Standing Rock (#1006)

Removal Site Evaluation Report

Final | September 22, 2018

Stantec

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

Standing Rock (#1006) Removal Site Evaluation Report - Final

September 22, 2018

Prepared for:

Navajo Nation AUM Environmental Response Trust
– First Phase

Prepared by:

Stantec Consulting Services Inc.

Title and Approval Sheet

Title: Standing Rock Removal Site Evaluation Report - Final

Approvals

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

10/9/18

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Navajo Nation Environmental Protection Agency
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Revision Log

Revision No.	Date	Description
0	March 28, 2018	Submission of Draft RSE report to Agencies for review
1	September 22, 2018	Submission of Final RSE report to Agencies

Sign-off Sheet

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

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

Prepared by Emily Yeager

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- 2017 Cooper aerial survey orthophotographs and data files
- Historical documents referenced in this RSE Report (refer to Section 7 for complete citation)
    - Brookins, 1977 – Upper Cretaceous Black Sand Deposits of the San Juan Basin
    - Chenoweth, 1957 – Radioactive Titaniferous Heavy-Mineral Deposits in the San Juan Basin, New Mexico and Colorado
    - McLemore, 1983 – Uranium and Thorium Occurrences in New Mexico: Distribution, Geology, Production, and Resources, with Selected Bibliography

- New Mexico Bureau of Geology and Mineral Resources, 2016 – Mineral Resources Assessment of Heavy Mineral, Beach-Placer Sandstone Deposits at Apache Mesa, Jicarilla Apache Reservation, Rio Arriba County, New Mexico
- USDOI, 1916 – Reconnaissance of Titaniferous Sandstone Deposits of Utah, Wyoming, New Mexico, and Colorado
- USEPA, 2007a – Abandoned Uranium Mines and the Navajo Nation. Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data
- USGS, 1982 – National Uranium Resource Evaluation Gallup Quadrangle Arizona and New Mexico
- Weston Solutions, 2009 - Navajo Abandoned Uranium Mine Site Screen Report Standing Rock AUM Site

Executive Summary

Introduction

The Standing Rock site (the Site) is located within the Navajo Nation, Eastern Navajo Bureau of Indian Affairs (BIA) Agency, Nahodishgish Chapter in northwestern New Mexico. The Site is one of 46 "priority" abandoned uranium mines (AUMs) within the Navajo Nation selected by the United States Environmental Protection Agency (USEPA) in collaboration with the Navajo Nation Environmental Protection Agency (NNEPA) for further evaluation based on radiation levels and potential for water contamination (USEPA, 2013). Mining for uranium occurred prior to, during, and after World War II, when the United States (US) sought a domestic source of uranium located on Navajo lands (USEPA, 2007a).

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

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

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

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[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 a region of beach-placer sandstone deposits known as the Point Lookout Sandstone. The Point Lookout Sandstone is known to contain minor natural deposits of radioactive zircon, monazite, columbium minerals, uranium, thorium, and titanium. The uranium deposits of the Point Lookout Sandstone are typically small, isolated occurrences of very low-grade uranium, and the uranium could only be considered as a minimal co-product (i.e., below the minimum economic grade and tonnage requirements). 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 an isolated mesa, surrounded by plains, with a maximum elevation of 6,830 ft above mean sea level (amsl), and an elevation change from the surrounding plains of approximately 80 ft amsl. On-site overland surface water flow, when present, either terminates within the unconsolidated deposits or drains north, southeast or southwest.

Based on the historical document review for the Site, the following is known about historical exploration and mining activities at the Site: (1) chip samples were collected from a bedrock outcrop during the 1957 US Department of the Interior (USDOI) reconnaissance (USDOI, 1961); (2) the Site was not economically viable for titanium or zircon mining (USDOI, 1961); (3) mining for uranium never occurred on the Site (McLemore, 1983); and (4) the only production reported at the Site was for road gravel (McLemore, 1983). In addition, local residents stated that they did not know of a historical uranium mine having been located at the Site, and the only historical "mining" the residents were aware of was the development of a gravel quarry located on top of the Site (i.e., Flat Top Hill) (Dinétahdóó, 2016). The residents recalled that material from the gravel quarry was used in the late 1960s and 1970s for paving Navajo Service Route 9. **Based on the historical information, it appears that the Site was not a uranium mine.**

In 2009 Weston Solutions (Weston) performed site screening on behalf of the USEPA. The screening included: (1) recording site observations (i.e., number of homes, water sources, and sensitive environments around the Site); (2) recording the type, number, and reclamation status of Site features; and (3) performing a surface gamma survey.

Summary of Removal Site Evaluation Activities

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

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

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

- **Site Characterization Activities and Assessment** included surface and subsurface soil and sediment sampling, and surface water and well water sampling. The results of the surface and subsurface soil and sediment sampling analyses were used to evaluate quarrying impacts and define the lateral and vertical extent of TENORM at the Site. The results of the surface water and well water analyses were used to evaluate quarrying impacts to surface water and well water.

Findings and Discussion

Surface and subsurface soil and sediment sampling results. Two background reference areas were selected to develop surface gamma, subsurface static gamma, Ra-226, and metals ILs for the Site. Arsenic, molybdenum, selenium uranium, and Ra-226 concentrations and gamma radiation measurements in soil/sediment exceeded their respective ILs and are confirmed constituents of potential concern (COPCs) for the Site. Based on the data analyses performed for this report along with the multiple lines of evidence, approximately 15.6 acres, out of the 56.8 acres of the Survey Area (i.e., the full areal of the Site surface gamma survey), were estimated to contain TENORM. Given that there is no evidence of historical uranium mining, TENORM that meets the USEPA definition (refer to Glossary) is the result of the impacts from historical quarrying that may have dispersed uranium contaminated rock and soils. Of the 15.6 acres that contain TENORM, 9.1 acres contain TENORM exceeding ILs. The volume of TENORM in excess of ILs was estimated to be 15,450 cubic yards (yd^3) (11,812 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. Additional correlation studies may be needed to identify the relationship between gamma and Ra-226.

Water sampling results. Water samples were collected from one surface water pond and two water wells. Sample analyses indicated that the pond water sample had total arsenic concentrations greater than the arsenic IL. Based on these results, total arsenic was confirmed as a COPC for the pond. Results of general chemistry parameters indicated that TDS and sulfate were also above their respective ILs for all three water features. Based on these results, TDS and sulfate are confirmed COPCs for all three water features. Because total arsenic exceeded its respective IL for the pond, and TDS and sulfate exceeded their respective ILs in the samples collected at all three water features, further characterization may be necessary at these locations to evaluate potential quarrying-related impacts.

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
yd^3	cubic yard
e.g.	exempli gratia
etc.	et cetera
et seq.	and what follows
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
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
CFR	Code of Federal Regulations
Cooper	Cooper Aerial Surveys Company
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
Fe	Iron
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
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 Regulations
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
R^2	Pearson's Correlation Coefficient
Ra-226	Radium 226
Ra-228	Radium 228
Redente	Redente Ecological Consultants
RSE	Removal Site Evaluation
SOP	standard operating procedure
Stantec	Stantec Consulting Services Inc.
T&E	threatened and endangered
Th-230	thorium 230
Th-232	thorium 232
TiO_2	titanium dioxide
ThO_2	thorium dioxide
TCP	Traditional Cultural Property
TDS	total dissolved solids
TENORM	Technologically Enhanced Naturally Occurring Radioactive Materials
U-235	uranium 235
U-238	uranium 238
U_3O_8	uranium oxide

UCL	upper confidence limit
US	United States
USAEC	US Atomic Energy Commission
USC	United States Code
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
UTL	upper tolerance limit
Weston	Weston Solutions
ZrO_2	zirconium dioxide

Glossary

Alluvium – material deposited by flowing water.

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

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

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

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

Geosyncline – a broad elongated depression in the earth's crust containing great thicknesses of sediment (Collins Dictionary, 2018).

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

Headward erosion – erosion by a stream of its bed in the upstream direction, so that a valley, ravine, etc., becomes longer (Oxford Dictionary, 2018).

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

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

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.

Quartzose – like, of, or rich in quartz (Collins Dictionary, 2018).

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.

Titaniferous - containing or yielding titanium (Collins Dictionary, 2018).

Traditional Cultural Property (TCP) – "a location of an event (a ceremony, belief, prayer, sweat lodge, plant gathering areas, and others as defined within the Navajo Nation Policy to Protect Traditional Cultural Properties) where the location itself maintains historic or traditional cultural value regardless of the value of any existing structure." (NNHPD, 2016)

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

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

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

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

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

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

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

1.0 INTRODUCTION

1.1 BACKGROUND

This report summarizes the purpose and objectives, field investigation activities, findings, and conclusions of Site Clearance and Removal Site Evaluation (RSE) activities conducted between August 2015 and August 2017 at the Standing Rock site (the Site) located in northwestern New Mexico, as shown in Figure 1-1. The Site is also identified by the United States Environmental Protection Agency (USEPA) as abandoned uranium mine (AUM) identification #1006 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 35.4 acres (1,542,024 square feet [ft^2]) and was provided as part of the *2007 AUM Atlas*. Per the *2007 AUM Atlas* this polygon and other factors represent the location and surface extent of the AUM.

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

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

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

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

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

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

1.2 OBJECTIVES AND PURPOSE OF THE REMOVAL SITE EVALUATION

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

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

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

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

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

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

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

Site Clearance field activities – included the following:

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

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

Baseline Studies activities – included the following:

- Background Reference Area Study – walkover gamma radiation survey (referred to hereafter as surface gamma survey), subsurface static gamma radiation measurements (referred to hereafter as subsurface static gamma measurements), surface and subsurface soil sampling, and laboratory analyses
- Site gamma survey – surface gamma survey
- Gamma Correlation Study – co-located surface static gamma measurements and exposure-rate measurements at fixed points, high-density surface gamma surveys (intended to cover 100 percent of the survey area), surface soil sampling, and laboratory analyses

Site Characterization Activities and Assessment – included the following:

- Characterization of surface soils and sediments – surface soil and sediment sampling and laboratory analyses.
- Characterization of subsurface soils and sediments – static gamma measurements (at surface and subsurface hand auger borehole locations), and subsurface sampling and laboratory analyses. Hand auger borehole locations are referred to hereafter as boreholes.
- Characterization of perennial surface water and well water – surface water and 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 *Standing Rock Site Clearance Data Report* (*Site Clearance Data Report*; MWH, 2016c) and summarized in Section 3.2 of this report. Details regarding the Baseline Study activities are provided in the *Draft Standing Rock Baseline Studies Field Report* (Stantec, 2017) and summarized in Section 3.3 of this report. Details regarding the Site Characterization Activities and Assessment are provided in Section 3.3 of this report. Findings are presented in Section 4.0 of this report.

1.3 REPORT ORGANIZATION

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

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

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

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

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

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

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

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

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

Tables Included at the end of this RSE report.

Figures Included at the end of this RSE report.

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

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

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

2.0 SITE HISTORY AND PHYSICAL CHARACTERISTICS

2.1 SITE HISTORY AND LAND USE

2.1.1 Mining Practices and Background

The Site is located on the Navajo Nation approximately 30 miles northwest of Crownpoint, New Mexico (refer to Figure 1-1 inset), on Flat Top Hill (refer to Figure 2-1). Historical documentation of activities that occurred on-site were reported in 1957, 1961, 1963, and 1983 as described below.

The Site is located in a region of beach-placer sandstone deposits (refer to Section 2.2.2.2) that are radioactive due to zircon, monazite, and columbium minerals (McLemore, 1983). High concentrations of titanium, iron, scandium, niobium, thorium, uranium, and rare earth elements are characteristic of beach-placer deposits (McLemore, 1983). Because of the high concentrations of titanium, these deposits are also known as titaniferous sandstone deposits (US Department of the Interior [USDOI], 1961). Deposits of titaniferous sandstone were brought to the attention of the Bureau of Mines by prospectors who submitted numerous samples for mineral identification and evaluation (USDOI, 1961). Prior to 1957, the Site was discovered by the US Geological Survey (USGS) and identified as a deposit for radioactive titaniferous heavy-minerals (Chenoweth, 1957). In 1957, the USDOI Bureau of Mines investigated titaniferous sandstone deposits in Utah, Wyoming, New Mexico, and Colorado for their economic potential of titanium and zircon (USDOI, 1961). The investigation included reconnaissance of the deposits, collection of deposit samples, and analyses of the samples. The Site was included in the investigation and was identified by township and range, and the deposit name of "Standing Rock". The township and range provided in USDOI (1961) is coincident with the Site (refer to Section 2.1.2). During the reconnaissance, the Bureau of Mines collected three chip samples from the Site (USDOI, 1961). The samples were collected from an exposed bedrock outcrop of the titaniferous sandstone deposit. No drilling or trenching was done by the Bureau of Mines to collect the chip samples. The samples collected from the Site contained an average of 4.3 percent TiO_2 (titanium dioxide), 0.3 percent ZrO_2 (zirconium dioxide), 27.1 percent Fe (iron), and 0.06 percent equivalent ThO_2 (thorium dioxide). The reconnaissance determined that mining of the titaniferous sandstone deposits for titanium and zircon would not be economically viable until the more extensive deposits of titanium and zircon in the US were mined out (USDOI, 1961).

In 1963 the USGS produced a 7.5 minute series topographic map of the area around the Site (USGS, 1963). The map showed Flat Top Hill and a gravel pit on Flat Top Hill. A portion of the 1963 USGS map is presented in Figure 2-1, showing the Site, which is coincident with Flat Top Hill and the USGS labeled gravel pit. Based on the creation date of the map, it can be assumed that the Site was used as a gravel pit (i.e., gravel quarry) before 1963.

In 1983 the New Mexico Bureau of Mines and Mineral Resources published an extensive report detailing the uranium and thorium occurrences in New Mexico (McLemore, 1983). Over

1,300 uranium and thorium occurrences were described in the report, and descriptions included information on location, commodities, production, development, geology, and classification of the occurrence (McLemore, 1983). The report was a compilation of uranium and thorium occurrences data, to be used to establish a database for use by health and safety personnel, government agencies in planning impact studies, uranium geologists, mineralogists, and the general public (McLemore, 1983). Over 1,000 citations were included in the bibliography and referenced in the uranium and thorium occurrence descriptions within the report. The Site was included in the report and was referred to as the "Standing Rock occurrence" (McLemore, 1983). The following information regarding the "Standing Rock occurrence" was presented in the report:

- The location of the "Standing Rock occurrence" was in McKinley County, New Mexico, Section 35.300 of Township 18 North, Range 14 West, New Mexico Principal Meridian. This location is coincident with the Site (refer to Section 2.1.2).
- The report identified 41 beach-placer deposits in New Mexico, including the Site.
- Out of the 41 identified beach-placer deposits, only one was mined, the Hogback #2 mine. In 1954 the Hogback #2 property was mined and yielded eight tons of "no-pay" ore producing three pounds of 0.02 percent U_3O_8 (uranium oxide) from the Lookout Sandstone. The Hogback #2 property was located approximately 100 miles southeast of the Site in San Juan County, New Mexico Section 15.323 of Township 30 North, Range 16 West, New Mexico Principal Meridian.
- Deposits containing uranium, thorium, zircon, rare earth elements, and gravel were reported for the Site.
- No uranium production occurred at the Site, and the only production reported at the Site was for road gravel (referred to as road metal on page 396 of McLemore, 1983).

Based on the historical document review for the Site, the following is known about historical exploration and mining activities at the Site: (1) chip samples were collected from a bedrock outcrop during the 1957 reconnaissance; (2) the Site was not economically viable for titanium or zircon mining; (3) mining for uranium never occurred on the Site; and (4) the only production reported at the Site was for road gravel (referred to as road metal on page 396 of McLemore, 1983). **Based on this historical information, it appears that the Site was not a uranium mine.**

2.1.2 Ownership and Surrounding Land Use

The Site is located within the Navajo Nation, Eastern Navajo Bureau of Indian Affairs (BIA) Agency in Section 35 of Township 18 North, Range 14 West, New Mexico Principal Meridian. Land ownership where the Site is located falls under Navajo Trust lands. The Site is located within the Nahodishgish Chapter of the Navajo Nation, as shown in Figure 1-1, and is in Grazing Unit 15, as designated by the Navajo Nation Division of Natural Resources (NNDNR, 2006). The Site is currently uninhabited. However, four home-sites are located within 0.25 miles of the Site, two more home-sites are located just outside the 0.25 mile boundary (0.3 miles), and a residential area is located approximately 1.1 miles southeast of the Site, as shown in Figure 2-2. Land use surrounding the Site is primarily rangeland for domestic sheep grazing (refer to Appendix E).

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 Nahodishgish Chapter officials and nearby residents and notified them of the work.

2.1.4 Previous Work at the Site

In 2009, Weston performed site screening on behalf of the USEPA (Weston, 2009). The screening included: (1) recording site observations (i.e., number of homes, water sources, and sensitive environments[3] around the Site); (2) recording the type, number, and reclamation status of Site features; and (3) performing a surface gamma survey. Weston reported seven home-sites were within 0.25 miles of the Site, four water wells within a one-mile radius of the Site, and no sensitive environments were identified. Weston also reported it observed no reclamation or mining features. Based on Weston's performance of a surface gamma survey, Weston determined that the highest gamma measurements were greater than 2.8 times the lowest site-specific background level used for its gamma screening. Weston used four different background levels for its screening.

2.2 PHYSICAL CHARACTERISTICS

2.2.1 Regional and Site Physiography

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

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

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

The Site is located in the southeast portion of the Colorado Plateau. Flat Top Hill, where the Site is located, is an isolated mesa, surrounded by plains, with a maximum elevation of 6,830 ft above mean sea level (amsl), and an elevation change from the surrounding plains of approximately 80 ft amsl, as shown in 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.

The geologic region surrounding the Site consists of the Cretaceous Mesa Verde Group, as shown in Figure 2-5. The Mesa Verde group is made up of sedimentary rocks that include the Point Lookout Sandstone, the Menefee Formation, and the Cliff House Sandstone (Wanek, 1959). The sedimentary rocks were formed in near-shore marine, and river floodplain and coastal swamp depositional environments (Griffitts, 1990 and Wanek, 1959). These depositional environments resulted in alternating layers of sandstone, shale, and coal beds, (Wanek, 1959). The Point Lookout Sandstone is a member of the primary Mesa Verde Group member, and regionally the Point Lookout Sandstone is known as a titaniferous sandstone deposit containing appreciable amounts of titanium and zirconium (USDOI, 1961). The USGS (1982) reported that regionally the Point Lookout Sandstone is unfavorable for uranium deposition for the following reasons: (1) high percentage of carbonate cement; (2) the general fine-grained nature of the sandstone; (3) the lack of arkosic material; (4) the isolation from ground-water flow after deposition and; (5) the lack of organic concentrations. Uranium does occur regionally in the Point Lookout Sandstone; however, the deposits are typically small, isolated occurrences of very low grade uranium (USGS, 1982). Uranium could only be considered as a minimal co-product (i.e., below the minimum grade and tonnage requirements) of the principal niobium and titanium bearing Point Lookout Sandstone (O'Sullivan, 1974 and Brookins, 1977). Regionally radioactivity of the Point Lookout Sandstone deposit was equal to that of a deposit containing 0.09 percent U_3O_8. However, chemical analyses of the regional Point Lookout Sandstone deposit resulted in a maximum of only 0.01 percent U_3O_8 (Chenoweth, 1957). Therefore, Point Lookout Sandstone deposits were not considered a commercial source for uranium (Chenoweth, 1957).

2.2.2.2 Site Geology

Bedrock outcrops on or adjacent to the Site are of the Point Lookout Sandstone and consist of tan, shaley sandstone that is overlain by iron oxide cemented quartzose sandstone made up of black, titanium rich sand (i.e., titaniferous sandstone [black sandstone]), as shown in Figure 2-6 and Appendix B-1 photograph number 1. The Point Lookout Sandstone is a beach-placer deposit that formed in a near-shore marine (i.e., beach) environment on the western shores of a sea that occupied the Rocky Mountain geosyncline during the Cretaceous period (USDOI, 1961).

The New Mexico Bureau of Geology and Mineral Resources (2016) described the titaniferous sandstone deposit on-site as follows:

> The Standing Rock deposit (also known as Flat Top Hill), is a dark orange-brown to yellow to red-brown, well-cemented, medium- to fine-grained, well to moderately sorted, sandstone lens with no cross bedding in the Point Lookout Sandstone. The deposit caps the mesa top of Flat Top Hill and overlies a tan to buff, cross bedded, medium-grained sandstone. The deposit is as much as five ft thick, 100 ft wide, and consists of at least two lenses striking North-50-degrees-West (N50°W) for approximately 5,000 ft. Calcite veining cuts the sandstone deposit locally. The deposit contains monazite, ilmenite, anatase, leucoxene, rutile, zircon, and magnetite. Mud cracks are found along the mesa, indicating subaerial exposure.

Unconsolidated deposits on-site are alluvium, colluvium, and eolian deposits consisting of silty sand, poorly graded sand, poorly graded sand with gravel, and/or well graded sand. During the Site Characterization field activities, boreholes were advanced through the unconsolidated deposits using a hand auger until refusal at bedrock or termination within native material (refer to Section 3.3.2.2 and Appendix C.2 for borehole logs). The unconsolidated deposits ranged in depth from 0.2 ft to greater than 2.1 ft below ground surface (bgs).

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

2.2.3 Regional Climate

The Colorado Plateau is located in a zone of arid temperate climates characterized by periods of drought and irregular precipitation, relatively warm to hot growing seasons, and winters with sustained periods of freezing temperatures (National Park Service, 2017). The average monthly high temperature at weather station 293422, Gallup Municipal airport, New Mexico (Western Regional Climate Center, 2017) located approximately32 miles southwest of the Site, ranges between 44.3 degrees Fahrenheit (°F) in January to 87.7°F in July. Daily temperature extremes reach as high as 100°F in summer and as low as -34°F in winter. Gallup Municipal airport receives an average annual precipitation of 11.1 inches, with August being the wettest month, averaging 1.92 inches, and June being the driest month, averaging 0.42 inches.

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

2.2.4 Surface Water Hydrology

The Site is located within the 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) is controlled along the watershed divide line (refer to Figure 2-7) by a decrease in elevation (refer to Figure 2-4) from the top of Flat Top Hill to the surrounding plains. Overland water flow direction arrows and the approximate extent of the watershed divide line at the Site are shown in Figure 2-7. Precipitation run-off on-site either terminates within the unconsolidated deposits or drains: (1) north, in several parallel patterned ephemeral drainages located along the northern extent of the Site, toward an un-named drainage (refer to Figure 2-2); (2) southeast, in one drainage located along the eastern extent of the Site, toward Narrow Canyon; or (3) southwest, in two drainages located along the southern extent of the Site, that terminate in the plains. Drainages and overland water flow directions are shown in Figures 2-4 and 2-7.

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

2.2.5 Vegetation and Wildlife

In the spring 2016, biological surveys were conducted as part of Site Clearance activities. In May 2016, Adkins conducted a wildlife survey, and also in May 2016, Redente Ecological Consultants (Redente), under contract to Stantec, conducted a spring 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 Site was sparsely vegetated grassland with sporadic shrubs (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 western scrub-jay (refer to Appendix E).

2.2.6 Cultural Resources

In May 2016, as part of Site Clearance activities, Dinétahdóó Cultural Resource Management (Dinétahdóó), under contract to Stantec, conducted a cultural resource survey, as well as ethnographic and historical data reviews, and interviewed local residents living near the Site (Dinétahdóó, 2016). The local residents stated that they did not know of a historical uranium mine having been located at the Site, and the only historical "mining" the residents were aware of was the development of a gravel quarry located on top of Flat Top Hill. The residents recalled that material from the gravel quarry was used in the late 1960s and 1970s for paving Navajo Service Route 9 (Svc Rte 9) (refer to Figure 2-3).

During the cultural resource survey Dinétahdóó identified one Traditional Cultural Property (TCP), one isolated occurrence, and one in-use site. The area of the TCP covers the entire top of Flat Top Hill (Dinétahdóó, 2016). Based on the survey findings Dinétahdóó recommended that the Trust consult with the Navajo Nation Historic Preservation Department (NNHPD) and the local Navajo family, who had potential interest in the TCP, prior to any RSE activities occurring on-site. Refer to Section 3.2.2.4 for details regarding the consultation. 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 Activity

During RSE activities, Stantec field personnel (field personnel) observed the following features indicative of potential quarrying activities at the Site: an excavation area, six potential stockpiles (PS-1 through PS-6), and a disturbed area. Details regarding these observations are presented in Section 3.2.2.1. These observations were used, along with additional lines of evidence (refer to Section 3.3.3), to identify areas at the Site where TENORM was present (refer to Section 4.6).

3.0 SUMMARY OF SITE INVESTIGATION ACTIVITIES

3.1 INTRODUCTION

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

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

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

The USEPA DQO Process is a seven-step process[4] that was performed as part of the *RSE Work Plan* to identify RSE data objectives. The goal of the USEPA DQO Process is to minimize expenditures related to data collection by eliminating unnecessary, duplicate, or overly precise data and verifies that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application. It provides a systematic procedure for defining the criteria that the survey design should satisfy. This approach provides a more effective survey design combined with a basis for judging the usability of the data collected (USEPA, 2006).

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

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

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

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

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

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

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

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

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

Sections 3.2 and 3.3 summarize the field investigation methods and procedures for data collection during the Site Clearance activities and the RSE activities, which are described in detail in the *RSE Work Plan,* Section 4. Appendix A 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); and (2) ESRI Shapefiles data contained in the *2007 AUM Atlas*.
- Review of previous studies, information related to potential past mining, and reclamation activities.
- Identification of the predominant wind direction in the region of the Site.

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

- Historical photographs (USGS, 2016) for the Site were selected from 1952, 1962, 1975, 1998, and 2005 for comparison against a current 2017 image (Cooper, 2017). The selected historical photographs are shown in Figure 3-1a. The topographical features in the1952 and 1962 photographs appeared to be similar. However, in the 1975 photograph a disturbed area was present along the southern half of the Site. Figure 3-1b compares the aerial photograph from 1952 and a current 2017 image. The 1952 historical photograph is presented because it provides the best resolution of what the Site looked like before the disturbed area was present on-site. The disturbed area is assumed to be a result of the historical gravel quarry that was on-site (refer to Section 2.1.1).

- The current aerial photograph review confirmed that four home-sites were located within 0.25 miles of the Site, two more home-sites were located just outside the 0.25 mile boundary (0.3 miles), and a residential area was located approximately 1.1 miles southeast of the Site, as shown in Figure 2-2. 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 quarrying) 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).

- Three 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 2-2.

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

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

3.2.2 Field Investigations

3.2.2.1 Site Mapping

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

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

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

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

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

- Topographic features

- Potential background reference areas
- Type of ground cover, including rock, soil, waste rock, etc.
- Physical hazards

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

- Claim boundaries – 100-ft buffers of the claim boundaries, as shown in Figure 2-7, were marked in the field with stakes and/or flagging and mapped with a global positioning system (GPS).
- Drainages – Field personnel mapped several drainages on-site (refer to Figure 2-7 and Section 2.2.4) that drain: (1) north, in several parallel-patterned ephemeral drainages located along the northern extent of the Site, toward an un-named drainage (refer to Figure 2-2); (2) southeast, in one drainage located along the eastern extent of the Site, toward Narrow Canyon; and/or (3) southwest, in two drainages located along the southern extent of the Site, that terminate in the plains. A photograph of one of the northwest drainages is shown in Appendix B-1 photograph number 9.
- Topographic features – The Site is an isolated, elongated mesa where the long axis strikes northwest to southeast. The mapped area can be divided into three topographic areas, as shown in Figure 2-4: (1) the mesa top; (2) the mesa sidewall; and (3) the surrounding plains. The mesa top slopes gently to the northwest, and there is approximately 80 ft of relief from the surrounding plains to the mesa top (refer to Figure 2-4). Numerous headward-eroding drainage channels have incised the north/northeastern edge of the mesa, which has resulted in an overall “comb-like” mesa geometry, where each tooth of the comb is a north to south trending ridge with an intervening drainage channel. As shown on Figure 2-4, there are six ridges (R-1 through R-6); Ridge 1 through Ridge 4 occur in the northwestern portion of the Site and the drainages in-between the ridges are more deeply incised than Ridge 5 and Ridge 6, which are located in the southeastern portion of the Site. Topographic features along the northern extent of the claim boundary are shown in Appendix B-1 photograph number 10.
- Graded potential grazing area – A graded potential grazing area was mapped, as shown in Figure 2-7. The area was a sparsely vegetated, large, flat surface made up of poorly graded material (potentially engineered material). A T-post and sprinkler system parts were observed by field personnel in this area, as shown in Appendix B-1 photograph number 2. The sprinkler system parts were not hooked up to a water source (i.e., there was no water source observed on the mesa top during the field investigation) and their purpose was unknown. The graded potential grazing area is also shown as part of the earthworks in Figure 2-6.
- Utilities – An underground water line (marked by T-posts) and an overhead power line were mapped, as shown in Figure 2-7. The two utilities parallel each other and ran from one home-site located south of the claim boundary to a grouping of home-sites located northeast of the claim boundary.
- Roads – One potential road was mapped within the claim boundary, as shown in Figure 2-7. The road ran from the claim boundary and terminated at the graded potential grazing area.

- Potential stockpiles – Six potential stockpiles (PS-1 through PS-6) consisting of gravel from the Site were mapped, as shown in Figure 2-7. PS-5 and PS-6 are shown in Appendix B-1 photograph numbers 4 and 7, respectively. The potential stockpiles are also included within the earthworks in Figure 2-6.

- Potential Haul Road – A potential haul road was mapped as shown in Figures 2-2 and 2-7. The potential haul road ran from W Rte 9 and split near the 100-ft claim buffer. The western branch ran to the mesa top and the eastern branch ran to PS-4.

- Excavation – An area of excavation into a potential stockpile was mapped as shown in Figure 2-7 and Appendix B-1 photograph number 3. A portion of PS-4 was excavated, leaving an excavation cut approximately 8.0 ft high. The area in front of the excavation cut appeared to have been leveled by machinery. The area of excavation is also shown as part of the earthworks in Figure 2-6.

- Disturbed areas – The north-eastern drainage and approximately 50 percent of the mesa top were mapped as two disturbed areas (DA-1 and DA-2), as shown in Figure 2-7. DA-1 included the mesa top, as well as the western branch of the potential haul road, which was approximately coincident with the north-eastern drainage. DA-2 included an area in-between the eastern branch of the potential haul road and the claim boundary buffer. The disturbed areas showed signs of being scraped/leveled by machinery. Bull dozer track marks and push lines (piles of broken rock lining the sides of the path cleared by the bull dozer; refer to Appendix B-1 photograph number 6) were observed by field personnel. Appendix B-1 photograph numbers 5, 6, 7, and 8 show the disturbed areas. The disturbed areas were also included within the earthworks in Figure 2-6. It was assumed that the disturbed areas on-site were associated with the gravel quarrying that occurred (refer to Section 2.1.1). Of note, a pit-like depression (e.g., from a “gravel pit”) was not observed by field personnel at the Site.

- Corral – Five corral areas were mapped, as shown in Figure 2-7. One of the corrals was located within the claim boundary and approximately 20 sheep were in the corral during Site mapping. The other four corrals, located outside the claim boundary, did not contain livestock during Site mapping, but there was evidence the corrals were actively being used.

- Water feature – Field personnel assessed the three water features identified from the desktop study, as shown in Figure 2-2. In addition, during site mapping activities field personnel mapped three additional water features: one well-pond and two temporary ponded areas located west and east of the Site, as shown in Figure 2-2. The water features and field personnel observations are included in Table 3-1a. The well-pond was an overflow pond associated with water well 15T-538. The temporary ponded areas were both created by blocking a drainage with an earthen dam, as shown in Appendix B-2 photograph numbers 14 and 15. Water was not observed by field personnel in either of the temporary ponded areas during RSE activities.

- Structures – Four home-sites were located within 0.25 miles of the Site, two more home-sites were located just outside the 0.25 mile boundary (0.3 miles), and a residential area was located approximately 1.1 miles southeast of the Site, as shown in Figure 2-2.

- Scattered debris – Debris are scattered over a 40 ft by 80 ft area along the northern claim boundary. The debris include steel cables, oil cans, a 55-gallon drum, sheet metal, car parts, and rubber spacers. It is unknown whether the debris is related to historical quarrying activities, they are not visible in historical photos.

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

In June 2018, the USEPA provided the Trust with a copy of a NNDWR database that was generated in 2018. The USEPA stated that there were discrepancies between the NNDWR water feature locations in the 2018 database and those provided in the 2016 NNDWR database used by the Trust. This information was provided after Site Characterization activities had occurred and was therefore not included in the RSE for the Site. Comparison of the 2018 NNDWR database against the 2016 NNDWR database and the *2007 AUM Atlas* will require additional field work and it is recommended that this be addressed in future studies for the Site.

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

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

Stantec proposed to perform aerial photography in order to provide an overview of the Site and identify features that could not otherwise be accomplished safely on foot. USEPA is not authorized to allow drones on sites it oversees: therefore, drone use was not an option. Although aerial photography was not included in the approved *Scope of Work* (MWH, 2016d), the Trustee notified the Agencies and obtained approval prior to commencement of the work. The Trust also consulted with Nahodishgish 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 quarrying-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 three potential background reference areas (BG-1 through BG-3) for the Site, as shown in Figure 3-2a and described in Appendix D.1. BG-1 and BG-2 were selected as suitable background reference areas for the Site for the following reasons:

- BG-1 encompassed an area of 986 ft^2 (approximately 0.02 acres), was located 1.2 miles northwest of the Site, and was upwind and hydrologically cross-gradient from the Site. The cobbles, gravels, residual soils, and bedrock outcrops at BG-1 represented the top of the mesa at the Site, and are the same geologic formation, the Point Lookout Sandstone, as shown in Figure 3-2b. The vegetation and ground cover at BG-1 were similar to the Site.

- BG-2 encompassed an area of 2,335 ft^2 (approximately 0.05 acres), was located 1.2 miles northwest of the Site, and was crosswind and hydrologically upgradient of the Site. Geologically, BG-2 represented the Quaternary deposits found in the drainages and on the plains below the Site, as shown in Figure 3-2b. The vegetation and ground cover at BG-2 were similar to the Site.

BG-3 was not selected as a background reference area for the Site. BG-1 was selected over BG-3 to represent the Site as a large majority of the Site is within the area of the mesa top and it is covered by bedrock, cobbles, and gravels similar to those observed in BG-1 (refer to Appendix D.1). The Agencies have suggested that additional study may be required to develop a background reference area for the Point Lookout Sandstone on the mesa top and mesa sidewall (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-quarrying conditions)

2. Provide a basis for establishing the ILs

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

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

3.2.2.3 Biological Surveys

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

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

The vegetation and wildlife surveys were conducted according to guidelines of the ESA and the NNDFW-Navajo Natural Heritage Program (NNHP), including the procedures set forth in the Biological Resource Land Use Clearance Policies and Procedures, RCS-44-08 (NNDFW, 2008), the Species Accounts document (NNHP, 2008), and the USFWS survey protocols and recommendations (USFWS, 1996).

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

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

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

> "Based on the information you [Stantec] provided [i.e., there is no habitat for any Federally listed species in the action area], we [the USFWS] believe no endangered or threatened species or critical habitat will be affected by the project; nor is this project

> likely to jeopardize the continued existence of any proposed species or adversely modify any proposed critical habitat" (Nystedt, 2016).

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

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

In preparation for the vegetation surveys, Redente submitted data requests for species of concern to the NNDFW and NNHP, and for Federal T&E species, to the USFWS. The NNDFW-NNHP responded to MWH by letter dated November 19, 2015. The letter provided a list of species of concern known to occur within the proximity of the Site and included their status as either Navajo Nation Endangered Species List (NNESL), and/or Federally Endangered, Federally Threatened, or Federal Candidate. The NNESL species were further classified as G2, G3, or G4[5]. A copy of this letter is included in Appendix E. 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; Sivinski's fleabane (G4), and Naturita milkvetch (G3). The USFWS listed one T&E plant species that may occur on-site: Zuni fleabane (USFWS threatened). Sivinski's fleabane is a native perennial forb that grows in Apache and McKinley Counties, New Mexico, and inhabits steep barren shale slopes in desert shrub and pinyon-juniper communities at elevations from 6,100 ft to 7,380 ft amsl. Naturita milkvetch is a native legume that occurs in McKinley and San Juan Counties, New Mexico, and inhabits sand filled pockets of sandstone and rimrock pavement in the pinyon-juniper communities at elevations from 5,000 ft to 7,000 ft amsl. Zuni fleabane is native perennial forb found in McKinley, San Juan, and Catron Counties, New Mexico, and is found growing on fine textured clay hillsides primarily in pinyon-juniper communities at elevations from 7,000 ft to 8,300 ft amsl.

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

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

habitat for the T&E species, specifically steep barren slopes, sand filled pockets of sandstone and rimrock pavement, and fine textured clay hillsides.

The Redente botanist did not identify any of the three T&E species at the Site, based on observations they made during the on-site survey. The botanist concluded they did not identify any of the T&E species at the Site because the Site was not a likely habitat for the T&E species and the heavily grazed condition of the Site would most likely impact the occurrence of these species. Observed vegetation communities on-site are predominantly desert grassland with sporadic shrubs.

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

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

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

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

3.2.2.4 Cultural Resource Survey

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

The survey included the areas of the claim boundary and the 100-ft claim boundary buffer, as shown in Figure 2-7. The survey identified the Site as a TCP, one isolated occurrence, and one in-use site. The area of the TCP covers the entire top of Flat Top Hill (Dinétahdóó, 2016). Based on the survey findings, Dinétahdóó recommended that the Trust consult with the NNHPD and the local Navajo family, who had potential interest in the TCP, prior to any RSE activities occurring on-site. On October 26, 2016, the Trust’s Community Liaison spoke with the local Navajo family regarding the TCP. One of the family members explained to the Trust’s Community Liaison why the TCP is of cultural importance. On December 5, 2016, the Trustee sent the information to the NNHPD in a letter, which also included a map of the Site for reference. On November 21, 2017, the Trustee sent an email to the NNHPD requesting a response regarding the TCP. The Trustee spoke with the NNHPD by telephone regarding the TCP. A consultation with NNHPD is required moving forward to verify that the approaches taken for the Site are in alignment with the NNHPD position on the TCP. For confidentiality reasons, details regarding the TCP, the isolated occurrence, and the in-use site 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 that RSE activities be halted at any time if cultural resources were encountered. Stantec complied with Dinétahdóó’s recommendations while conducting RSE activities on–site.

Dinétahdóó also escorted field personnel during the collection of subsurface soil samples at the background reference areas (refer to Section 3.3.1.1). The Trust and NNHPD agreed that Dinétahdóó’s archeologist would be present because the background reference area subsurface sample locations were outside of the area originally surveyed during the Site Clearance cultural resource survey.

3.3 SUMMARY OF REMOVAL SITE EVALUATION ACTIVITIES

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

3.3.1 Baseline Studies Activities

3.3.1.1 Background Reference Area Study

The Background Reference Area Study activities were completed at the background reference areas selected for the Site. Refer to Section 3.2.2.2 for an explanation of the selection of the background reference areas for the Site. The Background Reference Area Study included a surface gamma survey, static surface and subsurface gamma measurements, surface soil sampling, and subsurface soil sampling. The soil 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 area was representative of unmined (i.e., unexplored) 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 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 background reference area surface gamma survey at BG-1 was performed in March 2017 and at BG-2 in June 2017. ERG performed the surface gamma surveys using Ludlum Model 44-10 2-inch by 2-inch sodium iodide (NaI) high-energy gamma detectors (the detectors). Each detector was coupled to a Ludlum Model 2221 ratemeter/scaler that in turn was coupled to a Trimble ProXRT GPS unit with a NOMAD 900 series datalogger. The detector tagged individual gamma measurements with associated geopositions recorded using the Universal Transverse Mercator Zone 12 North coordinate system. ERG matched and calibrated the detector to a National Institute of Standards and Technology-traceable cesium-137 check source, and function-checked the equipment prior-to and after each workday. ERG performed the surveys by walking the background reference areas with the detector carried by hand, along transects that varied depending on encountered topography. The gamma measurements were collected with the height of the detector varying from 1 ft to 2 ft above ground surface (ags) with an average height of 1.5 ft ags to accommodate vegetation, rocks, or other surface features. If field personnel encountered an immovable obstruction (e.g., a tree) during the surface gamma surveys they went around the obstruction. Subsequent to each workday, ERG downloaded the gamma measurements to a computer and secure server.

The same equipment used for the surface gamma surveys was also used to collect static one-minute gamma measurements at the ground surface and down-hole (subsurface) at borehole location S10006-BG1-011 (BG-1) and S10006-BG2-011 (BG-2). Refer to Appendix C.2 for borehole logs. Static gamma measurements were categorized as surface measurements where they were collected at ground surface (0.0 ft) and as subsurface measurements where depths were below ground surface due to the influence of downhole geometric effects on subsurface static gamma measurements (refer to Section 4.1). Gamma measurements were collected according to the methods described in the *RSE Work Plan,* Section 4.2 and Appendix E.

Soil samples collected as part of the background study are detailed in Table 3-2 and sample locations are shown in Figure 3-3. Appendix B-2 photograph numbers 11 and 12 show surface gamma survey and soil sample collection at BG-1 and BG-2, respectively. Soil samples were categorized as surface samples where sample depths ranged from 0.0 to 0.5 ft bgs and as subsurface samples where sample depths were greater than 0.5 ft bgs. Field personnel collected the following samples from the background reference areas:

- BG-1 – In March 2017, 11 surface soil grab samples were collected from 11 locations. No subsurface soil samples were collected from BG-1. Borehole S10006-BG1-011was attempted at BG-1 but the hand auger met refusal on bedrock at 0.5 ft bgs. A grab sample was collected from 0 ft to 0.5 ft bgs at borehole S10006-BG1-011 but this was categorized as a surface sample.
- BG-2 – In August 2017, 11 surface soil grab samples were collected from 11 locations and one subsurface soil grab sample was collected from borehole S10006-BG2-011.

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

Samples were shipped to a USEPA approved laboratory, ALS Environmental Laboratories in Fort Collins, Colorado for analyses. Samples were collected according to the methods described in the *RSE Work Plan,* Section 3.8.1.1. The results of the surface gamma survey, static surface and subsurface gamma measurements, and surface and subsurface soil sample analytical results provided background reference data to guide the Site Characterization surface and subsurface soil/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. The surface gamma survey included surveying the centerline of the potential haul roads but did not include surveying the shoulders of the potential haul roads that are outside the main survey area. This is identified as a potential data gap in Section 4.9.

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

In November 2016, the surface gamma survey was performed using the methods and equipment described in Section 3.3.1.1. The surface gamma survey included the claim area, a 100-ft buffer around the claim area, and roads and drainages out to approximately 0.25 miles from the Site. The *RSE Work Plan* specified that the surface gamma survey would be an iterative process where the surface gamma survey would be extended laterally until gamma measurements appeared to be within background levels. Subsequent to each workday, the gamma measurements were evaluated by ERG and Stantec, and compared to the background reference area to determine if additional surface gamma surveying was needed.

The full extent of the surface gamma survey is referred to as the Survey Area, as shown in Figure 3-4. The Survey Area was 56.8 acres and was subdivided into two separate survey areas, as shown in Figure 3-4, based on *MARSSIM* criteria. Survey Area A is within the Point Lookout Sandstone (based on BG-1) and Survey Area B is within the Quaternary deposits (based on BG-2).

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 be used as screening tools for site assessments:

- Gamma measurements (in cpm) and concentrations of Ra-226 in surface soils (in picocuries per gram [pCi/g])
- Gamma measurements (in cpm) and exposure rates (in microRoentgens per hour [µR/hr])

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

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

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

In November 2016, field personnel identified five areas for the Gamma Correlation Study, as shown in Figure 3-5, by considering the results of the Site surface gamma survey (described in Section 3.3.1.2), field conditions (e.g., suitable terrain), and feasibility of sampling. To minimize variability when determining a correlation between gamma measurements (in cpm) and concentrations of Ra-226 in soil, the study area soils must: (1) represent a specific gamma measurement within the range of gamma measurements collected at the Survey Area; and (2) be as homogenous as possible with respect to soil type, and gamma measurement within the correlation area. At each area, field personnel completed a high-density surface gamma survey (intended to cover 100 percent of the survey area) and collected one five-point composite surface soil sample per area (refer to Table 3-2). Field personnel made a field modification from the *RSE Work Plan* by adjusting the size of the 900 ft^2 area smaller at three of the Gamma Correlation Study locations, to minimize the variability of gamma measurements observed. The area used for the Gamma Correlation Study is shown in Figure 3-5, where the box shown at the five study locations represents a 900 ft^2 area in comparison to the actual area covered for the study, as shown by the extent of the gamma measurements within each area.

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

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

3.3.1.4 Secular Equilibrium

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

3.3.2 Site Characterization Activities and Assessment

3.3.2.1 Surface Soil and Sediment Sampling

Site Characterization activities included surface soil and sediment sampling and associated laboratory analyses. The soil and sediment surface sampling locations within the Survey Area were selected based on professional judgment (i.e., non-randomly) to evaluate concentrations of Ra-226 and metals in relation to the surface gamma survey measurements and site features (e.g., historical quarrying 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 quarrying impacts (refer to Section 4.3). Soil/sediment samples were categorized as surface samples where sample depths ranged from 0.0 to 0.5 ft bgs and as subsurface samples where sample depths were greater than 0.5 ft bgs. Samples collected in drainages were classified as sediment samples.

In May 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 quarrying-related features are shown in Figure 3-6b. The number of surface samples collected within specific Site features are listed in Table 3-3. Twenty-seven surface soil/sediment grab samples were collected from 27 locations in the Survey Area (24 from Survey Area A and three from Survey Area B).

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 quarrying features and geologic features). Grab samples were collected with the intent to characterize specific intervals of interest (e.g., material within zones with elevated static gamma measurements). Composite samples were collected to provide a screening level assessment across an interval (e.g., sediment collected from a downgradient drainage). Surface and subsurface static gamma measurements were collected in the borehole using the same equipment as described in Section 3.3.1.1. Static gamma measurements were collected by holding the detector in the borehole for a one-minute integrated count and are not comparable to the surface gamma survey measurements, which were collected as a walkover survey.

Sixteen boreholes were advanced in the Survey Area (14 in Survey Area A and two in Survey Area B). The boreholes were advanced through the unconsolidated deposits (from 0.2 ft to 2.1 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) the borehole depth reached undisturbed native material; or (4) the termination reason was unknown at borehole S10006-SCX-006 (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 silty sand, poorly graded sand, poorly graded sand with gravel, and/or well graded sand (refer to Appendix C.2 for borehole information). A drill rig was not employed at the Site because exposed bedrock was prevalent on the mesa top and soil/sediment depths were estimated to be shallow.

In May 2016, samples were collected from the locations shown in Figure 3-6a and are summarized in Table 3-2. Sample locations and the locations of quarrying-related features are shown in Figure 3-6b. The number of subsurface samples collected within specific Site features are listed in Table 3-3. Twelve subsurface soil/sediment samples were collected from 11 borehole locations in the Survey Area (two subsurface samples were collected from borehole S10006-SCX-001 based on the professional judgement of field personnel). Ten subsurface samples were collected from Survey Area A and two from Survey Area B. Soil samples were not collected from S10006-SCX-003, per the *RSE Work Plan*, where samples were not required or intended to be collected at every subsurface borehole location. Field personnel made a professional judgement to not collect a sample when the borehole met refusal at 3.0 ft bgs. Field observations (e.g., depth to bedrock, etc.) from the borehole were used to evaluate the physical conditions of the subsurface.

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 Well Water and Surface Water Sampling

Three water features were identified during the Site Clearance desktop study and three water features were identified during the Site Clearance field investigations, as shown in Figure 2-2 and Table 3-1a. Three of the six water features were not sampled for the following reasons: the two temporary ponding areas were dry when field personnel were present on-site; and field personnel did not observe a well and/or surface water feature at the location of the well identified in the *2007 AUM Atlas* as 1082274/Well. Three of the six water features were sampled as detailed below.

On November 10, 2016, a well water sample (S10006-WL-001) was collected from the water well identified as 15T-529 by the NNDWR and *2007 AUM Atlas*. Water well 15T-529 was completed in December 1969 at a total depth of 1,294 ft bgs and was screened from 1,096 ft to 1,292 ft bgs (refer to Table 3-1b for additional well build specifications). Water well 15T-529 was a windmill well located 0.88 miles northwest of the Site and the well water sample was collected from the valve box that was used to control the supply of water from the water well to a livestock trough, as shown in Appendix B-2 photograph number 13.

On May 25, 2017, a well water sample (S10006-WL-002) was collected from the water well identified as 15T-538 by the NNDWR and *2007 AUM Atlas*. Water well 15T-538 was completed in October 1972 at a total depth of 971 ft bgs and was screened from 908 ft to 971 ft bgs (refer to Table 3-1b for additional well build specifications). Water well 15T-538 was a windmill well located 1.0 miles southeast of the Site, and the well water sample was collected from the storage tank associated with the water well, as shown in Appendix B-2 photograph number 16.

On May 25, 2017, a surface water sample (S10006-WS-001) was collected from a pond identified by Stantec as 15T-538 Pond. The pond was located 1.1 miles southeast of the Site and was an overflow pond associated with water well 15T-538, as shown in Appendix B-2 photograph number 17.

The water samples collected for dissolved metals analyses were 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, salinity, temperature, and oxidation reduction potential). Of note, salinity was not collected at water well 15T-538 or surface water location15T-538 Pond as part of the specified field measurements because the water quality meter the field personnel were using could not measure salinity. This was a deviation from the *RSE Work Plan*. Table 3-4 provides a summary of the water analyses. Results of these analyses were used to evaluate potential quarrying-related impacts to well water and surface water. Well water and surface water analytical results are presented in Section 4.8. Field forms are provided in Appendix C.3 and the laboratory analytical data and Data Usability Report for the analyses are provided in Appendix F. 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. US Atomic Energy Commission (USAEC) records
    c. Reclamation records
    d. Other documents relevant to the Site, including those in the *2007 AUM Atlas*
    e. Interviews with residents living closest to the Site (for those sites where residents were available for interview)
    f. Consultation and site visits with NAML staff to identify reclamation features (for those sites reclaimed by NAML)
2. Geology/Geomorphology
    a. Hydrology/transport pathways with drainage delineation
    b. Site-specific geologic mapping including areas of mineralization
    c. Topography
3. Disturbance Mapping
    a. Exploration
    b. Mining/Quarrying
    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. 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 reported.
    - **Representativeness** Based on the results of the sample preservation and holding time evaluation, the method and initial/continuing calibration blank (ICB/CCB) sample results, the field duplicate sample evaluation, and the reporting limit evaluation, the data are considered representative of the Site as qualified.
    - **Completeness** All media and QC sample results were valid and collected as scheduled (i.e., as planned in the *RSE Work Plan*); therefore, completeness for these is 100 percent.
    - **Comparability** Standard methods of sample collection and standard units of measure were used during this project. The analyses performed by the laboratory were in accordance with current USEPA methodology and the QAPP.

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

4.0 FINDINGS AND DISCUSSION

4.1 BACKGROUND REFERENCE AREA STUDY RESULTS AND CALCULATION OF INVESTIGATION LEVELS

The sample locations and results of the background reference area surface gamma survey are shown in Figure 4-1a. Analytical results of the samples collected from BG-1 and BG-2 are summarized in Table 4-1. The gamma measurements and surface soil sample analytical results collected from BG-1 and BG-2 were evaluated statistically to calculate ILs (refer to Appendix D.2) for each corresponding Survey Area (i.e., Survey Area A and Survey Area B, respectively). As previously discussed in Section 3.3.1.2, the Site was subdivided into two 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. The UTL represents a 95 percent UCL for the 95th percentile of a background dataset whereby Survey Area results above this value are not considered representative of background conditions. The UTL is a statistical parameter for the entire population of the variable, whereas the actual results are from a sample of the population. UTLs were calculated in accordance with USEPA's *ProUCL 5.1 Technical Guidance,* Sections 3.4 and 5.3.3 (USEPA, 2015). Appendix D.2 presents a comprehensive discussion on the derivation of the ILs for the Site, which are presented below. The *RSE Work Plan* also stated that gamma radiation measurements from the background surface and subsurface soil would be combined to develop the IL for surface gamma radiation at the Site. However, the surface gamma radiation ILs were instead developed from the surface gamma survey data only. The Agencies have commented that this should be noted as a deviation from the *RSE Work Plan.* The subsurface static gamma measurements were excluded for two reasons: (1) they were collected using a different method (static one-minute measurements versus a walkover gamma survey); and (2) because of the downhole geometric effects that influence subsurface static gamma measurements (refer to the discussion of geometric effects below).

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

- Arsenic – 4.33 milligrams per kilogram (mg/kg)
- Molybdenum – 0.733 mg/kg
- Selenium – 2.78 mg/kg
- Uranium – 4.27 mg/kg
- Vanadium – 534 mg/kg
- Ra-226 – 7.24 pCi/g
- Surface gamma measurements – 32,635 cpm

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

- Arsenic – 4.87 mg/kg
- Molybdenum – 0.532 mg/kg
- Selenium – an IL for selenium was not identified because selenium sample results in BG-2 were all non-detect.
- Uranium – 0.840 mg/kg
- Vanadium – 92.8 mg/kg
- Ra-226 – 1.50 pCi/g
- Surface gamma measurements – 15,570 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 areas of the Site, samples, or TENORM that exceed the IL based on the statistically derived IL values.

In addition to the surface gamma survey performed in background reference areas, subsurface static gamma measurements were collected in the boreholes completed in the background reference areas. The measurements collected in the BG-2 borehole (S10006-BG2-011) were used to establish a subsurface static gamma screening level for Survey Area B. As described below, a subsurface static gamma screening level was not established for Survey Area A. 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.

A borehole was completed in BG-1 (S10006-BG1-011) and was terminated at 0.5 ft bgs due to refusal on bedrock (refer to Appendix C.2). The subsurface static gamma measurement collected at 0.5 ft bgs in the borehole was measured at the bedrock surface and the measurement (60,378 cpm) was more than two times the gamma measurement (23,707 cpm) collected at ground surface. The subsurface static gamma measurement was not representative of the general radiological conditions at the Site and it was not identified as a subsurface static gamma IL. Therefore, the need for representative subsurface static gamma data for BG-1 is identified as a potential data gap. A borehole was completed in BG-2 (S10006-BG2-011) with a termination depth of 1.5 ft bgs (refer to Appendix C.2) and a subsurface static gamma measurement was identified as an IL was for Survey Area B.

The subsurface static gamma screening level from BG-2 provides a comparison and assessment tool for Survey Area B and is included as an IL for the Site. However, it is important to consider that the subsurface static gamma IL is based on a single measurement, and it is not statistically derived. For this reason, subsurface static gamma IL exceedances should be considered in conjunction with additional lines of evidence including: (1) down-hole trends of static gamma measurements; (2) changes in lithology within the borehole; and (3) a qualitative comparison of subsurface static gamma measurements to Ra-226 and/or metals concentrations in subsurface samples.

Subsurface static gamma measurements from the background reference areas are summarized in Table 4-2 and in Appendix C.2. Three subsurface gamma measurements of 20,613, 24,598, and 28,823 cpm were collected from borehole S10006-BG2-011 at down-hole depths of 0.5, 1.0, and 1.5 ft bgs, respectively. The lowest measured value, collected at or below 1.0 ft bgs (24,598 cpm), was selected as the subsurface static gamma IL for Survey Area B. It was not collected on bedrock and it was measured at a depth of 1.0 ft bgs. The subsurface static gamma screening level provides a comparison and assessment tool for Survey Area B and is included as an IL for the Site.

It is important to consider that the subsurface static gamma IL measurement 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 quarrying-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 each background reference area are used to set bin ranges with color coding to illustrate the spatial extent and patterns of surface gamma measurements within the entire Survey Area. The bins ranges were based on the minimum Site gamma measurement, the background area ILs, and the maximum Site gamma measurement. The maximum Site measurement (73,651 cpm) was less than three times the BG-1 IL and less than five times the BG-2 IL, and was detected in Survey Area A within the Disturbed Area 1 (DA-1) located on Ridge 5 (R-5) (refer to Figures 2-4, 2-7, 4-1b, and 4-1c).

Surface gamma measurements were generally highest on top of the mesa ridges (i.e., Ridge 1 though Ridge 6), and in central portions of the Site that were coincident with DA-1 and associated potential stockpiles (PS-2, -4, -5, and -6). For descriptions and photographs of these features refer to Section 3.2.2.1 and Appendix B-1 photograph numbers 3, 4, 5, 6, 7, and 8, respectively

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

- Survey Area A (refer to Figure 4-1c): surface gamma IL exceedances (greater than 32,635 cpm) mainly occurred on the mesa top and mesa ridges, and were inclusive of central portions of DA-1, the associated potential stockpiles, and the excavation area (refer to Figure 2-7). The greatest IL exceedances were located on top of Ridge 5.

- Survey Area B (refer to Figure 4-1d): surface gamma IL exceedances (greater than 15,570 cpm) mainly occurred in four areas: (1) along the northern Site boundary; (2) within portions of the drainage channels north of the Site; (3) along the potential haul road; and (4) along the base of the southern mesa sidewall. The maximum surface gamma exceedance in Survey Area B (42,718 cpm) occurred north of PS-4, located near the northeastern corner of the claim boundary. The majority of the Survey Area B surface gamma measurements did not exceed the Survey Area A surface gamma IL (32,635 cpm).

The gamma survey was not extended in Survey Area B until gamma measurements were less than the surface gamma IL, because at the time of the survey, in November 2016, the field team believed that background levels had been reached. Initially, one background reference area (BG-1) was being considered for the Site (refer Appendix D.1) and gamma measurements along the outside margin of the Survey Area were below the levels within BG-1. Upon further data review, a second background reference area (BG-2) was identified to represent the Quaternary deposits because potential impacts were observed within Quaternary deposits. Gamma survey data were collected on June 29, 2017 and the soil samples were collected on August 29, 2017. It was an oversight to not extend the survey in areas of Survey Area B that exceeded the IL developed from data from BG-2. Additionally, the survey was not extended laterally in the drainages and on the potential haul road where gamma measurements were greater than the IL. These are identified as potential data gaps in Section 4.9.

4.2.1.2 Subsurface Gamma Survey

Surface and subsurface static gamma measurements were collected at all 16 borehole locations. Surface and subsurface static gamma measurement locations are shown in Figure 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) A subsurface static gamma IL was not established for Survey Area A. The maximum subsurface static gamma measurement (86,564 cpm) was measured directly above weathered bedrock at a depth of 1.1 ft bgs in borehole S10006-SCX-005, which was located within PS-6. Excluding surface static gamma measurements (refer to Section 4.1), subsurface static gamma measurements decreased with depth in three boreholes (S10006-SCX-001, -SCX-013, -SCX-016), and subsurface static gamma measurements increased with depth in three boreholes (S1006-SCX-005, -SCX-010, SCX-011). At two borehole locations (S10006-SCX-009 and –SCX-015) the trend for the subsurface static gamma measurements was variable. When comparing the static gamma measurements collected at the surface to the first measurement collected down-hole (depths ranged between 0.2 and 0.5 ft bgs), static gamma measurements decreased at five borehole locations (S10006-SCX-006, -SCX-012, -SCX-014, -SCX-015, -SCX-016) and increased at the other nine borehole locations (S10006-SCX-001, -SCX-002, -SXC-003, -SCX-005, -SCX-007, -SCX-009, -SCX-010, -SCX-011, -SCX-013). No spatial patterns were observed with respect to downhole trends.

- Survey Area B – (refer to Figure 4-1d) subsurface static gamma measurements were collected in both Survey Area B boreholes (S10006-SCX-004, and -SCX-008). Subsurface static gamma measurements exceeded the Survey Area B IL of 24,598 cpm in both boreholes, and static gamma measurements were increasing with depth at both borehole locations. The maximum subsurface static gamma measurement (25,310 cpm) was measured directly above bedrock at a depth of 1.5 ft bgs in borehole S10006-SCX-008, which was located in a drainage along the base of the southwestern mesa sidewall. The maximum subsurface static gamma measurement was less than three percent higher than the subsurface static gamma IL.

4.2.2 Gamma Correlation Results

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

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

Figure 4-2a. The regression produced an adjusted R^2 value of 0.98 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:

$$\text{Gamma (cpm)} = 4{,}039 \times \text{Surface Soil Ra-226 (pCi/g)} + 10{,}693$$

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 (12,310 cpm) and greater than the maximum (37,858 cpm) mean gamma measurements from the Gamma Correlation Study are extrapolated from the regression model and are therefore uncertain. Using the correlation equation, the predicted Ra-226 concentration associated with the minimum mean gamma measurement is 0.4 pCi/g and the concentration associated with the maximum mean gamma measurement is 6.7 pCi/g. Therefore, predicted Ra-226 concentrations less than 0.4 pCi/g and greater than 6.7 pCi/g should be limited to qualitative use only. The correlation locations were intentionally selected to be focused on the lower range of gamma measurements observed at the Site. Mean gamma measurements for correlation locations ranged from 12,210 to 37,858 cpm. The correlation was focused on the lower range because future Removal or

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

The correlation equation predicted Ra-226 concentrations that were less than zero for gamma survey measurements less than 10,693 cpm. The predicted concentrations are shown in Figure 4-2a and the values less than zero are present on the southern and eastern areas of the Site (at the far extent of the gamma survey), the haul road, the drainage east of the Site, and the road south of the Site. The elevated predicted Ra-226 concentrations shown in Figure 4-2a occur in the same areas where the elevated surface gamma measurements occur (refer to Section 4.2.1). This is because the predicted Ra-226 concentrations are based on a correlation with the gamma measurements. Predicted Ra-226 concentrations in the Survey Area range from -0.5 to 15.6 pCi/g, with a mean of 3.0 pCi/g, and a standard deviation, of 2.1 pCi/g. Bin ranges in Figure 4-2a are based on these mean and standard deviation values.

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

When comparing the predicted Ra-226 concentrations to the Ra-226 laboratory concentrations, soil/sediment sample locations are generally not co-located with specific gamma measurement locations (refer to Figure 4-2b). Therefore, the measured Ra-226 laboratory concentrations can only be qualitatively compared to the nearby predicted Ra-226 concentrations. With the exception of five (out of 27) sample locations, the measured Ra-226 laboratory concentrations were within the applicable predicted Ra-226 bin ranges. In all five locations where the predicted Ra-226 concentration and the Ra-226 concentration detected in the soil/sediment sample did not agree, the predicted concentration was higher than the reported laboratory concentration detected in the soil/sediment sample. Of these, two locations (S10006-SCX-014 and -SCX-016) had notably higher predicted Ra-226 concentrations with greater than one standard deviation (2.1 pCi/g) difference. These two sample locations were located within the DA-1and PS-4, respectively. 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 ILs are highlighted with yellow halos. The predicted Ra-226 concentrations exceeded the Ra-226 ILs for approximately

25 percent of the Site. In addition, every soil/sediment sample location with a measured Ra-226 laboratory concentration that exceeded the ILs was in a location 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. In addition, ERG also identified that Th-232 and its decay products are in relatively higher abundance in the host rock at this AUM, an exception to the other AUMs addressed in the *RSE Work Plan*.

Information obtained from the Standing Rock correlation sampling campaign showed high levels of thorium-232 and its gamma-emitting decay products within the Standing Rock correlation plots. As a result of this observation, and as a precautionary measure, the project team opted to collect isotopic thorium data at an additional 41 surface soil/sediment sampling locations at the Standing Rock site. Specifically, isotopic thorium analysis was conducted so that, if necessary, the radium-226/gamma count rate regression could be corrected for the influence of gamma-emitting radionuclides in the thorium-232 decay series.

Whether it would be necessary to account for the influence of thorium-232 decay series radionuclides on the radium-226/gamma count rate regression was assessed via a multivariate linear regression model (MLR), which is a quantitative technique that accounts for the influence of multiple explanatory variables upon a single response variable. Because the MLR model indicated that thorium-232 decay series nuclides were not affecting the radium-226/gamma count rate regression, the thorium isotopic data were not included in any statistical analysis, and are reported in Tables 4-1, 4-3, 4-4a, and 4-4b as informative data.

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 27 surface soil/sediment grab samples (20 soil and seven sediment) from 27 locations, and 12 subsurface soil/sediment grab samples (six soil and six sediment) from 11 borehole locations were collected in Survey Areas A and B (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 and 4-4b. Figure 4-3 presents the spatial patterns, both laterally and vertically, of metals and Ra-226 detections and IL exceedances in the soil/sediment.

Ra-226 and/or one or more metals concentrations exceeded their respective ILs in 14 out of 27 surface soil/sediment samples (S10006-CX-001, -CX-003, -CX-004, -CX-005, -CX-006, -CX-010, -CX-011, -CX-012, -SCX-001, -SCX-002, -SCX-005, -SCX-006, -SCX-007, and -SCX-014) and in five subsurface sample locations (S10006-SCX-001, -SCX-001, -SCX-004, -SCX-005, and -SCX-007). In general, the greatest IL exceedances were centrally located in Survey Area A, and coincident with the DA-1. The majority of IL exceedances were for molybdenum, selenium and Ra-226; only two sample locations (S10006-CX-005 and -CX-010) had uranium concentrations that exceeded the ILs, and no sample locations exceeded the vanadium ILs. There were no metals or Ra-226 IL exceedances observed northwest of Ridge 5. In general, subsurface soil/sediment Ra-226 and metals IL exceedances occurred in borehole locations that also had surface soil/sediment IL exceedances. Surface and subsurface soil/sediment IL exceedances for each analyte, within each Survey Area, as shown on Figures 4-3, 4-4a through 4-4c, and 4-5, are described below:

- Ra-226
    - Survey Area A – the Ra-226 IL (7.24 pCi/g) was exceeded in six surface soil samples (S10006-CX-003, -CX-005, -CX-006, -CX-011, -CX-012, and -SCX-005) and one subsurface soil sample (S10006-SCX-005). Survey Area A Ra-226 concentrations ranged from 0.79 to 18.6 pCi/g. The maximum concentration (18.6 pCi/g) for both Survey Area A and the Site was from surface soil sample S10006-CX-005 located on Ridge 5, within DA-1.
    - Survey Area B – the Ra-226 IL (1.50 pCi/g) was only exceeded in one surface soil/sediment sample (S10006-CX-010), which was located north of the claim boundary, west of DA-2 and PS-3. Ra-226 concentrations in Survey Area B ranged from 0.97 to 1.86 pCi/g.
- Uranium
    - Survey Area A – the uranium IL (4.27 mg/kg) was exceeded in one surface soil sample (S10006-CX-005) with a concentration of 6.1 mg/kg, and was not exceeded in any subsurface sample locations. Sample S10006-CX-005 was located on Ridge 5, within DA-1.

  - Survey Area B – the uranium IL (0.840 mg/kg) was exceeded in one surface soil sample (S10006-CX-010) with a concentration of 1.2 mg/kg, and was not exceeded in any subsurface samples. Sample S10006-CX-010 was located west of DA-2 and PS-3.

As a broader point of reference, a regional study of the Western US documented uranium concentrations in soil that ranged from 0.68 to 7.9 mg/kg, with a mean value of 2.5 mg/kg (USGS, 1984). Uranium concentrations were within the typical range of regional values in soil/sediment samples in Survey Areas A and B.

- Arsenic
  - Survey Area A – the arsenic IL (4.33 mg/kg) was exceeded in three surface soil samples (S10006-CX-004, -CX-005, and -SCX-002) and was not exceeded in any subsurface samples. Survey Area A arsenic concentrations ranged from 1.9 to 5.5 mg/kg. The maximum arsenic detection (5.5 mg/kg) for Survey Area A and the Site was from surface soil sample S10006-CX-004 located on Ridge 6, in an undisturbed area.
  - Survey Area B – the arsenic IL (4.87 mg/kg) was only exceeded in one subsurface sediment sample (S10006-SCX-004), which was located in the drainage channel in the southeast corner of the Site. Arsenic concentrations ranged from 2.4 to 4.9 mg/kg.

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

- Molybdenum
  - Survey Area A – the molybdenum IL (0.733 mg/kg) was exceeded in nine surface soil/sediment samples (S10006-CX-001, -CX-004, -CX-011, -CX-012, -SCX-001, -SCX-002, -SCX-005, -SCX-007, and -SCX-014), and three subsurface sample locations (S10006-SCX-001, -SCX-005, and -SCX-007). Survey Area A molybdenum concentrations ranged from below the detection limit (0.21 mg/kg) to 1.5 mg/kg. The maximum concentration (1.5 mg/kg) for the Survey Area and the Site was from surface soil sample S10006-SCX-007 located within DA-1, just east of the PS-2.
  - Survey Area B – the molybdenum IL (0.532 mg/kg) was not exceeded in Survey Area B. Survey Area B molybdenum concentrations ranged from below the detection limit (0.21 mg/kg) to 0.42 mg/kg, and the maximum detection (0.42 mg/kg) occurred in surface soil sample S10006-CX-010, located west of DA-2 and PS-3.

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 in Survey Areas A and B were within the typical range of regional values in soil/sediment samples.

- Selenium
    - Survey Area A – the selenium IL (2.78 mg/kg) was exceeded in eight surface soil/sediment samples (S10006-CX-001, -CX-003, -CX-005, -CX-006, -CX-011, -CX-012, -SCX-005, and -SCX-006), and one subsurface sample location (S10006-SCX-005). Survey Area A selenium concentrations ranged from below the detection limit (0.99 mg/kg) to 4.6 mg/kg. The maximum detection (4.6 mg/kg) for Survey Area A and the Site was from surface soil sample S10006-CX-005 located on Ridge 5, within DA-1.
    - Survey Area B – An IL was not identified for selenium for Survey Area B (refer to Section 4.1). The only selenium detection in Survey Area A (1.3 mg/kg) occurred in surface soil sample S10006-CX-010, located west of DA-2 and PS-3.

As a broader point of reference, a regional study of the Western US documented selenium concentrations in soil that typically ranged from less than 0.10 to 4.3 mg/kg, with a mean value of 0.23 mg/kg (USGS, 1984). Selenium concentrations were within the range of regional background in Survey Area B, but exceeded the maximum regional value by 0.3 mg/kg in Survey Area A.

- Vanadium
    - Survey Area A – the vanadium IL (534 mg/kg) was not exceeded in any surface or subsurface soil/sediment sample locations. Survey Area A vanadium concentrations ranged from 23 to 500 mg/kg. The maximum vanadium detection (500 mg/kg) for Survey Area A and the Site was from surface soil sample S10006-CX-005 located on Ridge 5, within DA-1.
    - Survey Area B – the vanadium IL (92.8 mg/kg) was not exceeded in any soil/sediment samples. Survey Area B vanadium concentrations ranged from 25 to 91 mg/kg, and the maximum detection (91 mg/kg) was from surface soil sample S10006-CX-010 located west of DA-2 and PS-3.

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

4.4 CONSTITUENTS OF POTENTIAL CONCERN

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

4.5 AREAS THAT EXCEED THE INVESTIGATION LEVELS

The approximate lateral extent of surface gamma IL exceedances in soil/sediment is 25.6 acres, as shown in Figure 4-4a. To estimate this area, polygons were contoured around portions of the

Site that had multiple, contiguous surface gamma IL exceedances and then the total area within the polygons was calculated. Figures 4-4b and 4-4c show larger scale views of each of the two Survey Areas to better display those areas with multiple, contiguous surface gamma IL exceedances. With the exception of borehole locations S10006-SCX-002, -SCX-004, and -SCX-007, this estimate also included the surface and/or subsurface soil/sediment locations where Ra-226 and metals ILs were also exceeded.

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

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

The lateral extent of the IL exceedances (for surface gamma measurements) shown in Figure 4-4a were compared to the predicted Ra-226 concentrations that exceeded ILs in Figure 4-2c. The comparison showed that there was a similar spatial pattern for the predicted Ra-226 values that exceeded the Ra-226 ILs (Figure 4-2c) when compared to the surface gamma IL exceedances (Figure 4-4a). However, fewer predicted Ra-226 values exceeded the Ra-226 ILs, and therefore the lateral extent of predicted Ra-226 exceedances covered a smaller area than the actual surface gamma IL exceedances.

4.6 AREAS OF TENORM AND NORM

A multiple lines of evidence approach was used to evaluate the Site and distinguish areas of TENORM from areas of NORM within the Survey Area, as described in Section 3.3.3. While the Trust has not identified any indications of uranium mining at this Site, TENORM is likely from quarrying operations that disturbed naturally occurring uranium. **Therefore, the disturbance is identified herein as TENORM according to the USEPA definitions.**

Based on this evaluation, 15.6 acres, out of the 56.8 acres of the Survey Area, were estimated to contain TENORM at the Site. This estimate is inclusive of three areas: (1) DA-1, (2) DA-2; and (3) the potential haul road and drainages located north of the northern claim boundary. The area containing TENORM is shown in relation to the lateral extent of IL exceedances in Figure 4-6 and in relation to the gamma measurements in Figure 4-7.

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

- Historical Data Review
    - Historical document review indicated that, while the Site was identified as a deposit for radioactive titaniferous heavy metals, including titanium and zirconium (Chenoweth, 1957), the deposits would not be economically viable until the more extensive deposits of titanium and zircon in the US were mined out (USDOI, 1961).
    - Historical document review indicated that no uranium mining activities occurred at the Site; however, the Site was used as a historical gravel quarry (McLemore, 1983).
    - NAML and New Mexico Mining and Mineral Division did not have any reclamation records for the Site.
    - Local residents do not recall historical uranium mining occurring at the Site; however, they did indicate that a gravel quarry was located on the mesa. Furthermore, the residents recalled that material from the gravel quarry was used in the late 1960s and 1970s for paving Navajo Svc Rte 9.
- Geology/geomorphology
    - There are two geologic units at the Site: (1) the Point Lookout Sandstone of the Cretaceous Mesa Verde Group; and (2) the Quaternary deposits. The Point Lookout Sandstone is known to contain minor deposits of radioactive zircon, monazite, columbium minerals, and radioactive uranium, thorium, and titanium. The uranium deposits of the Point Lookout Sandstone are typically small, isolated occurrences of very low grade uranium. In addition, portions of the Site within the Point Lookout Sandstone consisted of shallow or outcropping bedrock. Therefore, the geology and geomorphology of the Site was conducive to the presence of NORM at or near the ground surface. The Trust assumes that soil/sediment or bedrock was disturbed during historical quarrying activities, which created the TENORM at the Site.
    - Several ephemeral drainage channels are present at the Site, primarily along the northern claim boundary. These channels have the capacity to potentially transport NORM/TENORM to the north, towards the un-named drainage. Several of these drainages contained sediment that exceeded the surface gamma IL for Survey Area B (Quaternary deposits); however, they did not exceed the surface gamma IL in Survey Area A (Point Lookout sandstone).
- Disturbance Mapping
    - Two disturbed areas were mapped on the Site that were inclusive of the northeastern drainage and approximately 50 percent of the mesa top. The disturbed areas showed signs of being scraped/levelled by machinery for the gravel quarry. Disturbances were not generally observed in the vicinity of Ridges 1-4, located in the northwestern portion of the Site.

  - Six potential stockpiles associated with portions of the disturbed areas were mapped at the Site. The potential stockpiles generally consisted of gravel and rock debris that was likely related to historical quarrying activities.

  - Visual evidence of an excavation area was observed in the vicinity of PS-4. The excavation cut was approximately 8.0 ft high and the ground adjacent to the excavation cut appeared to have been levelled by machinery.

  - There was visual evidence of a potential grazing area located in the southeastern portion of the Site. The area was a large, sparsely vegetated, flat surface made up of poorly graded material. Sprinkler system parts and a T-post were also observed by field personnel in this area; however, the sprinkler system parts were not hooked up to a water source.

  - One potential haul road was observed at the Site that ran south from Svc Rte 9, towards the Site. The potential haul road split off into two branches near the 100-ft claim buffer; the western branch continued south and was coincident with DA-1 within the drainage channel, and terminated on the mesa top. The eastern branch of the potential haul road ran southeast along the claim boundary for approximately 350 feet where it then turned to the south and terminated at the excavation area.

- Site Characterization:

  - DA-1 was located primarily on the mesa top, included portions of Survey Area A and Survey Area B, and encompassed PS-1, -2, -4, -5, and -6. The highest surface and subsurface gamma measurements for the Site were associated with a DA-1 on Ridge 5, and all but one soil/sediment sample location within DA-1 exceeded one or more IL (metals or Ra-226). The greatest metals or Ra-226 IL exceedances for the Site were from sample locations on Ridge 5 and Ridge 6.

  - DA-2 and PS-3 were located in the plains just north of the eastern branch of the potential haul road, and were located in Survey Area A. The surface gamma measurements did not exceed the IL in this area, and the surface soil sample collected adjacent to the disturbed area had uranium and Ra-226 IL concentrations that were less than two times their respective ILs.

  - The potential haul road and drainages located along the northern mesa sidewall that extended north into the surrounding plains included portions of Survey Areas A and B. Surface gamma measurements collected along the haul road generally exceeded the surface gamma IL for Survey Area B.

  - No mine waste was observed at the Site. TENORM present at the Site is from historical gravel quarrying operations.

  - Gamma survey measurements exceeded the surface gamma IL in the area of scattered debris located within Survey Area B.

  - Metals concentrations in samples collected outside the area of TENORM (13 locations) were less than or within the regional concentration values.

  - A subsurface static gamma IL was not established for Survey Area A and soil/sediment sample locations in Survey Area B were outside the TENORM boundary. Subsurface static gamma ILs were not used to delineate the vertical extent of TENORM that exceeded the IL in borehole locations at the Site.

The area of the Site considered to contain TENORM (i.e., multiple lines of evidence indicated or suggested the presence of impacts related to historical quarrying) was 15.6 acres, as shown on Figure 4-8a. Portions of the TENORM exceeded one or more IL, where approximately 9.1 acres contained TENORM that exceeded the surface gamma IL and the majority of the sample locations where Ra-226 and/or metals ILs were exceeded. TENORM exceeding the ILs was observed at two sample locations that were not coincident with areas of the Site that exceeded the surface gamma IL. TENORM that exceeded the ILs in Survey Area A and Survey Area B is shown on Figures 4-8b and 4-8c, respectively, and is compared to quarrying-related features in Figure 4-8d.

In addition, there were three areas that exceeded the surface gamma IL, but were not included in the TENORM boundary. These areas were located: (1) on the mesa top, sidewall and surrounding plains, approximately coincident with Ridges 1-4; (2) in areas outside the northeast claim boundary; and (3) in an area outside the southern claim boundary. There were no indications of disturbance due to historical quarrying activities in these areas; therefore, these areas are considered NORM.

4.7 TENORM VOLUME ESTIMATE

The volume estimate of TENORM that exceeded one or more IL is approximately 15,450 yd^3, as shown in Figure 4-9. The volume and area of TENORM associated with specific Site features is listed in Table 3-3. This estimate was calculated using ESRI ArcGIS Desktop 10.3.1 Spatial Analyst Extension cut/fill tool (ESRI, 2017) utilizing the 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 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 4-9. The assumptions that were used to calculate the volume of TENORM with IL exceedances were as follows:

General Assumptions

- Subsurface bedrock encountered in boreholes was not previously modified by human activity and is therefore assumed to be NORM.
- Exposed bedrock surfaces that did not show apparent signs of historical quarrying (scraping, levelling or clearing) were assumed to be unmodified by quarrying activities.

- The graded potential grazing area was not confirmed to be related to current site use and, therefore, it was assumed to be TENORM.

Group Assumptions

- Group 1 (5,834 yd^3) – a polygon was best fit around the area of TENORM on the Site where earthworks occurred, excluding the potential haul roads and PS-4 and PS-6. TENORM was assumed to extend to 0.5 ft bgs based on field personnel observations. Field personnel observations included borehole depths, the extent of visible disturbance on the surface, and the extent of bedrock visible at the surface. PS-5 was included in this polygon because TENORM in the area of PS-5 was assumed to extend to 0.5 ft bgs.

- Group 2 (7,201 yd^3) – PS-4 was estimated to contain 7,201 yd^3 of TENORM. The lateral extent of PS-4 was estimated based on field observations (e.g., the visible change in surface soil color between PS-4 and the corral to the west) and the contours in the area of PS-4 (refer to Figure 2-4). Contours of the depth of the potential stockpile were created to support this volume calculation through interpretation of the topographic contours (Cooper, 2017). The contours were based on: (1) an assumption that bedrock beneath the potential stockpile was a planar surface; (2) an assumption that all material within the footprint of the potential stockpile was stockpiled material; and (3) review of oblique imagery in Google Earth (Google Earth, 2018).

- Group 3 (286 yd^3) – PS-6 was estimated to contain 286 yd^3 of TENORM. The lateral extent of PS-6 was estimated based on field observations, including the presence of a standalone pile. Contours of the depth of the potential stockpile were created to support this volume calculation through interpretation of the topographic contours (Cooper, 2017) and bedrock being encountered at 1.2 ft bgs in one borehole (S10006-SCX-005) in the stockpile. The contours were based on: (1) an assumption that bedrock beneath the potential stockpile was a planar surface; (2) an assumption that all material within the footprint of the potential stockpile was stockpiled material; and (3) review of oblique imagery in Google Earth (Google Earth, 2018).

- Group 4 (283 yd^3) – based on field observations, TENORM in the area of the potential haul road was estimated to extend to 0.5 ft bgs. The haul road followed existing topography (i.e., fill material did not appear to have been used to create portions of the road).

- Group 5 (958 yd^3) – based on field observations, TENORM in the area of the drainages was estimated to extend to 1.0 ft bgs.

- Group 6 (888 yd^3) – A polygon was best fit around a portion of the potential haul road and adjacent disturbed areas that access the Site. The polygon was best fit based on field observations, and the area was identified as Site access on Figure 4-9. TENORM in soil within the Site access polygon is estimated to extend to an average of 1.5 ft bgs based on the molybdenum concentrations exceeding the IL observed in the S10006-SCX-001 borehole.

4.8 WELL WATER AND SURFACE WATER ANALYTICAL RESULTS

The well water and surface water samples collected as part of the Site Characterization activities was analyzed for the constituents listed in Section 3.3.2.3 to evaluate potential quarrying-related impacts. Three of the six potential water features were sampled. The locations of these water features are shown in Figure 2-1 and included the following:

- Water well 15T-529 (sample S10006-WL-001) located 0.88 miles northwest of the Site
- Water well 15T-538 (sample S10006-WL-002) located 1.0 miles southeast of the Site
- Overflow pond 15T-538 Pond (sample S10006-WS-001) associated with water well 15T-538

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

Analytical results indicated the surface water sample (S10006-WS-001) had a total arsenic concentration of 11 micrograms per liter (µg/L), which exceeded the arsenic IL (10 µg/L) by approximately 10 percent. All other metals and radionuclides were below their respective ILs in the three water samples. Results of general chemistry parameters indicated that TDS and sulfate were above their respective ILs in the three water samples. Based on these results, arsenic, TDS, and sulfate are confirmed COPCs for pond 15T-538 Pond. TDS and sulfate are confirmed COPCs for water wells 15T-529 and 15T-538. Because arsenic, TDS, and sulfate exceeded their respective ILs for the surface water sample, further characterization may be necessary at pond 15T-538 Pond to evaluate potential quarrying-related impacts. Because TDS and sulfate exceeded their respective ILs for the well water samples, further characterization may be necessary at water wells 15T-529 and 15T-538 to evaluate potential quarrying-related impacts. 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

Five 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. Salinity was not collected as part of the specified field measurements at two of the water sample locations because the water quality meter the field personnel were using could not measure salinity.
2. The approximate center-line of the potential haul road that runs north from the Site was surveyed, but the shoulders of the potential haul road were not surveyed.
3. The gamma survey was not extended in Survey Area B until gamma measurements were less than the surface gamma IL.

4. The gamma survey was not extended laterally from the drainages or the potential haul road where gamma measurements were greater than the IL.

5. Subsurface static gamma data for BG-1 is needed to determine a subsurface static gamma IL for Survey Area A.

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 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 database that the USEPA reviewed. It is recommended that the two databases are compared (with additional field work, if necessary) to confirm the locations of water features.

2. The Agencies suggested that additional study may be required to develop a background reference area for the Point Lookout Sandstone on the mesa top and mesa sidewall (NNEPA, 2018).

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

4. Subsurface samples were not collected in the potential haul road, PS-2, and PS-5. Further evaluation of the potential stockpiles and potential haul road may be required in the future.

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

5.0 SUMMARY AND CONCLUSIONS

This report details the purpose and objectives, field investigation activities, findings, and conclusions of the Site Clearance and RSE activities conducted for the Site between August 2015 and August 2017. The Site is known as the Standing Rock site and is also identified by the USEPA as AUM identification #1006 in the *2007 AUM Atlas*.

The primary objectives of the RSE are to provide data (e.g., review relevant information and collect data related to historical mining activities) required to evaluate relevant Site conditions and to support future Removal or Remedial Action evaluations at the Site. It is not intended to establish cleanup levels or determine cleanup options or potential remedies. The purpose of the RSE data are to determine the volume of TENORM at the Site in excess of ILs as a result of historical mining activities. ILs are based on the background gamma measurements (in cpm), and Ra-226 and metals concentrations, determined through statistical analyses, that are used to evaluate potential mining-related impacts. To meet these objectives, the RSE included historical data review, visual observations, surface gamma surveys, surface and subsurface static gamma measurements, and soil/sediment sampling and analyses. An estimate of areas containing TENORM was made based on an evaluation of the RSE information/data and multiple lines of evidence. Given that there is no evidence of historical uranium mining, TENORM that meets the USEPA definition (refer to Glossary) is the result of the impacts from historical quarrying that may have dispersed uranium contaminated rock and soils.

Surface water and well water samples were also collected as part of the RSE to evaluate potential quarrying-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.

The Site is located in a region of beach-placer sandstone deposits known as the Point Lookout Sandstone. The Point Lookout Sandstone is known to contain minor natural deposits of radioactive zircon, monazite, columbium minerals, and radioactive uranium, thorium, and titanium. The uranium deposits of the Point Lookout Sandstone are typically small, isolated occurrences of very low-grade uranium, and the uranium could only be considered as a minimal co-product (i.e., below the minimum economic grade and tonnage requirements). Based on the historical document review for the Site, the following is known about historical exploration and mining activities at the Site: (1) chip samples were collected from a bedrock outcrop during the 1957 reconnaissance; (2) the Site was not economically viable for titanium or zircon mining; (3) mining for uranium never occurred on the Site; and (4) the only production reported at the Site was for road gravel (referred to as road metal on page 396 of McLemore, 1983). In addition, local residents stated that they did not know of a historical uranium mine having been located at the Site, and the only historical "mining" the residents were aware of was the development of a gravel quarry located on top of Flat Top Hill. The residents recalled that material from the gravel quarry was used in the late 1960s and 1970s for paving Navajo Service Route 9 (Svc Rte 9). **Based on this historical information, it appears that the Site was not a uranium mine.**

Three potential background reference areas were considered. Two background reference areas (BG-1 and BG-2) were selected to develop surface gamma, Ra-226, and metals ILs for the two Survey Areas (Survey Areas A and B) at the Site. Subsurface static gamma ILs were developed for Survey Area A using on-site borehole location S10006-SCX-009 and for Survey Area B using the borehole located in BG-2 (S10006-BG2-011). Borehole S10006-SCX-009 was within Survey Area A and upwind from any disturbed areas. Since this location is close to disturbances at the Site, it technically does not meet MARSSIM criteria, but it is still considered useful as a subsurface IL to compare to the other subsurface static gamma measurements. This was a modification to the *RSE Work Plan*.

