Cove Mine Sites

Removal Site Evaluation Report

Final

October 2022

Cyprus Amax Minerals Company

Certification Page

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Jennifer Laggan

Cyprus Amax Minerals Company

Executive Summary

The United States of America (U.S.) and the Navajo Nation entered into a Consent Decree (CD) with Cyprus Amax Minerals Company (Cyprus Amax) and Western Nuclear, Inc. The CD was approved by the U.S. District Court for the District of Arizona and has an effective date of May 22, 2017. This Removal Site Evaluation (RSE) Report is submitted in accordance with the Statement of Work described in, and pursuant to, the terms of the CD. This RSE Report describes the activities performed and the results of investigations conducted to characterize chemical and radiological conditions at the Cove Mine Sites. Site characterization data collected at the Cove Mine Sites will be used to determine the area and volume of mining-impacted material, including technologically enhanced naturally occurring radioactive material (TENORM) resulting from historical mining activities using multiple lines of evidence. This RSE Report does not establish cleanup levels or evaluate potential cleanup options. According to the RSE, and after reasonable opportunity for review and comment by Navajo Nation Environmental Protection Agency (NNEPA), U.S. Environmental Protection Agency (U.S. EPA) may determine that additional work, such as interim Removal actions, risk assessment, removal action evaluation through an engineering evaluation/cost analysis (EE/CA), or removal action implementation, is required.

Nine CD Mine Sites are located in Cove Chapter of the Navajo Nation. U.S. EPA categorized one of these, Mesa III Northwest Mine (Mesa III Northwest), as a Priority Abandoned Uranium Mine Site (Priority Mine Site). Of the eight remaining, seven of the Cove Mine Sites are categorized as non-Priority Abandoned Uranium Mine Sites (non-Priority Mine Site), and one Cove Mine Site is categorized as a Proximate Mine Site. This RSE Report describes the activities performed and summarizes the results of the RSE investigation conducted to characterize chemical and radiological conditions at the Cove Mine Sites. The RSE Report also includes an evaluation of surface and groundwater within 1 mile of the Priority Mine Site and non-Priority Mine Sites as required under the CD. Evaluation of surface and groundwater is not required under the CD for Proximate Mine Sites.

Cove Mine Sites

The Cove Mine Sites are located on Tribal Trust Land in Cove Chapter of the Navajo Nation in Apache County, Arizona. The Mine Sites were predominately active in the 1950s through 1960s, with production totals varying by Mine Site. In the late 1980s, Navajo Abandoned Mine Lands (NAML) conducted an inventory of mining features in the Cove Area. In the early 2000s, as part of the Northern Navajo Abandoned Mine Lands Reclamation Project, NAML conducted reclamation activities at many of the Cove Mine Sites and non-CD mine sites in the Cove Area.

Mine Site reclamation activities conducted by NAML included consolidating and burying waste rock, scarifying and blocking access roads, and backfilling and closing mine features and portals. NAML reclamation was observed at some of the Mine Sites during recent investigations by U.S. EPA in 2010 (U.S. EPA 2010b to 2010l) and by Jacobs in 2017, 2018, and 2019. During these investigations, data were collected to further evaluate Mine Site conditions.

The Cove Mine Sites consist of 9 of 94 Mine Sites listed in the CD. The nine CD Mine Sites in the Cove Mine Area are as follows (Figure ES-1):

- Cato No. 2: The Cato No. 2 Mine Site is the northernmost of the Cove Mine Sites, located less than 1 mile north-northwest of Frank No. 1 Mine Site. The Mine Site is approximately 6.5 acres in size, most of which is inaccessible by field personnel (because of steep slopes or cliff ledges, for example). According to historical documentation, the Mine Site was mined between 1953 and 1954 and produced a total of 52 tons of ore. Results of the site-specific RSE are presented in Appendix A-1.
- Frank No. 1: The Frank No. 1 Mine Site comprises three noncontiguous areas that correspond to historical mine access points: North Portal, East Portal, and South Portal. It surrounds the Frank No. 2 Mine Site and is approximately 39 total acres over the three separate areas, most of which is inaccessible by field personnel (because of steep slopes or cliff ledges, for example). The Frank No. 1 Mine Site was mined by Frank Nacheenbetah from 1951 to 1957 and Climax Uranium

Company from 1957 to 1967. The mine produced 75,739 tons of ore. Results of the site-specific RSE are presented in Appendix A-2.

