1	1.6	1.5	2.2
Molybdenum	<0.18	<0.19	<0.21	<0.2	<0.2	<0.19	<0.18	<0.2	<0.18	<0.18	<0.18	<0.2	<0.19
Selenium	<0.92	<0.93	<1	<0.98	<0.99	<0.95	<0.92	<1	<0.9	<0.9	<0.92	<0.99	<0.96
Uranium	2.3	2.3	1.2	1.6	1.2	2	2.4	1.8	1.3	1.2	2.5	2.6	1.5
Vanadium	6.8	6.6	15	7.9	8.2	13	14	9.3	9.1	12	10	10	12
Radionuclides (pCi/g)													
Radium-226	1.58 ± 0.31	1.27 ± 0.28	1.79 ± 0.33	1.23 ± 0.27	1.18 ± 0.27	1.98 ± 0.33	2.94 ± 0.49	1.26 ± 0.28	0.92 ± 0.23	1.57 ± 0.31	2.04 ± 0.37	1.62 ± 0.3	1.26 ± 0.29

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data
[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

Table D.1-2
Potential Background Reference Area Soil and Sediment Sample Analytical Results
NA-0904
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification	S059-BG3-001	S059-BG3-002	S059-BG3-003	S059-BG3-004	S059-BG3-005	S059-BG3-006	S059-BG3-007	S059-BG3-008	S059-BG3-009	S059-BG3-010	S059-BG3-010 Dup	S059-SCX-003	S059-SCX-003
Date Collected	10/6/2016	10/6/2016	10/6/2016	10/6/2016	10/6/2016	10/6/2016	10/6/2016	10/6/2016	10/6/2016	10/6/2016	10/6/2016	10/11/2016	10/11/2016
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.2
Analyte (Units)													
Metals[1] (mg/kg)													
Arsenic	1.4	1.3	1.5	1.3 J+	1.4	1.4	1.4	1.5	1.7	2	2	2	1.9
Molybdenum	<0.17	<0.18	0.24	<0.18	<0.19	<0.2	<0.2	<0.19	<0.18	<0.19	<0.19	<0.2	<0.21
Selenium	<0.85	<0.89	<0.95	<0.88	<0.95	<0.98	<1	<0.94	<0.91	<0.95	<0.93	<0.98	<1
Uranium	0.4	0.45	0.59	0.6 J+	0.61	0.51	0.78	0.56	0.58	0.56	0.56	0.55	0.48
Vanadium	6.3	6.9	7.3	7.8 J+	8.2	9.5	9.3	11	17	12	12	9.4	7.8
Radionuclides (pCi/g)													
Radium-226	0.5 ± 0.23	0.43 ± 0.19	0.84 ± 0.23	0.86 ± 0.24	0.68 ± 0.2	0.49 ± 0.2	0.58 ± 0.21	0.61 ± 0.27	0.44 ± 0.17	0.79 ± 0.24 J-	0.61 ± 0.2 J-	0.62 ± 0.19	0.6 ± 0.2

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data
[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

Table D.1-2
Potential Background Reference Area Soil and Sediment Sample Analytical Results
NA-0904
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification	S059-BG4-001	S059-BG4-002	S059-BG4-002 Dup	S059-BG4-003	S059-BG4-004	S059-BG4-004 Dup	S059-BG4-005	S059-BG4-006	S059-BG4-006 Dup	S059-BG4-007	S059-BG4-008	S059-BG4-008 Dup
Date Collected	9/14/2017	9/14/2017	9/14/2017	9/14/2017	9/14/2017	9/14/2017	9/14/2017	9/14/2017	9/14/2017	9/14/2017	9/14/2017	9/14/2017
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	1.5	1.5	5.1	2.2	2.4	2	1.6	1.8	3.9	1.5	1.8	1.8
Molybdenum	0.27	<0.2	<0.19	0.28	<0.19	<0.2	<0.2	<0.2	0.61	<0.2	<0.19	0.21
Selenium	<0.98	<1	<0.97	<1	<0.95	<1	<0.99	<0.99	<1	<1	<0.96	<0.95
Uranium	0.69	0.67	1	0.66	0.85	0.72	0.69	0.71	0.77	0.59	0.7	0.71
Vanadium	5.9	6.5	7.8	6.6	8.2	7.4	6.9	6	6.9	5.9	6	6.2
Radionuclides (pCi/g)												
Radium-226	0.81 ± 0.22	0.61 ± 0.17 J-	0.52 ± 0.18 J-	0.56 ± 0.17	0.75 ± 0.19	0.8 ± 0.21	0.67 ± 0.19 J-	0.7 ± 0.19	0.76 ± 0.22	0.77 ± 0.21	0.67 ± 0.24	0.91 ± 0.21

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data
[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

Table D.1-2
Potential Background Reference Area Soil and Sediment Sample Analytical Results
NA-0904
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification	S059-BG4-009	S059-BG4-010	S059-BG4-011	S059-BG4-011
Date Collected	9/14/2017	9/14/2017	9/14/2017	9/14/2017
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.5
Analyte (Units)				
Metals[1] (mg/kg)				
Arsenic	2.5	1.5	1.7	1.8
Molybdenum	0.3	<0.19	<0.2	<0.21
Selenium	<0.99	<0.96	<0.99	<1.1
Uranium	0.87	0.66	0.76	0.76
Vanadium	7	7.2	7	6.8
Radionuclides (pCi/g)				
Radium-226	0.62 ± 0.17 J-	0.7 ± 0.2	0.71 ± 0.2 J-	0.7 ± 0.22

Notes
Bold Bolded result indicates positively identified compound
mg/kg milligrams per kilogram
pCi/g picocuries per gram
J Data are estimated due to associated quality control data
J- Data are estimated and are potentially biased low due to associated quality control data
J+ Data are estimated and are potentially biased high due to associated quality control data
[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

Table D.1-3
Soil and Sediment Sampling Summary
NA-0904
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	--	36%	82%	--	--	--
Minimum[1]	2	--	--	2.30	6.70	1.99
Minimum Detect[2]	--	0.370	1.10	--	--	--
Mean[1]	11.1	--	--	5.33	10.5	3.74
Mean Detects[2]	--	1.15	1.30	--	--	--
Median[1]	10.0	--	--	3.90	9.80	3.23
Median Detects[2]	--	1.10	1.30	--	--	--
Maximum[1]	23.0	--	--	13.0	18.0	6.26
Maximum Detect[2]	--	2.2	1.50	--	--	--
Distribution	Normal	Normal	Normal	Normal	Gamma	Normal
Coefficient of Variation[1]	0.715	--	--	0.634	0.361	0.413
CV Detects[2]	--	0.562	0.218	--	--	--
UCL Type	95% Student's-t UCL	95% KM (t) UCL	95% KM (t) UCL	95% Student's-t UCL	95% Adjusted Gamma UCL	95% Student's-t UCL
UCL Result	15.4	1.166	0.66	7.17	13.2	4.58
UTL Type	UTL Normal	UTL KM Normal	UTL KM Normal	UTL Normal	UTL Gamma WH	UTL Normal
UTL Result	33.4	2.756	1.65	14.8	23.2	8.08
Background Reference Area Study - Background Area 2 - Morrison Formation						
Total Number of Observations	10	10	10	10	10	10
Percent Non-Detects	--	100%	100%	--	--	--
Minimum[1]	1.40	--	--	1.20	6.80	0.920
Minimum Detect[2]	--	--	--	--	--	--
Mean[1]	1.97	--	--	1.75	10.5	1.65
Mean Detects[2]	--	--	--	--	--	--
Median[1]	1.70	--	--	1.70	9.65	1.58
Maximum[1]	4.20	--	--	2.50	15.0	2.94
Maximum Detect[2]	--	--	--	--	--	--
Distribution	Normal	Not Calculated	Not Calculated	Normal	Normal	Normal
Coefficient of Variation[1]	0.420	--	--	0.3	0.266	0.352
UCL Type	95% Student's-t UCL	Not Calculated	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	2.45	Not Calculated	Not Calculated	2.06	12.2	1.99
UTL Type	UTL Normal	Not Calculated	Not Calculated	UTL Normal	UTL Normal	UTL Normal
UTL Result	4.38	Not Calculated	Not Calculated	3.28	18.7	3.34

Table D.1-3
Soil and Sediment Sampling Summary
NA-0904
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 - Summerville Formation and Quaternary Deposits						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	91%	100%	--	--	--
Minimum[1]	1.30	--	--	0.40	6.30	0.430
Minimum Detect[2]	--	0.240	--	--	--	--
Mean[1]	1.54	--	--	0.563	9.52	0.622
Mean Detects[2]	--	0.240	--	--	--	--
Median[1]	1.40	--	--	0.560	9.30	0.610
Maximum[1]	2.00	--	--	0.780	17.0	0.860
Maximum Detect[2]	--	0.240	--	--	--	--
Distribution	Normal	Not Calculated	Not Calculated	Normal	Normal	Normal
Coefficient of Variation[1]	0.165	--	--	0.172	0.317	0.249
UCL Type	95% Student's-t UCL	Not Calculated	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	1.68	Not Calculated	Not Calculated	0.616	11.2	0.706
UTL Type	UTL Normal	Not Calculated	Not Calculated	UTL Normal	UTL Normal	UTL Normal
UTL Result	2.25	Not Calculated	Not Calculated	0.836	18.0	1.06
Background Reference Area Study - Background Area 4 - Quaternary Deposits						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	73%	100%	--	--	--
Minimum[1]	1.50	--	--	0.590	5.90	0.56
Minimum Detect[2]	--	0.270	--	--	--	--
Mean[1]	1.82	--	--	0.714	6.66	0.688
Mean Detects[2]	--	0.283	--	--	--	--
Median[1]	1.70	--	--	0.690	6.60	0.700
Median Detects[2]	--	0.280	--	--	--	--
Maximum[1]	2.50	--	--	0.870	8.20	0.810
Maximum Detect[2]	--	0.300	--	--	--	--
Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
Coefficient of Variation[1]	0.207	--	--	0.117	0.106	0.107
CV Detects[2]	--	0.054	--	--	--	--
UCL Type	95% Student's-t UCL	95% KM (t) UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	2.02	0.244	Not Calculated	0.759	7.04	0.728
UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
UTL Result	2.88	0.334	Not Calculated	0.948	8.65	0.895

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

CV	Coefficient of variation
KM	Kaplan Meier
mg/kg	Milligrams per kilogram
--	Not applicable
pCi/g	Picocuries per gram
WH	Wilson Hilferty

Table D.1-4
Surface Gamma Survey Summary
NA-0904
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)	Background Reference Area 5 (BG-5)	Background Reference Area 6 (BG-6)
Geologic Formation	Morrison Formation	Morrison Formation	Summerville Formation & Quaternary Deposits	Quaternary Deposits	Quaternary Deposits	Quaternary Deposits
Total Number of Observations	420	328	378	70	114	65
Minimum	7,875	7,118	5,599	7,158	6,818	7,305
Mean	12,994	9,369	8,668	8,463	8,392	8,901
Median	11,702	9,310	8,490	8,430	8,318	8,733
Maximum	27,166	13,741	12,226	10,204	10,301	10,535
Distribution	Normal	Normal	Normal	Normal	Normal	Normal
Coefficient of Variation	0.278	0.101	0.115	0.086	0.0816	0.082
UCL Type	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	13,285	9,455	8,753	8,608	8499	9,052
UTL Type	UTL Normal	UTL Normal	UTL Normal	UTL Normal	UTL Normal	UTL Normal
UTL Result	19,403	11,068	10,447	9,911	9696	10,361

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 overlain by minor Q deposits

REFERENCES:

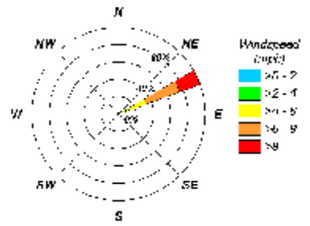
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

Wind Rose: NAML, 2007

Geology adapted from O'Sullivan, R.B., and Beikman, H.M (1963): O'Sullivan, R.B., and Beikman, H.M, 1963, Geology, structure and uranium deposits of the Shiprock quadrangle, New Mexico and Arizona: U.S. Geological Survey I-345, scale 1:250,000.

Cortez Airport, Colorado Wind Rose (KCEZ), 1996-2006



NAVAJO NATION
AUM Environmental Response Trust

LEGEND

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

Site Geology

HOLOCENE / PLEISTOCENE

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

JURASSIC

- Jms: Salt Wash Member of the Morrison Formation (Upper Jurassic) – white and moderate-orange, very fine- to medium-grained sandstone, and grayish-red shale.
- Js: Summerville Formation (Upper Jurassic) – Reddish-brown to light-orange very fine- to fine-grained flat bedded silty sandstone and reddish brown thin-bedded silty sandstone, siltstone, and claystone; forms banded steep slopes and cliffs.

N
W E
S

0 350 700
Feet

TITLE:
Geologic Map and Potential Background Reference Areas

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/27/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: D.1-1

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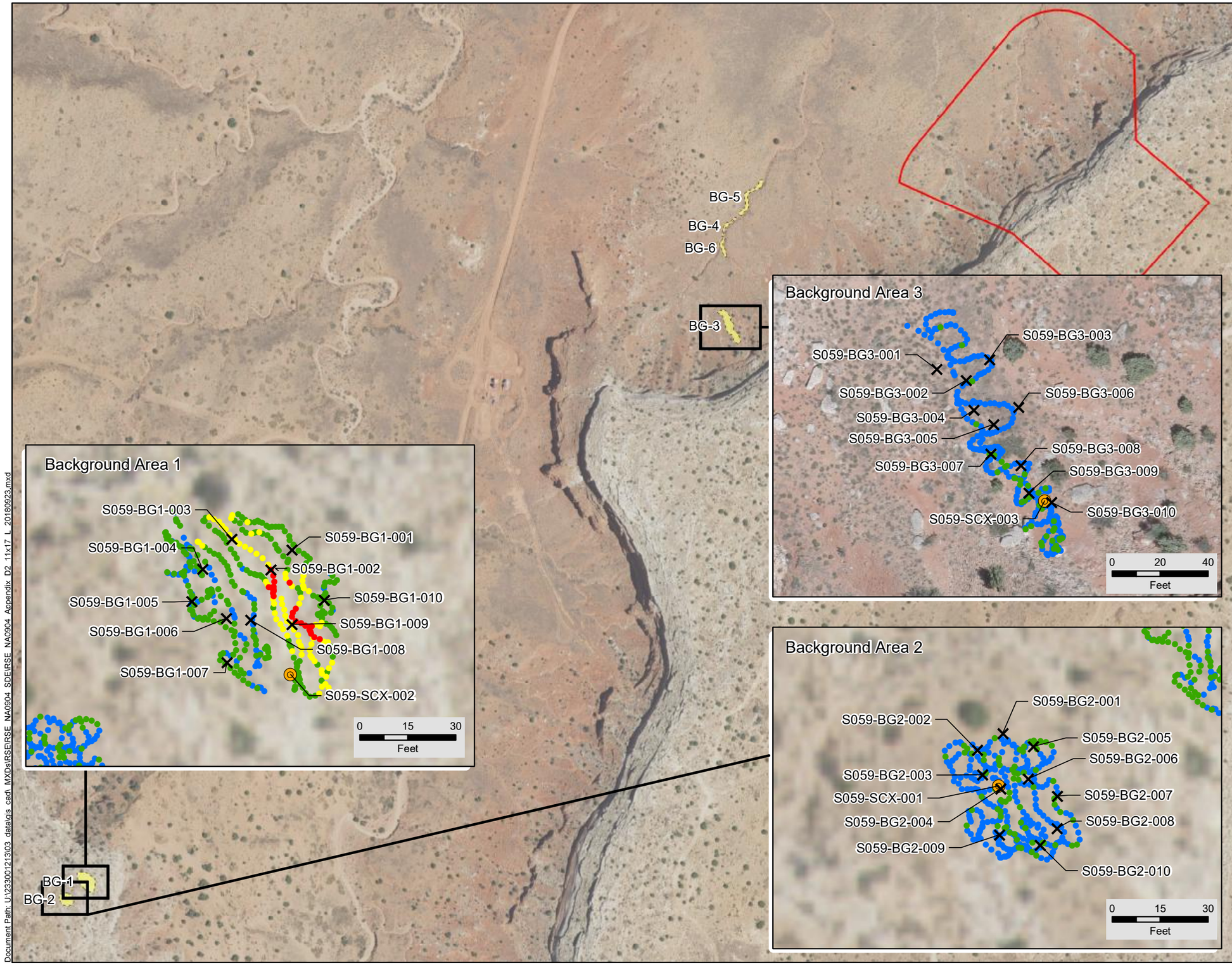

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Subsurface Borehole Location for Background Reference
- Potential Background Reference Area
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 5,599 - 10,000
- 10,001 - 15,000
- 15,001 - 20,000
- 20,001 - 27,166

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Main display and Background Areas 1 and 2 basemap image insets accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

Background Area 3 basemap image insets flown by Cooper Aerial Surveys Co. on June 16, 2017.

N W E S

0 300 600
Feet

TITLE:
Potential Background Reference Area Gamma Radiation Survey Results and Soil Sample Locations

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/27/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: D.1-2

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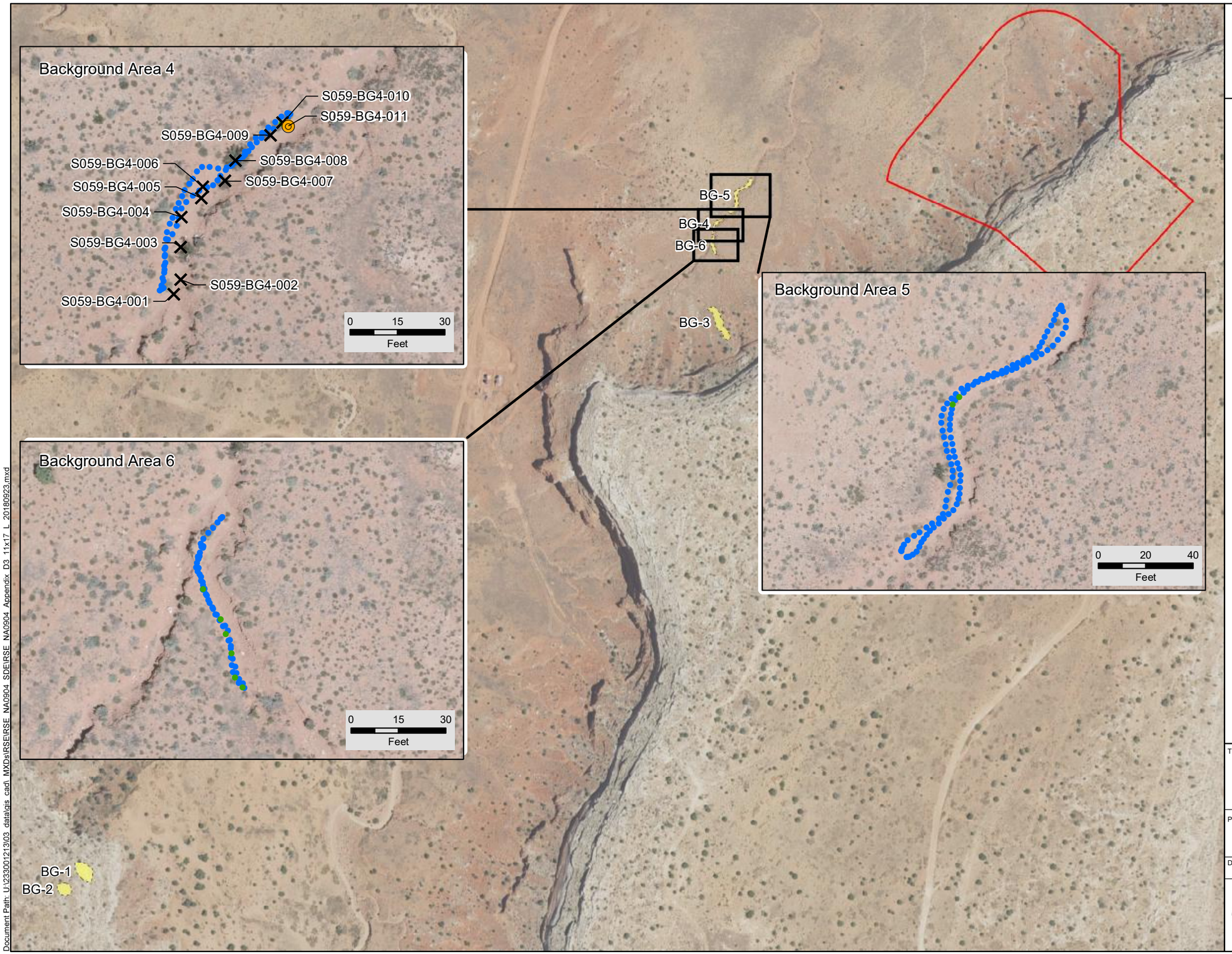

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Subsurface Borehole Location for Background Reference
- Potential Background Reference Area
- Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 5,599 - 10,000
- 10,001 - 15,000
- 15,001 - 20,000
- 20,001 - 27,166

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Main display basemap image accessed from the National Agriculture Imagery Program (NAIP) web mapping service (http://gis.apfo.usda.gov/arcgis/services) on 09/2018.

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

N
W E
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0 300 600
Feet

TITLE:
Potential Background Reference Area Gamma Radiation Survey Results and Soil Sample Locations

PROJECT:
Removal Site Evaluation
NA-0904 Mine Site

DATE: 9/27/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

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 NA-0904 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 three background reference areas and three Survey Areas. These areas are designated Background Reference Area 2 (BG-2), Background Reference Area 3 (BG-3), Background Reference Area 4 (BG-4), Survey Area A, Survey Area B, and Survey Area C. The Background Reference Areas BG-2, BG-3 and BG-4 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-2 and Survey Area A, BG-3 and Survey Area B, and BG-4 and Survey Area C (box plots, probability plots, hypothesis testing with Wilcoxon Mann-Whitney test). Soil sample and gamma radiation survey results were compared between BG-2 and Survey Area A, BG-3 and Survey Area B, and BG-4 and Survey Area C 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 required further inspection and evaluation. Unrepresentative values in a dataset have potential to yield distorted estimates of population parameters of interest (e.g., means, upper confidence limits, upper percentiles). Therefore, potential outliers in the Site data were evaluated further prior to performing data comparisons (Section 3.2) and developing the descriptive statistics (Section 3.3). In the context of this statistical evaluation, extreme values and statistical outliers are referred to as potential outliers.