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

Surface gamma measurements, and Ra-226 and metals concentrations, were generally highest in areas that were coincident with the disturbed areas and potential stockpiles. The maximum surface gamma measurement (73,651 cpm) was detected in Survey Area A, within DA-1 located on Ridge 5, and was less than three times the surface gamma IL for Survey Area A. The highest Ra-226 and metals concentrations were detected in soil samples within DA-1, and coincident with Ridge 5 and Ridge 6.

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

Based on the data analysis performed for this RSE report, along with the supporting lines of evidence, approximately 15.6 acres out of the 56.8 acres of the Survey Area were estimated to contain TENORM. **The TENORM is the result of gravel quarrying and not uranium mining.** This estimate is inclusive of three areas: (1) DA-1; (2) DA-2; and (3) the potential haul road and drainages located north of the northern claim boundary. The areas outside of the TENORM boundary show no signs of disturbance due to historical quarrying activities and are considered NORM (i.e., naturally occurring). Of the 15.6 acres that contained TENORM, 9.1 acres contain TENORM that exceeded the ILs. The volume of unconsolidated TENORM that exceeded ILs is estimated to be 15,450 yd^3 (11,812 cubic meters). An important consideration is that the areas considered NORM had COPC concentrations that generally did not exceed the Ra-226 or metals ILs.

A surface water sample was collected from pond15T-538 Pond and analytical results from the sample (S10006-WS-001) indicated arsenic, TDS, and sulfate were above their respective ILs. All other general chemistry parameters, metals, and radionuclides were below their respective ILs in the surface water sample. Well water samples were collected from water wells 15T-529 and 15T-538 and analytical results from the samples (S10006-WL-001 and S10006-WL-002) indicated that TDS and sulfate were above their respective ILs in the two well water samples. All metals and radionuclides were below their respective ILs in the well water samples and all other general chemistry parameters were below their respective ILs in the well water samples. Based on these results, arsenic, TDS, and sulfate are confirmed COPCs for pond 15T-538 Pond. TDS and sulfate are confirmed COPCs for water wells 15T-529 and 15T-538. Because arsenic, TDS, and sulfate exceeded their respective ILs for the surface water sample, further characterization may be necessary at pond 15T-538 Pond to evaluate potential quarrying-related impacts. Because TDS and sulfate exceeded their respective ILs for the well water samples, further characterization may be necessary at water wells 15T-529 and 15T-538 to evaluate potential quarrying-related impacts.

Five 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 Standing Rock 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 Standing Rock RSE were $613,150. In addition, Administrative costs provided by the Trust were estimated currently at $191,500[6,7]. Administrative costs will change due to continued community outreach and close out activities.

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[6] This cost is based on an approved budget of May 8, 2018; Administrative work, including community communications, are not yet complete.

[7] Administrative costs were averaged across all Sites.

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TABLES

Table 3-1a
Identified Water Features
Standing Rock
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Identified Water Feature	Source of Identified Water Feature	Water Feature Identification	Field Sample Identification	Field Personnel Observations
Well	2007 AUM Atlas[1], NNDWR	15T-529/Well/1082195	S10006-WL-001	Windmill well identified during the desktop study. This location was sampled as part of the RSE on November 10, 2016, sample location ID S10006-WL-001. Location 1082195 is the water trough or water valve box associated with the windmill well.
Well	2007 AUM Atlas[1], NNDWR	15T-538	S10006-WL-002	Windmill well identified during the desktop study. This location was sampled as part of the RSE on May 25, 2017, sample location ID S10006-WL-002
Well - Pond	Stantec	15T-538 Pond	S10006-WS-001	Overflow pond associated with 15T-538 well and identified during site mapping. This location was sampled as part of the RSE on May 25, 2017, sample location ID S10006-WS-001
Temporary Ponding Area	Stantec	Eastern Temporary Ponding Area	NA	Eastern temporary ponding area created by drainage channel that was blocked by earthen dam. Pooled water was not observed by field personnel at this location during RSE activities
Temporary Ponding Area	Stantec	Western Temporary Ponding Area	NA	Western temporary ponding area created by drainage channel that was blocked by earthen dam. Pooled water was not observed by field personnel at this location during RSE activities
No Feature	2007 AUM Atlas[1]	1082274/Well	NA	No well or surface water observed in this area. Water feature identified during the desktop study.

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
15T-529 and 15T-538
Standing Rock
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Description	Water Well Information
Tribal Well Number	15T-529
Easting[1]	742425
Northing[1]	3959959
Operator	Tribe Operations and Maintenance
Well Completed Date	12/10/1969
Elevation (ft amsl)	6,743
Well Depth (ft bgs)	1,294
Well Type	Water Well
Well Status	Active
Well Use	Livestock
Well Borehole Diameter (inches)	13.36
Well Casing Diameter (inches)	10.75 inches from 0.9 ft ags to 26 ft bgs, 7 inches from 26 to1,292 ft bgs
Top of Well Casing (ft ags)	0.9
Bottom of Well Casing (ft bgs)	1,292
Well Build Material	Steel
Top of Well Screen Perforation (ft bgs)	1,096
Bottom of Well Screen Perforation (ft bgs)	1,292

Description	Water Well Information
Tribal Well Number	15T-538
Easting[1]	744423
Northing[1]	3957075
Operator	Tribe Operations and Maintenance
Well Completed Date	10/10/1972
Elevation (ft amsl)	6,880
Well Depth (ft bgs)	971
Well Type	Water Well
Well Status	Active
Well Use	Domestic
Well Borehole Diameter (inches)	8.75
Well Casing Diameter (inches)	6.62 inches from 2.2 ft ags to 971 ft bgs
Top of Well Casing (ft ags)	2.2
Bottom of Well Casing (ft bgs)	971
Well Build Material	Steel
Top of Well Screen Perforation (ft bgs)	908
Bottom of Well Screen Perforation (ft bgs)	971

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
Standing Rock
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									Sample Types		
Sample Location	Sample Depth (ft bgs)	Sample Media	Sample Category	Sample Collection Method	Survey Area	Sample Date	Easting ¹	Northing ¹	Metals, Total	Ra-226	Thorium
Background Reference Area Study - Background Area 1											
S10006-BG1-001	0 - 0.5	soil	SF	grab	NA	3/24/2017	741807.08	3960317.05	N;FD;MS;MSD	N;FD	N;FD
S10006-BG1-002	0 - 0.5	soil	SF	grab	NA	3/24/2017	741808.12	3960319.60	N	N	N
S10006-BG1-003	0 - 0.5	soil	SF	grab	NA	3/24/2017	741807.15	3960321.16	N	N	N
S10006-BG1-004	0 - 0.5	soil	SF	grab	NA	3/24/2017	741804.93	3960317.35	N	N	N
S10006-BG1-005	0 - 0.5	soil	SF	grab	NA	3/24/2017	741804.48	3960318.94	N	N	N
S10006-BG1-006	0 - 0.5	soil	SF	grab	NA	3/24/2017	741804.89	3960320.49	N	N	N
S10006-BG1-007	0 - 0.5	soil	SF	grab	NA	3/24/2017	741802.12	3960318.84	N	N	N
S10006-BG1-008	0 - 0.5	soil	SF	grab	NA	3/24/2017	741801.53	3960321.18	N	N	N
S10006-BG1-009	0 - 0.5	soil	SF	grab	NA	3/24/2017	741800.53	3960320.55	N	N	N
S10006-BG1-010	0 - 0.5	soil	SF	grab	NA	3/24/2017	741804.42	3960322.69	N	N	N
S10006-BG1-011	0 - 0.5	soil	SF	grab	NA	3/24/2017	741803.66	3960320.01	N	N	N
Background Reference Area Study - Background Area 2											
S10006-BG2-001	0 - 0.5	soil	SF	grab	NA	8/29/2017	741792.68	3960261.68	N	N	--
S10006-BG2-002	0 - 0.5	soil	SF	grab	NA	8/29/2017	741794.65	3960258.75	N	N	--
S10006-BG2-003	0 - 0.5	soil	SF	grab	NA	8/29/2017	741797.91	3960258.20	N	N	--
S10006-BG2-004	0 - 0.5	soil	SF	grab	NA	8/29/2017	741793.64	3960255.46	N	N	--
S10006-BG2-005	0 - 0.5	soil	SF	grab	NA	8/29/2017	741789.33	3960255.52	N;MS;MSD	N	--
S10006-BG2-006	0 - 0.5	soil	SF	grab	NA	8/29/2017	741788.05	3960257.83	N	N	--
S10006-BG2-007	0 - 0.5	soil	SF	grab	NA	8/29/2017	741786.98	3960252.52	N	N	--
S10006-BG2-008	0 - 0.5	soil	SF	grab	NA	8/29/2017	741788.95	3960249.95	N	N	--
S10006-BG2-009	0 - 0.5	soil	SF	grab	NA	8/29/2017	741793.03	3960249.45	N;FD	N;FD	--
S10006-BG2-010	0 - 0.5	soil	SF	grab	NA	8/29/2017	741794.73	3960252.05	N	N	--
S10006-BG2-011	0 - 0.5	soil	SF	grab	NA	8/29/2017	741791.43	3960253.49	N	N	--
S10006-BG2-011	0.5 - 1.5	soil	SB	grab	NA	8/29/2017	741791.43	3960253.49	N	N	--
Correlation											
S10006-C01-001	0 - 0.5	soil	SF	5-point composite	NA	11/18/2016	743860.18	3959239.75	--	N;FD	N;FD
S10006-C02-001	0 - 0.5	soil	SF	5-point composite	NA	11/18/2016	743757.82	3959131.05	--	N	N
S10006-C03-001	0 - 0.5	soil	SF	5-point composite	NA	11/18/2016	743809.33	3959069.76	--	N	N
S10006-C04-001	0 - 0.5	soil	SF	5-point composite	NA	11/18/2016	744083.92	3959073.51	--	N	N
S10006-C05-001	0 - 0.5	soil	SF	5-point composite	NA	11/18/2016	744110.54	3958891.97	--	N	N
Characterization											
S10006-CX-001	0 - 0.5	soil	SF	grab	A	5/9/2017	743985.97	3959016.90	N	N	N
S10006-CX-002	0 - 0.5	soil	SF	grab	A	5/9/2017	744042.08	3959078.80	N	N	N
S10006-CX-003	0 - 0.5	soil	SF	grab	A	5/9/2017	743965.52	3959146.62	N;FD	N;FD	N;FD
S10006-CX-004	0 - 0.5	soil	SF	grab	A	5/9/2017	743880.03	3959145.45	N	N	N
S10006-CX-005	0 - 0.5	soil	SF	grab	A	5/9/2017	743791.47	3959182.65	N	N	N
S10006-CX-006	0 - 0.5	soil	SF	grab	A	5/9/2017	743709.54	3959116.48	N	N	N
S10006-CX-007	0 - 0.5	soil	SF	grab	A	5/9/2017	743612.97	3959156.40	N	N	N
S10006-CX-008	0 - 0.5	sediment	SF	grab	A	5/9/2017	743515.82	3959370.08	N;MS;MSD	N	N
S10006-CX-009	0 - 0.5	sediment	SF	grab	A	5/9/2017	743560.25	3959300.09	N	N	N
S10006-CX-010	0 - 0.5	soil	SF	grab	B	5/9/2017	743947.03	3959239.64	N	N	N
S10006-CX-011	0 - 0.5	soil	SF	grab	A	5/9/2017	744007.96	3959142.87	N	N	N
S10006-CX-012	0 - 0.5	soil	SF	grab	A	5/9/2017	744011.46	3959155.97	N	N	N

Notes

--	Not Sampled
N	Normal
FD	Field Duplicate
MS	Matrix Spike
MSD	Matrix Spike Duplicate
Ra-226	Radium 226
NA	Not Applicable
SB	Subsurface Sample
SF	Surface Sample
ft bgs	feet below ground surface
¹ Coordinate System:	NAD 1983 UTM Zone 12N

Table 3-2
Soil and Sediment Sampling Summary
Standing Rock
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									Sample Types		
Sample Location	Sample Depth (ft bgs)	Sample Media	Sample Category	Sample Collection Method	Survey Area	Sample Date	Easting ¹	Northing ¹	Metals, Total	Ra-226	Thorium
Characterization continued											
S10006-SCX-001	0 - 0.5	sediment	SF	grab	A	5/10/2017	743916.35	3959148.76	N	N	N
S10006-SCX-001	0.5 - 1.5	sediment	SB	grab	A	5/10/2017	743916.35	3959148.76	N	N	--
S10006-SCX-001	1.5 - 2.0	sediment	SB	grab	A	5/10/2017	743916.35	3959148.76	N	N	--
S10006-SCX-002	0 - 0.2	soil	SF	grab	A	5/11/2017	744041.02	3959026.89	N	N	N
S10006-SCX-004	0 - 0.5	sediment	SF	grab	B	5/11/2017	744129.22	3958907.41	N	N	N
S10006-SCX-004	0.5 - 2.0	sediment	SB	composite	B	5/11/2017	744129.22	3958907.41	N	N	--
S10006-SCX-005	0 - 0.5	soil	SF	grab	A	5/11/2017	743892.93	3959009.25	N	N	N
S10006-SCX-005	0.5 - 1.1	soil	SB	grab	A	5/11/2017	743892.93	3959009.25	N	N	--
S10006-SCX-006	0 - 0.4	soil	SF	grab	A	5/11/2017	743770.20	3959102.80	N	N	N
S10006-SCX-007	0 - 0.5	soil	SF	grab	A	5/11/2017	743814.15	3959095.70	N;FD	N;FD	N;FD
S10006-SCX-007	0.5 - 0.8	soil	SB	grab	A	5/11/2017	743814.15	3959095.70	N	N	--
S10006-SCX-008	0 - 0.5	sediment	SF	grab	B	5/11/2017	743580.41	3959162.17	N;MS;MSD	N	N
S10006-SCX-008	1 - 1.5	sediment	SB	grab	B	5/11/2017	743580.41	3959162.17	N	N	--
S10006-SCX-009	0 - 0.5	soil	SF	grab	A	5/11/2017	743514.06	3959320.53	N	N	N
S10006-SCX-009	0.5 - 1.0	soil	SB	grab	A	5/11/2017	743514.06	3959320.53	N	N	--
S10006-SCX-010	0 - 0.5	sediment	SF	grab	A	5/11/2017	743516.83	3959380.94	N	N	N
S10006-SCX-010	0.5 - 1.0	sediment	SB	grab	A	5/11/2017	743516.83	3959380.94	N	N	--
S10006-SCX-011	0 - 0.5	soil	SF	grab	A	5/11/2017	743568.30	3959333.73	N	N	N
S10006-SCX-011	0.5 - 0.9	soil	SB	grab	A	5/11/2017	743568.30	3959333.73	N	N	--
S10006-SCX-012	0 - 0.5	soil	SF	grab	A	5/11/2017	743582.34	3959300.99	N	N	N
S10006-SCX-013	0 - 0.5	sediment	SF	grab	A	5/11/2017	743611.66	3959269.59	N;FD	N;FD	N
S10006-SCX-013	0.5 - 1.0	sediment	SB	grab	A	5/11/2017	743611.66	3959269.59	N	N	--
S10006-SCX-014	0 - 0.3	soil	SF	grab	A	5/11/2017	743784.63	3959175.41	N	N	N
S10006-SCX-015	0 - 0.5	soil	SF	grab	A	5/11/2017	743811.91	3959228.08	N	N	N
S10006-SCX-015	0.5 - 1.0	soil	SB	grab	A	5/11/2017	743811.91	3959228.08	N	N	--
S10006-SCX-016	0 - 0.5	soil	SF	grab	A	5/11/2017	744003.05	3959137.20	N	N	N
S10006-SCX-016	0.5 - 1.0	soil	SB	grab	A	5/11/2017	744003.05	3959137.20	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
Site Feature Samples and Area
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Mine Feature	Surface Samples	Subsurface Samples	Area (sq. ft)	Volume of TENORM exceeding ILs (yd^3)
Potential Stockpile 1	0	0	17,807	NA
Potential Stockpile 2	1	0	1,593	30
Potential Stockpile 3	0	0	7,832	NA
Potential Stockpile 4	3	1	20,653	7,201
Potential Stockpile 5	0	0	3,938	73
Potential Stockpile 6	1	1	3,446	286
Disturbed Area 1	11*	5*	352,515	14,161
Disturbed Area 2	0	0	8,434	NA
Scattered Debris	0	0	3,123	--
Potential Haul Roads	0	0	15,298	283
Drainages	7	6	5,025	93
Excavation	0	0	1019	76

Notes

sq.ft - square feet

yd^3 - cubic yards

ILs - investigation levels

TENORM - technologically enhanced naturally occurring radioactive material

-- Discrete volume was not identified for feature

NA - Not applicable - TENORM did not exceed ILs within feature boundary

* - Sample counts include samples collected within the potential stockpiles and drainages mapped within Disturbed Area 1

Table 3-4
Water Sampling Summary
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					Sample Types							
Field Sample Identification	Water Feature Identification	Sample Date	Easting[1]	Northing[1]	Ra-226	Ra-228	Gross Alpha	Metals, Dissolved[2]	Metals, Total[2]	TDS	Anions	Cations
Surface Water												
S10006-WS-001	15T-538 Pond	5/25/2017	744456.12	3957233.70	N	N	N	N	N	N	N	N
Well Water												
S10006-WL-001	15T-529/Well/1082195	11/10/2016	742411.62	3959969.11	N;FD	N;FD	N;FD	N;FD;MS;MSD	N;FD;MS;MSD	N;FD	N;FD	N;FD
S10006-WL-002	15T-538	5/25/2017	744365.29	3957288.46	N	N	N	N	N	N	N;MS;MSD	N;MS;MSD

Notes

--	Not Sampled
N	Normal
FD	Field Duplicate
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] Mercury analysis also included laboratory MS/MSD, all other metals analyses did not include laboratory MS/MDS

Table 4-1
Background Reference Area Soil Sample Analytical Results
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Location Identification	S10006-BG1-001 Dup	S10006-BG1-001	S10006-BG1-002	S10006-BG1-003	S10006-BG1-004	S10006-BG1-005	S10006-BG1-006	S10006-BG1-007	S10006-BG1-008	S10006-BG1-009
Date Collected	3/24/2017	3/24/2017	3/24/2017	3/24/2017	3/24/2017	3/24/2017	3/24/2017	3/24/2017	3/24/2017	3/24/2017
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Analyte (Units)										
Metals[1] (mg/kg)										
Arsenic	2.9	3 J-	4	3.6	3.2	2.6	2.8	3.3	3.1	3.4
Molybdenum	0.63	0.66	0.6	0.57	0.53	0.47	0.51	0.51	0.57	0.51
Selenium	1.6	1.7 J-	1.6	1.2	1.9	1.9	2.2	1.7	1.5	2.5
Uranium	3.2	3.3	3.2	2.4	3	2.6	2.4	2.7	2.4	3.7
Vanadium	300	300	370	260	400	310	230	330	260	480
Radionuclides (pCi/g)										
Radium-226	4.05 ± 0.61	3.48 ± 0.51	5.09 ± 0.72	4.02 ± 0.58	4.21 ± 0.62 J-	4.52 ± 0.68	3.02 ± 0.49	3.27 ± 0.49 J-	2.42 ± 0.4 J-	6.56 ± 0.91
Thorium-228	5.01 ± 0.81	4.91 ± 0.79	7.5 ± 1.2	4.31 ± 0.7	6.11 ± 0.98	6.9 ± 1.1	4.24 ± 0.69	5.55 ± 0.9	3.36 ± 0.55	9.8 ± 1.5
Thorium-230	2.39 ± 0.4	2.3 ± 0.39	3.38 ± 0.56	2.18 ± 0.37	2.8 ± 0.47	2.95 ± 0.49	1.98 ± 0.34	2.6 ± 0.44	1.8 ± 0.31	3.87 ± 0.62
Thorium-232	4.59 ± 0.74	4.21 ± 0.68	6.7 ± 1.1	3.93 ± 0.64	5.4 ± 0.87	6.3 ± 1	3.85 ± 0.62	5.24 ± 0.84	2.99 ± 0.49	8.8 ± 1.4

Notes

Bold	Bolded result indicates positively identified compound
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
--	Not scheduled
J-	Data are estimated and are potentially biased low 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 4-1
Background Reference Area Soil Sample Analytical Results
Standing Rock
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Location Identification	S10006-BG1-010	S10006-BG1-011	S10006-BG2-001	S10006-BG2-002	S10006-BG2-003	S10006-BG2-004	S10006-BG2-005	S10006-BG2-006	S10006-BG2-007	S10006-BG2-008
Date Collected	3/24/2017	3/24/2017	8/29/2017	8/29/2017	8/29/2017	8/29/2017	8/29/2017	8/29/2017	8/29/2017	8/29/2017
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
Analyte (Units)										
Metals[1] (mg/kg)										
Arsenic	3.5	3.2	3.3	3.5	3.9	4.6	3.7	3	3.9	3.6
Molybdenum	0.66	0.55	0.28	0.36	0.4	0.5	0.36	0.3	0.37	0.32
Selenium	1.7	1.9	< 1	< 0.99	< 1	< 0.96	< 1	< 0.94	< 0.95	< 1
Uranium	3.6	2.6	0.66	0.59	0.59	0.59	0.73	0.47	0.67	0.56
Vanadium	370	270	66	49	54	57	74	43	74	56
Radionuclides (pCi/g)										
Radium-226	4.51 ± 0.67	3.43 ± 0.52	1.14 ± 0.27	1 ± 0.28	1.11 ± 0.25	1.09 ± 0.24	1.1 ± 0.27	0.82 ± 0.25	1.25 ± 0.25	1.06 ± 0.27
Thorium-228	5.49 ± 0.88	4.83 ± 0.78	--	--	--	--	--	--	--	--
Thorium-230	2.51 ± 0.42	2.32 ± 0.39	--	--	--	--	--	--	--	--
Thorium-232	4.7 ± 0.76	4.39 ± 0.71	--	--	--	--	--	--	--	--

Notes

Bold	Bolded result indicates positively identified compound
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
--	Not scheduled
J-	Data are estimated and are potentially biased low 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 4-1
Background Reference Area Soil Sample Analytical Results
Standing Rock
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Location Identification	S10006-BG2-009	S10006-BG2-009 Dup	S10006-BG2-010	S10006-BG2-011	S10006-BG2-011
Date Collected	8/29/2017	8/29/2017	8/29/2017	8/29/2017	8/29/2017
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.5
Analyte (Units)					
Metals[1] (mg/kg)					
Arsenic	3.7	3.6	3.5	4	3.8
Molybdenum	0.32	0.35	0.34	0.41	0.42
Selenium	< 0.99	< 0.99	< 0.97	< 1	< 1
Uranium	0.46	0.46	0.43	0.6	0.89
Vanadium	36	38	34	58	90
Radionuclides (pCi/g)					
Radium-226	0.68 ± 0.22	0.92 ± 0.22	0.75 ± 0.24	0.93 ± 0.25	1.93 ± 0.38
Thorium-228	--	--	--	--	--
Thorium-230	--	--	--	--	--
Thorium-232	--	--	--	--	--

Notes

Bold	Bolded result indicates positively identified compound
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
--	Not scheduled
J-	Data are estimated and are potentially biased low 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 4-2
Static Gamma Measurement Summary
Standing Rock
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Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S10006-BG1-011	Background Area 1	*	0.0	soil	23,707
S10006-BG1-011	Background Area 1	*	0.5	soil	60,378**
S10006-BG2-011	Background Area 2	*	0.5	soil	20,613
S10006-BG2-011	Background Area 2	*	1.0	soil	24,598
S10006-BG2-011	Background Area 2	*	1.5	soil	28,823
S10006-SCX-001	A	--	0.0	sediment	27,561
S10006-SCX-001	A	NA	0.5	sediment	35,690
S10006-SCX-001	A	NA	1.0	sediment	33,236
S10006-SCX-001	A	NA	1.5	sediment	30,316
S10006-SCX-001	A	NA	1.9	sediment	29,413
S10006-SCX-002	A	--	0.0	soil	26,794
S10006-SCX-002	A	NA	0.2	soil	37,545**
S10006-SCX-003	A	--	0.0	soil	25,641
S10006-SCX-003	A	NA	0.3	soil	32,081**
S10006-SCX-005	A	--	0.0	soil	42,212
S10006-SCX-005	A	NA	0.5	soil	71,021
S10006-SCX-005	A	NA	1.1	soil	86,564**
S10006-SCX-006	A	--	0.0	soil	31,057
S10006-SCX-006	A	NA	0.4	soil	30,775
S10006-SCX-007	A	--	0.0	soil	21,972
S10006-SCX-007	A	NA	0.8	soil	30,775**
S10006-SCX-009	A	--	0.0	soil	17,217
S10006-SCX-009	A	NA	0.5	soil	24,059
S10006-SCX-009	A	NA	1.0	soil	26,053
S10006-SCX-009	A	NA	1.5	soil	23,787
S10006-SCX-009	A	NA	2.1	soil	23,624**
S10006-SCX-010	A	--	0.0	sediment	27,243
S10006-SCX-010	A	NA	0.5	sediment	39,588
S10006-SCX-010	A	NA	1.0	sediment	48,368**
S10006-SCX-011	A	--	0.0	soil	22,048
S10006-SCX-011	A	NA	0.5	soil	31,583
S10006-SCX-011	A	NA	0.9	soil	35,367**
S10006-SCX-012	A	--	0.0	soil	25,226
S10006-SCX-012	A	NA	0.5	soil	21,963**

Notes

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

Table 4-2
Static Gamma Measurement Summary
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Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S10006-SCX-013	A	--	0.0	sediment	19,665
S10006-SCX-013	A	NA	0.5	sediment	22,381
S10006-SCX-013	A	NA	1.0	sediment	21,408
S10006-SCX-013	A	NA	1.5	sediment	19,737
S10006-SCX-013	A	NA	1.8	sediment	18,075**
S10006-SCX-014	A	--	0.0	soil	29,927
S10006-SCX-014	A	NA	0.3	soil	27,299**
S10006-SCX-015	A	--	0.0	soil	17,505
S10006-SCX-015	A	NA	0.5	soil	16,136
S10006-SCX-015	A	NA	1.0	soil	15,954
S10006-SCX-015	A	NA	1.5	soil	15,883
S10006-SCX-015	A	NA	2.1	soil	16,075
S10006-SCX-016	A	--	0.0	soil	41,710
S10006-SCX-016	A	NA	0.5	soil	38,823
S10006-SCX-016	A	NA	1.0	soil	29,015
S10006-SCX-016	A	NA	1.3	soil	27,643
S10006-SCX-004	B	--	0.0	sediment	12,745
S10006-SCX-004	B	24,598	0.5	sediment	17,390
S10006-SCX-004	B	24,598	1.0	sediment	20,241
S10006-SCX-004	B	24,598	1.5	sediment	22,094
S10006-SCX-004	B	24,598	2.0	sediment	**24,750****
S10006-SCX-008	B	--	0.0	sediment	13,049
S10006-SCX-008	B	24,598	0.5	sediment	16,741
S10006-SCX-008	B	24,598	1.0	sediment	21,235
S10006-SCX-008	B	24,598	1.5	sediment	**25,310****

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)
NA	A borehole in Survey Area A was not completed, therefore a subsurface static gamma investigation level was not established for Survey Area A
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Table 4-3
Gamma Correlation Study Soil Sample Analytical Results
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Location Identification	S10006-C01-001 Dup	S10006-C01-001	S10006-C02-001	S10006-C03-001	S10006-C04-001	S10006-C05-001
Date Collected	11/18/2016	11/18/2016	11/18/2016	11/18/2016	11/18/2016	11/18/2016
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Analyte (Units)						
Radionuclides (pCi/g)						
Radium-226	1.53 ± 0.34	1.76 ± 0.35	3.62 ± 0.57	6.93 ± 0.97	1.25 ± 0.28	0.68 ± 0.26
Thorium-228	1.55 ± 0.28	1.79 ± 0.33	5.91 ± 0.95	8.6 ± 1.4	1.29 ± 0.22	0.74 ± 0.14
Thorium-230	0.99 ± 0.19	0.96 ± 0.2	2.47 ± 0.42	3.17 ± 0.51	0.98 ± 0.18	0.68 ± 0.13
Thorium-232	1.59 ± 0.28	1.72 ± 0.31	5.79 ± 0.93	8.5 ± 1.3	1.25 ± 0.22	0.72 ± 0.13

Notes

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

Table 4-4a
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area A
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Location Identification		S10006-CX-001	S10006-CX-002	S10006-CX-003	S10006-CX-003 Dup	S10006-CX-004	S10006-CX-005	S10006-CX-006	S10006-CX-007	S10006-CX-008	S10006-CX-009
Date Collected		5/9/2017	5/9/2017	5/9/2017	5/9/2017	5/9/2017	5/9/2017	5/9/2017	5/9/2017	5/9/2017	5/9/2017
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
Sample Category		surface	surface	surface	surface	surface	surface	surface	surface	surface	surface
Sample Collection Method		grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
Media		soil	soil	soil	soil	soil	soil	soil	soil	sediment	sediment
Analyte (Units)											
Metals[1] (mg/kg)	Investigation Level										
Arsenic	4.33	3.4	2.7	3.5	3.2	5.5	4.5	3.6	3.1	2.7	2.4
Molybdenum	0.733	1.2	0.48	0.62	0.66	0.96	0.62	0.55	0.24	0.46	0.49
Selenium	2.78	3.2	<1	3.4	3.6	1.8	4.6	3.7	<0.99	1.3	1.1
Uranium	4.27	2.9	0.99	2.8	2.7	3.6	6.1	2.8	0.79	1.3	0.79
Vanadium	534	200	59	260	250	420	500	360	71	88	42
Radionuclides (pCi/g)											
Radium-226	7.24	5.12 ± 0.74	1.71 ± 0.32	8.8 ± 1.2	9.3 ± 1.2	5.53 ± 0.75	18.6 ± 2.3	7.7 ± 1.1	0.92 ± 0.24 UB	1.58 ± 0.28	0.98 ± 0.24 UB
Thorium-228	--	6.3 ± 1	1.58 ± 0.27	10.7 ± 1.7	10.1 ± 1.6	5.83 ± 0.93	27.9 ± 4.4	13.9 ± 2.2	1.23 ± 0.22	1.87 ± 0.32	1.14 ± 0.2
Thorium-230	--	2.71 ± 0.45 B	0.96 ± 0.18 B	3.99 ± 0.65 B	4.03 ± 0.65 B	3.02 ± 0.49 B	7.7 ± 1.2 B	4.14 ± 0.67 B	0.82 ± 0.16 B	1.03 ± 0.19 B	0.94 ± 0.17 B
Thorium-232	--	5.98 ± 0.96	1.54 ± 0.27	10.2 ± 1.6	10.2 ± 1.6	5.36 ± 0.85	26.6 ± 4.2	12.7 ± 2	1.01 ± 0.18	1.71 ± 0.29	1.11 ± 0.19

Notes

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
--	Not scheduled
[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
B	Analyte detected in an associated blank
J-	Data are estimated and are potentially biased low due to associated quality control data
UB	Analyte considered not detected based on associated blank data

Table 4-4a
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area A
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Location Identification		S10006-CX-011	S10006-CX-012	S10006-SCX-001	S10006-SCX-001	S10006-SCX-001	S10006-SCX-002	S10006-SCX-005	S10006-SCX-005	S10006-SCX-006	S10006-SCX-007
Date Collected		5/9/2017	5/9/2017	5/10/2017	5/10/2017	5/10/2017	5/11/2017	5/11/2017	5/11/2017	5/11/2017	5/11/2017
Depth (feet)		0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.5	1.5 - 2.0	0 - 0.2	0 - 0.5	0.5 - 1.1	0 - 0.4	0 - 0.5
Sample Category		surface	surface	surface	subsurface	subsurface	surface	surface	subsurface	surface	surface
Sample Collection Method		grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
Media		soil	soil	sediment	sediment	sediment	soil	soil	soil	soil	soil
Analyte (Units)											
Metals[1] (mg/kg)	Investigation Level										
Arsenic	4.33	3.8	3.7	3.5	3.3	3.1	4.4	4	3.8	3.1	3.4
Molybdenum	0.733	0.96	0.92	1.3	1.2	1.2	0.75	0.99	0.91	0.27	1.5
Selenium	2.78	3.8	3.5	1.6	1.3	1.5	1.9	4.5	4.1	3.2	2.4
Uranium	4.27	3.5	3.4	4.2	3.2	3.1	3.7	3.6	3.5	1.7	4.1
Vanadium	534	340	330	400	200	220	260	310	340	180	200
Radionuclides (pCi/g)											
Radium-226	7.24	8 ± 1.1	7.37 ± 0.99	3.93 ± 0.58	2.53 ± 0.46	3.25 ± 0.48	3.88 ± 0.6	7.3 ± 1	9.1 ± 1.2	3.07 ± 0.49	3.26 ± 0.51
Thorium-228	--	10.5 ± 1.7	10.6 ± 1.7	3.88 ± 0.63	--	--	2.85 ± 0.48	10.2 ± 1.6	--	5.16 ± 0.83	3.12 ± 0.51
Thorium-230	--	3.78 ± 0.62 B	3.92 ± 0.64 B	2.33 ± 0.39	--	--	2.21 ± 0.38	3.87 ± 0.64	--	2.23 ± 0.38	2.18 ± 0.36
Thorium-232	--	9.8 ± 1.5	10.2 ± 1.6	3.77 ± 0.61	--	--	2.7 ± 0.45	9.4 ± 1.5	--	4.99 ± 0.8	3.03 ± 0.49

Notes

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
--	Not scheduled
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
B	Analyte detected in an associated blank
J-	Data are estimated and are potentially biased low due to associated quality control data
UB	Analyte considered not detected based on associated blank data

Table 4-4a
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area A
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Location Identification		S10006-SCX-007	S10006-SCX-007 Dup	S10006-SCX-009	S10006-SCX-009	S10006-SCX-010	S10006-SCX-010	S10006-SCX-011	S10006-SCX-011	S10006-SCX-012
Date Collected		5/11/2017	5/11/2017	5/11/2017	5/11/2017	5/11/2017	5/11/2017	5/11/2017	5/11/2017	5/11/2017
Depth (feet)		0.5 - 0.8	0 - 0.5	0 - 0.5	0.5 - 1.0	0 - 0.5	0.5 - 1.0	0 - 0.5	0.5 - 0.9	0 - 0.5
Sample Category		subsurface	surface	surface	subsurface	surface	subsurface	surface	subsurface	surface
Sample Collection Method		grab	grab	grab	grab	grab	grab	grab	grab	grab
Media		soil	soil	soil	soil	sediment	sediment	soil	soil	soil
Analyte (Units)										
Metals[1] (mg/kg)	Investigation Level									
Arsenic	4.33	3	3.1	2.7	2.4	3.5	3	1.9	2.4	2.2
Molybdenum	0.733	0.92	1.2	0.73	0.38	0.63	0.61	0.33	0.37	0.25
Selenium	2.78	1.5	2.3	1.2	1.2	1.2	1.2	<1	1.1	2.2
Uranium	4.27	2.4	3.6	1.1	0.91	2.3	2.4	1	1.3	1.4
Vanadium	534	130	150	76	70	180	160	50	67	98
Radionuclides (pCi/g)										
Radium-226	7.24	2.74 ± 0.45	3.07 ± 0.46	1.41 ± 0.28	1.64 ± 0.36	3.06 ± 0.47	3.09 ± 0.46	2.22 ± 0.41	1.95 ± 0.36	2.08 ± 0.37
Thorium-228	--	--	2.99 ± 0.49	1.59 ± 0.27	--	3.38 ± 0.59	--	2.04 ± 0.34	--	2.61 ± 0.44
Thorium-230	--	--	1.87 ± 0.32	1.09 ± 0.2	--	1.92 ± 0.35	--	1.21 ± 0.21	--	1.14 ± 0.21
Thorium-232	--	--	2.98 ± 0.48	1.5 ± 0.26	--	3.39 ± 0.59	--	1.95 ± 0.32	--	2.32 ± 0.39

Notes

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
--	Not scheduled
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
B	Analyte detected in an associated blank
J-	Data are estimated and are potentially biased low due to associated quality control data
UB	Analyte considered not detected based on associated blank data

Table 4-4a
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area A
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Location Identification		S10006-SCX-013	S10006-SCX-013	S10006-SCX-013 Dup	S10006-SCX-014	S10006-SCX-015	S10006-SCX-015	S10006-SCX-016	S10006-SCX-016
Date Collected		5/11/2017	5/11/2017	5/11/2017	5/11/2017	5/11/2017	5/11/2017	5/11/2017	5/11/2017
Depth (feet)		0 - 0.5	0.5 - 1.0	0 - 0.5	0 - 0.3	0 - 0.5	0.5 - 1.0	0 - 0.5	0.5 - 1.0
Sample Category		surface	subsurface	surface	surface	surface	subsurface	surface	subsurface
Sample Collection Method		grab	grab	grab	grab	grab	grab	grab	grab
Media		sediment	sediment	sediment	soil	soil	soil	soil	soil
Analyte (Units)									
Metals[1] (mg/kg)	Investigation Level								
Arsenic	4.33	2.2	2.2	2.4	2.9	2.4	2.3	2.7	3.4
Molybdenum	0.733	<0.21	0.28	0.29	0.97	0.32	0.31	0.47	0.46
Selenium	2.78	<1	1.4	1.4	2.5	<1.1	<1.1	1.7	1.2
Uranium	4.27	0.45	1.1	1	1.3	0.79	0.71	1.6	1.2
Vanadium	534	23	74	75	110	37	29	140	72
Radionuclides (pCi/g)									
Radium-226	7.24	1.08 ± 0.27	1.67 ± 0.31	1.5 ± 0.33	2.7 ± 0.5	1.15 ± 0.27	0.79 ± 0.24 J-	3.62 ± 0.58	1.63 ± 0.34
Thorium-228	--	1.11 ± 0.2	--	--	4 ± 0.65	1.18 ± 0.21	--	5.46 ± 0.87	--
Thorium-230	--	0.78 ± 0.15	--	--	1.65 ± 0.28	0.92 ± 0.17	--	1.99 ± 0.34	--
Thorium-232	--	1.1 ± 0.2	--	--	3.61 ± 0.58	1.03 ± 0.18	--	5.2 ± 0.83	--

Notes

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
--	Not scheduled
[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
B	Analyte detected in an associated blank
J-	Data are estimated and are potentially biased low due to associated quality control data
UB	Analyte considered not detected based on associated blank data

Table 4-4b
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area B
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Location Identification		S10006-CX-010	S10006-SCX-004	S10006-SCX-004	S10006-SCX-008	S10006-SCX-008
Date Collected		5/9/2017	5/11/2017	5/11/2017	5/11/2017	5/11/2017
Depth (feet)		0 - 0.5	0 - 0.5	0.5 - 2.0	0 - 0.5	1 - 1.5
Sample Category		surface	surface	subsurface	surface	subsurface
Sample Collection Method		grab	grab	composite	grab	grab
Media		soil	sediment	sediment	sediment	sediment
Analyte (Units)						
Metals[1] (mg/kg)	Investigation Level					
Arsenic	4.87	2.4	3.1	4.9	2.5	3.3
Molybdenum	0.532	0.42	0.3	0.38	<0.21	0.25
Selenium	NA	1.3	<1.1	<1.1	<1.1	<1
Uranium	0.84	1.2	0.71	0.73	0.38	0.78
Vanadium	92.8	91	42	48	25 J-	76
Radionuclides (pCi/g)						
Radium-226	1.5	1.86 ± 0.37	1.16 ± 0.25	1.01 ± 0.25	0.97 ± 0.26	1.49 ± 0.29
Thorium-228	--	2.43 ± 0.41	1.06 ± 0.19	--	0.92 ± 0.18	--
Thorium-230	--	1.13 ± 0.21 B	0.72 ± 0.14	--	0.63 ± 0.14	--
Thorium-232	--	2.29 ± 0.39	0.98 ± 0.17	--	0.82 ± 0.16	--

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-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
--	Not scheduled
B	Analyte detected in an associated blank
J-	Data are estimated and are potentially biased low due to associated quality control data

Table 4-5
Summary of Investigation Level Exceedances in Soil at Borehole Locations
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Sample Location	Survey Area	Investigation Level Exceedances
S10006-SCX-001	A	Mo
S10006-SCX-002	A	As, Mo
S10006-SCX-004	B	As, Static Gamma
S10006-SCX-005	A	Mo, Se, Ra-226
S10006-SCX-006	A	Se
S10006-SCX-007	A	Mo
S10006-SCX-008	B	Static Gamma
S10006-SCX-014	A	Mo

Notes
As - Arsenic
Mo - Molybdenum
Ra-226 - Radium 226
Se - Selenium

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

Notes

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

(a) “Table of Regulated Drinking Water Contaminants”, Groundwater and Drinking Water (USEPA, 2016a).

(b) “Table of Secondary Drinking Water Standards”, Secondary Drinking Water Standards: Guidance for Nuisance Chemicals (USEPA, 2016b).

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

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

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

(f) Collected data will be used for water quality analysis purposes

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

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

Table 4-6b
Water Sampling Analytical Results
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Water Feature Identification		15T-529/Well/1082195	15T-529/Well/1082195	15T-529/Well/1082195	15T-529/Well/1082195	15T-538
Field Sample Identification		S10006-WL-001 Dup	S10006-WL-001 Dup	S10006-WL-001	S10006-WL-001	S10006-WL-002
Date Collected		11/10/2016	11/10/2016	11/10/2016	11/10/2016	5/25/2017
Matrix		Water Well	Water Well	Water Well	Water Well	Water Well
Preparation		Dissolved	Total	Dissolved	Total	Dissolved
Analyte (Units)						
Radionuclides (pCi/L)	Investigation Level					
Ra-226	5 ¹	NS	0.6 ± 0.22	NS	0.71 ± 0.25	NS
Ra-228	5 ¹	NS	2.64 ± 0.75	NS	3.18 ± 0.88	NS
Gross Alpha	--	NS	6.8 ± 3 B	NS	4.8 ± 2.7 B	NS
Adjusted Gross Alpha ²	15	NS	6.8	NS	4.8	NS
Gross Beta	--	NS	10.8 ± 2.9	NS	7.4 ± 2.8	NS
Mercury (ng/L)						
Mercury	2000	0.4 F	0.9	0.6	1.1	<0.5
Metals ³ (µg/L)						
Antimony	5.6	0.76	<0.3	0.75	<0.3	<0.3
Arsenic	10	<2	<2	<2	<2	<2
Barium	2000	20	34	20	31	19
Beryllium	4	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium	5	<0.3	<0.3	<0.3	<0.3	<0.3
Chromium, Total	100	<10	<10	<10	<10	<10
Cobalt	--	<1	<1	<1	<1	<1
Copper	1300	<10	28	<10	23	<10
Lead	15	0.63	1.2	0.71	1	<0.5
Molybdenum	--	<1	<1	<1	<1	<1
Nickel	610	<5	<5	<5	<5	<5
Selenium	50	<1	<1	<1	<1	<1
Silver	35	<0.1	<0.1	<0.1	<0.1	<0.1
Thallium	2	<0.2	<0.2	<0.2	<0.2	<0.2
Uranium	30	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	--	<1	<1	<1	<1	<1
Zinc	2100	<20	150	<20	120	<20
General Chemistry Parameters (mg/L)						
TDS	500	NS	1400	NS	1400	NS
Carbonate	--	NS	<20	NS	<20	NS
Bicarbonate	--	NS	220	NS	230	NS
Chloride	250	NS	8.1 D	NS	8.1 D	NS
Sulfate	250	NS	630 D	NS	610 D	NS
Calcium	--	21000	23000	22000	23000	20000
Sodium	--	310000	330000	320000	340000	210000
Field Parameters						
Oxidation Reduction Potential(millivolts)	--	NS	NS	NS	125.7	NS
pH(pH units)	--	NS	NS	NS	8.71	NS
Salinity(PPTV)	--	NS	NS	NS	0.96	NS
Specific Conductivity(µS/cm)	--	NS	NS	NS	1504	NS
Temperature(°C)	--	NS	NS	NS	14.8	NS
Turbidity(NTU)	--	NS	NS	NS	15	NS

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
NA	Adjusted Gross Alpha result is not applicable because it was negative, refer to note ²
NS	Not scheduled
Ra-226	Radium 226
Ra-228	Radium 228
TDS	Total Dissolved Solids
<	Result not detected above associated laboratory reporting limit
B	Analyte detected in an associated blank
D	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
F	Analyte was positively identified but the reported concentration is estimated; reported concentration is less than the reporting limit, but greater than the method detection 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

Table 4-6b
Water Sampling Analytical Results
Standing Rock
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase
Page 2 of 2

	Water Feature Identification	15T-529/Well/1082195	15T-538	15T-538 Pond	15T-538 Pond
	Field Sample Identification	S10006-WL-001 Dup	S10006-WL-002	S10006-WS-001	S10006-WS-001
	Date Collected	11/10/2016	5/25/2017	5/25/2017	5/25/2017
	Matrix	Water Well	Water Well	Surface Water	Surface Water
	Preparation	Dissolved	Total	Dissolved	Total
Analyte (Units)					
	Investigation Level				
Radionuclides (pCi/L)					
Ra-226	5 [1]	NS	0.61 ± 0.24	NS	0.95 ± 0.35
Ra-228	5 [1]	NS	0 ± 0.33	NS	0 ± 0.37
Gross Alpha	--	NS	2.2 ± 1.3	NS	0 ± 8.3
Adjusted Gross Alpha [2]	15	NS	2.2	NS	NA
Gross Beta	--	NS	4.8 ± 1.9	NS	26 ± 13
Mercury (ng/L)					
Mercury	2000	0.4 F	<0.5	3.7	29 D
Metals [3] (µg/L)					
Antimony	5.6	0.76	<0.3	1.1	0.53
Arsenic	10	<2	<2	4.6	11
Barium	2000	20	20	43	160
Beryllium	4	<0.5	<0.5	<0.5	0.84
Cadmium	5	<0.3	<0.3	<0.3	<0.3
Chromium, Total	100	<10	<10	<10	11
Cobalt	--	<1	<1	1.7	6.3
Copper	1300	<10	<10	<10	14
Lead	15	0.63	<0.5	<0.5	8.3
Molybdenum	--	<1	<1	6	4.7
Nickel	610	<5	<5	<5	14
Selenium	50	<1	<1	<1	1.3
Silver	35	<0.1	<0.1	<0.1	<0.1
Thallium	2	<0.2	<0.2	<0.2	<0.2
Uranium	30	<0.1	<0.1	3.3	3.7
Vanadium	--	<1	<1	9.8	30
Zinc	2100	<20	<20	<20	41
General Chemistry Parameters (mg/L)					
TDS	500	NS	740	NS	3900 J
Carbonate	--	NS	<20	NS	220
Bicarbonate	--	NS	180	NS	590
Chloride	250	NS	6.8	NS	34 D
Sulfate	250	NS	310 D	NS	1500 D
Calcium	--	21000	20000	17000	35000
Sodium	--	310000	200000	930000	900000
Field Parameters					
Oxidation Reduction Potential(millivolts)	--	NS	186.3	NS	206.7
pH(pH units)	--	NS	8.27	NS	9.65
Salinity(PPTV)	--	NS	NS	NS	NS
Specific Conductivity(µS/cm)	--	NS	1053	NS	3999
Temperature(°C)	--	NS	17.8	NS	17.5
Turbidity(NTU)	--	NS	1.06	NS	665

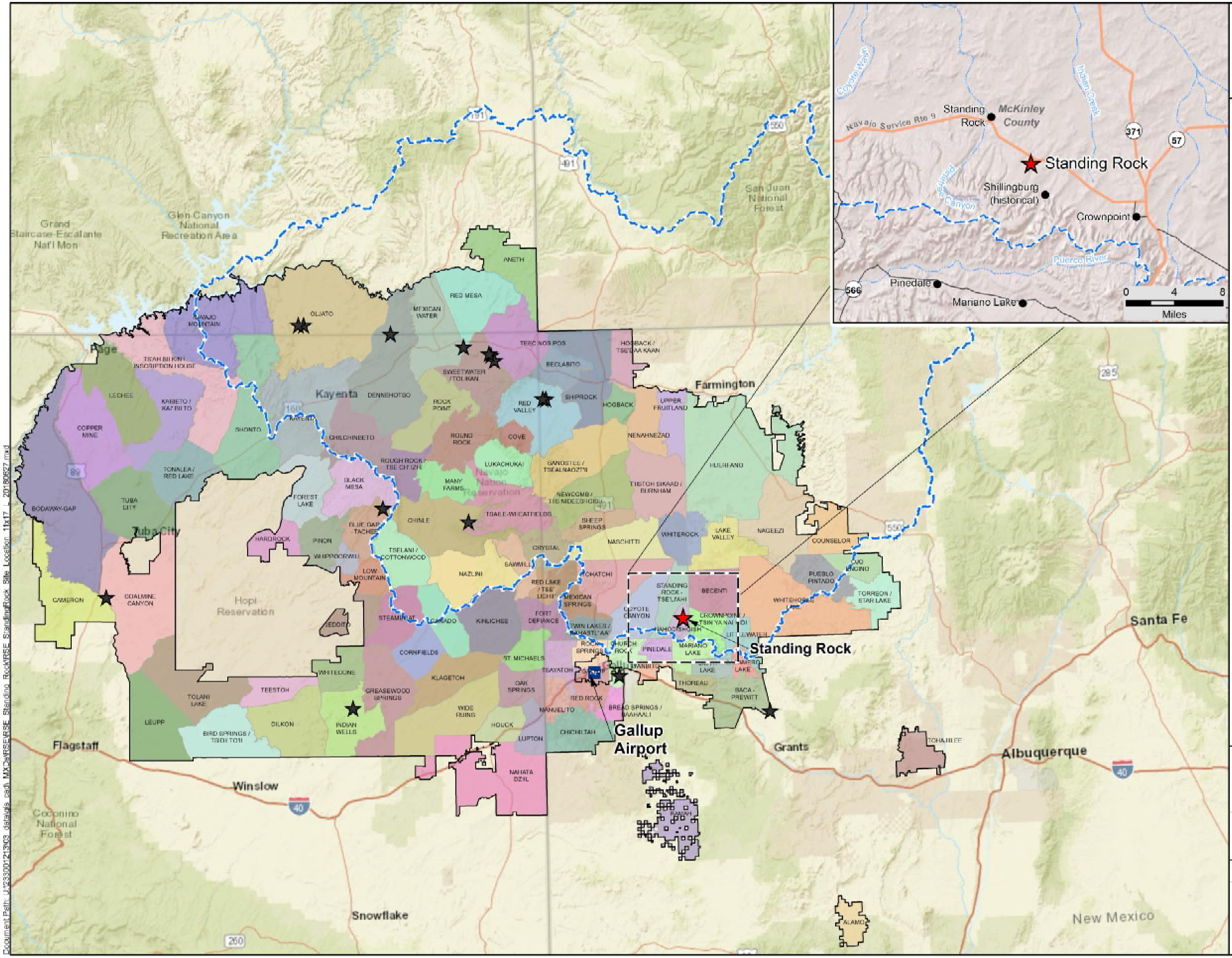
Notes

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result or reporting limit greater than or equal to the investigation lev
°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
NA	Adjusted Gross Alpha result is not applicable because it was negative, refer to note [2]
NS	Not scheduled
Ra-226	Radium 226
Ra-228	Radium 228
TDS	Total Dissolved Solids
<	Result not detected above associated laboratory reporting limit
B	Analyte detected in an associated blank
D	Analysis required a standard sample dilution of 10 times; reported values have been conver
F	Analyte was positively identified but the reported concentration is estimated; reported con
1	The Investigation Level for Ra-226 and Ra-228 have a combined limit of 5 pCi/L, and are not
2	Adjusted Gross Alpha = Gross alpha concentration - uranium concentration, using the conv (U.S. Department of Energy, 2011)
3	Analysis required sample dilution of 10 times; reported values have been converted to non-

FIGURES

FIGURE ACRONYMS/ABBREVIATIONS

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



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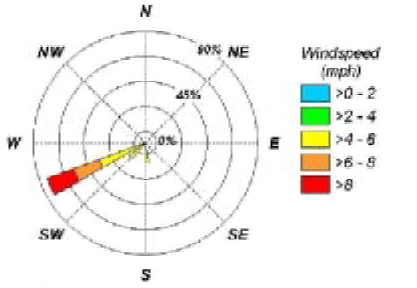
NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

★ Standing Rock Mine Site
★ Priority Abandoned Uranium Mine (AUM) Site
● Populated Place
State Highway
Major Road
Intermittent Stream
San Juan River Watershed
Navajo Nation Boundary
Navajo Nation Chapter

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



REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

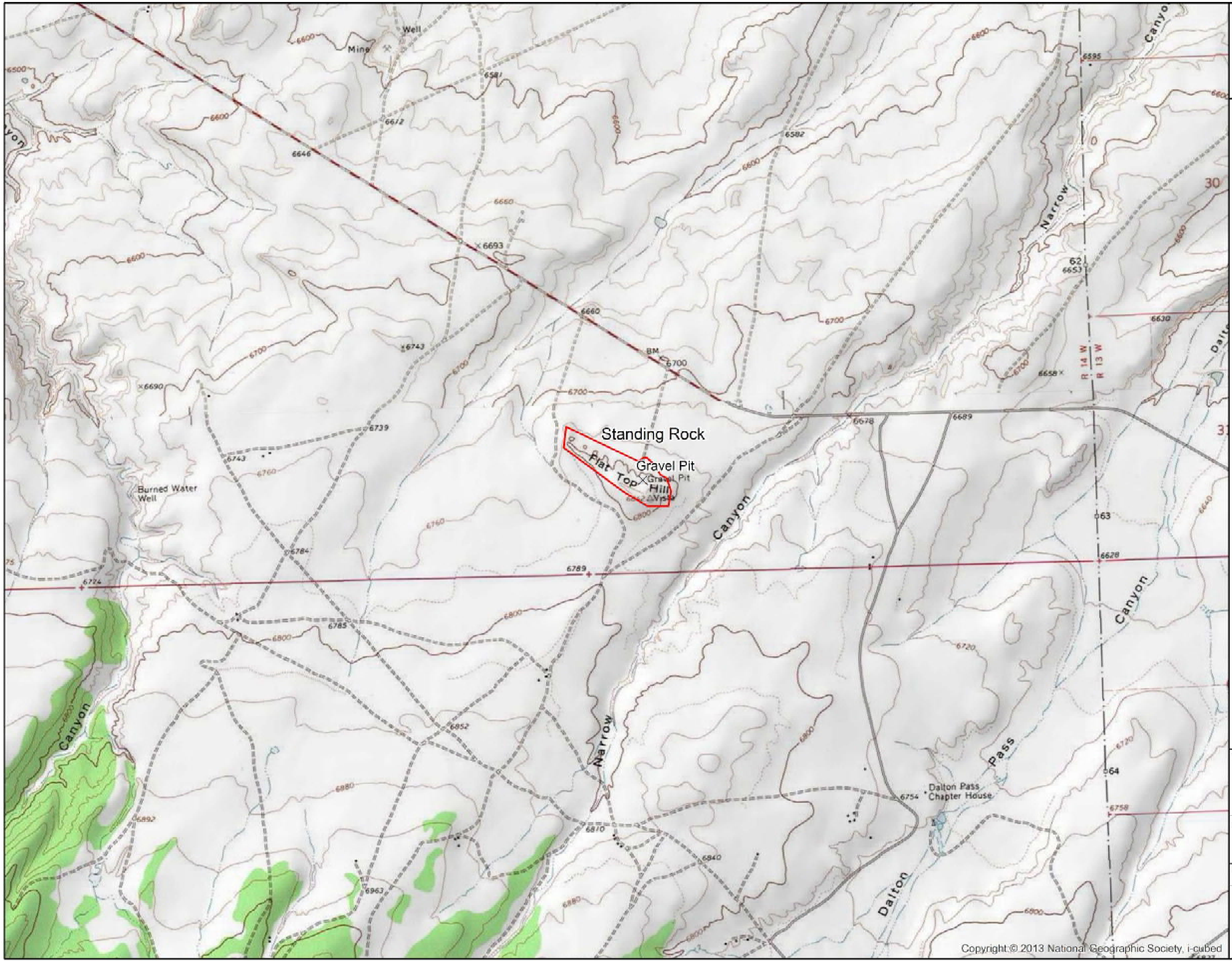
Wind Rose: USEPA, 2007a

0 25 50
Miles

TITLE:
Site Location

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 7/24/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: CBB REVIEWER: EDZ
	FIGURE: 1-1



NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

🟥 Claim Boundary

× Gravel Pit

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N
W E
S

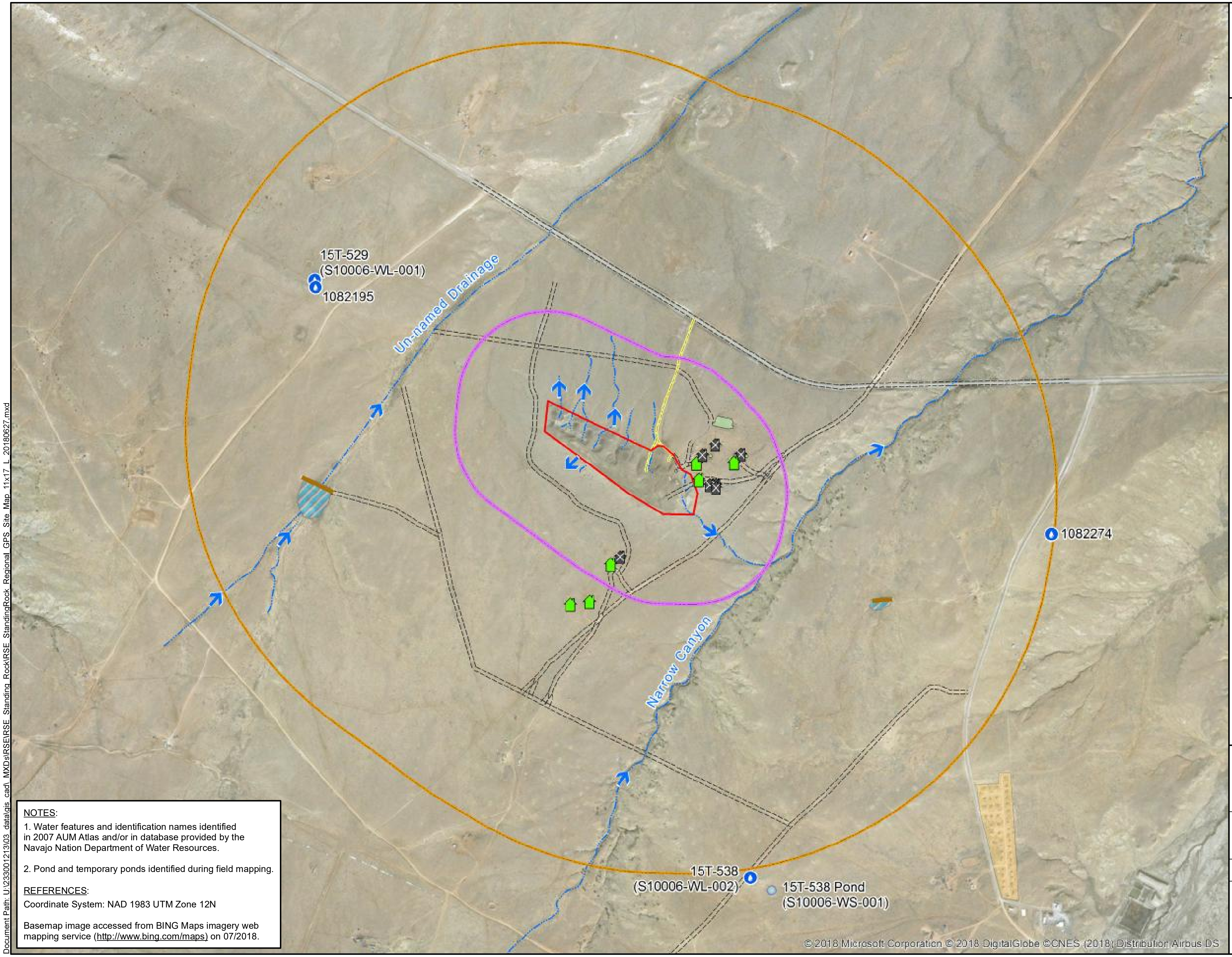
0 2,000 4,000
Feet

TITLE:
Regional Topographic Map

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 6/27/2018
DOCUMENT NAME: Removal Site Evaluation Report

Stantec
AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 2-1



NOTES:

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

2. Pond and temporary ponds identified during field mapping.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 07/2018.

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

- 💧 Site Clearance Identified Water Feature[1]
- 🏠 Habitable Building
- ☒ Uninhabitable Building
- ↑ Flow Direction
- ‐·‐·‐ Drainage
- ━ Earthen Dam
- ‐‐‐‐ Potential Haul Road
- ═══ Road
- 🟧 Residential Area
- 🟩 Corral
- 🟦 Pond[2]
- ▨ Temporary Pond[2]
- 🟥 Claim Boundary
- 🟪 1/4-Mile Claim Boundary Buffer
- 🟧 1-Mile Claim Boundary Buffer

N
W E
S

0 1,400 2,800
Feet

TITLE:

Site Features

PROJECT:

Removal Site Evaluation
Standing Rock Mine Site

DATE:	DOCUMENT NAME:
7/24/2018	Removal Site Evaluation Report

Stantec

AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 2-2

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Standing_Rock\RSE_StandingRock_Regional_GPS_Site_Map_11x17_L_20180627.mxd

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

→	Flow Direction
—	Road
—	Drainage
▭	Claim Boundary

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 06/2018.

N
W E
S

0 2,000 4,000
Feet

TITLE:

Regional Aerial Photograph

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 6/27/2018

DOCUMENT NAME: Removal Site Evaluation Report

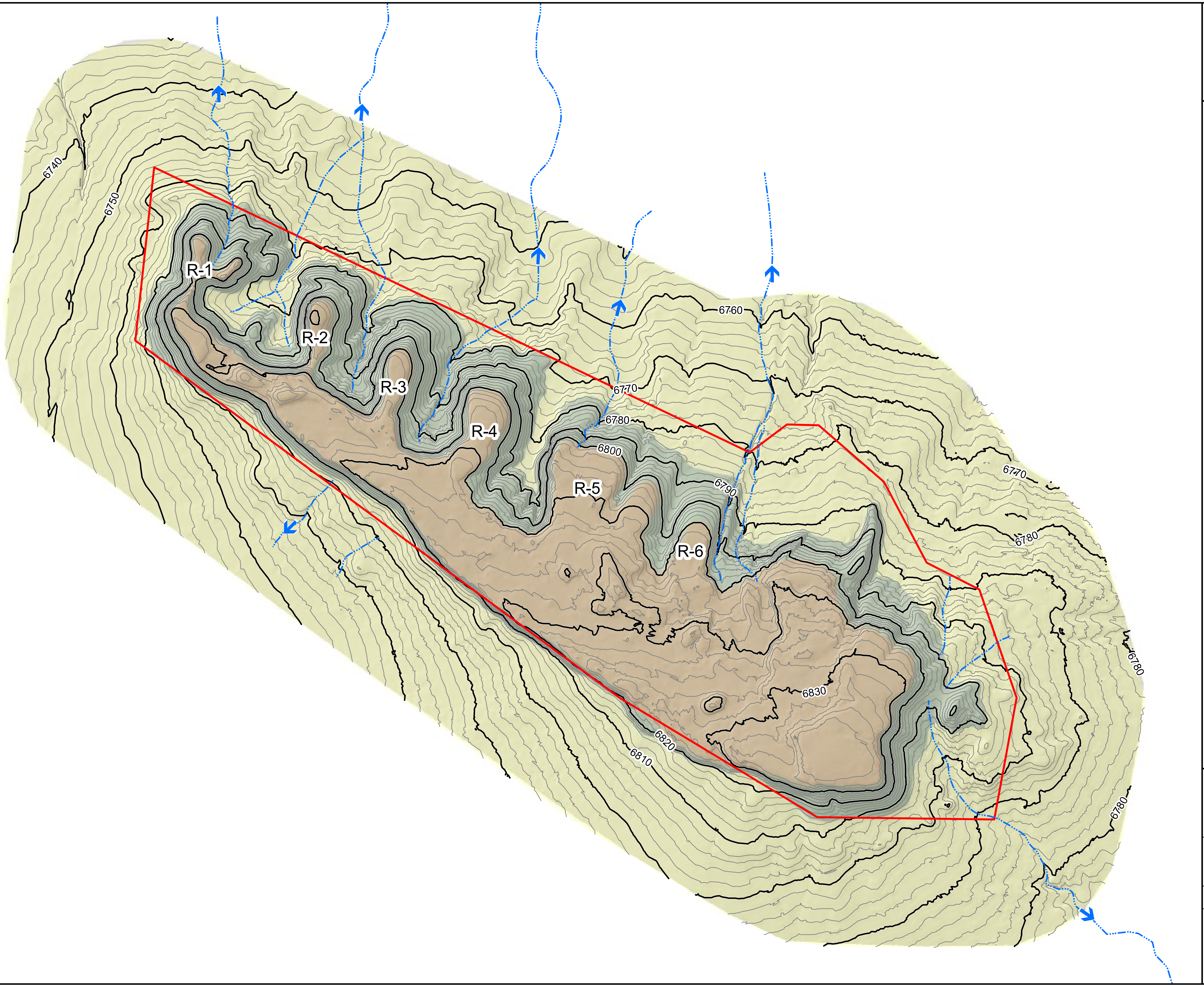
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 2-3

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Standing_Rock\RSE_StandingRock_Regional_Aerial_11x17_L_20180627.mxd



NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

↑	Flow Direction
-·-·-	Drainage
∼	Index Contour (10 ft Interval)
∼	Intermediate Contour (2 ft Interval)
🟥	Claim Boundary

Geomorphology Features

🟫	Mesa Top
🟩	Mesa Sidewall
🟨	Plains

NOTE:
R-1 = Ridge number 1

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
Standing Rock Mine Site

DATE: 6/27/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 2-4

Stantec

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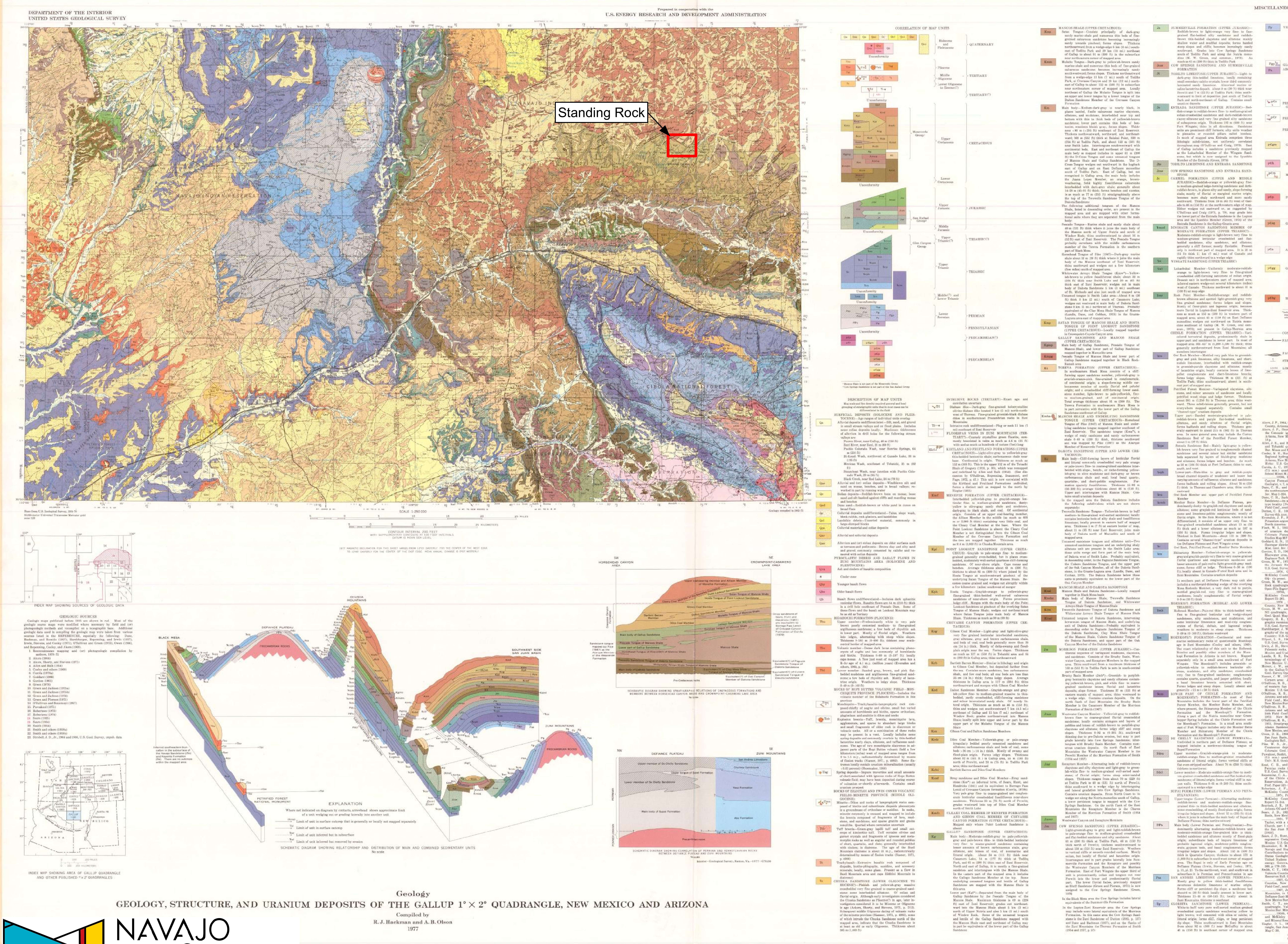
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

Prepared in cooperation with the
U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

MISCELLANEOUS INVESTIGATIONS SERIES
MAP I-981 (SHEET 1 OF 2)



Geology

GEOLOGY, STRUCTURE, AND URANIUM DEPOSITS OF THE GALLUP 1° × 2° QUADRANGLE, NEW MEXICO AND ARIZONA

Compiled by
R. J. Hackman and A. B. Olson
1977

NAVAJO
NATION
AUM Environmental
Response Trust-First Phase

TITLE:
Regional Geology

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 7/24/2018

DOCUMENT NAME:
Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 2-5

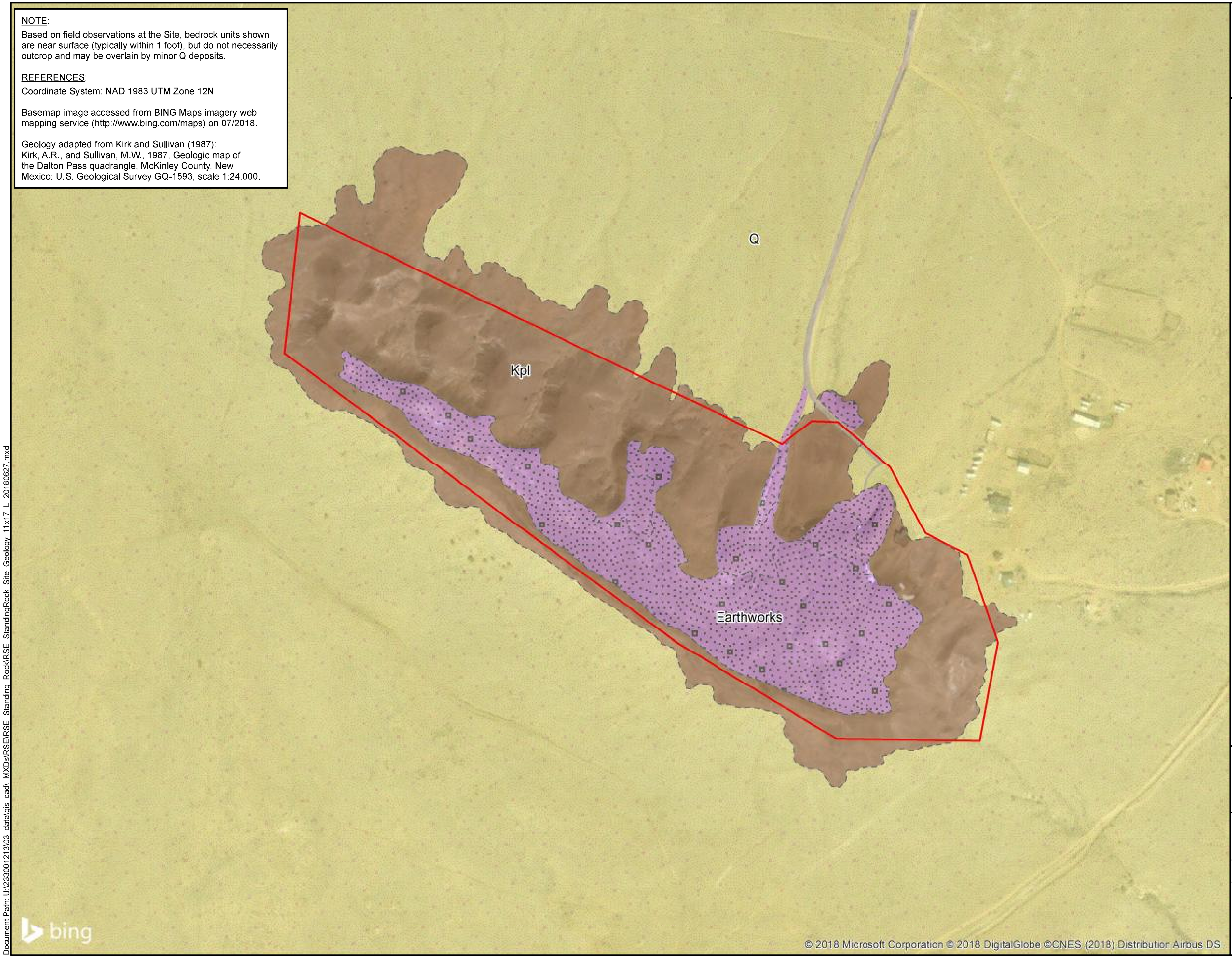
Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE\RSE_Standing_Rock\RSE_StandingRock_Geology_22x34_L_20180627.mxd

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 BING Maps imagery web mapping service (http://www.bing.com/maps) on 07/2018.

Geology adapted from Kirk and Sullivan (1987):
Kirk, A.R., and Sullivan, M.W., 1987, Geologic map of the Dalton Pass quadrangle, McKinley County, New Mexico: U.S. Geological Survey GQ-1593, scale 1:24,000.



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NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

🟥	Claim Boundary
╌	Geologic Contact (Inferred)

Site Geology

HOLOCENE

▨	Earthworks: Human-caused disturbance of the land surface at the Standing Rock mine site.
▨	Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly alluvial deposits, and eolian sand deposits.

CRETACEOUS

▨	Kpl: Point Lookout Sandstone (Upper Cretaceous) – Black, titanium rich sand deposit in iron oxide cemented quartzose sandstone. The black sandstone overlies tan shaley sandstone.

N
W E
S

0 300 600
Feet

TITLE:
Site Geology

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 7/24/2018

DOCUMENT NAME: Removal Site Evaluation Report

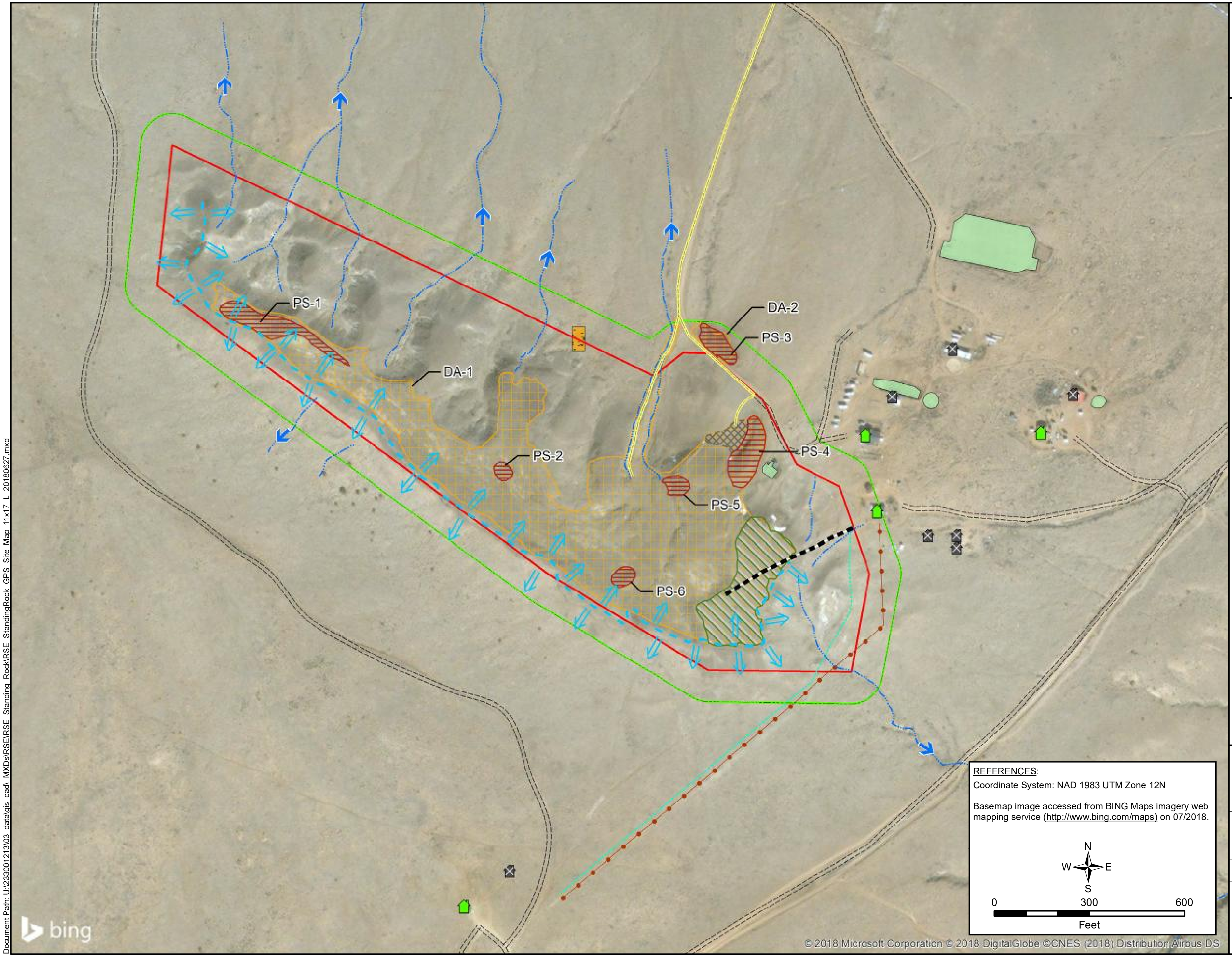
AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 2-6

Stantec

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Standing_Rock\RSE_StandingRock_Site_Geology_11x17_L_20180627.mxd



REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 07/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

⌂	Habitable Building
⌂	Uninhabitable Building
↑	Flow Direction
⇑	Approximate Overland Water Flow Direction
- - -	Approximate Watershed Divide Line
-·-·-	Drainage
———	Potential Haul Road
-●-●-	Powerline
······	Water Line
■ ■ ■	Potential Road
========	Road
🟩	Corral
▩	Excavation
▨	Graded Potential Grazing Area
🟧	Scattered Debris
▤	Potential Stockpile
▦	Disturbed Area
☐	Claim Boundary
☐	100-Foot Claim Buffer

TITLE:

Site Map

PROJECT:

Removal Site Evaluation
Standing Rock Mine Site

DATE: 7/24/2018

DOCUMENT NAME: Removal Site Evaluation Report

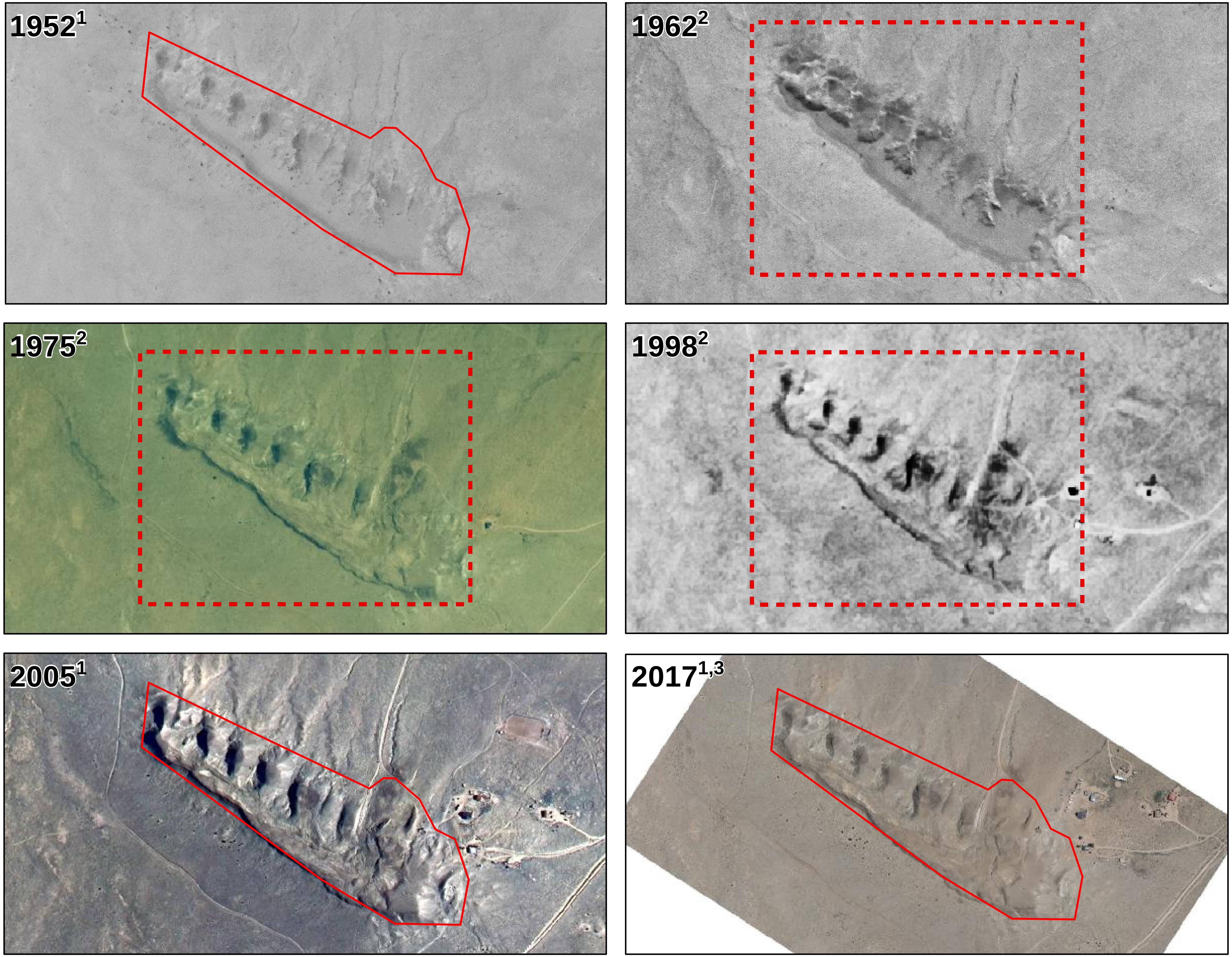
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 2-7

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Standing_Rock\RSE_StandingRock_GPS_Site_Map_11x17_L_20180627.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

🟥 Claim Boundary

▭ Approximate Site Location, not georeferenced

NOTES:

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

2. Image is not georeferenced, scale not available.

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

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

N
W E
S

0 700 1,400
Feet

TITLE:

Historical Aerial
Photograph Comparison

PROJECT:

Removal Site Evaluation
Standing Rock Mine Site

DATE: 6/27/2018

DOCUMENT NAME: Removal Site Evaluation Report

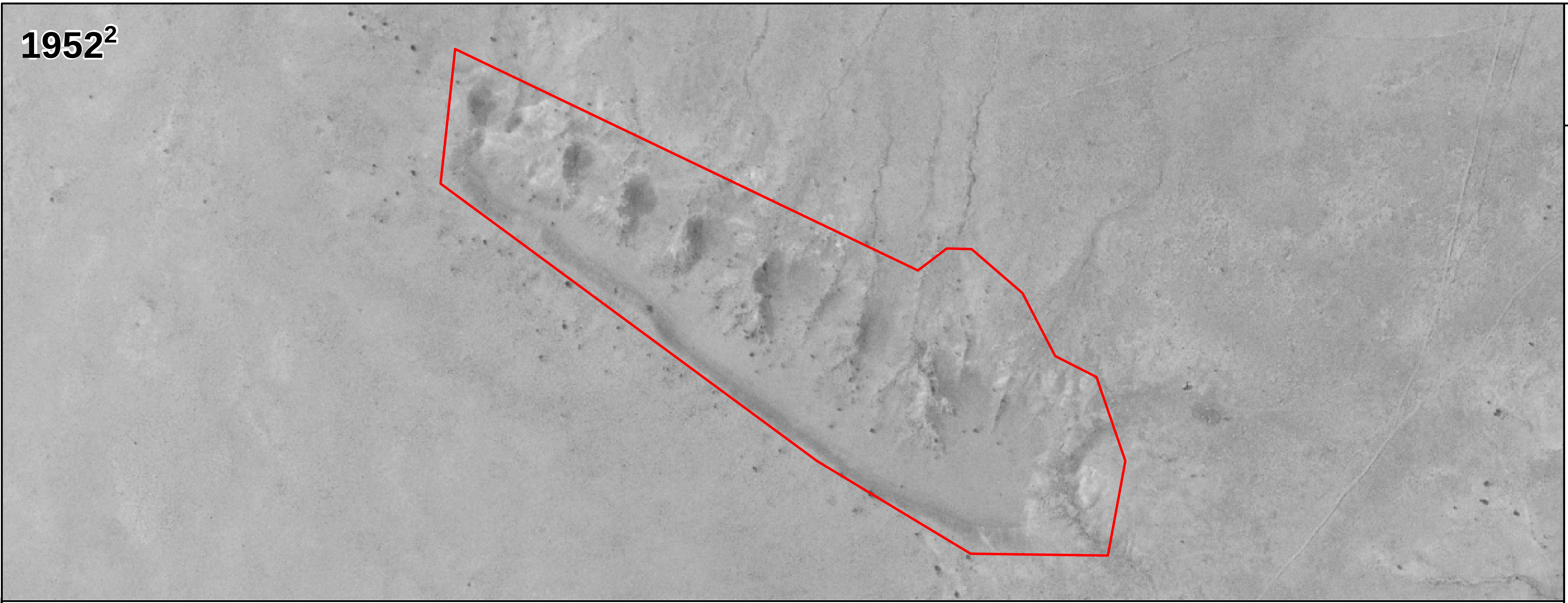
Stantec

AUTHOR: WDC

REVIEWER: CB

FIGURE: 3-1a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Standing_Rock\RSE_StandingRock_Historical_Aerial_Compilation_11x17_L_201780627.mxd


1952[2]


2017[3]

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

□ Claim Boundary

REFERENCES:

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

TITLE:
1952 Historical Aerial
Photograph Comparison

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 6/27/2018
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_Standing_Rock\RSE_StandingRock_Historical_Aerial_1952_11x17_L_20180627.mxd

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

▨	Potential Background Reference Area
🟥	Claim Boundary

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 07/2018.