- Frank No. 2: The Frank No. 2 Mine Site is located between the Frank No. 1 East Portal and Frank No. 1 South Portal. The investigation area for the Mine Site is approximately 3.9 acres in size, most of which is inaccessible by field personnel (because of steep slopes or cliff ledges, for example). Historical records relating to the Frank No. 2 Mine Site do not indicate any ore production. It is assumed that any production of ore from the Frank No. 2 Mine Site was included with the ore production from the Frank No. 1 Mine Site. Results of the site-specific RSE are presented in Appendix A-3.
- NA-0316: The NA-0316 Mine Site is located due east from the Frank No. 1 South Portal and south of the Main Mesa Road. The Mine Site is approximately 4.9 acres in size, most of which is inaccessible by field personnel (because of steep slopes or cliff ledges, for example). Historical records do not indicate any ore production from the NA-0316 Mine Site. Results of the site-specific RSE are presented in Appendix A-4.
- Mesa IV 1/4 Mine (Mesa IV 1/4): The Mesa IV 1/4 Mine Site is located 0.25 mile west of NA-0316 Mine Site, 1 mile northwest of Mesa III Northwest Mine Site, and 0.5 mile southwest of Frank No. 1 North Portal. The Mine Site is approximately 6 acres in size, most of which is inaccessible by field personnel (because of steep slopes or cliff ledges, for example). The Mine Site was mined between 1965 and 1968 and produced 344 tons of ore. Results of the site-specific RSE are presented in Appendix A-5.
- Mesa III Northwest: The Mesa III Northwest Mine Site is located less than 0.5 mile north of Mesa III West Mine (Mesa III West) Site. The Mine Site is approximately 13 acres in size, most of which is inaccessible by field personnel (because of steep slopes or cliff ledges, for example). The Mine Site was mined in 1966. Historical production records show a total of 735 tons of ore being produced from both the Mesa III Northwest and Mesa III West Mine Sites, and the totals are not broken out by Mine Site. Results of the site-specific RSE are presented in Appendix A-6.
- Mesa III West: The Mesa III West Mine Site is located 0.4 mile southwest of Mesa III Northwest and 0.9 mile west of Mesa II 1/4 Mine (Mesa II 1/4). The Mine Site is approximately 6.6 acres in size, most of which is inaccessible by field personnel (because of steep slopes or cliff ledges, for example). The Mesa III West Mine Site was mined in 1966. Results of the site-specific RSE are presented in Appendix A-7.
- Mesa II 1/4: The Mesa II 1/4 Mine Site is located less than 1 mile east of the Mesa III Northwest and Mesa III West Mine Sites. The Mine Site is approximately 5.9 acres in size, most of which is inaccessible by field personnel (because of steep slopes or cliff ledges, for example). The Mine Site was mined between 1963 and 1966 and produced a total of 725 tons of ore. Results of the site-specific RSE are presented in Appendix A-8.
- Billy Topaha: The Billy Topaha Mine Site is the southernmost of the Cove Mine Sites, located approximately 1 mile southeast of Mesa II 1/4. The Mine Site is approximately 9 acres in size, most of which is inaccessible by field personnel (because of steep slopes or cliff ledges, for example). The Mine Site was mined between 1959 and 1960 and produced a total of 703 tons of ore. Results of the site-specific RSE are presented in Appendix A-9.