A potential outlier value in a sample may be a true representative value in the test population (not a "discrepant" value), simply representing a degree of inherent variation present in the population. Furthermore, a statistical determination of one or more potential outliers does not indicate that the measurements are actually discrepant from the rest of the data set. Therefore, general statistical guidance does not recommend that extreme values (potential outliers) be removed from an analysis solely on a statistical basis. Statistical outlier tests can provide supportive information, but a reasonable scientific rationale needs to be identified for the removal of any potential outlier values (e.g., sampling error, records error, or the potential outlier is determined to violate underlying assumptions of the sampling design, such as the targeted geology).

At BG-2, BG-3, and BG-4, soil samples were collected randomly. Potential outliers in the BG-2, BG-3, and BG-4 datasets were examined using box plots, probability plots and statistical testing. Descriptive statistics were then calculated with and without the potential outliers, as applicable. Finally, the potential outlier values were evaluated to determine if a reason could be found to remove the data points before calculating the final statistics. The results of these evaluations are described in the following sections.

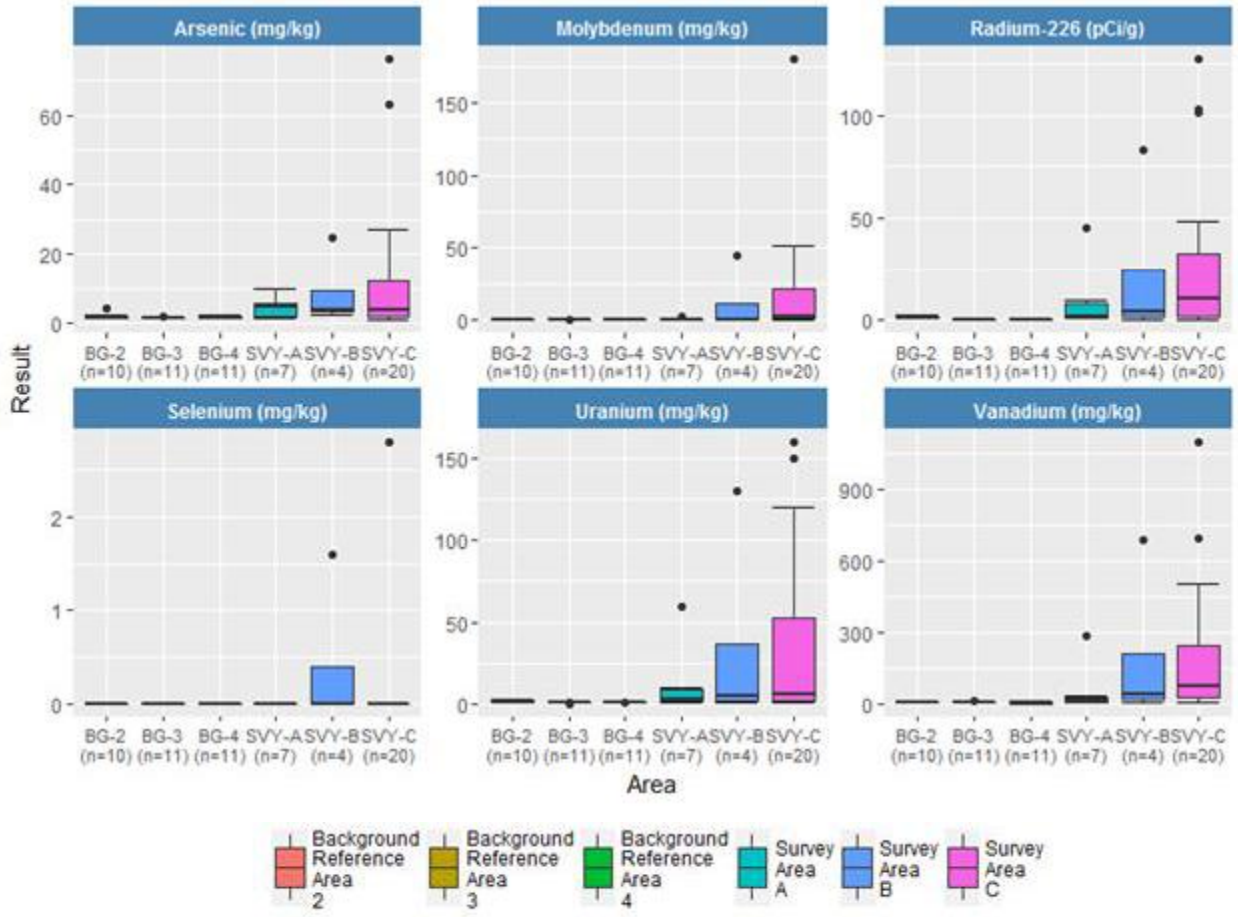
In Survey Areas A, B, and C soil samples were collected using a judgmental sampling approach. Specifically, some sample locations were selected to characterize areas of higher gamma radiation and, as a result, potential outlier values are not unexpected in the Survey Area sample statistics. Potential 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 and comparisons of the Survey Areas to BG-2, BG-3, and BG-4 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, are depicted by the whiskers (vertical lines), and any potential outliers are identified as singular dots. Potential outliers 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

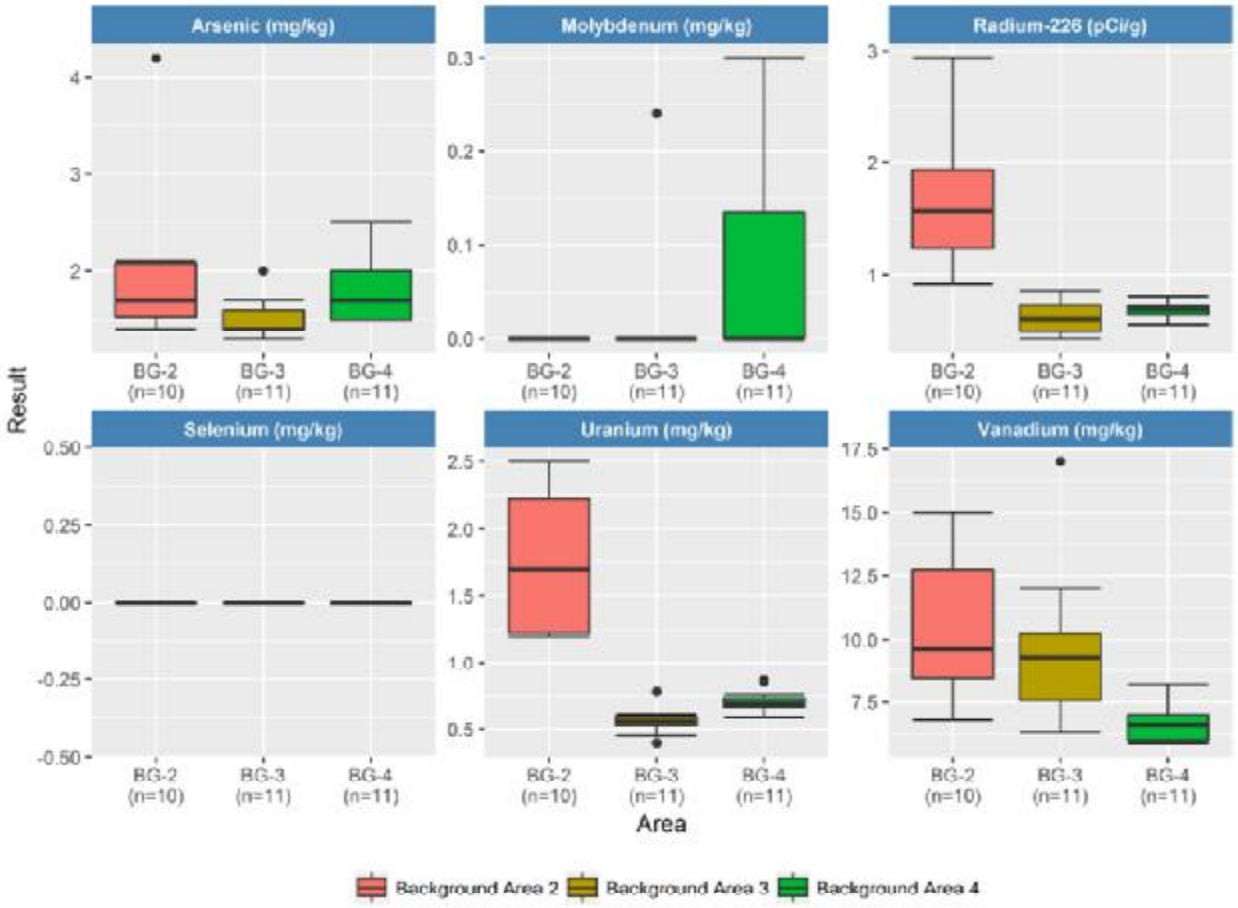
Figure 1A. Survey Areas A, B, C and Background Reference Areas 2 (BG-2), 3 (BG-3) and 4 (BG-4) Soil Sample Box Plots



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. Some potential outlier values are shown for both background reference areas and the Survey Areas at the Site.

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

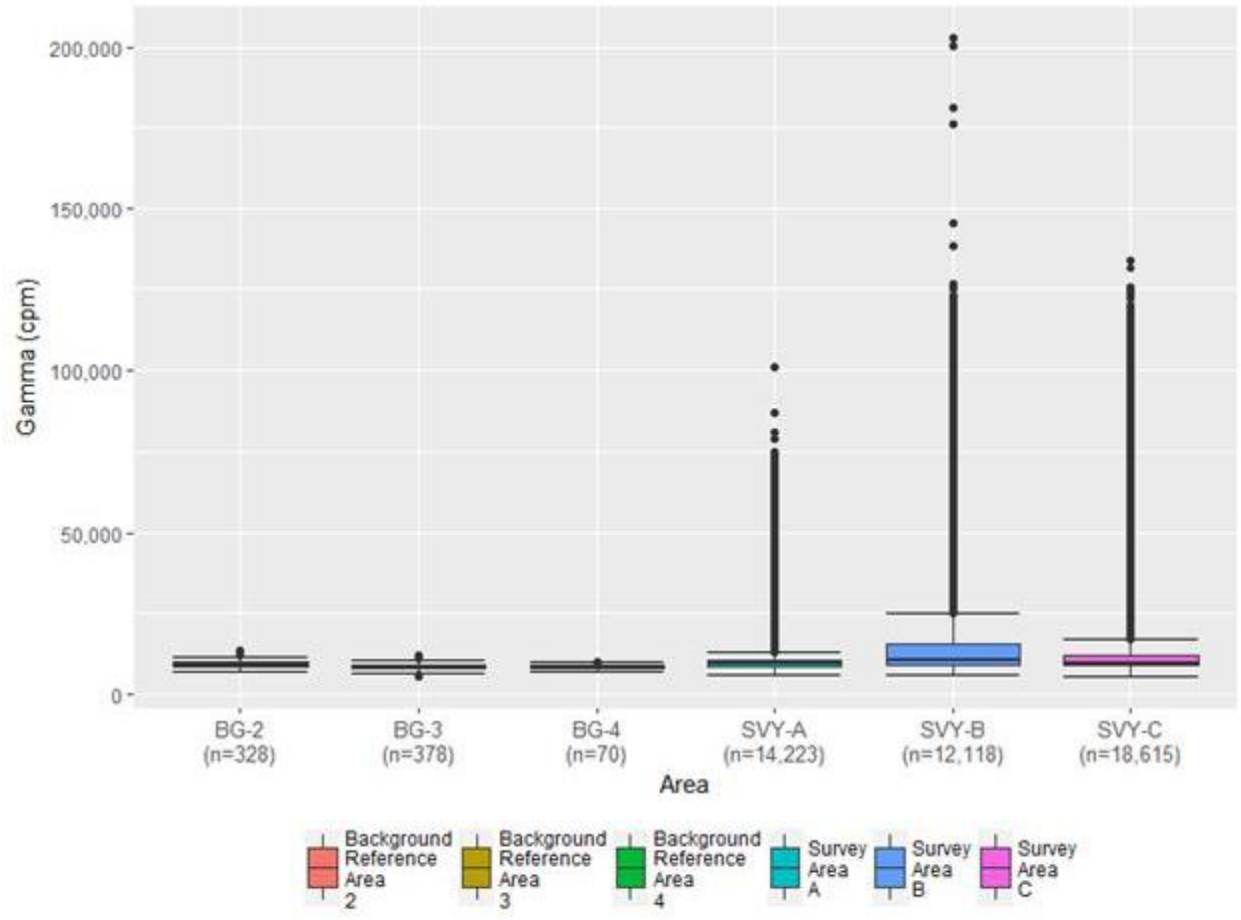
Figure 1B. Background Reference Areas 2 (BG-2), 3 (BG-3) and 4 (BG-4) Soil Sample Box Plots



As shown in the Figure 1B box plots, several potential outlier values are identified (i.e., above 1.5 times the interquartile range). For arsenic (As), one high value at BG-2 and two high values and BG-3, molybdenum (Mo) (one high value at BG-3), uranium (one high value and one low value at BG-3, and two high values at BG-4. One high value for vanadium (V) can also be seen at BG-3. These potential outliers are further evaluated with the use of probability plots in Section 3.1.2 and statistical outlier testing in Section 3.1.3.

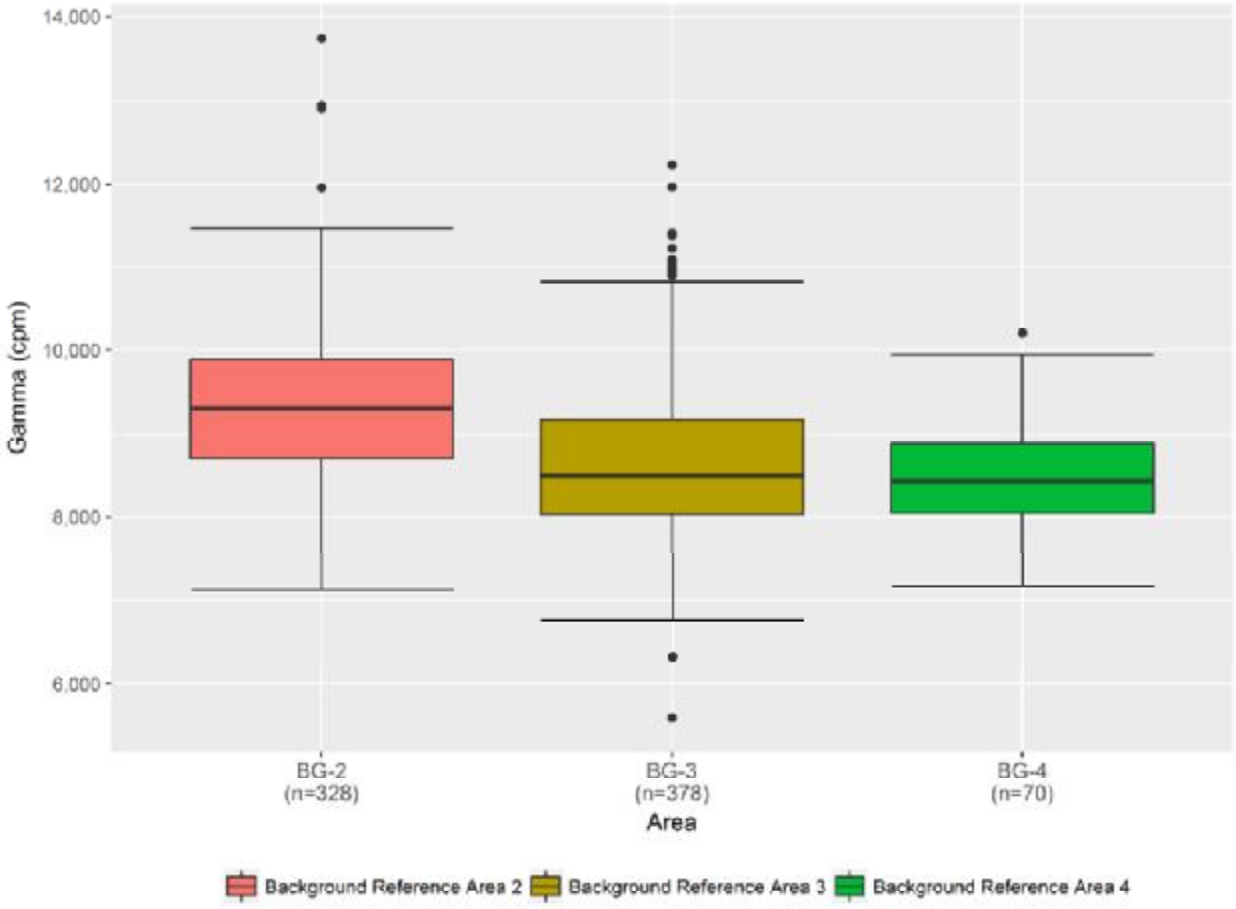
3.1.1.2 Gamma Radiation Results Box Plots

Figure 2A. Survey Areas and Background Reference Area Gamma Radiation Box Plots



The gamma radiation survey results box plots shown on Figure 2A depict differences in the data distribution for gamma measurements between background reference areas and Survey Areas. There are a number of potential outlier values in the box plots for the Survey Areas, which may indicate skewness or possibly non-normally distributed data, instead of outlier values. This has been further evaluated with the use of probability plots in Section 3.1.2 and statistical testing in Section 3.1.4. Based on a review of the Site geology, the potential gamma radiation outlier values observed for the Survey Area data on Figure 2A represent localized areas of higher gamma radiation with respect to other parts of the Survey Areas, as would be expected in areas with varying levels of mineralization, naturally occurring radioactive material (NORM), and potential TENORM.

Figure 2B. Background Reference Area Gamma Radiation Box Plots



Additionally, there are four, 16, and one potential outlier values shown for gamma data in the BG-2, BG-3, and BG-4 datasets, respectively (refer to Figure 2B). However, these potential outlier values are not very high, represent a very small proportion of the total BG-2, BG-3, and BG-4 gamma datasets, and there is no other compelling rationale to reject these data based on the box plot evaluations alone.

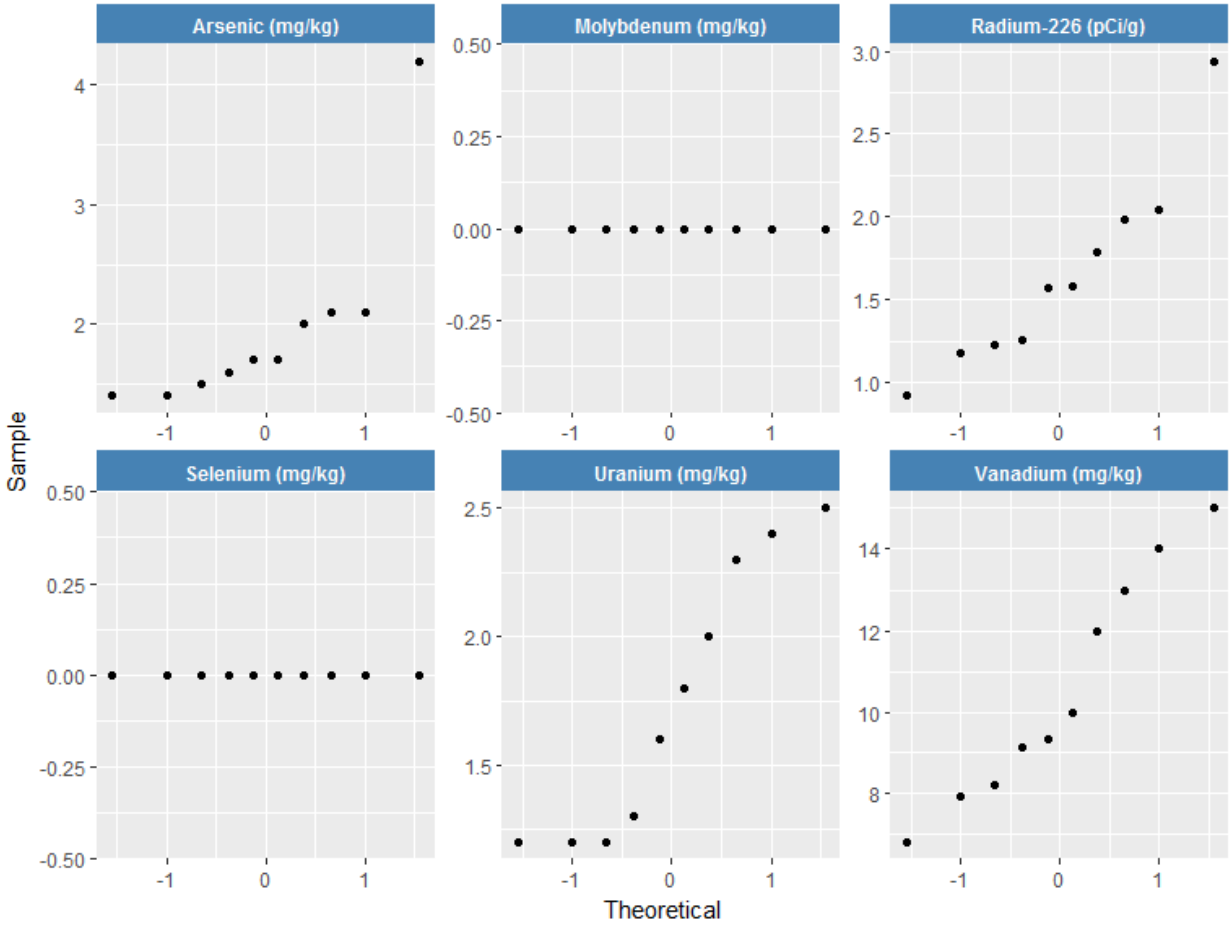
3.1.2 Probability Plots

The normal probability plot is a graphical technique for assessing whether or not a dataset 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 lognormally distributed data, and "S"-shaped lines may indicate two distinct groups within the dataset.