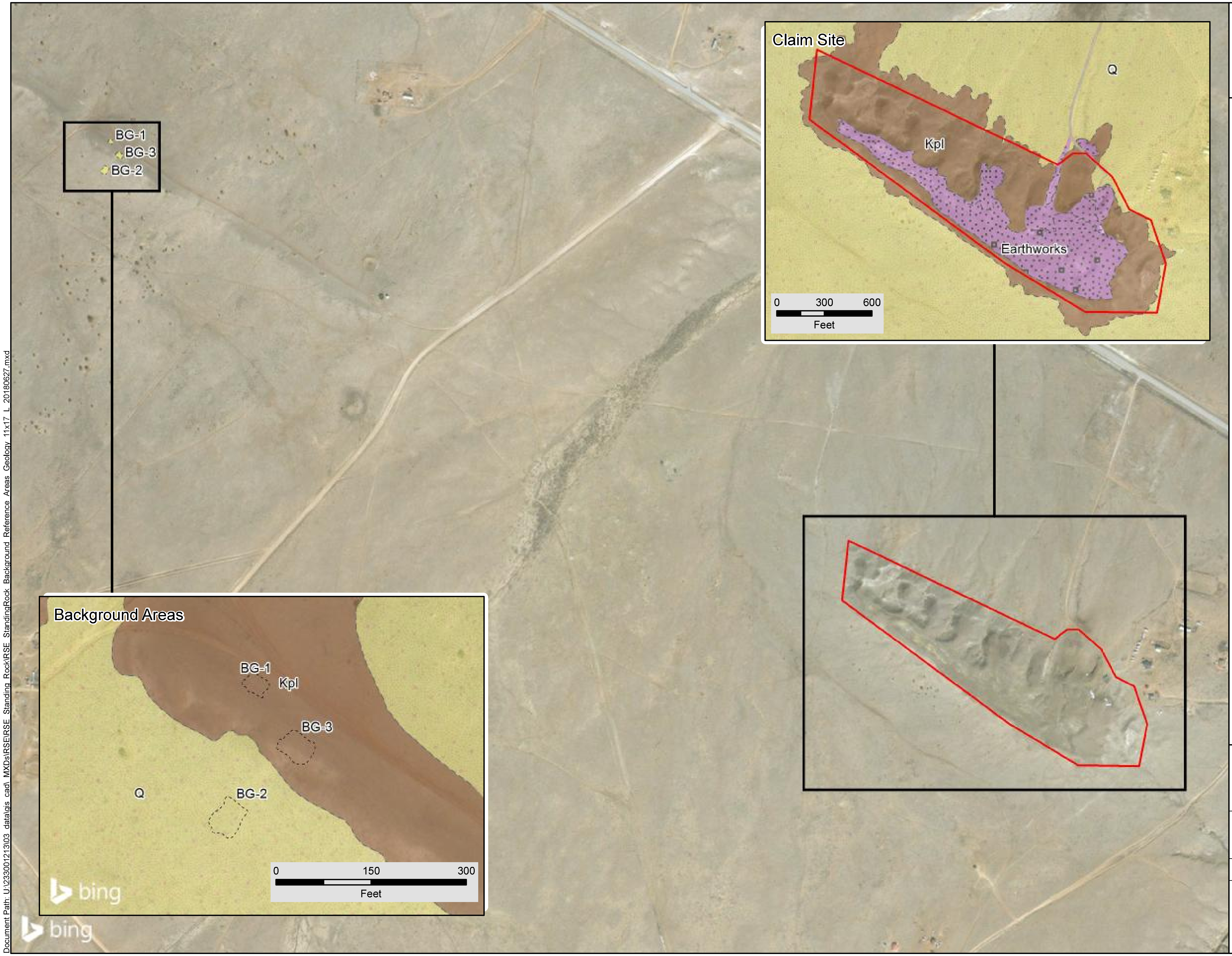
TITLE:
Potential Background Reference Areas

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 7/24/2018
DOCUMENT NAME: Removal Site Evaluation Report
AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 3-2a

Stantec

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Standing Rock\RSE StandingRock Background Reference Areas 11x17 L 20180627.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

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

Site Geology

HOLOCENE

- Earthworks: Human-caused disturbance of the land surface at the Standing Rock mine site.
- Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly alluvial deposits, and eolian sand deposits.

CRETACEOUS

- Kpl: Point Lookout Sandstone (Upper Cretaceous) – Black, titanium rich sand deposit in iron oxide cemented quartzose sandstone. The black sandstone overlies tan shaley sandstone.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N
W E
S

0 700 1,400
Feet

TITLE:
Potential Background Reference Areas Geology

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 8/24/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 3-2b

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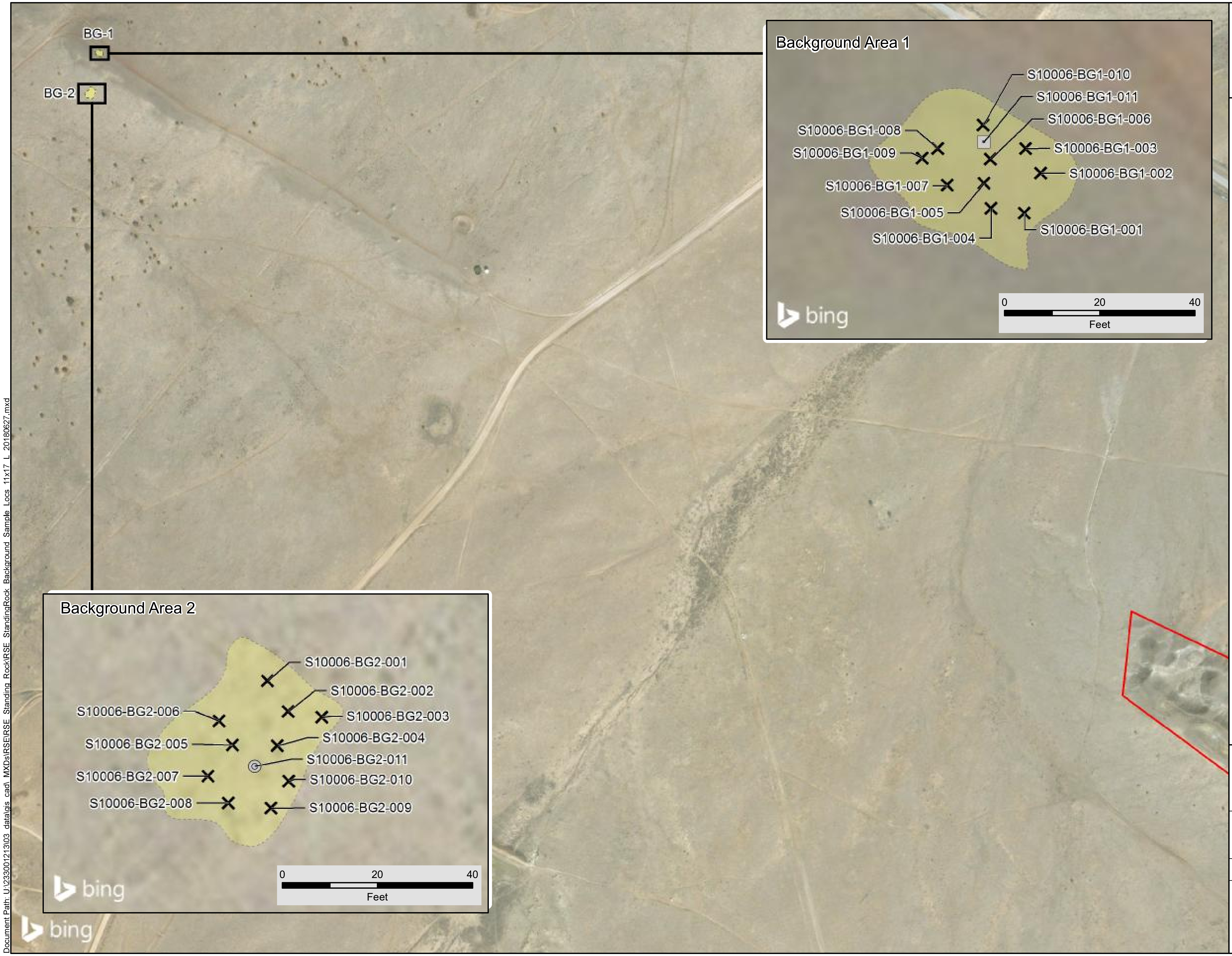


Document Path: U:\23300121303 data\gis cad\ MXDs\RSE\RSE\RSE Standing Rock\RSE StandingRock Background Sample Locs 11x17 L 20180627.mxd

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Borehole Location - Surface and Subsurface Samples
▣	Borehole Location - Surface Samples Only
🟨	Background Reference Area
🟥	Claim Boundary

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N
W E
S

0 500 1,000
Feet

TITLE:
Background Reference Areas - Soil Sample Locations

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 8/24/2018

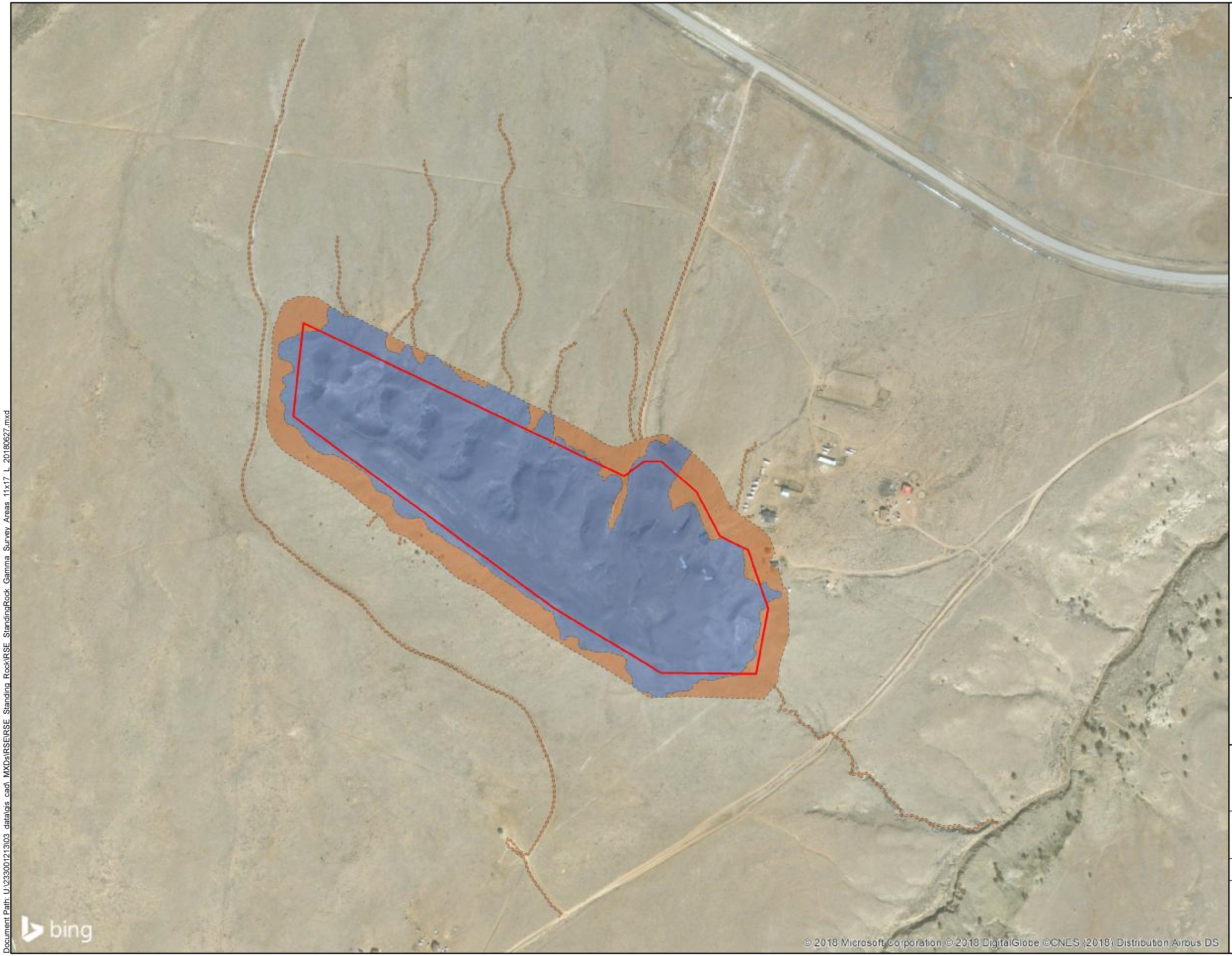
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 3-3



NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

- 🟦 Survey Area A
- 🟧 Survey Area B
- 🟥 Claim Boundary

Background Reference Area Associated with Survey Area	
Survey Area	Background Reference Area
A	BG-1
B	BG-2

NOTE:
Gamma survey area is approximately 56.8 acres.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N W E S

0 450 900
Feet

TITLE:
Gamma Radiation
Survey Areas

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 8/24/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 3-4

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Standing Rock\RSE StandingRock Gamma Survey Areas 11x17 L 20180627.mxd

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

☐ S10006-C01-001
Correlation Location
(30'x30')

🟥 Claim Boundary

🟩 100-Foot Claim Buffer

Gamma Survey

Counts per Minute (CPM)

●	9,015 - 15,570 (Minimum to BG-2 UTL)
●	15,571 - 32,635 (>BG-2 UTL - BG-1 UTL)
●	32,636 - 42,691 (>BG-1 UTL - Maximum)

NOTES:
UTL = Upper tolerance limit

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
Standing Rock Mine Site

DATE: 7/24/2018

DOCUMENT NAME:
Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 3-5

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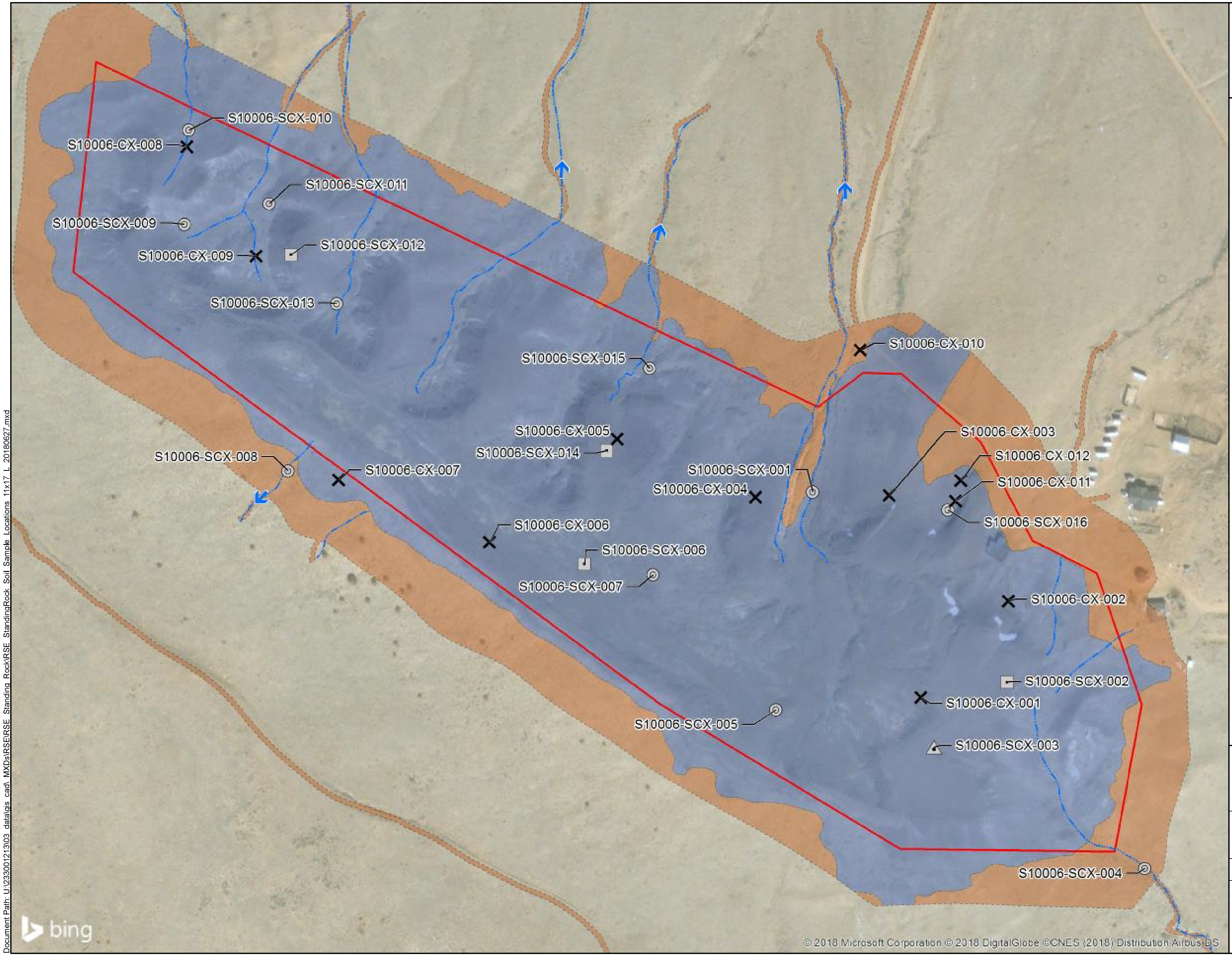

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NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

✕ Surface Sample Location
◎ Borehole Location - Surface and Subsurface Samples
▣ Borehole Location - Surface Samples Only
△ Borehole Location -Static Gamma Data Only
↑ Flow Direction
Drainage
🟦 Survey Area A
🟧 Survey Area B
🟥 Claim Boundary

NOTES:

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

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

Subsurface samples range from 0.5 - 2.0 ft bgs

Static gamma measurements range from 0 - 2.1 ft bgs

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

N
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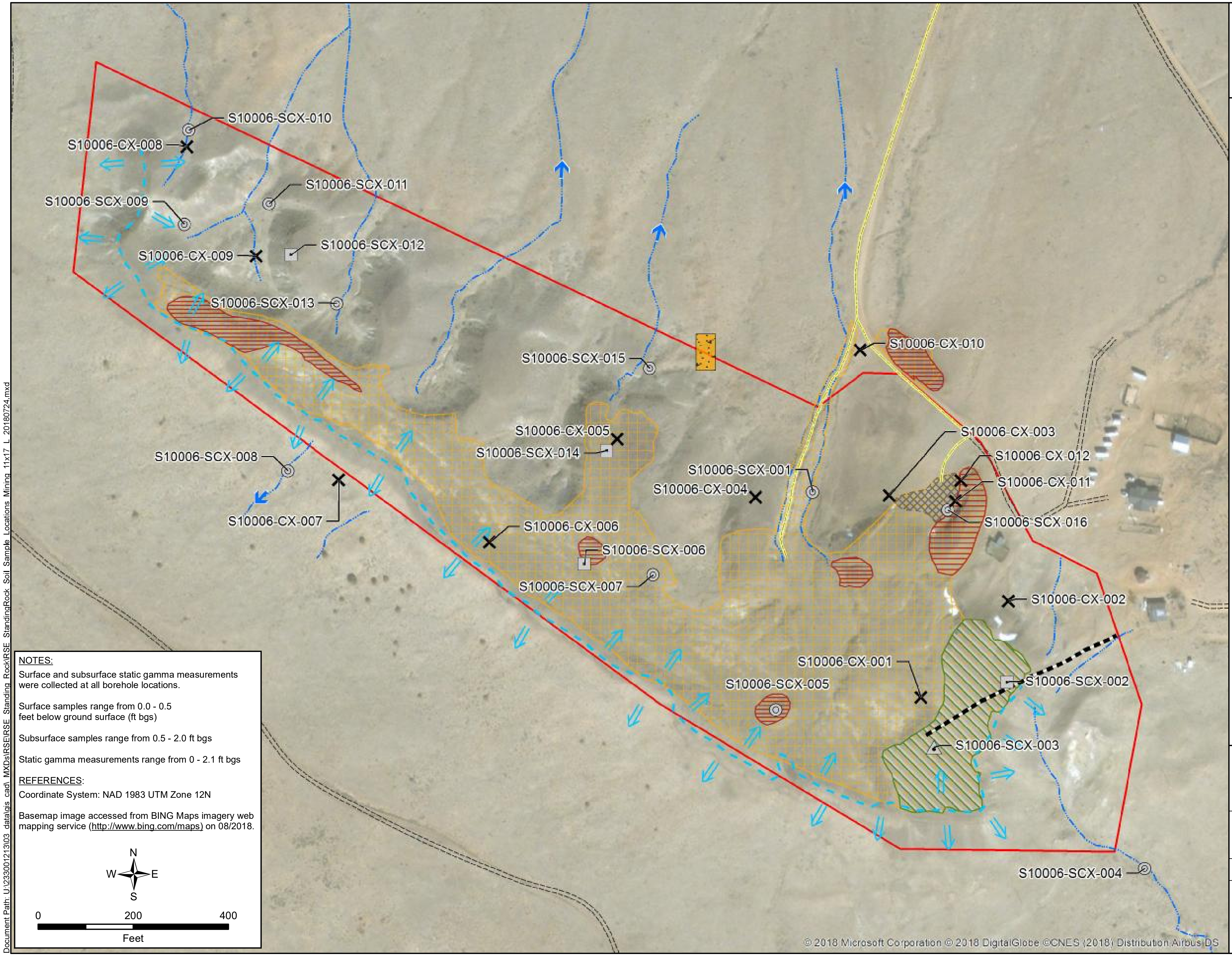
0 200 400
Feet

TITLE:
Site Characterization Surface and Subsurface Sample Locations

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 8/24/2018
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 samples range from 0.0 - 0.5 feet below ground surface (ft bgs)

Subsurface samples range from 0.5 - 2.0 ft bgs

Static gamma measurements range from 0 - 2.1 ft bgs

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- ◎ Borehole Location - Surface and Subsurface Samples
- ⊡ Borehole Location - Surface Samples Only
- △ Borehole Location -Static Gamma Data Only
- ↑ Flow Direction
- ⇧ Approximate Overland Water Flow Direction
- Drainage
- Approximate Watershed Divide Line
- Potential Haul Road
- Potential Road
- Road
- ▩ Excavation
- ▨ Graded Potential Grazing Area
- 🟧 Scattered Debris
- ▤ Potential Stockpile
- ▦ Disturbed Area
- ☐ Claim Boundary

TITLE:

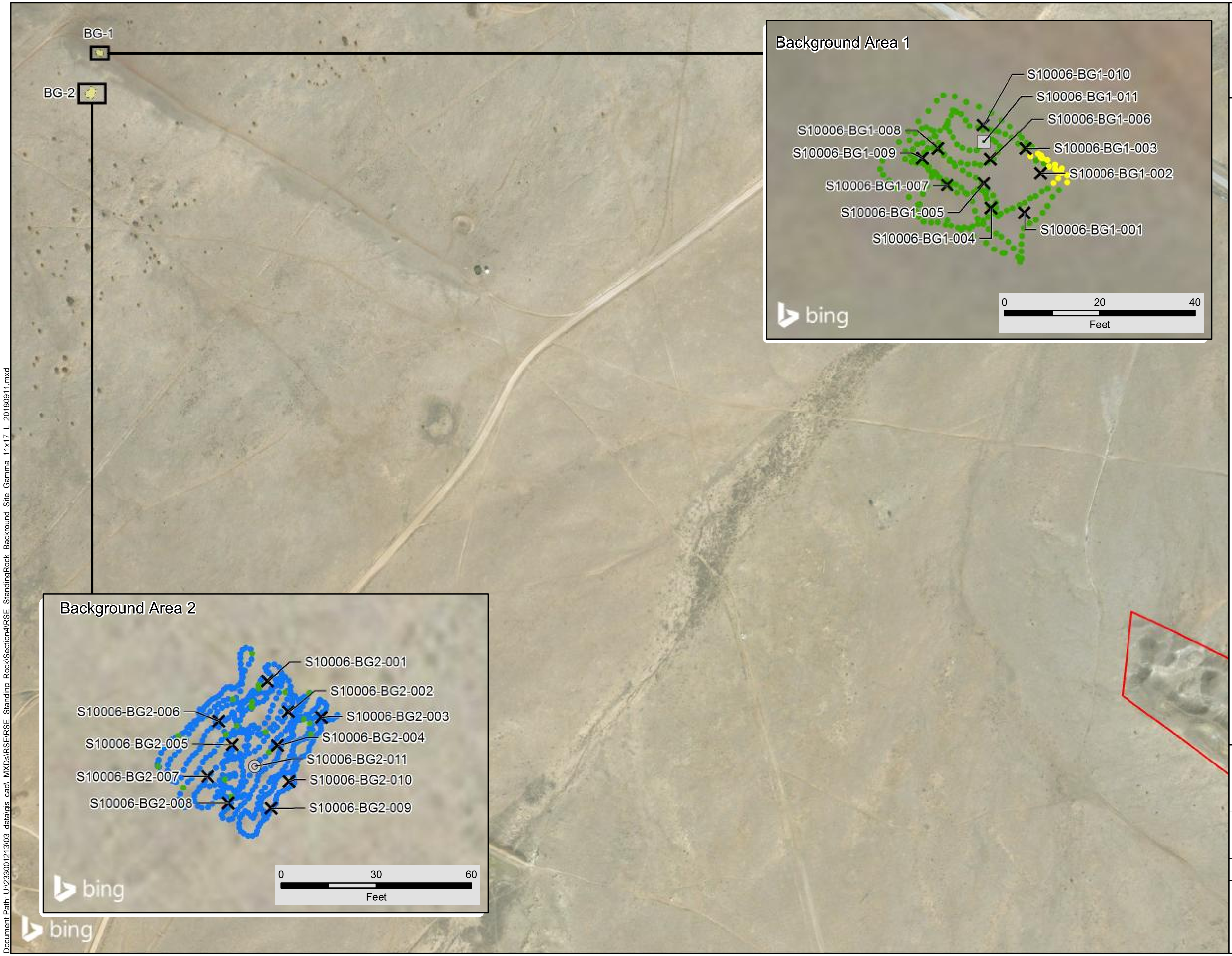
Sample Locations Compared to Mining-Related Features

PROJECT:

Removal Site Evaluation
Standing Rock Mine Site

DATE:	DOCUMENT NAME:	
8/24/2018	Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EDZ
	FIGURE: 3-6b	

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Standing Rock\RSE StandingRock Soil Sample Locations Mining 11x17 L 20180724.mxd



Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Standing Rock\Section4\RSE StandingRock Backround Site Gamma 11x17 L 20180911.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)

- ● 10,910 - 15,570 (Minimum to BG-2 IL)
- ● 15,571 - 32,635 (>BG-2 IL - BG-1 IL)
- ● 32,636 - 36,225 (>BG-1 IL - Maximum)

NOTE:
Gamma survey bins are applicable to Background Areas 1 and 2.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

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0 500 1,000
Feet

TITLE:
Background Reference Areas
Gamma Radiation Survey Results

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/21/2018

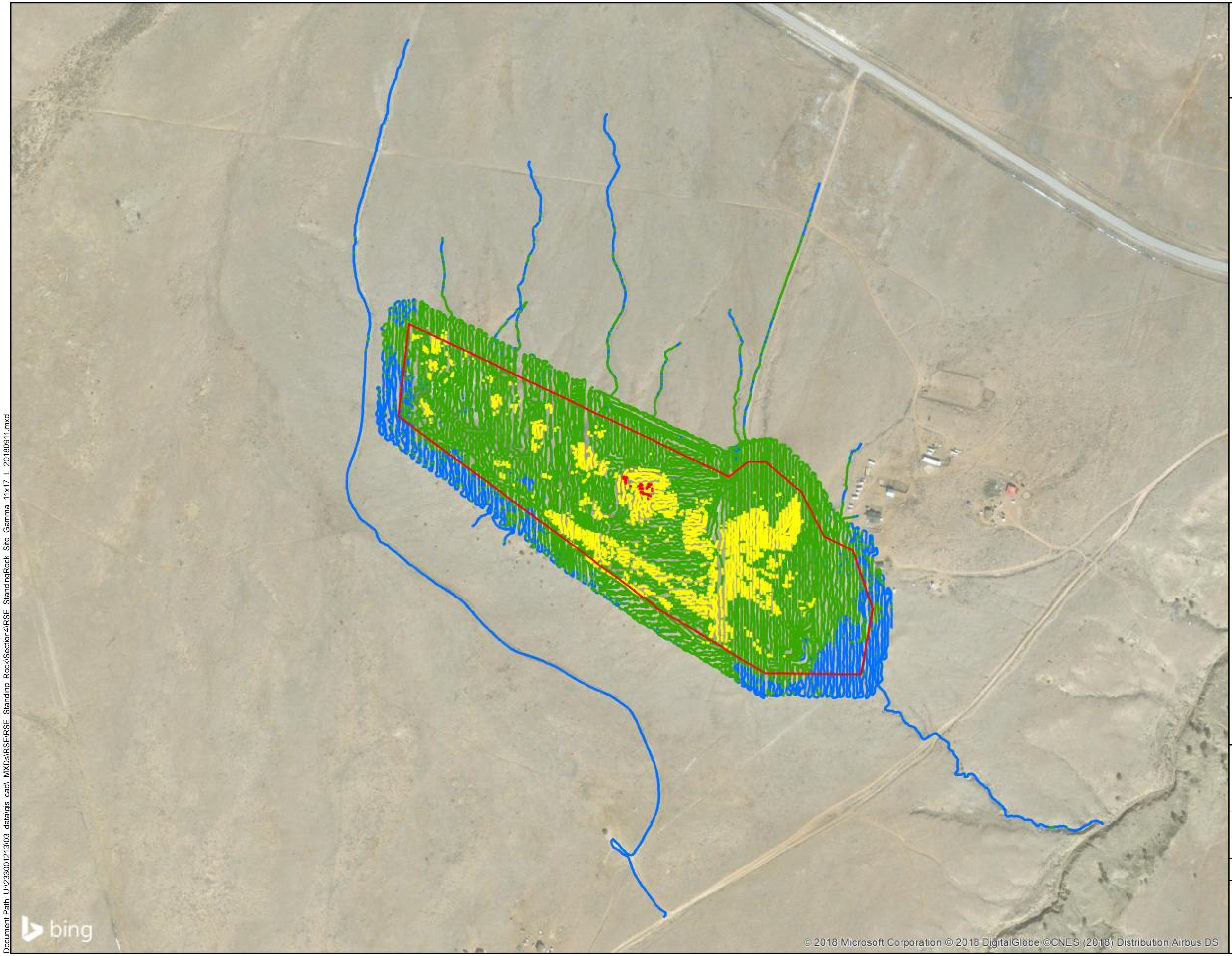
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-1a



NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

🟥 Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- ● 8,810 - 15,570 (Minimum to BG-2 IL)
- ● 15,571 - 32,635 (>BG-2 UTL - BG-1 IL)
- ● 32,636 - 65,270 (>BG-1 UTL - 2x BG-1 IL)
- ● 65,271 - 73,651 (>2x BG-1 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 BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

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0 450 900
Feet

TITLE:
Site Gamma Radiation Survey Results

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/11/2018

DOCUMENT NAME: Removal Site Evaluation Report

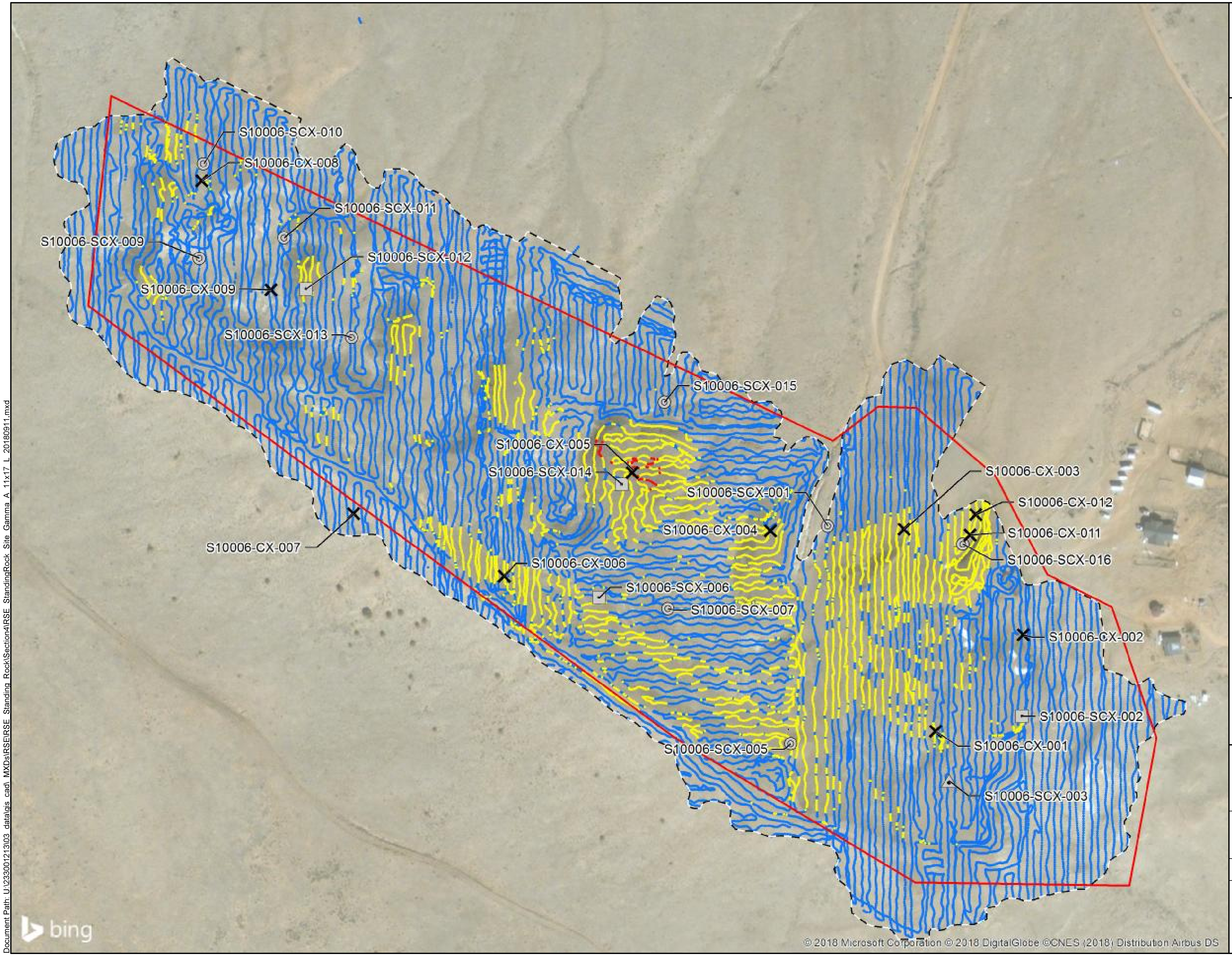
AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: 4-1b

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Standing_Rock\Section4\RSE_StandingRock_Site_Gamma_11x17_L_20180911.mxd



Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Standing Rock\Section4\RSE StandingRock Site Gamma A 11x17 L 20180911.mxd

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Borehole Location - Surface and Subsurface Samples
▣	Borehole Location - Surface Samples Only
△	Borehole Location - Static Gamma Data Only
⬚	Survey Area A
□	Claim Boundary

Gamma Survey

Counts per Minute (CPM)

●	9,945 - 32,635 (Minimum to BG-1 IL)
●	32,636 - 65,270 (>BG-1 IL - 2x BG-1 IL)
●	65,271 - 73,651 (>2x BG-1 IL - Maximum)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

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0 200 400
Feet

TITLE:
Gamma Radiation Survey Results
for Survey Area A

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/20/2018

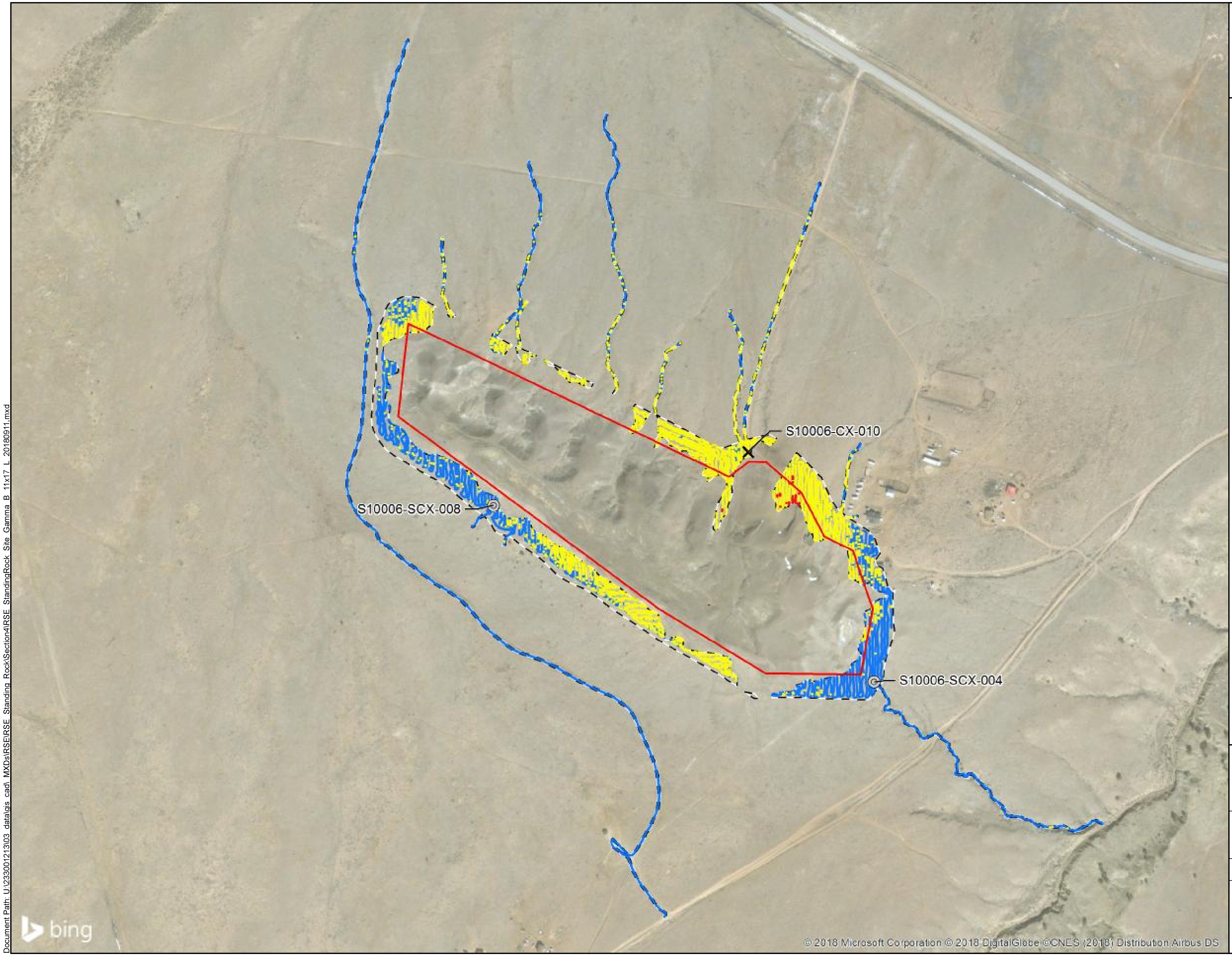
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-1c



Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Standing Rock\Section4\RSE StandingRock Site Gamma B 11x17 L 20180911.mxd

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Borehole Location - Surface and Subsurface Samples
⌜⌟	Survey Area B
🟥	Claim Boundary

Gamma Survey

Counts per Minute (CPM)

●	8,810 - 15,570 (Minimum to BG-2 IL)
●	15,571 - 31,140 (>BG-2 IL - 2x BG-2 IL)
●	31,141 - 42,718 (>2x BG-2 IL - Maximum)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

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0 450 900
Feet

TITLE:
Gamma Radiation Survey Results
for Survey Area B

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/11/2018

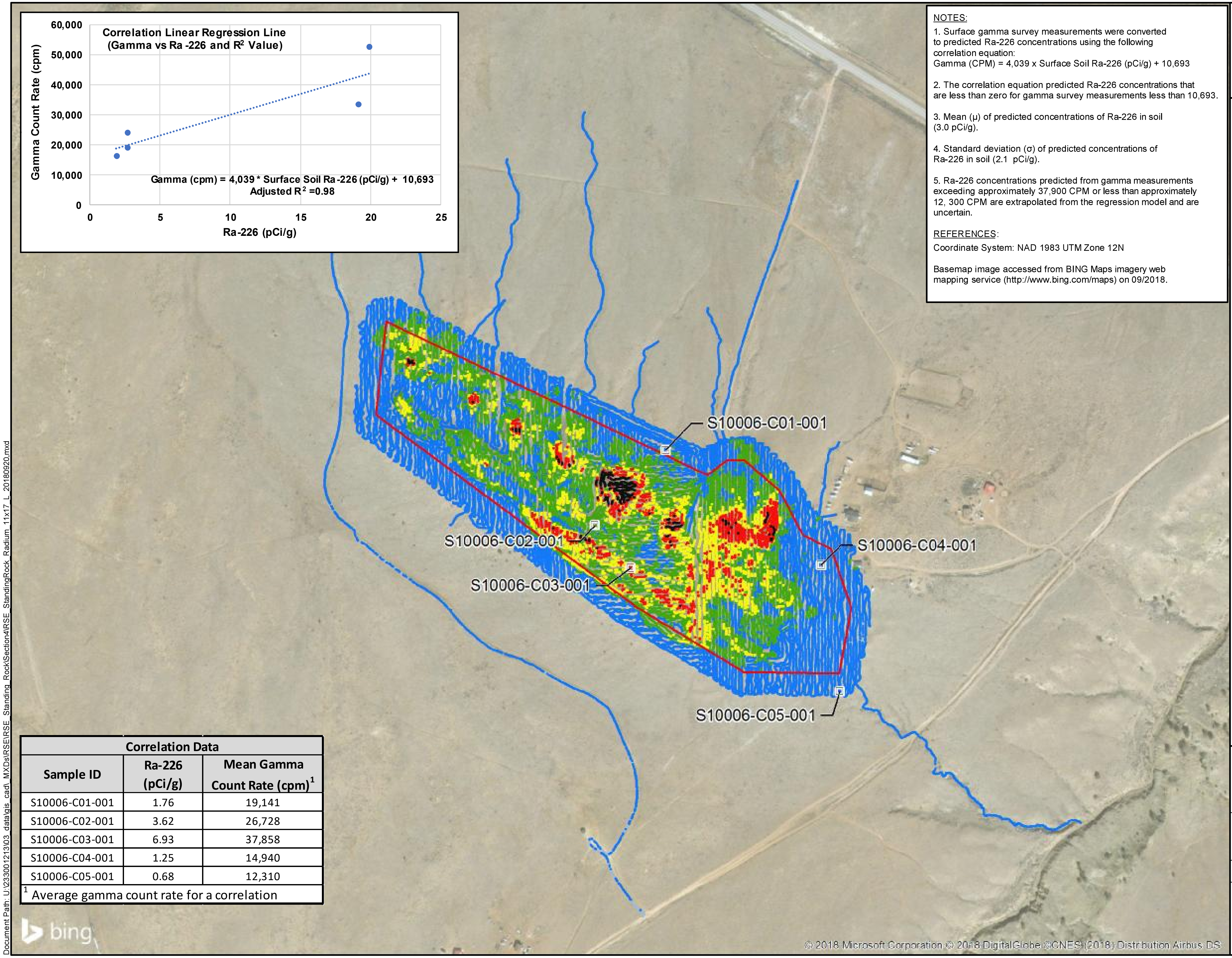
DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: 4-1d



NOTES:

1. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
Gamma (CPM) = 4,039 x Surface Soil Ra-226 (pCi/g) + 10,693

2. The correlation equation predicted Ra-226 concentrations that are less than zero for gamma survey measurements less than 10,693.

3. Mean (μ) of predicted concentrations of Ra-226 in soil (3.0 pCi/g).

4. Standard deviation (σ) of predicted concentrations of Ra-226 in soil (2.1 pCi/g).

5. Ra-226 concentrations predicted from gamma measurements exceeding approximately 37,900 CPM or less than approximately 12, 300 CPM are extrapolated from the regression model and are uncertain.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

Correlation Data		
Sample ID	Ra-226 (pCi/g)	Mean Gamma Count Rate (cpm)[1]
S10006-C01-001	1.76	19,141
S10006-C02-001	3.62	26,728
S10006-C03-001	6.93	37,858
S10006-C04-001	1.25	14,940
S10006-C05-001	0.68	12,310

[1] Average gamma count rate for a correlation

NAVAJO
NATION
AUM Environmental
Response Trust-First Phase

LEGEND

☐ S10006-C01-001 Correlation Location (30'x30')

🟥 Claim Boundary

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

- ● Less than 0[2]
- ● 0 - 3.0 (μ)[3]
- ● 3.1 - 5.1 (μ + 1σ[4])
- ● 5.2- 7.2 (μ + 2σ)
- ● 7.3 - 9.3 (μ + 3σ)
- ● 9.4 - 15.6[5]

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0 450 900
Feet

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

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/21/2018

DOCUMENT NAME: Removal Site Evaluation Report

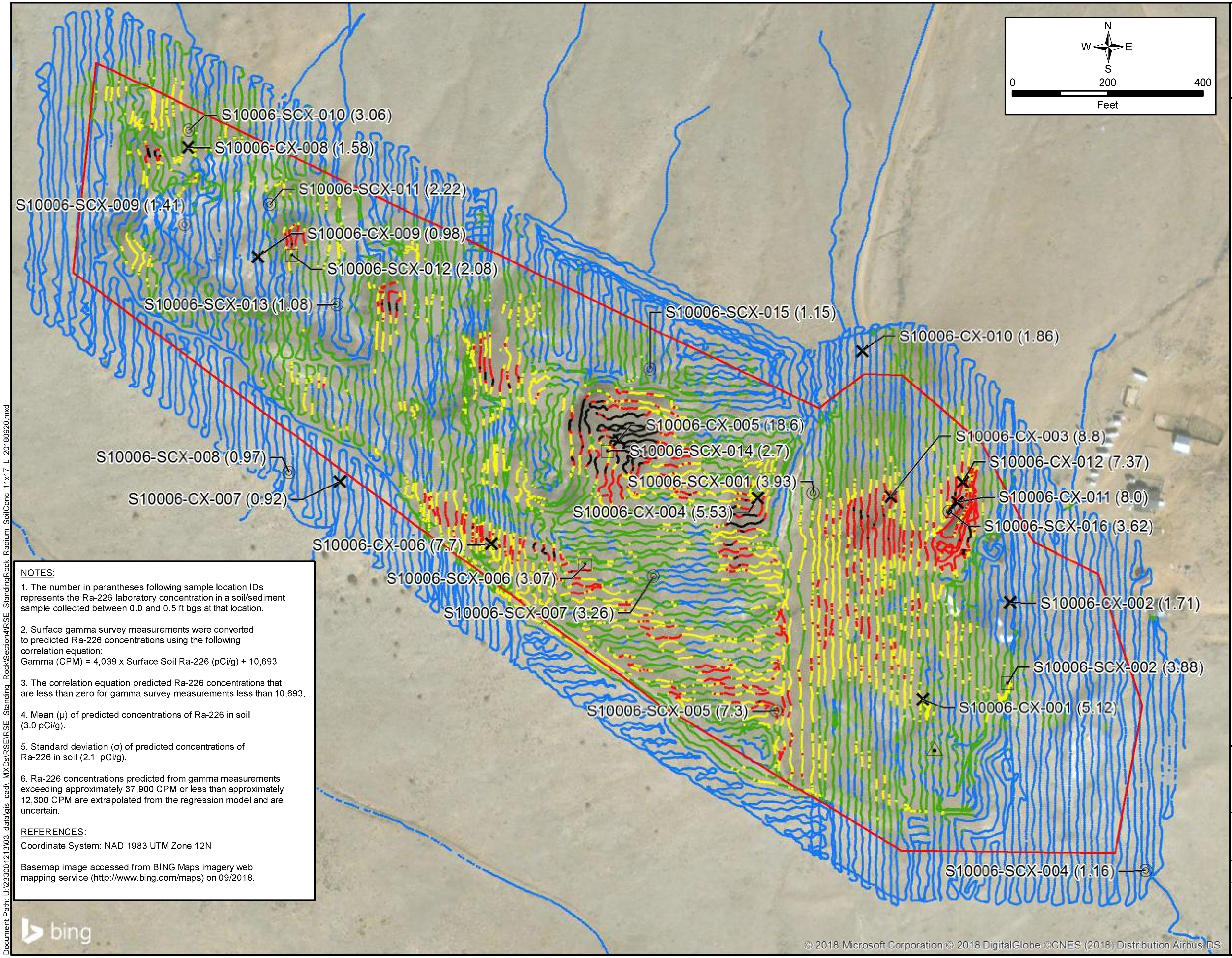
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-2a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE\RSE_Standing_Rock\Section4\RSE_StandingRock_Radium_11x17_L_20180920.mxd



NOTES:

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

2. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
Gamma (CPM) = 4,039 x Surface Soil Ra-226 (pCi/g) + 10,693

3. The correlation equation predicted Ra-226 concentrations that are less than zero for gamma survey measurements less than 10,693.

4. Mean (μ) of predicted concentrations of Ra-226 in soil (3.0 pCi/g).

5. Standard deviation (σ) of predicted concentrations of Ra-226 in soil (2.1 pCi/g).

6. Ra-226 concentrations predicted from gamma measurements exceeding approximately 37,900 CPM or less than approximately 12,300 CPM are extrapolated from the regression model and are uncertain.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Standing Rock\Section4\RSE StandingRock Radium SoilConc 11x17 L 20180920.mxd

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

✕ Surface Sample Location

◎ Borehole Location - Surface and Subsurface Samples

▣ Borehole Location - Surface Samples Only

△ Borehole Location -Static Gamma Data Only

▭ Claim Boundary

Predicted Ra-226 Concentration ^{2}(pCi/g)

● Less than 0^3

● 0 - 3.0 (μ)^4

● 3.1 - 5.1 (μ + 1σ^5)

● 5.2- 7.2 (μ + 2σ)

● 7.3 - 9.3 (μ + 3σ)

● 9.4 - 15.6^6

TITLE:

Predicted Ra-226 Concentrations in Soil Compared to Ra-226 Concentrations in Surface Soil/Sediment

PROJECT:

Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/21/2018

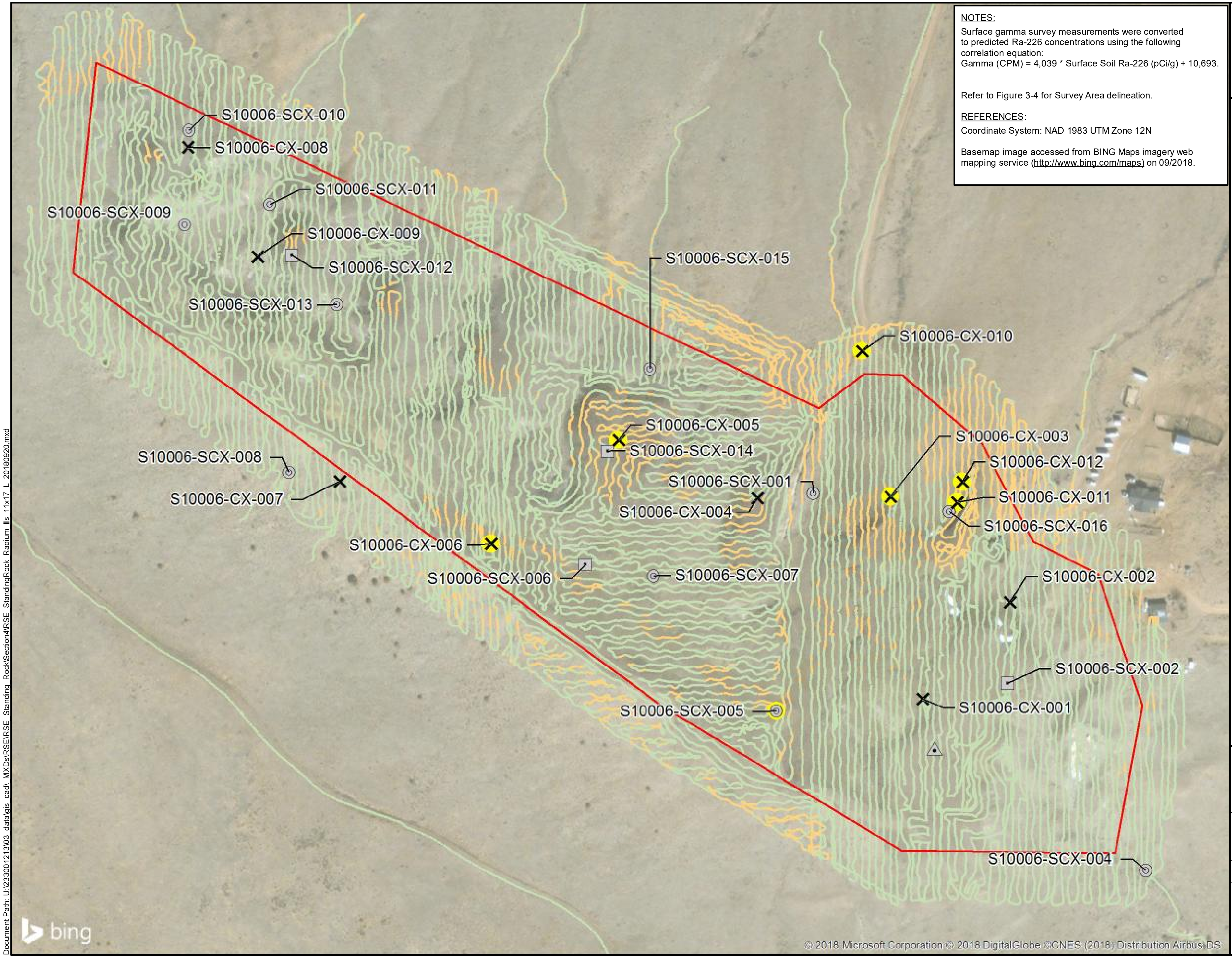
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-2b



NOTES:

Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
Gamma (CPM) = 4,039 * Surface Soil Ra-226 (pCi/g) + 10,693.

Refer to Figure 3-4 for Survey Area delineation.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Borehole Location - Surface and Subsurface Samples
⊡	Borehole Location - Surface Samples Only
△	Borehole Location -Static Gamma Data Only
●	Ra-226 IL Exceedance in Surface Soil
▭	Claim Boundary

Predicted Ra-226 Concentrations (pCi/g)

IL Not Exceeded
Survey Area A: -0.19 - 7.24
Survey Area B: -0.47 - 1.50

IL Exceeded
Survey Area A: 7.25 - 15.59
Survey Area B: 1.51 - 7.93

N
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0 200 400
Feet

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

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/20/2018
DOCUMENT NAME: Removal Site Evaluation Report
AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 4-2c

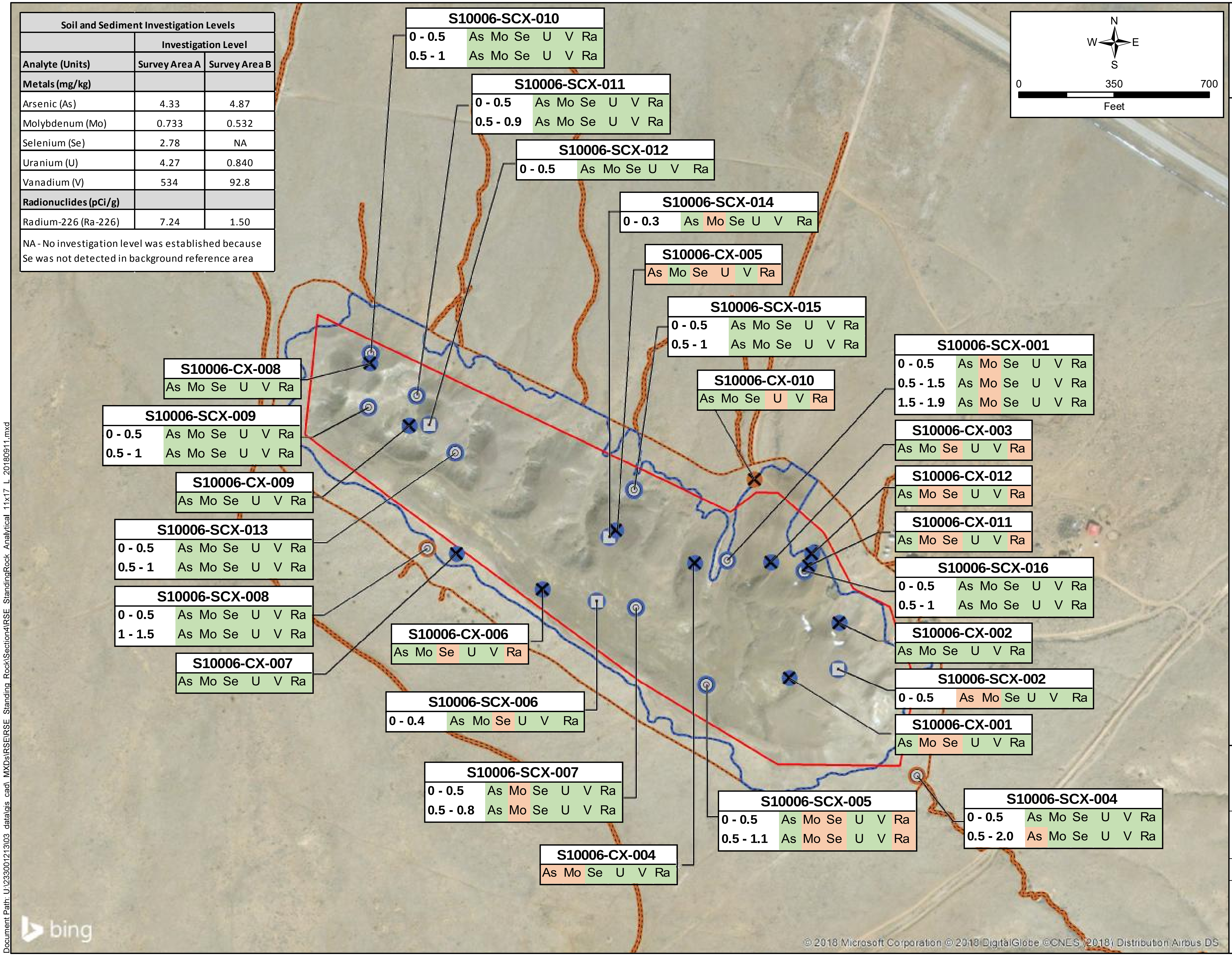
Stantec

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE\RSE_Standing_Rock\Section4\RSE_StandingRock_Radium_ILs_11x17_L_20180920.mxd

Soil and Sediment Investigation Levels

	Investigation Level	
Analyte (Units)	**Survey Area A**	**Survey Area B**
Metals (mg/kg)		
Arsenic (As)	4.33	4.87
Molybdenum (Mo)	0.733	0.532
Selenium (Se)	2.78	NA
Uranium (U)	4.27	0.840
Vanadium (V)	534	92.8
Radionuclides (pCi/g)		
Radium-226 (Ra-226)	7.24	1.50

NA - No investigation level was established because Se was not detected in background reference area



Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Standing_Rock\Section4\RSE_StandingRock_Analytical_11x17_L_20180911.mxd

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 A
- ▢ Survey Area B
- ▢ Claim Boundary
- 🟩 Investigation Level Not Exceeded
- 🟧 Investigation Level Exceeded

NOTE:
Sample intervals (e.g. 0 - 2.0) are in ft bgs.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

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

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/11/2018

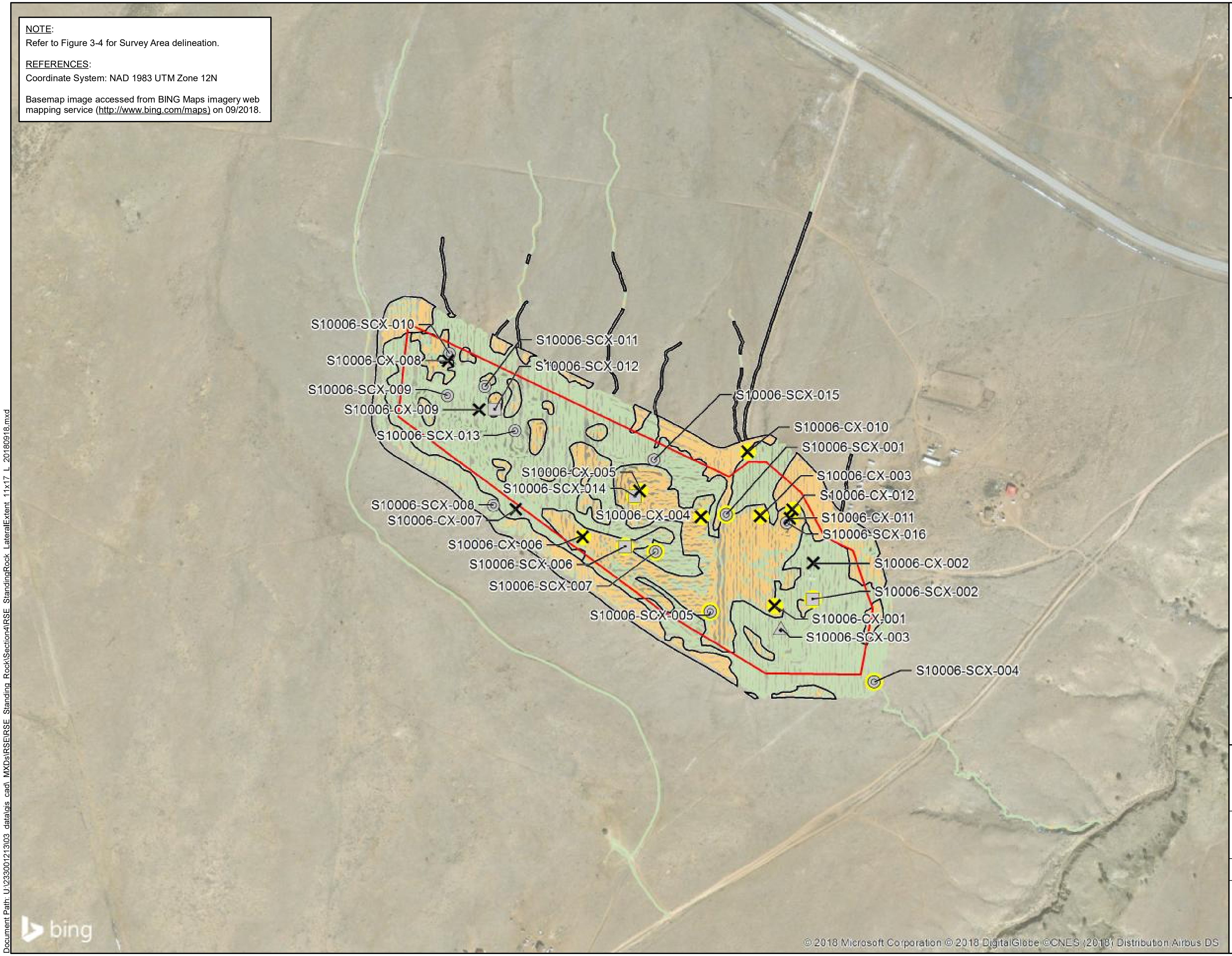
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-3



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

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- ◎ Borehole Location - Surface and Subsurface Samples
- ▣ Borehole Location - Surface Samples Only
- △ Borehole Location -Static Gamma Data Only
- ● IL Exceedance in Unconsolidated Material at Location
- ▢ Approximate Area where Surface Gamma ILs are Exceeded (25.6 acres)
- 🟥 Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- ● IL Not Exceeded
  Survey Area A: 9,945 - 32,635
  Survey Area B: 8,810 - 15,570
- ● IL Exceeded
  Survey Area A: 32,636 - 73,651
  Survey Area B: 15,571 - 42,718

N
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0 450 900
Feet

TITLE:
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/21/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-4a

Stantec

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Standing_Rock\Section4\RSE_StandingRock_LateralExtent_11x17_L_20180918.mxd

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE\RSE Standing Rock\Section4\RSE StandingRock LateralExtent SurveyAreaA 11x17 L 20180918.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Borehole Location - Surface and Subsurface Samples
▣	Borehole Location - Surface Samples Only
△	Borehole Location -Static Gamma Data Only
●	IL Exceedance in Unconsolidated Material at Location
▢	Approximate Area where Surface Gamma IL is Exceeded (13.7 acres)
▢	Claim Boundary

Gamma Survey
Counts per Minute (CPM)

●	IL Not Exceeded Survey Area A: 9,945 - 32,635
●	IL Exceeded Survey Area A: 32,636 - 73,651

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N
W E
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0 200 400
Feet

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

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/18/2018
DOCUMENT NAME: Removal Site Evaluation Report
AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 4-4b

Stantec

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 (11.9 acres)
🟥	Claim Boundary

Gamma Survey

Counts per Minute (CPM)

●	IL Not Exceeded Survey Area B: 8,810 - 15,570
●	IL Exceeded Survey Area B: 15,571 - 42,718

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

N
W E
S

0 450 900
Feet

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

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/18/2018

DOCUMENT NAME: Removal Site Evaluation Report

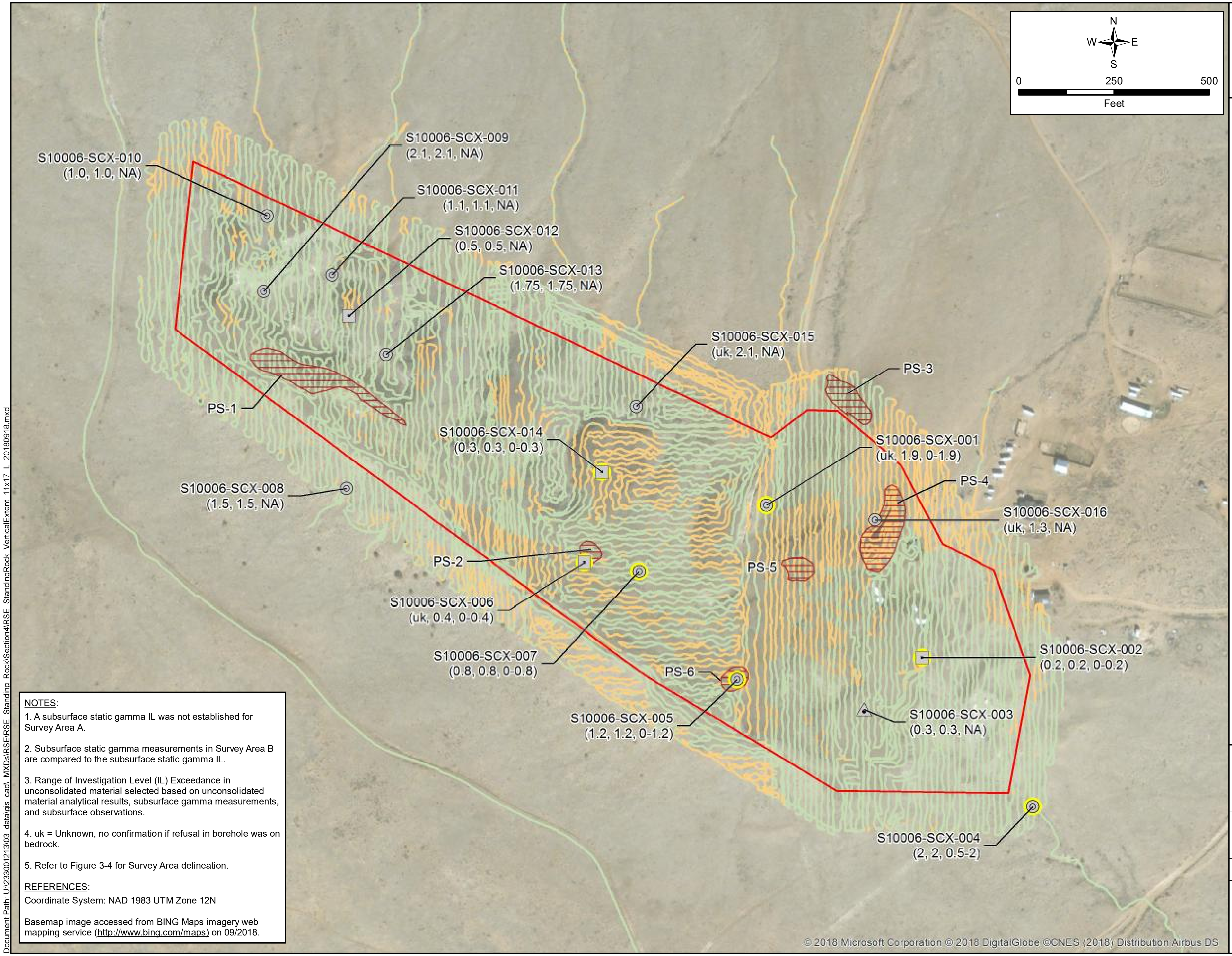
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-4c

Document Path: U:\23300121303_data\gis_cad_MXDs\RSE\RSE_Standing_Rock\Section4\RSE_StandingRock_LateralExtent_SurveyAreaB_11x17_L_20180918.mxd



NOTES:

1. A subsurface static gamma IL was not established for Survey Area A.

2. Subsurface static gamma measurements in Survey Area B are compared to the subsurface static gamma IL.

3. Range of Investigation Level (IL) Exceedance in unconsolidated material selected based on unconsolidated material analytical results, subsurface gamma measurements, and subsurface observations.

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

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

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Standing_Rock\Section4\RSE_StandingRock_VerticalExtent_11x17_L_20180918.mxd

NAVAJO
NATION
AUM Environmental
Response Trust-First Phase

LEGEND

◎	Borehole Location - Surface and Subsurface Sample Location (Depth of Bedrock, Borehole Depth, Depth Range of IL Exceedance in Unconsolidated Material ^{1})
▣	Borehole Location - Surface Samples Only (Depth of Bedrock, Borehole Depth, Depth Range of IL Exceedance in Unconsolidated Material ^{1})
▲	Borehole Location -Static Gamma Data Only
●	IL Exceedance in Unconsolidated Material at Location
▤	Potential Stockpile
☐	Claim Boundary

Gamma Survey

Counts per Minute (CPM)

●	IL Not Exceeded Survey Area A: 9,945 - 32,635 Survey Area B: 8,810 - 15,570
●	IL Exceeded Survey Area A: 32,636 - 73,651 Survey Area B: 15,571 - 42,718

TITLE:

Vertical Extent of IL Exceedances in Unconsolidated Material

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/21/2018

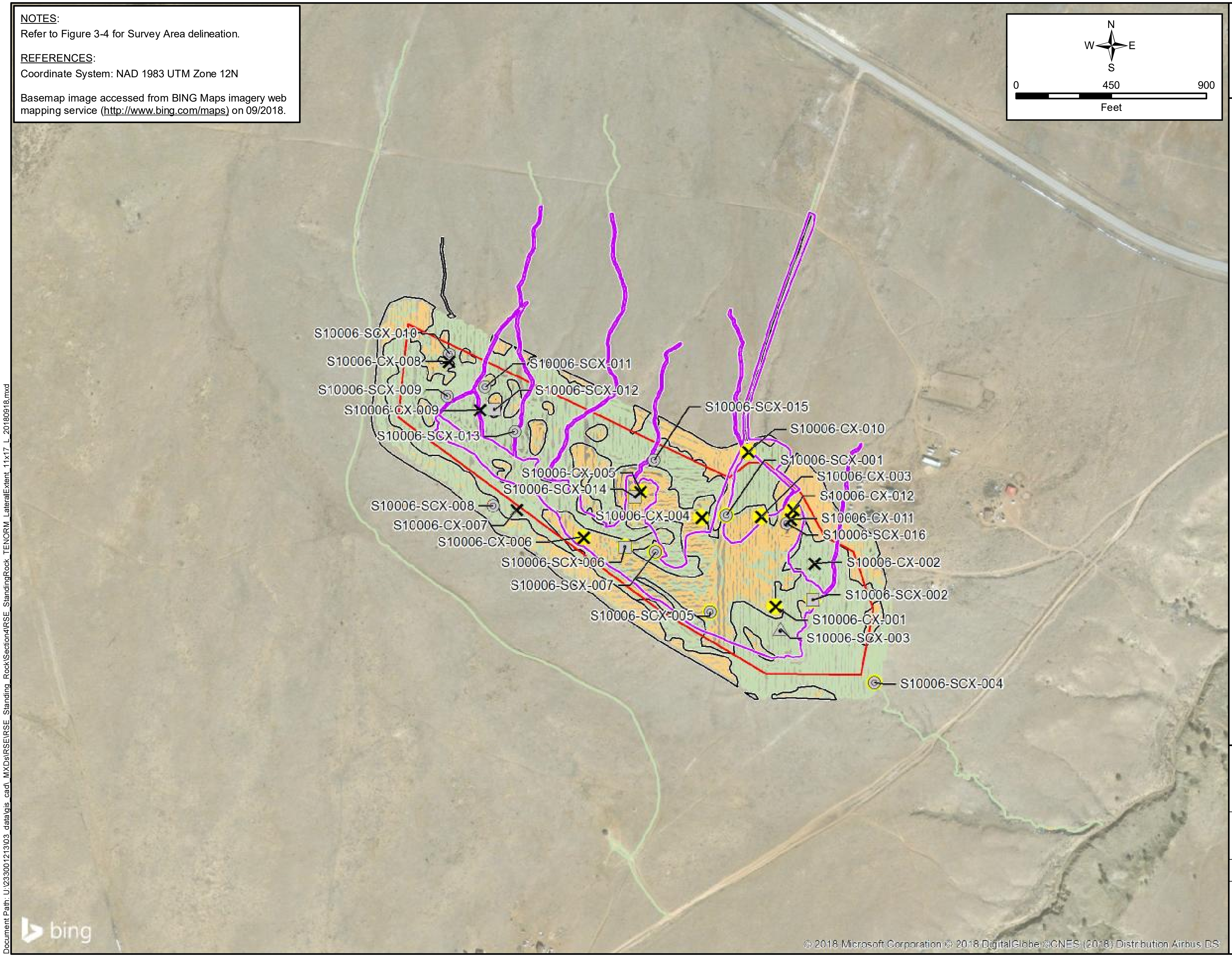
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-5



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

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- ◎ Borehole Location - Surface and Subsurface Samples
- ▣ Borehole Location - Surface Samples Only
- △ Borehole Location -Static Gamma Data Only
- ● IL Exceedance in Unconsolidated Material at Location
- TENORM (15.6 acres)
- ▢ Approximate Area where Surface Gamma ILs are Exceeded (25.6 acres)
- 🟥 Claim Boundary

Gamma Survey
Counts per Minute (CPM)

● IL Not Exceeded
Survey Area A: 9,945 - 32,635
Survey Area B: 8,810 - 15,570

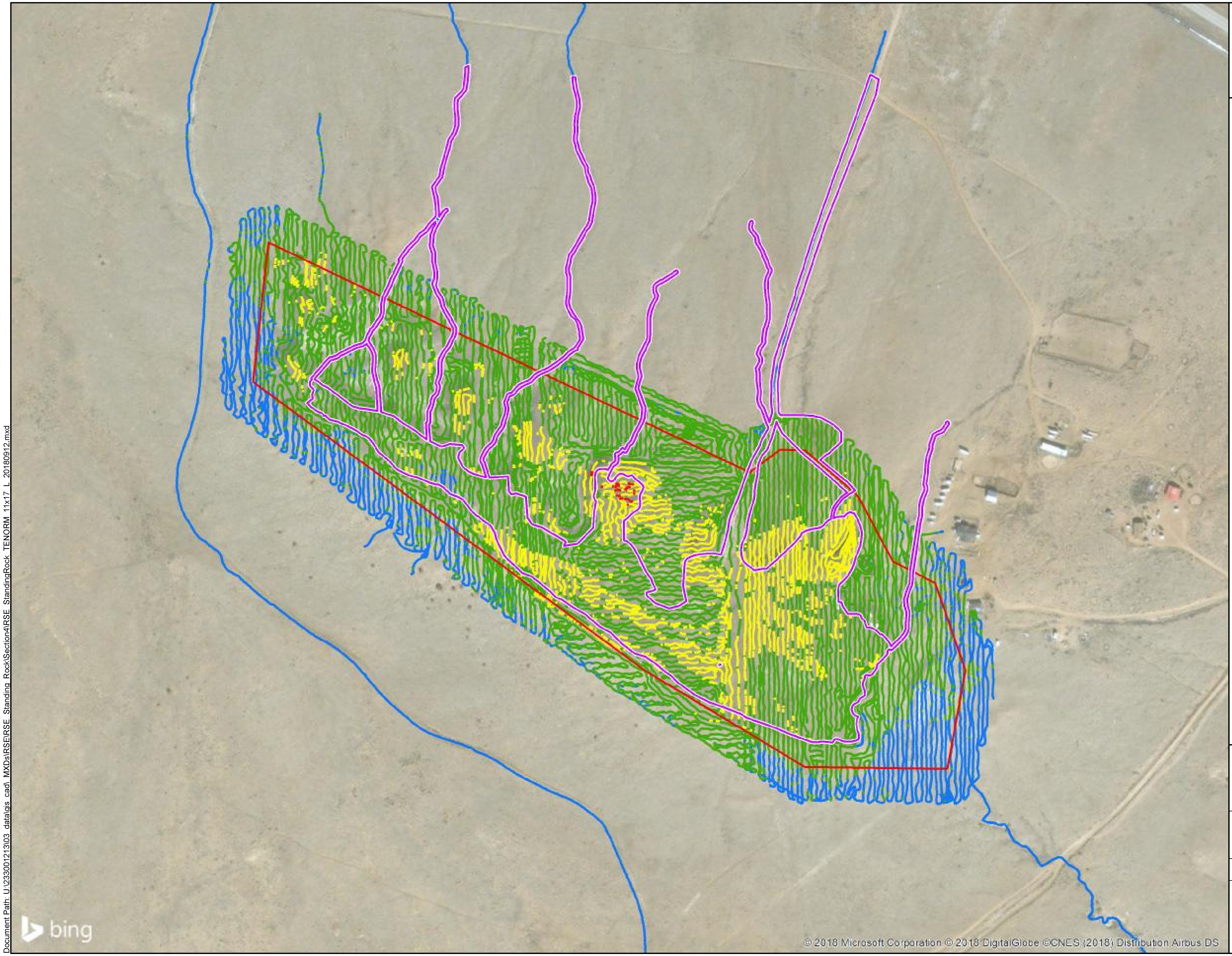
● IL Exceeded
Survey Area A: 32,636 - 73,651
Survey Area B: 15,571 - 42,718

TITLE:
TENORM Compared to
Lateral Extent of IL Exceedances

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

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

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Standing_Rock\Section4\RSE_StandingRock_TENORM_LateralExtent_11x17_L_20180918.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

▢	TENORM (15.6 acres)
▢	Claim Boundary

Gamma Survey

Counts per Minute (CPM)

●	8,810 - 15,570 (Minimum to BG-2 IL)
●	15,571 - 32,635 (>BG-2 IL - BG-1 IL)
●	32,636 - 65,270 (>BG-1 IL - 2x BG-1 IL)
●	65,271 - 73,651 (>2x BG-1 IL to Maximum)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

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TITLE:
TENORM Compared to Gamma Radiation Survey Results

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/12/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

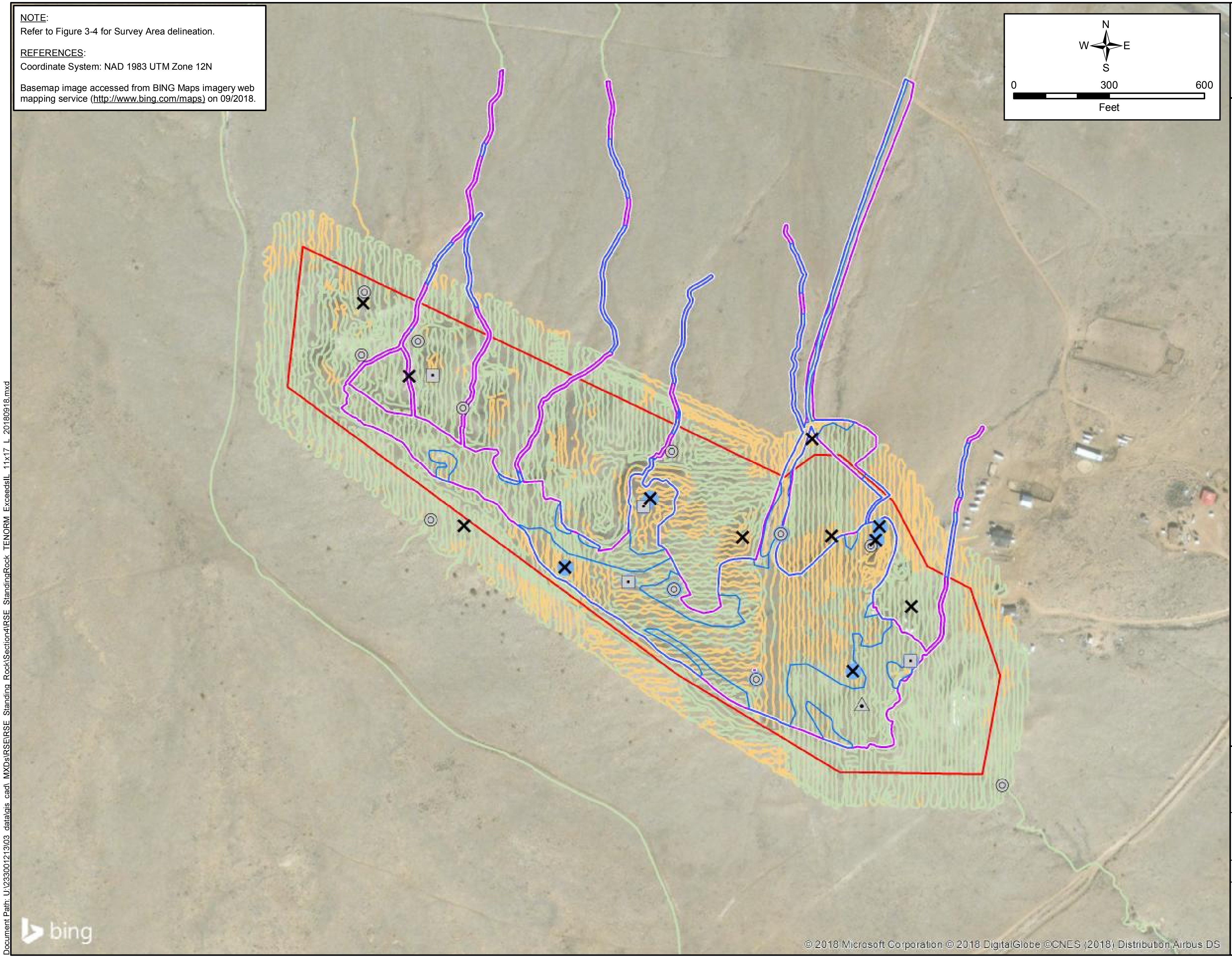
FIGURE: 4-7

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Standing_Rock\Section4\RSE_StandingRock_TENORM_11x17_L_20180912.mxd

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

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Borehole Location - Surface and Subsurface Samples
⊡	Borehole Location - Surface Samples Only
△	Borehole Location -Static Gamma Data Only
●	TENORM Exceeding IL in Unconsolidated Material at Location
▭	TENORM Area Exceeding Surface Gamma ILs (9.1 acres)
▭	TENORM (15.6 acres)
▭	Claim Boundary

Gamma Survey
Counts per Minute (CPM)

●	IL Not Exceeded Survey Area A: 9,945 - 32,635 Survey Area B: 8,810 - 15,570
●	IL Exceeded Survey Area A: 32,636 - 73,651 Survey Area B: 15,571 - 42,718

TITLE:
TENORM that Exceeds ILs

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/21/2018
DOCUMENT NAME: Removal Site Evaluation Report
AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 4-8a

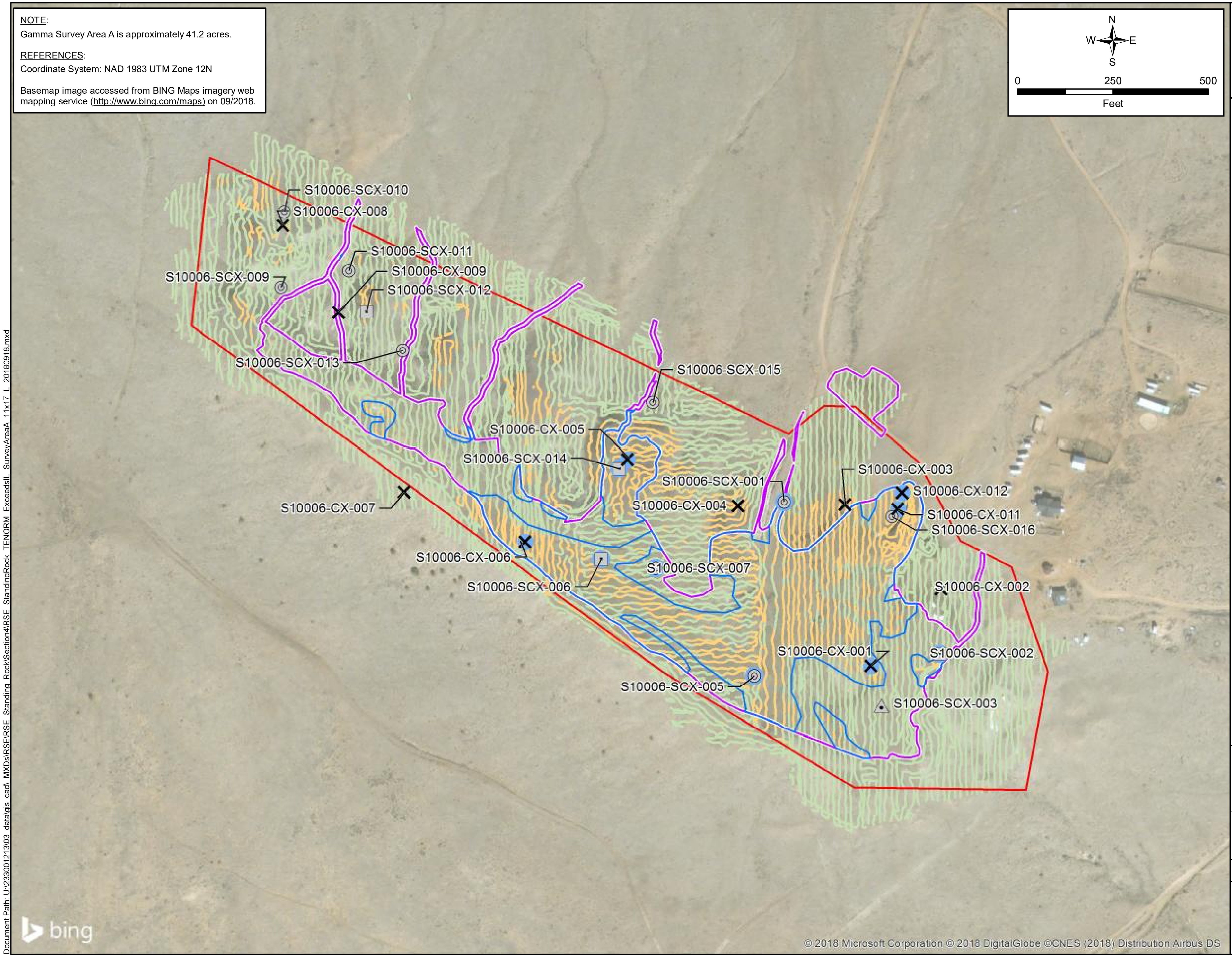
Stantec

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Standing Rock\Section4\RSE StandingRock TENORM ExceedsIL 11x17 L 20180918.mxd