U.S. EPA identified Mesa III Northwest as a Priority Mine Site because of its proximity to a potentially inhabited structure and because its gamma screening measurements were elevated to concentrations greater than U.S. EPA-identified background levels (U.S. EPA 2014b). The NA-0316 Mine Site is categorized as a Proximate Mine Site, and the remaining seven Mine Sites are categorized as non-Priority Mine Sites.

Removal Site Evaluation Investigation (2017 to 2019)

Between September 2017 and December 2019, Jacobs conducted field activities in accordance with the CD, the approved RSE Work Plan (CH2M 2017), the approved RSE Work Plan Addendum (CH2M 2018), and the Interim Action Work Plan (Jacobs 2019), collectively referred to hereafter as the Work Plans.

Through this investigation, the following information was developed to assist in evaluating the data quality objectives (DQOs):

1) Determine representative background threshold values (BTV) for the Cove Mine Sites. (A BTV is a calculated value that represents a typical value for gamma count rates and concentrations for primary contaminants of potential concern [COPCs] that naturally occur in the environment.)
2) Identify Investigation Level (IL) exceedances in soil and sediment by using site characterization data, including gamma count rates from walkover gamma scanning and from surface and subsurface soil and sediment sampling.
3) Statistically evaluate the relationship between concentrations of radium-226 (Ra-226) in soil and gamma count rates, as well as between gamma count rates and dose rates.
4) Investigate whether mining-related activities, such as blasting, machine maintenance and refueling, and use of electrical equipment, resulted in releases of explosives (including perchlorate), petroleum hydrocarbons, or polychlorinated biphenyls.
5) Identify whether there is evidence that surface water or groundwater, if present and able to be sampled, has been impacted by mining-related activities.
6) Estimate the lateral and vertical extents of mining-impacted material, including TENORM, at the Cove Mine Sites, including surface soil, subsurface soil, and sediment.

Findings and Discussion

Jacobs conducted field activities between September 2017 and December 2019 to address the DQOs (CH2M 2017, 2018, and Jacobs 2019) and evaluate the extent of naturally occurring radioactive material (NORM) and TENORM. The findings of the RSE are as follows:

DQO 1 Was Attained

Three background reference areas (BRAs) were selected based on the predominant geologic formations at the Mine Sites: the Morrison Formation, the Summerville Formation, and Chinle Formation (Figure ES-1). BTVs were calculated from gamma count rate and analytical concentrations for the primary COPC at each BRA. BTVs, in addition to U.S. EPA Regional Screening Levels (RSLs) if available, were used to derive ILs, which informed the evaluation of subsequent DQOs.

DQO 2 Was Attained with Data Gaps

The type and extent of affected environmental media were determined through gamma radiation survey, surface and subsurface soil sampling, and sediment sampling. Inaccessible areas were not evaluated, and vertical delineation was not achieved at some of the Mine Sites.

DQO 3 Was Attained with Data Gaps

Data were collected according to the Work Plan to determine whether a correlation existed between gamma count rate (in counts per minute [cpm]) and Ra-226 surface soil concentrations (in picocuries per gram). The correlation achieved acceptable statistical performance criteria and model validation. The correlation is therefore considered usable for estimating the lateral extent of Ra-226 soil concentrations during an EE/CA.

Data were collected in accordance with the Work Plan to determine whether a correlation existed between gamma count rate (in cpm) and dose rate (microrem per hour [µrem/hr]). Validation models indicated that predicted values were not aligned with measured values. Therefore, the correlation is not considered usable for estimating dose rate from gamma count rates. Cyprus Amax is exploring additional methodologies for dose rate correlation at Group 2 Mine Sites.

DQO 4 Was Attained

Data were collected in accordance with the Work Plan to evaluate whether mining-related activities released secondary COPCs into the environment. Mine Site soil sampling data for secondary COPCs were less than ILs, indicating no release of explosives (including perchlorate), petroleum hydrocarbons, or polychlorinated biphenyls.