3.1.2.1 Soil Sample Results Probability Plots

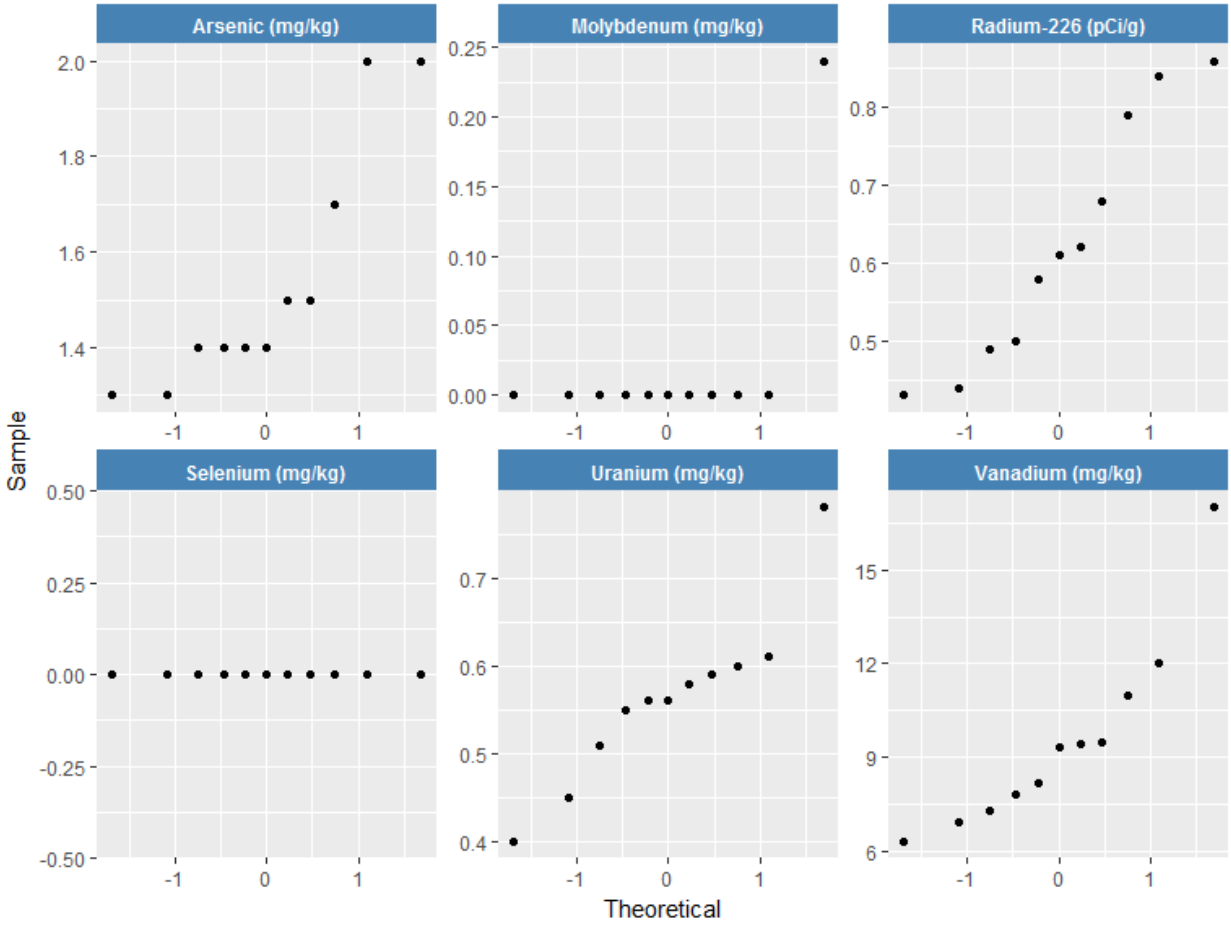
Figures 3 through 5 depict the probability plots for metals and Ra-226 results at BG-2, BG-3, and BG-4.

Figure 3. Background Reference Area 2 (BG-2) Soil Sample Probability Plots



One value for arsenic was identified as a potential outlier in the box plots in Figure 1B. When viewed in the probability plots in Figure 3, this value does appear to be higher than, and out of line with, the rest of the arsenic dataset. This value was tested for statistical significance as a potential outlier in Section 3.1.3. All 10 soil samples collected from BG-2 were non-detect for both molybdenum and selenium.

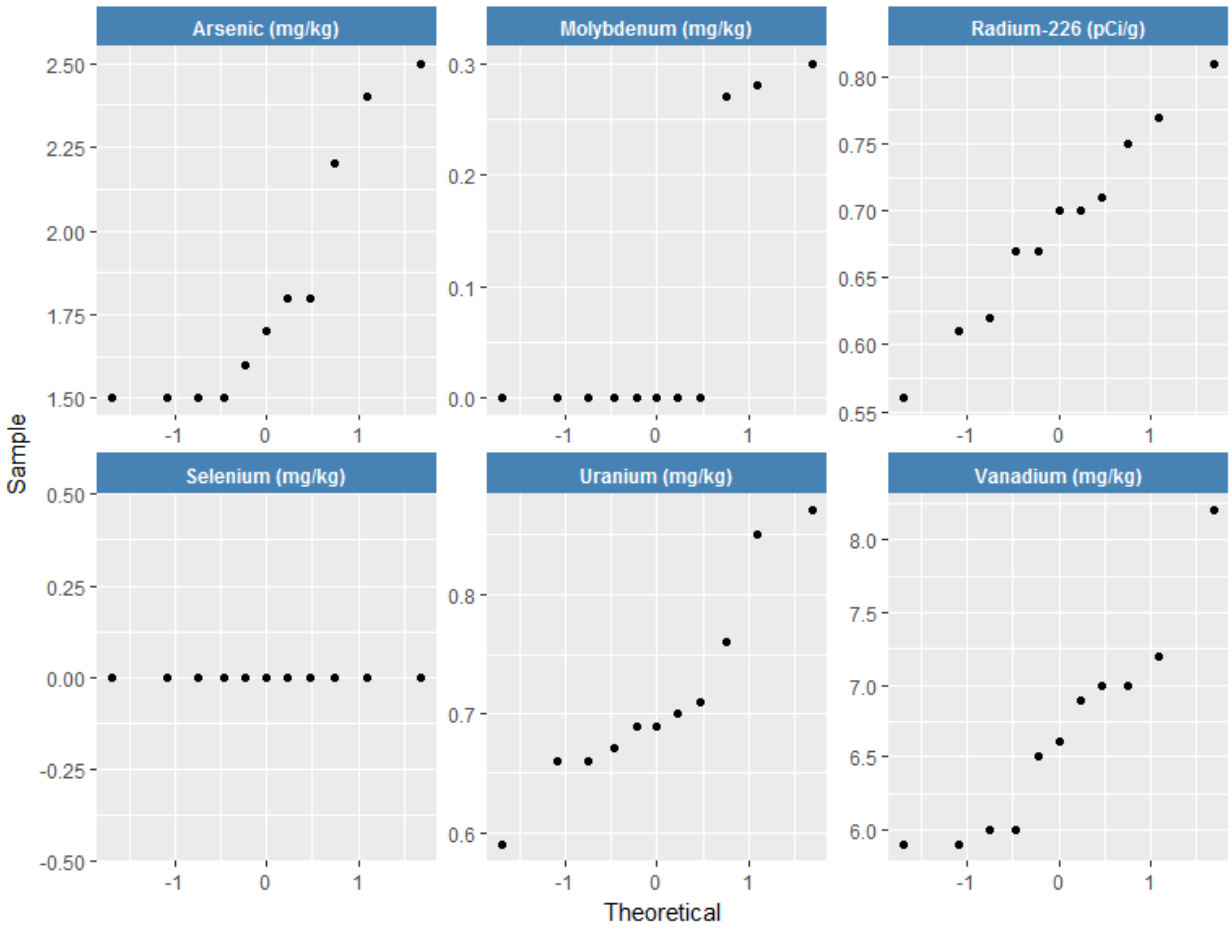
Figure 4. Background Reference Area 3 (BG-3) Soil Sample Probability Plots



Two high values in the arsenic dataset, one high value in the molybdenum dataset, one high value and one low value in the uranium dataset, and one high value in the vanadium dataset were identified as potential outliers in the box plots in Figure 1B. When viewed in the probability plots in Figure 4, the highest two arsenic values do appear to be higher than the rest of the arsenic values, but still conform to the general shape of the dataset. The highest molybdenum value is substantially higher than the rest of the dataset; however, the other 10 sample results at BG-3 were non-detect for molybdenum and the non-detect values were each plotted using an assigned value of 0 mg/kg. As a result, the single detection appears artificially elevated. The single detect in the molybdenum dataset is anomalous, but as the remaining non-detect values cannot be evaluated statistically it is not considered further as a potential outlier. The highest uranium value does appear to be substantially higher than the rest of the vanadium values, while the low value potential outlier conforms more closely to the general shape of the dataset. The high vanadium value also appears to be substantially higher than the rest of the vanadium dataset, but conforms to the general shape of the data distribution. These values were tested for

statistical significance as potential outliers in Section 3.1.3. All 11 soil samples collected from BG-3 were non-detect for selenium.

Figure 5. Background Reference Area 4 (BG-4) Soil Sample Probability Plots

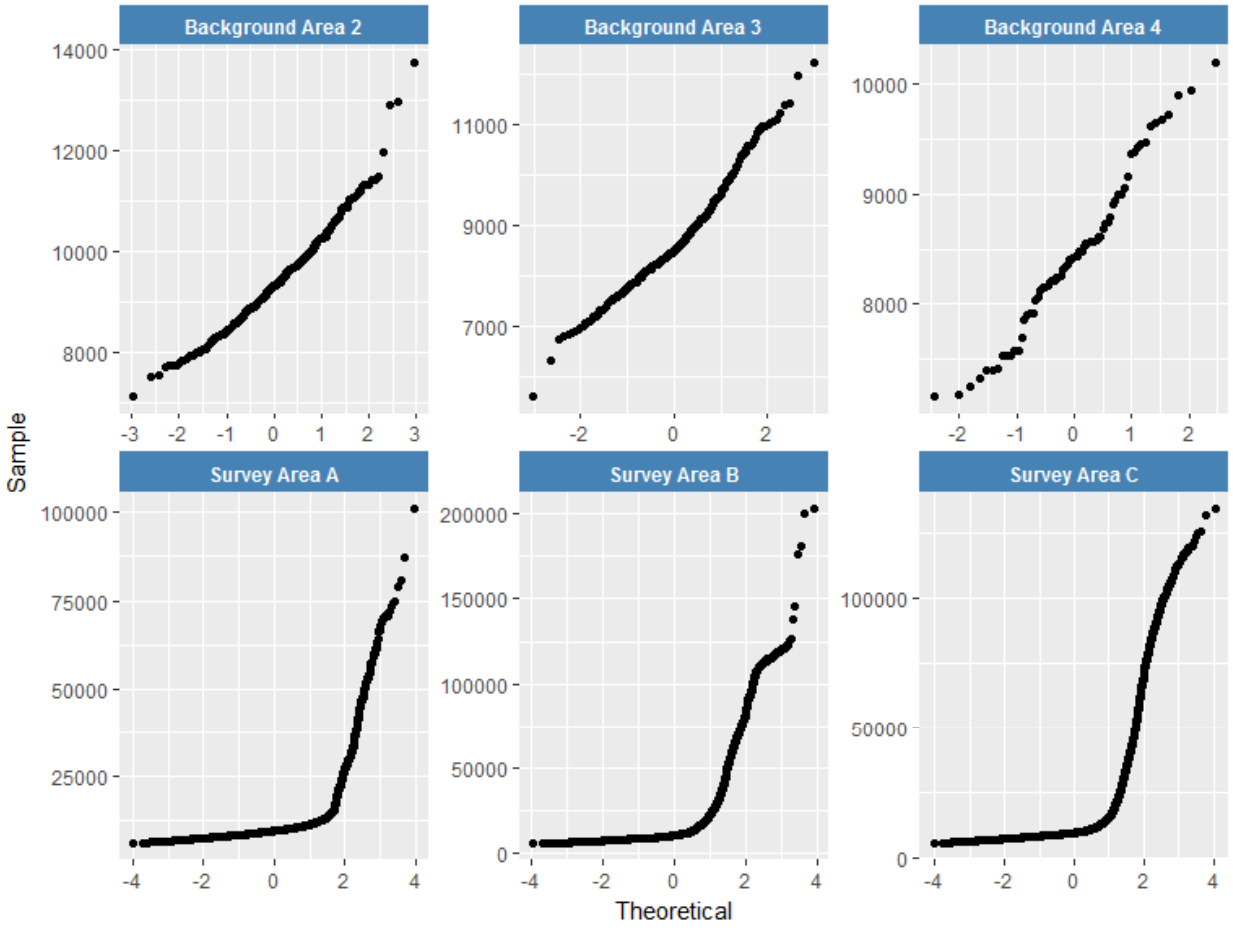


Two values for uranium were identified as potential high outliers in the box plots in Figure 1B. When viewed in the probability plot in Figure 5, these values do appear to be substantially higher than the rest of the values in this dataset. These values were tested for statistical significance as potential outliers in Section 3.1.3. All 11 soil samples at BG-4 were non-detect for selenium.

3.1.2.2 Gamma Survey Results Probability Plots

Figure 6 depicts the probability plots for gamma radiation results at the background reference areas and the Survey Areas.

Figure 6. Survey Area and Background Reference Area Gamma Probability Plots



Gamma survey results indicate a generally normal distribution in the background reference area datasets, and likely a non-normal distribution in the Survey Area datasets (Figure 6). When viewed in the probability plots, the values identified as potential outliers in the BG-2 gamma dataset do not appear to conform to the general shape of the distribution of the BG-2 gamma data, while the potential outliers in the BG-3 and BG-4 datasets do conform. Potential outliers at all three background reference areas do appear elevated in the Figure 6 probability plots, and these values are further evaluated with the use of statistical testing in Section 3.1.4.

The shape and smoothness of the probability plots for the Survey Area gamma results confirms that the gamma radiation data are more log-normally distributed than the background reference area gamma results. This suggests that these higher values are not potential outliers but rather are representative of the spatial variability of gamma radiation in the Survey Areas.

3.1.3 Potential Soil Sample Data Outliers

Seven high results and one low result are identified as potential outlier values in the background reference area datasets in the box plots in Figure 1B and probability plots in Figures 3 through 5.

These values are:

Background Reference Area 2 (BG-2)

- Arsenic: 4.20 mg/kg

Background Reference Area 3 (BG-3)

- Arsenic: 2.00 mg/kg, 2.00 mg/kg
- Uranium: 0.400 mg/kg (low); 0.780 mg/kg
- Vanadium: 17.0 mg/kg

Background Reference Area 4 (BG-4)

- Uranium: 0.870 mg/kg, 0.850 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 eight potential outlier values. The results of Dixon's Test are summarized in Table 1.

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

Area	Constituent	Location ID	Method	Hypothesis	p_Value	Conclusion
Background Reference Area 2 (BG-2)	As	S059-BG2-006	Dixon test for potential outliers	High value 4.20 is a potential outlier	< 0.05	Hypothesis accepted
Background Reference Area 3 (BG-3)	V	S059-BG3-009	Dixon test for potential outliers	High value 17.0 is a potential outlier	> 0.05	Hypothesis rejected
	As	S059-BG3-010	Dixon test for potential outliers	High value 2.00 is a potential outlier	> 0.05	Hypothesis rejected
		S059-SCX-003	Dixon test for potential outliers	High value 2.00 is a potential outlier	> 0.05	Hypothesis rejected
	U	S059-BG3-007	Dixon test for potential outliers	High value 0.780 is a potential outlier	> 0.05	Hypothesis rejected
		S059-BG3-001	Dixon test for potential outliers	Low value 0.400 is a potential outlier	> 0.05	Hypothesis rejected
Background Reference Area 4 (BG-4)	U	S059-BG4-009	Dixon test for potential outliers	High value 0.870 is a potential outlier	> 0.05	Hypothesis rejected
		S059-BG4-004	Dixon test for potential outliers	High value 0.850 is an outlier	> 0.05	Hypothesis rejected

As = Arsenic U = Uranium V = Vanadium

The test confirms that one of the eight potential outlier values tested, is statistically significant (p value <0.05). The statistically significant potential outlier value for arsenic in BG-2 was further investigated by reviewing sample forms, field notes and laboratory reports. Field staff and field notes indicated nothing abnormal about the location where this sample was collected, and the laboratory dataset does not show any data quality flags were applied to this value that would call its accuracy into question. Therefore, while this value is: 1) outside the interquartile range of the dataset (Figure 1B), 2) might not conform with the dataset distribution in the probability plot (Figure 4), and 3) is deemed a potential outlier by Dixon's Test, it was not removed from the background reference area dataset because no scientific reason was found to justify removing it. The value is considered representative of the natural variation at BG-2. However, descriptive statistics were calculated with and without this value for comparison (Section 3.3.1).

3.1.4 Potential Gamma Data Outliers

A total of 21 potential gamma survey outliers were observed among the background reference area gamma datasets; the 19 high and two low values were initially identified in the box plots in Figure 2B. When viewed in the probability plots in Figure 6, the highest BG-2 values do not appear to conform to the general distribution of the BG-2 gamma dataset. Likewise, for BG-3 and BG-4, the highest and lowest potential outlier values do not appear to conform to their respective general distributions in Figure 6.

Because the number of values in the background reference area gamma datasets is 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 potential outlier values presented in Table 2 represent 21 out of 776 data points (3 percent). One possible reason for the potential outliers in the gamma radiation dataset may be the presence of a localized source of radiation within the background reference areas. This was evaluated by examining the relative position of the potential outlier values relative to each other.

In BG-2, the four potential outlier values occur within an approximately 400 square foot area in the southern portion of BG-2. The values are not clustered together to any further extent. In BG-3, the fourteen high and two low potential outlier values are located in the southern portion of BG-3. These values are not clustered together to any extent. In BG-4, there is only one potential outlier value.

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)	13,741	High	Potential Outlier	Potential Outlier	Potential Outlier
	12,945	High	Potential Outlier	Potential Outlier	Potential Outlier
	12,900	High	Potential Outlier	Potential Outlier	Potential Outlier
	11,959	High	Potential Outlier	Potential Outlier	Potential Outlier
Background Reference Area 3 (BG-3)	12,226	High	Potential Outlier	Potential Outlier	Potential Outlier
	11,966	High	Potential Outlier	Potential Outlier	Potential Outlier
	11,399	High	Potential Outlier	Potential Outlier	Potential Outlier
	11,370	High	Potential Outlier	Potential Outlier	Potential Outlier
	11,219	High	Potential Outlier	Potential Outlier	Potential Outlier
	11,083	High	Potential Outlier	Potential Outlier	Potential Outlier
	11,067	High	Potential Outlier	Potential Outlier	Potential Outlier
	11,019	High	Potential Outlier	Potential Outlier	Potential Outlier
	10,991	High	Potential Outlier	Potential Outlier	Potential Outlier
	10,964	High	Potential Outlier	Potential Outlier	Potential Outlier
	10,958	High	Potential Outlier	Potential Outlier	Potential Outlier
	10,946	High	Potential Outlier	Potential Outlier	Potential Outlier
	10,910	High	Potential Outlier	Potential Outlier	Potential Outlier
	10,893	High	Potential Outlier	Potential Outlier	Potential Outlier
	6,318	Low	Potential Outlier	Potential Outlier	Potential Outlier
	5,599	Low	Potential Outlier	Potential Outlier	Potential Outlier
Background Reference Area 4 (BG-4)	10,204	High	Potential Outlier	Potential Outlier	Potential Outlier

cpm Counts per minute

While the potential outlier observations for the values presented in Table 2 explain the presence and position of these values in the dataset, nothing in field notes or the gamma data records indicates a scientific 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 at BG-2, BG-3 or BG-4. Therefore, the values are considered representative of the natural variation present in these background reference areas, and there is no basis to remove

them from the gamma dataset. However, descriptive statistics were calculated with and without these values for comparison (Section 3.3.2).

Potential outlier values in the gamma dataset for the Survey Areas appear in the Figure 2A box plots. However, because of the non-linear shape and continuous distribution of gamma results shown in the probability plot in Figure 6, 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 reference 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 three 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 reference 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 BG-2, BG-3, and BG-4 and the Survey Areas. Relative data distributions were investigated by evaluating the box plots and probability plots in Figures 1A through 6, 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 box plots 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 the Survey Areas. Arsenic, Ra-226 and uranium concentrations are lower at BG-2 than at

Survey Area A, while molybdenum and vanadium concentrations are similar between BG-2 and Survey Area A; selenium is non-detect at both BG-2 and Survey Area A. In comparing BG-3 and Survey Area B, all analytical constituent results are lower in the background reference area. Similarly, all analytical constituent results, except for selenium, are lower at BG-4 than at Survey Area C.

Analytical constituent-specific observations from the box plots in Figures 1A and 1B indicate:

- Arsenic. Arsenic results are similar across BG-2, BG-3, and BG-4. Survey Areas A, B, and C are also fairly similar and are all elevated relative to the background reference areas.
- Molybdenum. Molybdenum results are similar across BG-2, BG-3, BG-4, and Survey Area A, and are slightly elevated at both Survey Areas B and C.
- Ra-226. Ra-226 results appear similar between BG-2, BG-3, and BG-4. Concentrations of Ra-226 at Survey Area A are slightly elevated, and are even more elevated at Survey Areas B and C.
- Selenium. Selenium was detected at Survey Area B and C only.
- Uranium. Uranium results appear similar between BG-2, BG-3, and BG-4, and are slightly elevated at Survey Area A; uranium results at these areas are much lower than uranium results at Survey Area B and Survey Area C.
- Vanadium. Vanadium results are similar between BG-2, BG-3, BG-4 and Survey Area A; vanadium results at these areas are much lower than vanadium results at Survey Area B and Survey Area C.