NOTE:
Gamma Survey Area A is approximately 41.2 acres.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Borehole Location - Surface and Subsurface Samples
▣	Borehole Location - Surface Samples Only
△	Borehole Location -Static Gamma Data Only
●	TENORM Exceeding IL in Unconsolidated Material at Location
▢	TENORM Area Exceeding Surface Gamma IL (7.8 acres)
▢	TENORM (13.7 acres)
▢	Claim Boundary

Gamma Survey
Counts per Minute (CPM)

●	IL Not Exceeded Survey Area A: 9,945 - 32,635
●	IL Exceeded Survey Area A: 32,636 - 73,651

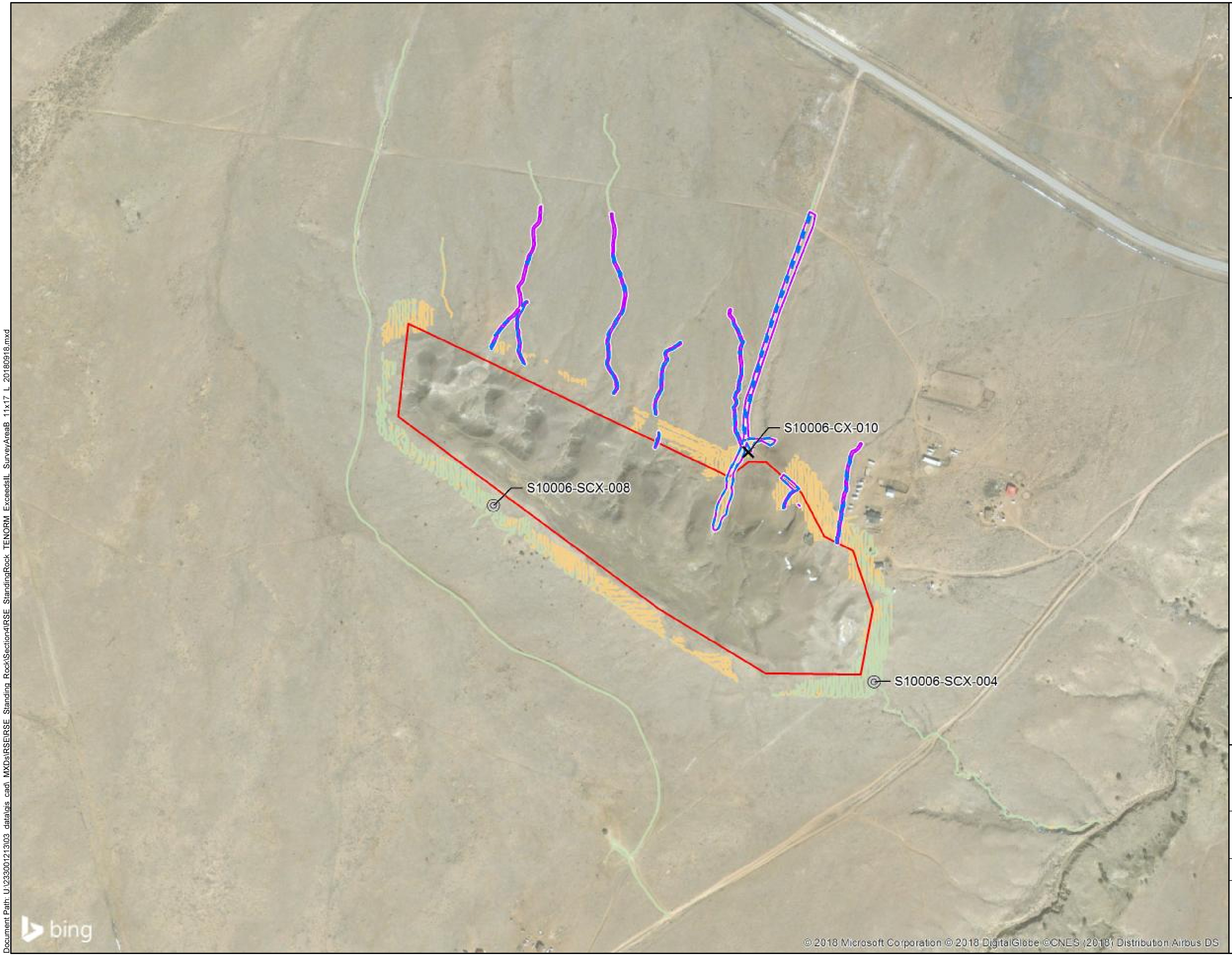
TITLE:
Survey Area A
TENORM that Exceeds ILs

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/21/2018
DOCUMENT NAME: Removal Site Evaluation Report
AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 4-8b

Stantec

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Standing_Rock\Section4\RSE_StandingRock_TENORM_ExceedsIL_SurveyAreaA_11x17_L_20180918.mxd



Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Standing Rock\Section4\RSE StandingRock TENORM ExceedsIL SurveyAreaB 11x17 L 20180918.mxd

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- ◎ Borehole Location - Surface and Subsurface Samples
- ⬚ TENORM Area Exceeding ILs (1.3 acres)
- ▢ TENORM (1.9 acres)
- 🟥 Claim Boundary

Gamma Survey
Counts per Minute (CPM)

- ● IL Not Exceeded
  Survey Area B: 8,810 - 15,570
- ● IL Exceeded
  Survey Area B: 15,571 - 42,718

NOTE:
Gamma Survey Area B is approximately 15.6 acres.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N
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0 450 900
Feet

TITLE:
Survey Area B
TENORM that Exceeds ILs

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/21/2018

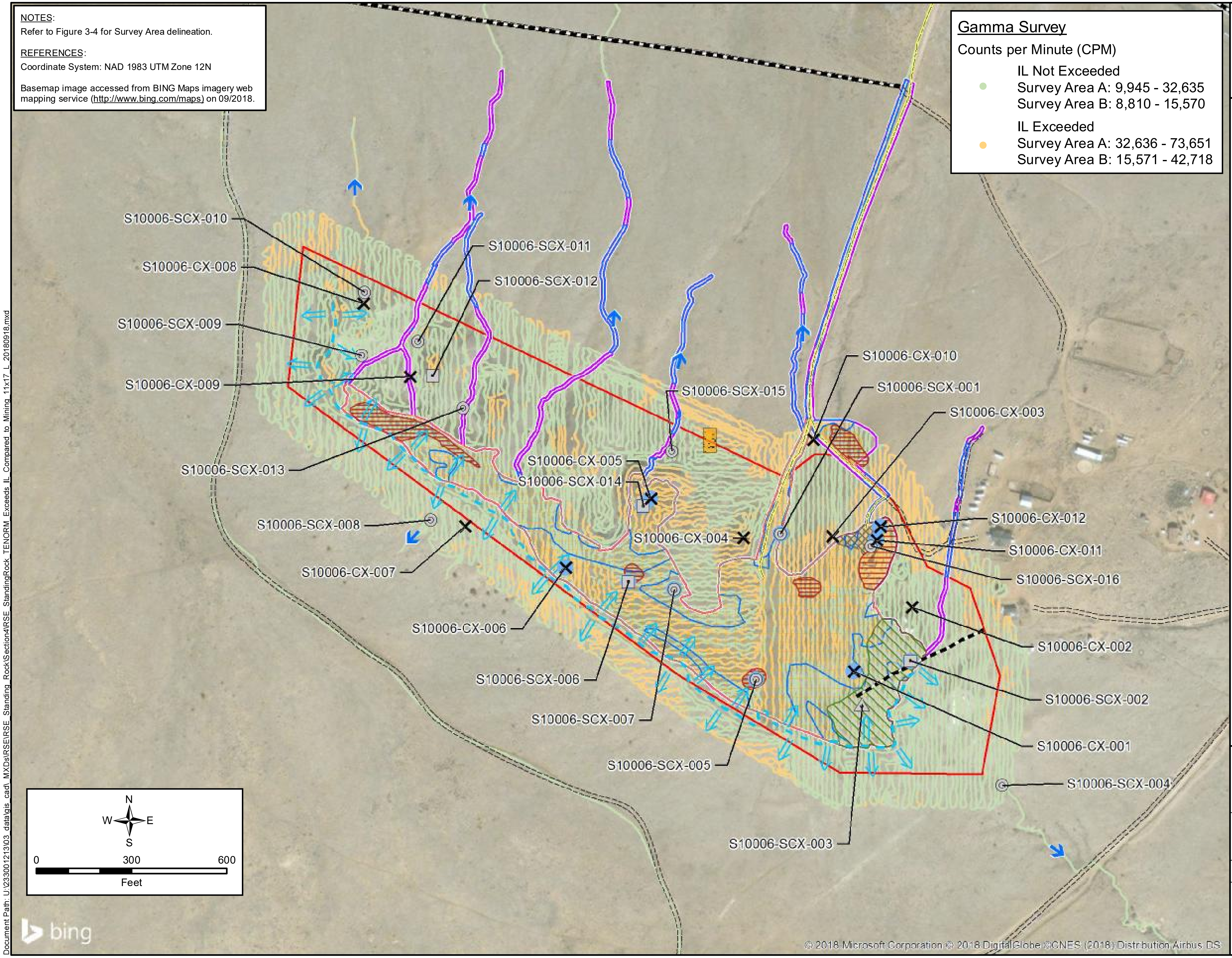
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-8c



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

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

Gamma Survey
Counts per Minute (CPM)

● IL Not Exceeded
Survey Area A: 9,945 - 32,635
Survey Area B: 8,810 - 15,570

● IL Exceeded
Survey Area A: 32,636 - 73,651
Survey Area B: 15,571 - 42,718

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- ◎ Borehole Location - Surface and Subsurface Samples
- ▣ Borehole Location - Surface Samples Only
- △ Borehole Location -Static Gamma Data Only
- ● TENORM Exceeding in Unconsolidated Material at Location
- ↑ Flow Direction
- ⇧ Approximate Overland Water Flow Direction
- - - Approximate Watershed Divide Line
- ------ Potential Haul Road
- ■■■ Potential Road
- ===== Road
- ▤ Potential Stockpile
- ▩ Excavation
- ▨ Graded Potential Grazing Area
- ▦ Scattered Debris
- ▤ Potential Stockpile
- ▦ Disturbed Area
- ▢ TENORM Area Exceeding Surface Gamma ILs (9.1 acres)
- ▢ TENORM (15.6 acres)
- ▢ Claim Boundary

TITLE:
TENORM that Exceeds ILs Compared to Mining Related Features

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/21/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

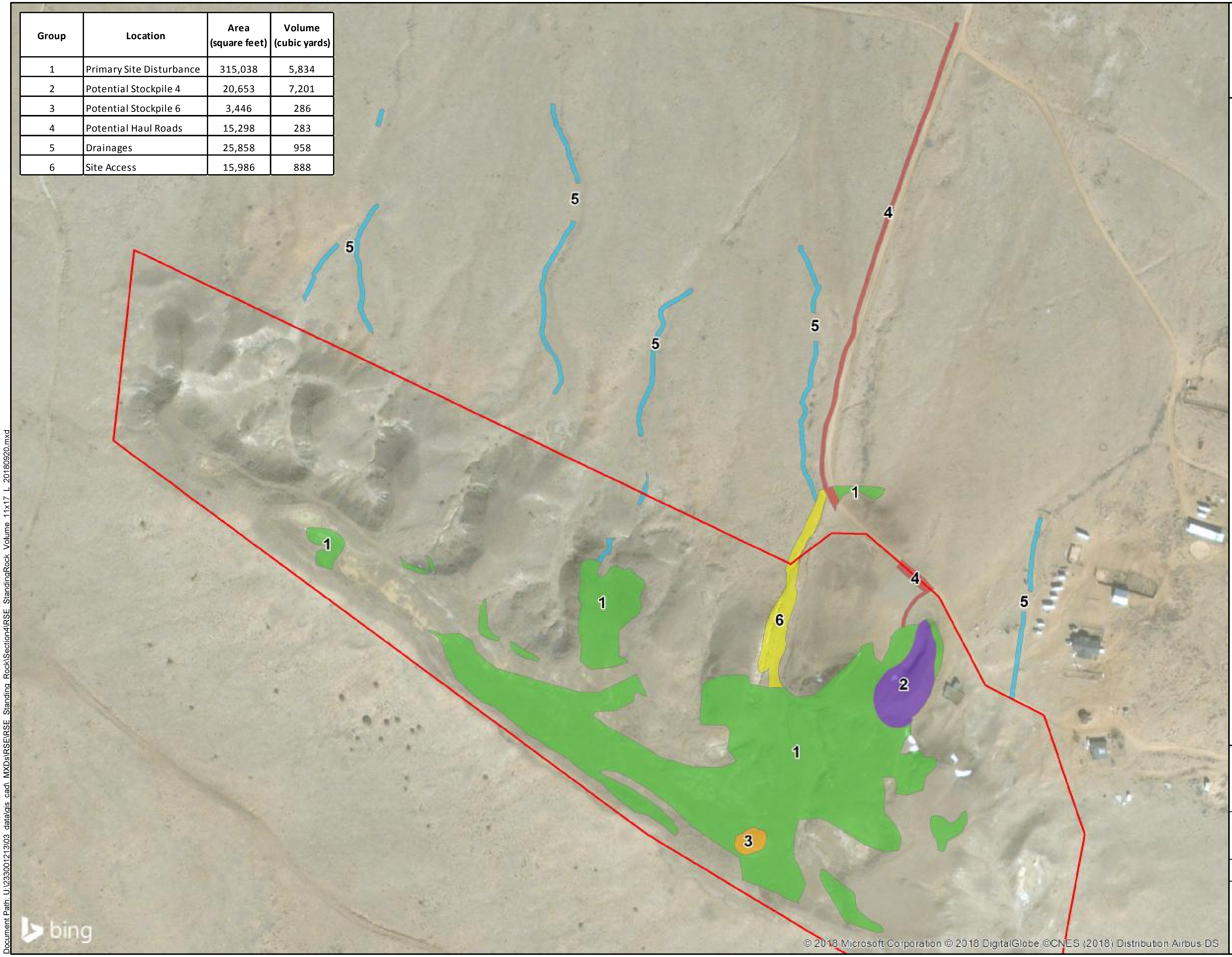
AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-8d

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Standing_Rock\Section4\RSE_StandingRock_TENORM_Exceeds_IL_Compared_to_Mining_11x17_L_20180918.mxd

Group	Location	Area (square feet)	Volume (cubic yards)
1	Primary Site Disturbance	315,038	5,834
2	Potential Stockpile 4	20,653	7,201
3	Potential Stockpile 6	3,446	286
4	Potential Haul Roads	15,298	283
5	Drainages	25,858	958
6	Site Access	15,986	888



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

▭ Claim Boundary

Average TENORM Depth by Group (feet below ground surface)

🟩 Group 1 - Primary Site Disturbance - 0.5 ft

🟪 Group 2 - Potential Stockpile 4 - Variable

🟧 Group 3 - Potential Stockpile 6 - Variable

🟥 Group 4 - Potential Haul Roads - 0.5 ft

🟦 Group 5 - Drainages - 1.0 ft

🟨 Group 6 - Site Access - 1.5 ft

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

TITLE:
Volume Estimate of
TENORM that Exceeds ILs

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/20/2018
DOCUMENT NAME: Removal Site Evaluation Report
AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 4-9

Stantec

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Standing_Rock\Section4\RSE_StandingRock_Volume_11x17_L_20180920.mxd

APPENDICES

Appendix A Radiological Characterization of the Standing Rock Abandoned Uranium Mine

Radiological Characterization of the Standing Rock Site

September 18, 2018

prepared for:

Stantec Consulting Services Inc.

2130 Resort Drive, Suite 350
Steamboat Springs, CO 80487

prepared by:

ERG

Environmental Restoration Group, Inc.

8809 Washington St. NE
Suite 150
Albuquerque, NM 87113

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Tables

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Acronyms

ANSI	American National Standards Institute
AUM	abandoned uranium mine
BG1	Background Reference Area 1
BG2	Background Reference Area 2
cpm	counts per minute
DQOs	data quality objectives
EPA	U.S. Environmental Protection Agency
ERG	Environmental Restoration Group, Inc.
ft	foot
GPS	global positioning system
MDC	Minimum Detectable Concentration
µR/h	microRoentgens per hour
pCi/g	picocuries per gram
R^2	Pearson's Correlation Coefficient
RSE	removal site evaluation
σ	standard deviation
Stantec	Stantec Consulting Services Inc.

Executive Summary

This report addresses the radiological characterization of the Standing Rock Site (the Site) located in the Nahodishgish Chapter of the Navajo Nation in Red Rock Valley, New Mexico. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. (ERG) of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) in accordance with 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 Site to exposure rates and concentrations of radium-226 in surface soils. The field activities addressed in this report were conducted on November 16 and 18, 2016; and March 24 and June 29, 2017. They included a GPS-based radiological survey of land surfaces over a Survey Area consisting of the claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer; and correlation studies.

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in the “Standing Rock 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.
- Gamma count rates in the claim area are naturally higher on the top of the outcrop than on its sides. There is evidence of earthwork on portions of the Site.
- Two potential Background Reference Areas were established.
- The mean relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface) is described by a linear model:

$$\text{Gamma Count Rate (cpm)} = 4039 \times [\text{radium-226 (pCi/g)}] + 10693$$

- 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 -0.5 to 15.6, with a central tendency (median) of 2.6 pCi/g.

- Thorium-232 and its decay products are in relatively higher abundance in the host rock at this Site, an exception to the other AUMs addressed in the RSE Work Plan. The thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226 in surface soil from gamma count rates.

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

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

$$\text{Exposure Rate } (\mu\text{R/h}) = 7\text{x}10^{-4} \text{ x Gamma Count Rate (cpm)} + 4.8211$$

- The distribution of exposure rates predicted using this model is rightward tailed. The values in the Survey Area range from 11.0 to 56.4, with a central tendency (median) of 19.6 µR/h.

1.0 Introduction

This report addresses the radiological characterization of the Standing Rock Site located in the Nahodishgish Chapter of the Navajo Nation near Gallup, New Mexico. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. (ERG) of Albuquerque, New Mexico and Stantec Consulting Services, Inc. (Stantec) The activities described here focus on the characterization of gamma radiation (gamma) emitted by uranium series radionuclides in surface soils at the Site.

This report provides the results of a 1) Global Positioning System (GPS)-based gamma radiation (gamma) survey and 2) comparisons of gamma count rates to exposure rates and concentrations of radium-226 in surface soils.

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

The field activities were conducted on November 16 and 18, 2016; and March 24 and June 29, 2017 in accordance with the methods described in the RSE Work Plan. The GPS-based radiological survey of land surfaces covered an approximately 57-acre Survey Area that included the claim area out to a 100-foot (ft) 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. Section 3.0 of the RSE Workplan provides the data quality objectives (DQOs) for the project.

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

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

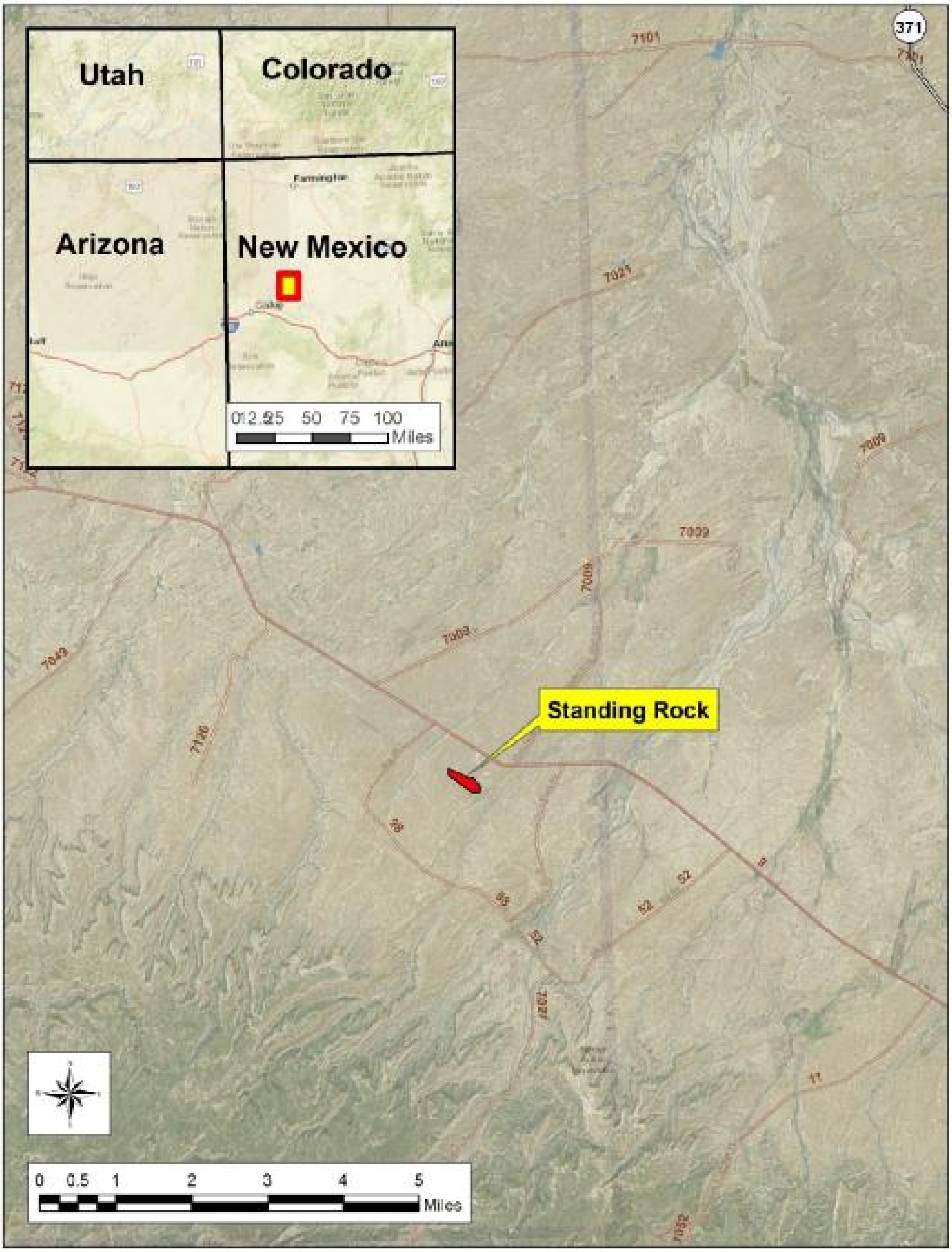


Figure 1. Location of the Standing Rock Site

2.0 GPS-Based Gamma Survey

This section addresses the GPS-based surveys conducted in two 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

Area	Ludlum Model 44-10	Ludlum Model 2221 Ratemeter/Scaler
Potential Background Reference Areas	PR303727[a]	254772[a]
	PR295014	196086
Survey Area	PR303727[a]	254772[a]
	PR295014	196086
	PR154615	138368
	PR150507	282966

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

2.1 Potential Background Reference Areas

Two potential Background Reference Areas were surveyed, the locations and results of which are depicted on Figure 2. BG1 and BG2 in the figure are Background Reference Areas 1 and 2, respectively.

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

- BG1 ranged from 19,646 to 36,225 counts per minute (cpm), with a mean and median of 26,494 and 26,306 cpm, respectively.

- BG2 ranged from 10,910 to 16,806 cpm, with a mean and median of 13,871 and 13,811 cpm, respectively.

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

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

	Gamma Count Rate (cpm)					
Potential Background Reference Area	**n**	**Minimum**	**Maximum**	**Mean**	**Median**	**Standard Deviation**
1	222	19,646	36,225	26,494	26,306	3,365
2	543	10,910	16,806	13,871	13,811	967

Notes:
cpm = counts per minute

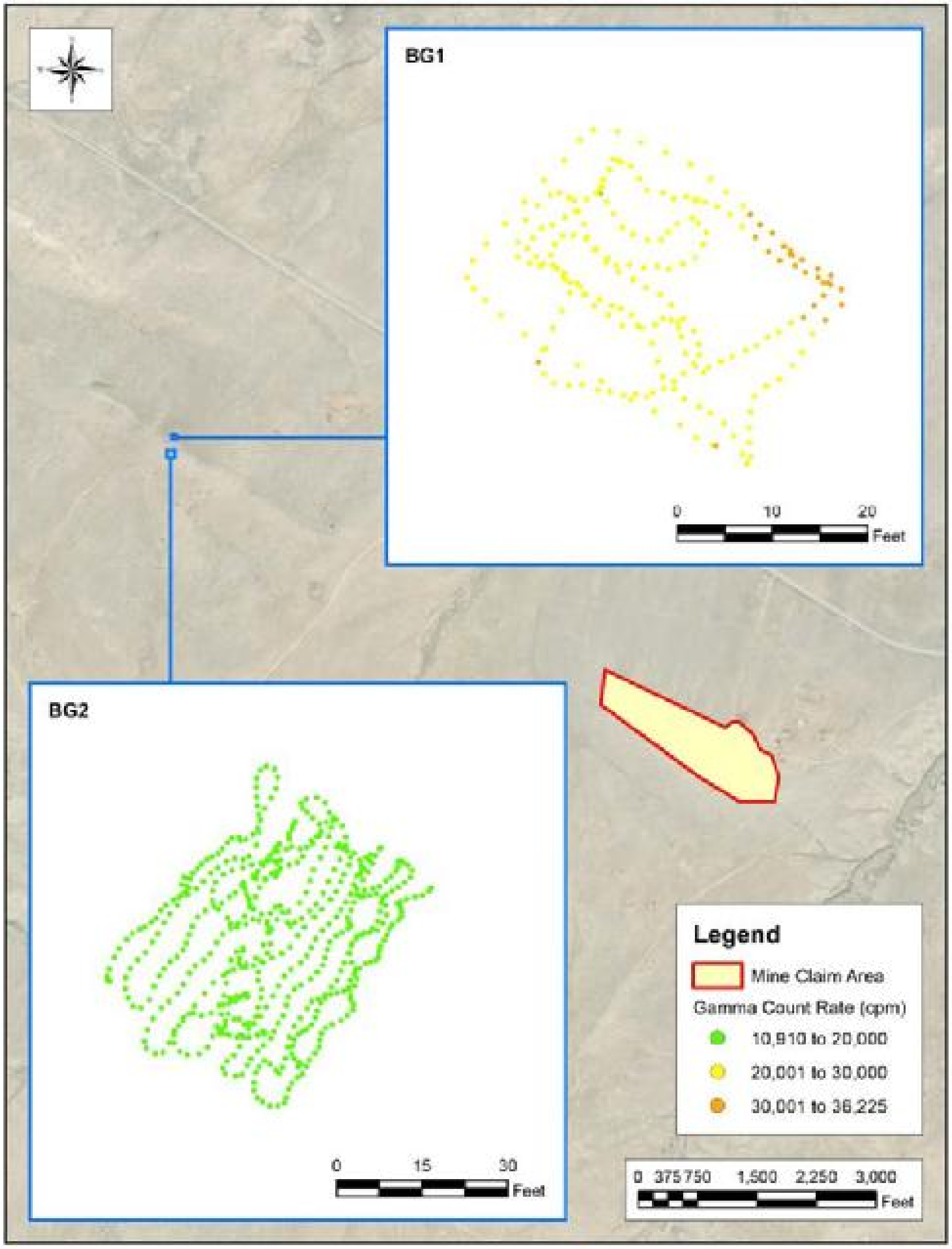
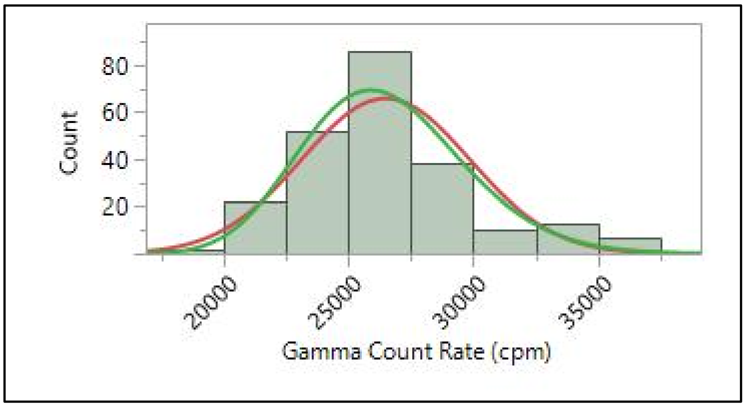
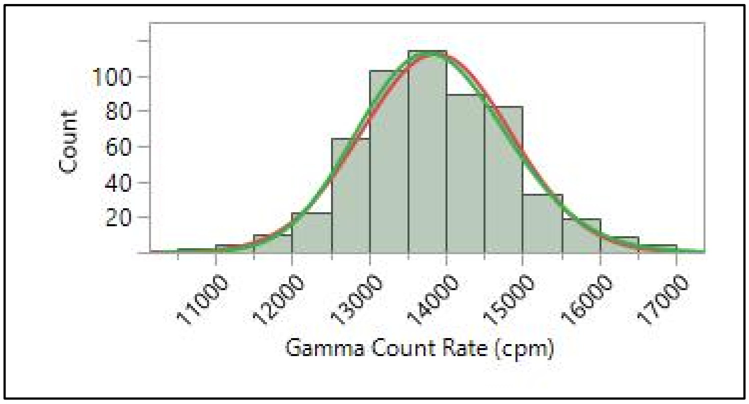


Figure 2. Gamma count rates in the potential Background Reference Areas



a. **Background Reference Area 1**



b. **Background Reference Area 2**

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

2.2 Survey Area

The gamma count rates observed in the Survey Area are depicted in Figure 4. Gamma count rates in the claim are naturally higher on the top of the outcrop than on its sides. There is evidence of earthwork on portions of the claim.

Figure 5 is a histogram of the gamma count rate measurements made in the Survey Area. As stated in Section 2.1, the red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could be expected if the distributions were normal or lognormal. The distribution of the right-tailed set of measurements, evaluated using U.S. Environmental Protection Agency software ProUCL, is not defined. The box plot in Figure 6 depicts cutoffs as horizontal bars, from bottom to top, for the following values or percentiles: minimum, 0.5, 2.5, 10, 25, 50, 75, 90, 97.5, 99.5, and maximum. The 25th, 50th, and 75th percentiles (the three horizontal lines of the box inside the box plot) are 16,410, 21,139, and 27,469 cpm, respectively.

Table 3 is a statistical summary of the measurements, which range from 8,810 to 73,651 cpm and have a central tendency (median) of 21,139 cpm.

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

Parameter	Gamma Count Rate (cpm)
n	60,068
Minimum	8,810
Maximum	73,651
Mean	22,886
Median	21,139
Standard Deviation	8,508

Notes:
cpm = counts per minute

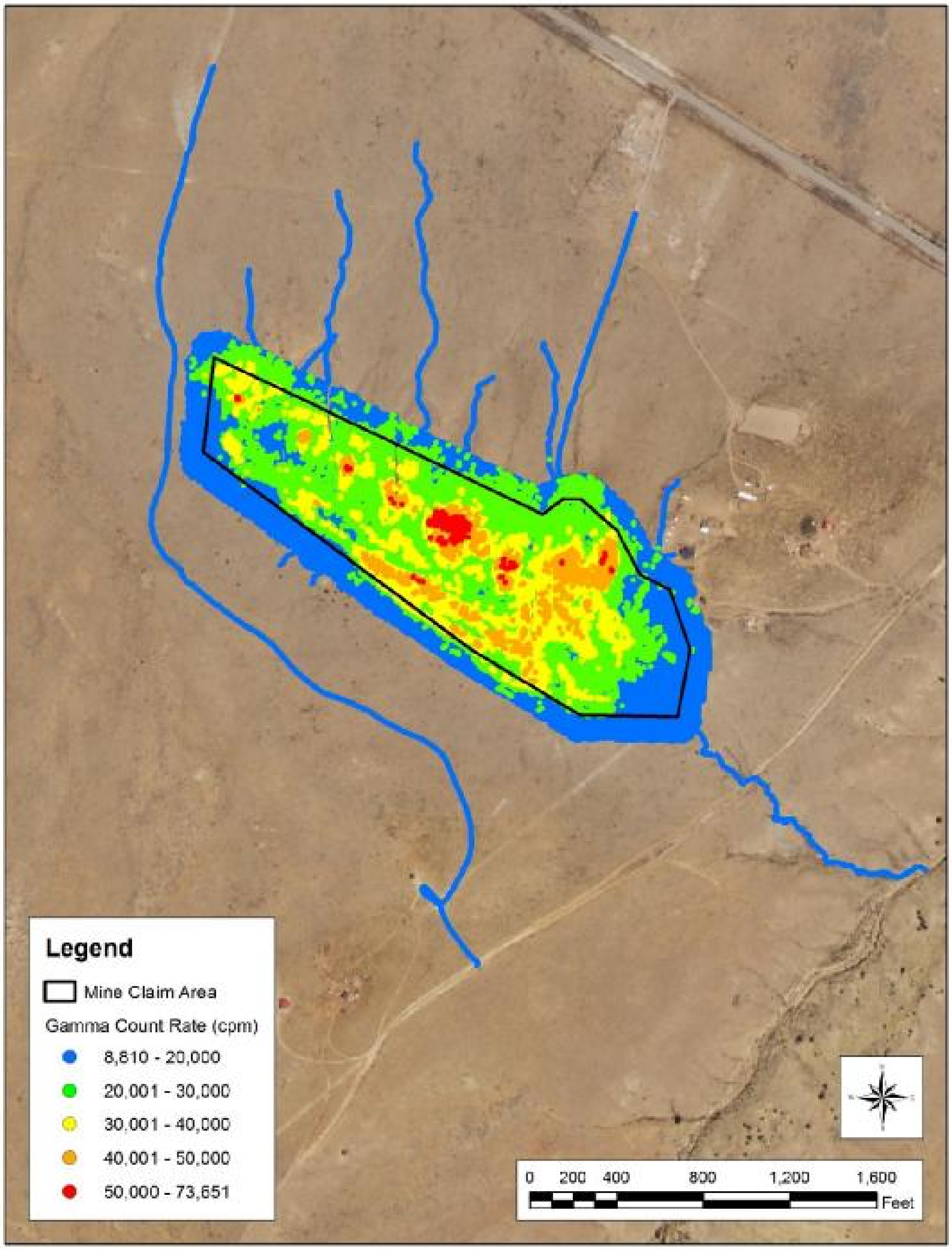


Figure 4. Gamma count rates in the Survey Area

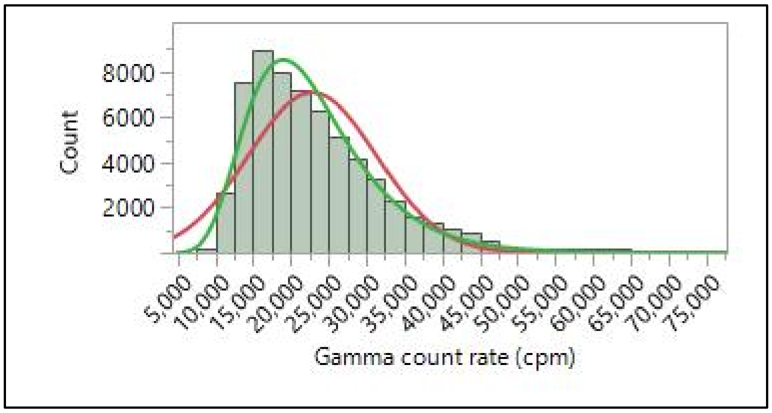


Figure 5. Histogram of gamma count rates in the Survey Area.

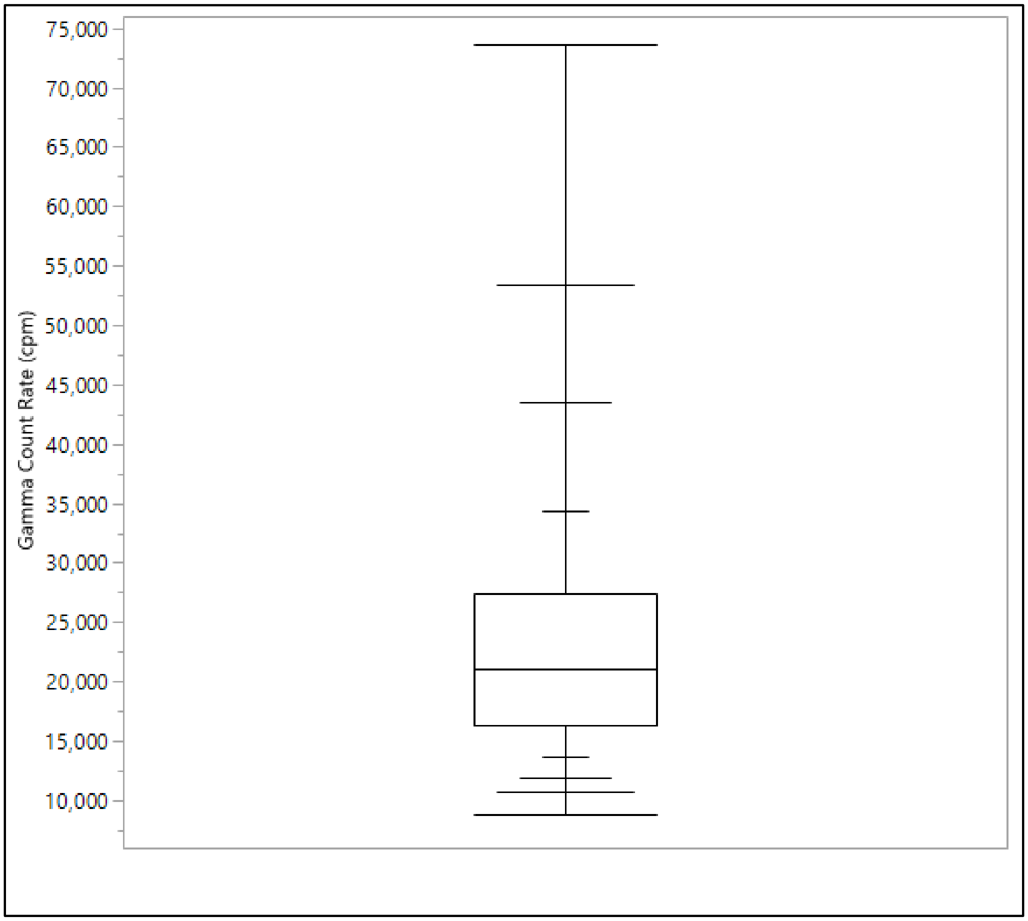


Figure 6. Box plot of gamma count rates in the Survey Area

3.0 Correlation Studies

The following sections address the correlation studies outlined in the RSE Work Plan, which are comparisons of radium-226 concentrations in surface soils and gamma count rates and comparisons of 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 November 18, 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 and to 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 measurements and radium-226 concentrations in the soil samples. The means of the gamma count rate measurements range from 12,310 to 37,858 cpm. The concentrations of radium-226 range from 0.68 to 6.93 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: Data Usability Report, Laboratory Analytical Data, and Data Validation Reports in the “Standing Rock Removal Site Evaluation Report” (Stantec, 2018).

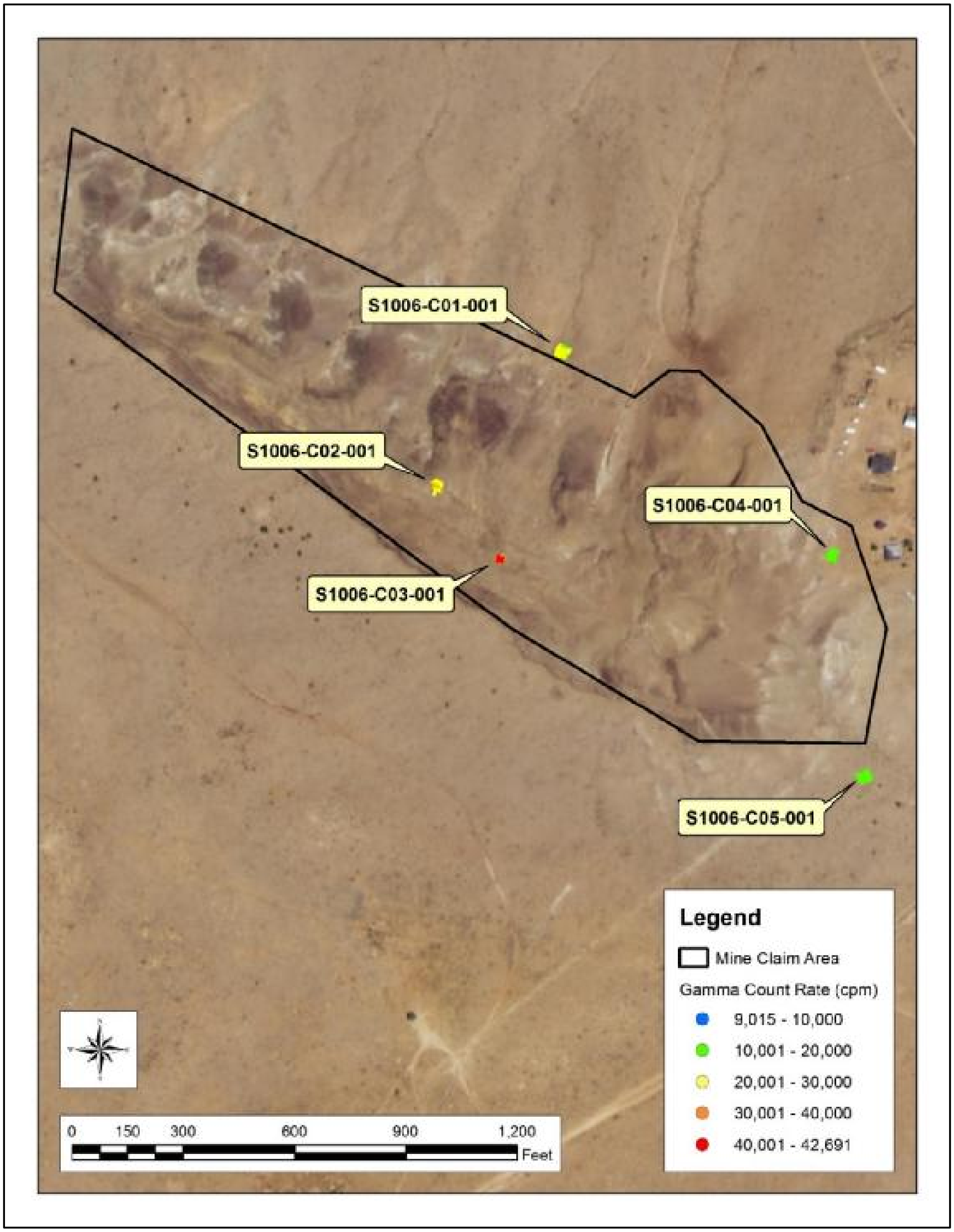


Figure 7. GPS-based gamma count rate measurements made for the correlation study

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**
S10006-C01-201	113.8	19,141	16,018	24,623	1,341	1.76	0.35	0.37
S10006-C02-001	79.8	26,728	23,710	33,691	1,538	3.62	0.57	0.58
S10006-C03-001	36.6	37,858	33,182	42,691	1,742	6.93	0.97	0.83
S10006-C04-001	86.5	14,940	12,563	18,531	1,141	1.25	0.28	0.38
S10006-C05-001	90.9	12,310	9,015	17,604	1,214	0.68	0.26	0.51

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

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

	Thorium-228 (pCi/g)			Thorium-230 (pCi/g)			Thorium-232 (pCi/g)		
Sample ID	**Result**	**Error ± 2 σ**	**MDC**	**Result**	**Error ± 2 σ**	**MDC**	**Result**	**Error ± 2 σ**	**MDC**
S10006-C01-201	1.79	0.33	0.1	0.96	0.20	0.10	1.72	0.31	0.02
S10006-C02-001	5.91	0.95	0.07	2.47	0.42	0.08	5.79	0.93	0.03
S10006-C03-001	8.6	1.4	0.1	3.17	0.51	0.07	8.5	1.3	0
S10006-C04-001	1.29	0.22	0.05	0.98	0.18	0.07	1.25	0.22	0.01
S10006-C05-001	0.74	0.14	0.05	0.68	0.13	0.07	0.72	0.13	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 0.98, as expressed in the equation:

$$\text{Gamma Count Rate (cpm)} = 4039 \times [\text{radium-226 (pCi/g)}] + 10693$$

The root mean square error and p-value for the model are 1.6×10^3 and less than 0.001, respectively; these parameters are not data quality objectives (DQOs) and are included only as information. The R^2 value for this model exceeds the project DQO of 0.8.

This equation was used to convert the gamma count rate measurements observed in the gamma surveys to predicted concentrations of radium-226. Table 6 presents summary statistics for the predicted concentrations of radium-226 in the Survey Area. The range of the predicted concentrations of radium-226 in the Survey Area is -0.5 to 15.6 pCi/g, with a mean and median of 3.0 and 2.6 pCi/g, respectively. Note that the radium-226 concentrations predicted from gamma count rate measurements exceeding approximately 35,000 cpm are extrapolated from the regression model and are outside of the correlation dataset and therefore inherently uncertain. While the gamma correlation equation can be used to convert gamma count rates to concentrations of Ra-226 in soil, the resulting radium concentrations are highly uncertain estimates, as the wide prediction interval bands illustrated in Figure 8 demonstrate. Users of the regression equation should be aware of the limitations of the dataset and be cautious when estimating radium-226 concentrations.

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

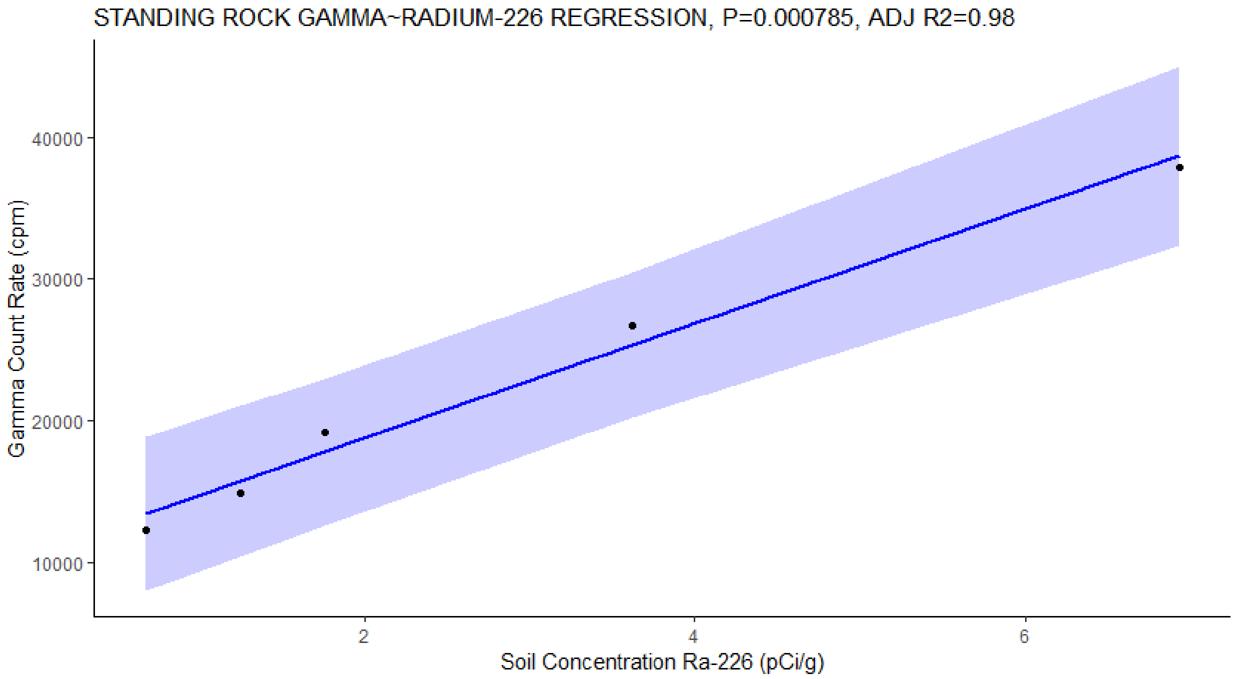


Figure 8. Correlation of gamma count rates and concentrations of radium-226 in surface soils (blue line) with 95% upper prediction level bands plotted (shaded blue area)

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

Parameter	Radium-226 (pCi/g)
n	60,068
Minimum	-0.5
Maximum	15.6
Mean	3.0
Median	2.6
Standard Deviation	2.1

Notes:
pCi/g = picocuries per gram

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

A multivariate linear regression (MLR) was used to evaluate the influence of thorium-232 and thorium-228 isotopes in the thorium series, on the average gamma count rate in the correlation locations. The MLR model was first run using radium-226, thorium-232, and thorium-228 as predictors of gamma count rate. The model failed to produce results because thorium-232 and thorium-228 are colinear. The MLR model was subsequently run without thorium-228. For the second model, the p-values for radium-226 and thorium-232 were both greater than 0.05 (0.20 and 0.51 respectively) and therefore not significant predictors of gamma count rate collectively. Thorium-232 and radium-226 were then each modelled individually as a predictor of gamma count rate. The p-value for thorium-232 coefficient was 0.002 with an adjusted R^2 of 0.96. The thorium-232 coefficient is significant and the R^2 value meets the project DQO. The p-value for radium-226 as a predictor of gamma count rate was also significant ($p < 0.001$), as described above, and the adjusted R^2 value (0.98) also met the applicable project DQO ($R^2 > 0.8$). Subsequently we conclude that the gamma count rate is well predicted by either thorium-232 or radium-226, but that it is not necessary to correct for the influence of thorium-232 and thorium-228 when using the radium-226 gamma correlation model.

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

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

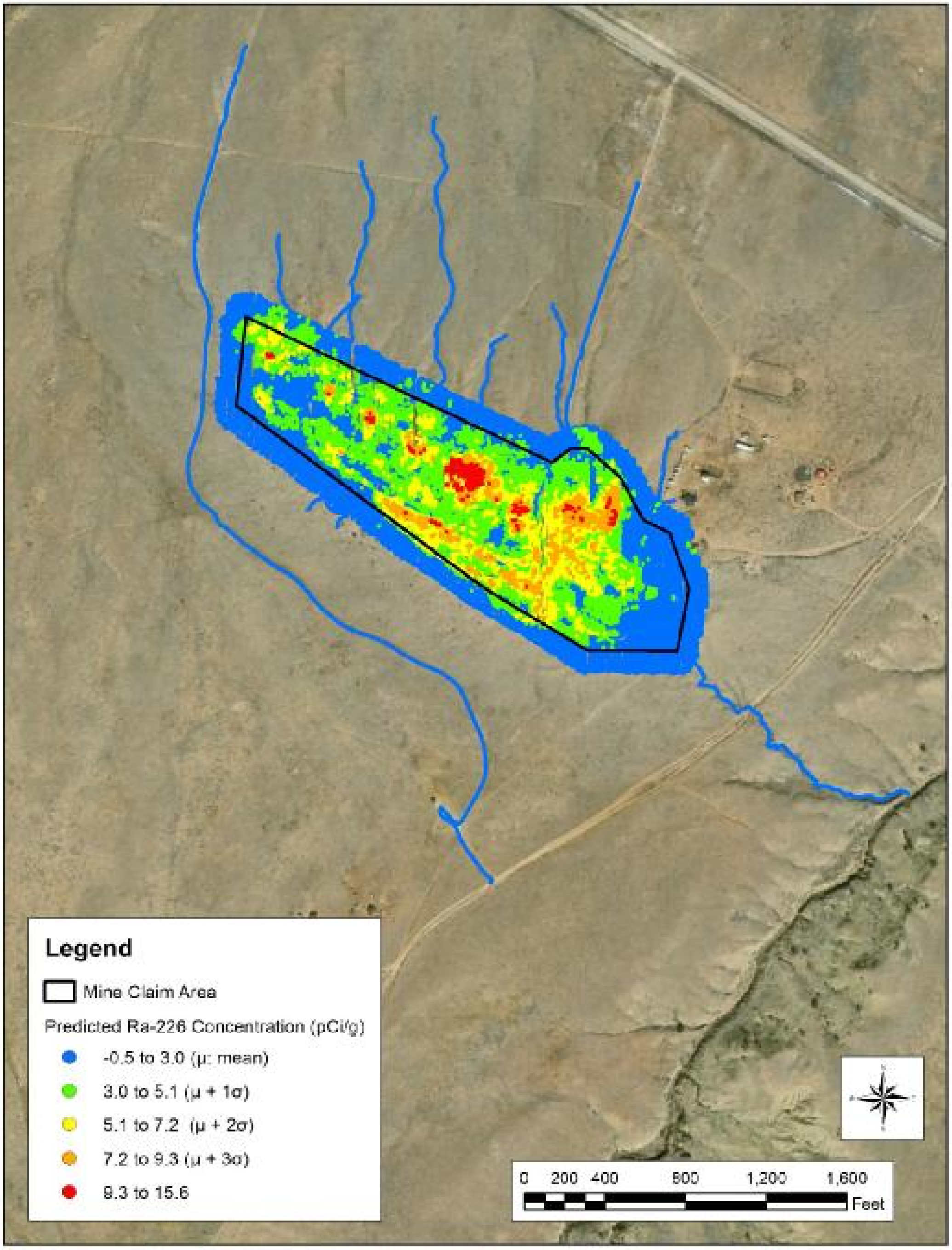


Figure 9. Predicted concentrations of radium-226 in the Survey Area

3.2 Equilibrium in the uranium series

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

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

Determination of secular equilibrium 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. Thus, an inconclusive result regarding secular equilibrium is not a study data gap, as the risk assessment phase may still proceed, provided that conservative assumptions are included regarding equilibrium concentrations of radium-226 decay products.

Regardless, the RSE Workplan specified that an evaluation of secular equilibrium would be made at each of the 16 Trust AUMs, and so a robust statistical examination of secular equilibrium status for 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 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 the Site proceeded as follows:

1. Construction of a figure that depicts soil concentrations of Th-230 plotted against soil concentrations of Ra-226.
2. Simple linear regression is performed on the dataset; the p-value and the adjusted R^2 are recorded. The resulting linear model and the 95% UCL bands are plotted on the figure generated in step 1.

3. The line y=x is added to the figure generated in step 2 (this line represents a perfect 1:1 ratio between Th-230 to Ra-226, indicative of secular equilibrium).

4. An examination of the model and the figure is made sequentially:

    a. If the p-value for the regression slope is insignificant (i.e., $p > 0.05$) or the adjusted R^2 does not meet the study's data quality objective (Adjusted $R^2 > 0.8$), ERG concludes that there is insufficient evidence to conclude that Ra-226 and Th-230 are in equilibrium (secular or otherwise).

    b. If the p-value for the regression slope is significant (i.e., $p < 0.05$) and the adjusted R^2 meets the DQO (Adjusted $R^2 > 0.8$) there are two possible conditions, which are evaluated via visual examination of the figure generated in step 3.

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

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

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

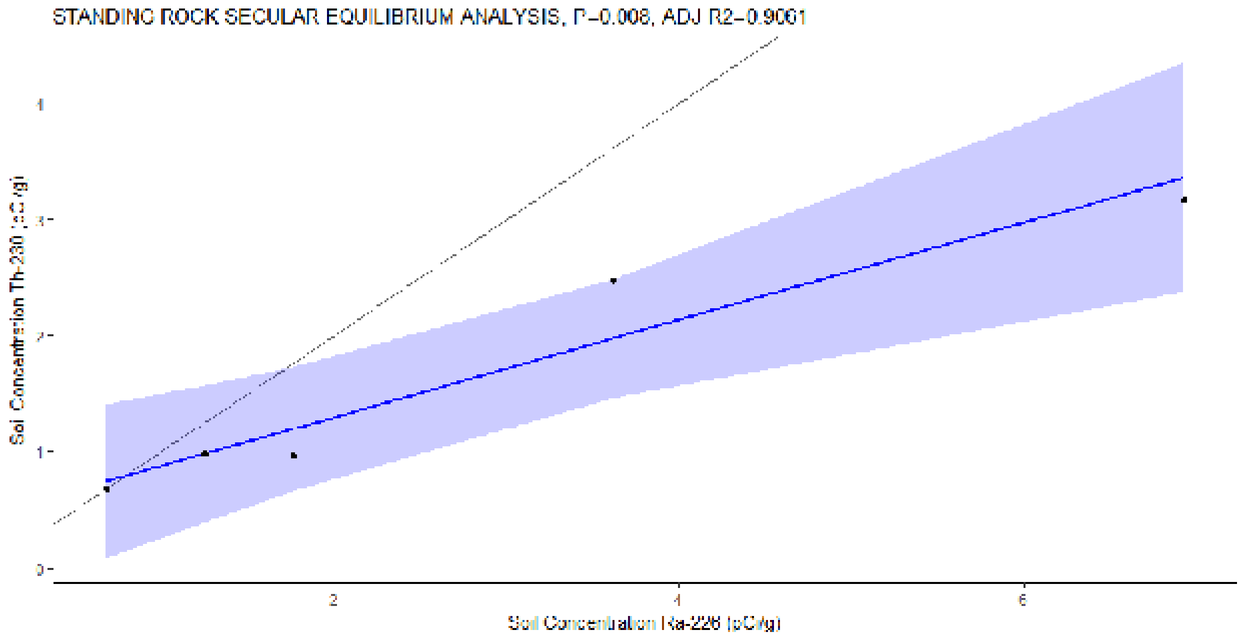


Figure 10. Evaluation of secular equilibrium in the uranium decay series

3.3 Exposure rates and gamma count rates

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

The gamma count rate and exposure rate measurements were made on November 18, 2016 at 0.5 m and 1 m above the ground surface, respectively. The gamma count rate measurements were made using one of the four sodium iodide detection systems used in the GPS-based gamma survey of the Survey Area (Serial Number PR303727/254772). The exposure rate measurements were made using a Reuter Stokes Model RSS-131 (Serial Number 07J00KM1) high pressure ionization chamber (HPIC) at six-second intervals for about 10 minutes. The exposure rate used in the comparison was the mean of these measurements, less those occurring in initial instrument spikes. The HPIC was in current calibration and function checked before and after use. A correction factor of 1.02 was applied to the measured value per the manufacturer's recommendation by the software of the unit. Calibration forms for the HPIC are provided in Appendix A.

Table 7 presents the results for the two types of measurements made at each of the five locations. Appendix B presents the individual (6-second) exposure rate measurements.

The best predictive relationship between the measurements is linear with a R^2 of 0.9845, which exceeds the applicable project DQO. The root mean square error and p-value for the model are 1.002488 and 0.0008, respectively; these parameters are not DQOs and are included only as information.

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

$$\text{Exposure Rate (microRoentgens per hour [}\mu\text{R/h])} = 7\text{x}10^{-4} \text{ x Gamma Count Rate (cpm)} + 4.8211$$

Figure 12 presents the exposure rates predicted from the gamma count rate measurements, the spatial and numerical distribution of which mirror those depicted in Figure 4.

Tables 8 and 9 present summary statistics for the predicted exposure rates in the potential Background Reference Areas and Survey Area, respectively. The range of predicted exposure rates at BG1 is 18.6 to 30.2 µR/h, with a mean and median of 23.4 and 23.2 µR/h, respectively. The range of predicted exposure rates at BG2 is 12.5 to 16.6 µR/h, with a mean and median of 14.5 µR/h. The range of predicted exposure rates in the Survey Area is 11.0 to 56.4 µR/h, with a mean and median of 20.8 and 19.6 µR/h, respectively.

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

Location	Gamma Count Rate (cpm)	Exposure Rate (µR/h)
S10006-C01-201	18,598	17.3
S10006-C02-001	26,624	21.6
S10006-C03-001	37,165	31
S10006-C04-001	15,012	15.2
S10006-C05-001	11,993	13.6

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

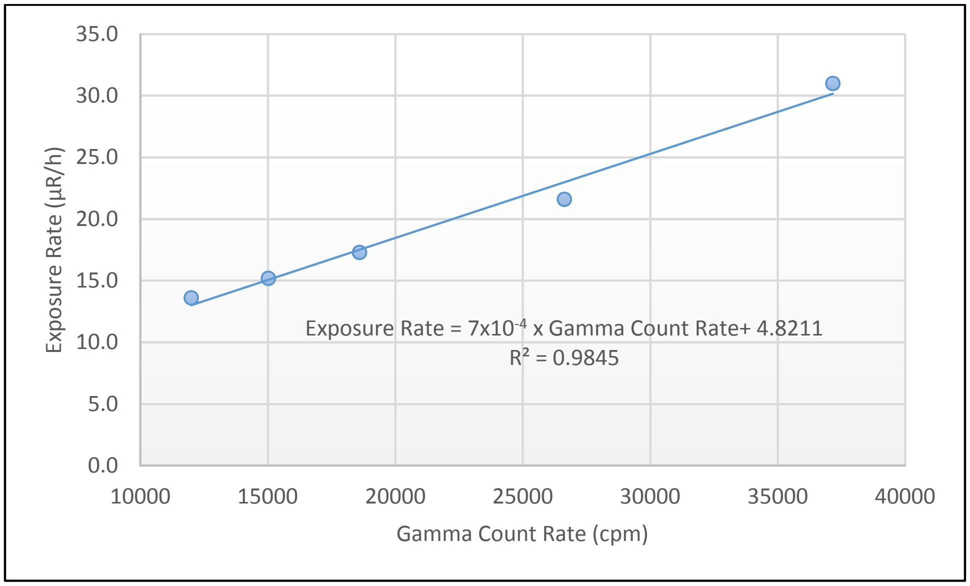


Figure 11. Correlation of gamma count rates and exposure rates

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

Potential Background Reference Area	BG1	BG2
Parameter	Exposure Rate (µR/h)	
n	222	543
Minimum	18.6	12.5
Maximum	30.2	16.6
Mean	23.4	14.5
Median	23.2	14.5
Standard Deviation	2.4	0.7

Notes:
µR/h = microRoentgens per hour

Table 9. Predicted exposure rates in the Survey Area.

Parameter	Exposure Rate (µR/h)
n	60,068
Minimum	11.0
Maximum	56.4
Mean	20.8
Median	19.6
Standard Deviation	6.0

Notes:
µR/h = microRoentgens per hour

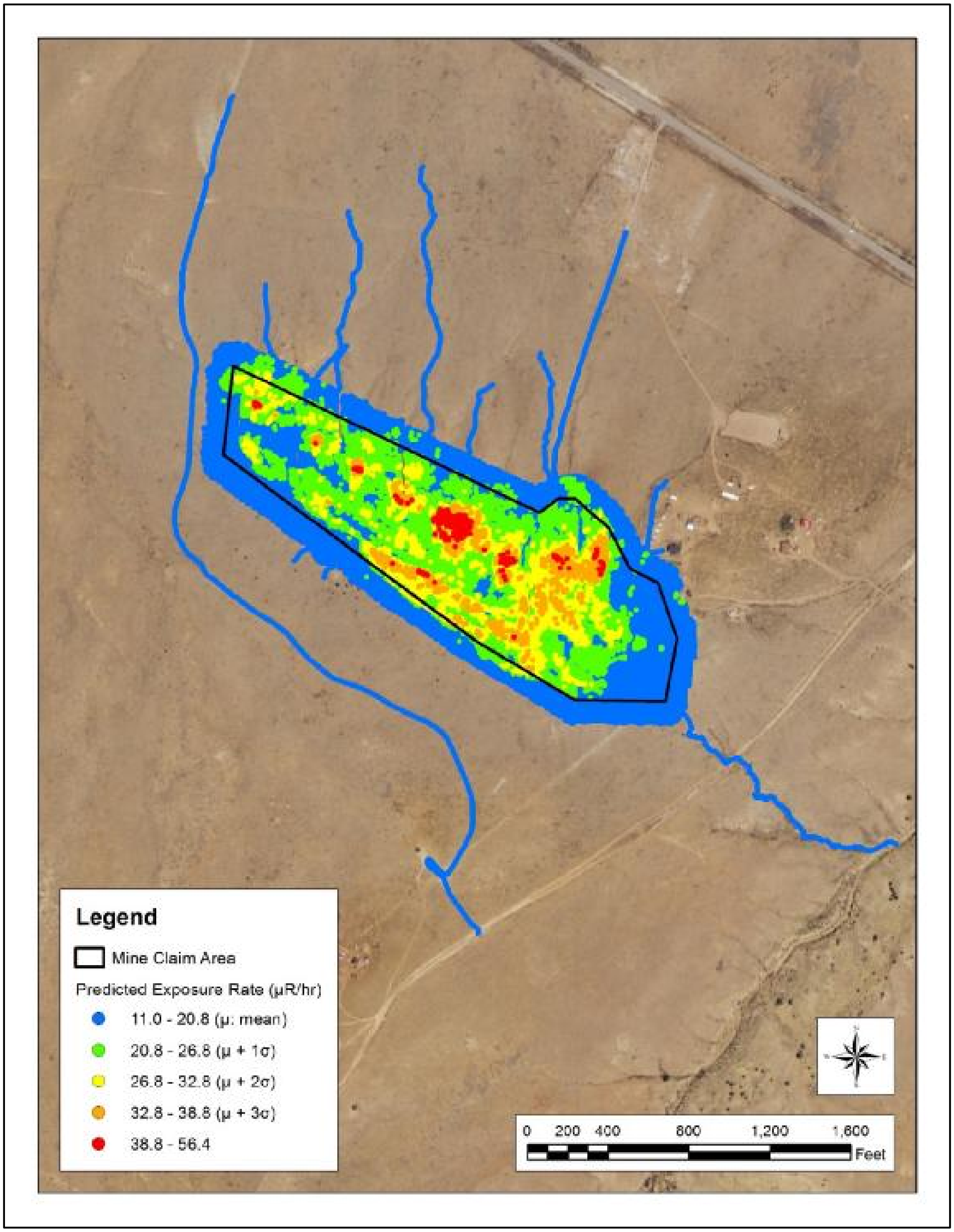


Figure 12. Predicted exposure rates in the Survey Area.

4.0 Deviations from the RSE Work Plan

The RSE Work Plan specifies that the comparison of gamma count rates and radium concentrations in surface soils was to occur in 900 square foot areas. Field personnel adjusted the areas as necessary, to minimize the variability of gamma count rates observed, particularly where the spatial distribution of waste rock was heterogeneous.

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; and remedy selection and design.

- Two potential Background Reference Areas have been established for this Site.

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

  Gamma Count Rate (cpm) = 4039 x [radium-226 (pCi/g)] + 10693

- 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 -0.5 to 15.6, with a central tendency (median) of 2.6 pCi/g.

- Thorium-232 and its decay products are in relatively higher abundance in the host rock at this Site, an exception to the other AUMs addressed in the RSE Work Plan. The thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226 in surface soil from gamma count rates.

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

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

  Exposure Rate (µR/h) = 7×10^{-4} x Gamma Count Rate (cpm) + 4.8211

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 11.0 to 56.4, with a central tendency (median) of 19.6 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. Standing Rock Removal Site Evaluation Report, October 2018.

Appendix A Instrument calibration and completed function check forms

ERG

Certificate of Calibration

Calibration and Voltage Plateau

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

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

✓ Mechanical Check
✓ F/S Response Check
✓ Geotropism
✓ Meter Zeroed

✓ THR/WIN Operation
✓ Reset Check
✓ Audio Check
✓ Battery Check (Min 4.4 VDC)

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

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

Threshold: 10 mV
Window:

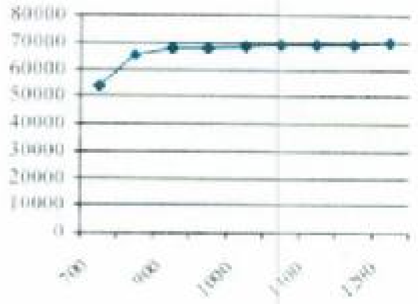
Barometric Pressure: 24.75 inches Hg
Temperature: 74 °F
Relative Humidity: 20 %

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	398857	400
x 1000	100	100	100		100
x 100	400	400	400	39913	400
x 100	100	100	100		100
x 10	400	400	400	3992	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	53620	
800	64979	
900	67955	
950	67795	
1000	68536	9542
1050	69153	
1100	69331	
1150	69346	
1200	69492	

Voltage Plateau



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

Reference Instruments and/or Sources:

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

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

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

Reviewed By: Cf Date: 7/20/16

ERG Form ITC. 101.A

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

ERG

Certificate of Calibration

Calibration and Voltage Plateau

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

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

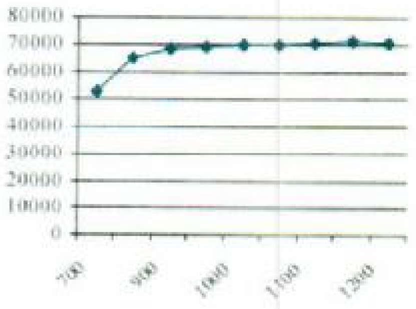
Relative Humidity: 20 %

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:

Reviewed By:

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

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

Date: 3-1-17

ERG Form ITC. 101.A

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Certificate of Calibration

Calibration and Voltage Plateau

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

Meter: Manufacturer: Ludlum Model Number: 2221r Serial Number: 196086

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

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

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:

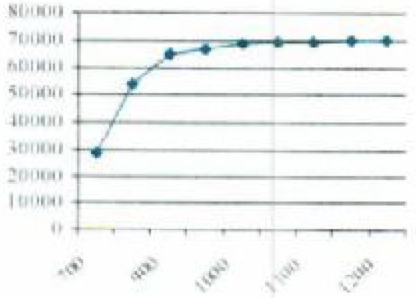
Barometric Pressure: 24.78 inches Hg
Temperature: 74 °F
Relative Humidity: 20 %

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:

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

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

Calibrated By:
Calibration Date: 7 8 16
Calibration Due: 7-8-17

Reviewed By:
Date: 7/20/16

ERG Form ITC. 101.A

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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:

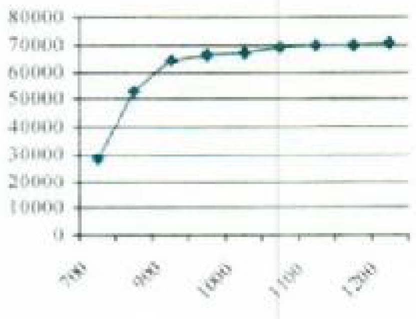
Barometric Pressure: 24.27 inches Hg
Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Threshold: 10 mV
Temperature: 78 °F
Source Geometry: ☑ Side ☐ Below ☐ Other:
Window:
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399386	400
x 1000	100	100	100		100
x 100	400	400	400	39949	400
x 100	100	100	100		100
x 10	400	400	400	3995	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	28235	
800	52834	
900	64481	
950	66468	
1000	67321	
1050	69009	
1100	69981	9079
1150	69564	
1200	70538	

Voltage Plateau



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

Reference Instruments and/or Sources:

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

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

Calibrated By:
Reviewed By:

Calibration Date: ~~3 March 17~~ 2/28/17
Calibration Due: ~~2 March 18~~ 2/28/18
Date: 3-1-17

ERG Form ITC. 101.A

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

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

Meter: Manufacturer: Ludlum Model Number: 2221r Serial Number: 138368

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

✓ Mechanical Check
✓ 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:

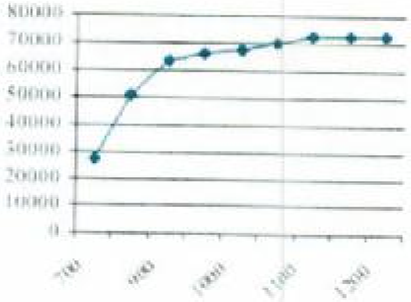
Barometric Pressure: 24.78 inches Hg
Temperature: 74 °F
Relative Humidity: 20 %

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	398436	400
x 1000	100	100	100		100
x 100	400	400	400	39845	400
x 100	100	100	100		100
x 10	400	400	400	3984	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	26998	
800	51037	
900	63340	
950	65550	
1000	67410	
1050	70113	
1100	72217	
1150	72561	9216
1200	72337	

Voltage Plateau



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

Reference Instruments and/or Sources:

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

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

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

Reviewed By:
Date: 7/20/16

ERG Form ITC. 101.A

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

ERG

Certificate of Calibration

Calibration and Voltage Plateau

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

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

☑ Mechanical Check
☑ F/S Response Check
☑ Geotropism
☑ Meter Zeroed

☑ THR/WIN Operation
☑ Reset Check
☑ Audio Check
☑ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☐ 72-inch ☑ Other: 60"

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

Threshold: 10 mV
Window:

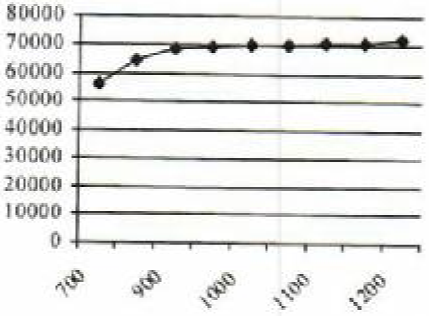
Barometric Pressure: 24.89 inches Hg
Temperature: 73 °F
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	398753	400
x 1000	100	100	100		100
x 100	400	400	400	39879	400
x 100	100	100	100		100
x 10	400	400	400	3989	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	56463	
800	64304	
900	68534	
950	69331	
1000	69868	9696
1050	70054	
1100	70609	
1150	70681	
1200	71955	

Voltage Plateau



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

Reference Instruments and/or Sources:

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

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

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

ERG Form ITC. 101.A

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

ERG

Certificate of Calibration

Calibration and Voltage Plateau

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

Meter: Manufacturer: Ludlum Model Number: 2221r Serial Number: 271435

Detector: Manufacturer: Ludlum Model Number: 44-10 Serial Number: PR295017

☐ Mechanical Check
☐ F/S Response Check
☐ Geotropism
☐ Meter Zeroed

☐ THR/WIN Operation
☐ Reset Check
☐ Audio Check
☐ Battery Check (Min 4.4 VDC)

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

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

Source Distance: ☐ Contact ☑ 6 inches ☐ Other:

Source Geometry: ☑ Side ☐ Below ☐ Other:

Threshold: 10 mV

Window:

Barometric Pressure: 24.66 inches Hg

Temperature: 76 °F

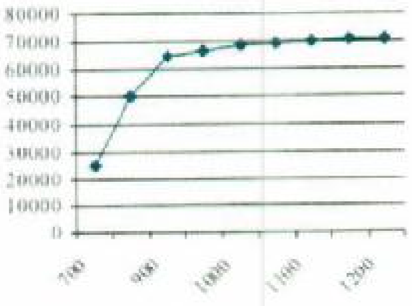
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

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

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

Voltage Plateau



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

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932

Fluke multimeter serial number: ☐ 87490128

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

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

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

☐ Other Source:

Calibrated By:

Calibration Date: 3 13-17

Calibration Due: 3-13-18

Reviewed By:

Date: 14 March 2017

ERG Form ITC. 101.A

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

K&S Associates, Inc.
1926 Elm Tree Drive
Nashville, Tennessee 37210-3718
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.