DQO 5 Was Attained with Data Gaps

Water data collected from locations within 1 mile of the Cove Mine Sites were from surface water features that were hydraulically and topographically upgradient of the Mine Sites and were therefore not impacted by mining-related activities. Water data from the bottom of the drainages were not collected because some areas of the drainages were inaccessible and no water was observed during RSE activities. Data collected by Weston Solutions Inc. at high-flow and low-flow conditions over 2 years (2015 to 2017) indicated potential mining impacts to surface water and sediments in the drainages of the Cove Area along which the CD Mine Sites are located. However, additional data are necessary to fully understand the contributions from naturally occurring ore-bearing formations and individual Mine Sites.

DQO 6 Was Attained

The volume of mining-impacted material, including TENORM, at the Cove Mine Sites was estimated to be 121,900 cubic yards. Site-specific volumes were estimated as follows:

- Cato No. 2 – 14,900 cubic yards
- Frank No. 1 – 61,900 cubic yards
- Frank No. 2 – 3,900 cubic yards
- NA-0316 – 11,400 cubic yards
- Mesa IV 1/4 – 8,300 cubic yards
- Mesa III Northwest – 3,600 cubic yards
- Mesa III West –3,600 cubic yards
- Mesa II 1/4 – 9,500 cubic yards
- Billy Topaha –5,000 cubic yards

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Acronyms and Abbreviations

°F	degrees Fahrenheit
µg/L	micrograms per liter
µR/hr	microroentgen per hour
µrem/hr	microrem per hour
AEC	Atomic Energy Commission
amsl	above mean sea level
ANSI	American National Standards Institute
ASPECT	Airborne Spectral Photometric Environmental Collection Technology
AUM	abandoned uranium mine
bgs	below ground surface
Bi-214	bismuth-214
BRA	background reference area
BTV	background threshold value
CD	Consent Decree
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COPC	contaminants of potential concern
cpm	count(s) per minute
CSM	conceptual site model
Cyprus Amax	Cyprus Amax Minerals Company
DCRM	Dinétahdóó Cultural Resources Management
DQO	data quality objective
EE/CA	engineering evaluation/cost analysis
ERG	Environmental Restoration Group
FESA	federal *Endangered Species Act*
GIS	geographic information system
GPS	global positioning system
HUC	hydrologic unit code
IL	investigation level
MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*
MBTA	*Migratory Bird Treaty Act*
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
MDER	minimum detectable exposure rate
mg/kg	milligrams per kilogram
Mine Sites	Cove Mine Sites

MSO	Mexican spotted owl
NaI	sodium iodide
NAML	Navajo Abandoned Mine Lands Program
NNDFW	Navajo Nation Department of Fish and Wildlife
NNEPA	Navajo Nation Environmental Protection Agency
NNHPD	Navajo Nation Historic Preservation Department
NNDOJ	Navajo Nation Department of Justice
NNSWQS	Navajo Nation Surface Water Quality Standards
No.	number
NORM	naturally occurring radioactive material
PCB	polychlorinated biphenyl
pCi/g	picocurie(s) per gram
pCi/L	picocurie(s) per liter
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
Ra-226	radium-226
RSE	Removal Site Evaluation
RSL	regional screening level
SOP	standard operating procedure
SOW	Statement of Work
TENORM	technologically enhanced naturally occurring radioactive material
TPH	total petroleum hydrocarbons
U.S. EPA	U.S. Environmental Protection Agency
USL	upper simultaneous limit
UTL	upper tolerance limit
Weston	Weston Solutions, Inc.