3.2.1.2 Gamma Radiation Box Plots and Probability Plots

The box plot comparison in Figures 2A and 2B suggests that median values are similar between background reference areas and Survey Areas. Gamma radiation data distributions between background reference areas and Survey Areas shown on Figure 6 are not similar (normal vs. non-normal, respectively). These observations 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 the 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 tests were not performed with soil sample data from BG-2, BG-3, and BG-4 or the Survey Areas. The gamma radiation data, however, do represent non-judgmental sampling, and so the Mann-Whitney test was appropriate for comparison between BG-2, BG-3, and BG-4 and the Survey Areas (Table 3). Therefore, the test was performed 2-sided between background areas, with and without potential outlier values, and the Survey Areas. The two-sided test accounts for results from one group being lower or higher than any other group (i.e., 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 2 (BG-2) vs Survey Area A	<0.05	Significant Difference
Background Reference Area 2 (BG-2) Potential Outliers Excluded vs Background Reference Area 2 (BG-2)	0.788	No Significant Difference
Background Reference Area 2 (BG-2) Potential Outliers Excluded vs Survey Area A	<0.05	Significant Difference
Background Reference Area 3 (BG-3) vs Survey Area B	<0.05	Significant Difference
Background Reference Area 3 (BG-3) Potential Outliers Excluded vs Background Reference Area 3 (BG-3)	0.455	No Significant Difference
Background Reference Area 3 (BG-3) Potential Outliers Excluded vs Survey Area B	<0.05	Significant Difference
Background Reference Area 4 (BG-4) vs Survey Area C	<0.05	Significant Difference
Background Reference Area 4 (BG-4) Potential Outliers Excluded vs Background Area 4 (BG-4)	0.886	No Significant Difference
Background Reference Area 4 (BG-4) Potential Outliers Excluded vs Survey Area C	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Background Reference Area 3 (BG-3)	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Background Area 4 (BG-4)	<0.05	Significant Difference
Background Reference Area 3 (BG-3) vs Background Reference Area 4 (BG-4)	0.205	No 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 B vs Survey Area C	<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 each of the Survey Areas with respect to their respective background reference areas; this observation is valid both with and without potential outliers in each of the background reference area datasets.
- Additionally, gamma results are statistically elevated at Survey Area A relative to Survey Area B and C, and at both Survey Area B relative to Survey Area C. Gamma results at BG-2 are statistically elevated relative to BG-3 and BG-4; however, gamma results at BG-3 are not statistically elevated relative to BG-4.
- The observation that gamma results at all three 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 the 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.
- The inclusion or removal of potential outlier values has no effect on the results of the Mann-Whitney test between BG-2 and Survey Area A, BG-3 and Survey Area B, or BG-4 and Survey Area C (i.e., there is not a significant statistical difference in gamma results between the background reference areas and the Survey Areas, with and without potential outlier values included).

3.3 DESCRIPTIVE STATISTICS

Descriptive statistics, including the upper confidence limit (UCL) of the mean and the 95-95 upper tolerance limit (UTL), were calculated from gamma survey data and soil sample results. Descriptive statistics are important for any data evaluation to present the basic statistics of a dataset with regards to its limits (maximum and minimum), central tendencies (mean and median) as well as data dispersion (coefficient of variance). The ILs for the Site 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

As described in Section 3.2.1.1, results for all analytical constituents appear elevated at Survey Area B and Survey Area C relative to Survey Area A and the background reference areas. Selenium was detected only at Survey Area B and C. An important consideration when comparing concentrations of metals and Ra-226 between background reference areas and Survey Areas is that selection of background reference areas is intended to identify areas that are 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 background reference areas was conducted in a random manner, whereas soil sampling for metals and Ra-226 in Survey Areas was judgmental. As a result, it is not surprising that some metals and Ra-226 concentrations in the Survey Areas appear to be elevated relative to concentrations in background reference areas. It should be noted, however, that concentrations of several of the metals analyzed for 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, detected concentrations of arsenic 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 uranium, vanadium and Ra-226. Elevated concentrations of these constituents in the Survey Areas are likely attributable to historical mining-related disturbances at the Site.

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 2 (BG-2) All Data	Total Number of Observations	10	10	10	10	10	10
	Percent Non-Detects	--	100%	100%	--	--	--
	Minimum[1]	1.40	--	--	1.20	6.80	0.920
	Minimum Detect[2]	--	--	--	--	--	--
	Mean[1]	1.97	--	--	1.75	10.5	1.65
	Mean Detects[2]	--	--	--	--	--	--
	Median[1]	1.70	--	--	1.70	9.65	1.58
	Maximum[1]	4.20	--	--	2.50	15.0	2.94
	Maximum Detect[2]	--	--	--	--	--	--
	Distribution	Normal	Not Calculated	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation[1]	0.420	--	--	0.300	0.266	0.352
	UCL Type	95% Student's-t UCL	Not Calculated	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	2.45	Not Calculated	Not Calculated	2.06	12.2	1.99
	UTL Type	UTL Normal	Not Calculated	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	4.38	Not Calculated	Not Calculated	3.28	18.7	3.34
Background Reference Area 2 (BG-2) Excluding Potential Outliers [3]	Total Number of Observations	9	--	--	--	--	--
	Minimum[1]	1.40	--	--	--	--	--
	Mean[1]	1.72	--	--	--	--	--
	Median[1]	1.70	--	--	--	--	--
	Maximum[1]	2.10	--	--	--	--	--
	Distribution	Normal	--	--	--	--	--
	Coefficient of Variation[1]	0.164	--	--	--	--	--
	UCL Type	95% Student's-t UCL	--	--	--	--	--
	UCL Result	1.90	--	--	--	--	--
	UTL Type	UTL Normal	--	--	--	--	--
	UTL Result	2.58	--	--	--	--	--
Background Reference Area 3 (BG-3) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	91%	100%	--	--	--
	Minimum[1]	1.30	--	--	0.400	6.30	0.430
	Minimum Detect[2]	--	0.240	--	--	--	--
	Mean[1]	1.54	--	--	0.563	9.52	0.622
	Mean Detects[2]	--	0.240	--	--	--	--
	Median[1]	1.40	--	--	0.560	9.30	0.610
	Maximum[1]	2.00	--	--	0.780	17.0	0.860
	Maximum Detect[2]	--	0.240	--	--	--	--
	Distribution	Normal	Not Calculated	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation[1]	0.165	--	--	0.172	0.317	0.249
	UCL Type	95% Student's-t UCL	Not Calculated	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	1.68	Not Calculated	Not Calculated	0.616	11.2	0.706
	UTL Type	UTL Normal	Not Calculated	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	2.25	Not Calculated	Not Calculated	0.836	18.0	1.06

APPENDIX D.2 STATISTICAL EVALUATION

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Area 4 (BG-4) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	73%	100%	--	--	--
	Minimum[1]	1.50	--	--	0.590	5.90	0.560
	Minimum Detect[2]	--	0.270	--	--	--	--
	Mean[1]	1.82	--	--	0.714	6.66	0.688
	Mean Detects[2]	--	0.283	--	--	--	--
	Median[1]	1.70	--	--	0.690	6.60	0.700
	Median Detects[2]	--	0.280	--	--	--	--
	Maximum[1]	2.50	--	--	0.870	8.20	0.810
	Maximum Detect[2]	--	0.300	--	--	--	--
	Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation[1]	0.207	--	--	0.117	0.106	0.107
	CV Detects[2]	--	0.054	--	--	--	--
	UCL Type	95% Student's-t UCL	95% KM (t) UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	2.02	0.244	Not Calculated	0.759	7.04	0.728
	UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	2.88	0.334	Not Calculated	0.948	8.65	0.895
Survey Area A	Total Number of Observations	7	7	7	7	7	7
	Percent Non-Detects	--	71%	100%	--	--	--
	Minimum[1]	1.20	--	--	0.990	6.30	0.940
	Minimum Detect[2]	--	0.960	--	--	--	--
	Mean[1]	4.39	--	--	12.4	56.2	9.53
	Mean Detects[2]	--	1.83	--	--	--	--
	Median[1]	4.70	--	--	3.20	16.0	1.80
	Median Detects[2]	--	1.83	--	--	--	--
	Maximum[1]	9.70	--	--	60.0	290	45.5
	Maximum Detect[2]	--	2.70	--	--	--	--
	Distribution	Normal	Unknown	Not Calculated	Gamma	Unknown	Gamma
	Coefficient of Variation[1]	0.673	--	--	1.72	1.84	1.70
	CV Detects[2]	--	0.672	--	--	--	--
	UCL Type	95% Student's-t UCL	95% KM (Chebyshev) UCL	Not Calculated	95% Adjusted Gamma UCL	95% Chebyshev (Mean, Sd) UCL	95% Adjusted Gamma UCL
	UCL Result	6.55	2.70	Not Calculated	63.3	227	51.3
	UTL Type	UTL Normal	Non-Parametric -Max	Not Calculated	UTL Gamma WH	UTL Non-Parametric	UTL Gamma WH
	UTL Result	14.4	2.70	Not Calculated	144	290	116
Survey Area B	Total Number of Observations	4	4	4	4	4	4
	Percent Non-Detects	--	50%	75%	--	--	--
	Minimum[1]	2.50	--	--	0.660	11.0	0.700
	Minimum Detect[2]	--	0.300	1.60	--	--	--
	Mean[1]	8.85	--	--	34.9	196	23.1
	Mean Detects[2]	--	22.7	1.60	--	--	--
	Median[1]	3.95	--	--	4.50	40.5	4.21
	Median Detects[2]	--	22.7	--	--	--	--
	Maximum[1]	25.0	--	--	130	690	83.2
	Maximum Detect[2]	--	45.0	1.60	--	--	--
	Distribution	Gamma	Unknown	Not Calculated	Gamma	Gamma	Gamma
	Coefficient of Variation[1]	1.22	--	--	1.82	1.69	1.74
	CV Detects[2]	--	1.40	--	--	--	--
	UCL Type	95% Adjusted Gamma UCL	99% KM (Chebyshev) UCL	Not Calculated	95% Adjusted Gamma UCL	95% Adjusted Gamma UCL	95% Adjusted Gamma UCL
	UCL Result	--	148	Not Calculated	--	--	--
	UTL Type	UTL Gamma WH	Non-Parametric -Max	Not Calculated	UTL Gamma WH	UTL Gamma WH	UTL Gamma WH
	UTL Result	171	45.0	Not Calculated	1,733	7,786	1,022

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Survey Area C	Total Number of Observations	20	20	20	20	20	20
	Percent Non-Detects	--	15%	90%	--	--	--
	Minimum[1]	0.970	--	--	0.550	9.20	0.750
	Minimum Detect[2]	--	0.220	2.80	--	--	--
	Mean[1]	12.8	--	--	41.3	201	27.0
	Mean Detects[2]	--	23.9	2.80	--	--	--
	Median[1]	3.85	--	--	6.35	77.0	10.8
	Median Detects[2]	--	3.20	--	--	--	--
	Maximum[1]	76.0	--	--	160	1,100	127
	Maximum Detect[2]	--	180	2.80	--	--	--
	Distribution	Unknown	Not Calculated	Not Calculated	Gamma	Gamma	Gamma
	Coefficient of Variation[1]	1.62	--	--	1.43	1.43	1.43
	CV Detects[2]	--	1.84	--	--	--	--
	UCL Type	95% Chebyshev (Mean, Sd) UCL	Gamma Adjusted KM-UCL	Not Calculated	95% Adjusted Gamma UCL	95% Adjusted Gamma UCL	95% Adjusted Gamma UCL
	UCL Result	32.9	55.9	Not Calculated	87.8	368	53.2
	UTL Type	UTL Non-Parametric	Not Calculated	Not Calculated	UTL Gamma WH	UTL Gamma WH	UTL Gamma WH
	UTL Result	76.0	Not Calculated	Not Calculated	294	1,185	176

[1] This statistic is reported by ProUCL when the dataset contains 100 percent detections.
[2] This statistic is reported by ProUCL when non-detect values exist in the dataset. The value reported is calculated using detections only.
[3] Statistics shown are for the constituents where statistical potential outliers were identified, calculated with the potential outliers removed.

CV Coefficient of variation
KM Kaplan Meier
mg/kg Milligrams per kilogram
-- Not applicable
pCi/g Picocuries per gram
WH Wilson Hilferty

Note The UTL result that is shown on the table is based on the output from ProUCL. ProUCL evaluates the data and provides all possible UCLs from its UCL module for three possible data distributions, then identifies a recommended UCL value. ProUCL does not identify a recommended UTL value. The UTLs are therefore based on the distribution of the recommended UCL. Please refer to *ProUCL Version 5.1 Technical Guide Statistical Software for Environmental Applications for Data Sets with and without Non-detect Observations* (EPA, 2015) for further information

3.3.2 Gamma Radiation Results Summary

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 2 (BG-2) All Data	Total Number of Observations	328
	Minimum	7,118
	Mean	9,369
	Median	9,310
	Maximum	13,741
	Distribution	Normal
	Coefficient of Variation	0.101
	UCL Type	95% Student's-t UCL
	UCL Result	9,455
	UTL Type	UTL Normal
	UTL Result	11,068
Background Reference Area 2 (BG-2) Excluding Potential Outliers	Total Number of Observations	324
	Minimum	7,118
	Mean	9,326
	Median	9,300
	Maximum	11,463
	Distribution	Normal
	Coefficient of Variation	0.093
	UCL Type	95% Student's-t UCL
	UCL Result	9,405
	UTL Type	UTL Normal
	UTL Result	10,879
Background Reference Area 3 (BG-3) All Data	Total Number of Observations	378
	Minimum	5,599
	Mean	8,668
	Median	8,490
	Maximum	12,226
	Distribution	Normal
	Coefficient of Variation	0.115
	UCL Type	95% Student's-t UCL
	UCL Result	8,753
	UTL Type	UTL Normal
	UTL Result	10,447
Background Reference Area 3 (BG-3) Excluding Potential Outliers	Total Number of Observations	362
	Minimum	6,749
	Mean	8,585
	Median	8,453
	Maximum	10,817
	Distribution	Normal
	Coefficient of Variation	0.100
	UCL Type	95% Student's-t UCL
	UCL Result	8,659
	UTL Type	UTL Normal
	UTL Result	10,115

Area	Statistic	Gamma (cpm)
Background Reference Area 4 (BG-4) All Data	Total Number of Observations	70
	Minimum	7,158
	Mean	8,463
	Median	8,430
	Maximum	10,204
	Distribution	Normal
	Coefficient of Variation	0.086
	UCL Type	95% Student's-t UCL
	UCL Result	8,608
	UTL Type	UTL Normal
	UTL Result	9,911
Background Reference Area 4 (BG-4) Excluding Potential Outliers	Total Number of Observations	69
	Minimum	7,158
	Mean	8,437
	Median	8,422
	Maximum	9,948
	Distribution	Normal
	Coefficient of Variation	0.083
	UCL Type	95% Student's-t UCL
	UCL Result	8,579
	UTL Type	UTL Normal
	UTL Result	9,835
Survey Area A	Total Number of Observations	14,158
	Minimum	6,110
	Mean	10,632
	Median	9,592
	Maximum	100,860
	Distribution	Normal
	Coefficient of Variation	0.508
	UCL Type	95% Student's-t UCL
	UCL Result	10,707
	UTL Type	UTL Normal
	UTL Result	19,624
Survey Area B	Total Number of Observations	11,365
	Minimum	5,921
	Mean	15,830
	Median	10,483
	Maximum	202,616
	Distribution	Unknown
	Coefficient of Variation	0.971
	UCL Type	95% Chebyshev (Mean, Sd) UCL
	UCL Result	16,458
	UTL Type	UTL Non-Parametric
	UTL Result	52,103
Survey Area C	Total Number of Observations	18,615
	Minimum	5,835
	Mean	14,600
	Median	9,802
	Maximum	133,973
	Distribution	Unknown
	Coefficient of Variation	1.01
	UCL Type	95% Chebyshev (Mean, Sd) UCL
	UCL Result	15,070
	UTL Type	UTL Non-Parametric
	UTL Result	44,004

cpm Counts per minute

The Mann-Whitney test indicated that gamma results measured within the Survey Areas are statistically elevated relative to gamma results measured in their respective background reference areas. This is to be expected, since 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, and C are based on Background Reference Areas BG-2, BG-3, and BG-4, respectively.

4.1 SURVEY AREA A INVESTIGATION LEVELS

- Arsenic (mg/kg): 4.38
- Molybdenum (mg/kg): None (all results non-detect)
- Selenium (mg/kg): None (all results non-detect)
- Uranium (mg/kg): 3.28
- Vanadium (mg/kg): 18.7
- Ra-226 (pCi/g): 3.34
- Gamma radiation measurements (cpm): 11,068

4.2 SURVEY AREA B INVESTIGATION LEVELS

- Arsenic (mg/kg): 2.25
- Molybdenum (mg/kg): None (91% of results non-detect)
- Selenium (mg/kg): None (all results non-detect)
- Uranium (mg/kg): 0.836
- Vanadium (mg/kg): 18.0
- Ra-226 (pCi/g): 1.06
- Gamma radiation measurements (cpm): 10,447

4.3 SURVEY AREA C INVESTIGATION LEVELS

- Arsenic (mg/kg): 2.88
- Molybdenum (mg/kg): 0.334
- Selenium (mg/kg): None (all results non-detect)
- Uranium (mg/kg): 0.948
- Vanadium (mg/kg): 8.65
- Ra-226 (pCi/g): 0.895
- Gamma radiation measurements (cpm): 9,911

5.0 REFERENCES

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Appendix E Cultural and Biological Resource Clearance Documents

BIOLOGICAL EVALUATION

For the Proposed:

NA-0904
Abandon Uranium Mine - Environmental Response Trust Project

Sponsored by:

MWH Global / Stantec

Prepared by:

Adkins Consulting, Inc.
180 East 12th Street, Unit 5
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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 NA-0904 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 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

NA-0904 is located in Apache County Arizona, approximately 80 miles west of Farmington, New Mexico at an elevation of approximately 5,900 feet. Global Positioning System coordinates are 36° 53’ 60” N by 109° 17’ 60” W NAD 83. The site is located on Navajo Tribal Trust Lands within the Bureau of Indian Affairs (BIA) Shiprock Agency. The legal description of the project surface location is as follows: Section 1, Township 40 North, Range 28 East, Gila Salt River Principle Meridian. Project area maps are provided in Appendix A.

2.2. Estimated Disturbance

MWH proposes a phased approach to scientific investigations at the NA-0904 AUM. The study area encompasses the claim boundary and a 100-foot perimeter buffer zone for a total of approximately 18.3 acres. Please refer to Appendix A for maps delineating the 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) includes the mine boundary with a 100-foot buffer zone surrounding the perimeter of the boundary. The affected environment or action area includes any area that may be directly or indirectly impacted by the proposed activities. Project area maps are provided in Appendix A.

3.1.1. Environmental Setting

Project activities would occur in northeastern Arizona located within the USEPA designated Arizona/New Mexico Plateau Level III Ecoregion. The Arizona/New Mexico Plateau occurs primarily in Arizona, Colorado, and New Mexico, with a small portion in Nevada. This ecoregion is approximately 45,870,500 acres, and the elevation ranges from 2,165 to 11,949 feet. The ecoregion's landscapes include low mountains, hills, mesas, foothills, irregular plains, alkaline basins, some sand dunes, and wetlands. This ecoregion is a large transitional region between the semiarid grasslands to the east, the drier shrublands and woodlands to the north, and the lower, hotter, less vegetated areas to the west and south.

NA-0904 is situated on the northerly slope of a cuesta formation approximately 3 miles northwest of Chezhindeza Mesa. Terrain in the eastern portion of the site is rocky within sagebrush / scrub land vegetation communities with scattered pinon juniper. The western portion of the site continues down a steep sandstone cliff face to a flat sagebrush valley with sandy soils and shallow ephemeral streams. A site specific description is presented below which is added with permission from the Redente site investigation report *Plant Survey Report for Species of Concern at NA-0904 Project Site* (Redente 2016) found in Appendix C.

Climate

The climate of the NA-0904 site is classified as semi-arid, with an average annual precipitation in the Teec Nos Pos area of 216 mm with the greatest precipitation months occurring in July and August. Average annual temperature is 13.3^{o} C.

Soils

The U.S. Department of Agriculture (USDA) Soil Survey for Apache County was published in 2011 in cooperation with the Bureau of Indian Affairs and the Navajo Nation. This area of Apache County is mainly escarpments separated by terraces and riverwashes, with slopes that range from 15 to 65%. The general mapping unit for the area is most likely Rock Outcrop-Shinume Complex and the soil type is Shinume; an eolian soil derived from sandstone (USDA 2011). Typical features include exposures of steep bedrock and cliffs with small exposures of flat or rolling bedrock, typically barren but may have sparse vegetation growing in cracks and crevices or in thin layers of eolian, alluvial, or colluvial material.

Land Use

The land type on the NA 0904 site is rangeland and the principal land use is wildlife habitat.

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 NA-0904 site is sparsely vegetated grassland with sporadic shrubs. Vegetative cover is estimated to be approximately 25 percent.

A site specific description is presented below which is added with permission from the Redente site investigation report *Plant Survey Report for Species of Concern at NA-0904 Project Site* (Redente 2016) found in Appendix C.

Plant Community Type

The vegetation on the NA 0904 site is part of the Colorado Plateau Shrub-Gralssland type (USDA 2011). The most common species on the site include broom snakeweed (*Gutierrizia sarathrae*), cliffrose (*Purshia stansburiana*), rubber rabbitbrush (*Ericameria nauseosa*), Utah serviceberry (*Amelanchier utahensis*), shadscale saltbush (Atriplex confertifolia), yucca (*Yucca baileyi*), Mormon tea (*Ephedra viridis*), (blue grama (*Bouteloua gracilis*), spike dropseed (*Sporobolus contractus*), galleta (*Pleuraphis jamesii*), and Indian ricegrass (*Achnatherum hymenoides*).

Fauna

Wildlife or evidence of wildlife observed within the PPA included common raven (*Corvus corax*), cottontail rabbit (S*ylvilagus* sp.), coyote (*Canis latrans*), mule deer (*Odocoileus hemionus*), turkey vulture (*Cathartes aura*), and prairie falcon (*Falco mexicanus*). Surveyors observed an active common raven (*Corvus corax*) nest in the sandstone cliffs within the PPA and observed a prairie falcon perched near the PPA. Additionally, a mound with numerous burrows characteristic of the banner-tailed kangaroo rat was observed approximately 400 feet northwest of the PPA boundary. Further analysis of sensitive species can be found in Section 4 of this document.