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 Royer
Richard Hardison Angela Royer
Title: Calibration Technician Title: Calibration Physicist

Log: M-53 Page: 73

Revision 12/12/2011

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

ACCREDITED
CALIBRATION CERT #

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

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

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

Form RSS

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	7-9-17

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

Comments:
NNERT

Source: Cs-137
Serial No.: 333-94
Activity: 5.12 uCi
Emission Rate: NA cpm/emissions
Source Date: 6-6-94
Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference points
11-18-16	0829	5.4	1015	101	51216	13360	37856	NW	Standing Rock
11-18-16	1517	5.3	1006	100	48629	10616	38013	NW	Gallup lot
11-19-16	0808	5.3	1014	100	43603	5712	37891	NW	Eunice Becenti
11-19-16	1400	5.1	1005	100	44923	5058	39865	NW	Eunice Becenti

12-6-16

Reviewed by: MM

Review Date: 11/29/16

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	7-9-17

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

Comments:

NNERT

Source: Cs-137

Serial No.: 333-94

Activity: 5.12 uCi

Emission Rate: NA cpm/emissions

Source Date: 6-6-94

Distance to Source: 6 inches

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

Reviewed by:

Review Date: 11/29/16

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	196086
Cal. Due Date:	7-9-17

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

Comments:

NNERT

Source: Cs-137

Serial No.: 333-94

Activity: 5.12 uCi

Emission Rate: NA cpm/emissions

Source Date: 6-6-94

Distance to Source: 6 inches

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

12-6-16

Reviewed by:

Review Date: 11/29/16

③

ERG

Single-Channel Function Check Log

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

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

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR154615
Cal. Due Date:	7-5-17

Comments:
NNERT

Source: Cs-137

Serial No.: 333-94

Activity: 5.2 uCi

Emission Rate: NA cpm/emissions

Source Date: 6-6-94

Distance to Source: 6 Inches

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

NW
12-6-16

Reviewed by:

Review Date: 11/29/16

ERG Form ITC.201.A

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	282966
Cal. Due Date:	10-31-17

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

Comments:

NNEAT

Source: Cs-137
Serial No.: 333-94
Activity: 5.12 uCi
Emission Rate: NA cpm/emissions
Source Date: 6-6-94
Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project Reference Points
11-12-16	0827	5.7	1010	102	48550	9744	38806	NW	Hoskie Tso
11-12-16	1351	5.6	1000	101	47089	8725	38364	NW	Hoskie Tso
11-16-16	0826	5.7	1011	102	50569	12266	38303	NW	Standing Rock
11-16-16	1516	5.6	1006	103	50039	11202	38837	NW	Gallup lot
11-18-16	0836	5.7	1017	104	52221	13620	38601	NW	Standing Rock
11-18-16	1530	5.6	1009	103	48820	10831	37989	NW	Gallup lot
11-19-16	0812	5.6	1016	104	44700	4940	39760	NW	Eunice Becenti
11-19-16	1407	5.5	1004	102	44961	4975	39986	NW	Eunice Becenti
					12-6-16				

Reviewed by: ____________ 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:

NNEAT

Source: Cs-137

Serial No.: 544-96

Activity: 4 uCi

Emission Rate: N/a cpm/emissions

Source Date: 4-18-96

Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-22-17	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:

Review Date: 11/06/17

ERG Form ITC.201.A

ERG

Single-Channel Function Check Log

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

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

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

Comments:
NNZAT

Source: Cs-137

Serial No.: 544-96

Activity: 4 uCi

Emission Rate: NA cpm/emissions

Source Date: 4-18-96

Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-20-17	0905	5.7	1003	101	40471	8507	31964	NW	Claim 28
3-20-17	1547	5.6	996	101	36470	5494	30976	NW	Chinle lot
3-21-17	0641	5.7	1004	101	37904	5597	32307	NW	Chinle lot
3-21-17	1654	5.6	999	101	36212	4929	31283	NW	Goulding's lot
3-22-17	0702	5.6	1001	101	35714	5119	30595	NW	Goulding's lot
3-22-17	1937	5.4	995	101	35087	4539	30548	NW	Charles Keith shooting range
3-23-17	0907	5.6	1004	101	36031	4879	31152	NW	NA-0928
3-23-17	1922	5.5	1004	101	41793	9955	31838	NW	Gallup lot
3-24-17	0810	5.5	1007	101	35608	4282	31326	NW	Eunice Becenti
3-24-17	1785	5.5	1000	101	41923	10785	31138	NW	Gallup lot
3-27-17	0833	5.5	1005	101	36943	4282	32661	NW	Eunice Becenti
3-27-17	1235	5.4	1000	101	35141	4013	31128	NW	Eunice Becenti

Reviewed by:

Review Date: 10/19/17

ERG

Single-Channel Function Check Log

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

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

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

Comments:
NNERT

Source: Cs-137

Serial No.: 544-96

Activity: 4 uCi

Emission Rate: NA cpm/emissions

Source Date: 4-18-96

Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-22-17	0705	5.6	1050	100	35820	5210	30610	NW	Goulding's lot
3-22-17	1425	5.5	1049	101	36169	4648	31521	NW	Charles Keith shooting range
3-23-17	0908	5.6	1056	102	35972	4828	31144	NW	NA-0928
3-23-17	1915	5.5	1055	102	41686	10757	30929	NW	Gallup lot
3-24-17	0805	5.5	1060	102	36151	4442	31709	NW	Eunice Becenti
3-24-17	1744	5.4	1051	101	41975	10993	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:

Review Date: ~~9~~ 10/9/17

ERG Form ITC.201.A

ERG

Single-Channel Function Check Log

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

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

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR295614
Cal. Due Date:	2-28-18

Comments:
NNERT

Source: Cs-137
Serial No.: 544-96
Activity: 4 uCi
Emission Rate: NA cpm/emissions
Source Date: 4-18-96
Distance to Source: 6 inches

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

Reviewed by:

Review Date: 10/9/17

ERG Form ITC.201.A

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	GE
Model:	RSS-131
Serial No.:	07J00KM1
Cal. Due Date:	6-29-17

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

Comments:
NNERT

Source: Cs-137

Serial No.: 333-94

Activity: 5.12 uCi

Emission Rate: NA cpm/emissions

Source Date: 6-6-94

Distance to Source: Contact housing

Date	Time	Battery	High Voltage	Threshhold	µR/h Source Counts	µR/h BKG Counts	Net Counts	Initials	Note(s): Project reference points
11-14-16	0530	~6.3	~400	NA	~27	~10	~17	NW	DoubleTree Flagstaff - rom
11-14-16	2005	~6.3	~400	NA	~29	~11	~18	NW	Best Western Holbrook - room
11-18-16	0623	~6.3	~400	NA	~27	~11	~16	NW	Best Western Gallup - room
11-18-16	1532	~6.2	~400	NA	~27	~11	~16	NW	Best Western Gallup - room

NW
12-6-16

Reviewed by:

Review Date: 11-29-16

Appendix B Exposure Rate Measurements

Date and Time	Exposure Rate (mR/h)	Location
11/18/2016 10:22	0.0549	Correlation Location 1
11/18/2016 10:22	0.0967	Correlation Location 1
11/18/2016 10:22	0.0855	Correlation Location 1
11/18/2016 10:22	0.0603	Correlation Location 1
11/18/2016 10:22	0.0413	Correlation Location 1
11/18/2016 10:22	0.0297	Correlation Location 1
11/18/2016 10:22	0.0235	Correlation Location 1
11/18/2016 10:22	0.0204	Correlation Location 1
11/18/2016 10:22	0.0189	Correlation Location 1
11/18/2016 10:22	0.0182	Correlation Location 1
11/18/2016 10:23	0.018	Correlation Location 1
11/18/2016 10:23	0.0179	Correlation Location 1
11/18/2016 10:23	0.0182	Correlation Location 1
11/18/2016 10:23	0.0182	Correlation Location 1
11/18/2016 10:23	0.0179	Correlation Location 1
11/18/2016 10:23	0.0177	Correlation Location 1
11/18/2016 10:23	0.0173	Correlation Location 1
11/18/2016 10:23	0.017	Correlation Location 1
11/18/2016 10:23	0.0168	Correlation Location 1
11/18/2016 10:23	0.017	Correlation Location 1
11/18/2016 10:24	0.017	Correlation Location 1
11/18/2016 10:24	0.0168	Correlation Location 1
11/18/2016 10:24	0.0166	Correlation Location 1
11/18/2016 10:24	0.0167	Correlation Location 1
11/18/2016 10:24	0.017	Correlation Location 1
11/18/2016 10:24	0.017	Correlation Location 1
11/18/2016 10:24	0.017	Correlation Location 1
11/18/2016 10:24	0.0174	Correlation Location 1
11/18/2016 10:24	0.0176	Correlation Location 1
11/18/2016 10:24	0.0177	Correlation Location 1
11/18/2016 10:25	0.0177	Correlation Location 1
11/18/2016 10:25	0.0173	Correlation Location 1
11/18/2016 10:25	0.0173	Correlation Location 1
11/18/2016 10:25	0.0178	Correlation Location 1
11/18/2016 10:25	0.0175	Correlation Location 1
11/18/2016 10:25	0.0172	Correlation Location 1
11/18/2016 10:25	0.0172	Correlation Location 1
11/18/2016 10:25	0.017	Correlation Location 1
11/18/2016 10:25	0.017	Correlation Location 1
11/18/2016 10:25	0.0172	Correlation Location 1
11/18/2016 10:26	0.0179	Correlation Location 1
11/18/2016 10:26	0.0177	Correlation Location 1
11/18/2016 10:26	0.0169	Correlation Location 1
11/18/2016 10:26	0.0163	Correlation Location 1
11/18/2016 10:26	0.0165	Correlation Location 1
11/18/2016 10:26	0.0166	Correlation Location 1
11/18/2016 10:26	0.0166	Correlation Location 1
11/18/2016 10:26	0.0168	Correlation Location 1
11/18/2016 10:26	0.0173	Correlation Location 1
11/18/2016 10:26	0.0173	Correlation Location 1
11/18/2016 10:27	0.0169	Correlation Location 1
11/18/2016 10:27	0.017	Correlation Location 1
11/18/2016 10:27	0.0177	Correlation Location 1
11/18/2016 10:27	0.018	Correlation Location 1
11/18/2016 10:27	0.018	Correlation Location 1
11/18/2016 10:27	0.018	Correlation Location 1
11/18/2016 10:27	0.0182	Correlation Location 1
11/18/2016 10:27	0.0179	Correlation Location 1
11/18/2016 10:27	0.0176	Correlation Location 1
11/18/2016 10:27	0.0176	Correlation Location 1
11/18/2016 10:28	0.018	Correlation Location 1
11/18/2016 10:28	0.018	Correlation Location 1
11/18/2016 10:28	0.0176	Correlation Location 1
11/18/2016 10:28	0.018	Correlation Location 1
11/18/2016 10:28	0.0182	Correlation Location 1
11/18/2016 10:28	0.0178	Correlation Location 1
11/18/2016 10:28	0.0168	Correlation Location 1
11/18/2016 10:28	0.0162	Correlation Location 1
11/18/2016 10:28	0.0158	Correlation Location 1
11/18/2016 10:28	0.0164	Correlation Location 1
11/18/2016 10:29	0.0168	Correlation Location 1
11/18/2016 10:29	0.0169	Correlation Location 1
11/18/2016 10:29	0.017	Correlation Location 1
11/18/2016 10:29	0.0175	Correlation Location 1
11/18/2016 10:29	0.0178	Correlation Location 1
11/18/2016 10:29	0.0178	Correlation Location 1
11/18/2016 10:29	0.0175	Correlation Location 1
11/18/2016 10:29	0.0173	Correlation Location 1
11/18/2016 10:29	0.0169	Correlation Location 1
11/18/2016 10:29	0.0168	Correlation Location 1
11/18/2016 10:30	0.017	Correlation Location 1
11/18/2016 10:30	0.017	Correlation Location 1
11/18/2016 10:30	0.0176	Correlation Location 1
11/18/2016 10:30	0.0177	Correlation Location 1
11/18/2016 10:30	0.0172	Correlation Location 1
11/18/2016 10:30	0.0168	Correlation Location 1
11/18/2016 10:30	0.0166	Correlation Location 1
11/18/2016 10:30	0.0169	Correlation Location 1
11/18/2016 10:30	0.0176	Correlation Location 1
11/18/2016 10:30	0.0177	Correlation Location 1
11/18/2016 10:31	0.0179	Correlation Location 1
11/18/2016 10:31	0.0177	Correlation Location 1
11/18/2016 10:31	0.0174	Correlation Location 1
11/18/2016 10:31	0.0178	Correlation Location 1
11/18/2016 10:31	0.018	Correlation Location 1
11/18/2016 10:31	0.0179	Correlation Location 1
11/18/2016 10:31	0.0176	Correlation Location 1
11/18/2016 10:31	0.0173	Correlation Location 1
11/18/2016 10:31	0.0172	Correlation Location 1
11/18/2016 10:31	0.017	Correlation Location 1
11/18/2016 10:32	0.017	Correlation Location 1
11/18/2016 10:32	0.017	Correlation Location 1
11/18/2016 10:32	0.0168	Correlation Location 1
11/18/2016 10:32	0.017	Correlation Location 1
11/18/2016 10:32	0.017	Correlation Location 1
11/18/2016 10:32	0.017	Correlation Location 1
11/18/2016 10:32	0.0173	Correlation Location 1
11/18/2016 10:32	0.0173	Correlation Location 1
11/18/2016 10:32	0.0173	Correlation Location 1
11/18/2016 10:53	0.0564	Correlation Location 2
11/18/2016 10:54	0.0998	Correlation Location 2
11/18/2016 10:54	0.09	Correlation Location 2

Standing Rock Exposure Rate Measurements for Correlation

Date and Time	Exposure Rate (mR/h)	Location
11/18/2016 10:54	0.0653	Correlation Location 2
11/18/2016 10:54	0.0461	Correlation Location 2
11/18/2016 10:54	0.0346	Correlation Location 2
11/18/2016 10:54	0.0284	Correlation Location 2
11/18/2016 10:54	0.0256	Correlation Location 2
11/18/2016 10:54	0.0244	Correlation Location 2
11/18/2016 10:54	0.0234	Correlation Location 2
11/18/2016 10:54	0.0223	Correlation Location 2
11/18/2016 10:55	0.0213	Correlation Location 2
11/18/2016 10:55	0.0206	Correlation Location 2
11/18/2016 10:55	0.0202	Correlation Location 2
11/18/2016 10:55	0.0208	Correlation Location 2
11/18/2016 10:55	0.0211	Correlation Location 2
11/18/2016 10:55	0.0216	Correlation Location 2
11/18/2016 10:55	0.0217	Correlation Location 2
11/18/2016 10:55	0.0221	Correlation Location 2
11/18/2016 10:55	0.0223	Correlation Location 2
11/18/2016 10:55	0.0223	Correlation Location 2
11/18/2016 10:56	0.0217	Correlation Location 2
11/18/2016 10:56	0.0211	Correlation Location 2
11/18/2016 10:56	0.021	Correlation Location 2
11/18/2016 10:56	0.0213	Correlation Location 2
11/18/2016 10:56	0.0211	Correlation Location 2
11/18/2016 10:56	0.0211	Correlation Location 2
11/18/2016 10:56	0.0215	Correlation Location 2
11/18/2016 10:56	0.0215	Correlation Location 2
11/18/2016 10:56	0.0213	Correlation Location 2
11/18/2016 10:56	0.021	Correlation Location 2
11/18/2016 10:57	0.0208	Correlation Location 2
11/18/2016 10:57	0.0207	Correlation Location 2
11/18/2016 10:57	0.021	Correlation Location 2
11/18/2016 10:57	0.0213	Correlation Location 2
11/18/2016 10:57	0.0211	Correlation Location 2
11/18/2016 10:57	0.0209	Correlation Location 2
11/18/2016 10:57	0.021	Correlation Location 2
11/18/2016 10:57	0.0211	Correlation Location 2
11/18/2016 10:57	0.0213	Correlation Location 2
11/18/2016 10:57	0.0216	Correlation Location 2
11/18/2016 10:58	0.0217	Correlation Location 2
11/18/2016 10:58	0.0222	Correlation Location 2
11/18/2016 10:58	0.0219	Correlation Location 2
11/18/2016 10:58	0.022	Correlation Location 2
11/18/2016 10:58	0.023	Correlation Location 2
11/18/2016 10:58	0.0229	Correlation Location 2
11/18/2016 10:58	0.0227	Correlation Location 2
11/18/2016 10:58	0.0225	Correlation Location 2
11/18/2016 10:58	0.0223	Correlation Location 2
11/18/2016 10:58	0.0223	Correlation Location 2
11/18/2016 10:59	0.022	Correlation Location 2
11/18/2016 10:59	0.0217	Correlation Location 2
11/18/2016 10:59	0.0218	Correlation Location 2
11/18/2016 10:59	0.0219	Correlation Location 2
11/18/2016 10:59	0.0221	Correlation Location 2
11/18/2016 10:59	0.0218	Correlation Location 2
11/18/2016 10:59	0.0219	Correlation Location 2
11/18/2016 10:59	0.0225	Correlation Location 2
11/18/2016 10:59	0.0227	Correlation Location 2
11/18/2016 10:59	0.0223	Correlation Location 2
11/18/2016 11:00	0.0217	Correlation Location 2
11/18/2016 11:00	0.0217	Correlation Location 2
11/18/2016 11:00	0.0222	Correlation Location 2
11/18/2016 11:00	0.0223	Correlation Location 2
11/18/2016 11:00	0.0221	Correlation Location 2
11/18/2016 11:00	0.0219	Correlation Location 2
11/18/2016 11:00	0.0219	Correlation Location 2
11/18/2016 11:00	0.0223	Correlation Location 2
11/18/2016 11:00	0.0221	Correlation Location 2
11/18/2016 11:00	0.0213	Correlation Location 2
11/18/2016 11:01	0.021	Correlation Location 2
11/18/2016 11:01	0.0211	Correlation Location 2
11/18/2016 11:01	0.0213	Correlation Location 2
11/18/2016 11:01	0.0211	Correlation Location 2
11/18/2016 11:01	0.021	Correlation Location 2
11/18/2016 11:01	0.0211	Correlation Location 2
11/18/2016 11:01	0.0216	Correlation Location 2
11/18/2016 11:01	0.0219	Correlation Location 2
11/18/2016 11:01	0.0216	Correlation Location 2
11/18/2016 11:01	0.0211	Correlation Location 2
11/18/2016 11:02	0.0211	Correlation Location 2
11/18/2016 11:02	0.0216	Correlation Location 2
11/18/2016 11:02	0.0218	Correlation Location 2
11/18/2016 11:02	0.022	Correlation Location 2
11/18/2016 11:02	0.0216	Correlation Location 2
11/18/2016 11:02	0.0216	Correlation Location 2
11/18/2016 11:02	0.0216	Correlation Location 2
11/18/2016 11:02	0.0218	Correlation Location 2
11/18/2016 11:02	0.0216	Correlation Location 2
11/18/2016 11:02	0.0216	Correlation Location 2
11/18/2016 11:03	0.0213	Correlation Location 2
11/18/2016 11:03	0.0219	Correlation Location 2
11/18/2016 11:03	0.0221	Correlation Location 2
11/18/2016 11:03	0.0219	Correlation Location 2
11/18/2016 11:03	0.0218	Correlation Location 2
11/18/2016 11:03	0.0218	Correlation Location 2
11/18/2016 11:03	0.0213	Correlation Location 2
11/18/2016 11:03	0.0213	Correlation Location 2
11/18/2016 11:03	0.0215	Correlation Location 2
11/18/2016 11:03	0.0213	Correlation Location 2
11/18/2016 11:04	0.0217	Correlation Location 2
11/18/2016 11:04	0.0219	Correlation Location 2
11/18/2016 11:04	0.0219	Correlation Location 2
11/18/2016 11:04	0.0218	Correlation Location 2
11/18/2016 11:04	0.0219	Correlation Location 2
11/18/2016 11:04	0.022	Correlation Location 2
11/18/2016 11:04	0.0223	Correlation Location 2
11/18/2016 11:22	0.058	Correlation Location 3
11/18/2016 11:22	0.104	Correlation Location 3
11/18/2016 11:22	0.0965	Correlation Location 3
11/18/2016 11:22	0.0727	Correlation Location 3
11/18/2016 11:22	0.0545	Correlation Location 3
11/18/2016 11:23	0.0433	Correlation Location 3
11/18/2016 11:23	0.0375	Correlation Location 3

Date and Time	Exposure Rate (mR/h)	Location
11/18/2016 11:23	0.0341	Correlation Location 3
11/18/2016 11:23	0.0326	Correlation Location 3
11/18/2016 11:23	0.0317	Correlation Location 3
11/18/2016 11:23	0.0313	Correlation Location 3
11/18/2016 11:23	0.0312	Correlation Location 3
11/18/2016 11:23	0.0311	Correlation Location 3
11/18/2016 11:23	0.0309	Correlation Location 3
11/18/2016 11:23	0.0306	Correlation Location 3
11/18/2016 11:24	0.0304	Correlation Location 3
11/18/2016 11:24	0.0305	Correlation Location 3
11/18/2016 11:24	0.0312	Correlation Location 3
11/18/2016 11:24	0.0317	Correlation Location 3
11/18/2016 11:24	0.0322	Correlation Location 3
11/18/2016 11:24	0.0322	Correlation Location 3
11/18/2016 11:24	0.0319	Correlation Location 3
11/18/2016 11:24	0.0319	Correlation Location 3
11/18/2016 11:24	0.0322	Correlation Location 3
11/18/2016 11:24	0.0319	Correlation Location 3
11/18/2016 11:25	0.0313	Correlation Location 3
11/18/2016 11:25	0.031	Correlation Location 3
11/18/2016 11:25	0.0308	Correlation Location 3
11/18/2016 11:25	0.0308	Correlation Location 3
11/18/2016 11:25	0.0306	Correlation Location 3
11/18/2016 11:25	0.0308	Correlation Location 3
11/18/2016 11:25	0.0309	Correlation Location 3
11/18/2016 11:25	0.0309	Correlation Location 3
11/18/2016 11:25	0.0311	Correlation Location 3
11/18/2016 11:25	0.031	Correlation Location 3
11/18/2016 11:26	0.031	Correlation Location 3
11/18/2016 11:26	0.0312	Correlation Location 3
11/18/2016 11:26	0.0316	Correlation Location 3
11/18/2016 11:26	0.0316	Correlation Location 3
11/18/2016 11:26	0.0312	Correlation Location 3
11/18/2016 11:26	0.0312	Correlation Location 3
11/18/2016 11:26	0.0309	Correlation Location 3
11/18/2016 11:26	0.031	Correlation Location 3
11/18/2016 11:26	0.031	Correlation Location 3
11/18/2016 11:26	0.0309	Correlation Location 3
11/18/2016 11:27	0.0305	Correlation Location 3
11/18/2016 11:27	0.0302	Correlation Location 3
11/18/2016 11:27	0.0304	Correlation Location 3
11/18/2016 11:27	0.0306	Correlation Location 3
11/18/2016 11:27	0.0305	Correlation Location 3
11/18/2016 11:27	0.0305	Correlation Location 3
11/18/2016 11:27	0.0308	Correlation Location 3
11/18/2016 11:27	0.0317	Correlation Location 3
11/18/2016 11:27	0.0317	Correlation Location 3
11/18/2016 11:27	0.031	Correlation Location 3
11/18/2016 11:28	0.0307	Correlation Location 3
11/18/2016 11:28	0.0306	Correlation Location 3
11/18/2016 11:28	0.0308	Correlation Location 3
11/18/2016 11:28	0.0307	Correlation Location 3
11/18/2016 11:28	0.0306	Correlation Location 3
11/18/2016 11:28	0.0306	Correlation Location 3
11/18/2016 11:28	0.0309	Correlation Location 3
11/18/2016 11:28	0.0312	Correlation Location 3
11/18/2016 11:28	0.0312	Correlation Location 3
11/18/2016 11:28	0.031	Correlation Location 3
11/18/2016 11:29	0.0315	Correlation Location 3
11/18/2016 11:29	0.032	Correlation Location 3
11/18/2016 11:29	0.032	Correlation Location 3
11/18/2016 11:29	0.0317	Correlation Location 3
11/18/2016 11:29	0.031	Correlation Location 3
11/18/2016 11:29	0.0312	Correlation Location 3
11/18/2016 11:29	0.0319	Correlation Location 3
11/18/2016 11:29	0.0319	Correlation Location 3
11/18/2016 11:29	0.0316	Correlation Location 3
11/18/2016 11:29	0.0311	Correlation Location 3
11/18/2016 11:30	0.0305	Correlation Location 3
11/18/2016 11:30	0.0302	Correlation Location 3
11/18/2016 11:30	0.0302	Correlation Location 3
11/18/2016 11:30	0.03	Correlation Location 3
11/18/2016 11:30	0.0302	Correlation Location 3
11/18/2016 11:30	0.0304	Correlation Location 3
11/18/2016 11:30	0.0309	Correlation Location 3
11/18/2016 11:30	0.0304	Correlation Location 3
11/18/2016 11:30	0.0298	Correlation Location 3
11/18/2016 11:30	0.0297	Correlation Location 3
11/18/2016 11:31	0.0299	Correlation Location 3
11/18/2016 11:31	0.03	Correlation Location 3
11/18/2016 11:31	0.0306	Correlation Location 3
11/18/2016 11:31	0.0306	Correlation Location 3
11/18/2016 11:31	0.0311	Correlation Location 3
11/18/2016 11:31	0.0312	Correlation Location 3
11/18/2016 11:31	0.0309	Correlation Location 3
11/18/2016 11:31	0.0306	Correlation Location 3
11/18/2016 11:31	0.031	Correlation Location 3
11/18/2016 11:31	0.0315	Correlation Location 3
11/18/2016 11:32	0.0316	Correlation Location 3
11/18/2016 11:32	0.0313	Correlation Location 3
11/18/2016 11:32	0.0313	Correlation Location 3
11/18/2016 11:32	0.0317	Correlation Location 3
11/18/2016 11:32	0.0316	Correlation Location 3
11/18/2016 11:32	0.0312	Correlation Location 3
11/18/2016 11:32	0.0305	Correlation Location 3
11/18/2016 11:32	0.03	Correlation Location 3
11/18/2016 11:32	0.0302	Correlation Location 3
11/18/2016 11:32	0.0316	Correlation Location 3
11/18/2016 11:33	0.0317	Correlation Location 3
11/18/2016 11:33	0.0312	Correlation Location 3
11/18/2016 11:33	0.0313	Correlation Location 3
11/18/2016 11:33	0.0313	Correlation Location 3
11/18/2016 11:57	0.0547	Correlation Location 4
11/18/2016 11:57	0.0962	Correlation Location 4
11/18/2016 11:57	0.0847	Correlation Location 4
11/18/2016 11:57	0.059	Correlation Location 4
11/18/2016 11:57	0.0398	Correlation Location 4
11/18/2016 11:57	0.0282	Correlation Location 4
11/18/2016 11:58	0.0216	Correlation Location 4
11/18/2016 11:58	0.018	Correlation Location 4
11/18/2016 11:58	0.0169	Correlation Location 4
11/18/2016 11:58	0.0164	Correlation Location 4

Date and Time	Exposure Rate (mR/h)	Location
11/18/2016 11:58	0.0161	Correlation Location 4
11/18/2016 11:58	0.0155	Correlation Location 4
11/18/2016 11:58	0.015	Correlation Location 4
11/18/2016 11:58	0.015	Correlation Location 4
11/18/2016 11:58	0.015	Correlation Location 4
11/18/2016 11:58	0.0148	Correlation Location 4
11/18/2016 11:59	0.0146	Correlation Location 4
11/18/2016 11:59	0.0147	Correlation Location 4
11/18/2016 11:59	0.0149	Correlation Location 4
11/18/2016 11:59	0.0151	Correlation Location 4
11/18/2016 11:59	0.0152	Correlation Location 4
11/18/2016 11:59	0.0155	Correlation Location 4
11/18/2016 11:59	0.0154	Correlation Location 4
11/18/2016 11:59	0.0152	Correlation Location 4
11/18/2016 11:59	0.0151	Correlation Location 4
11/18/2016 11:59	0.0151	Correlation Location 4
11/18/2016 12:00	0.0156	Correlation Location 4
11/18/2016 12:00	0.0155	Correlation Location 4
11/18/2016 12:00	0.0156	Correlation Location 4
11/18/2016 12:00	0.0156	Correlation Location 4
11/18/2016 12:00	0.0155	Correlation Location 4
11/18/2016 12:00	0.0155	Correlation Location 4
11/18/2016 12:00	0.0155	Correlation Location 4
11/18/2016 12:00	0.0151	Correlation Location 4
11/18/2016 12:00	0.015	Correlation Location 4
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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.

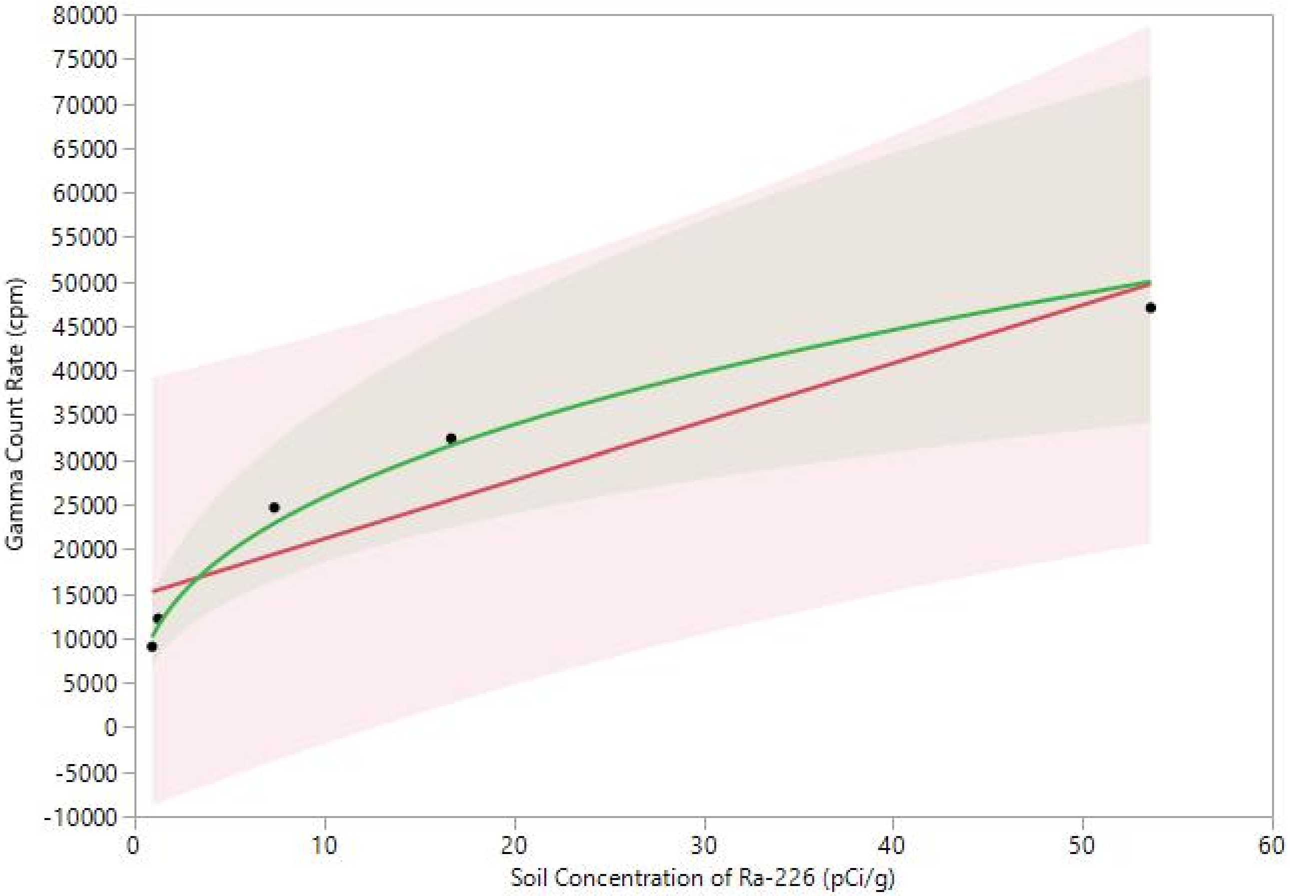

Figure 1. Regression models (linear versus power curve) for gamma count rate regressed on radium-226 showing 95% UPLs (upper prediction limits). Both models meet the study DQO for adjusted R^2 (greater than 0.8). Gamma count rate is not an especially strong predictor of soil concentration of radium-226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

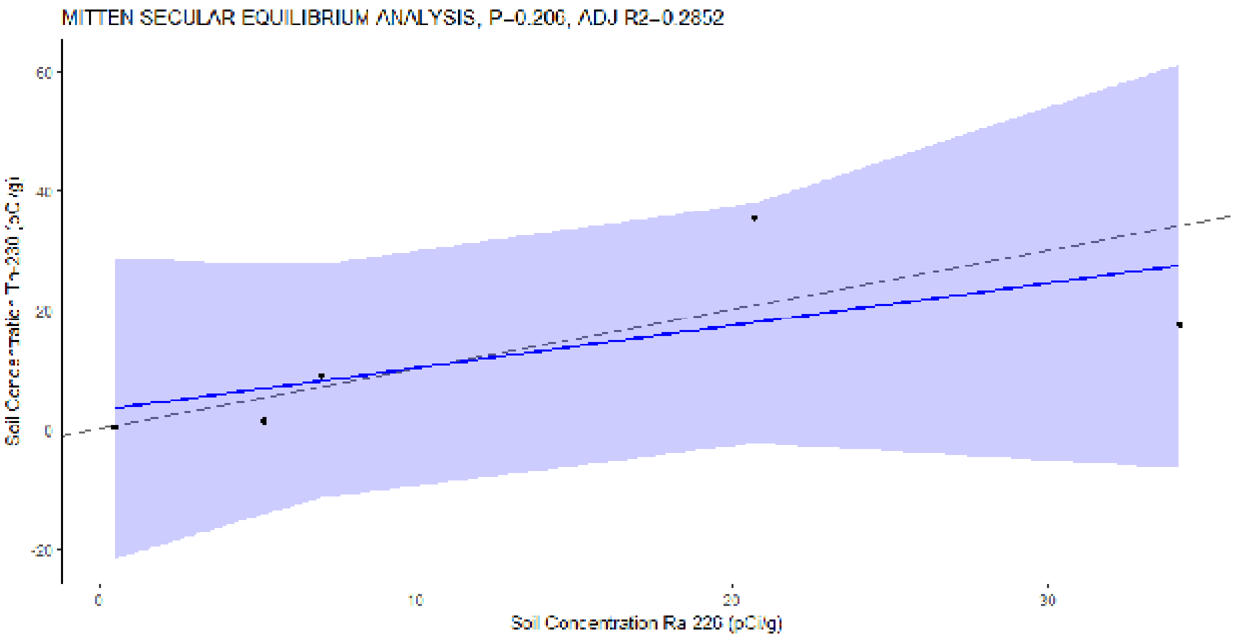

Figure 2. Result for Mitten secular equilibrium analysis, showing failure to meet p-value and adjusted R^2 criteria, i.e., the data are poorly correlated.

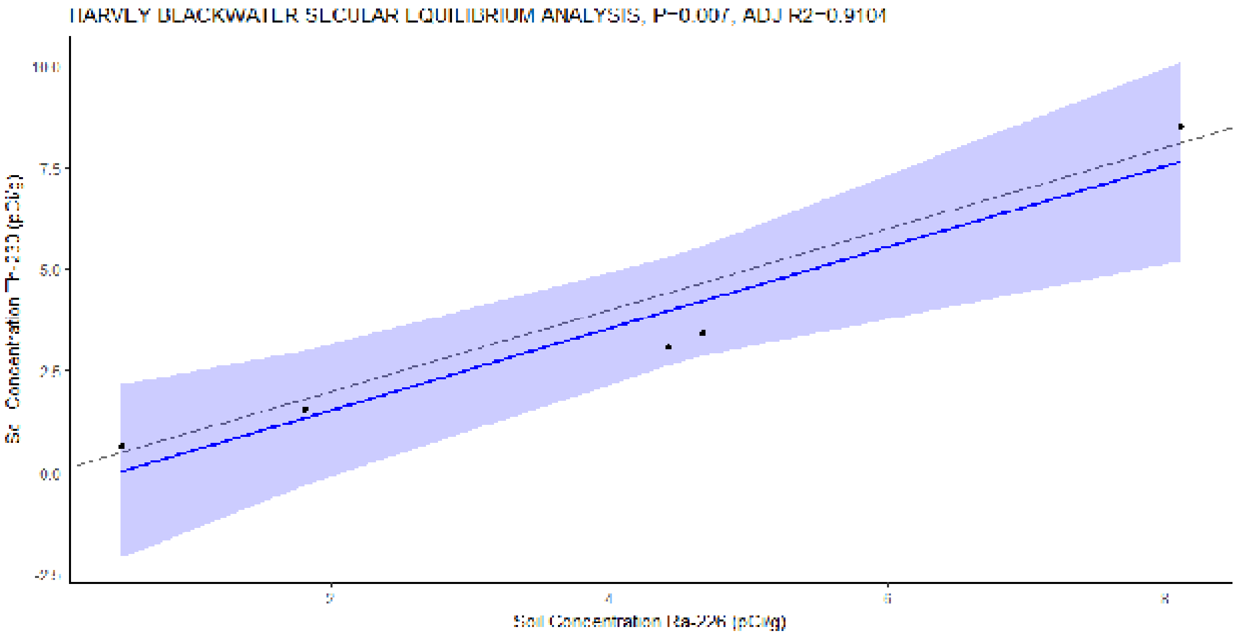

Figure 3. Result for Harvey Blackwater secular equilibrium analysis, showing excellent correlation between the data and the y=x line, i.e., Th-230 and Ra-226 are in secular equilibrium.

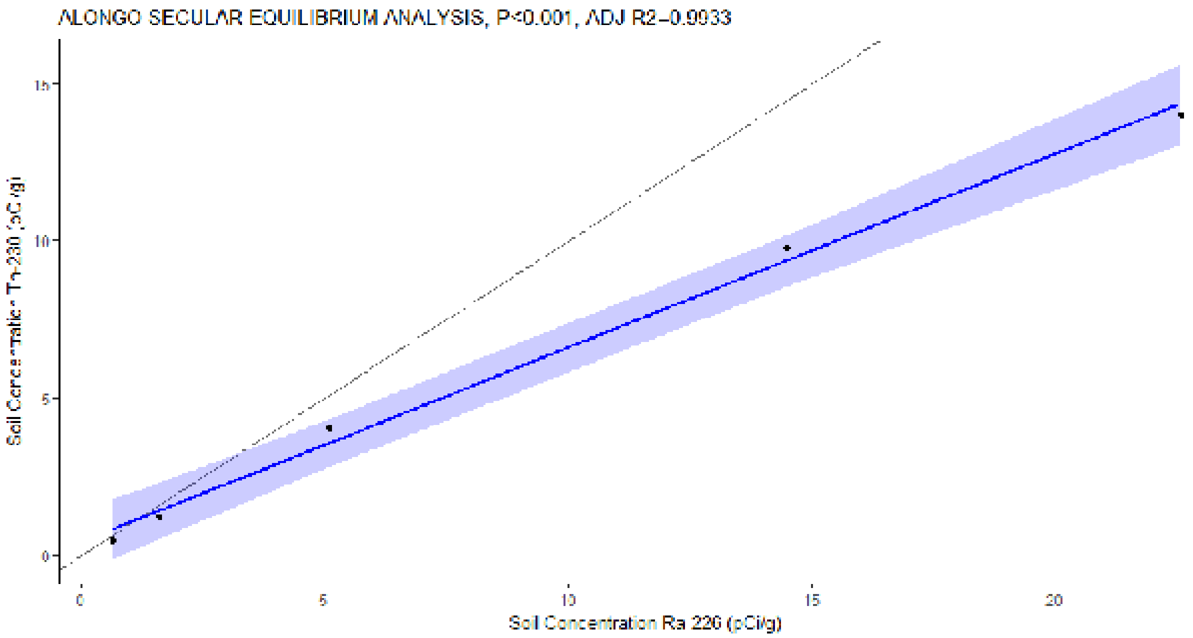

Figure 4. Result for Alongo Mines secular equilibrium analysis, showing excellent correlation between the data, but poor agreement with the y=x line, i.e., Th-230 and Ra-226 are in equilibrium, but not secular equilibrium.

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 "Radiological Characterization of the Standing Rock Abandoned Uranium Mine"

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

Radiological Characterization of the Standing Rock Abandoned Uranium Mine

Preliminary

January 4, 2018

prepared for:

Stantec Consulting Services Inc.

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Contents

Tables

Figures

Appendices

Acronyms

ANSI	American National Standards Institute
AUM	abandoned uranium mine
BG1	Background Reference Area 1
BG2	Background Reference Area 2
cpm	counts per minute
DQOs	data quality objectives
EPA	U.S. Environmental Protection Agency
ERG	Environmental Restoration Group, Inc.
ft	foot
GPS	global positioning system
MDL	method detection limit
μR/h	microRoentgens per hour
pCi/g	picocuries per gram
R^2	Pearson's Correlation Coefficient
RSE	removal site evaluation
σ	standard deviation
Stantec	Stantec Consulting Services Inc.

Executive Summary

This report addresses the radiological characterization of the Standing Rock abandoned uranium mine (AUM) located in the Nahodishgish Chapter of the Navajo Nation in Red Rock Valley, New Mexico. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) in accordance with 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 November 16 and 18, 2016; and March 24 and June 29, 2017. They included a GPS-based radiological survey of land surfaces over a Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer; and 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 "Standing Rock 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.
- Gamma count rates in the mine claim are naturally higher on the top of the outcrop than on its sides. There is evidence of earthwork on portions of the mine claim.
- Two 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 power regression model:

$$\text{Radium-226 Concentration (picocuries per gram [pCi/g])} = \\ 4\text{x}10^{-9}\,\text{(Gamma Count Rate in counts per minute [cpm])}^{2.0114}$$

- The distribution of concentrations of radium-226 in surface soils predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 0.3 to 24.7, with a central tendency (median) of 2.0 pCi/g.

- Thorium-232 and its decay progeny are in relatively higher abundance in the host rock at this AUM, an exception to the other AUMs addressed in the RSE Work Plan. The concentrations of thorium isotopes in the thorium series [thorium-232 (0.72 to 8.5 pCi/g) and thorium-228 (0.74 to 8.6 pCi/g)] parallel those of radium-226 in the same samples and appear not to affect the correlation of gamma count rates to radium-226 concentrations in surface soils. Thorium-232 and its decay progeny are in relatively higher abundance in the host rock at this AUM, an exception to the other AUMs addressed in the RSE Work Plan.

- 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 $7\text{x}10^{-4}$ + 4.8211

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 11.0 to 56.4, with a central tendency (median) of 19.6 µR/h.

1.0 Introduction

This report addresses the radiological characterization of the Standing Rock abandoned uranium mine (AUM) located in the Nahodishgish Chapter of the Navajo Nation near Gallup, New Mexico. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc of Albuquerque, New Mexico and Stantec Consulting Services, Inc. (Stantec) 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 the results of a 1) Global Positioning System (GPS)-based gamma radiation (gamma) survey and 2) comparisons of gamma count rates to exposure rates and concentrations of radium-226 in surface soils.

The field activities were conducted on November 16 and 18, 2016; and March 24 and June 29, 2017 in accordance with the methods described in the RSE Work Plan. The GPS-based radiological survey of land surfaces covered an approximately 53-acre Survey Area that included the mine claim area out to a 100-foot (ft) 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 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 “Standing Rock 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 “Standing Rock Removal Site Evaluation Report” (Stantec, 2018).

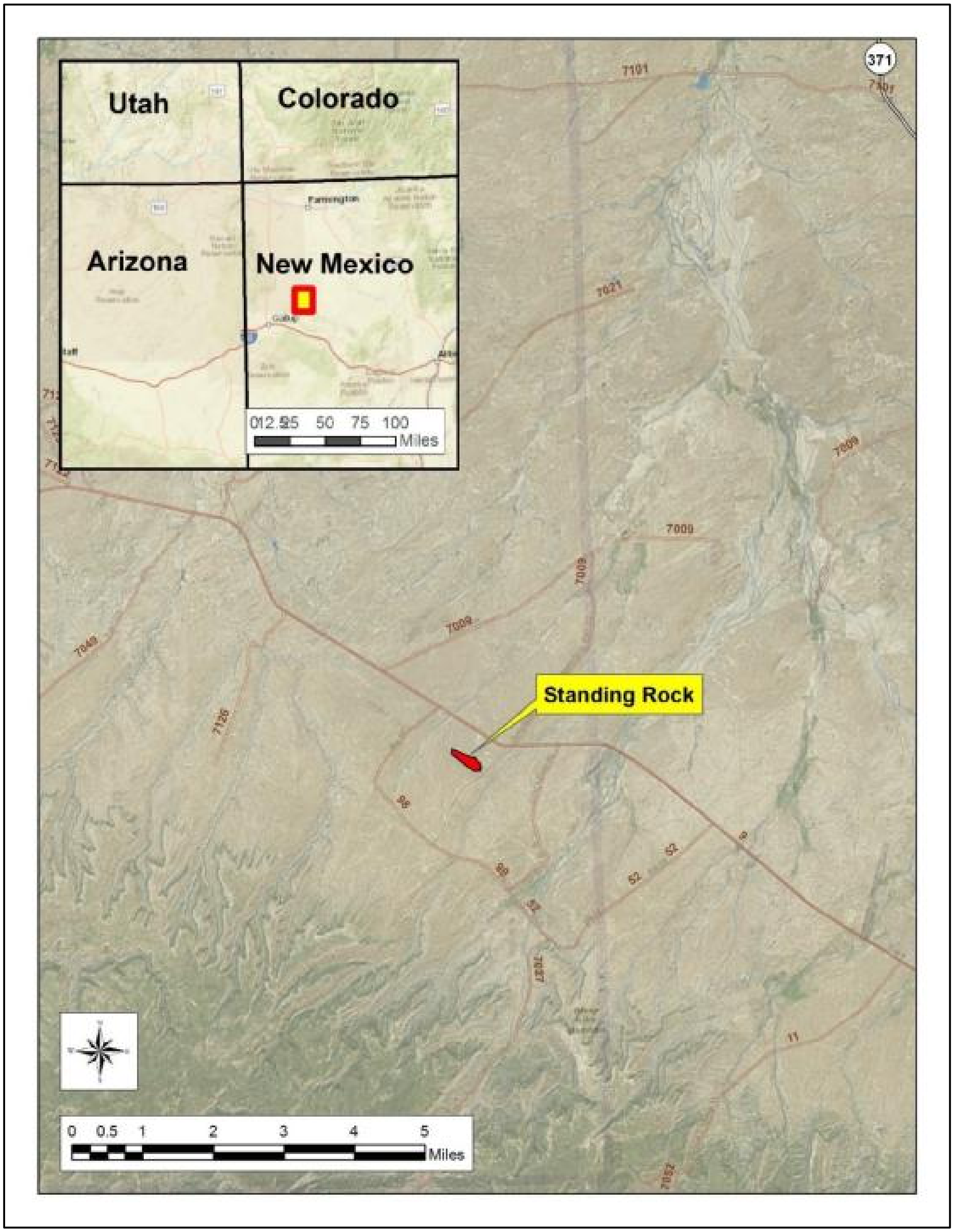


Figure 1. Location of the Standing Rock Abandoned Uranium Mine.

2.0 GPS-Based Gamma Survey

This section addresses the GPS-based survey conducted in two potential Background Reference Areas and the Survey Area. Table 1 lists the detection systems used in the survey, which were function-checked before and after each day of use and within calibration, in accordance with American National Standards Institute (ANSI) Standard N232A (ANSI, 1997). Appendix A presents the completed function check forms and calibration certificates for the instruments.

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

Area	Ludlum Model 44-10	Ludlum Model 2221 Ratemeter/Scaler
Potential Background Reference Areas	PR303727[a]	254772[a]
	PR295014	196086
Survey Area	PR303727[a]	254772[a]
	PR295014	196086
	PR154615	138368
	PR150507	282966

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

2.1 Potential Background Reference Areas

Two potential Background Reference Areas were surveyed, the locations and results of which are depicted on Figure 2. BG1 and BG2 in the figure are Background Reference Areas 1 and 2, respectively.

Table 2 lists a summary of the gamma count rates, which in BG1 ranged from 19,646 to 36,225 counts per minute (cpm), with a mean and median of 26,494 and 26,306 cpm, respectively. The gamma count rates in BG2 ranged from 10,910 to 16,806 cpm, with a mean and median of 13,871 and 13,811 cpm, respectively.

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

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

	Gamma Count Rate (cpm)					
Potential Background Reference Area	n	Minimum	Maximum	Mean	Median	Standard Deviation
1	222	19,646	36,225	26,494	26,306	3,365
2	543	10,910	16,806	13,871	13,811	967

Notes:
cpm = counts per minute

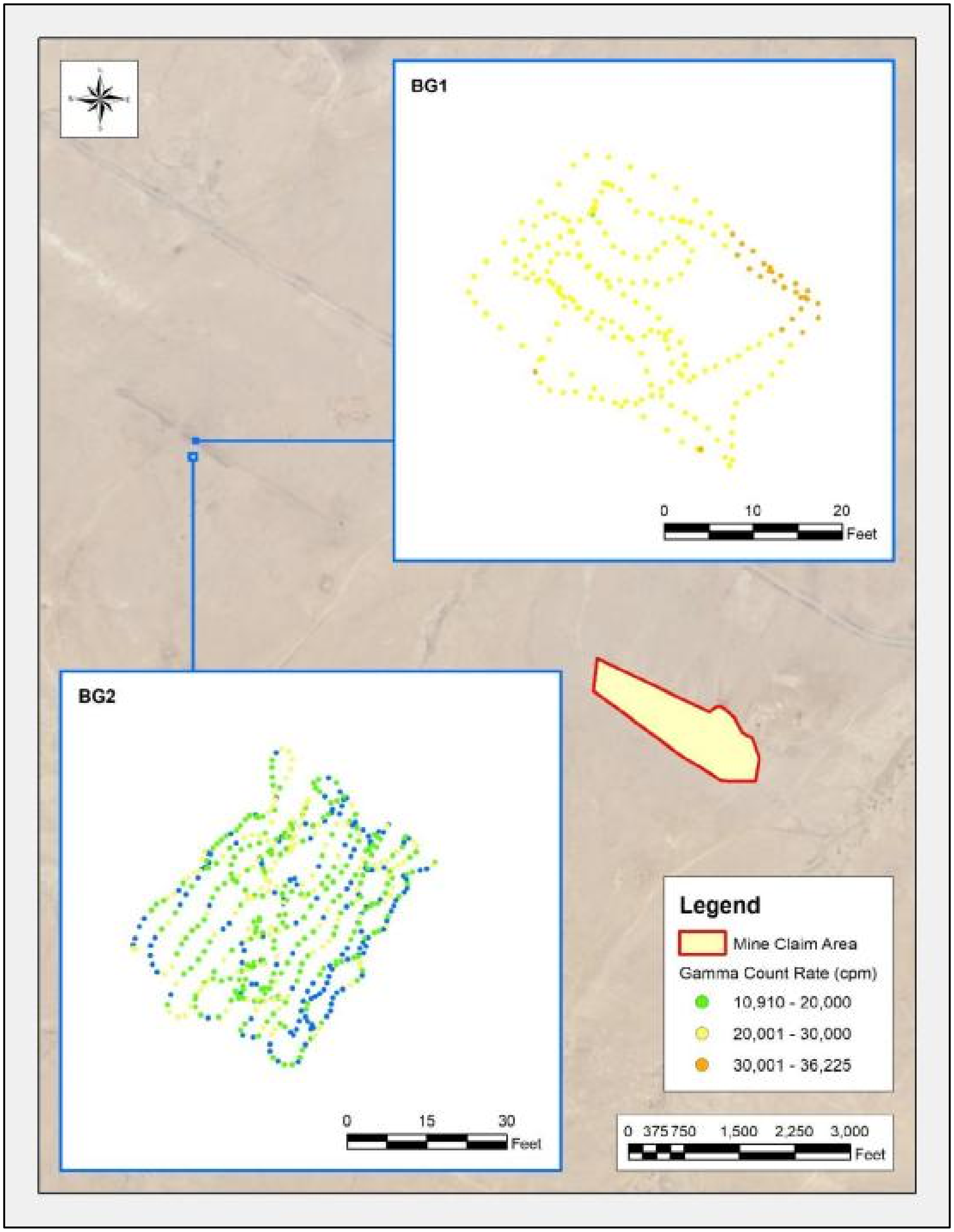
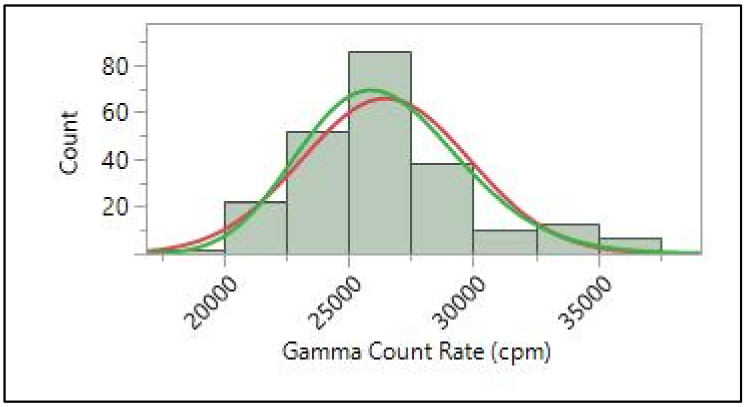
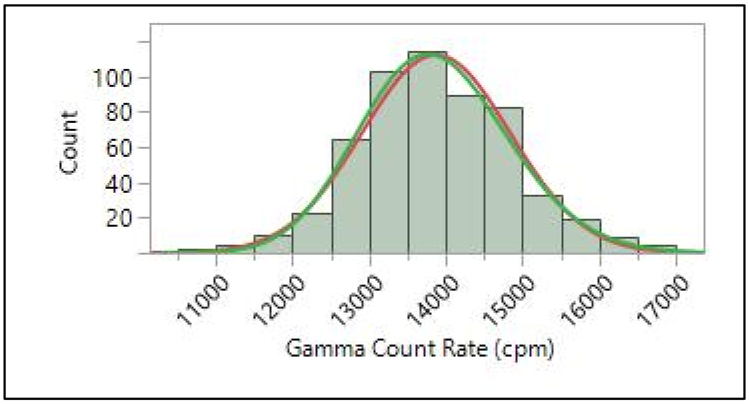


Figure 2. Gamma count rates in the potential Background Reference Areas.



a. **Background Reference Area 1**



b. **Background Reference Area 2**

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

2.2 Survey Area

The gamma count rates observed in the Survey Area are depicted in Figure 4. Gamma count rates in the mine claim are naturally higher on the top of the outcrop than on its sides. There is evidence of earthwork on portions of the mine claim.

Figure 5 is a histogram of the gamma count rate measurements made in the Survey Area. As stated in Section 2.1, the red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could be expected if the distributions were normal or lognormal. The distribution of the right-tailed set of measurements, evaluated using U.S. Environmental Protection Agency software ProUCL, is not discernible; 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 16,410, 21,139, and 27,469 cpm, respectively.

Table 3 is a statistical summary of the measurements, which range from 8,810 to 73,651 cpm and have a central tendency (median) of 21,139 cpm.

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

Parameter	Gamma Count Rate (cpm)
n	60,068
Minimum	8,810
Maximum	73,651
Mean	22,886
Median	21,139
Standard Deviation	8,508

Notes:
cpm = counts per minute

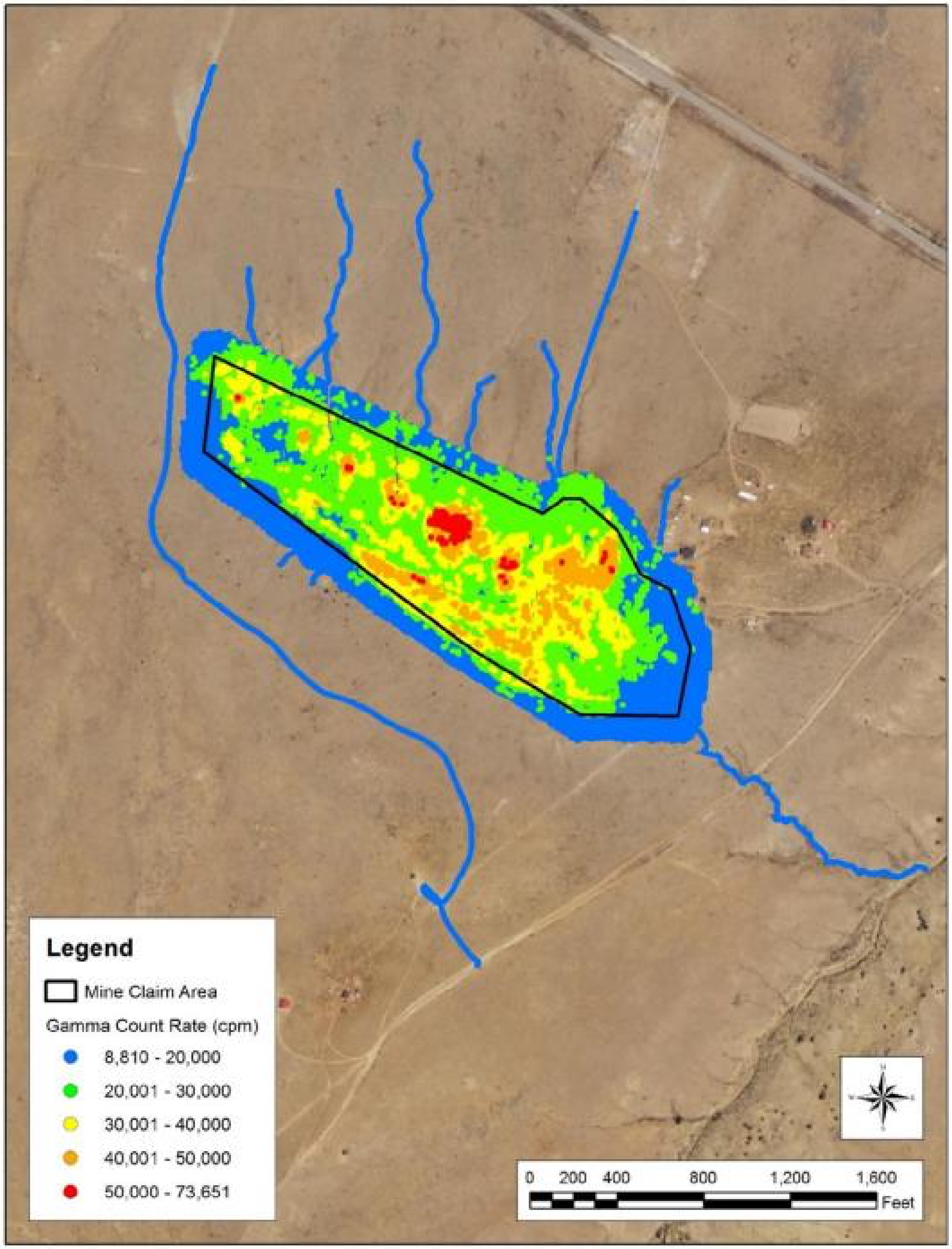


Figure 4. Gamma count rates in the Survey Area.

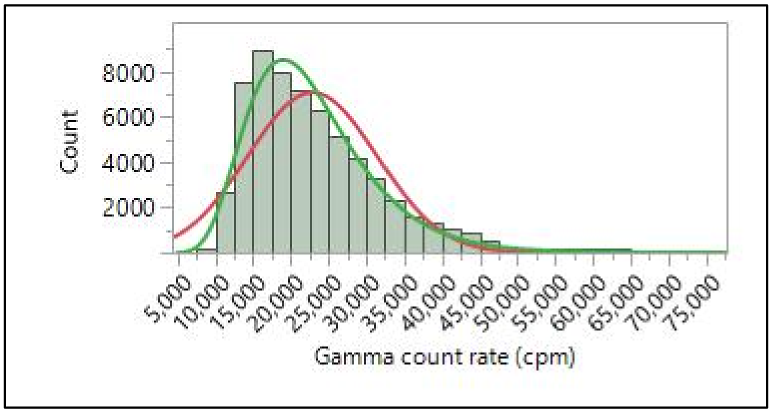


Figure 5. Histogram of gamma count rates in the Survey Area.

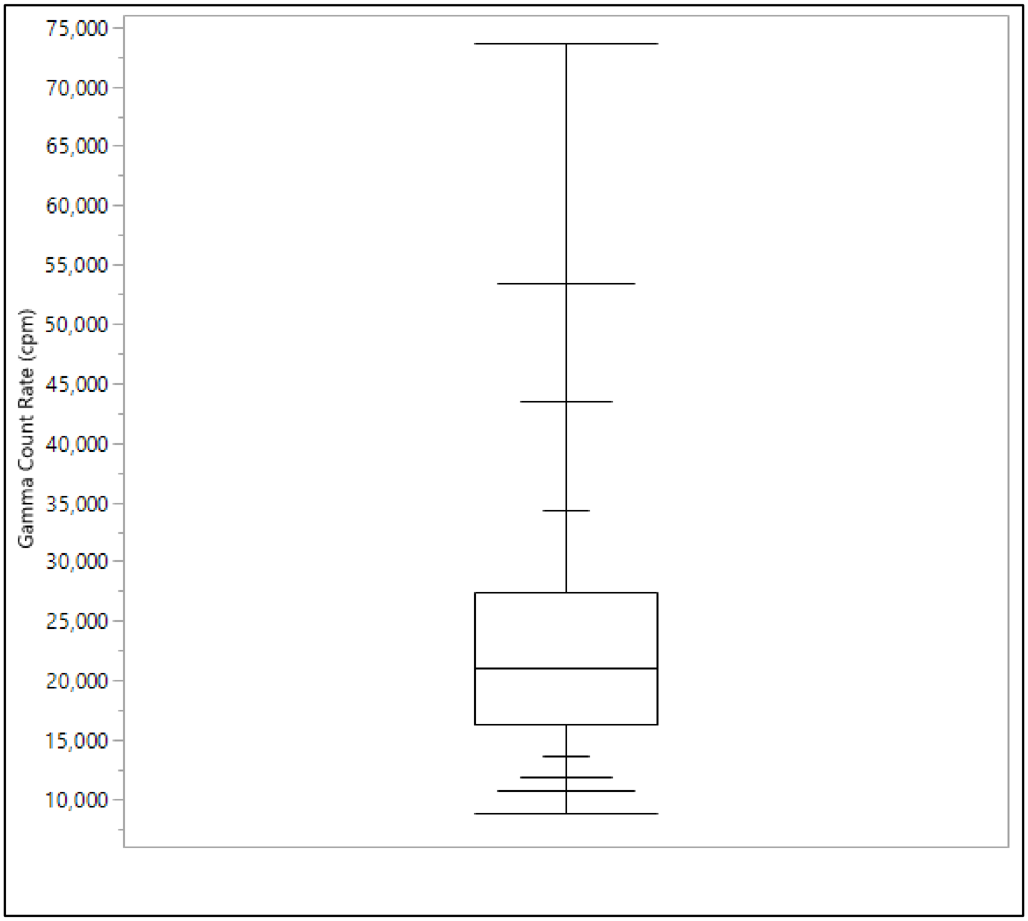


Figure 6. Box plot of gamma count rates in the Survey Area.

3.0 Correlation Studies

The following sections address the correlation studies outlined in the RSE Work Plan, which are comparisons of radium-226 concentrations in surface soils and gamma count rates and comparisons of 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 November 18, 2016 field personnel made GPS-based gamma count rates measurements and collected five-point composite samples of surface soils in each of five areas at the AUM. The activities were performed contemporaneously, by area and all on the same day, such that the two could be compared. Figure 7 shows the GPS-based gamma count rate measurements in the five areas (labeled with location identifiers).

The soil samples were analyzed by ALS Laboratories in 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 measurements and radium-226 concentrations in the soil samples. The means of the gamma count rate measurements range from 12,310 to 37,858 cpm. The concentrations of radium-226 range from 0.68 to 6.93 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: Data Usability Report, Laboratory Analytical Data, and Data Validation Reports in “Standing Rock Removal Site Evaluation Report” (Stantec, 2018).

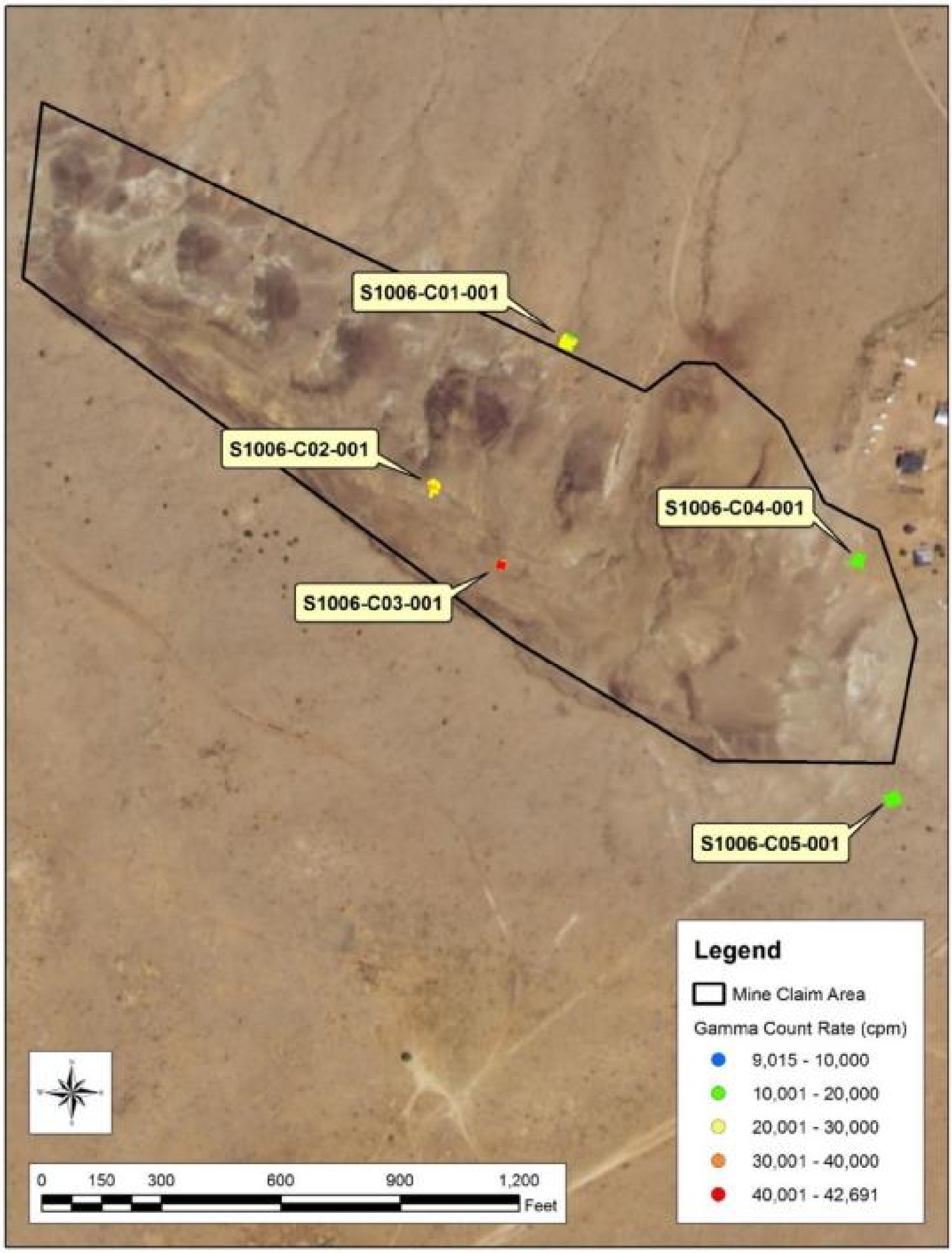


Figure 7. GPS-based gamma count rate measurements made for the correlation study.

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
S10006-C01-201	19,141	16,018	24,623	1,341	1.65	0.35	0.45
S10006-C02-001	26,728	23,710	33,691	1,538	3.62	0.57	0.58
S10006-C03-001	37,858	33,182	42,691	1,742	6.93	0.97	0.83
S10006-C04-001	14,940	12,563	18,531	1,141	1.25	0.28	0.38
S10006-C05-001	12,310	9,015	17,604	1,214	0.68	0.26	0.51

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
S10006-C01-201	1.7	0.31	0.09	0.98	0.20	0.10	1.66	0.30	0.02
S10006-C02-001	5.91	0.95	0.07	2.47	0.42	0.08	5.79	0.93	0.03
S10006-C03-001	8.6	1.4	0.1	3.17	0.51	0.07	8.5	1.3	0
S10006-C04-001	1.29	0.22	0.05	0.98	0.18	0.07	1.25	0.22	0.01
S10006-C05-001	0.74	0.14	0.05	0.68	0.13	0.07	0.72	0.13	0.02

Notes:
MDL = method detection limit
pCi/g = picocuries per gram
σ = standard deviation

A model was made of the results in Table 4, predicting the concentrations of radium-226 in surface soils from the mean gamma count rate in each area. The best predictive relationship between the measurements, shown in Figure 8, is a strong, power function with a Pearson's Correlation Coefficient (R^2) of 0.9897, as expressed in the equation:

$$\text{Radium-226 concentration (pCi/g)} = 4 \times 10^{-9} \times \text{Gamma Count Rate (cpm)}^{2.0114}$$

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 0.106198 and 0.0004, respectively; these parameters are not data quality objectives (DQOs) and are included only as information.

The concentrations of isotopes in the thorium series [thorium-232 (0.72 to 8.5 pCi/g) and thorium-228 (0.74 to 8.6 pCi/g)] parallel those of radium-226 in the same samples and appear not to affect the correlation. Thorium-232 and its decay progeny are in relatively higher abundance in the host rock at this AUM, an exception to the other AUMs addressed in the RSE Work Plan.

The equation above was used to convert the gamma count rate measurements observed in the gamma surveys to predicted concentrations of radium-226. Table 6 presents summary statistics for the predicted concentrations of radium-226 in the Survey Area. The range of the predicted concentrations of radium-226 in the Survey Area is 0.3 to 24.7 pCi/g, with a mean and median of 2.7 and 2.0 pCi/g, respectively. Note that the radium-226 concentrations predicted from gamma count rate measurements exceeding approximately 43,000 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..

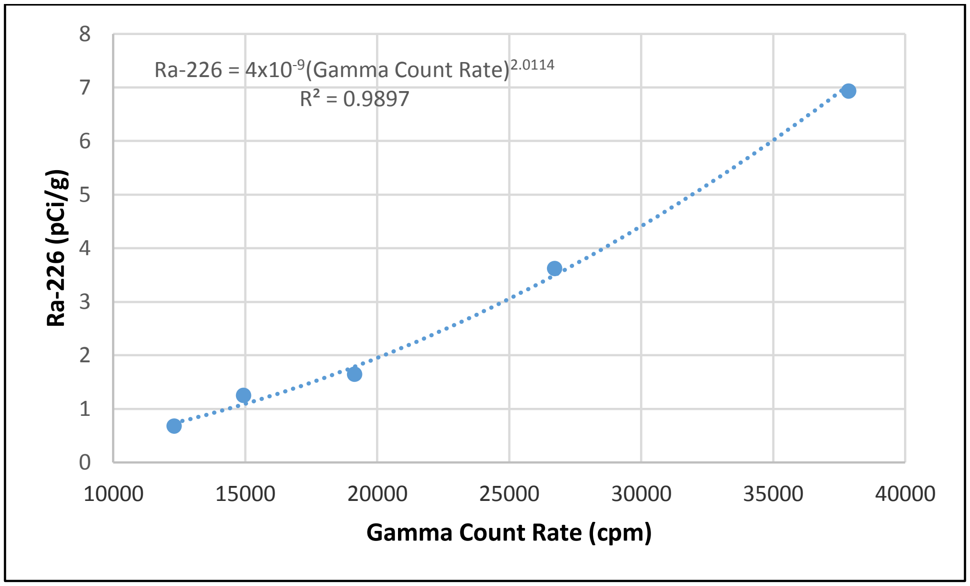


Figure 8. Correlation of gamma count rates and concentrations of radium-226 in surface soils.

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

Parameter	Radium-226 (pCi/g)
n	60,068
Minimum	0.3
Maximum	24.7
Mean	2.7
Median	2.0
Standard Deviation	2.2

Notes:
pCi/g = picocuries per gram

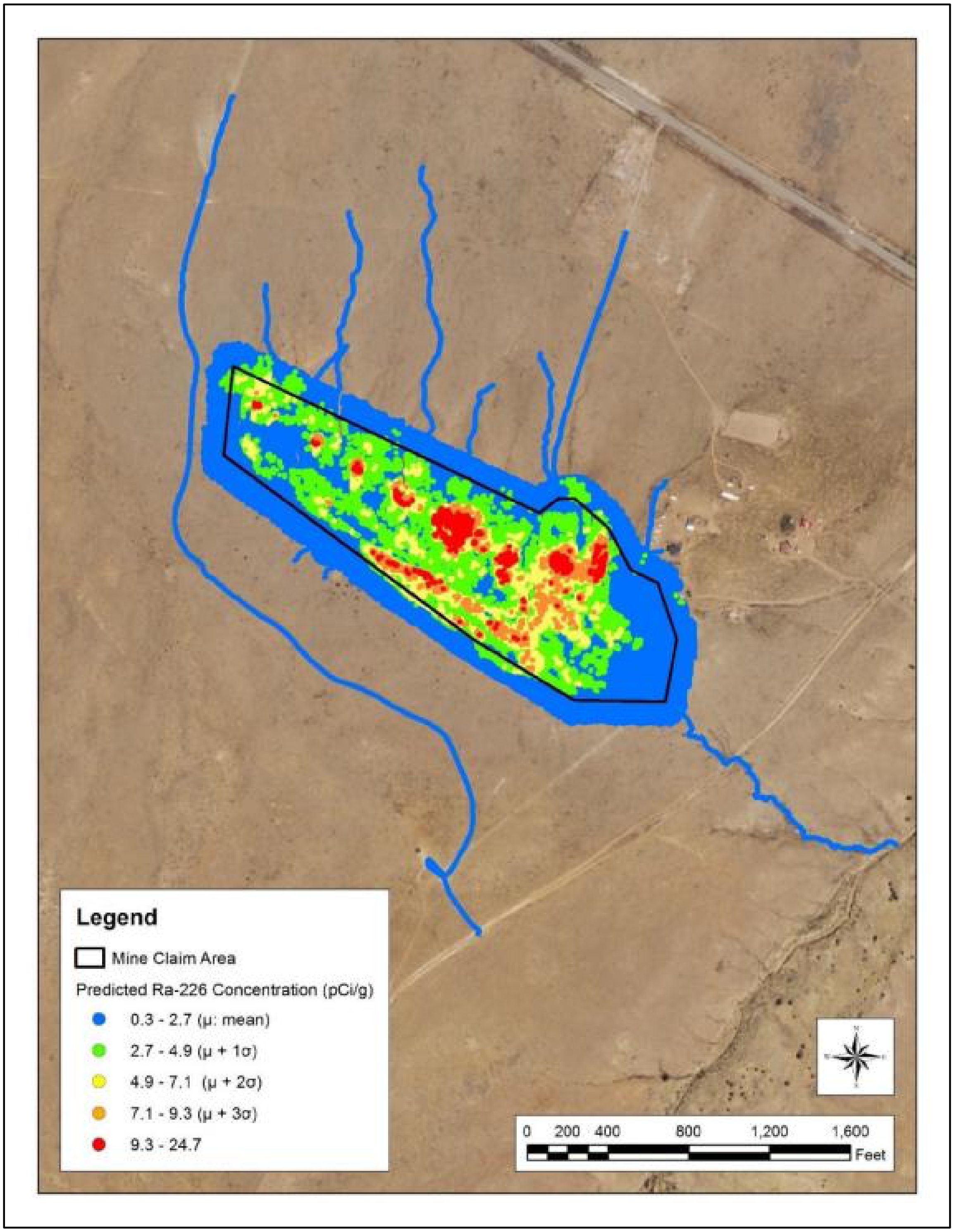


Figure 9. Predicted concentrations of radium-226 in the Survey Area.

3.2 Equilibrium in the uranium series

Secular equilibrium occurs when the activities of a parent radionuclide and its decay product are equal. This can occur in a closed system, when the half-life of the parent radionuclide is much larger than that of the decay product.

The ratio of the concentrations of radium-226 to thorium-230 can be used as an indicator of the status of equilibrium in the uranium series. The half-lives of thorium-230 and radium-226 are 77,000 and 1,600 years, respectively. The ratios in the five correlation samples are 1.7 (Sample S10006-C01-001), 1.5 (Sample S10006-C02-001), 2.2 (Sample S10006-C03-001), 1.3 (Sample S10006-C04-001), and 1.0 (Sample S10006-C05-001), indicating that thorium-230 is depleted in relation to radium-226 and, by extrapolation, the uranium series itself is not in secular equilibrium.

Note this observation is based on the results of five samples, subject to differing analytical methods. Gamma spectroscopy, the method used to determine the concentration of radium-226, assesses an intact portion of the whole sample as it was collected. The concentration of thorium-230 was determined by alpha spectroscopy of an acid-leached aliquot of the sample.

This evaluation is not related to the correlation of radium-226 concentrations in surface soils and gamma count rates. It may be used for a future risk assessment.

3.3 Exposure rates and gamma count rates

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

The gamma count rate and exposure rate measurements were made on November 18, 2016 at 0.5 m and 1 m above the ground surface, respectively. The gamma count rate measurements were made using one of the four sodium iodide detection systems used in the GPS-based gamma survey of the Survey Area (Serial Number PR303727/254772). The exposure rate measurements were made using a Reuter Stokes Model RSS-131 (Serial Number 07J00KM1) high pressure ionization chamber (HPIC) at six-second intervals for about 10 minutes. The exposure rate used in the comparison was the mean of these measurements, less those occurring in initial instrument spikes. The HPIC was in current calibration and function checked before and after use. Calibration forms for the HPIC are provided in Appendix A.

Table 7 presents the results for the two types of measurements made at each of the five locations. Appendix B presents the individual (6-second) exposure rate measurements.

The Pearson's Correlation Coefficient (R^2) is a measure of the dependence between two variables, and is expressed as a value between -1 and +1 where +1 is a positive correlation, 0 is no correlation, and -1 is a negative correlation. The best predictive relationship between the measurements is linear with a R^2 of 0.9845, strongly indicating a positive correlation. The root mean square error and p-value for the model are 1.002488 and 0.0008, respectively; these parameters are not DQOs and are included only as information.

The following equation is the linear regression (shown in Figure 10) between the mean exposure rate and gamma count rate results in Table 7 that was generated using MS Excel:

Exposure Rate (microRoentgens per hour [µR/h]) = $7\text{x}10^{-4}$ x Gamma Count Rate (cpm) + 4.8211

Figure 11 presents the exposure rates predicted from the gamma count rate measurements, the spatial and numerical distribution of which mirror those depicted in Figure 4.

Tables 8 and 9 present summary statistics for the predicted exposure rates in the potential Background Reference Areas and Survey Area, respectively. The range of predicted exposure rates at BG1 is 18.6 to 30.2 µR/h, with a mean and median of 23.4 and 23.2 µR/h, respectively. The range of predicted exposure rates at BG2 is 12.5 to 16.6 µR/h, with a mean and median of 14.5 µR/h. The range of predicted exposure rates in the Survey Area is 11.0 to 56.4 µR/h, with a mean and median of 20.8 and 19.6 µR/h, respectively.

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

Location	Gamma Count Rate (cpm)	Exposure Rate (µR/h)
S10006-C01-201	18,598	17.3
S10006-C02-001	26,624	21.6
S10006-C03-001	37,165	31
S10006-C04-001	15,012	15.2
S10006-C05-001	11,993	13.6

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

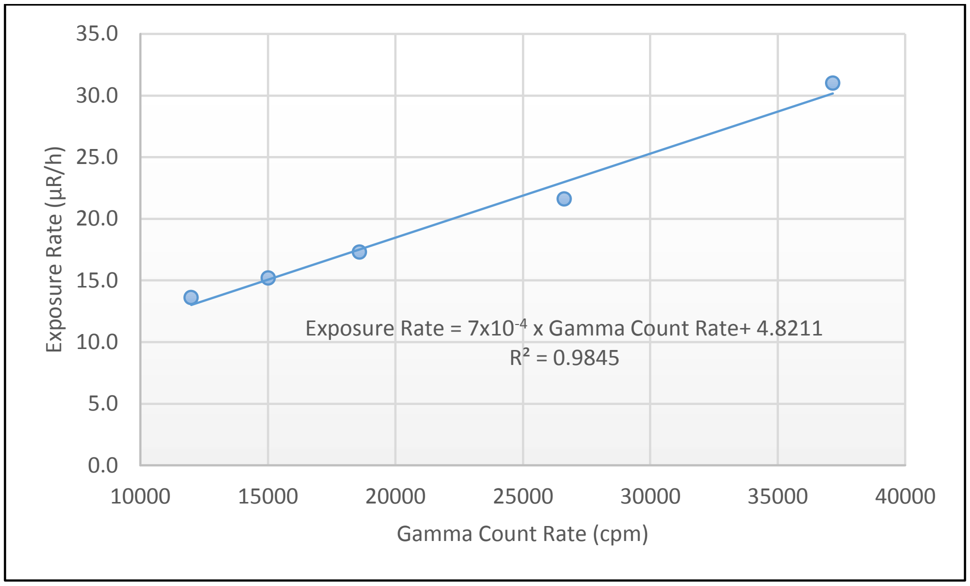


Figure 10. Correlation of gamma count rates and exposure rates.

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

Potential Background Reference Area	BG1	BG2
Parameter	Exposure Rate (µR/h)	
n	222	543
Minimum	18.6	12.5
Maximum	30.2	16.6
Mean	23.4	14.5
Median	23.2	14.5
Standard Deviation	2.4	0.7

Notes:
µR/h = microRoentgens per hour

Table 9. Predicted exposure rates in the Survey Area.

Parameter	Exposure Rate (µR/h)
n	60,068
Minimum	11.0
Maximum	56.4
Mean	20.8
Median	19.6
Standard Deviation	6.0

Notes:
µR/h = microRoentgens per hour

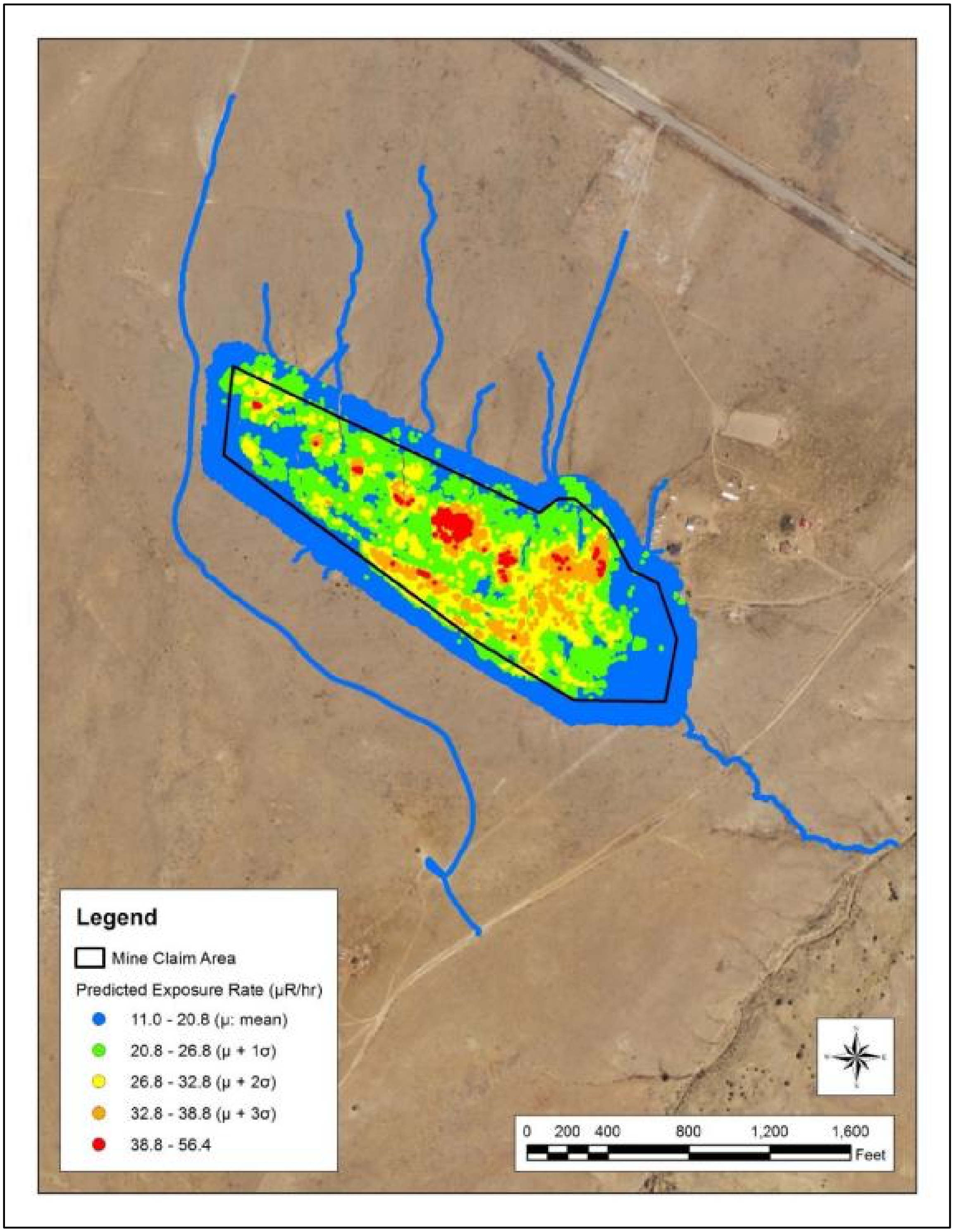


Figure 11. Predicted exposure rates in the Survey Area.

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; and remedy selection and design.

- Two potential Background Reference Areas have been established for this AUM.

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

  $$\text{Radium-226 Concentration (pCi/g)} = 4\text{x}10^{-9}\,(\text{Gamma Count Rate})^{2.0114}$$

- The distribution of concentrations of radium-226 in surface soils predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 0.3 to 24.7, with a central tendency (median) of 2.0 pCi/g.

- The concentrations of thorium isotopes in the thorium series [thorium-232 (0.72 to 8.5 pCi/g) and thorium-228 (0.74 to 8.6 pCi/g)] parallel those of radium-226 in the same samples and appear not to affect the correlation of gamma count rates to radium-226 concentrations in surface soils. Thorium-232 and its decay progeny are in relatively higher abundance in the host rock at this AUM, an exception to the other AUMs addressed in the RSE Work Plan.

- 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 $7\text{x}10^{-4}$ + 4.8211

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 11.0 to 56.4, with a central tendency (median) of 19.6 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. Standing Rock Removal Site Evaluation Report, January 2018.

Appendix A Instrument calibration and completed function check forms

ERG

Certificate of Calibration

Calibration and Voltage Plateau

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

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

✓ Mechanical Check
✓ F/S Response Check
✓ Geotropism
✓ Meter Zeroed

✓ THR/WIN Operation
✓ Reset Check
✓ Audio Check
✓ Battery Check (Min 4.4 VDC)

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

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

Threshold: 10 mV
Window:

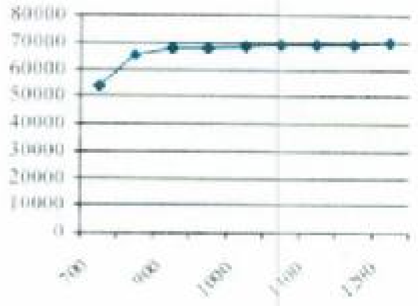
Barometric Pressure: 24.75 inches Hg
Temperature: 74 °F
Relative Humidity: 20 %

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	398857	400
x 1000	100	100	100		100
x 100	400	400	400	39913	400
x 100	100	100	100		100
x 10	400	400	400	3992	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	53620	
800	64979	
900	67955	
950	67795	
1000	68536	9542
1050	69153	
1100	69331	
1150	69346	
1200	69492	

Voltage Plateau



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

Reference Instruments and/or Sources:

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

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

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

Reviewed By: Date: 7/20/16

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

ERG

Certificate of Calibration

Calibration and Voltage Plateau

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

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

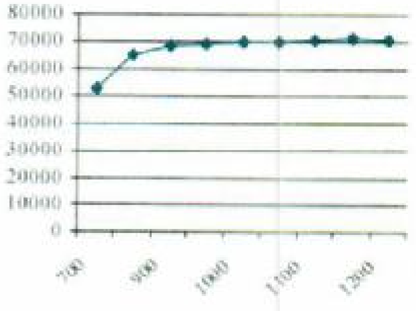
Barometric Pressure: 24.24 inches Hg
Temperature: 78 °F
Relative Humidity: 20 %

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:
Reviewed By:

Calibration Date: 2/28/17 ~~2 March 17~~ asH
Calibration Due: 2/28/18 ~~2 March~~ 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

ERG

Certificate of Calibration

Calibration and Voltage Plateau

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

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

✓ Mechanical Check
✓ F/S Response Check
✓ Geotropism
✓ Meter Zeroed

✓ THR/WIN Operation
✓ Reset Check
✓ Audio Check
✓ Battery Check (Min 4.4 VDC)

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

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

Threshold: 10 mV
Window:

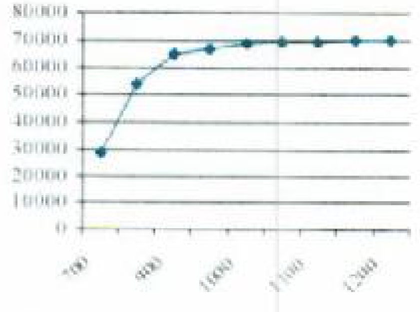
Barometric Pressure: 24.78 inches Hg
Temperature: 74 °F
Relative Humidity: 20 %

Instrument found within tolerance: ✓ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399802	400
x 1000	100	100	100		100
x 100	400	400	400	39989	400
x 100	100	100	100		100
x 10	400	400	400	3999	400
x 10	100	100	100		100
x 1	400	400	400	400	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	28456	
800	53330	
900	64430	
950	66209	
1000	68333	
1050	69077	
1100	69121	8924
1150	69973	
1200	70155	

Voltage Plateau



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

Reference Instruments and/or Sources:

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

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

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

Reviewed By:
Date: 7/20/16

ERG Form ITC. 101.A

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

ERG

Certificate of Calibration

Calibration and Voltage Plateau

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

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

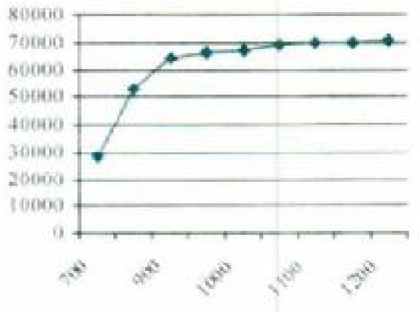
Barometric Pressure: 24.27 inches Hg
Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Threshold: 10 mV
Temperature: 78 °F
Source Geometry: ☑ Side ☐ Below ☐ Other:
Window:
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399386	400
x 1000	100	100	100		100
x 100	400	400	400	39949	400
x 100	100	100	100		100
x 10	400	400	400	3995	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	28235	
800	52834	
900	64481	
950	66468	
1000	67321	
1050	69009	
1100	69981	9079
1150	69564	
1200	70538	

Voltage Plateau



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

Reference Instruments and/or Sources:

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

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

Calibrated By:
Reviewed By:

Calibration Date: ~~3 March 17~~ 2/28/17 BLM
Calibration Due: BLM 2/28/18 ~~2 March~~ 18

Date: 3 1-17

ERG Form ITC. 101A

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

ERG

Certificate of Calibration

Calibration and Voltage Plateau

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

Meter: Manufacturer: Ludlum Model Number: 2221r Serial Number: 138368

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

✓ Mechanical Check
✓ 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:

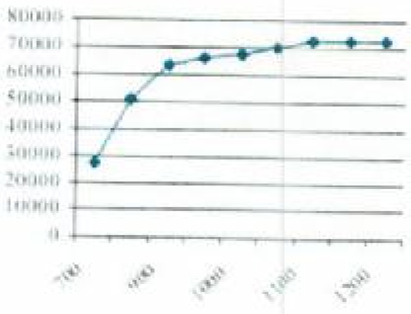
Barometric Pressure: 24.78 inches Hg
Temperature: 74 °F
Relative Humidity: 20 %

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	398436	400
x 1000	100	100	100		100
x 100	400	400	400	39845	400
x 100	100	100	100		100
x 10	400	400	400	3984	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	26998	
800	51037	
900	63340	
950	65550	
1000	67410	
1050	70113	
1100	72217	
1150	72561	9216
1200	72337	

Voltage Plateau



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

Reference Instruments and/or Sources:

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

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

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

Reviewed By:
Date: 7/20/16

ERG Form ITC. 101.A

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

ERG

Certificate of Calibration

Calibration and Voltage Plateau

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

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

☑ Mechanical Check
☑ F/S Response Check
☑ Geotropism
☑ Meter Zeroed

☑ THR/WIN Operation
☑ Reset Check
☑ Audio Check
☑ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☐ 72-inch ☑ Other: 60"

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

Threshold: 10 mV
Window:

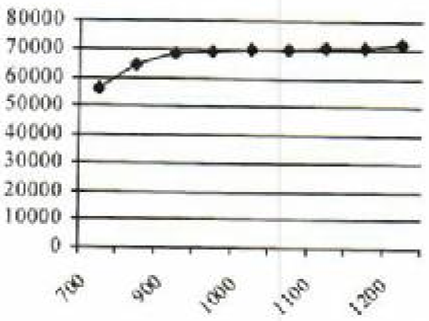
Barometric Pressure: 24.89 inches Hg
Temperature: 73 °F
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	398753	400
x 1000	100	100	100		100
x 100	400	400	400	39879	400
x 100	100	100	100		100
x 10	400	400	400	3989	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	56463	9696
800	64304	
900	68534	
950	69331	
1000	69868	
1050	70054	
1100	70609	
1150	70681	
1200	71955	

Voltage Plateau



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

Reference Instruments and/or Sources:

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

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

Calibrated By:
Reviewed By:

Calibration Date: 10.31-16
Calibration Due: 10-31-17
Date: 10/31/16

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of

ERG

Certificate of Calibration

Calibration and Voltage Plateau

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

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

☐ Mechanical Check
☐ F/S Response Check
☐ Geotropism
☐ Meter Zeroed

☐ THR/WIN Operation
☐ Reset Check
☐ Audio Check
☐ Battery Check (Min 4.4 VDC)

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

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

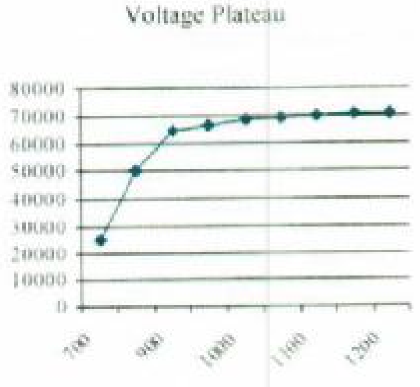
Threshold: 10 mV
Window:

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

Instrument found within tolerance: ☑ Yes ☐ No

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

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



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

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
☐ Alpha Source: Th-230 sn: 4098-03 @ 12,800dpm/6,520 cpm (1/4/1
☐ Beta Source: Tc-99 sn: 4099-03 @ 17,700dpm/11,100cpm (1/4/12

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

Calibrated By:
Calibration Date: 3-13-17
Calibration Due: 3-13-18

Reviewed By:
Date: 14 March 2017

ERG Form ITC - 101.A

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

K&S Associates, Inc.
1926 Elm Tree Drive
Nashville, Tennessee 37210-3718
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.