1. Introduction

This Removal Site Evaluation (RSE) Report describes the activities and results of investigations to characterize chemical and radiological conditions at nine Mine Sites (Mine Sites) in Cove Chapter for which Cyprus Amax Minerals Company (Cyprus Amax)[1] has responsibility. Jacobs[2] performed the activities for Cyprus Amax in accordance with the Consent Decree (CD) (United States of America and the Navajo Nation, 2017) entered into by the United States of America (U.S.), Navajo Nation, Cyprus Amax, and Western Nuclear, Inc., with an effective date of May 22, 2017. Jacobs performed fieldwork according to the CD, approved RSE Work Plan (CH2M 2017), the approved RSE Work Plan Addendum (CH2M 2018), and the Interim Action Work Plan (Jacobs 2019), which are collectively referred to as the Work Plans. U.S. Environmental Protection Agency (U.S. EPA) approved the Work Plans on September 13, 2017 (RSE Work Plan), May 31, 2018 (RSE Work Plan Addendum), and May 1, 2019 (Interim Action Work Plan), before commencement of the RSE field activities. This report presents the RSE results but does not establish cleanup levels or evaluate potential cleanup options. According to the RSE, and after reasonable opportunity for review and comment by Navajo Nation Environmental Protection Agency (NNEPA), U.S. EPA may determine that additional work, such as interim removal actions, risk assessment, removal action evaluation through an engineering evaluation/cost analysis (EE/CA), or removal action implementation, is required.

The Mine Sites consist of 9 of 94 Mine Sites listed in the CD that are located in Cove Chapter of the Navajo Nation (Figure 1-1 and Table 1-1). U.S. EPA categorized one Mine Site, Mesa III Northwest Mine (Mesa III Northwest), as a Priority Abandoned Uranium Mine Site (Priority Mine Site); a designation of “Priority” is because of the Mine Site’s proximity to potentially inhabited structures and gamma screening measurements (also referred to as gamma counts) elevated at levels greater than background levels (U.S. EPA 2014b). Of the remaining eight Mine Sites, U.S. EPA categorized seven of the Mine Sites as non-Priority Abandoned Uranium Mine Sites (non-Priority Mine Site), and one Mine Site is categorized as a Proximate Mine Site[3] (U.S. EPA 2014b). Proximate Mine Sites were not owned or operated by Cyprus Amax but were included in the CD because of their proximity to one or more CD Mine Sites as part of the CD negotiations. The Cove Mine Sites also include a 1-mile radius around the Mine Sites to facilitate evaluation of groundwater and surface water in proximity to the Mine Sites (Figure 1-2). In addition to the CD Mine Sites in Lukachukai Mountains, there are also mine sites that are being investigated under the Tronox settlement[4] and mine sites that do not have an identified responsible party.

The *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), also known as Superfund, was developed to allow U.S. EPA to facilitate or direct cleanup of contaminated sites, with the overarching goals of protecting human health and the environment, imposing financial accountability on the responsible parties, involving communities in the process, and returning sites to productive use. Cleaning up Superfund sites is a multi-phase process that includes assessment, decision making, cleanup, and operation and maintenance. The CERCLA process for abandoned uranium mines (AUMs) on the Navajo Nation is depicted on Figure 1-3. During the assessment phase, RSEs are conducted to evaluate the extent of contamination and associated risks. During the decision-making phase, potential cleanup solutions are evaluated and compared in an EE/CA and then presented to the public for input. Following the public comment period, the selected cleanup solution is documented in an Action Memorandum. During the cleanup

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[1] Cyprus Amax refers to its former subsidiaries, Climax Uranium Company, American Metal Inc., and Foote Mineral Company, and to the Vanadium Corporation of America, an entity to which Cyprus Amax has an indemnity obligation.

[2] On December 15, 2017, CH2M HILL Companies Ltd. and its subsidiaries including CH2M HILL, Inc. (CH2M) became part of Jacobs Engineering Group Inc. (Jacobs). CH2M/Jacobs performed the Removal Site Evaluation work, and Jacobs prepared this report. For this report, Jacobs and CH2M are referred to collectively as “Jacobs.”

[3] Proximate Mine Sites were not operated by any entity related to Cyprus Amax, but they were included in the CD because of their proximity to one or more Cyprus Amax Mine Sites. In accordance with the CD, characterization of surface water and groundwater will not be conducted at Proximate Mine Sites.