Hydrology/Wetlands

Under Executive Orders 11988 and 11990, Federal agencies are required to minimize the destruction, loss, or degradation of wetlands and floodplains, and preserve and enhance their natural and beneficial

values. These habitats should be conserved through avoidance, or mitigated to ensure that there would be no net loss of wetlands function and value.

Run-off from precipitation in the project area generally drains northeast for 8 miles through unnamed washes to Tsitah Wash. Tsitah Wash joins the San Juan River approximately 5 miles southeast of Aneth, Utah. The San Juan River, located approximately 20 miles northeast of the project area, is the nearest perennial water source. 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 20 miles of the PPA.

Cumulative impacts to surface waters would be negligible. Surface-disturbing activities other than the proposed action that may cause accelerated erosion include, but are not limited to, construction of roads, other facilities, and installation of trenches for utilities; road maintenance such as grading or ditch-cleaning; public recreational activities; vegetation manipulation and management activities; natural and prescribed fires; and livestock grazing. Because the proposed action would have a negligible impact to downstream surface water quality, the cumulative impact also would be negligible when added to other past, present, and reasonably foreseeable activities.

4. THREATENED, ENDANGERED, AND SENSITIVE SPECIES EVALUATION

The Endangered Species Act (ESA) of 1973 requires all federal departments and agencies to conserve threatened, endangered, and critical and sensitive species and the habitats on which they depend, and to consult with the U.S. Fish and Wildlife Service (USFWS) on all actions authorized, funded, or carried out by the agency to ensure that the action will not likely jeopardize the continued existence of any threatened and endangered species or adversely modify critical habitat.

4.1. Methods

4.1.1. Off-site Methods

Prior to conducting fieldwork, ACI compiled data on animal species listed under the ESA. Informal consultation was initiated by requesting an Official Species List from the USFWS Information, Planning, and Conservation System (IPaC) website (http://ecos.fws.gov/ipac/). ACI received the Official Species List (02EAAZ00-2016-SLI-0363) on April 8, 2016. See Table 1 for USFWS-listed threatened, endangered, or candidate species with potential to occur in the PPA.

The Navajo Nation Department of Fish and Wildlife (NNDFW), Navajo Natural Heritage Program (File # 15mwh101) sent MWH a NESL information letter dated 29 December, 2015. The letter suggests biologists determine habitat suitability within the project area for the provided list of species of concern with potential to occur on the 7.5-minute quadrangles containing the project boundaries. The Navajo species of concern listed in the NESL information letter are included in Table 2.a below.

In addition to the above listed species, ACI reviewed species protected under the MBTA with potential to occur in the proposed project and action area (Table 3).

4.1.2. On-site Survey Methods

An on-site pedestrian survey was conducted in April 2016 by ACI personnel permitted 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 cloudy with light rain.

Follow up surveys were conducted at the site specifically targeting Golden eagle (*Aquila chrysaetos*), Ferruginous hawk (*Buteo regalis*), American peregrine falcon (*Falco peregrinus*), and Western burrowing owl (*Athene cunicularia hypugaea*) 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 NA-0904 Project

Species	Status	Occurrence Within Region	Habitat	Potential to Occur within Action Area
BIRDS				
Mexican spotted owl (*Strix occidentalis lucida*)	Threatened with Designated Critical Habitat	Year-round range.[1]	Mixed conifer forests. Typically where unlogged, uneven-aged, closed-canopy forests occur in steep canyons.1	No potential. Action area does not provide suitable habitat for species to occur.
Western Yellow-Billed Cuckoo (*Coccyzus americanus*)	Threatened	Possible rare summer/breeding occurrences.[2]	In the southwestern U.S., associated with riparian woodlands dominated by cottonwood or willow trees. In New Mexico, native or exotic species may be used.[2]	No potential. Action area does not provide suitable habitat for species to occur.
FISHES				
Roundtail chub (*Gila robusta*)	Proposed Threatened	San Juan and Mancos Rivers. Rarely encountered in recent surveys; some found from Shiprock to near Lake Powell with most between Shiprock and Aneth. [2,3]	Rocky runs, rapids, and pools of creeks and small to large rivers; also large reservoirs in the upper Colorado River system.[2]	No potential. No perennial waters in or near the PPA. Action area is within the San Juan River watershed; however, negligible effects from the project to any drainage system are expected.

Table 1: USFWS IPaC Official Species List for the NA-0904 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.
MAMMALS				
Black-footed ferret (*Mustela nigripes*)	Endangered		Open habitat, including grasslands, steppe, and shrub steppe. Closely associated with prairie dog colonies. At least 40 hectares of prairie dog colony required to support one ferret.[2]	No potential. Action area does not provide suitable habitat for species to occur. Action area does not provide prairie dog colonies of sufficient size
Gray wolf (*Canus lupus*)	Proposed Experimental	In NE AZ, South of Hwy 60 in Apache, Coconino, and Navajo County; In NW NM, south of I-40 in Cibola, McKinley and Catron County.[2]	Not limited to any particular habitat type. Viable populations occur only where human population density and persecution level are low and prey densities are high. Birthing dens may be on bluffs or slopes among rocks or in enlarged badger holes. In Arizona and New Mexico, diet includes primarily elk and sometimes livestock, deer, rodents, or lagomorphs.[2]	No potential. Action area is outside of range for this species. No dens suitable for this species were found in the action area.
REPTILES				

Table 1: USFWS IPaC Official Species List for the NA-0904 Project

Species	Status	Occurrence Within Region	Habitat	Potential to Occur within Action Area
Northern Mexican gartersnake (*Thamnophis eques megalops*)	Threatened	Most of AZ; In SE NM including Catron, Grant and Hildago County [2]	Considered a riparian obligate except during dispersal behavior. Occurs chiefly in the following general habitat types: (1) Source-area wetlands [e.g., cienegas (mid-elevation wetlands with highly organic, reducing (basic, or alkaline) soils), stock tanks (small earthen impoundment), etc.]; (2) large river riparian woodlands and forests; and (3) streamside gallery forests (as defined by well-developed broadleaf deciduous riparian forests with limited, if any, herbaceous ground cover or dense grass). Occurs at elevations from 130 to 8,497 (ft).[2]	No potential. Action area does not provide suitable habitat for species to occur.

[1]USFWS; [2]NatureServe Explorer; [3]Navajo Endangered Species List, Species Accounts 2008

4.2.2. ESA-Listed Species Eliminated From Further Consideration

Table 1 includes seven (7) ESA-listed species that have the potential to occur in the project area based on the USFWS IPaC Official Species List. All of the species in Table 1 have been eliminated from further discussion in this report. There would be no direct, indirect or cumulative impacts to the species in Table 1.

4.3. NESL Species Analysis and Results

4.3.1. Navajo Endangered Species List (NESL) and Species of Concern

Table 2.a lists species of concern with potential to occur on the 7.5-minute quadrangle(s) containing the project boundaries. According to the NESL information letter received from the NFWD found in Appendix D, the golden eagle (*Aquila chrysaetos*) is 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			

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area
Northern Leopard Frog (*Lithobates pipiens*)	NESL G2	Springs, slow streams, marshes, bogs, ponds, canals, flood plains, reservoirs, and lakes; usually permanent water with rooted aquatic vegetation. In summer, commonly inhabits wet meadows and fields. Takes cover underwater, in damp niches, or in caves when inactive. Over winters usually underwater. Eggs are laid and larvae develop in shallow, still, permanent water (typically), generally in areas well exposed to sunlight.[3,4]	No potential. Action area does not provide suitable habitat for species to occur.
Colorado pikeminnow (*Ptychocheilus lucius)*	NESL G2 USFWS-E	Warm-water rivers and tributaries of the Colorado River basin.[3,4] Known to occur in San Juan River from Shiprock to Lake Powel. [3,4]	No potential. No perennial waters in or near the PPA. Action area is within the San Juan River watershed; however, negligible effects from the project to any drainage system are expected.
Southwestern Willow Flycatcher (*Empidonax traillii extimus*)	NESL G2 USFWS-E	Breeds in dense riparian habitat. [3,4]	No potential. Action area does not provide suitable habitat for species to occur.
Mountain plover *(Charadrius montanus)*	NESL G4	Typically nests in flat (<2% slope) to slightly rolling expanses of grassland, semi-desert, or badland, in an area with short, sparse vegetation, large bare areas (often >1/3 of total area), and that is typically disturbed (e.g. grazed); may also nest in plowed or fallow cultivation fields. Nest is a scrape in dirt often next to a grass clump or old cow manure pile. Migration habitat is similar to breeding habitat.[2,3]	No potential. Action area does not provide suitable habitat for species to occur.
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 habitat for species to occur. Sandstone cliffs within and surrounding the site provide potential nesting habitat.
Ferruginous hawk (*Buteo regalis*)	NESL G3	Breed in open country, usually prairies, plains and badlands; semi- desert grass-shrub, sagebrush-grass & piñon-juniper plant associations. [3]	Action area provides potential foraging habitat for species to occur. Sandstone cliffs within and surrounding the site provide potential nesting habitat.
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	Action area provides marginal potential foraging habitat for species to occur. No potential nesting habitat.

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area
		riparian woodlands, coniferous & deciduous forests, shrublands, prairies. [3]	
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. [3,4]	Action area provides suitable habitat for species to occur. Western portion of the site within the flat sagebrush valley provides potential habitat. Kangaroo rat mound with numerous burrows observed approximately 400 feet northwest of the PPA boundary.
Banner tailed kangaroo rat (*Dipodomys spectabilis*)	NESL G4	Potential range includes desertlands east of the Chuska Mountains, and east and north of Black Mesa in Apache Co., AZ and San Juan Co., UT. Dens are elaborate, distinctive burrow systems usually with 3-12 burrow openings on a discrete, raised mound (<or=1.2 m tall by 1.5-4.5 m diameter) in Great Basin desert grassland or desertscrub, with heavier soils. Presence of grasses is necessary. [3,5,6]	Action area provides suitable habitat for species to occur. Western portion of the site within the flat sagebrush valley provides potential habitat. Kangaroo rat mound with numerous burrows observed approximately 400 feet northwest of the PPA boundary. The characteristics of the burrows are consistent with this species.
PLANTS			
Parish's alkali grass (*Puccinellia parishii*)	NESL G4 NM-E	Alkaline springs, seeps, and seasonally wet areas that occur at the heads of drainages or on gentle slopes. Elevation: 2600-7200 feet.[2,3]	No potential. Action area does not provide suitable alkaline soils for species to occur.[5]
Zuni Fleabane (*Erigeron rhizomatus*)	NESL G2 USFWS-T	Found on fine textured clay hillsides of mid to high elevation between 7000 and 8300ft. It is known from clays derived from the Chinle Formation in the Zuni and Chuska Mountains, and to similar clays of the Baca Formation in the Datil and Sawtooth ranges in New Mexico.[3]	No potential. Action area does not provide suitable vegetation community.[5]

Species are listed by the NESL as; Group 2: Endangered (survival or recruitment in jeopardy); Group 3: Endangered (survival or recruitment in jeopardy in foreseeable future); and Group 4: Species of Consideration. NESL Species with New Mexico State Endangered or Threatened status are labeled as NM-T or NM-E.

Sources: 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 eleven (11) 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: Northern Leopard Frog (*Lithobates pipiens*), Colorado pikeminnow (*Ptychocheilus lucius),* Southwestern Willow Flycatcher (*Empidonax traillii extimus*), Mountain plover *(Charadrius montanus),* Zuni Fleabane *(Erigeron rhizomatus),* and Parish's alkali grass *(Puccinellia parishii)*. None of these species were observed during surveys of the proposed project area or immediate surroundings.

Critical habitats of these species do not exist within or adjacent to the proposed project area. There would be no direct, indirect or cumulative impacts to these species.

Habitat potential was assessed for the American peregrine falcon (*Falco peregrinus*) within the action area. ACI biologists determined the sandstone 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 reasons: Cliff walls are approximately 100 to 200 feet in height but are somewhat sloped and ledged instead of sheer, the surrounding area does not provide the preferred riparian or forested foraging habitat for this species, and the presence of prairie falcon typically distinguishes habitat from that of 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.	Action area provides potential foraging habitat for species to occur. Sandstone cliffs within and surrounding the site provide potential nesting habitat.
Ferruginous hawk (*Buteo regalis*)	NESL G3	Breed in open country, usually prairies, plains and badlands; semi-desert grass-shrub, sagebrush-grass & piñon-juniper plant associations.	Action area provides potential foraging habitat for species to occur. Sandstone cliffs within and surrounding the site provide potential nesting habitat.
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. [3,4]	Action area provides suitable habitat for species to occur. Western portion of the site within the open valley provides potential habitat. Kangaroo rat mound with numerous burrows observed approximately 400 feet northwest of the PPA boundary.
Banner tailed kangaroo rat (*Dipodomys spectabilis*)	NESL G4	Potential range includes desertlands east of the Chuska Mountains, and east and north of Black Mesa in Apache Co., AZ and San Juan Co., UT. Dens are elaborate, distinctive burrow systems usually with 3-12 burrow openings on a discrete, raised mound (<or=1.2 m tall by 1.5-4.5 m diameter) in Great Basin desert	Action area provides suitable habitat for species to occur. Western portion of the site within the flat sagebrush valley provides potential habitat. Kangaroo rat mound with numerous burrows observed approximately 400 feet northwest of the PPA boundary.

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area
		grassland or desertscrub, with heavier soils. Presence of grasses is necessary.[3,6]	The general characteristics of the burrows are consistent with this species.

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[5].

4.4. Migratory Bird Species

The Migratory Bird Treaty Act (MBTA) implements various treaties and conventions between the U.S. and Canada, Japan, Mexico and the former Soviet Union for the protection of migratory birds. Under the Act, taking, killing or possessing migratory birds is unlawful.

The bald eagle (*Haliaeetus leucocephalus*) was delisted under the ESA on August 9, 2007. Both the bald eagle and golden eagle (*Aquila chrysaetos*) are still protected under the MBTA and Bald and Golden Eagle Protection Act (BGEPA). The BGEPA affords both eagles protection in addition to that provided by the MBTA, in particular, by making it unlawful to "disturb" eagles.

In preparation for conducting the migratory bird survey, information from the New Mexico Partners In Flight website (http://www.hawksaloft.org/pif.shtml), the New Mexico PIF highest priority list of species of concern by vegetation type, the USFWS's Division of Migratory Bird Management website (http://www.fws.gov/migratorybirds/), and the 2002 Birds of Conservation Concern Report for the Southern Rockies/Colorado Plateau Bird Conservation Region (BCR) No. 16, were used to develop a list of high priority migratory bird species with potential to occur in the area of the proposed action. Species addressed previously will not be reiterated here.

Table 3: Priority Birds of Conservation Concern with Potential to Occur in the Project Area

Species Name	Habitat Associations	Potential to Occur in the Project Area
Black-throated sparrow (*Amphispiza bilineata*)	Xeric habitats dominated by open shrubs with areas of bare ground.	Suitable habitat is present within the action area for species to occur.
Brewer's sparrow (*Spizella breweri*)	Closely associated with sagebrush, preferring dense stands broken up with grassy areas.	No suitable habitat is present within the action area for species to occur.
Gray vireo (*Vireo vicinior*)	Open stands of piñon pine and Utah juniper (5,800 – 7,200 ft) with a shrub component and mostly bare ground; antelope bitterbrush, mountain mahogany, Utah serviceberry and big sagebrush often present. Broad, flat or gently sloped canyons, in areas with rock outcroppings, or near ridge-tops.	No suitable habitat is present within the action area for species to occur.
Loggerhead shrike (*Lanius ludovicianus*)	Open country interspersed with improved pastures, grasslands, and hayfields. Nests in sagebrush areas, desert scrub, and woodland edges.	Suitable habitat is present within the action area for species to occur.
Mountain bluebird (*Sialia currucoides*)	Open piñon-juniper woodlands, mountain meadows, and sagebrush shrublands; requires larger trees and snags for cavity nesting.	No suitable habitat is present within the action area for species to occur.

Mourning dove (*Zenaida macroura*)	Open country, scattered trees, and woodland edges. Feeds on ground in grasslands and agricultural fields. Roost in woodlands in the winter. Nests in trees or on ground.	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.	Marginal habitat is present within the action area for species to occur. Lack of significant sagebrush shrubland likely a limiting factor.
Scaled quail (*Callipepla squamata*)	Brushy arroyos, cactus flats, sagebrush or mesquite plains, desert grasslands, Plains grasslands, and agricultural areas. Good breeding habitat has a diverse grass composition, with varied forbs and scattered shrubs.	No suitable habitat present within the action area for species to occur. Lack of diverse grass composition with varied forbs likely a limiting factor.
Swainson's hawk (*Buteo swainsoni*)	A mixture of grassland, cropland, and shrub vegetation; nests on utility poles and in isolated trees in rangeland. Nest densities higher in agricultural areas.	Marginal habitat is present within the action area for species to occur.
Vesper sparrow (*Pooecetes gramineus*)	Dry montane meadows, grasslands, prairie, and sagebrush steppe with grass component; nests on ground at base of grass clumps.	No suitable habitat present within the action area for species to occur. Lack of significant grassland/prairie component a limiting factor.
Bald eagle (*Haliaeetus leucocephalus*)	Near lakes, rivers and cottonwood galleries. Nests near surface water in large trees. May forage terrestrially in winter	No suitable habitat present within the action area for species to occur.
Bendire's thrasher (*Toxostoma bendirei*)	Typically inhabits sparse desert shrubland & open woodland with scattered shrubs; breeds in scattered locations in central & western portions of NM; most common in southwest NM.	Suitable habitat is present within the action area for species to occur.
Piñon jay (*Gymnorhinus cyanocephalus*)	Foothills throughout CO and NM wherever large blocks of piñon-juniper woodland habitat occurs.	No suitable habitat present within the action area for species to occur.
Prairie falcon (*Falco mexicanus*)	Arid, open country, grasslands or desert scrub, rangeland; nests on cliff ledges, trees, power structures.	Action area provides potential foraging and nesting habitat for species to occur. On several occasions, a prairie falcon perched near the PPA during the April 2016 surveys of the PPA.

5. EFFECTS ANALYSIS

Effects or impacts can be either long term (permanent or residual) or short term (incidental or temporary). Short-term impacts affect the environment for only a limited period and then the environment reverts rapidly back to pre-action conditions. Long-term impacts are substantial and permanent alterations to the pre-existing environmental condition. Direct effects are those effects that are caused by the action and occur in the same time and place as the action. Indirect effects are those effects that are caused by or will result from the proposed action and are later in time but still reasonably certain to occur (USFWS 1998).

5.1. Direct and Indirect Effects

The PPA includes the claim boundary and a 100-foot perimeter buffer zone for a total of approximately 18.3 acres. The project will also include a walkover survey for gamma radiation across a small area known as the "background area" (see Appendix A for map). A few soil samples approximately 3 inches in diameter and up to 6 inches deep will be collected by hand in these areas. The proposed action would result in a short term increase in human activity within the PPA at varying degrees depending on the project phase:

- Phase I: Spring of 2016 activity would entail pedestrian biological surveys and land surveying. During 2016, work would entail pedestrian activity including gamma surveys, mapping, well sampling, and surface soil sampling. For this phase, there will be a maximum of 5 people onsite for no more than 5 to 7 days. Surface disturbance would be minimal and noise would be light.

- Phase II: Beginning in 2017, equipment including an excavator or small mobile drilling unit may be used to collect soil samples. Up to 8 people may be onsite all day for a period of one week. Equipment travel would be confined to a temporary travel corridor approximately 20 feet in width. Within the travel corridor, vegetation and surface soil would sustain some disturbance but would not be bladed or bulldozed. One or more soil samples may be taken using an excavator or small mobile drilling unit. During Phase II, noise may be moderate for a short duration, and surface disturbance will be light to moderate but confined to a minimal footprint within the study area. No permanent structures will be left on site.

Best Management Practices (BMPs) incorporated into project design will reduce potential impacts including: confining equipment travel to PPA boundary, minimizing travel corridors as much as practicable, limiting truck and equipment travel within the PPA when surfaces are wet and soil may become deeply rutted, and using previously disturbed areas for travel when possible.

5.1.1. Golden eagle, Ferruginous hawk

Habitat potential was assessed for the golden eagle and ferruginous hawk within the action area. ACI biologists determined the sandstone cliffs within and 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. ACI biologists did not see any sign of use by these species including old or inactive nests.

Phase I:
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.

Phase II:
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. The area is not currently occupied as a nest territory; Phase II activities that may occur within the breeding season may discourage adults from selecting the area as a new nest territory. Nest initiation or new 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; and for ferruginous hawk, 1 March to 1 May for nests with no eggs and until mid to late July for productive nests (Navajo Nation Division of Natural Resources, Department of Fish and Wildlife 2008b).

5.1.2. Western burrowing owl, Banner tailed kangaroo rat

ACI biologists determined the western portion of the site within the flat sagebrush valley provides potential habitat for western burrowing owl and banner tailed kangaroo rat. During the April 2016 surveys of the PPA, surveyors observed a cluster of burrows with the characteristics of a kangaroo rat mound approximately 400 feet northwest of the PPA boundary: dirt mounds were roughly 1-foot high and covered a 10 by 14-foot area. Pictures of the mound can be found in Appendix B, and the mound location is noted on aerial imagery in Appendix A.

The kangaroo rat mound approximately 400 feet northwest of the PPA boundary could also serve as potential burrowing owl nesting habitat. Observations following Navajo Natural Heritage Program (NNHP) protocol were conducted during April 2016 to identify any active nest sites in or near the PPA. No signs of burrowing owl use were noted.

Phase I:
Noise and surface disturbance will be low during pedestrian survey activity. Adult wildlife 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 disrupt adults from breeding or foraging behavior for a short period of time, but burrows or young would not be directly disturbed. Direct and indirect effects are expected to be negligible due to the distance from the PPA.

Phase II:
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.