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 Royer
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
Title: Calibration Technician

Reviewed By:
Title: Calibration Physicist

Checked By:
Prepared By: REH

Form RSS

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	7-9-17

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

Comments:
NNERT

Source: Cs-137
Activity: 5.12 uCi
Source Date: 6-6-94
Distance to Source: 6 inches
Serial No.: 333-94
Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference points
11-18-16	0829	5.4	1015	101	51216	13360	37856	NW	Standing Rock
11-18-16	1517	5.3	1006	100	48629	10616	38013	NW	Gallup lot
11-19-16	0808	5.3	1014	100	43603	5712	37891	NW	Eunice Becenti
11-19-16	1400	5.1	1005	100	44923	5058	39865	NW	Eunice Becenti

12-6-16

Reviewed by:

Review Date: 11/29/16

①

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	7-9-17

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

Comments:

NNERT

Source: Cs-137

Serial No.: 333-94

Activity: 5.12 uCi

Emission Rate: NA cpm/emissions

Source Date: 6-6-94

Distance to Source: 6 inches

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

Reviewed by: MM

Review Date: 11/29/16

ERG

Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	196086
Cal. Due Date:	7-9-17

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

Comments:
NNERT

Source: Cs-137

Serial No.: 333-94

Activity: 5.12 uCi

Emission Rate: NA cpm/emissions

Source Date: 6-6-94

Distance to Source: 6 inches

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

NW 12-6-16

Reviewed by:

Review Date: 11/29/16

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ERG

Single-Channel Function Check Log

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

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

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR154615
Cal. Due Date:	7-9-17

Comments:
NNEAT

Source: Cs-137
Activity: 5.12 uCi
Source Date: 6-6-94
Distance to Source: 6 Inches
Serial No.: 333-94
Emission Rate: NA cpm/emissions

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

NW
12-6-16

Reviewed by: MW

Review Date: 11/29/16

ERG Form ITC.201.A

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Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	282466
Cal. Due Date:	10-31-17

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

Comments:
NNEAT

Source: Cs-137

Serial No.: 333-94

Activity: 5.12 uCi

Emission Rate: NA cpm/emissions

Source Date: 6-6-94

Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project Reference Points
11-12-16	0827	5.7	1010	102	48550	9744	38806	NW	Hoskie Tso
11-12-16	1351	5.6	1000	101	47089	8725	38364	NW	Hoskie Tso
11-16-16	0826	5.7	1011	102	50569	12266	38303	NW	Standing Rock
11-16-16	1516	5.4	1006	103	50039	11202	38837	NW	Gallup lot
11-18-16	0836	5.7	1017	104	52221	13620	38601	NW	Standing Rock
11-18-16	1530	5.6	1009	103	48820	10831	37989	NW	Gallup lot
11-19-16	0812	5.6	1016	104	44700	4940	39760	NW	Eunice Becenti
11-19-16	1407	5.5	1004	102	44961	4975	39986	NW	Eunice Becenti
					12-6-16				

Reviewed by:

Review Date: 11/29/16

ERG Form ITC.201.A

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Single-Channel Function Check Log

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

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	2-28-18

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

Comments:
NNERT

Source: Cs-137

Serial No.: 544-96

Activity: 4 uCi

Emission Rate: N/a cpm/emissions

Source Date: 4-18-96

Distance to Source: 6 Inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-22-17	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	5.4	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:

Review Date: 11/06/17

ERG Form ITC.201.A

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Single-Channel Function Check Log

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

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

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

Comments:
NNZAT

Source: Cs-137
Serial No.: 544-96
Activity: 4 uCi
Emission Rate: NA cpm/emissions
Source Date: 4-18-96
Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-20-17	0905	5.7	1003	101	40471	8507	31964	NW	Claim 28
3-20-17	1547	5.6	996	101	36470	5494	30976	NW	Chinle lot
3-21-17	0641	5.7	1004	101	37904	5597	32307	NW	Chinle lot
3-21-17	1654	5.6	999	101	36212	4929	31283	NW	Goulding's lot
3-22-17	0702	5.6	1001	101	35714	5119	30595	NW	Goulding's lot
3-22-17	1937	5.4	995	101	35087	4539	30548	NW	Charles Keith shooting range
3-23-17	0907	5.6	1004	101	36031	4879	31152	NW	NA-0928
3-23-17	1922	5.5	1004	101	41793	9955	31838	NW	Gallup lot
3-24-17	0810	5.5	1007	101	35608	4282	31326	NW	Eunice Becenti
3-24-17	1785	5.5	1000	101	41923	10785	31138	NW	Gallup lot
3-27-17	0833	5.5	1005	101	36943	4282	32661	NW	Eunice Becenti
3-27-17	1235	5.4	1000	101	35141	4013	31128	NW	Eunice Becenti

Reviewed by:

Review Date: 10/19/17

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Single-Channel Function Check Log

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

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

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

Comments:
NNERT

Source: Cs-137

Serial No.: 544-96

Activity: 4 uCi

Emission Rate: NA cpm/emissions

Source Date: 4-18-96

Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-22-17	0705	5.6	1050	100	35820	5210	30610	NW	Goulding's lot
3-22-17	1425	5.5	1049	101	36169	4648	31521	NW	Charles Keith shooting range
3-23-17	0908	5.6	1056	102	35972	4828	31144	NW	NA-0928
3-23-17	1915	5.5	1055	102	41686	10757	30929	NW	Gallup lot
3-24-17	0805	5.5	1060	102	36151	4442	31709	NW	Eunice Becenti
3-24-17	1744	5.4	1051	101	41975	10993	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:

Review Date: ~~9~~ 10/9/17

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Single-Channel Function Check Log

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

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

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR295614
Cal. Due Date:	2-28-18

Comments:
NNERT

Source: Cs-137

Serial No.: 544-96

Activity: 4 uCi

Emission Rate: NA cpm/emissions

Source Date: 4-18-96

Distance to Source: 6 inches

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

Reviewed by:

Review Date: 10/9/17

ERG

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

Single-Channel Function Check Log

METER	
Manufacturer:	GE
Model:	RSS-131
Serial No.:	07J00KM1
Cal. Due Date:	6-29-17

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

Comments:
NNEAT

Source: Cs-137
Serial No.: 333-94
Activity: 5.12 uCi
Emission Rate: NA cpm/emissions
Source Date: 6-6-94
Distance to Source: Contact-housing

Date	Time	Battery	High Voltage	Threshhold	Source Counts µR/h	BKG Counts µR/h	Net Counts	Initials	Note(s): Project reference points
11-14-16	0530	~6.3	~400	NA	~27	~10	~17	NW	DoubleTree Flagstaff - room
11-14-16	2005	~6.3	~400	NA	~29	~11	~18	NW	Best Western Holbrook - room
11-18-16	0623	~6.3	~400	NA	~27	~11	~16	NW	Best Western Gallup - room
11-18-16	1532	~6.2	~400	NA	~27	~11	~16	NW	Best Western Gallup - room

NW
12-6-16

Reviewed by:

Review Date: 11-29-16

Appendix B Exposure Rate Measurements

Date and Time	Exposure Rate (mR/h)	Location
11/18/2016 10:22	0.0549	Correlation Location 1
11/18/2016 10:22	0.0967	Correlation Location 1
11/18/2016 10:22	0.0855	Correlation Location 1
11/18/2016 10:22	0.0603	Correlation Location 1
11/18/2016 10:22	0.0413	Correlation Location 1
11/18/2016 10:22	0.0297	Correlation Location 1
11/18/2016 10:22	0.0235	Correlation Location 1
11/18/2016 10:22	0.0204	Correlation Location 1
11/18/2016 10:22	0.0189	Correlation Location 1
11/18/2016 10:22	0.0182	Correlation Location 1
11/18/2016 10:23	0.018	Correlation Location 1
11/18/2016 10:23	0.0179	Correlation Location 1
11/18/2016 10:23	0.0182	Correlation Location 1
11/18/2016 10:23	0.0182	Correlation Location 1
11/18/2016 10:23	0.0179	Correlation Location 1
11/18/2016 10:23	0.0177	Correlation Location 1
11/18/2016 10:23	0.0173	Correlation Location 1
11/18/2016 10:23	0.017	Correlation Location 1
11/18/2016 10:23	0.0168	Correlation Location 1
11/18/2016 10:23	0.017	Correlation Location 1
11/18/2016 10:24	0.017	Correlation Location 1
11/18/2016 10:24	0.0168	Correlation Location 1
11/18/2016 10:24	0.0166	Correlation Location 1
11/18/2016 10:24	0.0167	Correlation Location 1
11/18/2016 10:24	0.017	Correlation Location 1
11/18/2016 10:24	0.017	Correlation Location 1
11/18/2016 10:24	0.017	Correlation Location 1
11/18/2016 10:24	0.0174	Correlation Location 1
11/18/2016 10:24	0.0176	Correlation Location 1
11/18/2016 10:24	0.0177	Correlation Location 1
11/18/2016 10:25	0.0177	Correlation Location 1
11/18/2016 10:25	0.0173	Correlation Location 1
11/18/2016 10:25	0.0173	Correlation Location 1
11/18/2016 10:25	0.0178	Correlation Location 1
11/18/2016 10:25	0.0175	Correlation Location 1
11/18/2016 10:25	0.0172	Correlation Location 1
11/18/2016 10:25	0.0172	Correlation Location 1
11/18/2016 10:25	0.017	Correlation Location 1
11/18/2016 10:25	0.017	Correlation Location 1
11/18/2016 10:25	0.0172	Correlation Location 1
11/18/2016 10:26	0.0179	Correlation Location 1
11/18/2016 10:26	0.0177	Correlation Location 1
11/18/2016 10:26	0.0169	Correlation Location 1
11/18/2016 10:26	0.0163	Correlation Location 1
11/18/2016 10:26	0.0165	Correlation Location 1
11/18/2016 10:26	0.0166	Correlation Location 1
11/18/2016 10:26	0.0166	Correlation Location 1
11/18/2016 10:26	0.0168	Correlation Location 1
11/18/2016 10:26	0.0173	Correlation Location 1
11/18/2016 10:26	0.0173	Correlation Location 1
11/18/2016 10:27	0.0169	Correlation Location 1
11/18/2016 10:27	0.017	Correlation Location 1
11/18/2016 10:27	0.0177	Correlation Location 1
11/18/2016 10:27	0.018	Correlation Location 1
11/18/2016 10:27	0.018	Correlation Location 1
11/18/2016 10:27	0.018	Correlation Location 1
11/18/2016 10:27	0.0182	Correlation Location 1
11/18/2016 10:27	0.0179	Correlation Location 1
11/18/2016 10:27	0.0176	Correlation Location 1
11/18/2016 10:27	0.0176	Correlation Location 1
11/18/2016 10:28	0.018	Correlation Location 1
11/18/2016 10:28	0.018	Correlation Location 1
11/18/2016 10:28	0.0176	Correlation Location 1
11/18/2016 10:28	0.018	Correlation Location 1
11/18/2016 10:28	0.0182	Correlation Location 1
11/18/2016 10:28	0.0178	Correlation Location 1
11/18/2016 10:28	0.0168	Correlation Location 1
11/18/2016 10:28	0.0162	Correlation Location 1
11/18/2016 10:28	0.0158	Correlation Location 1
11/18/2016 10:28	0.0164	Correlation Location 1
11/18/2016 10:29	0.0168	Correlation Location 1
11/18/2016 10:29	0.0169	Correlation Location 1
11/18/2016 10:29	0.017	Correlation Location 1
11/18/2016 10:29	0.0175	Correlation Location 1
11/18/2016 10:29	0.0178	Correlation Location 1
11/18/2016 10:29	0.0178	Correlation Location 1
11/18/2016 10:29	0.0175	Correlation Location 1
11/18/2016 10:29	0.0173	Correlation Location 1
11/18/2016 10:29	0.0169	Correlation Location 1
11/18/2016 10:29	0.0168	Correlation Location 1
11/18/2016 10:30	0.017	Correlation Location 1
11/18/2016 10:30	0.017	Correlation Location 1
11/18/2016 10:30	0.0176	Correlation Location 1
11/18/2016 10:30	0.0177	Correlation Location 1
11/18/2016 10:30	0.0172	Correlation Location 1
11/18/2016 10:30	0.0168	Correlation Location 1
11/18/2016 10:30	0.0166	Correlation Location 1
11/18/2016 10:30	0.0169	Correlation Location 1
11/18/2016 10:30	0.0176	Correlation Location 1
11/18/2016 10:30	0.0177	Correlation Location 1
11/18/2016 10:31	0.0179	Correlation Location 1
11/18/2016 10:31	0.0177	Correlation Location 1
11/18/2016 10:31	0.0174	Correlation Location 1
11/18/2016 10:31	0.0178	Correlation Location 1
11/18/2016 10:31	0.018	Correlation Location 1
11/18/2016 10:31	0.0179	Correlation Location 1
11/18/2016 10:31	0.0176	Correlation Location 1
11/18/2016 10:31	0.0173	Correlation Location 1
11/18/2016 10:31	0.0172	Correlation Location 1
11/18/2016 10:31	0.017	Correlation Location 1
11/18/2016 10:32	0.017	Correlation Location 1
11/18/2016 10:32	0.017	Correlation Location 1
11/18/2016 10:32	0.0168	Correlation Location 1
11/18/2016 10:32	0.017	Correlation Location 1
11/18/2016 10:32	0.017	Correlation Location 1
11/18/2016 10:32	0.017	Correlation Location 1
11/18/2016 10:32	0.0173	Correlation Location 1
11/18/2016 10:32	0.0173	Correlation Location 1
11/18/2016 10:32	0.0173	Correlation Location 1
11/18/2016 10:53	0.0564	Correlation Location 2
11/18/2016 10:54	0.0998	Correlation Location 2
11/18/2016 10:54	0.09	Correlation Location 2

Date and Time	Exposure Rate (mR/h)	Location
11/18/2016 10:54	0.0653	Correlation Location 2
11/18/2016 10:54	0.0461	Correlation Location 2
11/18/2016 10:54	0.0346	Correlation Location 2
11/18/2016 10:54	0.0284	Correlation Location 2
11/18/2016 10:54	0.0256	Correlation Location 2
11/18/2016 10:54	0.0244	Correlation Location 2
11/18/2016 10:54	0.0234	Correlation Location 2
11/18/2016 10:54	0.0223	Correlation Location 2
11/18/2016 10:55	0.0213	Correlation Location 2
11/18/2016 10:55	0.0206	Correlation Location 2
11/18/2016 10:55	0.0202	Correlation Location 2
11/18/2016 10:55	0.0208	Correlation Location 2
11/18/2016 10:55	0.0211	Correlation Location 2
11/18/2016 10:55	0.0216	Correlation Location 2
11/18/2016 10:55	0.0217	Correlation Location 2
11/18/2016 10:55	0.0221	Correlation Location 2
11/18/2016 10:55	0.0223	Correlation Location 2
11/18/2016 10:55	0.0223	Correlation Location 2
11/18/2016 10:56	0.0217	Correlation Location 2
11/18/2016 10:56	0.0211	Correlation Location 2
11/18/2016 10:56	0.021	Correlation Location 2
11/18/2016 10:56	0.0213	Correlation Location 2
11/18/2016 10:56	0.0211	Correlation Location 2
11/18/2016 10:56	0.0211	Correlation Location 2
11/18/2016 10:56	0.0215	Correlation Location 2
11/18/2016 10:56	0.0215	Correlation Location 2
11/18/2016 10:56	0.0213	Correlation Location 2
11/18/2016 10:56	0.021	Correlation Location 2
11/18/2016 10:57	0.0208	Correlation Location 2
11/18/2016 10:57	0.0207	Correlation Location 2
11/18/2016 10:57	0.021	Correlation Location 2
11/18/2016 10:57	0.0213	Correlation Location 2
11/18/2016 10:57	0.0211	Correlation Location 2
11/18/2016 10:57	0.0209	Correlation Location 2
11/18/2016 10:57	0.021	Correlation Location 2
11/18/2016 10:57	0.0211	Correlation Location 2
11/18/2016 10:57	0.0213	Correlation Location 2
11/18/2016 10:57	0.0216	Correlation Location 2
11/18/2016 10:58	0.0217	Correlation Location 2
11/18/2016 10:58	0.0222	Correlation Location 2
11/18/2016 10:58	0.0219	Correlation Location 2
11/18/2016 10:58	0.022	Correlation Location 2
11/18/2016 10:58	0.023	Correlation Location 2
11/18/2016 10:58	0.0229	Correlation Location 2
11/18/2016 10:58	0.0227	Correlation Location 2
11/18/2016 10:58	0.0225	Correlation Location 2
11/18/2016 10:58	0.0223	Correlation Location 2
11/18/2016 10:58	0.0223	Correlation Location 2
11/18/2016 10:59	0.022	Correlation Location 2
11/18/2016 10:59	0.0217	Correlation Location 2
11/18/2016 10:59	0.0218	Correlation Location 2
11/18/2016 10:59	0.0219	Correlation Location 2
11/18/2016 10:59	0.0221	Correlation Location 2
11/18/2016 10:59	0.0218	Correlation Location 2
11/18/2016 10:59	0.0219	Correlation Location 2
11/18/2016 10:59	0.0225	Correlation Location 2
11/18/2016 10:59	0.0227	Correlation Location 2
11/18/2016 10:59	0.0223	Correlation Location 2
11/18/2016 11:00	0.0217	Correlation Location 2
11/18/2016 11:00	0.0217	Correlation Location 2
11/18/2016 11:00	0.0222	Correlation Location 2
11/18/2016 11:00	0.0223	Correlation Location 2
11/18/2016 11:00	0.0221	Correlation Location 2
11/18/2016 11:00	0.0219	Correlation Location 2
11/18/2016 11:00	0.0219	Correlation Location 2
11/18/2016 11:00	0.0223	Correlation Location 2
11/18/2016 11:00	0.0221	Correlation Location 2
11/18/2016 11:00	0.0213	Correlation Location 2
11/18/2016 11:01	0.021	Correlation Location 2
11/18/2016 11:01	0.0211	Correlation Location 2
11/18/2016 11:01	0.0213	Correlation Location 2
11/18/2016 11:01	0.0211	Correlation Location 2
11/18/2016 11:01	0.021	Correlation Location 2
11/18/2016 11:01	0.0211	Correlation Location 2
11/18/2016 11:01	0.0216	Correlation Location 2
11/18/2016 11:01	0.0219	Correlation Location 2
11/18/2016 11:01	0.0216	Correlation Location 2
11/18/2016 11:01	0.0211	Correlation Location 2
11/18/2016 11:02	0.0211	Correlation Location 2
11/18/2016 11:02	0.0216	Correlation Location 2
11/18/2016 11:02	0.0218	Correlation Location 2
11/18/2016 11:02	0.022	Correlation Location 2
11/18/2016 11:02	0.0216	Correlation Location 2
11/18/2016 11:02	0.0216	Correlation Location 2
11/18/2016 11:02	0.0216	Correlation Location 2
11/18/2016 11:02	0.0218	Correlation Location 2
11/18/2016 11:02	0.0216	Correlation Location 2
11/18/2016 11:02	0.0216	Correlation Location 2
11/18/2016 11:03	0.0213	Correlation Location 2
11/18/2016 11:03	0.0219	Correlation Location 2
11/18/2016 11:03	0.0221	Correlation Location 2
11/18/2016 11:03	0.0219	Correlation Location 2
11/18/2016 11:03	0.0218	Correlation Location 2
11/18/2016 11:03	0.0218	Correlation Location 2
11/18/2016 11:03	0.0213	Correlation Location 2
11/18/2016 11:03	0.0213	Correlation Location 2
11/18/2016 11:03	0.0215	Correlation Location 2
11/18/2016 11:03	0.0213	Correlation Location 2
11/18/2016 11:04	0.0217	Correlation Location 2
11/18/2016 11:04	0.0219	Correlation Location 2
11/18/2016 11:04	0.0219	Correlation Location 2
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11/18/2016 11:04	0.0219	Correlation Location 2
11/18/2016 11:04	0.022	Correlation Location 2
11/18/2016 11:04	0.0223	Correlation Location 2
11/18/2016 11:22	0.058	Correlation Location 3
11/18/2016 11:22	0.104	Correlation Location 3
11/18/2016 11:22	0.0965	Correlation Location 3
11/18/2016 11:22	0.0727	Correlation Location 3
11/18/2016 11:22	0.0545	Correlation Location 3
11/18/2016 11:23	0.0433	Correlation Location 3
11/18/2016 11:23	0.0375	Correlation Location 3

Date and Time	Exposure Rate (mR/h)	Location
11/18/2016 11:23	0.0341	Correlation Location 3
11/18/2016 11:23	0.0326	Correlation Location 3
11/18/2016 11:23	0.0317	Correlation Location 3
11/18/2016 11:23	0.0313	Correlation Location 3
11/18/2016 11:23	0.0312	Correlation Location 3
11/18/2016 11:23	0.0311	Correlation Location 3
11/18/2016 11:23	0.0309	Correlation Location 3
11/18/2016 11:23	0.0306	Correlation Location 3
11/18/2016 11:24	0.0304	Correlation Location 3
11/18/2016 11:24	0.0305	Correlation Location 3
11/18/2016 11:24	0.0312	Correlation Location 3
11/18/2016 11:24	0.0317	Correlation Location 3
11/18/2016 11:24	0.0322	Correlation Location 3
11/18/2016 11:24	0.0322	Correlation Location 3
11/18/2016 11:24	0.0319	Correlation Location 3
11/18/2016 11:24	0.0319	Correlation Location 3
11/18/2016 11:24	0.0322	Correlation Location 3
11/18/2016 11:24	0.0319	Correlation Location 3
11/18/2016 11:25	0.0313	Correlation Location 3
11/18/2016 11:25	0.031	Correlation Location 3
11/18/2016 11:25	0.0308	Correlation Location 3
11/18/2016 11:25	0.0308	Correlation Location 3
11/18/2016 11:25	0.0306	Correlation Location 3
11/18/2016 11:25	0.0308	Correlation Location 3
11/18/2016 11:25	0.0309	Correlation Location 3
11/18/2016 11:25	0.0309	Correlation Location 3
11/18/2016 11:25	0.0311	Correlation Location 3
11/18/2016 11:25	0.031	Correlation Location 3
11/18/2016 11:26	0.031	Correlation Location 3
11/18/2016 11:26	0.0312	Correlation Location 3
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11/18/2016 11:26	0.0309	Correlation Location 3
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11/18/2016 11:26	0.031	Correlation Location 3
11/18/2016 11:26	0.0309	Correlation Location 3
11/18/2016 11:27	0.0305	Correlation Location 3
11/18/2016 11:27	0.0302	Correlation Location 3
11/18/2016 11:27	0.0304	Correlation Location 3
11/18/2016 11:27	0.0306	Correlation Location 3
11/18/2016 11:27	0.0305	Correlation Location 3
11/18/2016 11:27	0.0305	Correlation Location 3
11/18/2016 11:27	0.0308	Correlation Location 3
11/18/2016 11:27	0.0317	Correlation Location 3
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11/18/2016 11:27	0.031	Correlation Location 3
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11/18/2016 11:28	0.0307	Correlation Location 3
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11/18/2016 11:29	0.0317	Correlation Location 3
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11/18/2016 11:29	0.0312	Correlation Location 3
11/18/2016 11:29	0.0319	Correlation Location 3
11/18/2016 11:29	0.0319	Correlation Location 3
11/18/2016 11:29	0.0316	Correlation Location 3
11/18/2016 11:29	0.0311	Correlation Location 3
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11/18/2016 11:30	0.0302	Correlation Location 3
11/18/2016 11:30	0.0304	Correlation Location 3
11/18/2016 11:30	0.0309	Correlation Location 3
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11/18/2016 11:31	0.0306	Correlation Location 3
11/18/2016 11:31	0.0311	Correlation Location 3
11/18/2016 11:31	0.0312	Correlation Location 3
11/18/2016 11:31	0.0309	Correlation Location 3
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11/18/2016 11:32	0.0313	Correlation Location 3
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11/18/2016 11:32	0.0302	Correlation Location 3
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11/18/2016 11:58	0.0169	Correlation Location 4
11/18/2016 11:58	0.0164	Correlation Location 4

Date and Time	Exposure Rate (mR/h)	Location
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11/18/2016 11:58	0.015	Correlation Location 4
11/18/2016 11:58	0.015	Correlation Location 4
11/18/2016 11:58	0.0148	Correlation Location 4
11/18/2016 11:59	0.0146	Correlation Location 4
11/18/2016 11:59	0.0147	Correlation Location 4
11/18/2016 11:59	0.0149	Correlation Location 4
11/18/2016 11:59	0.0151	Correlation Location 4
11/18/2016 11:59	0.0152	Correlation Location 4
11/18/2016 11:59	0.0155	Correlation Location 4
11/18/2016 11:59	0.0154	Correlation Location 4
11/18/2016 11:59	0.0152	Correlation Location 4
11/18/2016 11:59	0.0151	Correlation Location 4
11/18/2016 11:59	0.0151	Correlation Location 4
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11/18/2016 12:00	0.0156	Correlation Location 4
11/18/2016 12:00	0.0156	Correlation Location 4
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11/18/2016 12:00	0.0155	Correlation Location 4
11/18/2016 12:00	0.0155	Correlation Location 4
11/18/2016 12:00	0.0151	Correlation Location 4
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11/18/2016 12:00	0.0149	Correlation Location 4
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11/18/2016 12:01	0.0142	Correlation Location 4
11/18/2016 12:01	0.0143	Correlation Location 4
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11/18/2016 12:03	0.0158	Correlation Location 4
11/18/2016 12:03	0.0158	Correlation Location 4
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11/18/2016 12:03	0.015	Correlation Location 4
11/18/2016 12:03	0.0154	Correlation Location 4
11/18/2016 12:03	0.0156	Correlation Location 4
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11/18/2016 12:04	0.0149	Correlation Location 4
11/18/2016 12:04	0.0149	Correlation Location 4
11/18/2016 12:04	0.0147	Correlation Location 4
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11/18/2016 12:06	0.0155	Correlation Location 4
11/18/2016 12:06	0.0155	Correlation Location 4
11/18/2016 12:06	0.0156	Correlation Location 4
11/18/2016 12:06	0.0154	Correlation Location 4
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11/18/2016 12:06	0.0144	Correlation Location 4
11/18/2016 12:07	0.0145	Correlation Location 4
11/18/2016 12:07	0.0148	Correlation Location 4
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Date and Time	Exposure Rate (mR/h)	Location
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11/18/2016 12:33	0.0137	Correlation Location 5
11/18/2016 12:33	0.0141	Correlation Location 5
11/18/2016 12:33	0.014	Correlation Location 5
11/18/2016 12:33	0.0135	Correlation Location 5
11/18/2016 12:33	0.0132	Correlation Location 5
11/18/2016 12:33	0.0132	Correlation Location 5
11/18/2016 12:33	0.0136	Correlation Location 5
11/18/2016 12:33	0.0133	Correlation Location 5
11/18/2016 12:34	0.0131	Correlation Location 5
11/18/2016 12:34	0.0129	Correlation Location 5
11/18/2016 12:34	0.0127	Correlation Location 5
11/18/2016 12:34	0.0129	Correlation Location 5
11/18/2016 12:34	0.0137	Correlation Location 5
11/18/2016 12:34	0.0141	Correlation Location 5
11/18/2016 12:34	0.0137	Correlation Location 5
11/18/2016 12:34	0.0134	Correlation Location 5
11/18/2016 12:34	0.0131	Correlation Location 5
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11/18/2016 12:35	0.0127	Correlation Location 5
11/18/2016 12:35	0.0131	Correlation Location 5
11/18/2016 12:35	0.0136	Correlation Location 5
11/18/2016 12:35	0.0137	Correlation Location 5
11/18/2016 12:35	0.0133	Correlation Location 5
11/18/2016 12:35	0.0134	Correlation Location 5
11/18/2016 12:35	0.0132	Correlation Location 5
11/18/2016 12:35	0.0132	Correlation Location 5
11/18/2016 12:35	0.0137	Correlation Location 5
11/18/2016 12:35	0.0137	Correlation Location 5
11/18/2016 12:36	0.0135	Correlation Location 5
11/18/2016 12:36	0.0135	Correlation Location 5
11/18/2016 12:36	0.0137	Correlation Location 5
11/18/2016 12:36	0.0137	Correlation Location 5
11/18/2016 12:36	0.0134	Correlation Location 5
11/18/2016 12:36	0.0132	Correlation Location 5
11/18/2016 12:36	0.013	Correlation Location 5
11/18/2016 12:36	0.0134	Correlation Location 5
11/18/2016 12:36	0.0134	Correlation Location 5
11/18/2016 12:36	0.0133	Correlation Location 5
11/18/2016 12:37	0.0134	Correlation Location 5
11/18/2016 12:37	0.0132	Correlation Location 5
11/18/2016 12:37	0.0136	Correlation Location 5
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11/18/2016 12:37	0.0142	Correlation Location 5
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11/18/2016 12:38	0.014	Correlation Location 5
11/18/2016 12:38	0.0143	Correlation Location 5
11/18/2016 12:38	0.0141	Correlation Location 5
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11/18/2016 12:38	0.0134	Correlation Location 5
11/18/2016 12:38	0.0139	Correlation Location 5
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11/18/2016 12:39	0.0143	Correlation Location 5
11/18/2016 12:39	0.0137	Correlation Location 5
11/18/2016 12:39	0.0133	Correlation Location 5
11/18/2016 12:39	0.013	Correlation Location 5
11/18/2016 12:39	0.013	Correlation Location 5
11/18/2016 12:39	0.0131	Correlation Location 5
11/18/2016 12:39	0.0134	Correlation Location 5
11/18/2016 12:39	0.0138	Correlation Location 5
11/18/2016 12:39	0.014	Correlation Location 5
11/18/2016 12:40	0.0138	Correlation Location 5
11/18/2016 12:40	0.0141	Correlation Location 5
11/18/2016 12:40	0.014	Correlation Location 5
11/18/2016 12:40	0.0137	Correlation Location 5
11/18/2016 12:40	0.0137	Correlation Location 5
11/18/2016 12:40	0.0137	Correlation Location 5
11/18/2016 12:40	0.0137	Correlation Location 5
11/18/2016 12:40	0.0136	Correlation Location 5
11/18/2016 12:40	0.0137	Correlation Location 5
11/18/2016 12:40	0.0139	Correlation Location 5
11/18/2016 12:41	0.0136	Correlation Location 5
11/18/2016 12:41	0.0135	Correlation Location 5
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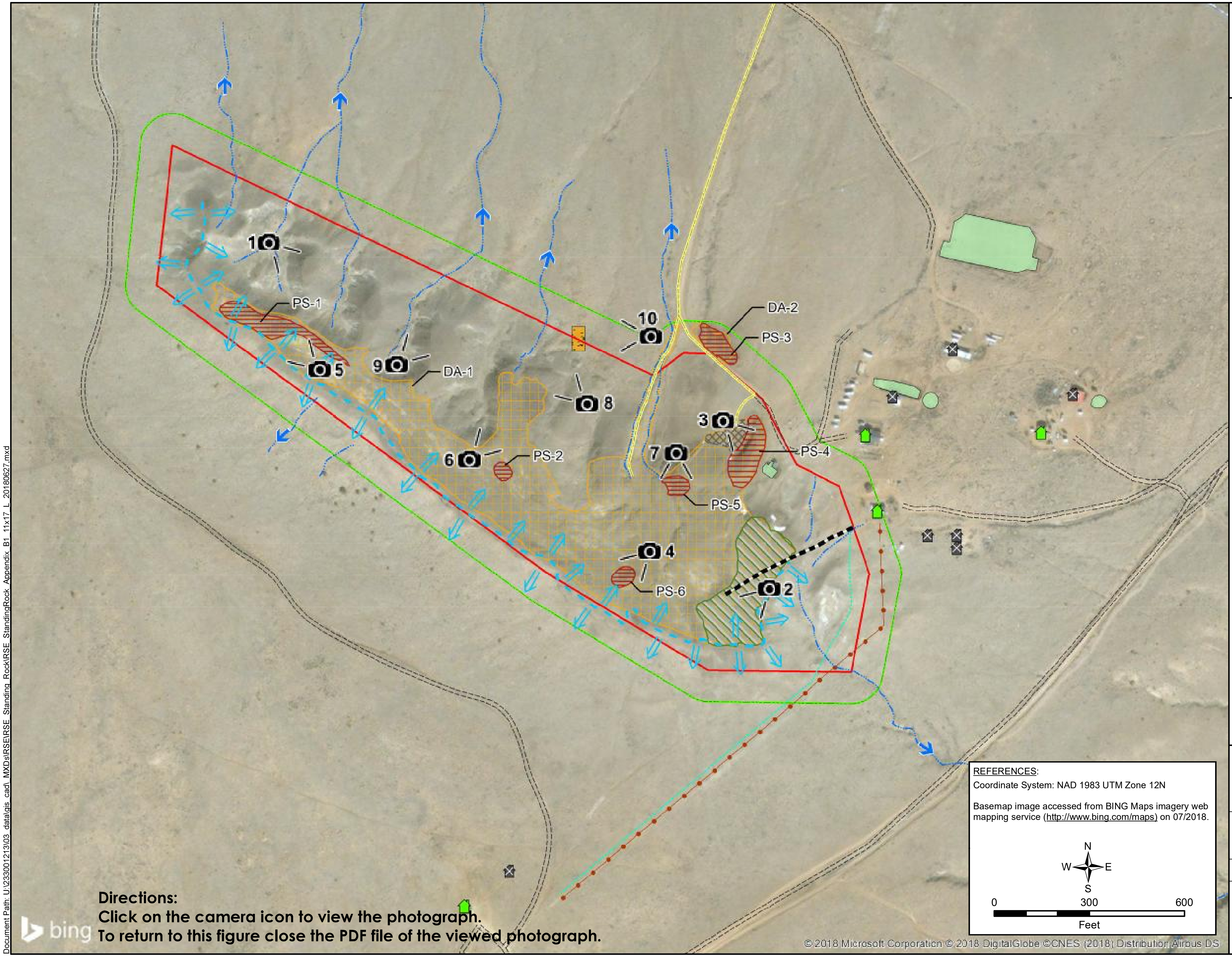
11/18/2016 12:41	0.0142	Correlation Location 5
11/18/2016 12:41	0.0141	Correlation Location 5
11/18/2016 12:41	0.0138	Correlation Location 5
11/18/2016 12:41	0.0135	Correlation Location 5
11/18/2016 12:41	0.0131	Correlation Location 5
11/18/2016 12:41	0.0131	Correlation Location 5
11/18/2016 12:41	0.0129	Correlation Location 5
11/18/2016 12:42	0.0131	Correlation Location 5
11/18/2016 12:42	0.0136	Correlation Location 5
11/18/2016 12:42	0.0135	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.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 07/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

📷	Photograph Indicating Direction Taken
🟩	Habitable Building
☒	Uninhabitable Building
↑	Flow Direction
⇑	Approximate Overland Water Flow Direction
- - -	Approximate Watershed Divide Line
-·-·-	Drainage
——	Potential Haul Road
-●-●-	Powerline
······	Water Line
■■■■	Potential Road
=====	Road
🟩	Corral
▩	Excavation
▨	Graded Potential Grazing Area
🟧	Scattered Debris
🟥	Potential Stockpile
▦	Disturbed Area
☐	Claim Boundary
☐	100-Foot Claim Buffer

TITLE:
Site Photographs

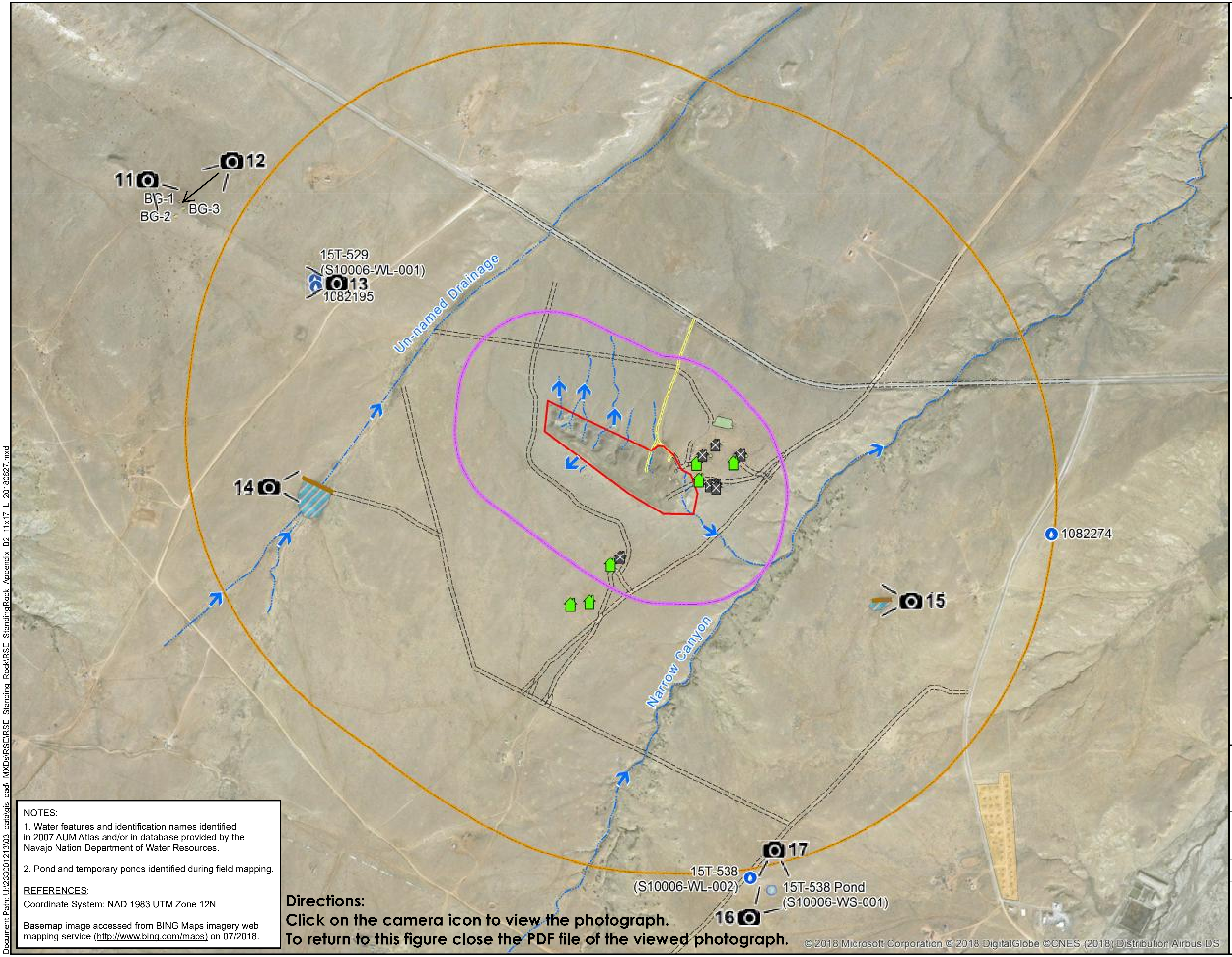
PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 7/24/2018
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB
REVIEWER: EDZ
FIGURE: B-1

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Standing Rock\RSE StandingRock Appendix B1 11x17 L 20180627.mxd



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

2. Pond and temporary ponds identified during field mapping.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 07/2018.

Directions:
Click on the camera icon to view the photograph.
To return to this figure close the PDF file of the viewed photograph.

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Standing_Rock\RSE_StandingRock_Appendix_B2_11x17_L_20180627.mxd

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

- Photograph Indicating Direction Taken
- Site Clearance Identified Water Feature[1]
- Habitable Building
- Uninhabitable Building
- Flow Direction
- Drainage
- Earthen Dam
- Potential Haul Road
- Road
- Residential Area
- Corral
- Pond[2]
- Potential Background Reference Area (BG-1)
- Temporary Pond[2]
- Claim Boundary
- 1/4-Mile Claim Boundary Buffer
- 1-Mile Claim Boundary Buffer

N
W E
S

0 1,400 2,800
Feet

TITLE:
Regional Site Photographs

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 7/24/2018	DOCUMENT NAME: Removal Site Evaluation Report
	AUTHOR: CBB
	REVIEWER: EDZ
Stantec	FIGURE: B-2

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 Stanley Rock (S10006)

SAMPLE I.D. S10006-BG1-001, 201

SAMPLE COLLECTION DATE 3/24/17

SAMPLE COLLECTION TIME 1440

SAMPLE COLLECTED BY KJ

WEATHER CONDITIONS 40-60°F, Sunny, 15% gravels, dry, med brown

FIELD USCS DESCRIPTIONS Fine silty sand

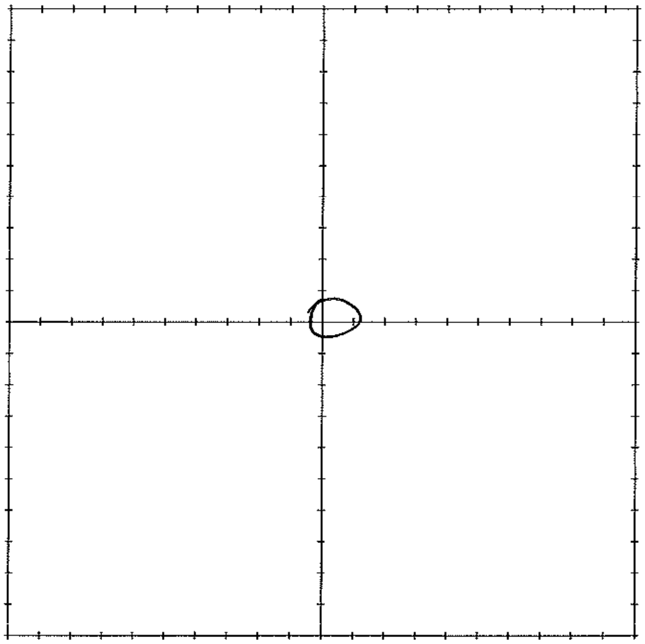
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals, Isotopic thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock (S10006)

SAMPLE I.D. S10006-BG1-002

SAMPLE COLLECTION DATE 3/24/17

SAMPLE COLLECTION TIME 1455

SAMPLE COLLECTED BY KJ

WEATHER CONDITIONS 40-60°F, Sunny

FIELD USCS DESCRIPTIONS Fine silty sand, 20% gravel, dry, Med. brown

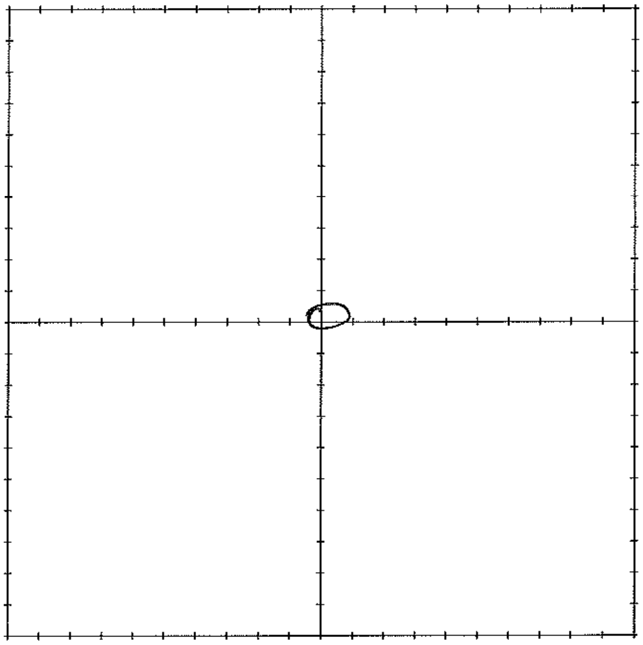
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals, Isotopic Thorium.



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock (S10006)

SAMPLE I.D. S10006-BG1-003

SAMPLE COLLECTION DATE 3/24/17

SAMPLE COLLECTION TIME 1510

SAMPLE COLLECTED BY KJ

WEATHER CONDITIONS 40-60° F, Sunny

FIELD USCS DESCRIPTIONS Sandy silt, med. brown, dry, 15% gravels

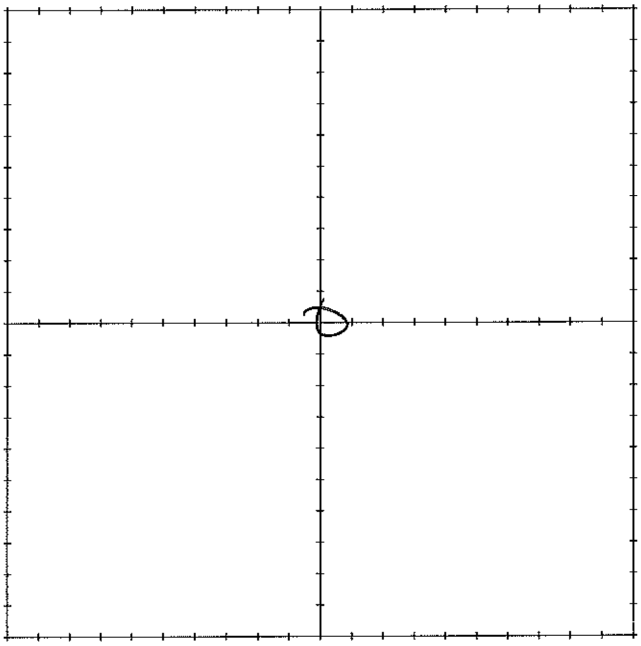
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Stanly Rock (S10006)

SAMPLE I.D. S10006-BG1-064

SAMPLE COLLECTION DATE 3/24/17

SAMPLE COLLECTION TIME 1512

SAMPLE COLLECTED BY KJ

WEATHER CONDITIONS 40-60°F, Sunny

FIELD USCS DESCRIPTIONS Sandy Silt, red. brown, dry, 15% gravel

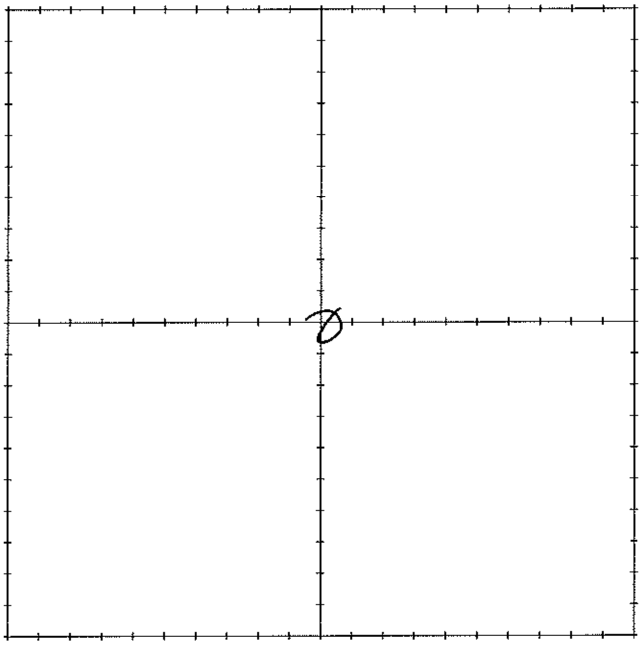
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) Ziploc

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock (SL0006)

SAMPLE I.D. SL0006-BG1-005

SAMPLE COLLECTION DATE 3/24/17

SAMPLE COLLECTION TIME 1520

SAMPLE COLLECTED BY KJ

WEATHER CONDITIONS 40-60°F, Sunny

FIELD USCS DESCRIPTIONS Fine silty sand, 20% gravel, dry, med. brown

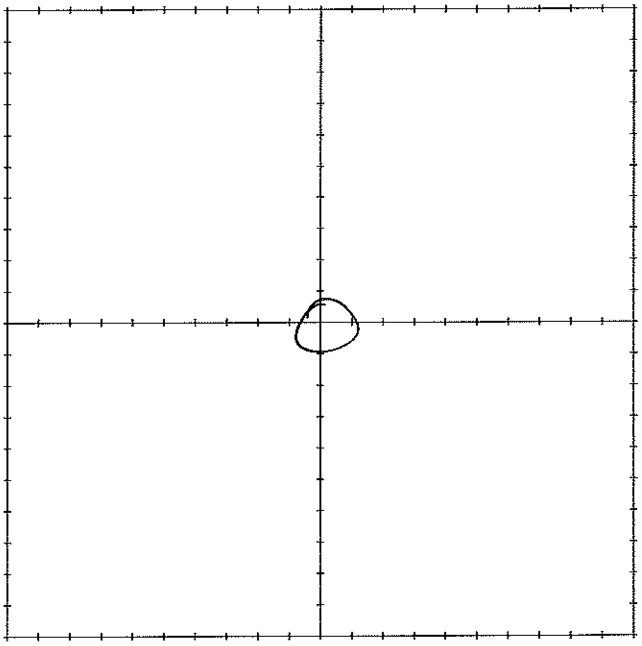
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock (S10006)

SAMPLE I.D. S10006-BG1-006

SAMPLE COLLECTION DATE 3/24/17

SAMPLE COLLECTION TIME 1526

SAMPLE COLLECTED BY KJ

WEATHER CONDITIONS 40°-60°F, Sunny

FIELD USCS DESCRIPTIONS Fine silty sand, 15% gravel, dry, med. brown, grains redder w/ depth

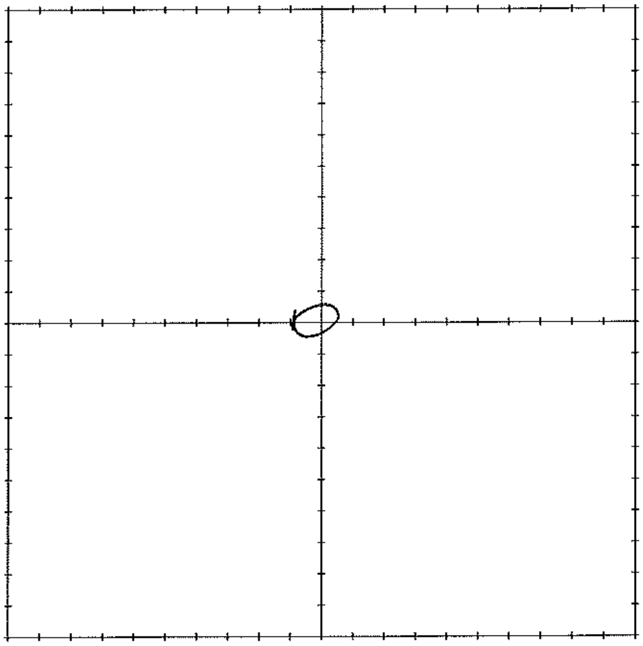
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock (S10006)

SAMPLE I.D. S10006-BG1-007

SAMPLE COLLECTION DATE 3/24/17

SAMPLE COLLECTION TIME 1530

SAMPLE COLLECTED BY KJ

WEATHER CONDITIONS 40°-60°F, Sunny

FIELD USCS DESCRIPTIONS Fine silty sand, 25% gravl, dry, med. brown

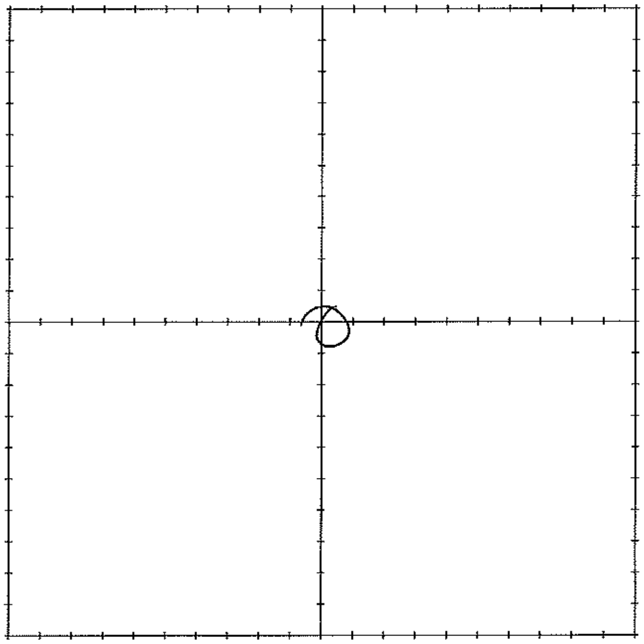
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Road (S10006)

SAMPLE I.D. S10006-BG1-008

SAMPLE COLLECTION DATE 3/24/17

SAMPLE COLLECTION TIME 1535

SAMPLE COLLECTED BY KJ

WEATHER CONDITIONS 40-60°F, Sunny

FIELD USCS DESCRIPTIONS Fine silty sand, 25% gravels, dry, med. brown

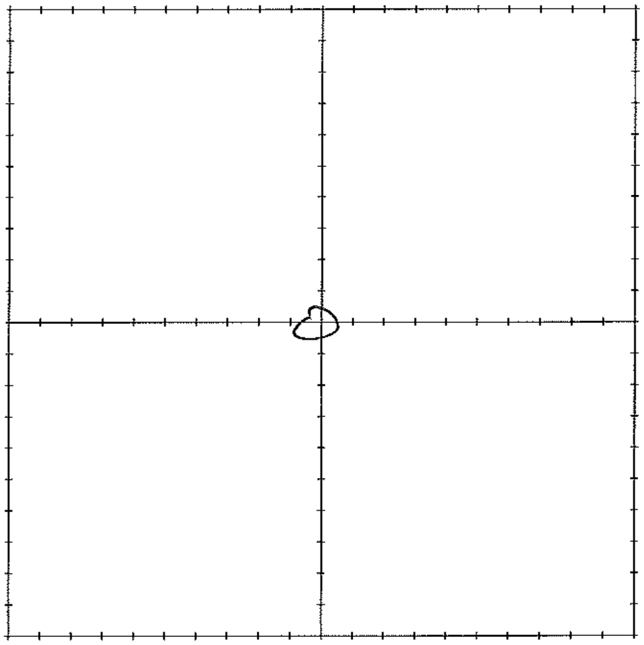
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Stanley Road (S10006)

SAMPLE I.D. S10006-BG1-009

SAMPLE COLLECTION DATE 3/24/17

SAMPLE COLLECTION TIME 1540

SAMPLE COLLECTED BY KJ

WEATHER CONDITIONS 40-60°F, Sunny

FIELD USCS DESCRIPTIONS Fine silty sand, ≈10% gravels, dry, med brown

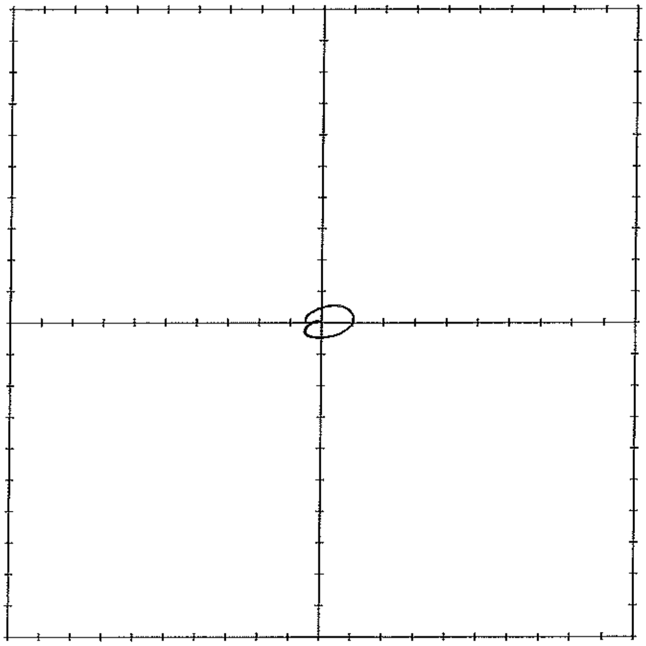
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock (S10006)

SAMPLE I.D. S10006-BG1-010

SAMPLE COLLECTION DATE 3/24/17

SAMPLE COLLECTION TIME 1550

SAMPLE COLLECTED BY KS

WEATHER CONDITIONS 40°-60°F, Sunny

FIELD USCS DESCRIPTIONS Fine silty sand, 15% gravel, dry, med. brown

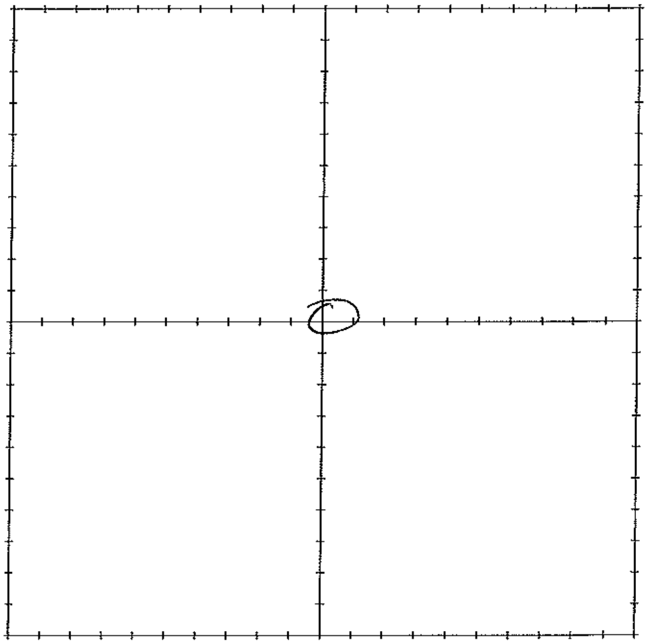
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock

SAMPLE I.D. 10006 - BG2 - 001

SAMPLE COLLECTION DATE 8/29/17

SAMPLE COLLECTION TIME 09:20

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 85 F

FIELD USCS DESCRIPTIONS (SP) poorly graded sand, Brown, Dry, loose 100% fine sand, Trace roots

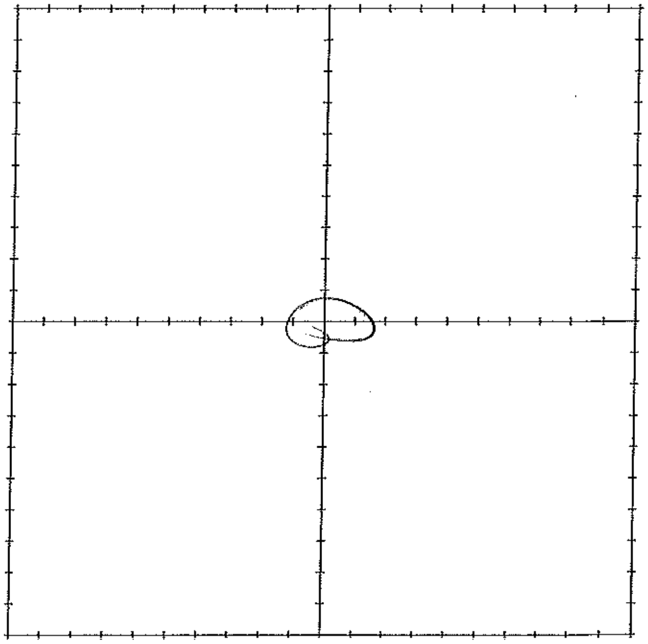
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock

SAMPLE I.D. S10006-B62-002

SAMPLE COLLECTION DATE 8/29/17

SAMPLE COLLECTION TIME 9:25

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny

FIELD USCS DESCRIPTIONS (SP) poorly graded sand. Brown, Dry loose, Fine sand with trace gravel. gravel is subrounded Dark brown quartzite

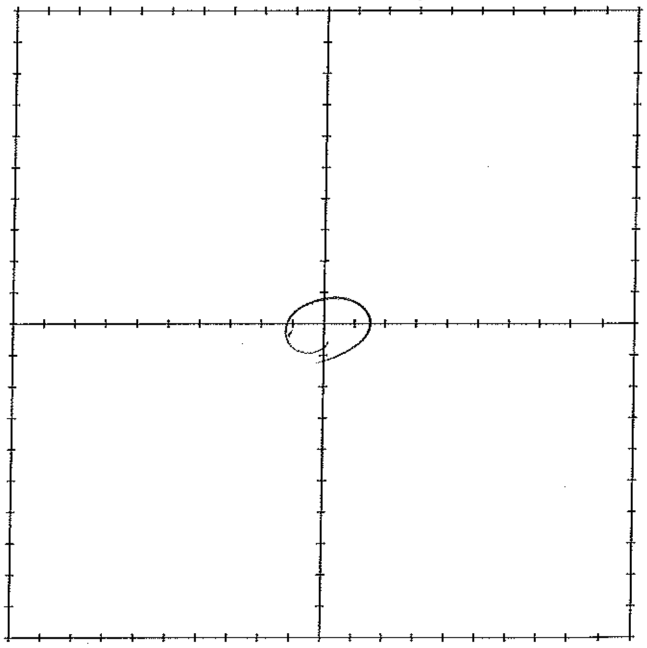
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 Standing Rock

SAMPLE I.D. S10006-3G2-003

SAMPLE COLLECTION DATE 8/29/17

SAMPLE COLLECTION TIME 09:40

SAMPLE COLLECTED BY AL

WEATHER CONDITIONS Sunny 85'F

FIELD USCS DESCRIPTIONS (SP) Poorly graded Sand. Brown, Dry, loose, Fine sand trace gravels Pale Brown subrounded

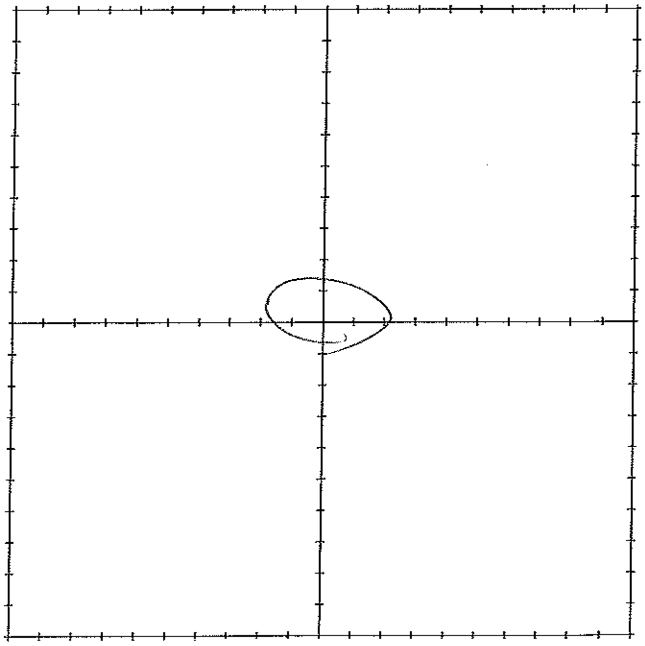
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 Standing Rock

SAMPLE I.D. S10066-BG2-004

SAMPLE COLLECTION DATE 8/29/17

SAMPLE COLLECTION TIME 0950

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS SUNNY 85°F

FIELD USCS DESCRIPTIONS (SP) poorly graded sand, Brown, Dry, loose, fine sand trace roots and gravels, gravels are subrounded Dark Brown Quartzite

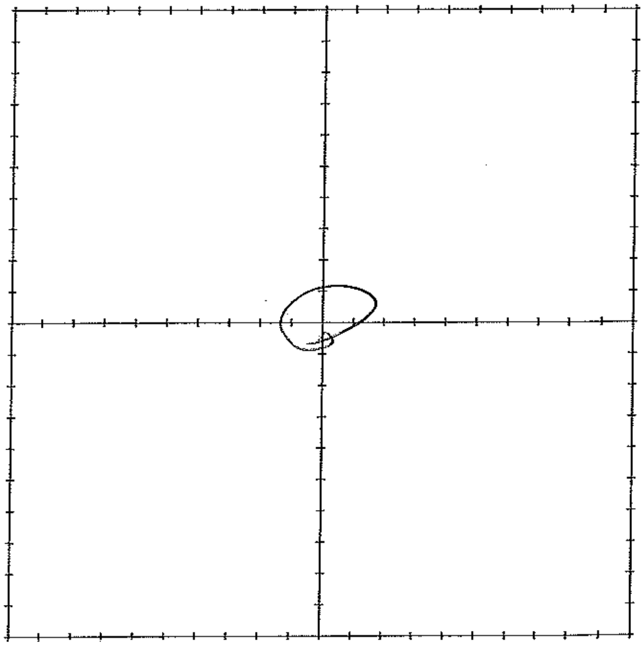
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock

SAMPLE I.D. S10006-BG2-005 (+MS, MSD)

SAMPLE COLLECTION DATE 8/29/17

SAMPLE COLLECTION TIME 1000

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS ~~(SP)~~ Sunny 85°F

FIELD USCS DESCRIPTIONS (SP) poorly graded sand, Brown, Dry, loose, fine sand, trace gravels, subrounded Dark Brown Quartzite

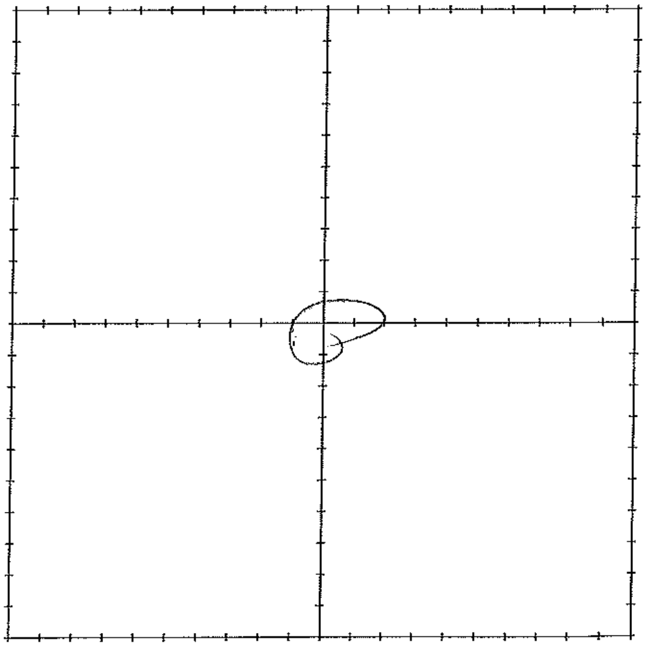
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 Standing Rock

SAMPLE I.D. S10006-BGZ-006

SAMPLE COLLECTION DATE 8/29/17

SAMPLE COLLECTION TIME 1010

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 85°F

FIELD USCS DESCRIPTIONS (SP)

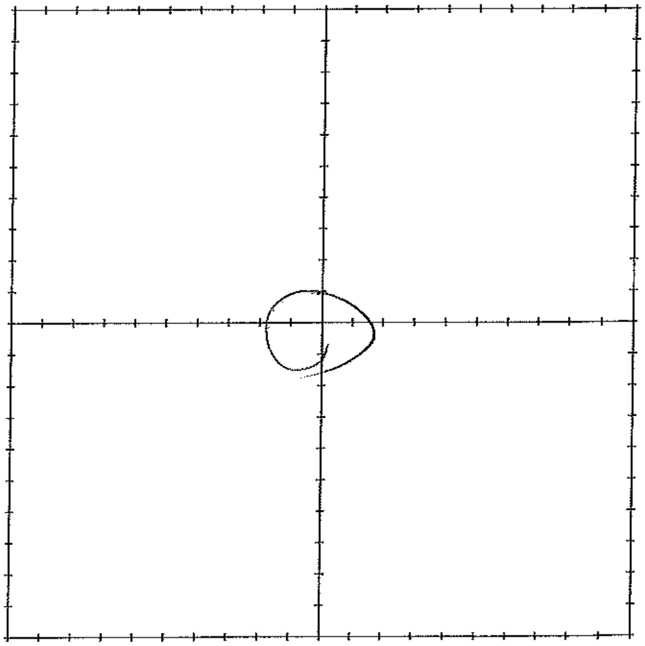
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE)

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock

SAMPLE I.D. S10006-BG2-0017

SAMPLE COLLECTION DATE 8/29/17

SAMPLE COLLECTION TIME 1020

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS (~~SP~~) Sunny 85°F

FIELD USCS DESCRIPTIONS (SP) Poorly graded sand, Brown, Dry, loose fine sand, Trace roots

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

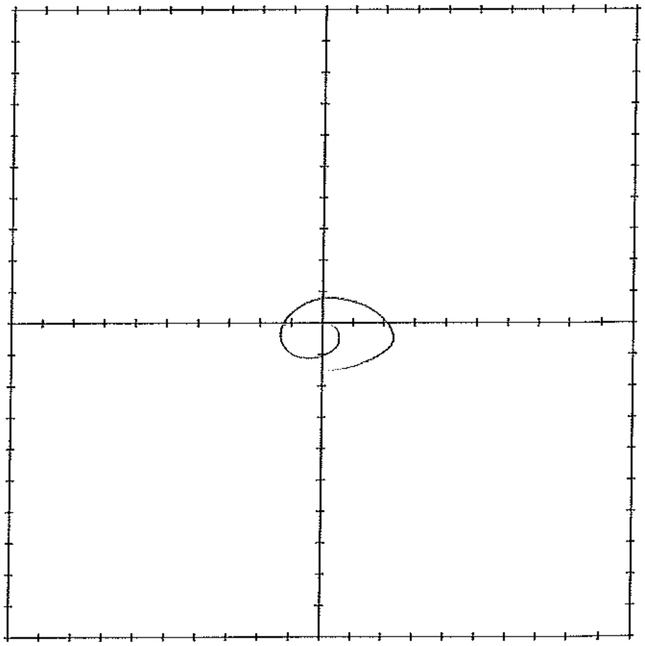
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 Standing Rock

SAMPLE I.D. SD006-BG2-008

SAMPLE COLLECTION DATE 8/29/17

SAMPLE COLLECTION TIME 1030

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS SUNNY 85°F

FIELD USCS DESCRIPTIONS (SP) poorly graded sand, Dry, loose, Brown, fine sand trace roots and subrounded gravels Quartzite

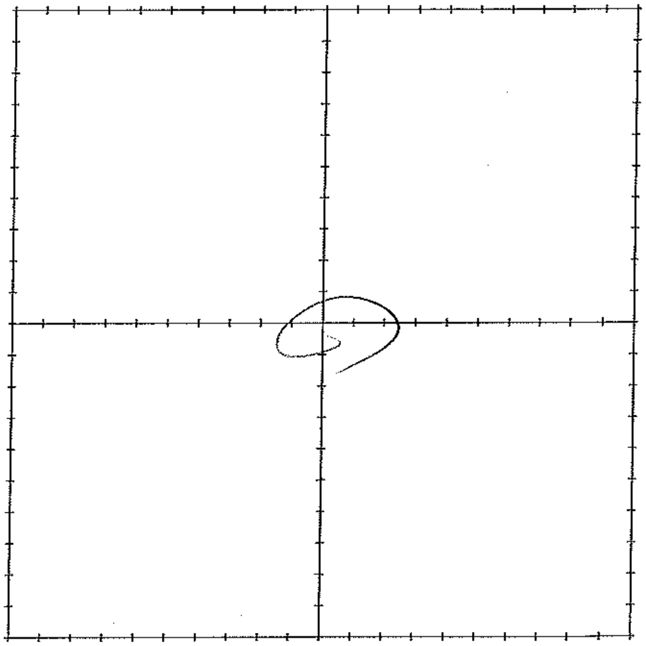
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplocs

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock

SAMPLE I.D. S10006-B62-009 (+ Duplicate)

SAMPLE COLLECTION DATE 8/29/17

SAMPLE COLLECTION TIME 1040

SAMPLE COLLECTED BY LL

WEATHER CONDITIONS ~~(SP)~~ Sunny 85 F

FIELD USCS DESCRIPTIONS (SP) poorly graded Sand, Brown, Dry loose, trace roots, Fine Sand

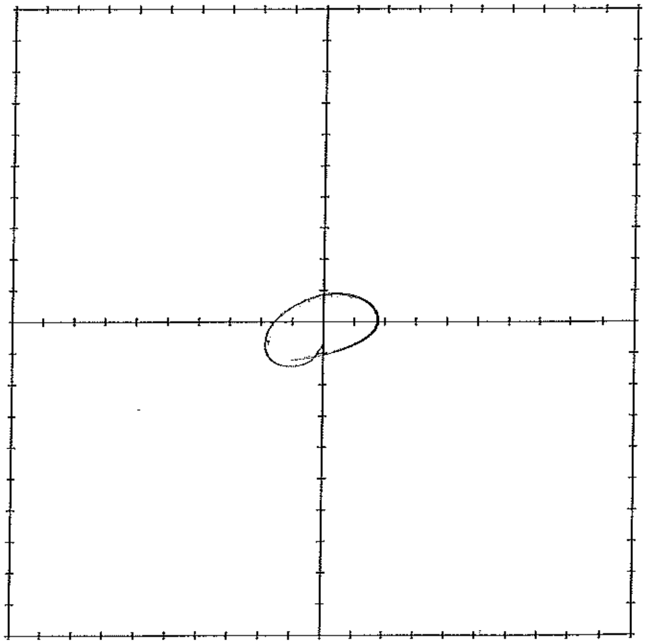
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplocks

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock

SAMPLE I.D. S10006-BG2-010

SAMPLE COLLECTION DATE 8/29/17

SAMPLE COLLECTION TIME 1050

SAMPLE COLLECTED BY ak

WEATHER CONDITIONS Sunny 85°F

FIELD USCS DESCRIPTIONS (SP) poorly graded Sand, Brown, Dry loose 100% Fine Sand

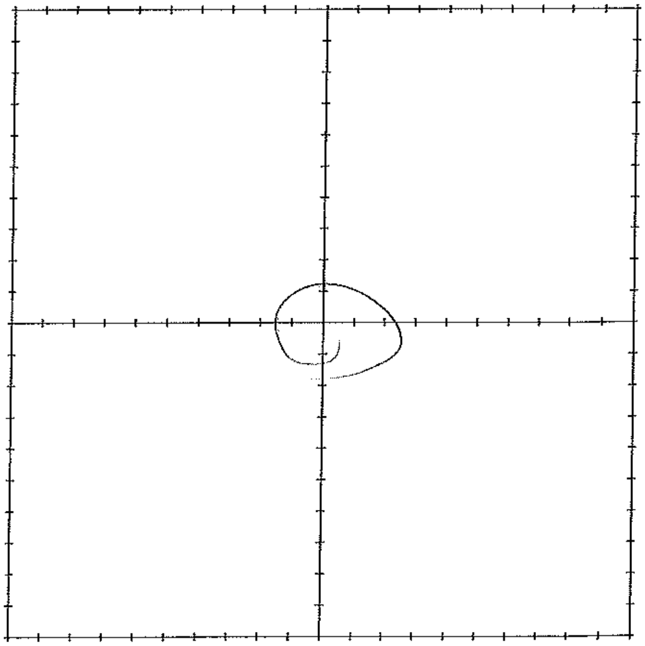
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplocks

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S10006 - C01 - 001 [Standing Rock]

SAMPLE I.D. S10006 - C01 - 001

SAMPLE COLLECTION DATE 11/18/2016

SAMPLE COLLECTION TIME 09:25

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS ~45° F, light breeze, Sunny

FIELD USCS DESCRIPTIONS Light brown, fine grained sand

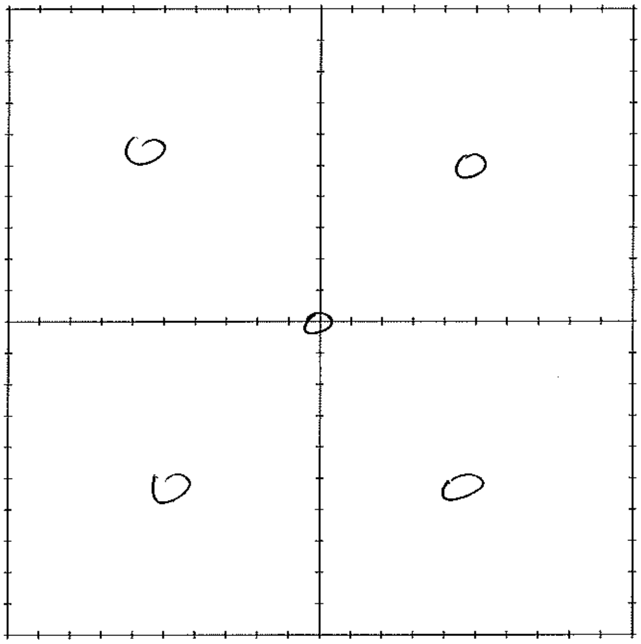
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 Ziplock

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S10006-C02-001 [Standing Rock]

SAMPLE I.D. S10006-C02-001

SAMPLE COLLECTION DATE 11/18/2016

SAMPLE COLLECTION TIME 09:50

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS ~45°F, light Breeze, Sunny

FIELD USCS DESCRIPTIONS Light brown, fine-grained sand

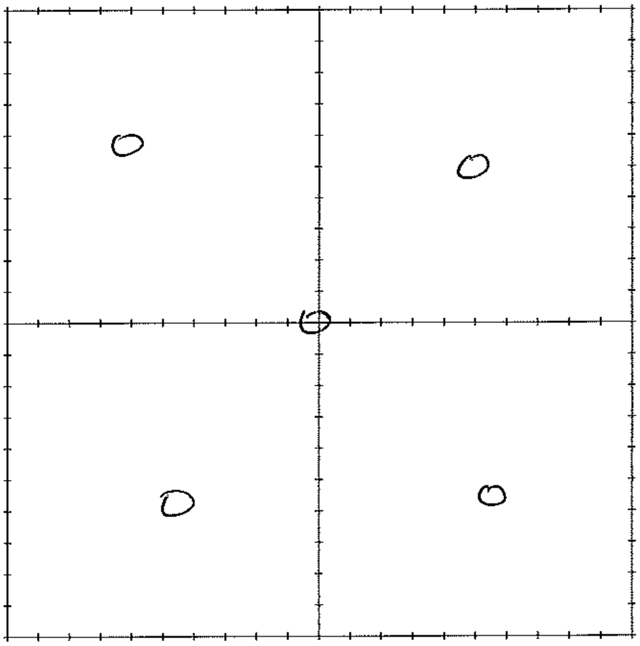
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 Ziplock

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S10006-C03-001 [Standing Rock]

SAMPLE I.D. S10006-C03-001

SAMPLE COLLECTION DATE 11/18/2016

SAMPLE COLLECTION TIME 10:20

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS ~45°F, light breeze, Sunny

FIELD USCS DESCRIPTIONS Brown fine-grained sand.