[4] Pursuant to the settlement of the Tronox Incorporated bankruptcy proceeding, *In re Tronox Inc.*, No. 09-10156 (AGL [Bkr. S.D.N.Y.]), the United States and Navajo Nation settled, resolved, and recovered funds from Tronox Incorporated, Kerr-McGee Corporation, and related subsidiaries of Anadarko Petroleum Corporation to address certain abandoned uranium mines located in the Navajo Nation, including 23 abandoned uranium mines listed and identified in Appendix B to the CD. The 23 mine sites are identified because the Vanadium Corporation of America was historically involved with them; however, the CD does not require that Cyprus Amax perform any work at the 23 mine sites. U.S. EPA currently is performing investigations at these 23 mine sites.

phase, the selected cleanup solution is designed and implemented. During the operation and maintenance phase, the sites will be monitored and maintained to keep the public and the environment safe. Community involvement, coordination with applicable Nation Navajo governmental agencies, and planning for a site's future are ongoing throughout the process.

The information in this RSE Report is intended to describe the results of investigations to help inform the four nested stages of problem solving, consistent with CERCLA and the Fundamental Laws of the Diné. This RSE Report recognizes that under the Fundamental Laws of the Diné, the four problem-solving stages are (1) thinking (nitsahakees), (2) planning (nahat'a), (3) implementation (lina/jina'), and (4) eventual results (sihasin).The activities and results of the investigation to characterize chemical and radiological conditions at the Mine Site, as summarized in this RSE Report, will be used by U.S. EPA and NNEPA, along with a risk assessment and EE/CA, if warranted, as they are thinking (nitsahakees) before any removal action for the Mine Site.

1.1 Objectives

The primary objective of completing the RSE at the Mine Sites is to provide the data required to evaluate the site conditions and to estimate the volume and area of mining-impacted materials, including technologically enhanced naturally occurring radioactive material (TENORM) related to historical mining activities. This RSE Report was not intended to establish cleanup levels or evaluate future potential remedies, which may result in different volumes of mining-impacted material, including TENORM, requiring remediation.

The terms "naturally occurring radioactive material" (NORM) and TENORM are not defined in federal environmental statutes or regulations. At U.S. EPA's direction, NORM and TENORM are used in this RSE Report with the meanings provided in an April 2008 U.S. EPA guidance document (EPA 402-R-08-005):

> The term NORM is defined as "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 daughter products that are undisturbed as a result of human activities."
>
> The term TENORM is defined 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." "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.'

U.S. EPA's definition does not require a material's radiological concentrations or properties to actually have been increased by human activity in order to be called TENORM; instead, a material may be called TENORM under U.S. EPA's definition simply because it has been "disturbed" in its natural setting in a way that increases potential exposure. At U.S. EPA's direction, to be consistent with other similar reports overseen by U.S. EPA on the Navajo Nation, this RSE Report uses TENORM terminology, in addition to the plain language that more clearly describes these materials, such as waste rock and impacted material on the Mine Site, haul roads, and drainages, for example.

1.2 Overview

On behalf of Cyprus Amax, Jacobs initiated RSE activities at the Cove Mine Sites, following previous U.S. EPA investigations. Specifically, U.S. EPA contracted with Weston Solutions, Inc. (Weston) to complete site-screening investigations in 2010, which found gamma radiation present at Cove Mine Sites at measurements greater than an average background for the area (U.S. EPA 2022). U.S. EPA prepared site-specific screening reports for the Mine Sites; these reports are summarized in the site-specific Mine Site evaluations in Appendix A.