- For kangaroo rat: the kangaroo rat mound is located approximately 400 feet northwest of the PPA boundary. If project activities are confined to the PPA, no direct or indirect impacts are expected to this species.
- For burrowing owl: the kangaroo rat burrows located approximately 400 feet northwest of the PPA boundary are not occupied by burrowing owl as of the 2016 breeding season.

5.1.3. Migratory Birds

The PPA encompasses approximately 18.3 acres of potential migratory bird habitat in the form of Great Basin Desert scrub. No trees would be removed as a result of the proposed project.

During the April 2016 survey of the PPA surveyors observed an active common raven (*Corvus corax*) nest in the sandstone cliffs within the PPA; and on several occasions, a prairie falcon perched near the PPA as well. Pictures can be found in Appendix B, and the sighting locations are noted on aerial imagery in Appendix A.

Phase I:
Noise and surface disturbance will be low during pedestrian survey activity. Adult migratory birds would not be directly impacted by Phase I because of their mobility and ability to avoid areas of human activity. Minor human presence during project activities within the breeding season may indirectly disturb or displace adults from nests and foraging habitats for a short period of time. Direct and indirect effects are expected to be short term and minor.

Phase II:
Adult migratory birds would not be directly harmed by the activities because of their mobility and ability to avoid areas of human activity. During Phase II, noise may be moderate but for a short duration, and surface disturbance will be light to moderate but confined to a minimal footprint within the study area. No permanent structures will be left on site. No active nests within the PPA are expected to be directly impacted during Phase II if activities occur outside of the typical migratory bird breeding season. 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. Direct impacts are more likely if surface disturbing activities occur during the breeding season (April 1 through August 15).

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, Ferruginous hawk

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. Western burrowing owl, Banner tailed kangaroo rat

As stated above in Section 5.2.1, foreseeable human activity in the area would contribute to cumulative effects; however if equipment travel is confined to the PPA, no direct or indirect impacts, and therefore no cumulative impacts, are expected from the proposed action.

5.2.3. 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 18.3 acres of potential migratory bird habitat in the form of Great Basin Desert scrub. During Phase I, noise and surface disturbance will be low during pedestrian survey activity. Direct and indirect effects are expected to be short term and negligible. For Phase II, the total surface disturbance is unknown at this point; however equipment movement would be confined to only a few temporary travel corridors. Within the travel corridors, vegetation and surface soil would sustain some disturbance but would not be bladed or bulldozed. Possible direct impacts would be short term and are more likely if surface disturbing activities occur during the breeding season (April 1 through August 31). 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 20 miles of the PPA.

Navajo Endangered Species List (NESL) and Species of Concern

Four (4) NESL and Navajo species of concern have 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 and nesting habitat for the following: golden eagle and ferruginous hawk. Potential habitat for burrowing owl and banner tailed kangaroo rat is located approximately 400 feet northwest of the PPA boundary.

Potential effects to these 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 on these species; however, with the implementation of recommendations discussed in Section 7 below, it is unlikely that the proposed action would result in detriment to the four (4) NESL and Navajo species of concern.

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 Date
Wildlife Biologist
Adkins Consulting
505.787.4088

8.3. References

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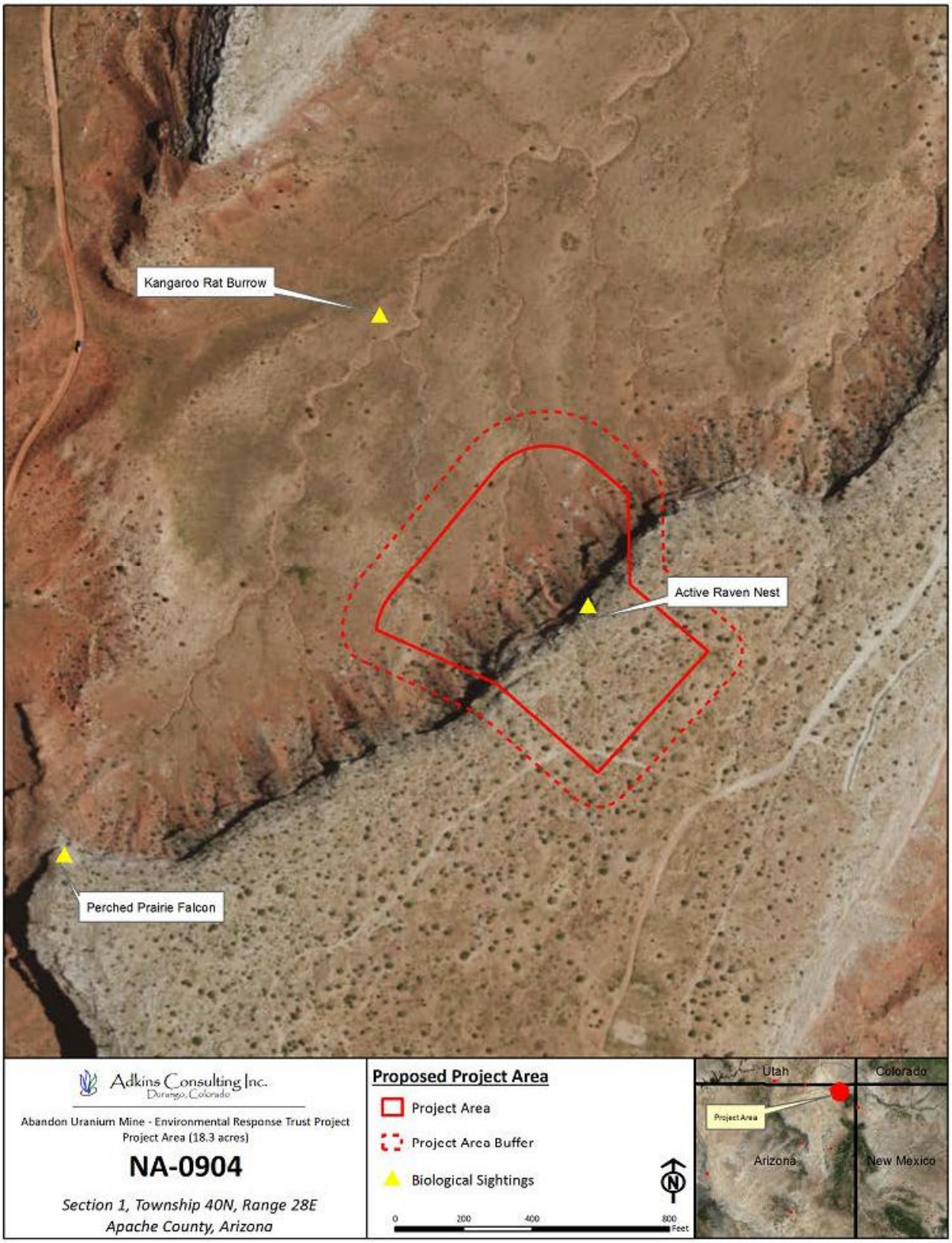
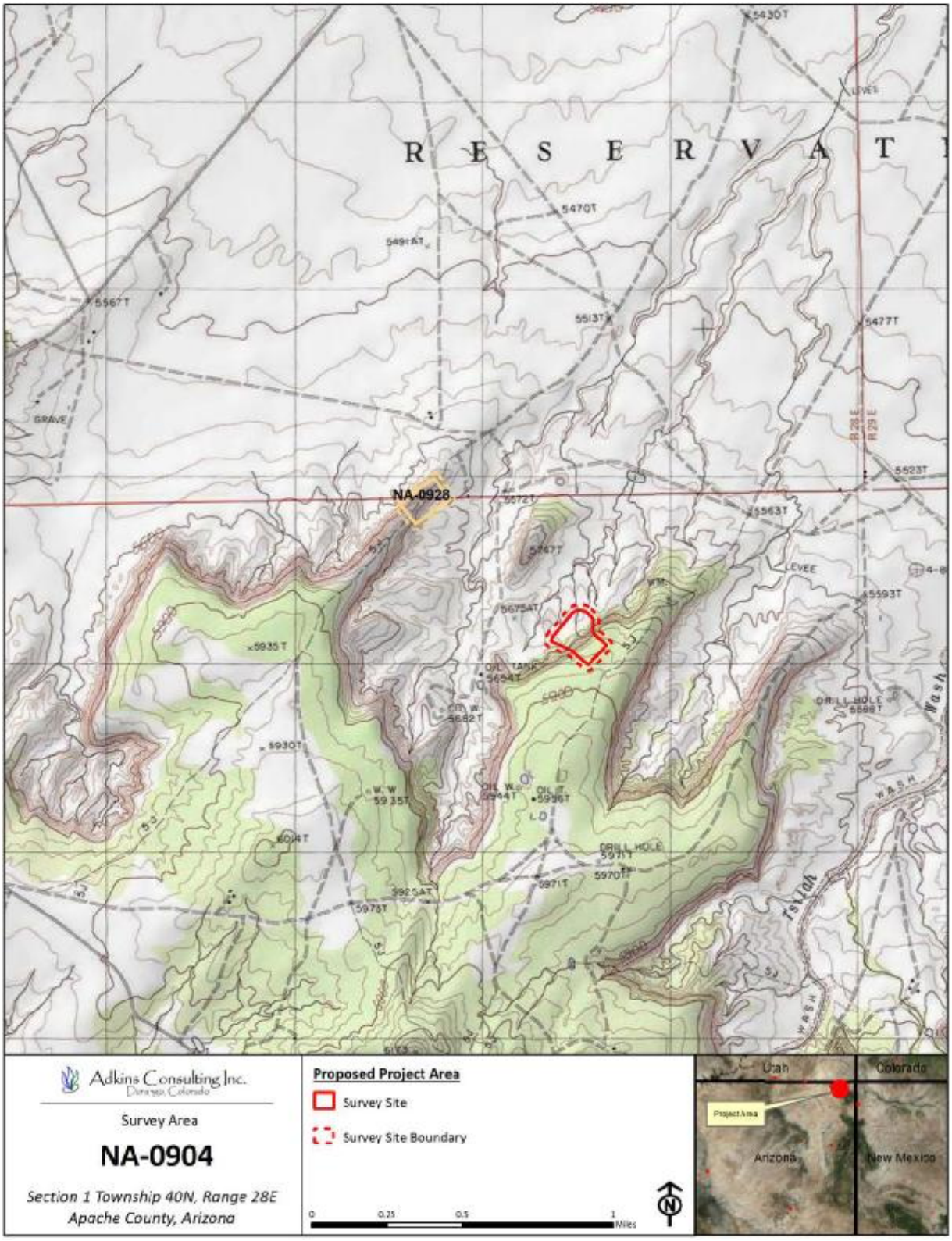
APPENDIX A. MAPS




Kangaroo Rat Burrow
Active Raven Nest
Perched Prairie Falcon
Adkins Consulting Inc.
Durango, Colorado
Abandon Uranium Mine - Environmental Response Trust Project
Project Area (18.3 acres)
NA-0904
Section 1, Township 40N, Range 28E
Apache County, Arizona
Proposed Project Area
Project Area
Project Area Buffer
Biological Sightings
N
0
200
400
800
Feet
Utah
Colorado
Project Area
Arizona
New Mexico



Adkins Consulting Inc.
Durango, Colorado

Survey Area

NA-0904

Section 1 Township 40N, Range 28E
Apache County, Arizona

Proposed Project Area

Survey Site

Survey Site Boundary

0 0.25 0.5 1 Miles

N

APPENDIX B. PHOTOGRAPHS



Looking north from west side of PPA



East facing cliff



Top of mesa looking south



Looking west from bottom of east side of PPA



Looking south from the northeast portion of the PPA



Kangaroo rat mound



Kangaroo rat mound





Perched prairie falcon



Raven nest

APPENDIX C. REDENTE PLANT SURVEY REPORT

Navajo Nation AUM Environmental Response Trust



Plant Survey Report for Species of Concern At NA-0904 Project Site Apache County, Arizona August 2016

Prepared by:
Redente Ecological Consultants
1322 Alene Circle
Fort Collins, CO 80525

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INTRODUCTION

Purpose of Report

A biological survey was conducted at the NA-0904 site as part of the Navajo Nation AUM Environmental Response Trust Project. The purpose of the survey is to determine if plant species of concern are present within the claim boundary and extending 100 feet around the site. Biological clearance is required at each site prior to any site investigation to determine if the project may affect potential species-of-concern or potential federal threatened and endangered (T&Es) species and/or critical habitat.

Site Location

NA-0904 is located in Apache County Arizona, approximately 130 km (81 miles) west of Farmington, New Mexico at an elevation of approximately 1,789 m (5,869 ft). Global Positioning System coordinates are 36º 54' 04" N by 109º 17' 05" W (North American Datum of 1983). The site is located on Tribal Trust Land (TTL).

Environmental Setting

Climate

The climate of the NA-0904 site is classified as semi-arid, with an average annual precipitation of 216 mm (8.5 in) with the greatest precipitation months occurring in July and August. Average annual temperature is 13.3º C (56º F).

Soils

The U.S. Department of Agriculture (USDA) Soil Survey for Apache County was published in 2011 in cooperation with the Bureau of Indian Affairs and the Navajo Nation. This area of Apache County is mainly escarpments separated by terraces and riverwashes, with slopes that range from 15 to 65%. The general mapping unit for the area is most likely Rock Outcrop-Shinume Complex and the soil type is Shinume; an eolian soil derived from sandstone (USDA 2011). Typical features include exposures of steep bedrock and cliffs with small exposures of flat or rolling bedrock, typically barren but may have sparse vegetation growing in cracks and crevices or in thin layers of eolian, alluvial, or colluvial material.

Plant Community Type

The vegetation on the NA-0904 site is part of the Colorado Plateau Shrub-Grassland type (USDA 2011). The most common species on the site include broom snakeweed (*Gutierrizia sarathrae*), cliffrose (*Purshia stansburiana*), rubber rabbitbrush (*Ericameria nauseosa*), Utah serviceberry (*Amelanchier utahensis*), shadscale saltbush (Atriplex confertifolia), yucca (*Yucca baileyi*), Mormon tea (*Ephedra viridis*), (blue grama (*Bouteloua gracilis*), spike dropseed (*Sporobolus contractus*), galleta (*Pleuraphis jamesii*), and Indian ricegrass (*Achnatherum hymenoides*).

Land Use

The land type on the NA-0904 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 one endangered plant species that may occur in the project area—Parish's alkaligrass (*Puccinellia parishii*). The USFWS listed Zuni fleabane (*Erigeron rhizomatus*) as an additional 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 of 2016 during the appropriate season to observe the phenological characteristics of the special status plant species that were necessary for identification.

The botanical survey team was assisted during the survey by GIS trained staff from MWH with training specifically in the use of the Trimble GeoExplorer 6000 Series. 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 alkali seeps for *Puccinellia parishii* and fine-textured clay hillsides for *Erigeron rhizomatus.* 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 2 plant species of concern were identified as potentially occurring within the proximity of the project area. These species included *Puccinellia parishii and Erigeron rhizomatus*. *Puccinellia parishii* is a native annual grass that grows in a series of widely disjunct populations ranging from southern California to eastern Arizona and western New Mexico in alkaline seeps, springs and seasonally wet areas and washes at elevations between 1,525 and 2,195 m (5,003 and 7,201 ft). *Erigeron rhizomatus* is a native perennial forb found in Apache County. It is found growing on fine textured clay hillsides primarily in Pinyon-Juniper type. It occurs at elevation ranges between 2,135 and 2,530 m (7,005 and 8,301 ft).

The survey at NA-0904 on May 7, 2016 did not identify any of the two species that have been listed as potential species of concern for this site. There was appropriate habitat at NA-0904 for *Puccinellia parishii*, in that seasonally wet areas and washes were identified

but there was no evidence of alkalinity on the soil surface from salt accumulation. Habitat at NA-0904 may not be appropriate for the occurrence of *Erigeron rhizomatus* because the primary plant community type of Pinyon-Juniper occurs outside of the NA-0904 site.



Photo #1—Overview of general landscape and plant community at NA-0904.



Photo #2—Overview of general landscape and plant community at NA-0904.

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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.ndfw.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.ndfw.org/sp_account.htm).

Potential Species lists species that are potentially within proximity to the project area and need to be evaluated for presence/absence. If no species are found within the Known or Potential Species lists, the project is not expected to affect any federally listed species, nor significantly impact any tribally listed species or other species of concern. Potential for species has been determined primarily on habitat characteristics and species range information. A thorough habitat analysis, and if necessary, species specific surveys, are required to determine the potential for each species.

Species of concern include protected, candidate, and other rare or otherwise sensitive species, including certain native species and species of economic or cultural significance. For legally protected species, the following tribal and federal statuses are indicated: NESL, federal Endangered Species Act (ESA), Migratory

Bird Treaty Act (MBTA), and Eagle Protection Act (EPA). No legal protection is afforded species with only ESA candidate, NESL group 4 status, and species listed on the Sensitive Species List. Please be aware of these species during surveys and inform the NNDFW of observations. Reported observations of these species and documenting them in project planning and management is important for conservation and may contribute to ensuring they will not be up listed in the future.

In any and all correspondence with NNDFW or NNHP concerning this project please cite the Data Request Code associated with this document. It can be found in this report on the top right corner of the every page. Additionally please cite this code in any biological evaluation documents returned to our office.

1. Known Species *(NESL=Navajo Endangered Species List, FE=Federally Endangered, FT=Federally Threatened, FC=Federal Candidate)*

Species

AMPE = Amsonia peeblesii / Peebles' Blue-star NESL G4
AQCH = Aquila chrysaetos / Golden Eagle NESL G3
CASP = Carex specuicola / Navajo Sedge NESL G3 FT
LIPI = Lithobates pipiens / Northern Leopard Frog NESL G2
PEAMCI = Perognathus amplus cineris / Wupatki Pocket Mouse NESL G4
PUPA = Puccinellia parishii / Parish's Alkali Grass NESL G4

**All or parts of this project currently are within areas protected by the Golden and Bald Eagle Nest Protection Regulations; consult with NNDFW zoologist or EA Reviewer for more information and recommendations.

2. Potential Species

Species

ALGO = Allium gooddingii / Gooding's Onion NESL G3
AMPE = Amsonia peeblesii / Peebles' Blue-star NESL G4
AQCH = Aquila chrysaetos / Golden Eagle NESL G3
ASBE = Astragalus beathii / Beath Milk-vetch NESL G4
ASNA = Astragalus naturitensis / Naturita Milk-vetch NESL G3
ASWE = Asclepias welshii / Welsh's Milkweed NESL G3 FT
ATCU = Athene cunicularia / Burrowing Owl NESL G4
BURE = Buteo regalis / Ferruginous Hawk NESL G3
CASP = Carex specuicola / Navajo Sedge NESL G3 FT
CHMO = Charadrius montanus / Mountain Plover NESL G4
CIME = Cinclus mexicanus / American Dipper NESL G3
CIRY = Cirsium rydbergii / Rydberg's Thistle NESL G4
CYUT = Cystopteris utahensis / Utah Bladder-fern NESL G4
EMTREX = Empidonax traillii extimus / Southwestern Willow Flycatcher NESL G2 FE
ERAC = Erigeron acomanus / Acoma Fleabane NESL G3
ERRH = Erigeron rhizomatus / Rhizome Fleabane/zuni Fleabane NESL G2 FT
ERRO = Errazurizia rotundata / Round Dunebroom NESL G3
ERSI = Erigeron sivinskii / Sivinski's Fleabane NESL G4
FAPE = Falco peregrinus / Peregrine Falcon NESL G4
GIRO = Gila robusta / Roundtail Chub NESL G2
LENA = Lesquerella navajoensis / Navajo Bladderpod NESL G3
LIPI = Lithobates pipiens / Northern Leopard Frog NESL G2
MUNI = Mustela nigripes / Black-footed Ferret NESL G2 FE

PEAMCI = Perognathus amplus cineris / Wupatki Pocket Mouse NESL G4
PLZO = Platanthera zothecina / Alcove Bog-orchid NESL G3
PRSP = Primula specuicola / Cave Primrose NESL G4
PTLU = Ptchocheilus lucius / Colorado Pikeminnow NESL G2
PUPA = Puccinellia parishii / Parish's Alkali Grass NESL G4
SAPAER = Salvia pachyphylla ssp eremopictus / Arizona Rose Sage NESL G4
STOCLU = Strix occidentalis lucida / Mexican Spotted Owl NESL G3 FT
VUMA = Vulpes macrotis / Kit Fox NESL G4
ZIVA = Zigadenus vaginatus / Alcove Death Camass NESL G3

3. Quadrangles (7.5 Minute)

Quadrangles

Cameron SE (35111-G3) / AZ
Dalton Pass (35108-F3) / NM
Del Muerto (36109-B4) / AZ
Dos Lomas (35107-C7) / NM
Gallup East (35108-E6) / NM
Garnet Ridge (36109-H7) / AZ, UT
Horse Mesa (36109-F1) / AZ, NM
Indian Wells (35110-D1) / AZ
Mexican Hat SE (37109-A7) / UT, AZ
Oljeto (37110-A3) / UT, AZ
Toh Atin Mesa East (36109-H3) / AZ, UT
Toh Atin Mesa West (36109-H4) / AZ, UT

4. Project Summary *(EO1 Mile/EO 3 Miles=elements occuring within 1 & 3 miles., MSO=mexican spotted owl PACs, POTS=potential species, RCP=Biological Areas)*

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
Alongo Mines	None	AQCH	Horse Mesa (36109-F1) / AZ, NM	None	LIPI, FAPE, EMTREX, CHMO, BURE, ATCU, AQCH, ZIVA, PUPA, PLZO, CIRY, CASP	Area 3
Barton 3	None	None	Toh Atin Mesa West (36109-H4) / AZ, UT	None	PTLU, GIRO, EMTREX, CHMO, BURE, ATCU, AQCH, ZIVA, PLZO, CIRY, CASP	Area 3
Boyd Tisi No. 2 Western	None	AMPE, PEAMCI, LIPI	Cameron SE (35111-G3) / AZ	None	LIPI, PEAMCI, FAPE, EMTREX, BURE, AQCH, ERRO, ASBE, AMPE	Area 3
Charles Keith	None	None	Oljeto (37110-A3) / UT, AZ	None	LIPI, FAPE, EMTREX, CHMO, BURE, AQCH	Area 1, Area 3