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

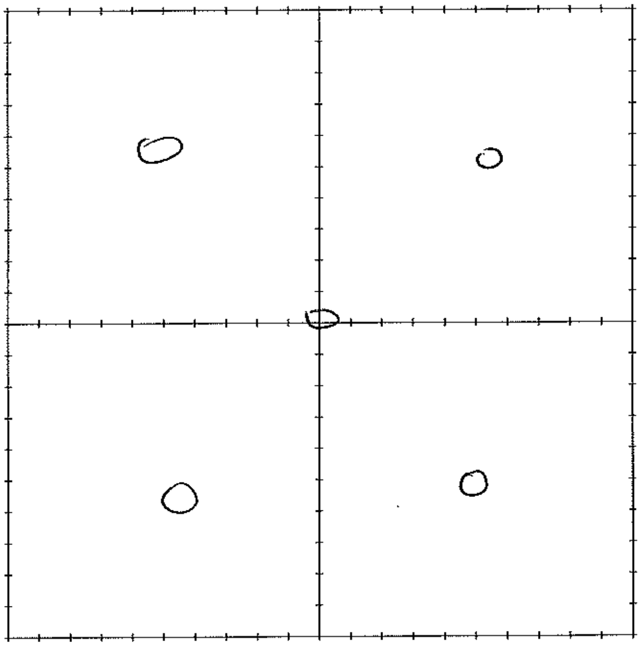
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 Ziplock

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S10006-C04-001 [Standing Rock]

SAMPLE I.D. S10006-C04-001

SAMPLE COLLECTION DATE 11/18/2016

SAMPLE COLLECTION TIME 10:55

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS ~45° F, light breeze, Sunny

FIELD USCS DESCRIPTIONS Fine tan sand, trace <½" gravels

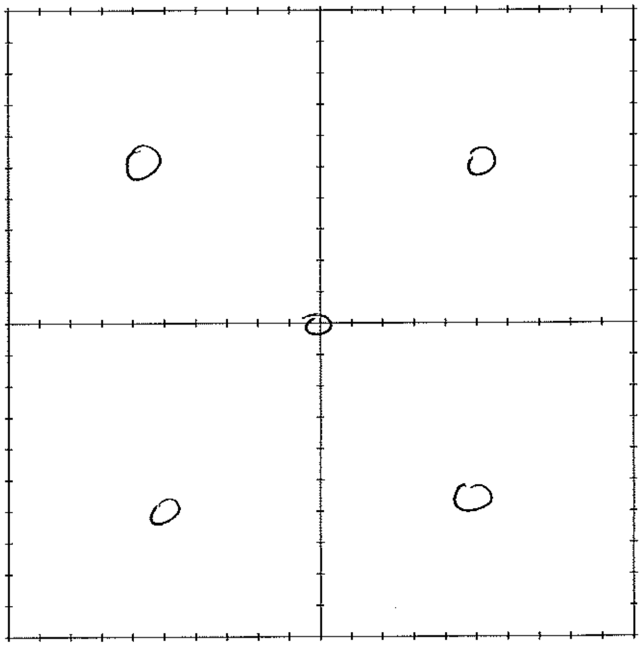
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 Ziplock

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 510006-C05-001 [Standing Rock]

SAMPLE I.D. 510006-C05-001

SAMPLE COLLECTION DATE 11/18/2016

SAMPLE COLLECTION TIME 11:25

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS ~45°F, Sunny, light breeze

FIELD USCS DESCRIPTIONS Red, Fine-grained sand, poorly-sorted

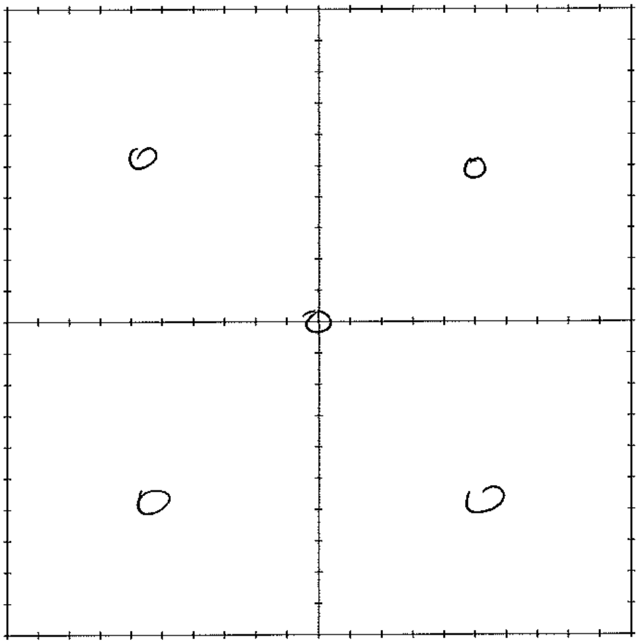
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 Ziplock

ANALYSES: Ra-226, Isotopic thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Stanly Rock

SAMPLE I.D. S10006 - CX-001

SAMPLE COLLECTION DATE 5/9/17

SAMPLE COLLECTION TIME 1100

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS 40's, rain

FIELD USCS DESCRIPTIONS Tan brown/red sand, 1/8-1/4", platy elongated gravel

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

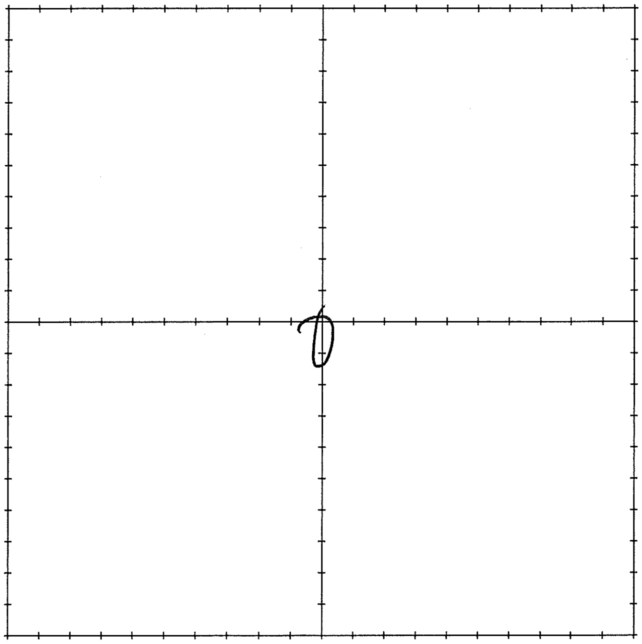
QUALIFIERS: ☒ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☒ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Stanley Rock

SAMPLE I.D. S10006-CX-002

SAMPLE COLLECTION DATE 5/9/17

SAMPLE COLLECTION TIME 1120

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 40's, rain

FIELD USCS DESCRIPTIONS Fine tan sand, trace <1/8" rock frags

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

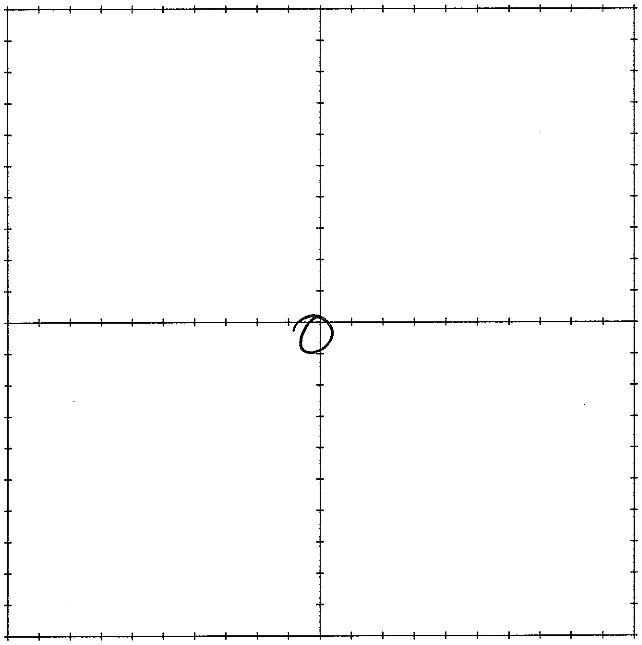
QUALIFIERS: ☒ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, ~~[illegible]~~ mw Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock (S10006)

SAMPLE I.D. S10006 - CX-003, 203

SAMPLE COLLECTION DATE 5/9/17

SAMPLE COLLECTION TIME 1134

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 40's, rainy

FIELD USCS DESCRIPTIONS Fine med/tan sand, subrounded 1/2"-1" gravel (trace)

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

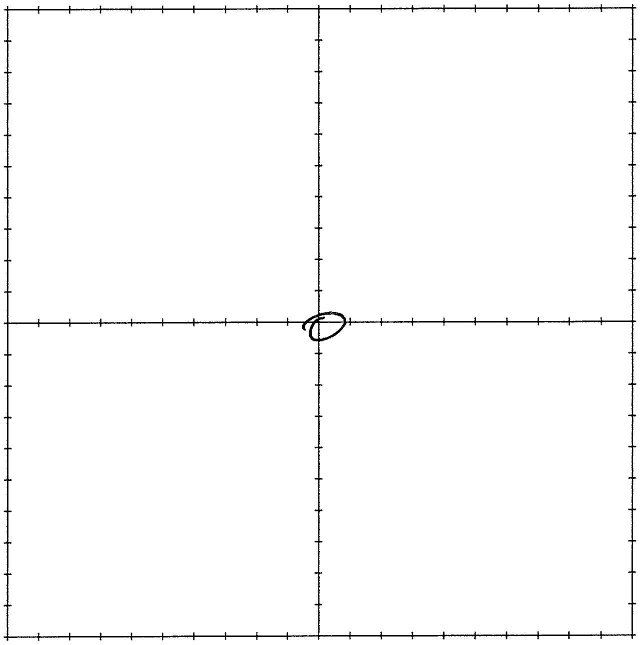
QUALIFIERS: ☒ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☒ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock (S10006)

SAMPLE I.D. S10006 - CX - 004

SAMPLE COLLECTION DATE 5/9/17

SAMPLE COLLECTION TIME 1154

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 40's, rain

FIELD USCS DESCRIPTIONS Fine gravel to v. coarse sand, pumpkin brown gravels (50%)

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

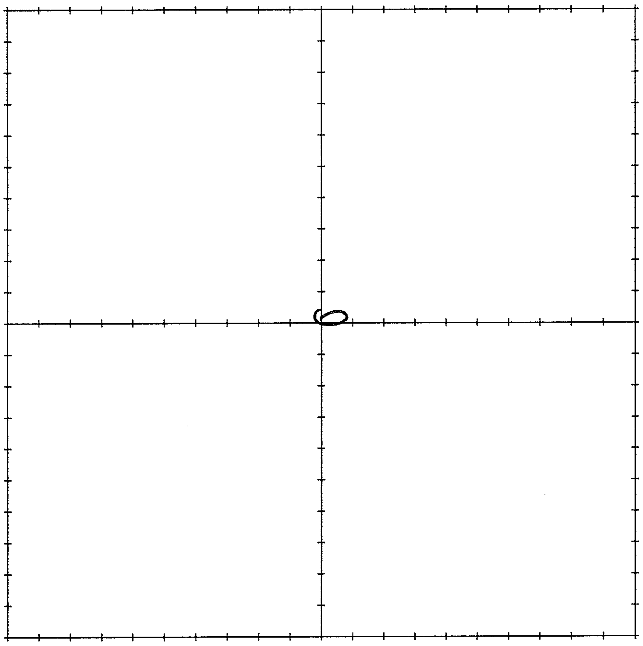
QUALIFIERS: ☐ TRACE ☐ MINOR ☒ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☒ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock (810006)

SAMPLE I.D. 810006-CX-005

SAMPLE COLLECTION DATE 5/9/17

SAMPLE COLLECTION TIME 1207

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 40's, raining

FIELD USCS DESCRIPTIONS Fine red sand matrix (30-40%) angular gravels, plates, ranging ½"-6"

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

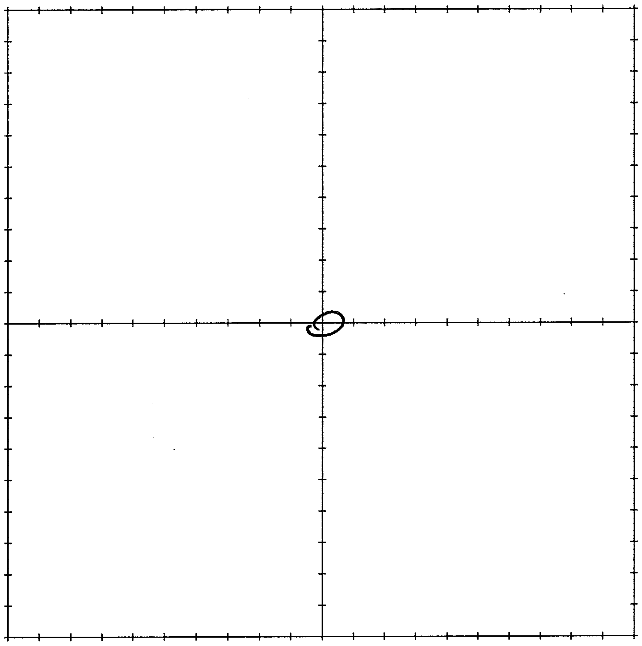
QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metal's



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Starling Rock (SL0006)

SAMPLE I.D. SL0006-CX-006

SAMPLE COLLECTION DATE 5/9/17

SAMPLE COLLECTION TIME 1223

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 40's, rainy

FIELD USCS DESCRIPTIONS Very fine red sand, angular frags (1/2"-2") minor

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

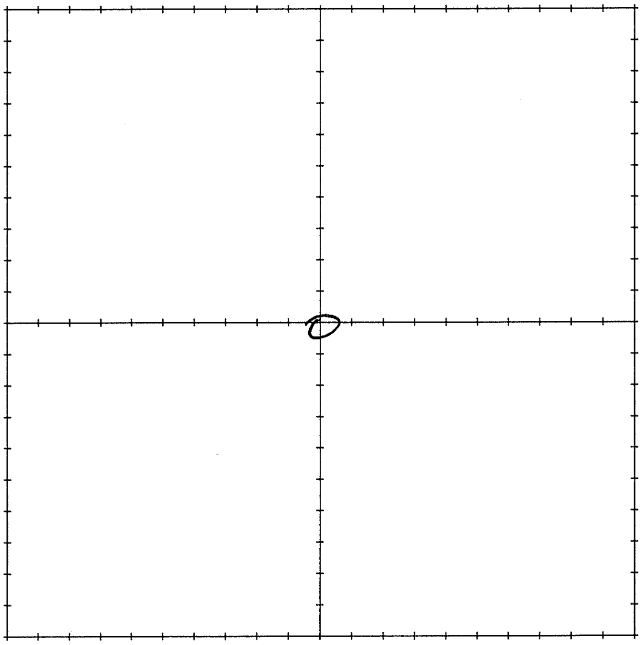
QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☒ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) ~~[illegible]~~ 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock (SL0006)

SAMPLE I.D. SL0006 - CX - 007

SAMPLE COLLECTION DATE 5/9/17

SAMPLE COLLECTION TIME 1237

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS ~40's rainy

FIELD USCS DESCRIPTIONS Fine tan sand, well sorted

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

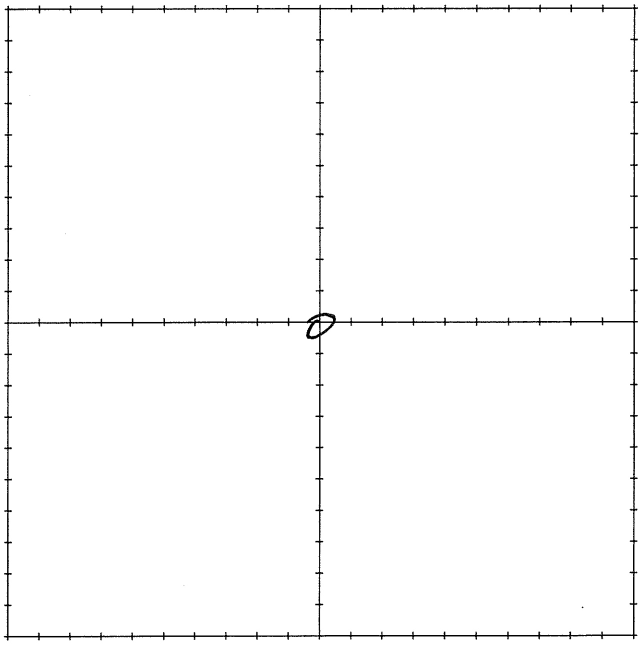
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Stanly Rock (SL0006)

SAMPLE I.D. SL0006 - CX - 008 MS/MSD

SAMPLE COLLECTION DATE 5/9/17

SAMPLE COLLECTION TIME 1255

SAMPLE COLLECTED BY MW/CC

WEATHER CONDITIONS 40's rainy

FIELD USCS DESCRIPTIONS Fine tan sand, 30% med sand, subangular grvls

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

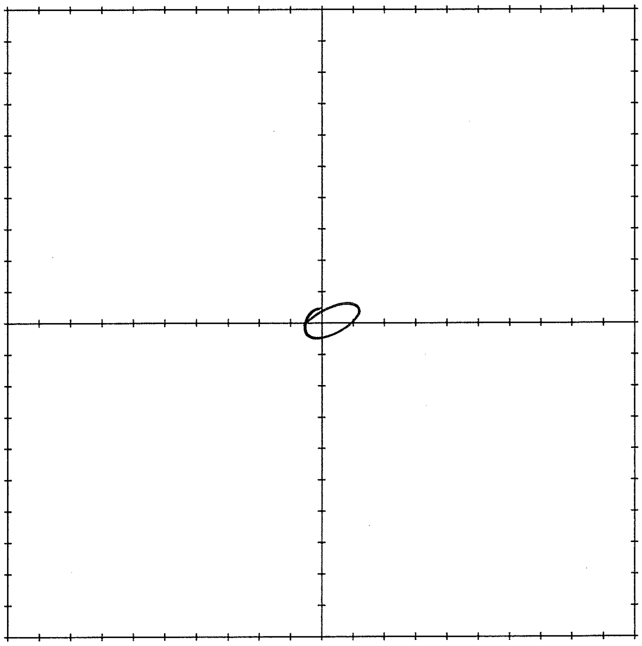
QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☒ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock (S1000ce)

SAMPLE I.D. S1000c-CX-~~008~~ 009, ~~MS/MSD~~ ch

SAMPLE COLLECTION DATE 5/9/17

SAMPLE COLLECTION TIME 1304

SAMPLE COLLECTED BY MW/~~[illegible]~~ CL

WEATHER CONDITIONS 40's, rainy

FIELD USCS DESCRIPTIONS Light tan sand, 70/30 tan/black sand

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

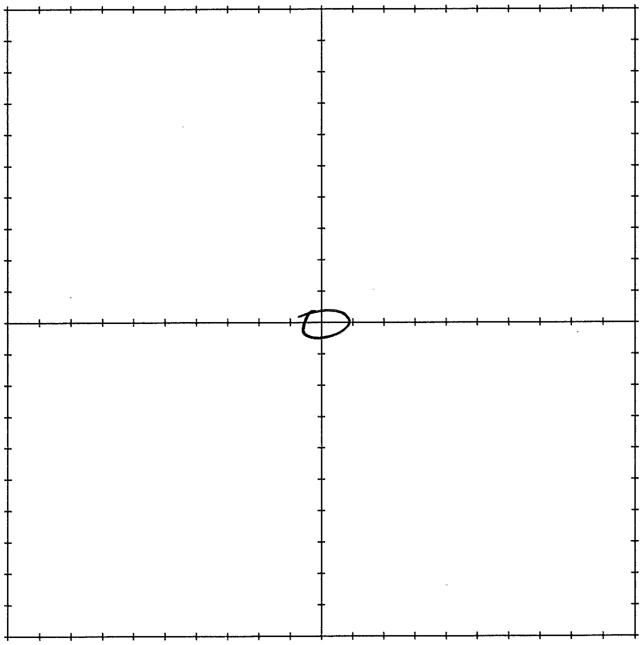
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Staging Rock (S10006)

SAMPLE I.D. S10006 - CX-010

SAMPLE COLLECTION DATE 5/9/17

SAMPLE COLLECTION TIME 1321

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 40's, Raining

FIELD USCS DESCRIPTIONS Light red fine sand

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

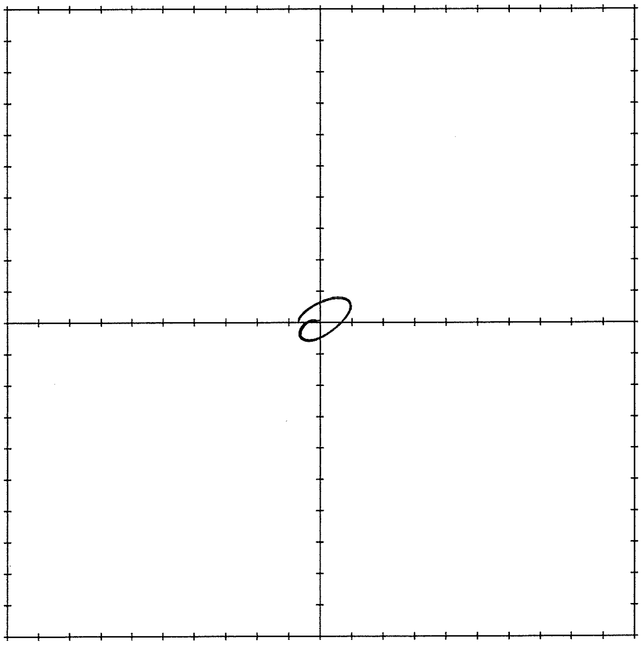
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Stanley Road (S10006)

SAMPLE I.D. S10006 - CX - 011

SAMPLE COLLECTION DATE 5/11/17

SAMPLE COLLECTION TIME 1502

SAMPLE COLLECTED BY MW/CL

WEATHER CONDITIONS 50-60's, Rainy

FIELD USCS DESCRIPTIONS Fine light brown sand

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

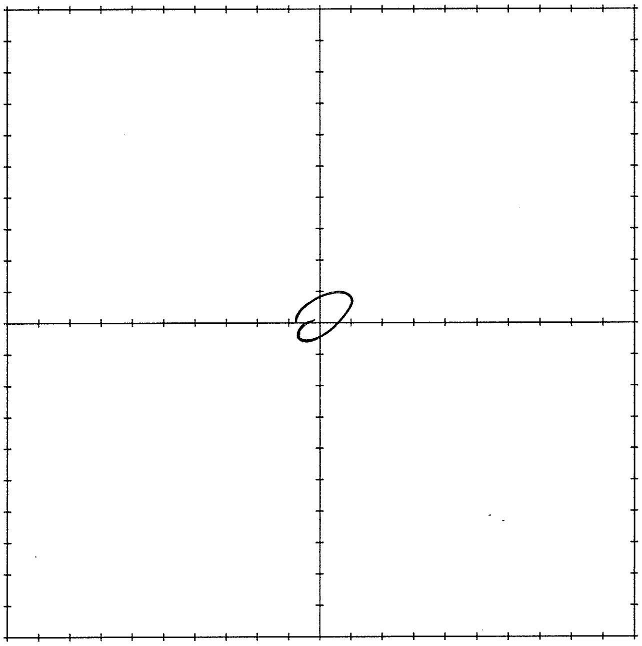
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Standing Rock (S10006)

SAMPLE I.D. S10006-CX-~~011~~ 012

SAMPLE COLLECTION DATE 5/11/17

SAMPLE COLLECTION TIME 1506

SAMPLE COLLECTED BY MW/LL

WEATHER CONDITIONS 50-60's rainy

FIELD USCS DESCRIPTIONS Fine light-brown sand

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

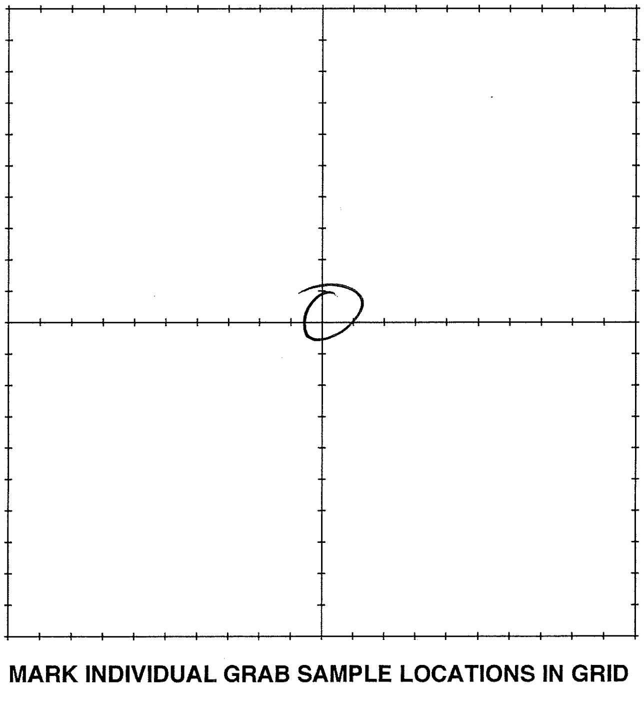
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

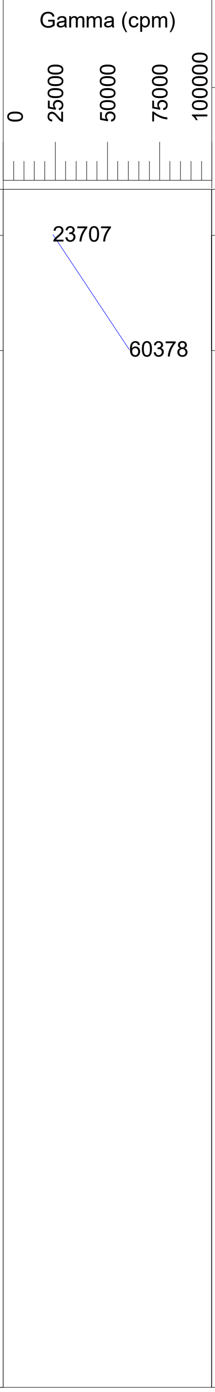
MWH

C.2 Hand Auger Borehole Logs

BOREHOLE ID: **S10006-BG1-011**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Standing Rock

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 13N
EASTING: 638573.33 NORTHING: 4089027.66
DATE STARTED: 3/24/2017 DATE STARTED: 3/24/2017
TOTAL DEPTH (ft.): 0.5 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Kelly Johnson



DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	SUBSURFACE SAMPLE INFORMATION			
			SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		SILTY SAND (SM): brown fine silty sand.	S10006-BG1-011-01	0-0.5	grab	3.43
		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on bedrock.				
1						
2						
3						
4						
5						

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

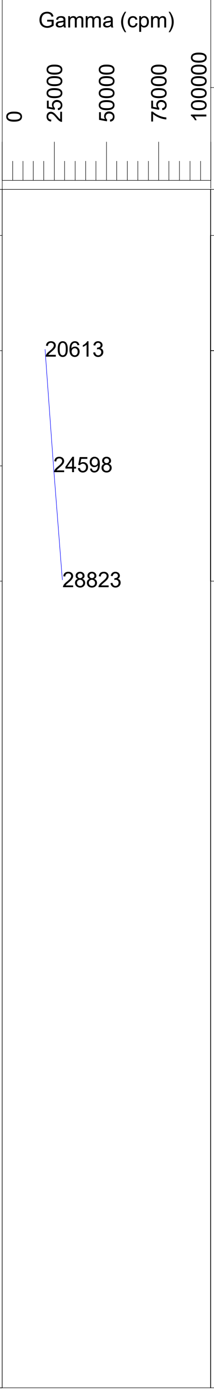
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S10006-BG2-011**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Standing Rock

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 13N
EASTING: 741789.63 NORTHING: 3960254.76
DATE STARTED: 8/29/2017 DATE STARTED: 8/29/2017
TOTAL DEPTH (ft.): 1.5 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn



DEPTH (feet)	LITHOLOGICAL GRAPHIC	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): brown, fine sand 98%, dry, loose. Trace gravels subrounded. Trace roots.		S10006-BG2-011-01	0-0.5	grab	0.93
	▨	increase gravel content.	20613				
1	▨	POORLY GRADED SAND (SP): brown fine sand 85%, dry, loose. Gravels 15% subrounded.	24598	S10006-BG2-011-02	0.5-1.5	grab	1.93
		Terminated hand auger borehole at 1.5 ft. below ground surface. Reason for termination unknown.	28823				
2							
3							
4							
5							

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

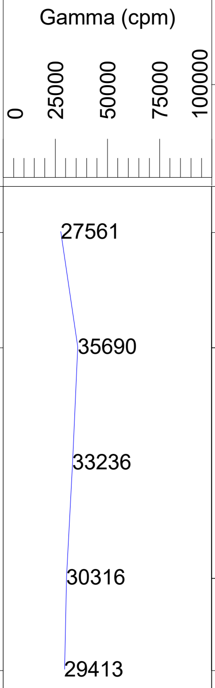
grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S10006-SCX-001**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Standing Rock

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:	743916.35	NORTHING:	3959148.76
DATE STARTED:	5/10/2017	DATE STARTED:	5/10/2017
TOTAL DEPTH (ft.):	1.9	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Luis Rodriguez		



SUBSURFACE SAMPLE INFORMATION

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		WELL GRADED SAND (SW): medium grained, with some silt.	S10006-SCX-001-1	0-0.5	grab	3.93
1		increase in sand grains.	S10006-SCX-001-2	0.5-1.5	grab	2.53
			S10006-SCX-001-3	1.5-1.9	grab	3.25
2		Terminated hand auger borehole at 1.9 ft. below ground surface; gamma measurements recorded below initial background level. No refusal.				
3						
4						
5						

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

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID: **S10006-SCX-002**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Standing Rock

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: 744041.02 NORTHING: 3959026.89
DATE STARTED: 5/11/2017 DATE STARTED: 5/11/2017
TOTAL DEPTH (ft.): 0.2 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 50000 100000 150000 200000	SUBSURFACE SAMPLE INFORMATION			
				SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	▨	POORLY GRADED SAND WITH GRAVEL (SP): red, fine sand, gravels are angular, dry. Terminated hand auger borehole at 0.2 ft. below ground surface. Refusal on rock.	26794 37545	S10006-SCX-002-1	0-0.2	grab 🟨	3.88
1							
2							
3							
4							
5							

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

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec

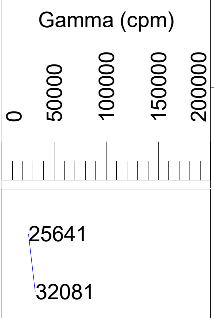
NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S10006-SCX-003**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Standing Rock

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: 743994.08
NORTHING: 3958985.36
DATE STARTED: 5/11/2017
DATE STARTED: 5/11/2017
TOTAL DEPTH (ft.): 0.3
BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SUBSURFACE SAMPLE INFORMATION			
				SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		No lithological description recorded. Down hole gamma scan completed to 0.3 ft. below ground surface. Refusal on bedrock.	25641 32081	No Sample			No sample collected. No results.
1							
2							
3							
4							
5							



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

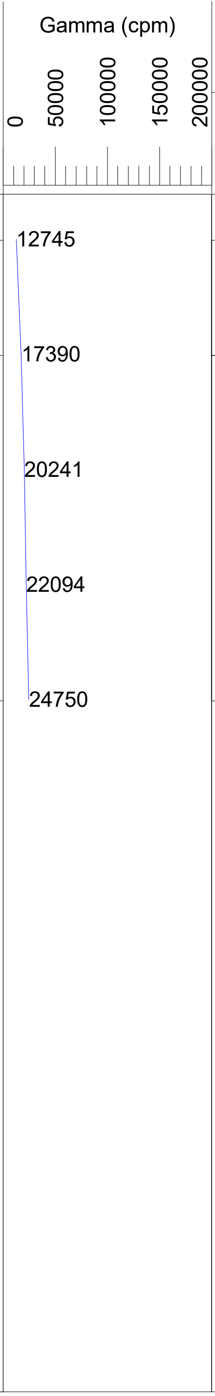
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S10006-SCX-004**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Standing Rock

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: 744129.22
NORTHING: 3958907.41
DATE STARTED: 5/11/2017
DATE STARTED: 5/11/2017
TOTAL DEPTH (ft.): 2
BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez



DEPTH (feet)	LITHOLOGICAL GRAPHIC	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): red, fine grained sand.	12745	S10006-SCX-004-1	0-0.5	grab	1.16
	▨	few gravels, gravels are 0.5 inches to 1.0 inch diameter.	17390	S10006-SCX-004-2	0.5-2	comp	1.01
1	▨		20241				
	▨		22094				
2		Terminated hand auger borehole at 2.0 ft. below ground surface. Refusal on bedrock.	24750				
3							
4							
5							

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

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec

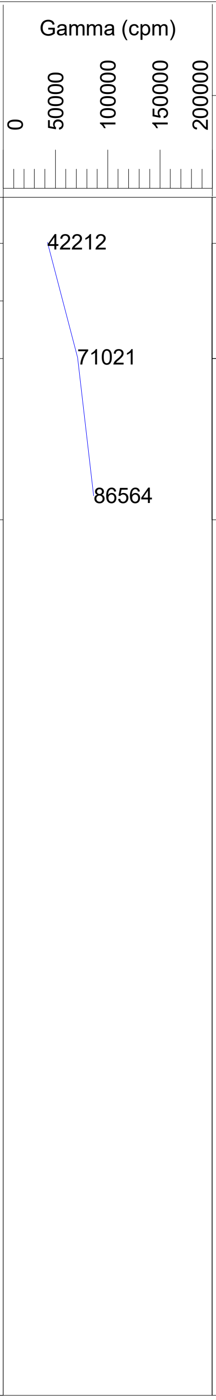
NAVAJO NATION
AUM Environmental Response Trust - First Phase

BOREHOLE ID: **S10006-SCX-005**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Standing Rock

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: 743892.93 NORTHING: 3959009.24
DATE STARTED: 5/11/2017 DATE STARTED: 5/11/2017
TOTAL DEPTH (ft.): 1.2 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED SAND (SP): brown, fine grained sand, moist.
	few gravels, gravels are 0.25 inches to 2.0 inch diameter.
	with medium grained gravel.
1	
	Terminated hand auger borehole at 1.2 ft. below ground surface. Refusal on weathered bedrock.
2	
3	
4	
5	



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S10006-SCX-005-1	0-0.5	grab	7.30
S10006-SCX-005-2	0.5-1.1	grab	9.10

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

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S10006-SCX-006**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Standing Rock

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: 743770.2
NORTHING: 3959102.8
DATE STARTED: 5/11/2017
DATE STARTED: 5/11/2017
TOTAL DEPTH (ft.): 0.4
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): brown, fine grained sand, trace silt and gravel.	31057	S10006-SCX-006-1	0-0.4	grab 🟨	3.07
		Terminated hand auger borehole at 0.4 ft. below ground surface. Reason for termination unknown.	30775				
1							
2							
3							
4							
5							

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

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID: **S10006-SCX-007**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Standing Rock

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: 743814.15 NORTHING: 3959095.7
DATE STARTED: 5/11/2017 DATE STARTED: 5/11/2017
TOTAL DEPTH (ft.): 0.8 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez

DEPTH (feet)	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 grained sand, moist.	21972	S10006-SCX-007-1 S10006-SCX-207-1	0-0.5	grab	3.26 3.07
	light brown, few coarse sand, trace large gravel.		S10006-SCX-007-2	0.5-0.8	grab	2.74
	Terminated hand auger borehole at 0.8 ft. below ground surface. Refusal on hard surface or rock.	30775				
1						
2						
3						
4						
5						

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

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec

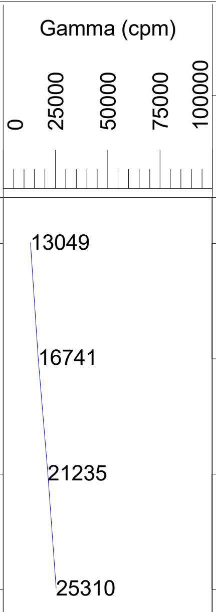
NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S10006-SCX-008**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Standing Rock

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: 743580.41 NORTHING: 3959162.16
DATE STARTED: 5/11/2017 DATE STARTED: 5/11/2017
TOTAL DEPTH (ft.): 1.5 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED SAND (SP): brown, fine grained sand.
1	brown to red, moist.
1.5	Terminated hand auger borehole at 1.5 ft. below ground surface. Refusal on hard sandstone rock.



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S10006-SCX-008-1	0-0.5	grab	0.97
S10006-SCX-008-2	1-1.5	grab	1.49

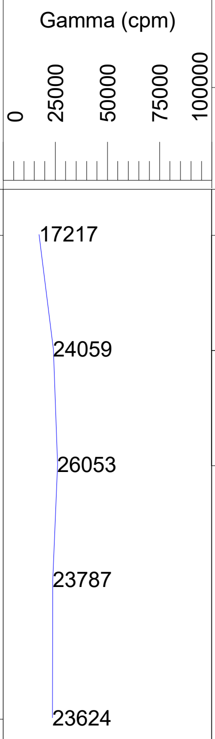
Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

BOREHOLE ID: **S10006-SCX-009**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Standing Rock

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: 743514.05 NORTHING: 3959320.53
DATE STARTED: 5/11/2017 DATE STARTED: 5/11/2017
TOTAL DEPTH (ft.): 2.1 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED SAND (SP): brown, fine grained sand.
2.1	Terminated hand auger borehole at 2.1 ft. below ground surface. Refusal on hard rock.



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S10006-SCX-009-1	0-0.5	grab	1.41
S10006-SCX-009-2	0.5-1	grab	1.64

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

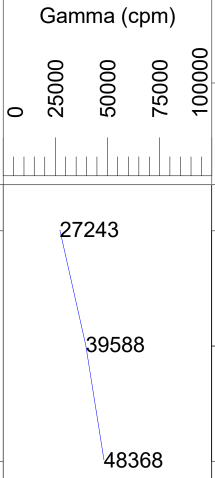
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S10006-SCX-010**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Standing Rock

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: 743516.83 NORTHING: 3959380.94
DATE STARTED: 5/11/2017 DATE STARTED: 5/11/2017
TOTAL DEPTH (ft.): 1 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez



DEPTH (feet)	LITHOLOGICAL DESCRIPTION	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	POORLY GRADED SAND (SP): light brown, fine grained sand, trace coarse sand.	S10006-SCX-010-1	0-0.5	grab	3.06
		S10006-SCX-010-2	0.5-1	grab	3.09
1	Terminated hand auger borehole at 1 ft. below ground surface. Refusal on rock.				
2					
3					
4					
5					

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

grab = grab sample
comp = composite sample

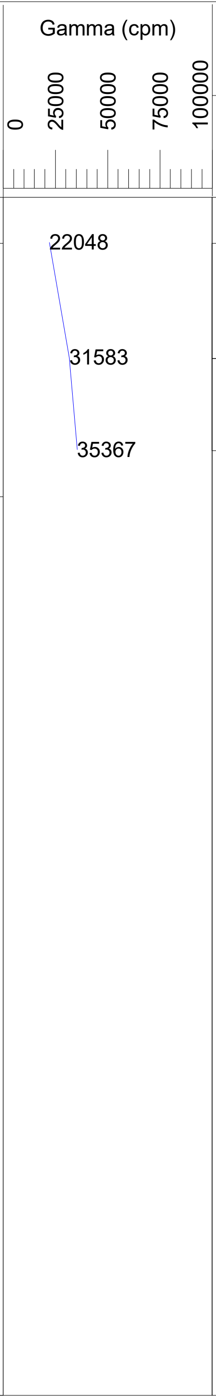
- - - - = approximate contact

BOREHOLE ID: **S10006-SCX-011**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Standing Rock

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: 743568.3
NORTHING: 3959333.73
DATE STARTED: 5/11/2017
DATE STARTED: 5/11/2017
TOTAL DEPTH (ft.): 1.1
BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED SAND (SP): light brown, fine grained sand, trace medium grained sand.
1.1	Terminated hand auger borehole at 1.1 ft. below ground surface. Refusal on rock.



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S10006-SCX-011-1	0-0.5	grab	2.22
S10006-SCX-011-2	0.5-0.9	grab	1.95

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

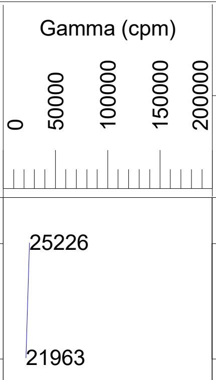
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S10006-SCX-012**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Standing Rock

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: 743582.34 NORTHING: 3959300.99
DATE STARTED: 5/11/2017 DATE STARTED: 5/11/2017
TOTAL DEPTH (ft.): 0.5 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez



DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SUBSURFACE SAMPLE INFORMATION			
				SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	▨	WELL GRADED SAND (SW): light brown, trace coarse sand.	25226	S10006-SCX-012-1	0-0.5	grab 🟨	2.08
		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on rock.	21963				
1							
2							
3							
4							
5							

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

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec

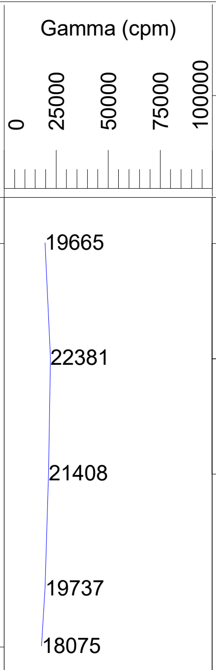
NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S10006-SCX-013**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Standing Rock

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:	743611.66	NORTHING:	3959269.59
DATE STARTED:	5/11/2017	DATE STARTED:	5/11/2017
TOTAL DEPTH (ft.):	1.75	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Luis Rodriguez		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION
0–1.75	▨	POORLY GRADED SAND (SP): brown, red, medium grained sand, moist.
1.75		Terminated hand auger borehole at 1.75 ft. below ground surface. Refusal on rock.



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S10006-SCX-013-1 S10006-SCX-213-1	0-0.5	grab	1.08 1.50
S10006-SCX-013-2	0.5-1	grab	1.67

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: **S10006-SCX-014**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Standing Rock

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: 743784.63 NORTHING: 3959175.41
DATE STARTED: 5/11/2017 DATE STARTED: 5/11/2017
TOTAL DEPTH (ft.): 0.3 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): brown, yellow, fine grained sand.	29927 27299	S10006-SCX-014-1	0-0.3	grab 🟨	2.70
		Terminated hand auger borehole at 0.3 ft. below ground surface. Refusal on rock.					
1							
2							
3							
4							
5							

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

grab = grab sample
comp = composite sample

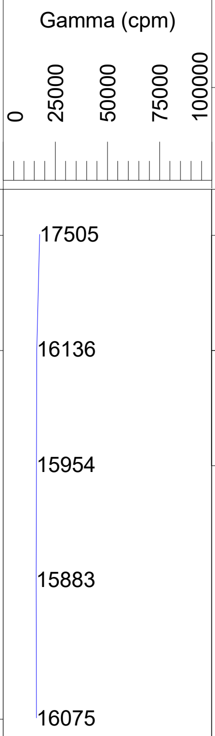
- - - - = approximate contact

BOREHOLE ID:	**S10006-SCX-015**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Standing Rock

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:	743811.91	NORTHING:	3959228.08
DATE STARTED:	5/11/2017	DATE STARTED:	5/11/2017
TOTAL DEPTH (ft.):	2.1	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Luis Rodriguez		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION
0		POORLY GRADED SAND (SP): light brown, fine grained sand, dry.
		with calcium carbonate, white.
1		
2		
		Terminated hand auger borehole at 2.1 ft. below ground surface in undisturbed native material.
3		
4		
5		



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S10006-SCX-015-1	0-0.5	grab	1.15
S10006-SCX-015-2	0.5-1	grab	0.79

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

grab = grab sample
comp = composite sample

- - - - = approximate contact

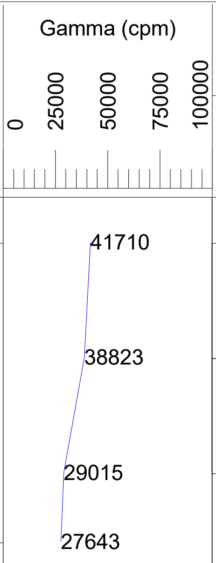
Navajo Nation AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S10006-SCX-016**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Standing Rock

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: 744003.05 NORTHING: 3959137.2
DATE STARTED: 5/11/2017 DATE STARTED: 5/11/2017
TOTAL DEPTH (ft.): 1.3 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED SAND (SP): light brown, fine grained sand, 10% medium grained gravels.
1.3	Terminated hand auger borehole at 1.3 ft. below ground surface because gamma measurements were below initial background level. No refusal.



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S10006-SCX-016-1	0-0.5	grab	3.62
S10006-SCX-016-2	0.5-1	grab	1.63

Depth scale: 0, 1, 2, 3, 4, 5

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

C.3 Water Sample Field Forms

WATER SAMPLE COLLECTION FORM

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

Date 5/25/17 **Arrival Time** 1144

Field Personnel

J Koster K Johnson

SITE DESCRIPTION

Surface Water ☒ **Well Water** ☐

Station Name Standing Rock pond near 15T-538 **Station Number** 15T-538 pond

Site Description Overflow Pond at 15T-538 well, Approx 15'x25' in size. Lots of evap minerals, windy

Water Characteristics (color, odor, appearance): murky, light brown, No odor Plants growing

SAMPLE COLLECTION

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

Sample ID: S10006-WS-001 **Sample Time:** 1155

LOC ID S10006-WS-001

Field Measurements

Parameter	Sample 1 (normal sample)	Sample 2 (field dup or MS)	Sample 3 (MSD)
Time	1213		
pH	9.65		
Conductivity (µS/cm)	3999		
Turbidity (NTU)	665		
Water Temperature (°C)	17.5		
Salinity	—		
Oxidation Reduction Potential (mV)	206.7		

Entered 6/16/2017

SURFACE WATER FLOW MEASUREMENT FORM

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

Date 5/25/17 **Time** 1144 **Station Number** ST-538 POND

Field Personnel: K. Johnson J. Kester

Flow by Capture Method

Measurement Number	Time (sec)	Volume (L)

- Pond fed by overflow from stock tank

-

Entered 6/16/2017

WATER SAMPLE COLLECTION FORM

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

Date 11 / 10 / 2016 **Arrival Time** 1330

Field Personnel

K. Johnson , C. Lee

Entered 12/20/2016

SITE DESCRIPTION

Surface Water ☐ **Well Water** ☑

Station Name Standing Rock, NW of site **Station Number** 15T-529

Site Description Windmill well, box/vault w/valve & trough

Sample the vault/box

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

SAMPLE COLLECTION

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

Sample ID: S10006-WL-001 S10006-WL-201 **Sample Time:** 1415

Field Measurements			
Parameter	Sample 1 (normal sample)	Sample 2 (field dup or MS)	Sample 3 (MSD)
Time	~~1450~~ 1415		
pH	8.71		
Conductivity (µS/cm)	1504	11/10/2016	
Turbidity (NTU)	15.0		
Water Temperature (°C)	14.8		
Salinity	0.96		
Oxidation Reduction Potential (mV)	125.7		

SURFACE WATER FLOW MEASUREMENT FORM

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

Date 11 / 10 /2016 **Time** 1450 **Station Number** 157-529

Field Personnel: K. Johnson C. Lee

Flow by Capture Method

Measurement Number	Time (sec)	Volume (L)
Well	~~FROG~~ TROUGH	N/A

WATER SAMPLE COLLECTION FORM

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

Date 5 /25 /2017 **Arrival Time** 1005

Field Personnel
J. Kester, K. Johnson

SITE DESCRIPTION

Surface Water ☐ **Well Water** ☒

Station Name Standing Rock S. Well **Station Number** 15T-538

Site Description Windmill well & Associated stock tank.
Sampled from tank

Water Characteristics (color, odor, appearance): Clear, odorless

SAMPLE COLLECTION

Collection Method: 1L bottle, Horizontal-bottle, Swing-sampler, Other(PP - Peristaltic Pump), Up-stream / Across-stream

Sample ID: ~~S10006-WS-004~~ KJ S10006-WL-002 **Sample Time:** 1050
LOC ID S10006-WL-002

Field Measurements			
Parameter	**Sample 1 (normal sample)**	**Sample 2 (field dup or MS)**	**Sample 3 (MSD)**
Time	1049		
pH	8.27		
Conductivity (µS/cm)	1053		
Turbidity (NTU)	1.06 NTU		
Water Temperature (°C)	17.8 °C		
Salinity	—		
Oxidation Reduction Potential (mV)	186.3		

Entered 6/16/2017

SURFACE WATER FLOW MEASUREMENT FORM

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

Date 3/25/2017 **Time** 1049 **Station Number** 15T-538
S10006-WL-0

Field Personnel: K. Johnson J. Kester

Flow by Capture Method

Measurement Number	Time (sec)	Volume (L)

Sampled Tank

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 Standing Rock 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 March 2017, one potential background reference area (BG-1) was identified to represent the geologic unit at the Site, the Point Lookout Sandstone. The gamma survey and collection of soil samples at BG-1 were completed in March 2017. Following review of data collected at BG-1 and the Site, it was determined that additional potential background reference areas may be required to characterize soil and sediments on the plains and the mesa sidewall. Two additional potential background reference areas were identified and gamma surveys were conducted at these potential background reference areas in June 2017. BG-2 represents the Quaternary deposits on the plains, and BG-3 represents the Point Lookout Sandstone on the mesa sidewall. During further review of the Baseline Studies data, it was determined that BG-3 would not be used to represent the Site, as described in Section 3.0 below. Soil samples were collected at BG-2 in August 2017.

The locations of the three potential background reference areas (BG-1, BG-2, and BG-3) are shown along with the site geology and predominant wind direction in Figure D.1-1. The potential background reference areas are described below.

- BG-1 encompasses an area of 986 ft^2 (approximately 0.02 acres), is located 1.2 miles northwest of the Site, and is upwind and hydrologically cross-gradient from the Site. The cobbles, gravels, residual soils, and bedrock outcrops at BG-1 represent the top of the mesa at the Site, and are the same geologic unit, the Point Lookout Sandstone. The vegetation and ground cover at BG-1 are similar to the Site.

- BG-2 encompasses an area of 2,335 ft^2 (approximately 0.05 acres), is located 1.2 miles northwest of the Site, and is crosswind and hydrologically up-gradient of the Site. Geologically, BG-2 represents the Quaternary deposits found in the drainages and on the plains below the Site. The vegetation and ground cover at BG-2 are similar to the Site.

- BG-3 encompasses an area of 2,054 ft^2 (approximately 0.05), is located 1.2 miles northwest of the Site, and is upwind and hydrologically up-gradient of the Site. Geologically, BG-3 represents the Point Lookout Sandstone unit on the mesa sidewall at the Site. BG-3 contains poorly formed residual soils and thin sandstone beds exposed in places. The vegetation and ground cover at BG-3 are similar to the mesa sidewalls at the Site.

The potential background reference area evaluation included walkover gamma surveys, surface static gamma measurements (at borehole location in BG-1), subsurface static gamma measurements (at borehole locations in BG-1 and BG-2), surface soil samples at BG-1 and BG-2, and subsurface soil samples at BG-2. Subsurface soil samples could not be collected in the borehole at BG-1 due to refusal on bedrock at 0.5 ft below ground surface (bgs). Field personnel collected the following surface and subsurface samples, as shown in Figure D.1-2 and summarized in Table 4-1 in the RSE Report:

- BG-1: Eleven surface soil grab samples from 11 locations
- BG-2: Eleven surface soil grab samples from 11 locations, one subsurface soil grab sample from borehole location S10006-BG2-011

Samples were categorized as surface soil 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. Table 4-1 in the RSE Report provides the results of the sample analyses. Field forms, including borehole logs, are provided in Appendix C of the RSE Report.

The gamma survey measurements for the three potential background reference areas are shown in Figure D.1-2. The same equipment used for the walkover gamma survey was also used for static one-minute gamma measurements at the ground surface and subsurface at borehole location S10006-BG1-011 (BG-1), and for subsurface static gamma measurements at S10006-BG2-011 (BG-2). Gamma measurements were collected according to the methods described in the Removal Site Evaluation Work Plan (MWH, 2016).

3.0 SELECTION OF BACKGROUND REFERENCE AREA

Background reference areas were needed to represent the two geologic units present at or near the Site where disturbances may have occurred: BG-1 and BG-3 were representative of the Point Lookout Sandstone, and BG-2 was representative of the Quaternary Deposits. Subsequent to performing the gamma survey at BG-3, it was not selected as a background reference area. BG-1 was selected over BG-3 to represent the Site as a large majority of the Site is within the area of the mesa top and it is covered by bedrock, cobbles, and gravels similar to those observed in BG-1. Gamma survey measurements and soil sample results collected from BG-1 and BG-2, and the subsurface static gamma measurement collected at BG-2, were used for the remainder of the Removal Site Evaluation of the Site.

4.0 REFERENCES

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

USEPA, 2000. *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM), EPA 402-R-97-016, Rev. 1.

Table D.1-1
Soil and Sediment Sampling Summary
Standing Rock
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase
Page 1 of 1

Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Reference Area Study - Background Area 1 - Point Lookout Sandstone						
Total Number of Observations	11	11	11	11	11	11
Minimum[1]	2.60	0.470	1.20	2.40	230	2.42
Mean[1]	3.25	0.558	1.80	2.90	326	4.05
Median[1]	3.20	0.550	1.70	2.70	310	4.02
Maximum[1]	4.00	0.660	2.50	3.70	480	6.56
Distribution	Normal	Normal	Normal	Normal	Normal	Normal
Coefficient of Variation[1]	0.119	0.111	0.192	0.168	0.228	0.280
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	3.46	0.592	1.99	3.17	366	4.67
UTL Type	UTL Normal	UTL Normal	UTL Normal	UTL Normal	UTL Normal	UTL Normal
UTL Result	4.33	0.733	2.78	4.27	534	7.24
Background Reference Area Study - Background Area 2 - Quaternary Deposits						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	--	100%	--	--	--
Minimum[1]	3.00	0.280	--	0.430	34.0	0.680
Minimum Detect[2]	--	--	--	--	--	--
Mean[1]	3.70	0.360	--	0.577	54.6	0.994
Mean Detects[2]	--	--	--	--	--	--
Median[1]	3.70	0.360	--	0.590	56.0	1.06
Maximum[1]	4.60	0.500	--	0.730	74.0	1.25
Maximum Detect[2]	--	--	--	--	--	--
Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
Coefficient of Variation[1]	0.112	0.170	--	0.162	0.248	0.179
UCL Type	95% Student's-t UCL	95% Student's-t UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	3.93	0.393	Not Calculated	0.628	62.1	1.09
UTL Type	UTL Normal	UTL Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
UTL Result	4.87	0.532	Not Calculated	0.840	92.8	1.50

Notes

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

[1] This statistic is reported by ProUCL when the dataset contains 100 percent detections.

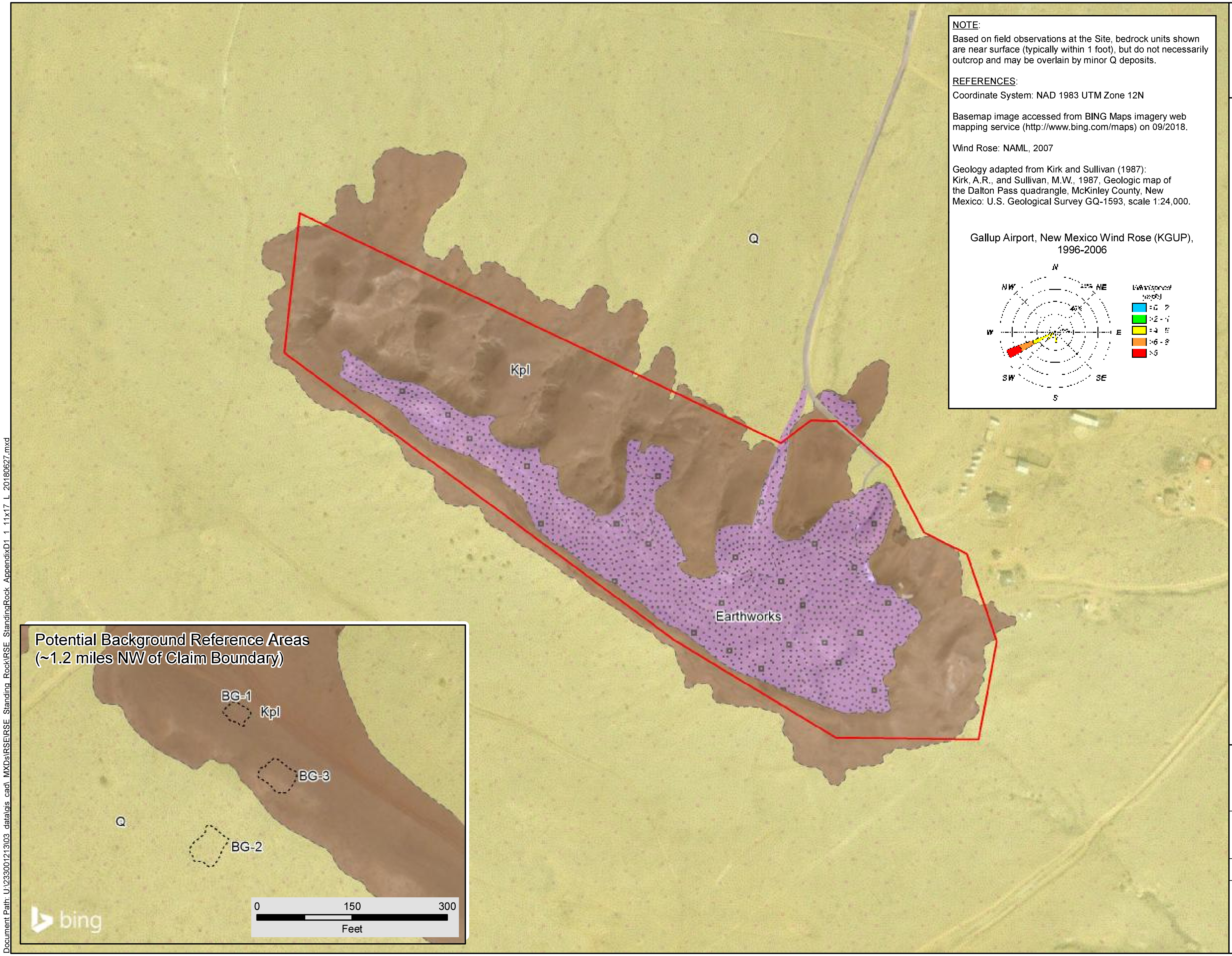
[2] This statistic is reported by ProUCL when non-detect values exist in the dataset. The value reported is calculated using detections only.

Table D.1-2
Surface Gamma Survey Summary
Standing Rock
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Geologic Formation Statistic	Background Reference Area 1 (BG-1) Point Lookout Sandstone	Background Reference Area 2 (BG-2) Quaternary Deposits	Background Reference Area 3 (BG-3) Point Lookout Sandstone
Total Number of Observations	222	543	494
Minimum (cpm)	19,646	10,910	13,974
Mean (cpm)	26,494	13,871	20,023
Median (cpm)	26,306	13,811	20,537
Maximum (cpm)	36,225	16,806	26,488
Standard Deviation (cpm)	3,365	967	2,639
Distribution	Normal	Normal	NORMAL
Coefficient of Variation	0.127	0.07	0.132
UCL Type	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result (cpm)	26,867	13,939	20,218
UTL Type	UTL Normal	UTL Normal	UTL Normal
UTL Result (cpm)	32,635	15,570	24,675

Notes

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



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

Wind Rose: NAML, 2007

Geology adapted from Kirk and Sullivan (1987):
Kirk, A.R., and Sullivan, M.W., 1987, Geologic map of the Dalton Pass quadrangle, McKinley County, New Mexico: U.S. Geological Survey GQ-1593, scale 1:24,000.

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

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

⬚ Potential Background Reference Area

🟥 Claim Boundary

╌ Geologic Contact (Inferred)

Site Geology

HOLOCENE

▨ Earthworks: Human-caused disturbance of the land surface at the Standing Rock mine site.

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

CRETACEOUS

▨ Kpl: Point Lookout Sandstone (Upper Cretaceous) – Black, titanium rich sand deposit in iron oxide cemented quartzose sandstone. The black sandstone overlies tan shaley sandstone.

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TITLE:

Geologic Map and Potential Background Reference Areas

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 9/20/2018

DOCUMENT NAME: Removal Site Evaluation Report

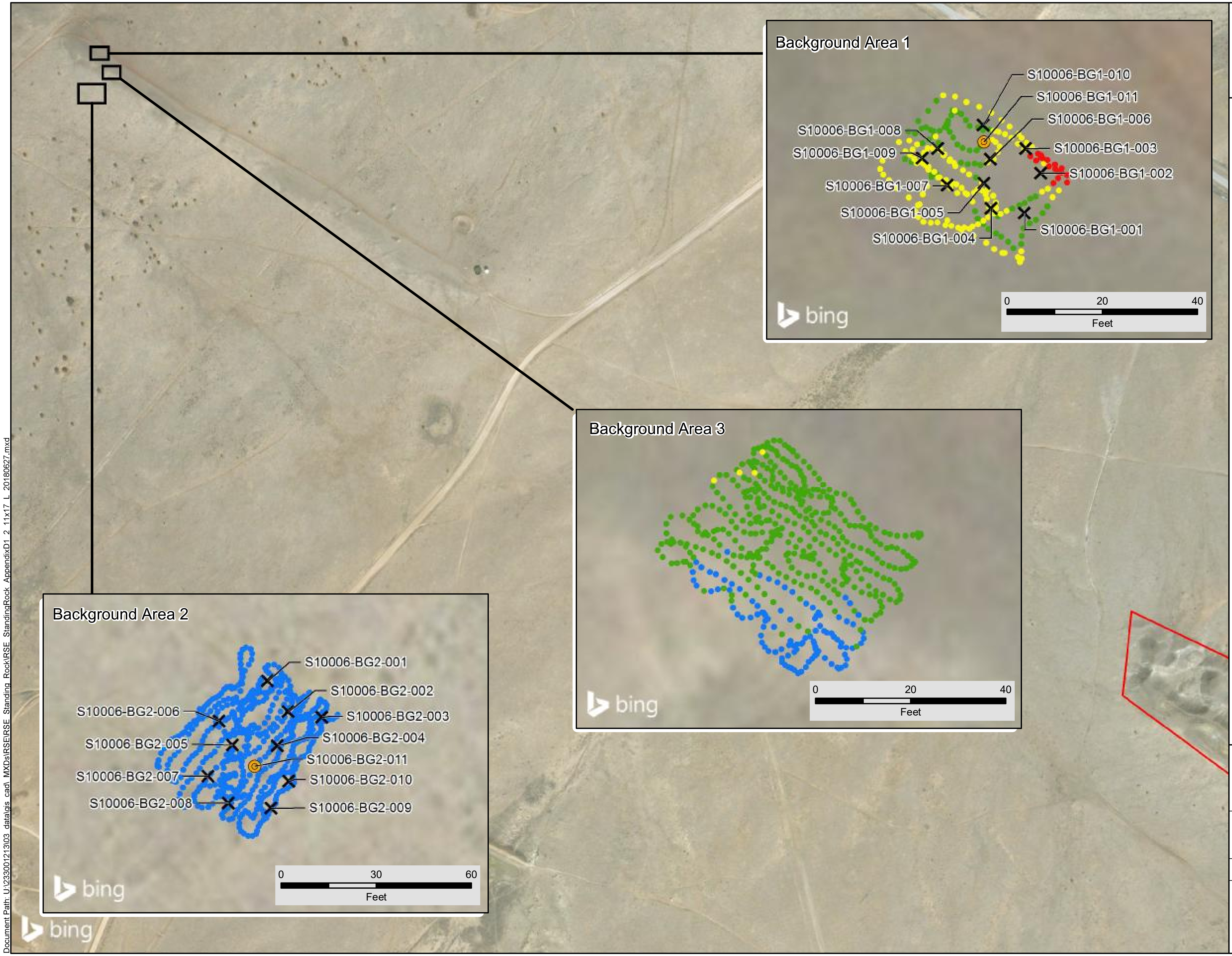
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: D.1-1

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Standing Rock\RSE StandingRock AppendixD1 1 11x17 L 20180627.mxd



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AUM Environmental
Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Subsurface Borehole Location for Background Reference
▭	Claim Boundary

Gamma Survey

Counts per Minute (CPM)

●	10,910 - 17,500
●	17,501 - 25,000
●	25,001 - 32,500
●	32,501 - 36,225

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 06/2018.

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TITLE:
Potential Background Reference Area
Gamma Radiation Survey Results and
Soil Sample Locations

PROJECT:
Removal Site Evaluation
Standing Rock Mine Site

DATE: 6/27/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: D.1-2

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 Standing Rock 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 two background references areas and two survey areas. These areas are designated Background Reference Area 1 (BG-1), Background Reference Area 2 (BG-2), Survey Area A and Survey Area B. Background Reference Areas BG-1 and BG-2 were selected to represent the Site’s natural conditions as described in Appendix D.1. The gamma radiation survey data and soil sample analytical results for the background reference areas and survey areas were evaluated to determine the appropriate ILs for the Site as follows:

1. Identify and examine potential outlier values. Potential outlier values were identified statistically and, if justified upon further examination, removed from a dataset prior to further evaluation and calculations. No data were removed from the dataset for the calculations presented in this appendix.

2. Compare data populations between BG-1 and Survey Area A, and BG-2 and Survey Area B (box plots, probability plots, hypothesis testing with Wilcoxon Mann-Whitney test). Soil sample and gamma radiation survey results were compared between BG-1 and Survey Area A, and BG-2 and Survey Area B qualitatively and quantitatively to evaluate similarity or difference in data distributions between the areas, and as a component of evaluating background reference area adequacy and representativeness.

3. Develop descriptive statistics. Descriptive statistics for gamma survey results and soil sample analytical results (e.g., number of observations, mean, maximum, median, etc.) were generated to facilitate qualitative comparisons of soil sample and gamma radiation survey results from one area to another.

4. Select ILs for the Site based on the results of the statistical evaluations.

3.0 RESULTS

The following sections present the evaluation of potential outlier values in the dataset, calculated descriptive statistics, and comparison of data populations between groups in support of determining ILs for use at the Site.

3.1 POTENTIAL OUTLIER VALUES

A potential outlier is a data point within a random sample of a population that is different enough from the majority of other values in the sample as to be considered potentially unrepresentative of the population, and therefore requires further inspection and evaluation. Unrepresentative values in a dataset have potential to yield distorted estimates of population parameters of interest (e.g., means, upper confidence limits, upper percentiles). Therefore, potential outliers in the Site data were evaluated further prior to performing data comparisons (Section 3.2) and developing the descriptive statistics (Section 3.3). In the context of this statistical evaluation, extreme values and statistical outliers are referred to as potential outliers.

A potential outlier value in a sample may be a true representative value in the test population (not a ‘discrepant’ value), simply representing a degree of inherent variation present in the population. Furthermore, a statistical determination of one or more potential outliers does not indicate that the measurements are discrepant from the rest of the data set. Therefore, general statistical guidance does not recommend that extreme values (potential outliers) be removed from an analysis solely on a statistical basis. Statistical outlier tests can provide supportive information, but a reasonable scientific rationale needs to be identified for the removal of any potential outlier values (e.g., sampling error, records error, or the potential outlier is determined to violate underlying assumptions of the sampling design, such as the targeted geology).

In the background reference areas, soil samples were collected randomly. Potential outliers in the BG-1 and BG-2 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.

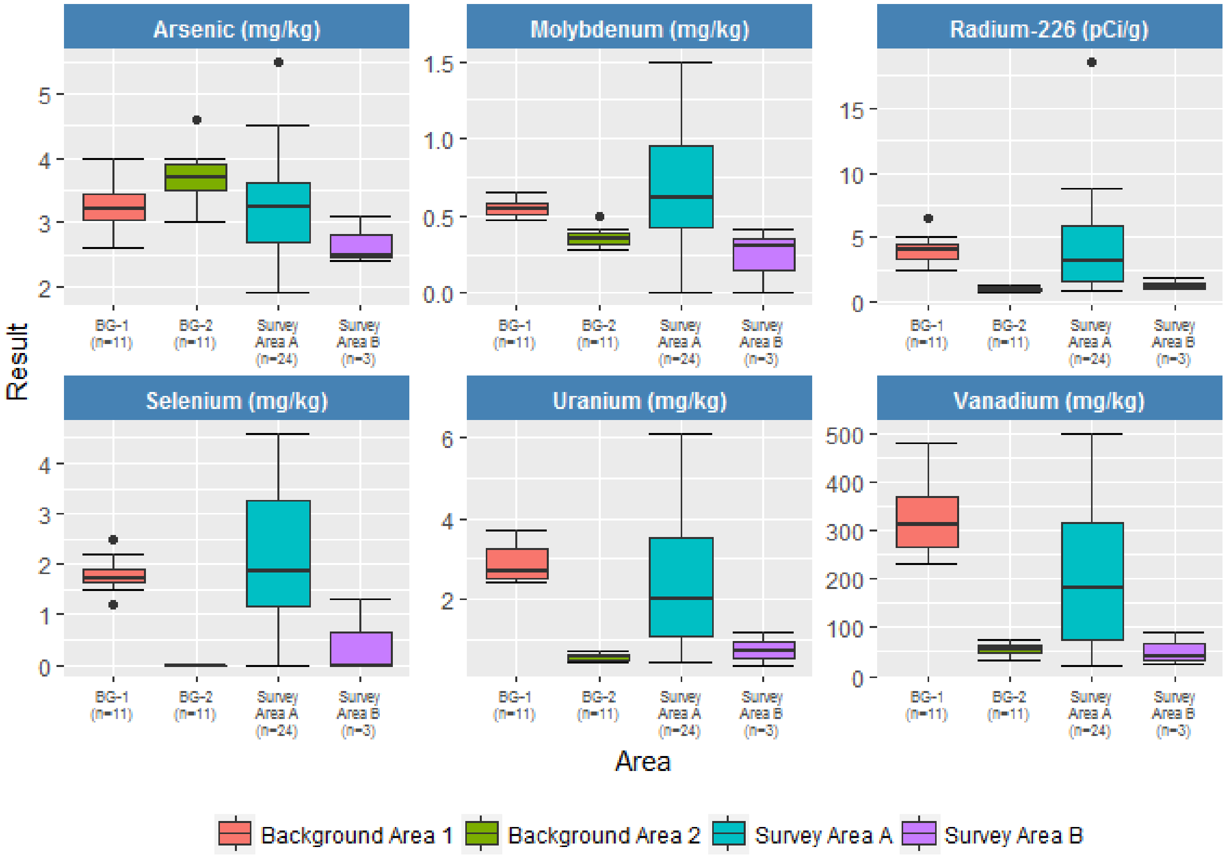
In the survey areas at Standing Rock, soil samples were collected using a judgmental sampling approach. Specifically, some sample locations were selected to characterize areas of higher gamma radiation and, as a result, potential outlier values are not unexpected in the Survey Area sample statistics. Potential outliers in this context mean values that are well-separated from the majority of the data set coming from the far/extreme tails of the data distribution (USEPA, 2016a). Descriptive statistics for the Survey Areas and some comparisons to background reference areas are still presented for qualitative assessment. However, potential outlier values in the Survey Areas are not evaluated further nor removed from the dataset.

3.1.1 Box plots

Box plots depict descriptive statistics from a group of data (Figure 1A). The interquartile range is represented by the bounds of the box, the minimum and maximum values, not including potential outlier values (extreme values), are depicted by the whiskers (vertical lines), and any potential outliers are identified as singular dots. Potential outliers in this context are defined as values outside 1.5 times the interquartile range above or below the box.

3.1.1.1 Soil Sample Results Box Plots

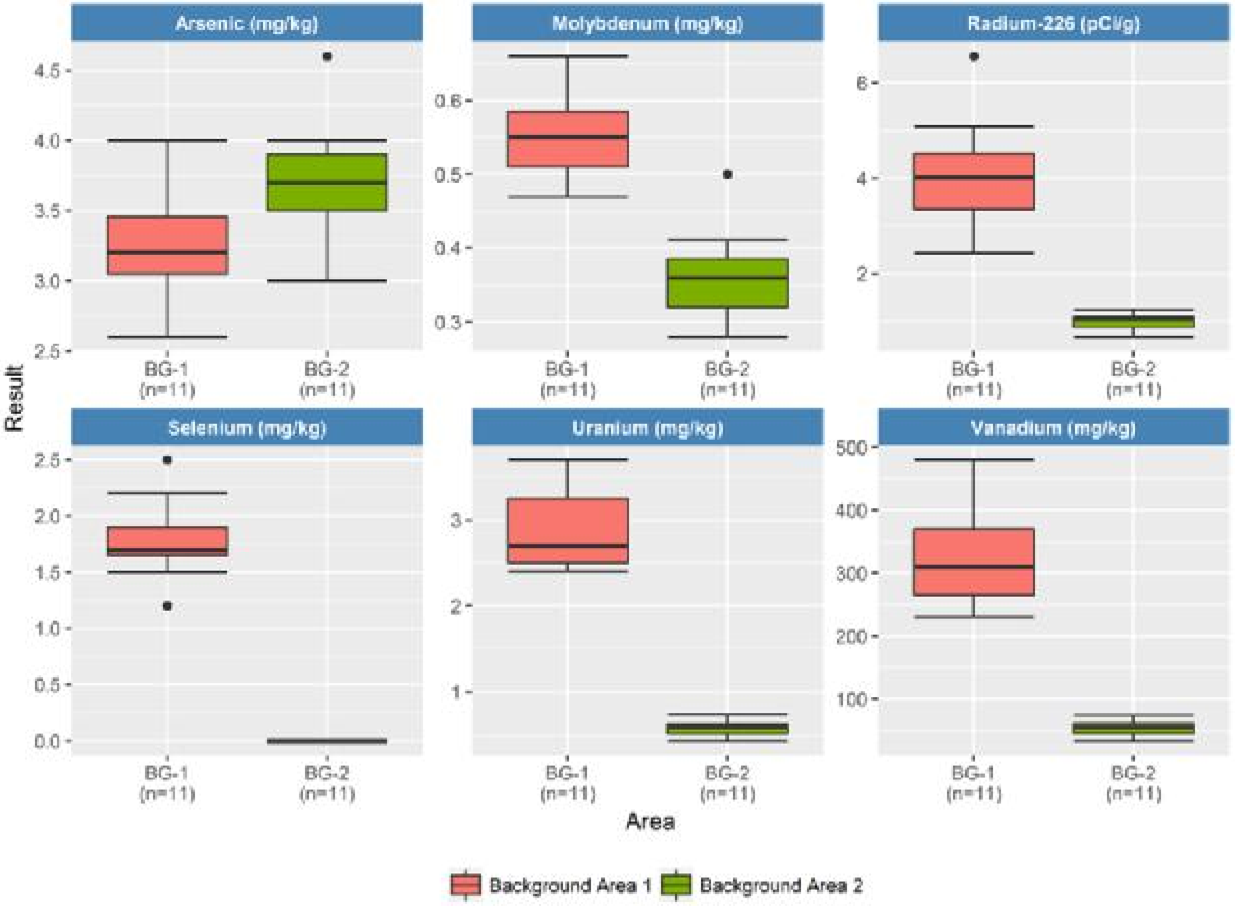
Figure 1A. Survey Areas A and B, and Background Reference Areas 1 (BG-1) and 2 (BG-2) Soil Sample Boxplots



The soil sample box plots shown on Figure 1A depict differences in the data distributions for analytical constituent concentrations between BG-1, BG-2 and Survey Areas A and B. Some potential outlier values are shown for BG-1, BG-2 and Survey Area A.

Potential outlier values are of greatest concern in the BG-1 and BG-2 datasets as these data are used to determine the ILs. Background reference area data are presented alone in Figure 1B.

Figure 1B. Background Reference Areas 1 (BG-1) and 2 (BG-2) Soil Sample Boxplots



One value each for arsenic (As), molybdenum (Mo), and Ra-226, and two values for selenium (Se), are identified as potential outliers (i.e., values outside 1.5 times the interquartile range) in the boxplots shown in Figure 1B for the BG-1 and BG-2 datasets. These potential outlier values are further evaluated with the use of probability plots in Section 3.1.2 and statistical testing in Section 3.1.3.

3.1.1.2 Gamma Radiation Results Box Plots

The gamma radiation survey results boxplots shown on Figure 2A depict differences in the data distribution for gamma measurements between BG-1, BG-2 and Survey Areas A and B. The number of potential outlier values in the Survey Area boxplots indicate high skewness or possibly non-normally distributed data, instead of outlier values. Based on Site geology, the potential gamma radiation outlier values observed for the Survey Areas data on Figure 2A represent localized areas of higher gamma radiation with respect to other parts of the Survey Area; as would be expected in areas with varying levels of mineralization, naturally occurring radioactive material (NORM) and potential TENORM.

Figure 2A. Survey Area and Background Reference Area Gamma Radiation Boxplots

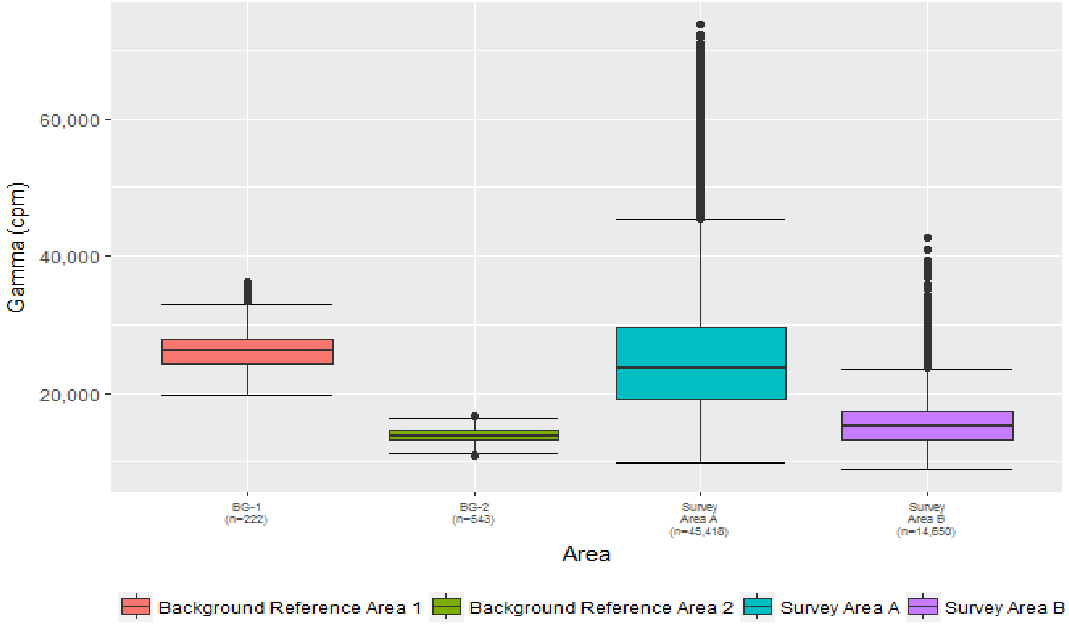
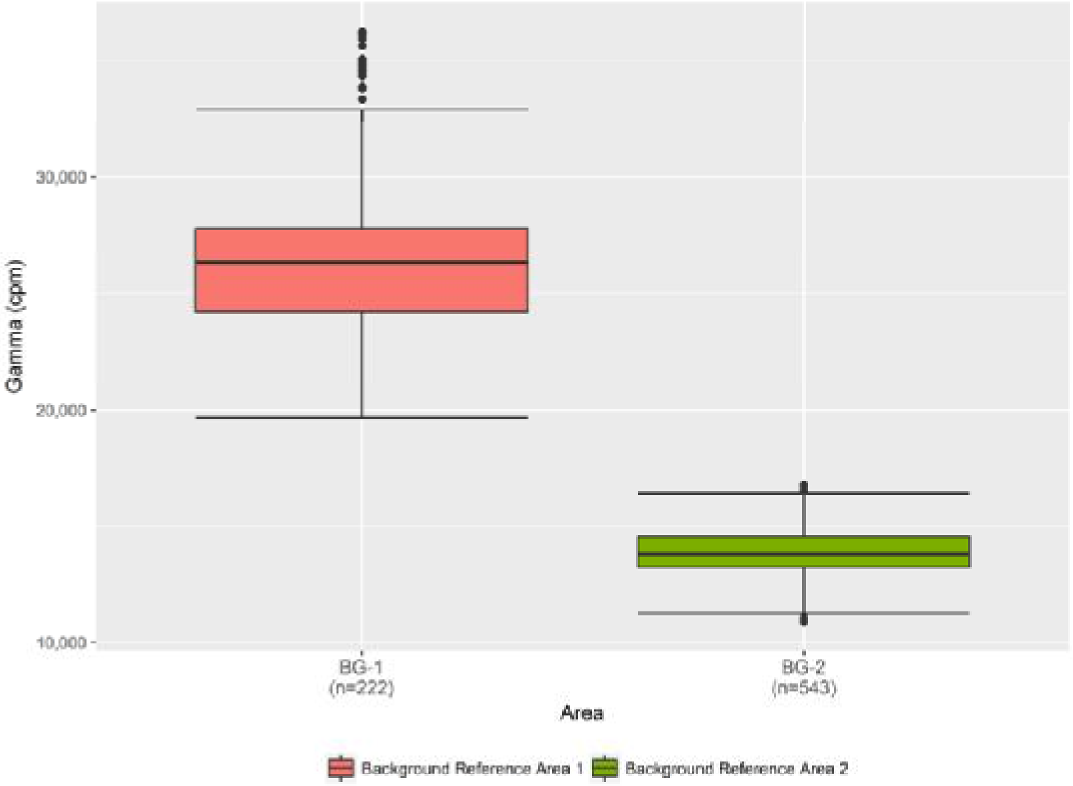


Figure 2B. Background Reference Area Gamma Radiation Boxplots



As shown in Figure 2B, there are 16 high potential outlier values shown for gamma data in the BG-1 dataset, and five in the BG-2 dataset (three high and two low). These potential outlier values do not represent skewed data as do the Survey Area results, and the gamma data are shown to be more normally distributed in BG-1 and BG-2 than in the Survey Areas. The potential outlier values shown for BG-1 and BG-2 are most likely representative of natural variation of gamma in these areas. These observations are further evaluated with the use of probability plots in Section 3.1.2 and statistical testing in Section 3.1.4.

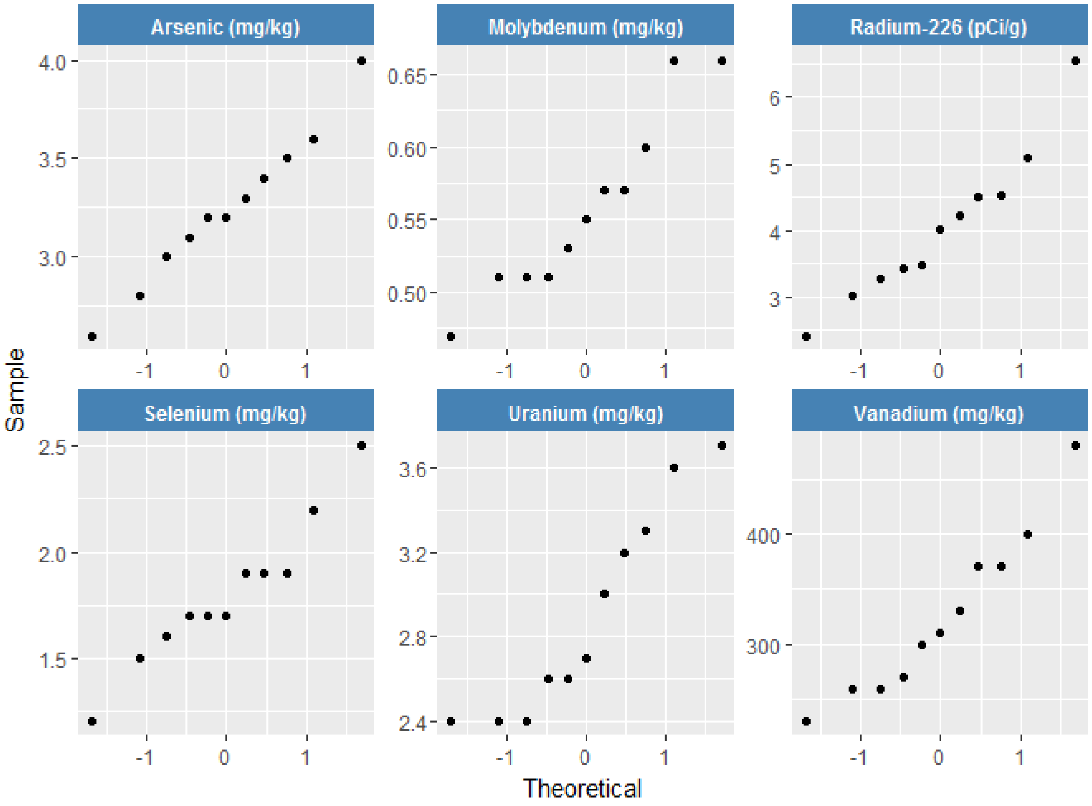
3.1.2 Probability Plots

The normal probability plot is a graphical technique for assessing whether or not a data set is approximately normally distributed and where there may be potential outlier values. The data are plotted against a theoretical normal distribution in such a way that the points, if normally distributed, should form an approximate straight line. Curved lines may indicate non-normally or lognormally distributed data, and "S"-shaped lines may indicate two distinct groups within the dataset.

3.1.2.1 Soil Sample Results Probability Plots

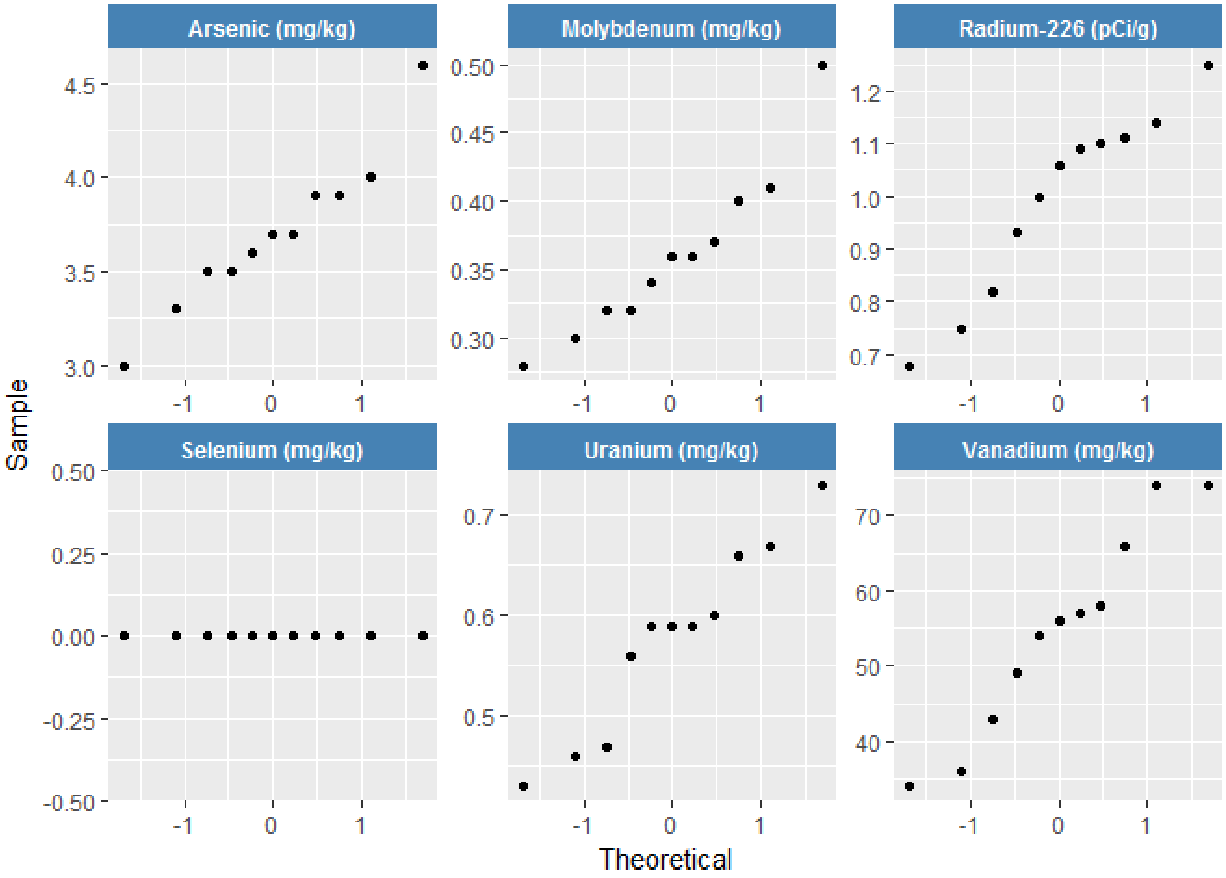
Figures 3 and 4 depict the probability plots for metals and Ra-226 results at BG-1 and BG-2, respectively.

Figure 3. Background Reference Area 1 (BG-1) Soil Sample Probability Plots



One high value for Ra-226 and two values for selenium (high and low) were identified as potential outliers (i.e., values outside 1.5 times the interquartile range) in the BG-1 box plots in Figure 1B. When viewed in the probability plots in Figure 3, these values do not appear to be substantially higher, lower, or out of line with the rest of their respective datasets, suggesting that they represent natural variability within their datasets. In addition, the values for each metal and Ra-226 are nearly linear in Figure 3, indicating normally-distributed datasets. The three potential outlier values identified in the boxplots in Figure 1B are tested further for statistical significance as potential outliers in Section 3.1.3.

Figure 4. Background Reference Area 2 (BG-2) Soil Sample Probability Plots

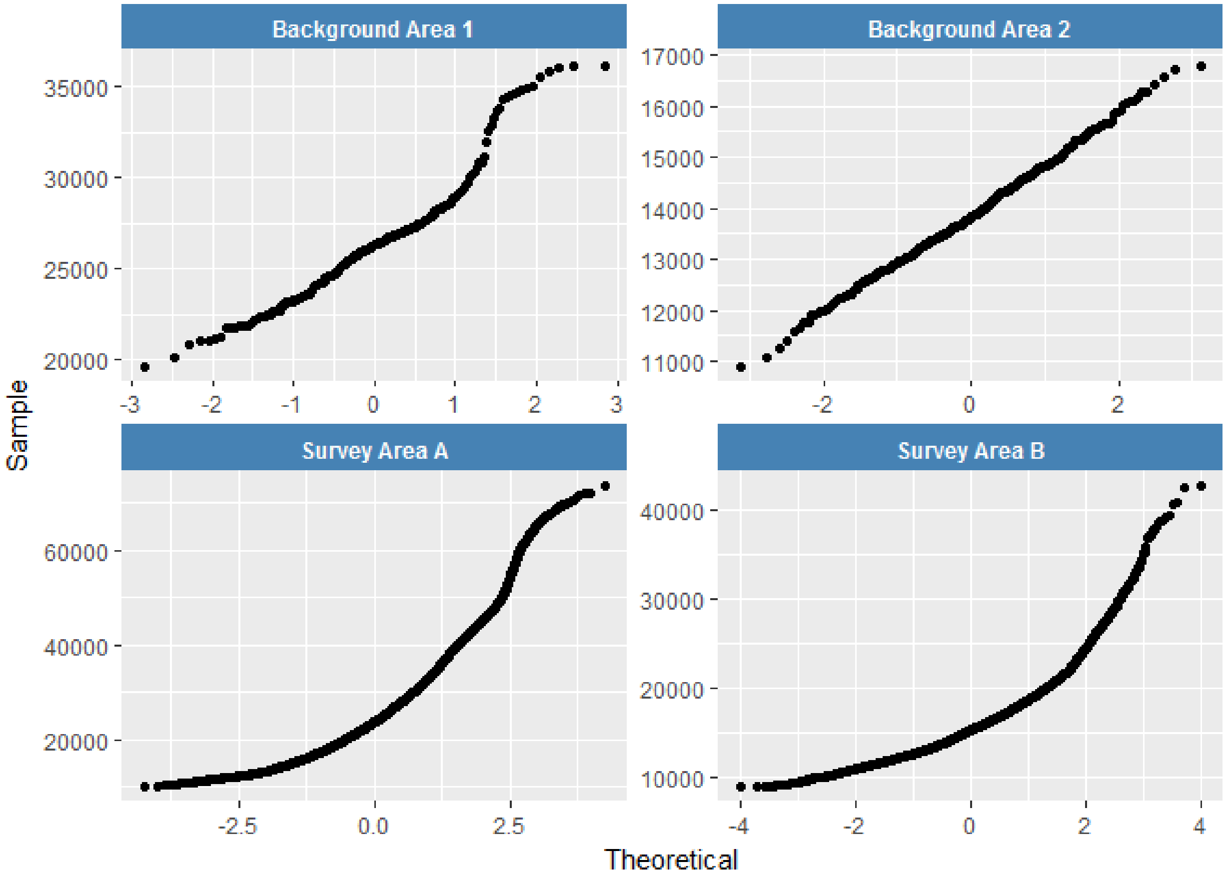


One value each for arsenic and molybdenum were identified as potential outliers (i.e., values outside 1.5 times the interquartile range) in the BG-2 box plots in Figure 1B. When viewed in the probability plots in Figure 4, these values do appear to be higher than, and out of line with, the rest of their respective datasets. These potential outlier values are further tested for statistical significance in Section 3.1.3. All 11 soil samples at BG-2 were non-detect for selenium.

3.1.2.2 Gamma Survey Results Probability Plots

The BG-1 gamma probability plot in Figure 5 is S-shaped, indicating a sub-group of higher gamma radiation values which may be distinct from the rest of the dataset, and non-normal distribution. A similar pattern is shown for the corresponding survey area, Survey Area A. This result is likely attributable to naturally-occurring, localized portions of higher-gamma geology in both BG-1 and Survey Area A. Additionally, the shape and smoothness of the probability plot for the Survey Area A gamma results confirms that the gamma radiation data are more log-normally distributed than the BG-1 gamma results. This suggests that these higher values in Survey Area A are not potential outliers, but rather are representative of the spatial variability of gamma radiation in Survey Area A. The highest 16 gamma values at BG-1 were identified as potential outliers in the box plots in Figure 2B (i.e., values outside 1.5 times the interquartile range). These values are further evaluated for statistical significance in Section 3.1.4.

Figure 5. Survey Area and Background Reference Area Gamma Probability Plots



The BG-2 gamma probability plot in Figure 5 is linear, indicating normal distribution. The shape and smoothness of the probability plot for the Survey Area B gamma results confirms that the gamma radiation data are more normally distributed than the BG-2 gamma results. This suggests that these higher values in Survey Area B are not potential outliers, but rather are representative of the spatial variability of gamma radiation in Survey Area B and may represent migration of NORM from Area A (refer to Figure 3-4). The highest five gamma values at BG-2 were identified as potential outliers in the box plots in Figure 2B (i.e., values outside 1.5 times the interquartile range). These values are further evaluated for statistical significance in Section 3.1.4.

3.1.3 Potential Soil Sample Data Outliers

Four high results and one low result are identified as potential outlier values in the boxplots in Figure 1B and probability plots in Figures 3 and 4. These values are:

Background Reference Area 1 (BG-1)

- Selenium: 1.20 mg/kg (low); 2.50 (high) mg/kg
- Ra-226: 6.56 pCi/g

These three values do not strongly appear to be potential outliers relative to the rest of their respective datasets when viewed in the probability plots in Figure 3. However, these three values were tested for statistical significance as potential outliers and the results are summarized in Table 1.

Background Reference Area 2 (BG-2)

- Arsenic: 4.60 mg/kg
- Molybdenum: 0.500 mg/kg

These two values do appear to be potential outliers relative to the rest of their respective datasets when viewed in the probability plots in Figure 4. These values also were tested for statistical significance as potential outliers and the results are summarized in Table 1.

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 five potential soil sample outlier values identified in the BG-1 and BG-2 datasets. The results of Dixon’s Test are summarized in Table 1. The test confirms that none of the five potential soil sample outliers tested are statistically significant (p value <0.05). All values were retained for calculating statistics in Section 3.3.

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

Area	Constituent	Location ID	Method	Hypothesis	p_Value	Conclusion
Background Reference Area 1 (BG-1)	Ra-226	S10006-BG1-009	Dixon test for potential outliers	high value 6.56 is a potential outlier	> 0.05	Hypothesis rejected
	Se	S10006-BG1-006	Dixon test for potential outliers	low value 1.20 is a potential outlier	> 0.05	Hypothesis rejected
	Se	S10006-BG1-009	Dixon test for potential outliers	high value 2.50 is a potential outlier	> 0.05	Hypothesis rejected
Background Reference Area 2 (BG-2)	As	S10006-BG2-004	Dixon test for potential outliers	high value 4.60 is a potential outlier	> 0.05	Hypothesis rejected
	Mo	S10006-BG2-004	Dixon test for potential outliers	high value 0.500 is a potential outlier	> 0.05	Hypothesis rejected

As = Arsenic Mo = Molybdenum Ra-226 = Radium 226 Se = Selenium

3.1.4 Potential Gamma Data Outliers

The gamma datasets for BG-1 and BG-2 showed 16 and five high potential outlier values respectively. These values were identified in the boxplots in Figure 2B.

When viewed in the probability plots in Figure 5, the BG-1 gamma probability plot is S-shaped, indicating a sub-group of higher gamma radiation values which may be distinct from the rest of the dataset, and non-normal distribution. A similar S-shaped distribution is shown for the corresponding Survey Area A.

The BG-2 gamma probability plot in Figure 5 is linear, indicating normal distribution. The shape and smoothness of the probability plot for the Survey Area B gamma results confirms that the gamma radiation data are more log-normally distributed than the BG-2 gamma results.

Because the number of gamma values in the BG-1 and BG-2 data sets is >30, Dixon's Test was not appropriate for testing potential outlier values. Instead, potential outliers were evaluated 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 (i.e., values outside 1.5 times the interquartile range) results are also provided in Table 2.

The potential outlier values evaluated were deemed significant by the methods used, as shown in Table 2. This mathematic result is not surprising due to the high number of values in these data sets, and the fact that the bulk of the values are clustered into a normal distribution, with relatively low numbers of higher values present. Interpretation of the probability plots and review of the validity of the gamma radiation results themselves are more reliable than the mathematical tests for determining the presence of any aberrant values under these circumstances.

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

Area	Value (cpm)	Interquartile Range Result	Z Score Result	t Score Result	Chi Sq Score Result
Background Reference Area 1 (BG-1)	36,225	High	Potential Outlier	Potential Outlier	Potential Outlier
	36,163	High	Potential Outlier	Potential Outlier	Potential Outlier
	36,056	High	Potential Outlier	Potential Outlier	Potential Outlier
	35,891	High	Potential Outlier	Potential Outlier	Potential Outlier
	35,609	High	Potential Outlier	Potential Outlier	Potential Outlier
	35,054	High	Potential Outlier	Potential Outlier	Potential Outlier
	34,978	High	Potential Outlier	Potential Outlier	Potential Outlier
	34,862	High	Potential Outlier	Potential Outlier	Potential Outlier
	34,768	High	Potential Outlier	Potential Outlier	Potential Outlier
	34,672	High	Potential Outlier	Potential Outlier	Potential Outlier
	34,552	High	Potential Outlier	Potential Outlier	Potential Outlier
	34,413	High	Potential Outlier	Potential Outlier	Potential Outlier
	34,312	High	Potential Outlier	Potential Outlier	Potential Outlier
	33,867	High	Potential Outlier	Potential Outlier	Potential Outlier
	33,754	High	Potential Outlier	Potential Outlier	Potential Outlier
	33,328	High	Potential Outlier	Potential Outlier	Potential Outlier
Background Reference Area 2 (BG-2)	16,806	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,728	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,559	High	Potential Outlier	Potential Outlier	Potential Outlier
	11,073	Low	Potential Outlier	Potential Outlier	Potential Outlier
	10,910	Low	Potential Outlier	Potential Outlier	Potential Outlier

cpm	Counts per minute

One possible reason for the potential outliers in a gamma radiation dataset may be the presence of a localized source of radiation. The gamma results were reviewed spatially and within the BG-1 dataset the potential outlier values were found to be clustered together in the eastern portion of BG-1, while the few potential outlier values at BG-2 were randomly located within the BG-2 area. A localized area of higher gamma radiation at BG-1 represents naturally-occurring conditions. Additionally, the gamma probability plots for BG-1 and Survey Area A each have an S shape, appearing to have localized areas of higher gamma. Therefore, BG-1 is representative of Survey Area A, and no scientific reason was found to remove the higher BG-1 values from the BG-1 gamma dataset. However, descriptive statistics are calculated with and without these values for comparison in Section 3.3.2.

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 reference area each was selected to represent the two 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-1, BG-2 and the Survey Area A and B. Relative data distributions were investigated by evaluating the boxplots and probability plots in Figures 1A through 5, 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

The boxplot comparison in Figures 1A and 1B suggests that mean metals and Ra-226 values may differ between BG-1, BG-2 and Survey Area A and B. Except for arsenic, which is elevated at BG-2, concentrations tend to be higher at BG-1 and Survey Area A than at BG-2 and Survey Area B. The mean concentrations tend to be similar at BG-1 and Survey Area A and BG-2 and Survey Area B, except for arsenic, which is higher at BG-2 than Survey Area B, and vanadium, which is higher at BG-1 than at Survey Area A. When interpreting the soil sample boxplots in Figures 1A and 1B, it is important to note that samples at BG-1 and BG-2 were collected randomly, while samples in the Survey Areas were collected judgmentally. Analytical constituent-specific observations from the boxplots in Figures 1A and 1B indicate:

- Arsenic. Arsenic concentrations appear similar in BG-1 and Survey Area A, slightly higher in BG-2 than BG-1, and higher in BG-1, BG-2, and Survey Area A compared to Survey Area B. Values for all four groups are generally grouped around an average value of 3 mg/kg.

- Molybdenum. Molybdenum concentrations are low (averaged less than 1 mg/kg) in all groups. The concentrations are higher in BG-1 and Survey Area A than BG-2 and Survey Area B, although variability in concentrations is high in Survey Area A.

- Ra-226. The concentrations of Ra-226 are higher in BG-1 and Survey Area A than BG-2 and Survey Area B, averaging around 4 pCi/g at BG-1 and Survey Area A, and 1 pCi/g at BG-2 and Survey Area B.

- Selenium. The concentrations of selenium are higher in BG-1 and Survey Area A than BG-2 and Survey Area B. Concentrations in BG-1 and Survey Area A averaged around 2 mg/kg; BG-2 had no detections of selenium, and Survey Area B had one detection at 1.30 mg/kg.

- Uranium. The concentrations of uranium are higher in BG-1 and Survey Area A than BG-2 and Survey Area B, averaging around 2 - 3 mg/kg at BG-1 and Survey Area A, compared with 0.5-0.75 mg/kg at BG-2 and Survey Area B.

- Vanadium. The concentrations of vanadium in BG-1 and Survey Area A averaged around 200 - 300 mg/kg. These are much higher than BG-2 and Survey Area B, averaged around 50 mg/kg.

3.2.1.2 Gamma Radiation Boxplots and Probability Plots

The boxplot comparison in Figures 2A and 2B suggests that mean, median and interquartile range gamma values are similar between BG-1 and Survey Area A, and BG-2 and Survey Area B. The mean gamma count is higher at BG-1 than at Survey Area A, and lower at BG-2 than Survey Area B; maximum gamma counts at Survey Areas are higher than those at background reference areas. Gamma values in BG-1 and Survey Area A are higher than those in BG-2 and Survey Area B. 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 BG-1 and BG-2 were collected randomly, while soil samples in Survey Area A and B were collected judgmentally (see Section 3.1). Mann-Whitney testing is not appropriate for comparative analysis if one or both groups contain data collected using a judgmental approach. Therefore, the Mann-Whitney test was not performed for soil sample data between background reference areas and Survey Areas. The gamma radiation data, however, do represent non-judgmental sampling, and so the Mann-Whitney test was appropriate for comparison between BG-1, BG-2 and Survey Area A and B (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 1 (BG-1) vs Survey Area A	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 1 (BG-1) Potential Outliers Excluded	0.198	No Significant Difference
Background Reference Area 1 (BG-1) Potential Outliers Excluded vs Survey Area A	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Survey Area B	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Background Reference Area 2 (BG-2) Potential Outliers Excluded	0.958	No Significant Difference
Background Reference Area 2 (BG-2) Potential Outliers Excluded vs Survey Area B	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 2 (BG-2)	<0.05	Significant Difference
Background Reference Area 1 (BG-1) Potential Outliers Excluded vs Background Area 2 (BG-2)	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 2 (BG-2) Potential Outliers Excluded	<0.05	Significant Difference
Background Reference Area 1 (BG-1) Potential Outliers Excluded vs Background Reference Area 2 (BG-2) Potential Outliers Excluded	<0.05	Significant Difference
Survey Area A vs Survey Area B	<0.05	Significant Difference

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

- Mean gamma results are calculated as statistically higher in BG-1 than Survey Area A by the Mann-Whitney test. This result is not affected by the removal of potential outliers from BG-1. However, the high number of values in the gamma radiation datasets contributes to this finding, because the means of the two groups are quite close to each other (26,494 vs. 25,208 cpm). It may be more instructive to consider the distribution of data shown in the probability plots in Figure 5, where each group is shown to be non-normally distributed with a population of higher values, with much higher values existing in Survey Area A.

- Mean gamma results are calculated as statistically higher in Survey Area B than BG-2 by the Mann-Whitney test (15,688 vs. 13,870 cpm). This result is not affected by the removal of potential outliers from BG-2.

3.3 DESCRIPTIVE STATISTICS

Descriptive statistics, including the upper confidence limit (UCL) of the mean and the 95-95 upper tolerance limit (UTL), were calculated from gamma survey data and soil sample results. Descriptive statistics are important for any data evaluation to present the basic statistics of a data set with regards to its limits (maximum and minimum), central tendencies (mean and median) as well as data dispersion (coefficient of variance). The ILs for the Site also are taken from the descriptive statistics, namely the 95-95 UTL. The UTL value is selected by ProUCL as the maximum value in the dataset when the data are determined to be non-parametric. The parameters and constituents evaluated include gamma radiation, arsenic, molybdenum, selenium, uranium, vanadium, and Ra-226. Selenium results for BG-2 were 100 percent non-detect; therefore, no statistics were calculated for selenium at BG-2.

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 were calculated for all data. The potential soil outliers identified in Figure 1B were not removed from the dataset as there was no scientific rationale for the data to be excluded. Select descriptive statistics for these constituents are presented in Tables 4 and 5.

3.3.1 Soil Sample Analytical Results Summary

As shown in Figures 1A and 1B, arsenic, molybdenum, and selenium results appear similar between BG-1 and Survey Area A, while Ra-226, uranium, and vanadium appear elevated at BG-1 compared with Survey Area A. Except for arsenic, results for BG-1 and Survey Area A are higher than results for BG-2 and Survey Area B; for arsenic, results are similar for all areas, although they are higher for the background reference areas than for the Survey Areas. Arsenic, molybdenum, and vanadium results are higher at BG-2 than at Survey Area B; results for Ra-226 and uranium are similar between BG-2 and Survey Area B. Selenium was not detected at BG-2, and only detected once at Survey Area B. An important consideration when comparing concentrations of metals and Ra-226 between background reference areas and Survey Areas is that the background reference areas were selected to be representative of the geology present in the region, whereas the Site is in an area of mineralized bedrock likely to have localized, naturally elevated uranium concentrations (see RSE Report Section 3.2.2.2). It should be noted that, with the exception of selenium in Survey Area A, concentrations of all of the metals measured in Survey Area A and B are within the range of metals concentrations typically observed in Western U.S. soils (United States Geological Survey [USGS], 1984):

- Arsenic (mean = 5.5 mg/kg; range <0.10 – 97 mg/kg)
- Molybdenum (mean = 0.85 mg/kg; range <3 – 7 mg/kg)
- Selenium (mean = 0.23 mg/kg; range <0.1 – 4.3 mg/kg)
- Uranium (mean = 2.5 mg/kg; range 0.68 – 7.9 mg/kg)
- Vanadium (mean = 70 mg/kg; range 7 – 500 mg/kg)

As shown in Table 4, maximum detected concentrations of arsenic, molybdenum, vanadium, and uranium in the Survey Areas are within typical ranges reported for Western U.S soils.

Table 4 presents the descriptive statistics output from the ProUCL software for the soil sample results.

Table 4. Summary of Soil Sampling Results

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Reference Area 1 (BG-1) All Data	Total Number of Observations	11	11	11	11	11	11
	Minimum[1]	2.60	0.470	1.20	2.40	230	2.42
	Mean[1]	3.25	0.558	1.80	2.90	326	4.05
	Median[1]	3.20	0.550	1.70	2.70	310	4.02
	Maximum[1]	4.00	0.660	2.50	3.70	480	6.56
	Distribution	Normal	Normal	Normal	Normal	Normal	Normal
	Coefficient of Variation[1]	0.119	0.111	0.192	0.168	0.228	0.280
	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	3.46	0.592	1.99	3.17	366	4.67
	UTL Type	UTL Normal	UTL Normal	UTL Normal	UTL Normal	UTL Normal	UTL Normal
	UTL Result	4.33	0.733	2.78	4.27	534	7.24
Background Reference Area 2 (BG-2) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	--	100%	--	--	--
	Minimum[1]	3.00	0.280	--	0.430	34.0	0.680
	Minimum Detect[2]	--	--	--	--	--	--
	Mean[1]	3.70	0.360	--	0.577	54.6	0.994
	Mean Detects[2]	--	--	--	--	--	--
	Median[1]	3.70	0.360	--	0.590	56.0	1.06
	Maximum[1]	4.60	0.500	--	0.730	74.0	1.25
	Maximum Detect[2]	--	--	--	--	--	--
	Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation[1]	0.112	0.170	--	0.162	0.248	0.179
	UCL Type	95% Student's-t UCL	95% Student's-t UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	3.93	0.393	Not Calculated	0.628	62.1	1.09
	UTL Type	UTL Normal	UTL Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	4.87	0.532	Not Calculated	0.840	92.8	1.50
Survey Area A	Total Number of Observations	24	24	24	24	24	24
	Percent Non-Detects	--	4%	21%	--	--	--
	Minimum[1]	1.90	--	--	0.450	23.0	0.920
	Minimum Detect[2]	--	0.240	1.10	--	--	--
	Mean[1]	3.24	--	--	2.34	197	4.38
	Mean Detects[2]	--	0.696	2.57	--	--	--
	Median[1]	3.25	--	--	2.00	180	3.17
	Median Detects[2]	--	0.620	2.40	--	--	--
	Maximum[1]	5.50	--	--	6.10	500	18.6
	Maximum Detect[2]	--	1.50	4.60	--	--	--
	Distribution	Normal	Normal	Normal	Normal	Normal	Gamma
	Coefficient of Variation[1]	0.259	--	--	0.622	0.711	0.894
	CV Detects[2]	--	0.505	0.444	--	--	--
	UCL Type	95% Student's-t UCL	95% KM (t) UCL	95% KM (t) UCL	95% Student's-t UCL	95% Student's-t UCL	95% Adjusted Gamma UCL
	UCL Result	3.54	0.801	2.66	2.85	246	5.98
	UTL Type	UTL Normal	UTL KM Normal	UTL KM Normal	UTL Normal	UTL Normal	UTL Gamma WH
	UTL Result	5.18	1.48	4.96	5.71	521	15.5

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Survey Area B	Total Number of Observations	3	3	3	3	3	3
	Percent Non-Detects	--	33%	67%	--	--	--
	Minimum[1]	2.40	--	--	0.380	25.0	0.970
	Minimum Detect[2]	--	0.300	1.30	--	--	--
	Mean[1]	2.67	--	--	0.763	52.7	1.33
	Mean Detects[2]	--	0.360	1.30	--	--	--
	Median[1]	2.50	--	--	0.710	42.0	1.16
	Median Detects[2]	--	0.360	--	--	--	--
	Maximum[1]	3.10	--	--	1.20	91.0	1.86
	Maximum Detect[2]	--	0.420	1.30	--	--	--
	Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation[1]	0.142	--	--	0.541	0.651	0.352
	CV Detects[2]	--	0.236	--	--	--	--
	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	3.31	0.515	Not Calculated	1.46	110	2.12
	UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	5.57	0.969	Not Calculated	3.92	315	4.92

[1]	This statistic is reported by ProUCL when the dataset contains 100 percent detections.
[2]	This statistic is reported by ProUCL when non-detect values exist in the dataset. The value reported is calculated using detections only.
CV	Coefficient of variation
KM	Kapplan Meier
mg/kg	Milligrams per kilogram
--	Not applicable
pCi/g	Picocuries per gram
WH	Wilson Hilferty
Note	The UTL result that is shown on the table is based on the output from ProUCL. ProUCL evaluates the data and provides all possible UCLs from its UCL module for three possible data distributions, then identifies a recommended UCL value. ProUCL does not identify a recommended UTL value. The UTLs are therefore based on the distribution of the recommended UCL. Please refer to ProUCL Version 5.1 Technical Guide Statistical Software for Environmental Applications for Data Sets with and without Non-detect Observations (EPA, 2015) for further information

3.3.2 Gamma Radiation Results Summary

Table 5 presents the descriptive statistics output from the ProUCL software for the gamma radiation survey results.

Table 5. Summary of Walk-over Gamma Results

Area	Statistic	Gamma (cpm)
Background Reference Area 1 (BG-1) All Data	Total Number of Observations	222
	Minimum	19,646
	Mean	26,494
	Median	26,306
	Maximum	36,225
	Distribution	Normal
	Coefficient of Variation	0.127
	UCL Type	95% Student's-t UCL
	UCL Result	26,867
	UTL Type	UTL Normal
	UTL Result	32,635
Background Reference Area 1 (BG-1) Excluding Potential Outliers	Total Number of Observations	206
	Minimum	19,646
	Mean	25,840
	Median	26,090
	Maximum	32,869
	Distribution	Normal
	Coefficient of Variation	0.096
	UCL Type	95% Student's-t UCL
	UCL Result	26,127
	UTL Type	UTL Normal
	UTL Result	30,401
Background Reference Area 2 (BG-2) All Data	Total Number of Observations	543
	Minimum	10,910
	Mean	13,871
	Median	13,811
	Maximum	16,806
	Distribution	Normal
	Coefficient of Variation	0.070
	UCL Type	95% Student's-t UCL
	UCL Result	13,939
	UTL Type	UTL Normal
	UTL Result	15,570

Area	Statistic	Gamma (cpm)
Background Reference Area 2 (BG-2) Excluding Potential Outliers	Total Number of Observations	538
	Minimum	11,256
	Mean	13,866
	Median	13,811
	Maximum	16,431
	Distribution	Normal
	Coefficient of Variation	0.067
	UCL Type	95% Student's-t UCL
	UCL Result	13,932
	UTL Type	UTL Normal
	UTL Result	15,503
Survey Area A	Total Number of Observations	45,418
	Minimum	9,945
	Mean	25,208
	Median	23,689
	Maximum	73,651
	Distribution	Normal
	Coefficient of Variation	0.331
	UCL Type	95% Student's-t UCL
	UCL Result	25,273
	UTL Type	UTL Normal
	UTL Result	39,049
Survey Area B	Total Number of Observations	14,650
	Minimum	8,810
	Mean	15,688
	Median	15,207
	Maximum	42,718
	Distribution	Normal
	Coefficient of Variation	0.220
	UCL Type	95% Student's-t UCL
	UCL Result	15,735
	UTL Type	UTL Normal
	UTL Result	21,430

cpm counts per minute

4.0 INVESTIGATION LEVELS

The calculated 95-95 UTL values described in Section 3.3 are used as the ILs for gamma measurement results and soil sampling results because they reflect the natural variability in the background data, and provide an upper limit from background data to be used for single-point comparisons to Survey Area data. The ILs for analytical results of soil samples and gamma radiation results in Survey Areas A and B are based on Background Reference Areas BG-1 and BG-2, respectively.

4.1 SURVEY AREA A INVESTIGATION LEVELS

- Arsenic (mg/kg): 4.33
- Molybdenum (mg/kg): 0.733
- Selenium (mg/kg): 2.78
- Uranium (mg/kg): 4.27
- Vanadium (mg/kg): 534
- Ra-226 (pCi/g): 7.24
- Gamma radiation measurements (cpm): 32,635

4.2 SURVEY AREA B INVESTIGATION LEVELS

- Arsenic (mg/kg): 4.87
- Molybdenum (mg/kg): 0.532
- Selenium (mg/kg): None (All results non-detect)
- Uranium (mg/kg): 0.840
- Vanadium (mg/kg): 92.8
- Ra-226 (pCi/g): 1.50
- Gamma radiation measurements (cpm): 15,570

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Appendix E Cultural and Biological Resource Clearance Documents

BIOLOGICAL EVALUATION

For the Proposed:

Standing Rock
Abandon Uranium Mine - Environmental Response Trust Project

Sponsored by:

MWH Global / Stantec

Prepared by:

Adkins Consulting, Inc.
180 East 12th Street, Unit 5
Durango, Colorado 81301

Revised August 2016
June 2016

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1. INTRODUCTION AND PROJECT BACKGROUND

The federal Endangered Species Act (ESA) of 1973, 16 U.S.C. §1531 et seq., requires all federal departments and agencies to conserve threatened, endangered, and critical and sensitive species and the habitats on which they depend, and to consult with the U.S. Fish and Wildlife Service (USFWS) on all actions authorized, funded, or carried out by each agency to ensure that the action will not likely jeopardize the continued existence of any threatened and endangered species or adversely modify critical habitat [USFWS 1998]. This report describes the potential for federal ESA-listed species and Navajo Nation Endangered Species List (NESL) endangered, threatened, candidate, or otherwise designated sensitive flora and fauna to occur in the proposed action area. The action area with regard to the ESA is defined as any area that may be directly or indirectly impacted by the proposed action [50 CFR §402.02]. This report is intended to provide the responsible official with information to make determinations of effect on species with special conservation status.

As the result of settlement by the United States, the Navajo Nation AUM Environmental Response Trust—First Phase was established to evaluate certain abandoned uranium mines located across the Navajo Nation. The project requires investigation of these sites prior to potential remediation activities in the future. MWH Global, a division of Stantec (MWH), will conduct exploratory activities at the Standing Rock 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

Standing Rock is located in McKinley County New Mexico, approximately 40 miles northeast of Gallup, New Mexico at an elevation of approximately 6,820 feet. Global Positioning System coordinates are 35^{o} 75’ N by 108^{o} 35’ W NAD 83. The site is located on Navajo Tribal Trust Lands within the Bureau of Indian Affairs (BIA) Eastern Agency. The legal description of the project surface location is as follows: Sections 34 and 35, Township 18 North, Range 14 West, New Mexico Principle Meridian (NMPM). Project area maps are provided in Appendix A.

2.2. Estimated Disturbance

MWH proposes a phased approach to scientific investigations at the Standing Rock AUM. The study area encompasses the claim boundary and a 100-foot perimeter buffer zone for a total of approximately 50.1 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) at Standing Rock 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 northwestern New Mexico located within the USEPA designated Arizona/New Mexico Plateau Level III Ecoregion. The Arizona/New Mexico Plateau occurs primarily in Arizona, Colorado, and New Mexico, with a small portion in Nevada. This ecoregion is approximately 45,870,500 acres, and the elevation ranges from 2,165 to 11,949 feet. The ecoregion’s landscapes include low mountains, hills, mesas, foothills, irregular plains, alkaline basins, some sand dunes, and wetlands. This ecoregion is a large transitional region between the semiarid grasslands to the east, the drier shrublands and woodlands to the north, and the lower, hotter, less vegetated areas to the west and south.

Standing Rock is situated on a low rise, Flat Top Hill, approximately 3 miles northeast of an east-west trending mesa. 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 Standing Rock Project Site* (Redente 2016) found in Appendix C.

> *Climate*
>
> The climate of the Standing Rock site is classified as semi-arid, with an average annual precipitation in the Gallup area of 292 mm with the greatest precipitation months occurring in July and August. Average annual temperature is 9.4^{o} C.

Soils

The U.S. Department of Agriculture (USDA) Soil Survey for McKinley County was published in 2005 and covers most of the county with the exception of a portion of the northwest part of the county where Standing Rock is located. The survey covers areas to the south and east of the Standing Rock site. This area of McKinley County is mainly plateaus and mesas with slopes that range from 0 to 15%. Based on the topographic features of the site, the general mapping unit for the area is most likely Razito-Shiprock and the soil type is Razito; an eolian soil derived from sandstone (USDA 2005). Typical features include mesas cuestas (a hill or ridge with a gentle slope on one site and a steep slope on the other side), and valley sites.

Land Use

The land type on the Standing Rock site is rangeland and the principal land use is domestic grazing, primarily sheep. The area is heavily grazed and the site is in fair to poor condition.

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 Standing Rock 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 Standing Rock Project Site* (Redente 2016) found in Appendix C.

> *Plant Community Type*
>
> The vegetation on the Standing Rock site is part of the Grama-galleta steppe according to Bailey (1980). The most common species on the site include blue grama (*Bouteloua gracilis*), sand dropseed (*Sporobolus cryptandrus*), galleta (*Pleuraphis jamesii*), Indian ricegrass (*Achnatherum hymenoides*), fourwing saltbush (*Atriplex canescens*), rubber rabbitbrush (*Ericameria nauseosa*), broom snakeweed (*Gutierrizia sarathrae*), and Mormon tea (*Ephedra viridis*).

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 Western scrub-jay (*Aphelocoma californica*). No signs of consistent raptor use such as whitewash or nests were observed. No prairie dog (*Cynomys* sp.) burrows were recorded within the PPA or immediate vicinity. Further analysis of sensitive species can be found in Section 4 of this document.

Hydrology/Wetlands

Under Executive Orders 11988 and 11990, Federal agencies are required to minimize the destruction, loss, or degradation of wetlands and floodplains, and preserve and enhance their natural and beneficial values. These habitats should be conserved through avoidance, or mitigated to ensure that there would be no net loss of wetlands function and value.

Run-off from precipitation in the project area generally drains northeast through Narrow Canyon to Indian Creek. Indian Creek joins Chaco Wash, the nearest perennial water source, approximately 30 miles north of the PPA. There are no wetlands, seeps, springs, or riparian areas within the proposed project area. The proposed project activities would contribute to a negligible increase in sedimentation down gradient of the project area. This increase is not anticipated to be a factor due to the distance from perennial waters. ESA-listed fish species are not known to occur in Chaco Wash, nor is it considered critical habitat of any ESA-listed species.

Cumulative impacts to surface waters would be negligible. Surface-disturbing activities other than the proposed action that may cause accelerated erosion include, but are not limited to, construction of roads, other facilities, and installation of trenches for utilities; road maintenance such as grading or ditch-cleaning; public recreational activities; vegetation manipulation and management activities; natural and prescribed fires; and livestock grazing. Because the proposed action would have a negligible impact to downstream surface water quality, the cumulative impact also would be negligible when added to other past, present, and reasonably foreseeable activities.

4. THREATENED, ENDANGERED, AND SENSITIVE SPECIES EVALUATION

The Endangered Species Act (ESA) of 1973 requires all federal departments and agencies to conserve threatened, endangered, and critical and sensitive species and the habitats on which they depend, and to consult with the U.S. Fish and Wildlife Service (USFWS) on all actions authorized, funded, or carried out by the agency to ensure that the action will not likely jeopardize the continued existence of any threatened and endangered species or adversely modify critical habitat.

4.1. Methods

4.1.1. Off-site Methods

Prior to conducting fieldwork, ACI compiled data on animal species listed under the ESA. Informal consultation was initiated by requesting an Official Species List from the USFWS Information, Planning, and Conservation System (IPaC) website (http://ecos.fws.gov/ipac/). ACI received the Official Species List (02ENNM00-2016-SLI-0448) on April 8, 2016. See Table 1 for USFWS-listed threatened, endangered, or candidate species with potential to occur in the PPA.

The Navajo Nation Department of Fish and Wildlife (NNDFW), Navajo Natural Heritage Program (File # 15mwh101) sent MWH a NESL information letter dated 29 December, 2015. The letter suggests biologists determine habitat suitability within the project area for the provided list of species of concern with potential to occur on the 7.5-minute quadrangles containing the project boundaries. The Navajo species of concern listed in the NESL information letter are included in Table 2.a below.

In addition to the above listed species, ACI reviewed species protected under the MBTA with potential to occur in the proposed project and action area (Table 3).

4.1.2. On-site Survey Methods

An on-site pedestrian survey was conducted in April 2016 by ACI personnel under a permit issued by NNDFW. The purpose of the survey was to assess habitat potential for ESA-listed or NESL animal species. Field biologists with considerable experience identifying local wildlife species lead survey crews. The survey consisted of walking transects ten feet apart throughout the PPA including a survey buffer of approximately 50 feet beyond the PPA edge of disturbance. The surrounding areas were visually inspected with binoculars for nests, raptors, or past signs of raptor use. Weather conditions were clear with a slight breeze. All plant and wildlife species observed in the action area were recorded, and digital photos were taken (Appendix B).

Redente conducted surveys for plant species of concern. The results of the 2016 Redente biological investigations will be incorporated in Sections 4.2 and 4.3 of this report and can be found in entirety attached as Appendix C.

4.2. ESA-Listed Species Analysis and Results

4.2.1. Species from the USFWS IPaC Official Species List

Table 1 includes ESA-listed species that have the potential to occur in the project area based on the USFWS IPaC Official Species List. Biologists evaluated habitat suitability within and surrounding the PPA for the species in Table 1.

Table 1: USFWS Species List for the Standing Rock Project

Species	Status	Occurrence Within Region	Habitat	Potential to Occur within Action Area
BIRDS				
Southwestern Willow Flycatcher (*Empidonax traillii extimus*)	Endangered with Designated Critical Habitat	Summer/breeding range.[2]	Breeds in dense riparian habitat.[2]	No potential. Action area does not provide suitable habitat for species to occur.
Mexican spotted owl (*Strix occidentalis lucida*)	Threatened with Designated Critical Habitat	Year-round range.[1]	Mixed conifer forests. Typically where unlogged, uneven-aged, closed-canopy forests occur in steep canyons.[1]	No potential. Action area does not provide suitable habitat for species to occur.
Western Yellow-Billed Cuckoo (*Coccyzus americanus*)	Threatened	Possible rare summer/breeding occurrences.[2]	In the southwestern U.S., associated with riparian woodlands dominated by cottonwood or willow trees. In New Mexico, native or exotic species may be used.[2]	No potential. Action area does not provide suitable habitat for species to occur.
FISHES				
Zuni Bluehead Sucker (*Catostomus discobolus yarrowi*)	Endangered	Native to headwater streams of the Little Colorado River in east-central AZ and west-central NM; current range in NM is limited to the upper Río Nutria drainage.[2]	Low-velocity pools and pool-runs with seasonally dense perilithic and periphytic algae, particularly shady, cobble/boulder/bedrock substrates in streams with frequent runs and pools.[2]	No potential. Action area does not provide suitable habitat for species to occur.
PLANTS				

Table 1: USFWS Species List for the Standing Rock Project

Species	Status	Occurrence Within Region	Habitat	Potential to Occur within Action Area
Zuni Fleabane (*Erigeron rhizomatus*)	Threatened	Chuska Mts from Lukachukai and west of Red Valley, Apache Co., AZ south to Navajo in McKinley County, NM.	Typically only found on fine textured clay hillsides of mid to high elevation between ca. 7000 and 8300ft. It is known from clays derived from the Chinle Formation in the Zuni and Chuska Mountains, and to similar clays of the Baca Formation in the Datil and Sawtooth ranges in New Mexico.[2]	No potential. Action area does not provide suitable habitat for species to occur. No individuals found during the 2016 Redente site surveys.[4]

[1]USFWS; [2]NatureServe Explorer; [3]Navajo Endangered Species List, Species Accounts 2008; [4]Redente 2016

4.2.2. ESA-Listed Species Eliminated From Further Consideration

Table 1 includes five (5) ESA-listed species that have the potential to occur in the project area based on the USFWS IPaC Official Species List. All of the species in Table 1 have been eliminated from further discussion in this report. There would be no direct, indirect or cumulative impacts to the species in Table 1.

4.3. NESL Species Analysis and Results

4.3.1. Navajo Endangered Species List (NESL) and Species of Concern

Table 2.a lists species of concern with potential to occur on the 7.5-minute quadrangle(s) containing the project boundaries. According to the NESL information letter received from the NFWD found in Appendix D, there is no record of species of concern occurring on or near the project site. Biologists evaluated the potential for species of concern listed in the table below to occur within the project area.

Additionally, the NESL information letter requested that the potential for black-footed ferret (*Mustela nigripes*) be evaluated if prairie dog towns of sufficient size (per NFWD guidelines) occur in the project area, and that potential for Parish's alkali grass (*Puccinellia parishii*) be evaluated if wetland conditions exist that contain white alkaline crusts. Species listed by the USFWS in Table 1 are not reiterated here.

Table 2.a: Navajo Endangered Species List (NESL) and Species of Concern

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area
ANIMALS			
Kit fox (*Vulpes macrotis*)	NESL G4	Desert grassland or desert scrub w/ soft, alluvial or silty-clay soils often w/ sparse shrubs and grasses.[3]	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.	No potential. Action area does not provide suitable habitat for species to occur.

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area
		Migration habitat is similar to breeding habitat.[3]	
Black-footed ferret (*Mustela nigripes*)	USFWS Endangered	Open habitat, including grasslands, steppe, and shrub steppe. Closely associated with prairie dog colonies. At least 40 hectares of prairie dog colony required to support one ferret.[1]	No potential. Action area does not provide suitable habitat for species to occur. Action area does not provide prairie dog colonies of sufficient size
Western burrowing owl (*Athene cunicularia hypugaea*)	NESL G4	Open grasslands and sometimes other open areas (such as vacant lots). Nests in abandoned burrows, such as those dug by prairie dogs. [1,3]	No potential. Action area does not provide suitable habitat for species to occur.
Golden eagle (Aquila chrysaetos)	NESL G3	In the west, mostly open habitats in mountainous, canyon terrain. Nests primarily on cliffs.[1,3]	Action area provides potential foraging habitat for species to occur.
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. [1,3]	Action area provides potential foraging habitat for species to occur.
American peregrine falcon (Falco peregrinus)	NESL G4 NM-T	Nest in ledges or potholes on cliffs in wooded/forested habitats; Forage over riparian woodlands, coniferous & deciduous forests, shrublands, prairies.[1,3]	Action area provides potential foraging habitat for species to occur.

Species are listed by the NESL as; Group 2: Endangered (survival or recruitment in jeopardy); Group 3: Endangered (survival or recruitment in jeopardy in foreseeable future); and Group 4: Species of Consideration. NESL Species with New Mexico State Endangered or Threatened status are labeled as NM-T or NM-E.

Sources: [1]New Mexico Natural Heritage Program 2010, [2]NatureServe Explorer; [3]Navajo Endangered Species List, Species Accounts 2008, [4] IUCN Red List, [5]Redente 2016, [6] Hammerson et al 2004.

4.3.2. NESL Species Eliminated From Further Consideration

Table 2.a includes seven (7) NESL and Navajo Species of Concern that have the potential to occur in the project area based on general geographical association. The following species have been eliminated from further discussion in this report because the action area does not provide suitable habitat for them to occur: Kit fox (*Vulpes macrotis*), Mountain plover *(Charadrius montanus),* Black-footed ferret (*Mustela nigripes*), and Western burrowing owl (*Athene cunicularia hypugaea*). None of these species were observed during surveys of the proposed project area or immediate surroundings. Critical habitats of these species do not exist within or adjacent to the proposed project area. There would be no direct, indirect or cumulative impacts to these species.

4.3.3. NESL Species Warranting Further Analysis

Table 2.b lists NESL and Navajo Species of Concern with potential to occur within the proposed project area based on habitat suitability or actual record of observation.

Table 2.b: NESL and Navajo Species of Concern Warranting Further Analysis

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area
ANIMALS			
Golden eagle (*Aquila chrysaetos*)	NESL G3	In the west, mostly open habitats in mountainous, canyon terrain. Nests primarily on cliffs.[1,4]	Action area provides potential foraging habitat for species to occur.

Species	**Status**	**Habitat Associations**	**Potential to Occur in Project or Action Area**
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. [1,4]	Action area provides potential foraging habitat for species to occur.
American peregrine falcon (*Falco peregrinus*)	NESL G4 NM-T	Nest in ledges or potholes on cliffs in wooded/forested habitats; Forage over riparian woodlands, coniferous & deciduous forests, shrublands, prairies.	Action area provides potential foraging habitat for species to occur.

Species are listed by the NESL as; Group 2: Endangered (survival or recruitment in jeopardy); Group 3: Endangered (survival or recruitment in jeopardy in foreseeable future); and Group 4: Species of Consideration. NESL Species with New Mexico State Endangered or Threatened status are labeled as NM-T or NM-E.

Sources: [1]New Mexico Natural Heritage Program 2010, [2]NatureServe Explorer; [3]Navajo Endangered Species List, Species Accounts 2008, [4] IUCN Red List, [5]Redente 2016, [6] Hammerson et al 2004.

4.4. Migratory Bird Species

The Migratory Bird Treaty Act (MBTA) implements various treaties and conventions between the U.S. and Canada, Japan, Mexico and the former Soviet Union for the protection of migratory birds. Under the Act, taking, killing or possessing migratory birds is unlawful.

The bald eagle (*Haliaeetus leucocephalus*) was delisted under the ESA on August 9, 2007. Both the bald eagle and golden eagle (*Aquila chrysaetos*) are still protected under the MBTA and Bald and Golden Eagle Protection Act (BGEPA). The BGEPA affords both eagles protection in addition to that provided by the MBTA, in particular, by making it unlawful to "disturb" eagles.

In preparation for conducting the migratory bird survey, information from the New Mexico Partners In Flight website (http://www.hawksaloft.org/pif.shtml), the New Mexico PIF highest priority list of species of concern by vegetation type, the USFWS's Division of Migratory Bird Management website (http://www.fws.gov/migratorybirds/), and the 2002 Birds of Conservation Concern Report for the Southern Rockies/Colorado Plateau Bird Conservation Region (BCR) No. 16, were used to develop a list of high priority migratory bird species with potential to occur in the area of the proposed action. Species addressed previously will not be reiterated here.

Table 3: Priority Birds of Conservation Concern with Potential to Occur in the Project Area

Species Name	**Habitat Associations**	**Potential to Occur in the Project Area**
Black-throated sparrow (*Amphispiza bilineata*)	Xeric habitats dominated by open shrubs with areas of bare ground.	Suitable habitat is present within the action area for species to occur.
Brewer's sparrow (*Spizella breweri*)	Closely associated with sagebrush, preferring dense stands broken up with grassy areas.	No suitable habitat is present within the action area for species to occur.
Gray vireo (*Vireo vicinior*)	Open stands of piñon pine and Utah juniper (5,800 – 7,200 ft) with a shrub component and mostly bare ground; antelope bitterbrush, mountain mahogany, Utah serviceberry and big sagebrush often present. Broad, flat or gently sloped canyons, in areas with rock outcroppings, or near ridge-tops.	No suitable habitat is present within the action area for species to occur.
Loggerhead shrike (*Lanius ludovicianus*)	Open country interspersed with improved pastures, grasslands, and hayfields. Nests in sagebrush areas, desert scrub, and woodland edges.	Suitable habitat is present within the action area for species to occur.

Mountain bluebird (*Sialia currucoides*)	Open piñon-juniper woodlands, mountain meadows, and sagebrush shrublands; requires larger trees and snags for cavity nesting.	No suitable habitat is present within the action area for species to occur.
Mourning dove (*Zenaida macroura*)	Open country, scattered trees, and woodland edges. Feeds on ground in grasslands and agricultural fields. Roost in woodlands in the winter. Nests in trees or on ground.	Suitable habitat is present within the action area for species to occur.
Sage sparrow (*Amphispiza belli*)	Large and contiguous areas of tall and dense sagebrush. Negatively associated with seral mosaics and patchy shrublands and abundance of greasewood.	No suitable habitat is present within the action area for species to occur.
Sage thrasher (*Oreoscoptes montanus*)	Shrub-steppe dominated by big sagebrush.	Marginal habitat is present within the action area for species to occur. Lack of significant sagebrush shrubland likely a limiting factor.
Scaled quail (*Callipepla squamata*)	Brushy arroyos, cactus flats, sagebrush or mesquite plains, desert grasslands, Plains grasslands, and agricultural areas. Good breeding habitat has a diverse grass composition, with varied forbs and scattered shrubs.	No suitable habitat present within the action area for species to occur. Lack of diverse grass composition with varied forbs likely a limiting factor.
Swainson's hawk (*Buteo swainsoni*)	A mixture of grassland, cropland, and shrub vegetation; nests on utility poles and in isolated trees in rangeland. Nest densities higher in agricultural areas.	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 AZ and scattered locations in central & western NM; most common in southwest NM.	Suitable habitat is present within the action area for species to occur.
Piñon jay (*Gymnorhinus cyanocephalus*)	Foothills throughout CO and NM wherever large blocks of piñon-juniper woodland habitat occurs.	No suitable habitat present within the action area for species to occur.
Prairie falcon (*Falco mexicanus*)	Arid, open country, grasslands or desert scrub, rangeland; nests on cliff ledges, trees, power structures.	Action area provides potential foraging habitat for species to occur.

5. EFFECTS ANALYSIS

Effects or impacts can be either long term (permanent or residual) or short term (incidental or temporary). Short-term impacts affect the environment for only a limited period and then the environment reverts rapidly back to pre-action conditions. Long-term impacts are substantial and permanent alterations to the pre-existing environmental condition. Direct effects are those effects that are caused by the action and occur in the same time and place as the action. Indirect effects are those effects that are caused by or will result from the proposed action and are later in time but still reasonably certain to occur (USFWS 1998).

5.1. Direct and Indirect Effects

The PPA includes the claim boundary and a 100-foot perimeter buffer for a total of approximately 50.1 acres. The project will also include a walkover survey for gamma radiation across a small area known as the “background area” (see Appendix A for map). A few soil samples approximately 3 inches in diameter and up to 6 inches deep will be collected by hand in these areas. The proposed action would result in a short term increase in human activity within the PPA at varying degrees depending on the project phase:

- Phase I: Spring of 2016 activity would entail pedestrian biological surveys and land surveying. During 2016, work would entail pedestrian activity including gamma surveys, mapping, well sampling, and surface soil sampling. For this phase, there will be a maximum of 5 people onsite for no more than 5 to 7 days. Surface disturbance would be minimal and noise would be light.
- Phase II: Beginning in 2017, equipment including an excavator or small mobile drilling unit may be used to collect one or more soil samples. Up to 8 people may be onsite all day for a period of one week. Equipment travel would be confined to a temporary travel corridor approximately 20 feet in width. Within the travel corridor, vegetation and surface soil would sustain some disturbance but would not be bladed or bulldozed. During Phase II, noise may be moderate for a short duration, and surface disturbance will be light to moderate but confined to a minimal footprint within the study area. No permanent structures will be left on site.

Best Management Practices (BMPs) incorporated into project design will reduce potential impacts including: confining equipment travel to PPA boundary, minimizing travel corridors as much as practicable, limiting truck and equipment travel within the PPA when surfaces are wet and soil may become deeply rutted, and using previously disturbed areas for travel when possible.

5.1.1. Golden eagle, Ferruginous hawk, American peregrine falcon

Due to the mobility of adult raptors and the lack of appropriate nesting sites in the vicinity of the proposed project area, it is unlikely that the proposed project would result in 1) injury to a raptor, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior. Short term audial and visual disturbances associated with the Phase II activity could cause minor indirect habitat loss by temporarily deterring raptors from using available habitat adjacent to the proposed project area.

5.1.2. Migratory Birds

The PPA encompasses approximately 50.1 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.

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. Direct impacts are more likely if surface disturbing activities occur during the breeding season (April 1 through August 15); however, surface disturbance will be confined to

a minimal footprint (likely less than one acre) within the study area. The increased human presence during project activities within the breeding season may indirectly disturb or displace adults from nests and foraging habitats for a short period of time.

5.2. Cumulative Effects

Cumulative impacts of an action include the total effects on a resource or ecosystem. Cumulative effects in the context of the Endangered Species Act pertain to non-Federal actions, and are reasonably certain to occur in the action area (USFWS 1998).

5.2.1. Golden eagle, Ferruginous hawk, American peregrine falcon

Additional existing surface disturbances within the action area include unimproved access roads to the residences nearby, all-terrain vehicle use and active wildlife and livestock grazing. Local plant and animal pest control and small scale farming are also activities that occur in the vicinity. These foreseeable actions would cumulatively impact raptors through habitat loss or contamination. Human activity may also increase available prey base if the activity leads to an increase in rodent population numbers. The intensity of indirect effects would be dependent upon the species, its life history, time of year and/or day and the type and level of human and vehicular activity is occurring.

5.2.2. Migratory Birds

With the implementation of BMPs discussed in Section 5.1, the cumulative impact of the proposed action on migratory birds would be low based on the minimal surface disturbance involved and the availability of adjacent similar habitats.

6. CONCLUSIONS

U.S. Fish and Wildlife Service Listed Species (USFWS)

ACI conducted informal consultation with the USFWS and received an Official Species List for the proposed project area. Qualified ACI biologists evaluated habitat suitability within and surrounding the PPA for these species and concluded the potential does not exist for USFWS-listed species to occur within the proposed project area. No further consultation with the USFWS is required.

Migratory Birds

The proposed action phases would result in short term activity within approximately 50.1 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 15). Effects to potential habitat for migratory birds is anticipated to be minor and short term due to the limited degree of vegetation and soil disruption and the abundance of adjacent habitat for these species.

Wetlands

Under Executive Orders 11988 and 11990, Federal agencies are required to minimize the destruction, loss, or degradation of wetlands and floodplains, and preserve and enhance their natural and beneficial values. These habitats should be conserved through avoidance, or mitigated to ensure that there would be no net loss of wetlands function and value. No impacts to wetlands are anticipated. The proposed project activities would contribute to a negligible increase in sedimentation down gradient of the project area. This increase is not anticipated to be a factor due to the distance from perennial waters. There is no suitable habitat for ESA-listed fish in Chaco Wash, nor is it considered critical habitat of any ESA-listed species.

Navajo Endangered Species List (NESL) and Species of Concern

Three (3) NESL and Navajo species of concern have potential to occur within the PPA based on habitat suitability or actual record of observation. Based on site surveys, ACI determined the PPA contains potential foraging habitat for the following: golden eagle, ferruginous hawk, and American peregrine falcon. Due to the mobility of adult raptors and the lack of appropriate nesting sites in the vicinity of the proposed project area, it is unlikely that the proposed project would result in detriment to the raptors.

7. RECOMMENDATIONS FOR AVOIDANCE

ACI recommends that the proponent implement standard Best Management Practices (BMPs) designed to protect sensitive wildlife species during project activity including: confining equipment travel to PPA boundary, minimizing travel corridors as much as practicable, limiting truck and equipment travel within the PPA when surfaces are wet and soil may become deeply rutted, and using previously disturbed areas for travel when possible.

8. SUPPORTING INFORMATION

8.1. Consultation and Coordination

John Nystedt, Fish and Wildlife Biologist/AESO Tribal Coordinator
USFWS AZ Ecological Services Office - Flagstaff Suboffice
Southwest Forest Science Complex, 2500 S Pine Knoll Dr, Rm 232
Flagstaff, AZ 86001

Pam Kyselka, Project Reviewer and
Chad Smith, Zoologist
Navajo Nation Department of Fish and Wildlife
Natural Heritage Program
PO Box 1480
Window Rock, AZ 86515

8.2. Report Preparers and Certification

Adkins Consulting, Inc.
180 E. 12th Street, Unit 5
Durango, Colorado 81301
Lori Gregory, Biologist; Sarah McCloskey, Field Biologist; Arnold Clifford, Lead Field Biologist

It is believed by Adkins Consulting that the proposed action would not violate any of the provisions of the Endangered Species Act of 1973, as amended. Conclusions are based on actual field examination and are correct to the best of my knowledge.

10 June 2016

Lori Gregory
Wildlife Biologist
Adkins Consulting
505.787.4088

Date

8.3. References

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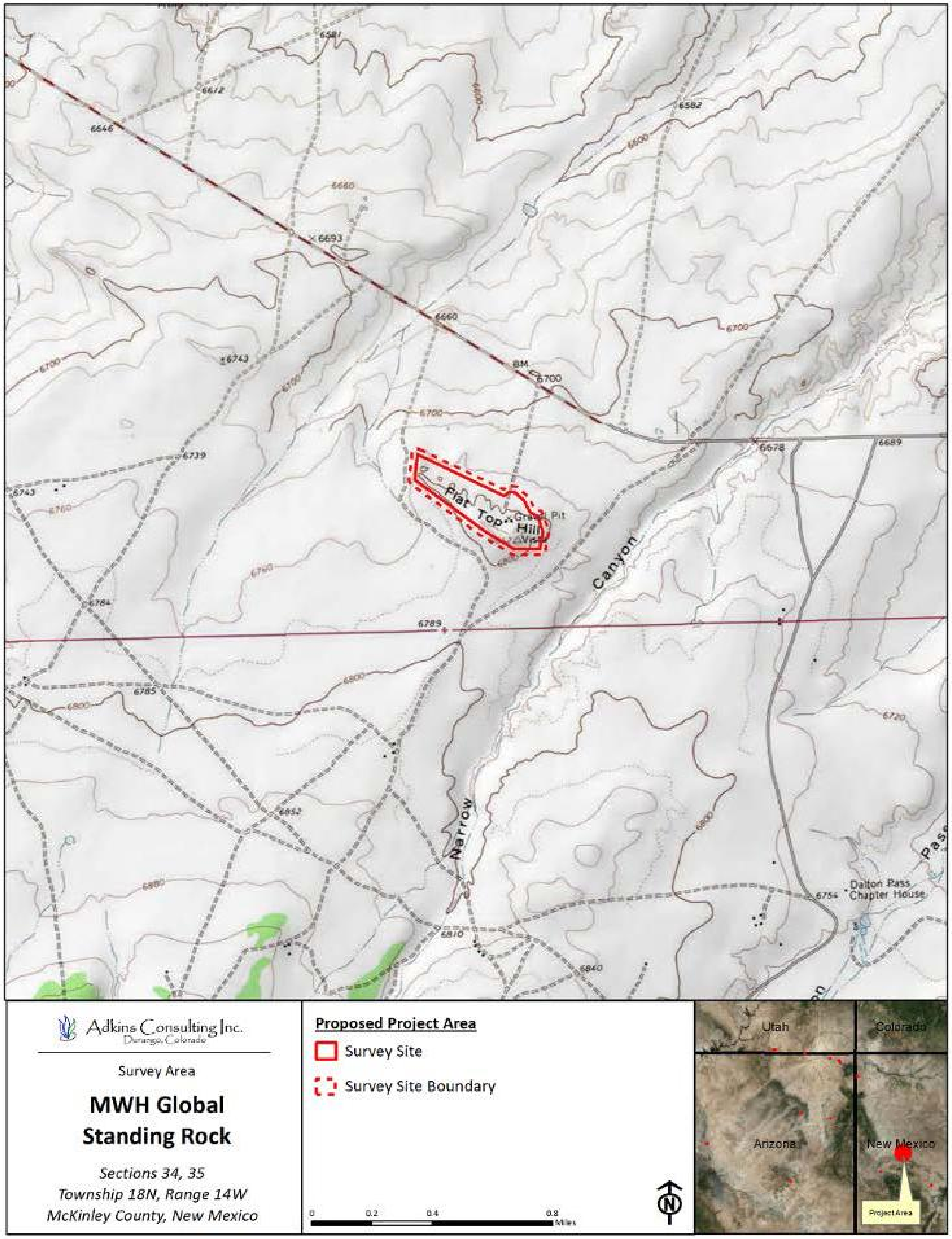
APPENDIX A. MAPS


Adkins Consulting Inc.
Durango, Colorado
Survey Area
MWH Global
Standing Rock
Sections 34, 35
Township 18N, Range 14W
McKinley County, New Mexico
Proposed Project Area
Survey Site
Survey Site Boundary
0
0.2
0.4
0.8
Miles
N
Utah
Colorado
Arizona
New Mexico
Project Area
Flat Top Hill
Gravel Pit
Canyon
Narrow
Pass
Dalton Pass Chapter House
BM
6700
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6600
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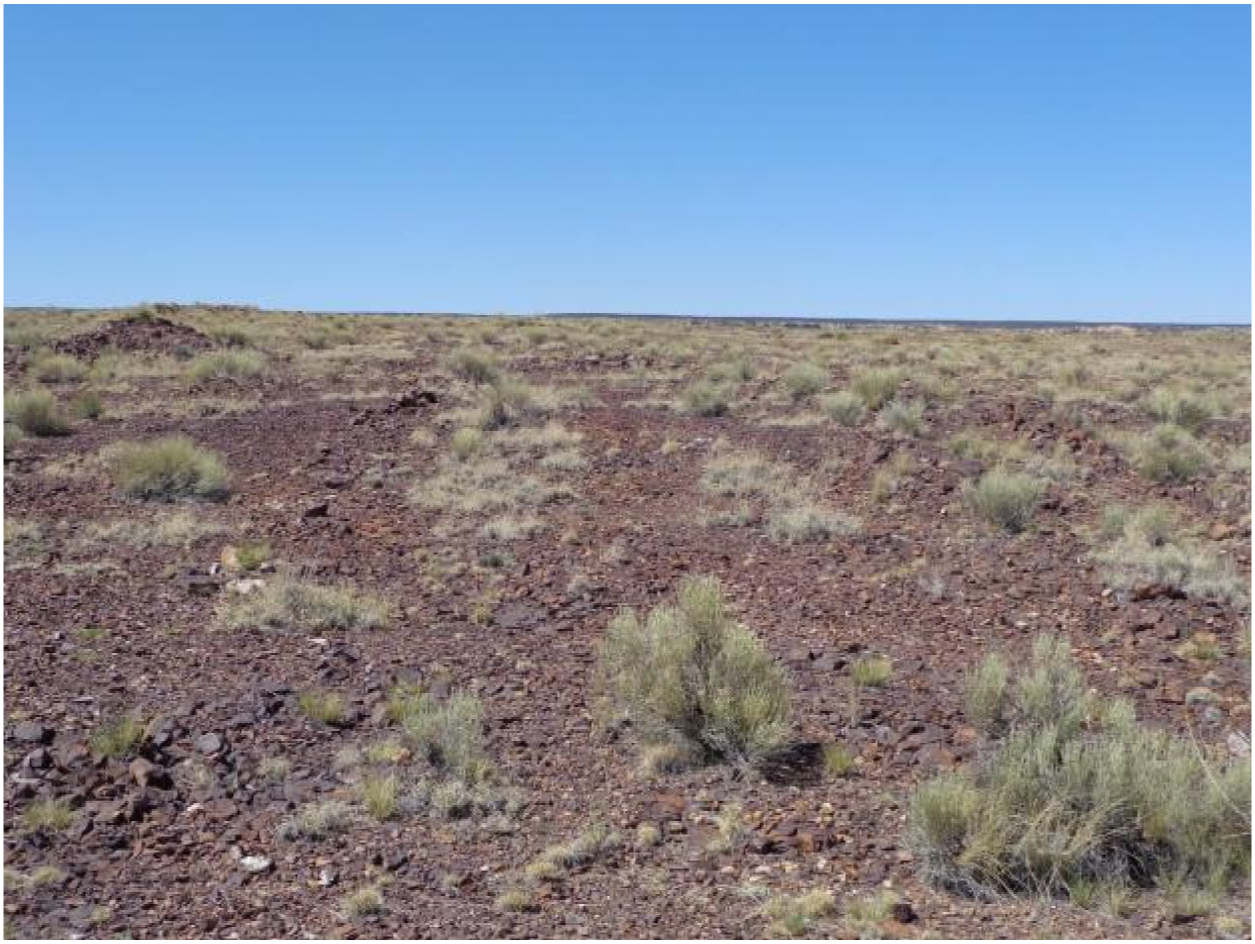
APPENDIX B. PHOTOGRAPHS

APPENDIX C. REDENTE PLANT SURVEY REPORT

Navajo Nation AUM Environmental Response Trust



Plant Survey Report for Species of Concern At Standing Rock Project Site McKinley County, New Mexico

August, 2016

Prepared by:
Redente Ecological Consultants
1322 Alene Circle
Fort Collins, CO 80525

TABLE OF CONTENTS

INTRODUCTION

Purpose of Report

A biological survey was conducted at the Standing Rock site as part of the Navajo Nation AUM Environmental Response Trust. The purpose of the survey is to determine if plant species of concern are present within the claim boundary and extending 100 feet around the site. Biological clearance is required at each site prior to any site investigation to determine if the project may affect potential species-of-concern or potential federal threatened and endangered (T&Es) species and/or critical habitat.

Site Location

Standing Rock is located in McKinley County New Mexico, approximately 65 km northeast of Gallup, New Mexico at an elevation of approximately 2,070 m (6,791 ft). Global Positioning System coordinates are 35° 44' 46" N by 108° 18' 13" W (North American Datum of 1983). The site is located on Tribal Trust Land (TTL).

Environmental Setting

Climate

The climate of the Standing Rock site is classified as semi-arid. The average annual precipitation at the closest official weather station in Gallup, New Mexico is 292 mm (11.5 in), with the greatest precipitation months occurring in July and August. Average annual temperature is 9.4° C (49° F).

Soils

The U.S. Department of Agriculture (USDA) Soil Survey for McKinley County was published in 2005 and covers most of the county with the exception of a portion of the northwest part of the county where Standing Rock is located. The survey covers areas to the south and east of the Standing Rock site. This area of McKinley County is mainly plateaus and mesas with slopes that range from 0 to 15%. Based on the topographic features of the site, the general mapping unit for the area is most likely Razito-Shiprock and the soil type is Razito; an eolian soil derived from sandstone (USDA 2005). Typical features include mesas, cuestas (which are hills or ridges with a gentle slope on one site and a steep slope on the other side), and valley sites.

Plant Community Type

The vegetation on the Standing Rock site is part of the Grama-galleta steppe according to Bailey (1980). The most common species on the site include blue grama (*Bouteloua gracilis*), sand dropseed (*Sporobolus cryptandrus*), galleta (*Pleuraphis jamesii*), Indian ricegrass (*Achnatherum hymenoides*), fourwing saltbush (*Atriplex canescens*), rubber rabbitbrush (*Ericameria nauseosa*), broom snakeweed (*Gutierrizia sarathrae*), and Mormon tea (*Ephedra viridis*).

Land Use

The land type on the Standing Rock site is rangeland and the principal land use is domestic grazing, primarily sheep. The area is heavily grazed and the site is in fair to poor condition.

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 two endangered plant species that may occur in the project area. These species included Sivinski’s fleabane (*Erigeron sivinskii*), and Naturita milkvetch (*Astragalus naturitensis*). 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 steep barren slopes, sand filled pockets of sandstone and rimrock pavement, and fine textured clay hillsides. The most emphasis was placed in areas with suitable habitat for the species of concern. If a species of concern was identified, the location would be recorded using the point or polygon feature in the GPS units. Further, the population size was planned to be obtained either by direct counts, estimations, or by sampling the population.

Field botanists documented every field visit on field forms, by area, and took photographs of field conditions and species of concern, if found on site. The botanist also recorded all plant communities and plant species observed during each field visit. Plant community types were also photographed to document site conditions (Photos #1 and #2).

RESULTS

A total of 3 plant species of concern were identified as potentially occurring within the proximity of the project area. These species included *Erigeron sivinskii*, *Astragalus naturitensis and Erigeron rhizomatus*. *Erigeron sivinskii* is a native perennial forb that has a general distribution in Apache and McKinley Counties and inhabits steep barren shale slopes in Desert Shrub and Pinyon-Juniper communities at elevations between 1,860 and 2,250 m. *Astragalus naturitensis* is a native legume that occurs in McKinley and San Juan Counties and inhabits sand filled pockets of sandstone and rimrock pavement in the Pinyon-Juniper community type. Populations have been recorded for this species at elevations between 1,525 to 2,135 m. *Erigeron rhizomatus* is native perennial forb found in McKinley, San Juan and Catron Counties. It is found growing on fine textured clay hillsides primarily in Pinyon-Juniper type. It occurs at elevation ranges between 2,135 and 2,530 m.

The survey at Standing Rock on May 4 and 5, 2016 did not identify any of the three species that have been listed as potential species of concern for this site. The habitat at Standing Rock may not be appropriate for the occurrence of any of the three species because the primary plant community type of Pinyon-Juniper occurs outside of the Standing Rock site. In addition, the heavily grazed condition of the site would most likely impact the occurrence of these species if they were present at some time in the past.

Photo #1—Overview of general landscape and plant community at Standing Rock.

Photo #2—Overview of general landscape and plant community at Standing Rock.

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LIST OF PREPARERS

Redente, Edward F. Plant Ecologist. B.A., M.S. and Ph.D. Over 40 years of experience in plant ecology and plant survey studies throughout the semi-arid and arid western U.S. Author or Co-author of over 200 publications.

APPENDIX D. NESL LETTER

NNHP
Navajo Natural Heritage Program

PO Box 1480
Window Rock, AZ
86515

P 928.871.6472
F 928.871.7603

http://nnhp.nndfw.org

15mwh101

19-November-2015

Eileen Dornfest - Project Manager
MWH Americas
3665 John F Kennedy Parkway
Bldg 1, Suite 206
Ft. Collins, CO 80525

SUBJECT: Navajo Nation AUM Environmental Response Trust (ERT) Project - 16 Abandoned Uranium Mine (AUM) Sites

Eileen Dornfest,

NNHP has performed an analysis of your project in comparison to known biological resources of the Navajo Nation and has included the findings in this letter. The letter is composed of seven parts. The sections as they appear in the letter are:

1. **Known Species** – a list of all species within relative proximity to the project
2. **Potential Species** – a list of potential species based on project proximity to respective suitable habitat
3. **Quadrangles** – an exhaustive list of quads containing the project
4. **Project Summary** – a categorized list of biological resources within relative proximity to the project grouped by individual project site(s) or quads
5. **Conditional Criteria Notes** – additional details concerning various species, habitat, etc.
6. **Personnel Contacts** – a list of employee contacts
7. **Resources** – identifies sources for further information

Known Species lists “species of concern” known to occur within proximity to the project area. Planning for avoidance of these species is expected. If no species are displayed then based upon the records of the Navajo Nation Department of Fish and Wildlife (NNDFW) there are no “species of concern” within proximity to the project. Refer to the Navajo Endangered Species List (NESL) Species Accounts for recommended avoidance measures, biology, and distribution of NESL species on the Navajo Nation (http://nnhp.nndfw.org/sp_account.htm).

Potential Species lists species that are potentially within proximity to the project area and need to be evaluated for presence/absence. If no species are found within the Known or Potential Species lists, the project is not expected to affect any federally listed species, nor significantly impact any tribally listed species or other species of concern. Potential for species has been determined primarily on habitat characteristics and species range information. A thorough habitat analysis, and if necessary, species specific surveys, are required to determine the potential for each species.

Species of concern include protected, candidate, and other rare or otherwise sensitive species, including certain native species and species of economic or cultural significance. For legally protected species, the following tribal and federal statuses are indicated: NESL, federal Endangered Species Act (ESA), Migratory

Bird Treaty Act (MBTA), and Eagle Protection Act (EPA). No legal protection is afforded species with only ESA candidate, NESL group 4 status, and species listed on the Sensitive Species List. Please be aware of these species during surveys and inform the NNDFW of observations. Reported observations of these species and documenting them in project planning and management is important for conservation and may contribute to ensuring they will not be up listed in the future.

In any and all correspondence with NNDFW or NNHP concerning this project please cite the Data Request Code associated with this document. It can be found in this report on the top right corner of the every page. Additionally please cite this code in any biological evaluation documents returned to our office.

1. Known Species *(NESL=Navajo Endangered Species List, FE=Federally Endangered, FT=Federally Threatened, FC=Federal Candidate)*

Species

AMPE = Amsonia peeblesii / Peebles' Blue-star NESL G4
AQCH = Aquila chrysaetos / Golden Eagle NESL G3
CASP = Carex specuicola / Navajo Sedge NESL G3 FT
LIPI = Lithobates pipiens / Northern Leopard Frog NESL G2
PEAMCI = Perognathus amplus cineris / Wupatki Pocket Mouse NESL G4
PUPA = Puccinellia parishii / Parish's Alkali Grass NESL G4

**All or parts of this project currently are within areas protected by the Golden and Bald Eagle Nest Protection Regulations; consult with NNDFW zoologist or EA Reviewer for more information and recommendations.

2. Potential Species

Species

ALGO = Allium gooddingii / Gooding's Onion NESL G3
AMPE = Amsonia peeblesii / Peebles' Blue-star NESL G4
AQCH = Aquila chrysaetos / Golden Eagle NESL G3
ASBE = Astragalus beathii / Beath Milk-vetch NESL G4
ASNA = Astragalus naturitensis / Naturita Milk-vetch NESL G3
ASWE = Asclepias welshii / Welsh's Milkweed NESL G3 FT
ATCU = Athene cunicularia / Burrowing Owl NESL G4
BURE = Buteo regalis / Ferruginous Hawk NESL G3
CASP = Carex specuicola / Navajo Sedge NESL G3 FT
CHMO = Charadrius montanus / Mountain Plover NESL G4
CIME = Cinclus mexicanus / American Dipper NESL G3
CIRY = Cirsium rydbergii / Rydberg's Thistle NESL G4
CYUT = Cystopteris utahensis / Utah Bladder-fern NESL G4
EMTREX = Empidonax traillii extimus / Southwestern Willow Flycatcher NESL G2 FE
ERAC = Erigeron acomanus / Acoma Fleabane NESL G3
ERRH = Erigeron rhizomatus / Rhizome Fleabane/zuni Fleabane NESL G2 FT
ERRO = Errazurizia rotundata / Round Dunebroom NESL G3
ERSI = Erigeron sivinskii / Sivinski's Fleabane NESL G4
FAPE = Falco peregrinus / Peregrine Falcon NESL G4
GIRO = Gila robusta / Roundtail Chub NESL G2
LENA = Lesquerella navajoensis / Navajo Bladderpod NESL G3
LIPI = Lithobates pipiens / Northern Leopard Frog NESL G2
MUNI = Mustela nigripes / Black-footed Ferret NESL G2 FE

PEAMCI = Perognathus amplus cineris / Wupatki Pocket Mouse   NESL G4
PLZO = Platanthera zothecina / Alcove Bog-orchid   NESL G3
PRSP = Primula specuicola / Cave Primrose   NESL G4
PTLU = Ptchocheilus lucius / Colorado Pikeminnow   NESL G2
PUPA = Puccinellia parishii / Parish's Alkali Grass   NESL G4
SAPAER = Salvia pachyphylla ssp eremopictus / Arizona Rose Sage   NESL G4
STOCLU = Strix occidentalis lucida / Mexican Spotted Owl   NESL G3   FT
VUMA = Vulpes macrotis / Kit Fox   NESL G4
ZIVA = Zigadenus vaginatus / Alcove Death Camass   NESL G3

3. Quadrangles (7.5 Minute)

Quadrangles

Cameron SE (35111-G3) / AZ
Dalton Pass (35108-F3) / NM
Del Muerto (36109-B4) / AZ
Dos Lomas (35107-C7) / NM
Gallup East (35108-E6) / NM
Garnet Ridge (36109-H7) / AZ, UT
Horse Mesa (36109-F1) / AZ, NM
Indian Wells (35110-D1) / AZ
Mexican Hat SE (37109-A7) / UT, AZ
Oljeto (37110-A3) / UT, AZ
Toh Atin Mesa East (36109-H3) / AZ, UT
Toh Atin Mesa West (36109-H4) / AZ, UT

4. Project Summary *(EO1 Mile/EO 3 Miles=elements occuring within 1 & 3 miles., MSO=mexican spotted owl PACs, POTS=potential species, RCP=Biological Areas)*

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
Alongo Mines	None	AQCH	Horse Mesa (36109-F1) / AZ, NM	None	LIPI, FAPE, EMTREX, CHMO, BURE, ATCU, AQCH, ZIVA, PUPA, PLZO, CIRY, CASP	Area 3
Barton 3	None	None	Toh Atin Mesa West (36109-H4) / AZ, UT	None	PTLU, GIRO, EMTREX, CHMO, BURE, ATCU, AQCH, ZIVA, PLZO, CIRY, CASP	Area 3
Boyd Tisi No. 2 Western	None	AMPE, PEAMCI, LIPI	Cameron SE (35111-G3) / AZ	None	LIPI, PEAMCI, FAPE, EMTREX, BURE, AQCH, ERRO, ASBE, AMPE	Area 3
Charles Keith	None	None	Oljeto (37110-A3) / UT, AZ	None	LIPI, FAPE, EMTREX, CHMO, BURE, AQCH	Area 1, Area 3

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
Eunice Becenti	None	None	Gallup East (35108-E6) / NM	None	FAPE, EMTREX, ATCU, AQCH, LENA, ERSI, ERRH, ERAC	Area 3
Harvey Blackwater No. 3	AQCH	AQCH, PUPA	Garnet Ridge (36109-H7) / AZ, UT	None	VUMA, LIPI, FAPE, EMTREX, CIME, BURE, ATCU, AQCH, ZIVA, PUPA, PRSP, PLZO, CIRY, CASP, ASWE	Area 3
Harvey Blackwater No. 3	AQCH	AQCH, PUPA	Mexican Hat SE (37109-A7) / UT, AZ	None	VUMA, FAPE, EMTREX, ATCU, AQCH, ZIVA, PLZO, CIRY, CASP, ASWE	Area 1
Hoskie Tso No. 1	AQCH	AQCH	Indian Wells (35110-D1) / AZ	None	FAPE, CHMO, BURE, ATCU, AQCH, SAPAER	Area 3
Mitten No. 3	None	AQCH	Oljeto (37110-A3) / UT, AZ	None	LIPI, FAPE, EMTREX, CHMO, BURE, AQCH	Area 3
NA-0904	None	AQCH	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, ATCU, AQCH, PUPA	Area 3
NA-0928	None	None	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, ATCU, AQCH, PUPA	Area 3
Oak124, Oak125	AQCH	AQCH	Horse Mesa (36109-F1) / AZ, NM	None	LIPI, FAPE, EMTREX, CHMO, BURE, AQCH, ZIVA, PUPA, PLZO, CIRY, CASP	Area 3
Occurrence B	None	AQCH, CASP	Del Muerto (36109-B4) / AZ	None	LIPI, FAPE, EMTREX, CIME, AQCH, ZIVA, PLZO, CYUT, CIRY, CASP, ALGO	Area 3
Section 26 (Desiddero Group)	None	None	Dos Lomas (35107-C7) / NM	None	FAPE, CHMO, ATCU, AQCH	Area 3
Standing Rock	None	None	Dalton Pass (35108-F3) / NM	None	VUMA, MUNI, FAPE, CHMO, BURE, ATCU, AQCH, ERSI, ASNA	Area 3

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
Tsosie 1	AQCH	AQCH	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, AQCH, PUPA	Area 1, Area 3

5. Conditional Criteria Notes *(Recent revisions made please read thoroughly. For certain species, and/or circumstances, please read and comply)*

A. **Biological Resource Land Use Clearance Policies and Procedures (RCP)** - The purpose of the RCP is to assist the Navajo Nation government and chapters ensure compliance with federal and Navajo laws which protect, wildlife resources, including plants, and their habitat resulting in an expedited land use clearance process. After years of research and study, the NNDFW has identified and mapped wildlife habitat and sensitive areas that cover the entire Navajo Nation.
The following is a brief summary of six (6) wildlife areas:
1.***Highly Sensitive Area*** – recommended no development with few exceptions.
2.***Moderately Sensitive Area*** – moderate restrictions on development to avoid sensitive species/habitats.
3.***Less Sensitive Area*** – fewest restrictions on development.
4.***Community Development Area*** – areas in and around towns with few or no restrictions on development.
5.***Biological Preserve*** – no development unless compatible with the purpose of this area.
6.***Recreation Area*** – no development unless compatible with the purpose of this area.
None - outside the boundaries of the Navajo Nation
This is not intended to be a full description of the RCP please refer to the our website for additional information at http://www.nndfw.org/clup.htm.

B. **Raptors** – If raptors are known to occur within 1 mile of project location: Contact Chad Smith at 871-7070 regarding your evaluation of potential impacts and mitigation.
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

TOPOGRAPHIC MAPS ATTACHED:

- Blue Gap Quadrangle, Arizona-Apache Co.
- Cameron SE Quadrangle, Arizona-Coconino Co.
- Cameron South Quadrangle, Arizona-Coconino Co.
- Del Muerto Quadrangel, Arizona-Apache Co.
- Five Buttes Quadrangle, Arizona-Navajo Co.
- Garnet Ridge Quadrangle, Arizona-Utah
- Horse Mesa Quadrangle, Arizona-New Mexico
- Indian Wells Quadrangle, Arizona-Navajo Co.
- Tah Chee Wash Quadrangle, Arizona-Apache Co.
- Toh Atin Mesa East Quadrangle, Arizona-Utah
- Toh Atin Mesa West Quadrangle, Arizona-Utah
- Bluewater Quadrangle, New Mexico
- Bread Springs Quadrangle, New Mexico-McKinley Co.
- Dalton Pass Quadrangle, New Mexico-McKinley Co.
- Dos Lomas Quadrangle, New Mexico
- Gallup East Quadrangle, New Mexico-McKinley Co.
- Sand Spring Quadrangle, New Mexico-San Juan Co.
- Standing Rock Quadrangle, New Mexico-McKinley Co.
- Mexican Hat SE Quadrangle, Utah-San Juan Co.
- Oljato Quadrangle, Utah-San Juan Co.

THE NAVAJO NATION
HISTORIC PRESERVATION DEPARTMENT
PO Box 4950, Window Rock, Arizona 86515
TEL: (928) 871-7198 **FAX:** (928) 871-7886

CULTURAL RESOURCES COMPLIANCE FORM

ROUTE COPIES TO:	**NNHPD NO.: HPD-16-565 - *REVISED***
☑ DCRM	**OTHER PROJECT NO.: DCRM 2016-09**

PROJECT TITLE: A Cultural Resource Inventory of Three Abandoned Uranium Mines for MWH Global, Inc.: (Eunice Becenti, Standing Rock, and Section 26 Desidero Group) in Church Rock, Nahodishgish, and Baca/Prewitt Chapters, Navajo Nation

LEAD AGENCY: BIA/NR

SPONSOR: Sadie Hoskie, Trustee, Navajo Nation AUM, Environmental Response Trust, PO Box 3330, Window Rock, Arizona 86515

PROJECT DESCRIPTION: The proposed undertaking will involve the removal site evaluations to define the horizontal extent of contamination in surface soil and sediments a three former uranium mine areas. The area of potential effect is 51.8-acres. Ground disturbing activities will be intensive and extensive with the use of heavy equipment.

LAND STATUS:	Navajo Tribal Trust													
CHAPTER:	Church Rock, Nahodishgish, Baca/Prewitt													
LOCATION:	*T.*	15	*N.,*	*R.*	17	*W*	*Sec.*	28;	Gallup East	Quadrangle,	McKinley	County	New Mexico	NMPM
	T.	18	*N.,*	*R.*	14	*W-*	*Sec.*	34/35;	Dalton Pass	Quadrangle,	McKinley	County	New Mexico	NMPM
	T.	13	*N.,*	*R.*	10	*W-*	*Sec.*	26;	Don Lomas	Quadrangle,	McKinley	County	New Mexico	NMPM

PROJECT ARCHAEOLOGIST:	Clifford Werito, Tristin Moone, Rena Martin, Arlo Werito with Klara Kelley and Harris Francis
NAVAJO ANTIQUITIES PERMIT NO.:	B16161
DATE INSPECTED:	5/2/2016 - 5/16/2016
DATE OF REPORT:	7/5/2016
TOTAL ACREAGE INSPECTED:	87.6 – ac
METHOD OF INVESTIGATION:	Class III pedestrian inventory with transects spaced 15 m apart.

LIST OF CULTURAL RESOURCES FOUND:	**(1) Site (NM-R-47-01); (4) Isolated Occurrences (IO), (2) In-Use Sites (IUS); (1) Traditional Cultural Property (TCP)**
LIST OF ELIGIBLE PROPERTIES:	**(1) TCP**
LIST OF NON-ELIGIBLE PROPERTIES:	**(1) Site (NM-R-47-01); (4) IO; (2) IUS**
LIST OF ARCHAEOLOGICAL RESOURCES:	**None**

EFFECT/CONDITIONS OF COMPLIANCE: No adverse effect with the following conditions:

Site NM-R-47-01:
No further work is warranted.

TCP:

1. TCP boundary will be marked/flagged by qualified archaeologist prior to remediation activities.

2. TCP will be avoided by all mining activities & a qualified archaeologist will monitor all activities within 100-ft of the TCP.

If TCP cannot be avoided:

Mitigation measures will be initiated by the sponsor in consultation with NNHPD and with the Chee Bob Thompson family.

In the event of a discovery [*"discovery"* means any previously unidentified or incorrectly identified cultural resources including but not limited to archaeological deposits, human remains, or locations reportedly associated with Native American religious/traditional beliefs or practices], all operations in the immediate vicinity of the discovery must cease, and the Navajo Nation Historic Preservation Department must be notified at (928) 871-7198.

FORM PREPARED BY: **Tamara Billie**
FINALIZED: September 9, 2016

Notification to Proceed Recommended ☑ Yes ☐ No
Conditions: ☑ Yes ☐ No

Tamara Bill · 9/9/16
The Navajo Nation Historic Preservation Office Date

Navajo Region Approval ☒ Yes ☐ No

SEP 28 2016
BIA – Navajo Regional Office Date
Acting

NNDFW Review No. 15mwh101-sr

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.: Standing Rock - 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 50.1 acres.

LOCATION: 35°75'N 108°35'W, Nahodishgishi Chapter, McKinley County, New Mexico

REPRESENTATIVE: Lori Gregory, Adkins Consulting, Inc. for MWH Global/Stantec

ACTION AGENCY: U.S. Environmental Protection Agency and Navajo Nation

B.R. REPORT TITLE / DATE / PREPARER: BE-Standing Rock Abandoned Uranium Mine Project/AUG 2016/Lori Gregory, Plant Survey Report for Species of Concern At Standing Rock 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)

☐ ______________________ ☐ ______________________

<u>2 NTC § 164 Recommendation</u>: Signature Date

☒Approval

☐Conditional Approval (with memo) 11/18/16

☐Disapproval (with memo) Gloria M. Tom, Director, Navajo Nation Department of Fish and Wildlife

☐Categorical Exclusion (with request letter)

☐None (with memo)

*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.1Data 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 Standing Rock Site (the Site) as part of the Removal Site Evaluation (RSE) performed for the Navajo Nation AUM Environmental Response Trust—First Phase. The purpose of the validation was to ascertain the data usability measured against the data quality objectives (DQOs) and confirm that results obtained are scientifically defensible.

Samples were collected between November 10, 2016 and August 29, 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 with the exception of one sample for the analysis of total dissolved solids (TDS). Sample S10006-WS-001 was analyzed for TDS six days outside of hold time. The laboratory has indicated that this sample was originally analyzed within hold time with a high relative percent difference (RPD) on the duplicate. The sample was re-analyzed out of hold time with passing QC. The sample result was qualified as estimated with a "J" flag.

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 with the exception of 2 samples for the analysis of radium-226, 13 samples for the analysis of thorium-230, and 2 samples for the analysis of gross alpha. The samples for the analysis of radium-226 were qualified with a "UB" flag to indicate blank contamination and reported as not detected at the reporting limit. The samples for the analysis of thorium-230 and gross alpha were qualified with a "B" flag to indicate a positive detection in the sample and the associated method blank (see Table F.1-1).

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 three metals. Table F.1-1 lists the analytes where an MS and/or MSD percent recovery was outside the acceptance criteria. Sample results were qualified with a "J-" flag to indicate the results were estimated and potentially biased low. All MS/MSD RPDs were within acceptance criteria.

Laboratory Duplicate Sample Evaluation. For some analyses, the laboratory prepared and analyzed a duplicate sample. RPD results were evaluated between the parent and laboratory duplicate samples. Sample results qualified due to laboratory duplicate RPDs outside of the acceptance criteria are listed on Table F.1-1. The sample results were qualified with a "J" flag to indicate an estimated result.

Serial Dilution Evaluation. All serial dilution percent differences were within acceptance criteria.

Interference Check Sample Evaluation. All interference check samples were within acceptance criteria.

Laboratory Control Sample/Laboratory Control Sample Duplicate Evaluation. All LCS and LCSD recoveries were within acceptance criteria. All LCS/LCSD RPDs were within acceptance criteria.

Field Duplicate Evaluation. The RPDs were less than the guidance RPD of 30 percent established in the QAPP for all field duplicate pairs, with the exception of results for three metals, one gross alpha and gross beta, and one radium-226. The sample IDs, sample results, and RPDs for those results that did not meet the guidance RPD are listed in Table F.1-2. Sample results were not qualified due to RPDs exceeding the guidance criteria, as described in the QAPP.

Minimum Detectable Concentration Evaluation. All minimum detectable concentrations met reporting limits with the exception of 21 samples for the analysis of radium-226, 3 samples for the analysis of gross alpha, and 2 samples for the analysis of gross beta. 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 four samples analyzed for radium-226. The sample density exceeded the limit of +/- 15% of the density of the calibration standard. In all cases the results were qualified with a "J-" flag as estimated, potentially biased low (see Table F.1-1).

Completeness Evaluation. All samples and QC samples were collected as scheduled, resulting in 100 percent sampling completeness for this project. Based on the results of the data validation described in the previous sections, all data are considered valid as qualified. No data were rejected; consequently, analytical completeness was 100 percent, which met the 95 percent analytical completeness goal established in the QAPP.

Comparability Evaluation. Comparability is a qualitative parameter that expresses the confidence that one data set may be compared to another. For this project, sample collection and analysis followed standard methods and the data were reported using standard units of measure as specified in the QAPP. In addition, QC data for this project indicate the data are comparable. As a result, the data from this project should be comparable to other data collected at this Site using similar sample collection and analytical methodology.

3.0 DATA VALIDATION SUMMARY

Precision. Based on the MS/MSD sample, LCS/LCSD sample, laboratory duplicate sample, and field duplicate results, the data are precise as qualified.

Accuracy. Based on the ICAL, ICV, CCV, MS/MSD, and LCS, the data are accurate as reported.

Representativeness. Based on the results of the sample preservation and holding time evaluation, the method and ICB/CCB blank sample results, the field duplicate sample evaluation, and the RL evaluation, the data are considered representative of the Site as qualified.

Completeness. All media and QC sample results were valid and collected as scheduled; therefore, completeness for this RSE is 100 percent.

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

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

Table F.1-1
Summary of Qualified Data
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Field Sample Identification	Sample Date	Analysis Code	Analyte	Sample Result	Units	QC Type	QC Result	QC Limit	Added Flag	Comment
S10006-WL-001	11/10/16	E900.0	Gross alpha	4.8	pCi/l	Method Blank	0.82 +/- 0.47	< 0.70	B	Method blank contamination.
S10006-WL-201	11/10/16	E900.0	Gross alpha	6.8	pCi/l	Method Blank	0.82 +/- 0.47	< 4.2	B	Method blank contamination.
S10006-BG1-001	3/24/17	SW6020	Arsenic	3	mg/kg	MS MSD	74% 73%	75% - 125% 75% - 125%	J-	Result is estimated, potentially biased low. MS and MSD recoveries below acceptance criteria.
S10006-BG1-001	3/24/17	SW6020	Selenium	1.7	mg/kg	MS MSD	69% 69%	75% - 125% 75% - 125%	J-	Result is estimated, potentially biased low. MS and MSD recoveries below acceptance criteria.
S10006-BG1-004	3/24/17	E901.1	Radium-226	4.21	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S10006-BG1-008	3/24/17	E901.1	Radium-226	2.42	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S10006-BG1-007	3/24/17	E901.1	Radium-226	3.27	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S10006-CX-001	5/9/17	ASTM D3972	Thorium-228	6.3	pCi/g	Method Blank	0.026 +/- 0.015	< 0.019	B	Method blank contamination.
S10006-CX-009	5/9/17	ASTM D3972	Thorium-228	1.14	pCi/g	Method Blank	0.026 +/- 0.015	< 0.019	B	Method blank contamination.
S10006-CX-010	5/9/17	ASTM D3972	Thorium-228	2.43	pCi/g	Method Blank	0.026 +/- 0.015	< 0.019	B	Method blank contamination.
S10006-CX-011	5/9/17	ASTM D3972	Thorium-228	10.5	pCi/g	Method Blank	0.026 +/- 0.015	< 0.019	B	Method blank contamination.
S10006-CX-012	5/9/17	ASTM D3972	Thorium-228	10.6	pCi/g	Method Blank	0.026 +/- 0.015	< 0.019	B	Method blank contamination.
S10006-CX-002	5/9/17	ASTM D3972	Thorium-228	1.58	pCi/g	Method Blank	0.026 +/- 0.015	< 0.019	B	Method blank contamination.

Notes
mg/kg milligrams per kilogram
mg/l milligrams per liter
pCi/g picocuries per gram
pCi/l picocuries per liter
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
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Field Sample Identification	Sample Date	Analysis Code	Analyte	Sample Result	Units	QC Type	QC Result	QC Limit	Added Flag	Comment
S10006-CX-003	5/9/17	ASTM D3972	Thorium-228	10.7	pCi/g	Method Blank	0.026 +/- 0.015	< 0.019	B	Method blank contamination.
S10006-CX-203	5/9/17	ASTM D3972	Thorium-228	10.1	pCi/g	Method Blank	0.026 +/- 0.015	< 0.019	B	Method blank contamination.
S10006-CX-004	5/9/17	ASTM D3972	Thorium-228	5.83	pCi/g	Method Blank	0.026 +/- 0.015	< 0.019	B	Method blank contamination.
S10006-CX-005	5/9/17	ASTM D3972	Thorium-228	27.9	pCi/g	Method Blank	0.026 +/- 0.015	< 0.019	B	Method blank contamination.
S10006-CX-006	5/9/17	ASTM D3972	Thorium-228	13.9	pCi/g	Method Blank	0.026 +/- 0.015	< 0.019	B	Method blank contamination.
S10006-CX-007	5/9/17	ASTM D3972	Thorium-228	1.23	pCi/g	Method Blank	0.026 +/- 0.015	< 0.019	B	Method blank contamination.
S10006-CX-008	5/9/17	ASTM D3972	Thorium-228	1.87	pCi/g	Method Blank	0.026 +/- 0.015	< 0.019	B	Method blank contamination.
S10006-CX-007	5/9/17	E901.1	Radium-226	0.92	pCi/g	Method Blank	0.29 +/- 0.20	< 0.28	UB	Method blank contamination. Result is qualified as not detected at the sample concentration.
S10006-CX-009	5/9/17	E901.1	Radium-226	0.98	pCi/g	Method Blank	0.29 +/- 0.20	< 0.28	UB	Method blank contamination. Result is qualified as not detected at the sample concentration.
S10006-SCX-008-1	5/11/17	SW6020	Vanadium	2.5	mg/kg	MS MSD	72% 60%	75% - 125% 75% - 125%	J-	Result is estimated, potentially biased low. MS and MSD recoveries below acceptance criteria.
S10006-SCX-015-2	5/11/17	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.
S10006-WS-001	5/25/17	E160.1	TDS	3900	mg/l	Hold Time	13 days	7 days	J	Sample analyzed outside hold time.
S10006-BG2-005	8/29/17	SW6020	Vanadium	74	mg/kg	LR	26%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.

Notes
mg/kg milligrams per kilogram
mg/l milligrams per liter
pCi/g picocuries per gram
pCi/l picocuries per liter
LCS laboratory control sample
LR laboratory replicate (duplicate)
MS matrix spike
MSD matrix spike duplicate
RPD relative percent difference

Table F.1-2
Results that did not Meet the Relative Percent Difference Guidance
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Primary Sample / Duplicate Indentification	Sample Date	Parameter	Primary Result	Duplicate Result	Units	RPD (%)
S10006-WL-001/S10006-WL-201	11/10/2016	Dissolved Mercury	0.6	0.40	ng/L	40
S10006-WL-001/S10006-WL-201	11/10/2016	Gross alpha	4.8	6.80	pCi/l	34
S10006-WL-001/S10006-WL-201	11/10/2016	Gross beta	7.4	10.80	pCi/l	37
S10006-SCX-013-1/S10006-SCX-213-1	5/11/2017	Uranium	0.45	1.0	mg/kg	76
S10006-SCX-013-1/S10006-SCX-213-1	5/11/2017	Vanadium	2.3	7.5	mg/kg	199
S10006-SCX-013-1/S10006-SCX-213-1	5/11/2017	Radium-226	1.08	1.50	pCi/g	33

Notes
mg/kg milligrams per kilogram
ng/L nanograms per liter
pCi/g picocuries per gram
pCi/l picocuries per liter
RPD relative percent difference