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
Eunice Becenti	None	None	Gallup East (35108-E6) / NM	None	FAPE, EMTREX, ATCU, AQCH, LENA, ERSI, ERRH, ERAC	Area 3
Harvey Blackwater No. 3	AQCH	AQCH, PUPA	Garnet Ridge (36109-H7) / AZ, UT	None	VUMA, LIPI, FAPE, EMTREX, CIME, BURE, ATCU, AQCH, ZIVA, PUPA, PRSP, PLZO, CIRY, CASP, ASWE	Area 3
Harvey Blackwater No. 3	AQCH	AQCH, PUPA	Mexican Hat SE (37109-A7) / UT, AZ	None	VUMA, FAPE, EMTREX, ATCU, AQCH, ZIVA, PLZO, CIRY, CASP, ASWE	Area 1
Hoskie Tso No. 1	AQCH	AQCH	Indian Wells (35110-D1) / AZ	None	FAPE, CHMO, BURE, ATCU, AQCH, SAPAER	Area 3
Mitten No. 3	None	AQCH	Oljeto (37110-A3) / UT, AZ	None	LIPI, FAPE, EMTREX, CHMO, BURE, AQCH	Area 3
NA-0904	None	AQCH	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, ATCU, AQCH, PUPA	Area 3
NA-0928	None	None	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, ATCU, AQCH, PUPA	Area 3
Oak124, Oak125	AQCH	AQCH	Horse Mesa (36109-F1) / AZ, NM	None	LIPI, FAPE, EMTREX, CHMO, BURE, AQCH, ZIVA, PUPA, PLZO, CIRY, CASP	Area 3
Occurrence B	None	AQCH, CASP	Del Muerto (36109-B4) / AZ	None	LIPI, FAPE, EMTREX, CIME, AQCH, ZIVA, PLZO, CYUT, CIRY, CASP, ALGO	Area 3
Section 26 (Desiddero Group)	None	None	Dos Lomas (35107-C7) / NM	None	FAPE, CHMO, ATCU, AQCH	Area 3
Standing Rock	None	None	Dalton Pass (35108-F3) / NM	None	VUMA, MUNI, FAPE, CHMO, BURE, ATCU, AQCH, ERSI, ASNA	Area 3

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
Tsosie 1	AQCH	AQCH	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, AQCH, PUPA	Area 1, Area 3

5. Conditional Criteria Notes *(Recent revisions made please read thoroughly. For certain species, and/or circumstances, please read and comply)*

A. **Biological Resource Land Use Clearance Policies and Procedures (RCP)** - The purpose of the RCP is to assist the Navajo Nation government and chapters ensure compliance with federal and Navajo laws which protect, wildlife resources, including plants, and their habitat resulting in an expedited land use clearance process. After years of research and study, the NNDFW has identified and mapped wildlife habitat and sensitive areas that cover the entire Navajo Nation.
The following is a brief summary of six (6) wildlife areas:
1.***Highly Sensitive Area*** – recommended no development with few exceptions.
2.***Moderately Sensitive Area*** – moderate restrictions on development to avoid sensitive species/habitats.
3.***Less Sensitive Area*** – fewest restrictions on development.
4.***Community Development Area*** – areas in and around towns with few or no restrictions on development.
5.***Biological Preserve*** – no development unless compatible with the purpose of this area.
6.***Recreation Area*** – no development unless compatible with the purpose of this area.
None - outside the boundaries of the Navajo Nation
This is not intended to be a full description of the RCP please refer to the our website for additional information at http://www.nndfw.org/clup.htm.

B. **Raptors** – If raptors are known to occur within 1 mile of project location: Contact Chad Smith at 871-7070 regarding your evaluation of potential impacts and mitigation.
o **Golden and Bald Eagles**- If Golden or Bald Eagle are known to occur within 1 mile of the project, decision makers need to ensure that they are not in violation of the Golden and Bald Eagle Nest Protection Regulations found at http://nnhp.nndfw.org/docs_reps/gben.pdf.
o **Ferruginous Hawks** – Refer to "Navajo Nation Department of Fish and Wildlife's Ferruginous Hawk Management Guidelines for Nest Protection" http://nnhp.nndfw.org/docs_reps.htm for relevant information on avoiding impacts to Ferruginous Hawks within 1 mile of project location.
o **Mexican Spotted Owl** - Please refer to the Navajo Nation Mexican Spotted Owl Management Plan http://nnhp.nndfw.org/docs_reps.htm for relevant information on proper project planning near/within spotted owl protected activity centers and habitat.

C. **Surveys** – Biological surveys need to be conducted during the appropriate season to ensure they are complete and accurate please refer to NN Species Accounts http://nnhp.nndfw.org/sp_account.htm. Surveyors on the Navajo Nation must be permitted by the Director, NNDFW. Contact Jeff Cole at (928) 871-7068 for permitting procedures. Questions pertaining to surveys should be directed to the NNDFW Zoologist (Chad Smith) for animals at 871-7070, and Botanist (Andrea Hazelton) for plants at (928)523-3221. Questions regarding biological evaluation should be directed to Jeff Cole at 871-7068.

D. **Oil/Gas Lease Sales** – Any settling or evaporation pits that could hold contaminants should be lined and covered. Covering pits, with a net or other material, will deter waterfowl and other migratory bird use. Lining pits will protect ground water quality.

E. **Power line Projects** – These projects need to ensure that they do not violate the regulations set forth in the Navajo Nation Raptor Electrocution Prevention Regulations found at http://nnhp.nndfw.org/docs_reps/repr.pdf.

F. **Guy Wires** – Does the project design include guy wires for structural support? If so, and if bird species may occur in relatively high concentrations in the project area, then guy wires should be equipped with highly visual markers to reduce the potential mortality due to bird-guy wire collisions. Examples of visual markers include aviation balls and bird flight diverters. Birds can be expected to occur in relatively high concentrations along migration routes (e.g., rivers, ridges or other distinctive linear topographic features) or where important habitat for breeding, feeding, roosting, etc. occurs. The U.S. Fish and Wildlife Service recommends marking guy wires with at least one marker per 100 meters of wire.

G. **San Juan River** – On 21 March 1994 (Federal Register, Vol. 59, No. 54), the U.S. Fish and Wildlife Service designated portions of the San Juan River (SJR) as critical habitat for Ptychocheilus lucius (Colorado pikeminnow) and Xyrauchen texanus (Razorback sucker). Colorado pikeminnow critical habitat includes the SJR and its 100-year floodplain from the State Route 371 Bridge in T29N, R13W, sec. 17 (New Mexico Meridian) to Neskahai Canyon in the San Juan arm of Lake Powell in T41S, R11E, sec. 26 (Salt Lake Meridian) up to the full pool elevation. Razorback sucker critical habitat includes the SJR and its 100-year floodplain from the Hogback Diversion in T29N, R16W, sec. 9 (New Mexico Meridian) to the full pool elevation at the mouth of Neskahai Canyon on the San Juan arm of Lake Powell in T41S, R11E, sec. 26 (Salt Lake Meridian). All actions carried out, funded or authorized by a federal agency which may alter the constituent elements of critical habitat must undergo section 7 consultation under the Endangered Species Act of 1973, as amended. Constituent elements are those physical and biological attributes essential to a species conservation and include, but are not limited to, water, physical habitat, and biological environment as required for each particular life stage of a species.

H. **Little Colorado River** - On 21 March 1994 (Federal Register, Vol. 59, No. 54) the U.S. Fish and Wildlife Service designated Critical Habitat along portions of the Colorado and Little Colorado Rivers (LCR) for Gila cypha (humpback chub). Within or adjacent to the Navajo Nation this critical habitat includes the LCR and its 100-year floodplain from river mile 8 in T32N R6E, sec. 12 (Salt and Gila River Meridian) to its confluence with the Colorado River in T32N R5E sec. 1 (S&GRM) and the Colorado River and 100-year floodplain from Nautuloid Canyon (River Mile 34) T36N R5E sec. 35 (S&GRM) to its confluence with the LCR. All actions carried out, funded or authorized by a federal agency which may alter the constituent elements of Critical Habitat must undergo section 7 consultation under the Endangered Species Act of 1973, as amended. Constituent elements are those physical and biological attributes essential to a species conservation and include, but are not limited to, water, physical habitat, and biological environment as required for each particular life stage of a species.

I. **Wetlands** – In Arizona and New Mexico, potential impacts to wetlands should also be evaluated. The U.S. Fish & Wildlife Service's National Wetlands Inventory (NWI) maps should be examined to determine whether areas classified as wetlands are located close enough to the project site(s) to be impacted. In cases where the maps are inconclusive (e.g., due to their small scale), field surveys must be completed. For field surveys, wetlands identification and delineation methodology contained in the "Corps of Engineers Wetlands Delineation Manual" (Technical Report Y-87-1) should be used. When wetlands are present, potential impacts must be addressed in an environmental assessment and the Army Corps of Engineers, Phoenix office, must be contacted. NWI maps are available for examination at the Navajo Natural Heritage Program (NNHP) office, or may be purchased through the U.S. Geological Survey (order forms are available through the NNHP). The NNHP has complete coverage of the Navajo Nation, excluding Utah, at 1:100,000 scale; and coverage at 1:24,000 scale in the southwestern portion of the Navajo Nation. In Utah, the U.S. Fish & Wildlife Service's National Wetlands Inventory maps are not yet available for the Utah portion of the Navajo Nation, therefore, field surveys should be completed to determine whether wetlands are located close enough to the project site(s) to be impacted. For field surveys, wetlands identification and delineation methodology contained in the "Corps of Engineers Wetlands Delineation Manual" (Technical Report Y-87-1) should be used. When wetlands are present, potential impacts must be addressed in an environmental assessment and the Army Corps of Engineers, Phoenix office, must be contacted. For more information contact the Navajo Environmental Protection Agency's Water Quality Program.

J. **Life Length of Data Request** – The information in this report was identified by the NNHP and NNDFW's biologists and computerized database, and is based on data available at the time of this response. If project planning takes more than two (02) years from the date of this response, verification of the information provided herein is necessary. It should not be regarded as the final statement on the occurrence of any species, nor should it substitute for on-site surveys. Also, because the NNDFW information is continually updated, any given information response is only wholly appropriate for its respective request.

K. **Ground Water Pumping** - Projects involving the ground water pumping for mining operations, agricultural projects or commercial wells (including municipal wells) will have to provide an analysis on the effects to surface water and address potential impacts on all aquatic and/or wetlands species listed below. NESL Species potentially impacted by ground water pumping: Carex specuicola (Navajo Sedge), Cirsium rydbergii (Rydberg's Thistle), Primula specuicola (Cave Primrose), Platanthera zothecina (Alcove Bog Orchid), Puccinellia parishii (Parish Alkali Grass), Zigadenus vaginatus (Alcove Death Camas), Perityle specuicola (Alcove Rock Daisy), Symphyotrichum welshii (Welsh's American-aster), Coccyzus americanus (Yellow-billed Cuckoo), Empidonax traillii extimus (Southwestern Willow Flycatcher), Rana pipiens (Northern Leopard Frog), Gila cypha (Humpback Chub), Gila robusta (Roundtail Chub), Ptychocheilus lucius (Colorado Pikeminnow), Xyrauchen texanus (Razorback Sucker), Cinclus mexicanus (American Dipper), Speyeria nokomis (Western Seep Fritillary), Aechmophorus clarkia (Clark's Grebe), Ceryle alcyon (Belted Kingfisher), Dendroica petechia (Yellow Warbler), Porzana carolina (Sora), Catostomus discobolus (Bluehead Sucker), Cottus bairdi (Mottled Sculpin), Oxyloma kanabense (Kanab Ambersnail)

6. Personnel Contacts

Wildlife Manager
Sam Diswood
928.871.7062
sdiswood@nndfw.org

Zoologist
Chad Smith
928.871.7070
csmith@nndfw.org

Botanist
Vacant

Biological Reviewer
Pamela Kyselka
928.871.7065
pkyselka@nndfw.org

GIS Supervisor
Dexter D Prall
928.645.2898
prall@nndfw.org

Wildlife Tech
Sonja Detsoi
928.871.6472
sdetsoi@nndfw.org

7. Resources

National Environmental Policy Act

Navajo Endangered Species List:
http://nnhp.nndfw.org/endangered.htm

Species Accounts:
http://nnhp.nndfw.org/sp_account.htm

Biological Investigation Permit Application
http://nnhp.nndfw.org/study_permit.htm

Navajo Nation Sensitive Species List
http://nnhp.nndfw.org/study_permit.htm

Various Species Management and/or Document and Reports
http://nnhp.nndfw.org/docs_reps.htm

Consultant List
(Coming Soon)

Dexter D Prall, GIS Supervisor - Natural Heritage Program
Navajo Nation Department of Fish and Wildlife

MWH

BUILDING A BETTER WORLD

November 18, 2015

TO: Navajo Natural Heritage Program
Navajo Nation Dept. of Fish and Wildlife
ATTN: Sonja Detsoi and Dexter Prall
P.O. Box 1480
Window Rock, AZ 86515

FROM: MWH Americas
ATTN: Eileen Dornfest, Project Manager
3665 John F Kennedy Parkway
Bldg 1, Suite 206
Ft. Collins, CO 80525
Phone: (970) 377-9410
Fax: (970) 377-9406
E-mail: Eileen.Dornfest@mwhglobal.com

SUBJECT: Request for T and E Information for 16 Abandoned Uranium Mine (AUM) Sites

PROJECT NAME:
Navajo Nation AUM Environmental Response Trust (ERT) Project

LOCATION:
16 AUM Sites (attached in GIS shape files and USGS topographic maps)

SUMMARY DESCRIPTION OF PROJECT:
The work is to be conducted at 16 Abandoned Uranium Mines (AUMs) and includes Removal Site Evaluations (RSEs) according to CERCLA at each of the Sites. The RSEs are site investigations that include the following activities:

- conducting background soil studies
- conducting gamma radiation scans of surface soils
- sampling surface and subsurface soils and sediments related to historic mining operations
- assessing radiation exposure inside mine operations buildings, homes, or other nearby structures (if present at the Sites)
- sampling existing and accessible groundwater wells
- mitigating physical hazards and other interim response actions
- preparing a final written report documenting the work performed and information obtained for each of the Sites

MWH

BUILDING A BETTER WORLD

TOPOGRAPHIC MAPS ATTACHED:

- Blue Gap Quadrangle, Arizona-Apache Co.
- Cameron SE Quadrangle, Arizona-Coconino Co.
- Cameron South Quadrangle, Arizona-Coconino Co.
- Del Muerto Quadrangel, Arizona-Apache Co.
- Five Buttes Quadrangle, Arizona-Navajo Co.
- Garnet Ridge Quadrangle, Arizona-Utah
- Horse Mesa Quadrangle, Arizona-New Mexico
- Indian Wells Quadrangle, Arizona-Navajo Co.
- Tah Chee Wash Quadrangle, Arizona-Apache Co.
- Toh Atin Mesa East Quadrangle, Arizona-Utah
- Toh Atin Mesa West Quadrangle, Arizona-Utah
- Bluewater Quadrangle, New Mexico
- Bread Springs Quadrangle, New Mexico-McKinley Co.
- Dalton Pass Quadrangle, New Mexico-McKinley Co.
- Dos Lomas Quadrangle, New Mexico
- Gallup East Quadrangle, New Mexico-McKinley Co.
- Sand Spring Quadrangle, New Mexico-San Juan Co.
- Standing Rock Quadrangle, New Mexico-McKinley Co.
- Mexican Hat SE Quadrangle, Utah-San Juan Co.
- Oljato Quadrangle, Utah-San Juan Co.

3665 John F Kennedy Pkwy.
Bldg 1, Suite 206
Ft. Collins, CO 80525

TEL 970 377 9410
FAX 970 377 9406
www.mwhglobal.com

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:___NA-0904_____

DATE: ____04/08/2016_____

WEATHER: _____Cloudy, light rain, winds 5 – 10 mph, mid 50's_____

PERSONELL ONSITE: __Arnold Clifford (Principal Biologist), Sarah McCloskey (Field Assistant)_____

_____

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CONTRACTORS ONSITE NOTES:

The eastern portion of the site is located on top of a mesa, the terrain is rocky within sagebrush / scrub land vegetation communities with scattered pinon juniper. The western portion of the site continues down a steep sandstone cliff face to a flat sagebrush valley with sandy soils and shallow ephemeral streams. The sandstone cliffs within and surrounding the site provide potential habitat for Peregrine Falcons and possibly Golden Eagles. The western portion of the site within the flat sagebrush valley provides potential habitat for both burrowing owls and banner tailed kangaroo rats. Site will require further 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: NA-0904

DATE: 4/18/16

WEATHER: Partly cloudy, calm, temps mid 50's

PERSONNEL ONSITE: Sarah McCloskey (Principal Biologist), Sarah Cowley (Field Assistant)

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CONTRACTORS ONSITE NOTES:

Background: During the previous habitat assessment survey, habitat was documented for Golden Eagles, Peregrine Falcons, and Burrowing Owls.

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:

Golden Eagle – A single pedestrian survey with high-power optics for nest sites or breeding adults from 1 MAR-15 JUN.

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 and Golden Eagle. Surveyors arrived at the project site at 4:20 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 continuing father down the canyon until dark. Surveyors left the site at 8:25 p.m.

Additional Information: This concludes the required surveys for the Golden Eagle at the NA-0904 site. Surveyors will revisit site tomorrow (4/19/16) to complete the morning portion of the Peregrine Falcon survey.

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: NA-0904

DATE: 4/19/16

WEATHER: Partly cloudy, calm, temps mid 40's to high 40's

PERSONNEL ONSITE: Arnold Clifford (Principal Biologist), Sarah McCloskey (Field Assistant), Sarah Cowley (Field Assistant)

==========

CONTRACTORS ONSITE NOTES:

Background: During the previous habitat assessment survey, habitat was documented for Golden Eagles, Peregrine Falcons and Burrowing Owls. Surveys were completed for Golden Eagle last night (4/18/16). The evening portion of the first Peregrine Falcon survey was also completed the last night.

Purpose: To perform the morning portion of the first Peregrine Falcon survey per 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 project site at 6:25 a.m. at first light 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 continuing father down the canyon until the 4 hour survey time limit expired. Surveyors left the site at 10:30 a.m.

THE NAVAJO NATION
HISTORIC PRESERVATION DEPARTMENT
PO Box 4950, Window Rock, Arizona 86515
TEL: (928) 871-7198 FAX: (928) 871-7886

CULTURAL RESOURCE COMPLIANCE FORM

ROUTE COPIES TO:	NNHPD NO.: HPD-16-588
☑ DCRM	OTHER PROJECT NO.: DCRM 2016-06

PROJECT TITLE: A Cultural Resource Inventory of Eight Abandoned Uranium Mines (Northern Region) for MWH Americas, Inc. in the Western and Shiprock Agencies of the Navajo Nation, in Utah, Arizona, and New Mexico.

LEAD AGENCY: BIA/NR

SPONSOR: Sadie Hoskie, Trustee, Navajo National AUM, Environmental Response Trust, P.O. Box 3330, Window Rock, AZ 86515

PROJECT DESCRIPTION: The proposed undertaking will involve proposing to complete Removal Site Evaluations to define the horizontal extent of contamination in surface soils and sediments at the eight former uranium mine areas. The proposed undertaking may involve intensive ground disturbance with the use of heavy equipment and hand tools. The area of potential effect is 54.4-acres.

LAND STATUS:	Navajo Tribal Trust												
CHAPTER:	Oljato, Dennehotso, Mexican Water, Sweetwater, and Red Valley												
LOCATION:	*T.*	43	*S.,*	*R.*	24&14	*E-*	*Sec.*	14&24;	Oljato	Quadrangle,	San Juan	County	UT	SLPM
	T.	43	*S.,*	*R.*	14	*E-*	*Sec.*	13;	Oljato	Quadrangle,	San Juan	County	UT	SLPM
	T.	43	*S.,*	*R.*	19&23	*E-*	*Sec.*	UP;	Garnet Ridge	Quadrangle,	Apache	County	AZ	G&SRPM
	T.	43	*N.,*	*R.*	19	*E-*	*Sec.*	UP;	Mexican Hat	Quadrangle,	Apache	County	AZ	G&SRPM
	T.	41&40	*N.,*	*R.*	27, 28& 23	*E-*	*Sec.*	UP;	Toh Atin Mesa West	Quadrangle,	Apache	County	AZ	G&SRPM
	T	29	*N.,*	*R.*	21	*W-*	*Sec.*	UP;	Horse Mesa	Quadrangle,	San Juan	County	NM	NMPM

PROJECT ARCHAEOLOGIST:	Rena Martin
NAVAJO ANTIQUITIES PERMIT NO.:	B16728
DATE INSPECTED:	4/16/2016, 5/18/2016
DATE OF REPORT:	7/15/2016
TOTAL ACREAGE INSPECTED:	105.2 – ac
METHOD OF INVESTIGATION:	Class III pedestrian inventory with transects spaced 10 m apart.
LIST OF CULTURAL RESOURCES FOUND:	**(8) sites (UT-B-59-8, UT-C-63-12, AZ-I-5-25, AZ- I-7-72, AZ-I-6-79, NM-I-24-87, NM-I-24-88, NM-I-24-89) (1) In Use Area (23) Isolated Occurrences (IOs)**
LIST OF ELIGIBLE PROPERTIES:	**(8) sites (UT-B-59-8, UT-C-63-12, AZ-I-5-25, AZ-I-7-72, AZ-I-6-79, NM-I-24-87, NM-I-24-88, NM-I-24-89)**
LIST OF NON-ELIGIBLE PROPERTIES:	**(1) In Use Area, (23) IOs**
LIST OF ARCHAEOLOGICAL RESOURCES:	**(5) sites (UT-B-59-8, UT-C-63-12, AZ-I-7-72, AZ-I-6-79, NM-I-24-89)**

EFFECT/CONDITIONS OF COMPLIANCE: No historic properties affected with the following conditions:

Sites: UT-B-59-8, UT-C-63-12, AZ-I-5-25, AZ- I-7-72, AZ-I-6-79, NM-I-24-87, NM-I-24-89:
1. Prior to any construction, the site boundaries will be flagged and/or temporarily fenced under the direction of a qualified archaeologist & shown to the construction foreman.
2. All ground disturbance within the 50 ft. of the site boundaries will be monitored by a qualified archaeologist.
3. No construction, equipment or vehicular traffic will be allowed within the site boundaries.
4. A brief letter/report documenting the result of the monitoring will be submitted to NNHPD within 30 days of monitoring activities.
5. All future maintenance activities shall avoid the site by a minimum of 50 ft. from the site boundaries.

Site NM-I-24-88:
Given the environmental hazards the mine possesses, and the thorough extent of the ethnographic information, all research potential has been exhausted. No further work is warranted.

TCPs.
No effect by proposed undertaking.

In the event of a discovery [*"discovery"* means any previously unidentified or incorrectly identified cultural resources including but not limited to archaeological deposits, human remains, or locations reportedly associated with Native American religious/traditional beliefs or practices], all operations in the immediate vicinity of the discovery must cease, and the Navajo Nation Historic Preservation Department must be notified at (928) 871-7198.

FORM PREPARED BY: **Tamara Billie**
FINALIZED: September 9, 2016

Notification to Proceed Recommended ☑ Yes ☐ No
Conditions: ☑ Yes ☐ No

Tamara Billie 9/9/16
The Navajo Nation Historic Preservation Office — Date

Navajo Region Approval ☒ Yes ☐ No

SEP 2 8 2016
BIA Navajo Regional Office (Acting) — Date

11/7/16

NNDFW Review No. 15mwh101-na0904

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.: NA-0904 - 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 18.3 acres.

LOCATION: 36°53'60"N 109°17'60"W, Sweetwater Chapter, Apache County, Arizona

REPRESENTATIVE: Lori Gregory, Adkins Consulting, Inc. for MWH Global/Stantec

ACTION AGENCY: U.S. Environmental Protection Agency and Navajo Nation

B.R. REPORT TITLE / DATE / PREPARER: BE-NA-0904 Abandoned Uranium Mine Project/AUG 2016/Lori Gregory, Plant Survey Report for Species of Concern At NA-0904 Project Site/AUG 2016/Redente Ecological Consultants

SIGNIFICANT BIOLOGICAL RESOURCES FOUND: Area 3. Suitable nesting habitat is present in the project area for Migratory Birds not listed under the NESL or ESA. Migratory Birds and their habitats are protected under the Migratory Bird Treaty Act (16 USC §703-712) and Executive Order 13186. Under the EO, all federal agencies are required to consider management impacts to protect migratory non-game birds.

POTENTIAL IMPACTS

NESL SPECIES POTENTIALLY IMPACTED: NA

FEDERALLY-LISTED SPECIES AFFECTED: NA

OTHER SIGNIFICANT IMPACTS TO BIOLOGICAL RESOURCES: NA

AVOIDANCE / MITIGATION MEASURES: Mitigation measures will be implemented to ensure that there are no impacts to migratory birds that could potentially nest in the project area.

CONDITIONS OF COMPLIANCE*: NA

FORM PREPARED BY / DATE: Pamela A. Kyselka/17 NOV 2016

COPIES TO: (add categories as necessary)

☐ _____ ☐ _____

2 NTC § 164 Recommendation:	Signature	Date
☒Approval ☐Conditional Approval (with memo) ☐Disapproval (with memo) ☐Categorical Exclusion (with request letter) ☐None (with memo)	Gloria M. Tom, Director, Navajo Nation Department of Fish and Wildlife	11/18/16

*I understand and accept the conditions of compliance, and acknowledge that lack of signature may be grounds for the Department not recommending the above described project for approval to the Tribal Decision-maker.

Representative's signature Date

From:	Nystedt, John
To:	Justin Peterson
Cc:	Lori Gregory; Pam Kyselka; tbillie@navajo-nsn.gov; Harrilene Yazzie; Melissa Mata
Subject:	Navajo Nation AUM Environmental Response Trust - -First Phase
Date:	Monday, November 07, 2016 4:08:30 PM
Attachments:	image001.png

Justin,

Thank you for your November 6, 2016, email. This email documents our response regarding the subject project, in compliance with section 7 of the Endangered Species Act of 1973 (ESA) as amended (16 U.S.C. 1531 et seq.). Based on the information you provided, we believe no endangered or threatened species or critical habitat will be affected by this project; nor is this project likely to jeopardize the continued existence of any proposed species or adversely modify any proposed critical habitat. No further review is required for this project at this time. Should project plans change or if new information on the distribution of listed or proposed species becomes available, this determination may need to be reconsidered. In all future communication on this project, please refer to consultation numbers given below.

In keeping with our trust responsibilities to American Indian Tribes, by copy of this email, we will notify the Navajo Nation, which may be affected by the proposed action and encourage you to invite the Bureau of Indian Affairs to participate in the review of your proposed action.

Should you require further assistance or if you have any questions, please contact me as indicated below, or my supervisor, Brenda Smith, at 556-2157. Thank you for your continued efforts to conserve endangered species.

Claim 28	02EAAZ00-2016-SLI-0358
Section 26 (Desiddero Group)	02ENNM00-2016-SLI-0447
Mitten #3	06E23000-2016-SLI-0210
NA-0904	02EAAZ00-2016-SLI-0363
Occurrence B	02EAAZ00-2016-SLI-0361
Standing Rock	02ENNM00-2016-SLI-0448
Alongo Mines	02ENNM00-2016-SLI-0465
Tsosie 1*	02EAAZ00-2016-SLI-0364
Boyd Tisi No. 2 Western	02EAAZ00-2016-SLI-0355
Harvey Blackwater #3	02EAAZ00-2016-SLI-0356 / 06E23000-2016-SLI-0207
Oak 124/125	02ENNM00-2016-SLI-0466
NA-0928	02EAAZ00-2016-SLI-0360
Hoskie Tso #1	02EAAZ00-2016-SLI-0362
Charles Keith	06E23000-2016-SLI-0208
Barton 3	02EAAZ00-2016-SLI-0354
Eunice Becenti	02ENNM00-2016-SLI-0444

* It is our understanding that the Tsosie No. 1 site has been put on hold indefinitely due to access issues. However, provided the results of the survey were negative (i.e., no potential for

any ESA-listed species) then we would come to the same conclusion, above, as for the other 15 projects.

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Fish and Wildlife Biologist/AESO Tribal Coordinator
USFWS AZ Ecological Services Office - Flagstaff Suboffice
Southwest Forest Science Complex, 2500 S Pine Knoll Dr, Rm 232
Flagstaff, AZ 86001-6381 (928) 556-2160 Fax-2121 Cell:(602) 478-3797
http://www.fws.gov/southwest/es/arizona/

Appendix F Data Usability Report, Laboratory Analytical Data, and Data Validation Reports

F.1 Data Usability Report

F.2 Laboratory Analytical Data and Data Validation Reports

(provided in a separate electronic file due to its file size and length)

F.1 Data Usability Report

DATA USABILITY REPORT

1.0 INTRODUCTION

This data usability report presents a summary of the validation results for the sample data collected from the NA-0904 Site (the Site) as part of the Removal Site Evaluation (RSE) performed for the Navajo Nation AUM Environmental Response Trust—First Phase. The purpose of the validation was to ascertain the data usability measured against the data quality objectives (DQOs) and confirm that results obtained are scientifically defensible.

Samples were collected between October 5, 2016 and September 14, 2017 and were analyzed by ALS Environmental of Ft. Collins, Colorado, for all methods except mercury in water. ACZ Laboratories, Inc. of Steamboat Springs, Colorado, analyzed water samples for mercury. Samples were analyzed for one or more of the following:

- Radium-226 in soil by United States Environmental Protection Agency (USEPA) Method 901.1
- Metals in soil by USEPA Method SW6020
- Isotopic thorium in soil by USDOEAS-06/EMSL/LV
- Radium-226 in water by USEPA Method 903.1
- Radium-228 in water by USEPA Method 904
- Gross alpha/beta in water by USEPA Method 900
- Total and dissolved metals in water by USEPA 200.8
- Total dissolved solids in water by USEPA 160.1
- Alkalinity in water by USEPA 310.1
- Chloride and sulfate in water by USEPA 300.0
- Total and dissolved mercury in water by USEPA Method 1631

Samples were collected and analyzed according to the procedures and specific criteria presented in the *Quality Assurance Project Plan, Navajo Nation AUM Environmental Response Trust (QAPP)* (MWH, 2016).

Project data were validated as follows:

- Laboratory Data Consultants, Inc. (LDC) of Carlsbad, California, performed validation of all radiological soil and water data, plus ten percent of the non-radiological data (Level IV only)

- All non-radiological soil and water data were validated by the Stantec Consulting Services Inc. (Stantec; formerly MWH) Project Chemist (Level III only)
- All samples received Level III data validation
- Ten percent of the sample results for all methods received a more detailed Level IV validation

The analytical data were validated based on the results of the following data evaluation parameters or quality control (QC) samples:

- Compliance with the QAPP
- Sample preservation
- Sample extraction and analytical holding times
- Initial calibration (ICAL), initial calibration verification (ICV), and continuing calibration verification (CCV) results
- Method and initial/continuing calibration blank (ICB/CCB) sample results
- Matrix spike/matrix spike duplicate (MS/MSD) sample results
- Laboratory duplicate results
- Serial dilution (metals analysis only)
- Interference check samples (ICS) (metals analysis only)
- Laboratory control sample (LCS) and laboratory control sample duplicate (LCSD) results
- Field duplicate sample results
- Minimum detectable concentration (radiological analyses only)
- Reporting limits
- Sample result verification
- Completeness evaluation
- Comparability evaluation

Sample results that were qualified due to quality control parameters outside of acceptance criteria are listed on Table F.1-1.

2.0 DATA VALIDATION RESULTS

Stantec reviewed the data validation reports and assessed the qualified data against the DQOs for the project. The following summarizes the data validation findings for each of the data evaluation parameters.

2.1 QUALITY ASSURANCE PROJECT PLAN COMPLIANCE EVALUATION

Based on the data validation, all samples were analyzed following the quality control criteria specified in the QAPP, with the following exception: ALS routinely dilutes all metals samples by a factor of 10 times in order to protect their ICP-MS instrument from the adverse effects of running samples with high total dissolved solids. This also includes running a long series of samples (as is common in a production laboratory) with intermediate dissolved solids. The vulnerable parts of the instrument are the nebulizer, which produces an aerosol, and the cones, which disperse the aerosol. These areas form scaly deposits from the samples in the sample solution, despite the nitric acid and other acids present in the digestate. These parts of the instrument periodically need to be taken apart and cleaned, but in a production setting the laboratory wants to avoid any downtime as much as possible. As an ameliorating factor, the laboratory also takes account of this dilution factor up front in the project planning stages. The laboratory will not quote a reporting limit for this instrument that cannot be achieved after the 10 times dilution required for the instrument. Not all of the requested reporting limits can be met using the laboratory's routine protocol. The dilution is narrated by the laboratory merely as a matter of transparency, as well as for the validator's information. The dilution should have no impact on the project's sensitivity goals.

Sample Preservation Evaluation. All samples were preserved as specified in the QAPP.

Holding Time Evaluation. All analytical holding times were met.

Initial Calibration, Initial Calibration Verification, and Continuing Calibration Verification Evaluation. All ICAL, ICV, and CCV results were within acceptance criteria.

Method Blank Evaluation. No sample data were qualified due to method blank results.

Initial and Continuing Calibration Blank Evaluation. No sample data were qualified due to ICB/CCB data.

Matrix Spike/Matrix Spike Duplicate Samples Evaluation. All MS/MSD recoveries were within acceptance criteria with the exception of several metals. Table F-1 lists the analytes where an MS and/or MSD percent recovery was outside the acceptance criteria. Sample results were qualified with a "J+" flag for results that are estimated and potentially biased high; sample results were qualified with a "J-" flag for results that are estimated and potentially biased low. Several

MS/MSD RPDs were outside acceptance criteria. The results were qualified with a "J" flag if not otherwise qualified.

Laboratory Duplicate Sample Evaluation. For some analyses, the laboratory prepared and analyzed a duplicate sample. RPD results were evaluated between the parent and laboratory duplicate samples. Several RPDs were outside acceptance criteria for the analysis of metals. Sample results were qualified as estimated with a "J" flag if not otherwise qualified.

Serial Dilution Evaluation. All serial dilution percent differences were within acceptance criteria except for one sample analyzed for uranium and one sample analyzed for vanadium. The sample results were qualified as estimated with a "J" flag if not otherwise qualified.

Interference Check Sample Evaluation. All interference check samples were within acceptance criteria.

Laboratory Control Sample/Laboratory Control Sample Duplicate Evaluation. All LCS and LCSD recoveries were within acceptance criteria. All LCS/LCSD RPDs were within acceptance criteria.

Field Duplicate Evaluation. The RPDs were less than the guidance RPD of 30 percent established in the QAPP for all field duplicate pairs, with the exception of results for nine metals. The primary cause for RPDs exceeding 30 percent for some duplicate pairs is assumed to be the heterogeneity/variability of soil samples. The sample IDs, sample results, and RPDs for those results that did not meet the guidance RPD are listed in Table F.1-2. Sample results were not qualified due to RPDs exceeding the guidance criteria, as described in the QAPP.

Minimum Detectable Concentration Evaluation. All minimum detectable concentrations met reporting limits with the exception of nine 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 fourteen 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 repor

Completeness. All media and QC sample results were valid and collected as scheduled; therefore, completeness for this RSE is 100 percent.

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

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

Table F.1-1
Summary of Qualified Data
NA-0904
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
S059-BG1-009	10/5/16	SW6020	Uranium	3.3	mg/kg	MS	141%	75% - 125%	J+	Result is estimated, potentially biased high.
						MSD	126%	75% - 125%		MS and MSD recoveries above acceptance criteria.
S059-BG1-002	10/5/16	SW6020	Uranium	9.3	mg/kg	MS	-109%	75% - 125%	J-	Result is estimated, potentially biased low.
						MSD	-12%	75% - 125%		MS and MSD recoveries below acceptance criteria. Serial dilution %D greater than control limit. LR RPD outside acceptance criteria.
						Serial Dilution	16%	10%		
						LR	28%	20%		
S059-BG1-002	10/5/16	SW6020	Arsenic	19	mg/kg	MSD	140%	75% - 125%	J+	Result is estimated, potentially biased high. MSD recovery above acceptance criteria.
S059-BG1-002	10/5/16	SW6020	Vanadium	12	mg/kg	Serial Dilution	20%	10%	J	Result is estimated, bias unknown. Serial dilution %D greater than control limit.
S059-BG1-001	10/5/16	E901.1	Radium-226	5.13	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S059-BG3-004	10/6/16	SW6020	Uranium	0.6	mg/kg	MS	155%	75% - 125%	J+	Result is estimated, potentially biased high. MS recovery above acceptance criteria. MS/MSD RPD outside acceptance criteria.
						MS/MSD RPD	25%	20%		
S059-BG3-004	10/6/16	SW6020	Arsenic	1.3	mg/kg	MS	134%	75% - 125%	J+	Result is estimated, potentially biased high. MS recovery above acceptance criteria. MS/MSD RPD outside acceptance criteria.
						MS/MSD RPD	23%	20%		
S059-BG3-004	10/6/16	SW6020	Vanadium	7.8	mg/kg	MS	158%	75% - 125%	J+	Result is estimated, potentially biased high. MS recovery above acceptance criteria. MS/MSD RPD outside acceptance criteria.
						MS/MSD RPD	25%	20%		
S059-BG3-210	10/6/16	E901.1	Radium-226	0.61	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S059-BG3-010	10/6/16	E901.1	Radium-226	0.79	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
LCS laboratory control sample
LR laboratory replicate (duplicate)
MS matrix spike
MSD matrix spike duplicate
RPD relative percent difference

Table F.1-1
Summary of Qualified Data
NA-0904
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
S059-SCX-009-1	4/12/17	SW6020	Molybdenum	180	mg/kg	LR	193%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S059-SCX-009-1	4/12/17	SW6020	Arsenic	27	mg/kg	MS MSD LR	-106% -120% 145%	75% - 125% 75% - 125% 20%	J-	Result is estimated, potentially biased low. MS and MSD recoveries below acceptance criteria. LR RPD outside acceptance criteria.
S059-SCX-009-1	4/12/17	SW6020	Vanadium	100	mg/kg	MS/MSD RPD LR	21% 31%	20% 20%	J	Result is estimated, bias unknown. MS/MSD RPD outside acceptance criteria. LR RPD outside acceptance criteria.
S059-SCX-009-1	4/12/17	SW6020	Uranium	20	mg/kg	LR	27%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S059-SCX-010-3	4/12/17	E901.1	Radium-226	5.3	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S059-SCX-016-3	4/13/17	SW6020	Arsenic	44	mg/kg	MS/MSD RPD LR	45% 43%	20% 20%	J	Result is estimated, bias unknown. MS/MSD RPD outside acceptance criteria. LR RPD outside acceptance criteria.
S059-SCX-016-3	4/13/17	SW6020	Molybdenum	38	mg/kg	MS MSD LR	201% 302% 77%	75% - 125% 75% - 125% 20%	J+	Result is estimated, potentially biased high. MS and MSD recoveries above acceptance criteria. LR RPD outside
S059-SCX-016-3	4/13/17	SW6020	Selenium	2	mg/kg	MSD MS/MSD RPD	140% 25%	75% - 125% 20%	J+	Result is estimated, potentially biased high. MSD recovery above acceptance criteria. MS/MSD RPD outside acceptance criteria.
S059-SCX-016-3	4/13/17	SW6020	Uranium	160	mg/kg	MS/MSD RPD LR	65%	20%	J	Result is estimated, bias unknown. MS/MSD RPD outside acceptance criteria.
S059-SCX-016-3	4/13/17	SW6020	Vanadium	970	mg/kg	MS/MSD RPD LR	128% 75%	20% 20%	J	Result is estimated, bias unknown. MS/MSD RPD outside acceptance criteria. LR RPD outside acceptance criteria.

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
LCS laboratory control sample
LR laboratory replicate (duplicate)
MS matrix spike
MSD matrix spike duplicate
RPD relative percent difference

Table F.1-1
Summary of Qualified Data
NA-0904
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
S059-CX-013	4/13/17	SW6020	Uranium	1.9	mg/kg	MS MSD MS/MSD RPD LR	15% 128% 43% 42%	75% - 125% 75% - 125% 20% 20%	J	Result is estimated, bias unknown. MS and MSD recoveries outside acceptance criteria. MS/MSD RPD outside acceptance criteria. LR RPD outside acceptance criteria.
S059-CX-013	4/13/17	SW6020	Arsenic	2.1	mg/kg	LR	65%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S059-CX-013	4/13/17	SW6020	Vanadium	35	mg/kg	MS MSD MS/MSD RPD LR	331% -22% 69% 94%	75% - 125% 75% - 125% 20% 20%	J	Result is estimated, bias unknown. MS and MSD recoveries outside acceptance criteria. MS/MSD RPD outside acceptance criteria. LR RPD outside acceptance criteria.
S059-CX-013	4/13/17	E901.1	Radium-226	0.91	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S059-CX-213	4/13/17	E901.1	Radium-226	1.02	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S059-CX-006	4/12/17	SW6020	Vanadium	9.2	mg/kg	MSD	126%	75% - 125%	J+	Result is estimated, potentially biased high. MSD recovery above acceptance criteria.
S059-CX-012	4/12/17	E901.1	Radium-226	2.88	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S059-SCX-013-2	4/12/17	SW6020	Uranium	1.3	mg/kg	MS MSD LR	142% 138% 114%	75% - 125% 75% - 125% 20%	J+	Result is estimated, potentially biased high. MS and MSD recoveries above acceptance criteria. LR RPD outside
S059-SCX-013-2	4/12/17	SW6020	Vanadium	21	mg/kg	MS MSD LR	172% 245% 66%	75% - 125% 75% - 125% 20%	J+	Result is estimated, potentially biased high. MS and MSD recoveries above acceptance criteria. LR RPD outside
S059-SCX-004-3	4/11/17	E901.1	Radium-226	6.84	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S059-BG4-009	9/14/17	E901.1	Radium-226	0.62	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
LCS laboratory control sample
LR laboratory replicate (duplicate)
MS matrix spike
MSD matrix spike duplicate
RPD relative percent difference

Table F.1-1
Summary of Qualified Data
NA-0904
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
S059-BG4-011-01	9/14/17	E901.1	Radium-226	0.71	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S059-BG4-002	9/14/17	E901.1	Radium-226	0.61	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S059-BG4-202	9/14/17	E901.1	Radium-226	0.52	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S059-BG4-005	9/14/17	E901.1	Radium-226	0.67	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
LCS laboratory control sample
LR laboratory replicate (duplicate)
MS matrix spike
MSD matrix spike duplicate
RPD relative percent difference

Table F.1-2
Results that did not Meet the Relative Percent Difference Guidance
NA-0904
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 (%)
S059-SCX-017-1/S059-SCX-217-1	4/13/2017	Arsenic	76	38	mg/kg	67%
S059-SCX-017-1/S059-SCX-217-1	4/13/2017	Molybdenum	51	28	mg/kg	58%
S059-CX-013/S059-CX-213	4/13/2017	Arsenic	2.1	0.85	mg/kg	85%
S059-CX-013/S059-CX-213	4/13/2017	Uranium	1.9	1.1	mg/kg	53%
S059-CX-013/S059-CX-213	4/13/2017	Vanadium	35	7	mg/kg	133%
S059-CX-005/S059-CS-205	4/12/2017	Uranium	0.99	0.69	mg/kg	36%
S059-BG4-002/S059-BG4-202	9/14/2017	Arsenic	1.5	5.1	mg/kg	109%
S059-BG4-002/S059-BG4-202	9/14/2017	Uranium	0.67	1	mg/kg	40%
S059-BG4-006/S059-BG4-206	9/14/2017	Arsenic	1.8	3.9	mg/kg	74%

Notes
mg/kg milligrams per kilogram
RPD relative percent difference