Jacobs conducted the RSE investigations in accordance with the CD, Statement of Work (SOW), and Work Plans (CH2M 2017, 2018; Jacobs 2019) and included the following activities:

- Cultural resource surveys
- Biological surveys
- Site mapping to digitize and georeference Mine Site features and physical attributes
- Review of historical documents pertaining to the Mine Sites
- Gamma scanning of surface soils and sediment to determine the extent of potentially impacted areas
- Surface and subsurface soil and sediment sampling to determine the lateral and vertical extents of contaminants of potential concern (COPCs) related to mining-impacted material, including TENORM
- Sampling of surface water and water from existing water supply wells within 1 mile of the Mine Sites
- Reporting

According to the SOW, the RSE Report should include the following components:

- A summary of the results of the RSE activities
- Field and validated laboratory data, including gamma scan results
- Laboratory reports
- Data validation results
- Summary tables, graphs, and maps
- Identification of the vertical and lateral extents of mining-impacted material, including TENORM
- Conclusions that indicate whether historical activities at the Mine Sites have potentially impacted nearby surface water and groundwater.

The RSE Work Plans (CH2M 2017, 2018) define “impacts” to the Mine Sites as exceedances of COPCs compared to an IL that equates to a site-specific background threshold value (BTV) or U.S. EPA Regional Screening Level (RSL), whichever is higher. As further explained in the RSE Work Plans, this approach is too simplistic because uranium and metals are naturally occurring in the environment and typically display a range of concentrations in their natural state. Therefore, reported concentrations of constituents that exceeded the IL may be indicative of natural conditions and not related to historical mining activities. Therefore, a multiple-lines-of-evidence approach has been developed for each Mine Site to evaluate materials impacted by historical mining activities, including the designation of NORM and TENORM.

Following approval of the RSE Report, additional work at the Cove Mine Sites may be required, which may include conducting a risk assessment and potential evaluation of remedial alternatives through an EE/CA. Site-specific cleanup levels will be calculated during the risk assessment in the EE/CA, and the volume of mining-impacted material, including TENORM, may change.

1.3 Project Management and Organization

The Work Plans describe management and organization of the Cove RSE (CH2M 2017, 2018). A brief synopsis of the project’s management and organization is provided in the following paragraphs. Ms. Jennifer Laggan, representative of Cyprus Amax and Project Coordinator under the CD, provided project management and oversight services to Jacobs.

The project manager, Ms. Dawn Townsen/Jacobs, and field investigation task manager, Mr. Gavin Wagoner/ Jacobs, managed the implementation of activities specified in the Work Plans. Ms. Kira Aiello/Jacobs served as the Senior Technical Consultant; Mr. Eric Packard /Jacobs served as the radiation health physicist; Mr. Aditya Tyagi/Jacobs served as the statistician; and Mr. Joshua Painter/Jacobs acted as the health and safety officer. Table 1-2 lists the Jacobs project management team and additional team members.

Jacobs subcontracted specialized services as necessary. Dinétahdóó Cultural Resources Management (DCRM) performed the cultural resource assessments, and Hemlock Environmental Consulting, LLC and Earth and Sky, LLC[5] performed the biological monitoring. ALS Environmental Laboratory in Fort Collins, Colorado, provided analytical laboratory services.

At different stages of the project, U.S. EPA Region 9 Remedial Project Managers, Ms. Linda Reeves and Mr. Kenyon Larsen, and NNEPA Remedial Project Managers, Mr. Binod Chaudhary, Ms. Valinda Shirley, Ms. Tennille Denetdeel, and Ms. Dawn Begay, provided regulatory oversight.

1.4 Report Organization

This RSE Report documents the activities performed during the Mine Sites RSEs and is structured as follows:

- Section 1 summarizes the RSE investigation objectives, project management and organization, and report organization.
- Section 2 generally describes the Cove Mine Sites, including operational and reclamation history, ownership and land use, regional and site-specific geology, and hydrogeology, and summarizes cultural and biological assessments. Site-specific Mine Site details are provided in Appendix A.
- Section 3 summarizes the RSE methodology.
- Section 4 includes results of RSE investigations, field activities, and radium-226 (Ra-226) correlation for surface soil. Site-specific Mine Site results are provided in Appendix A.
- Section 5 summarizes the Cove Mine Sites RSE investigation water sampling.
- Section 6 summarizes mining-impacted materials, including TENORM area and volumes identified at the Cove Mine Sites.
- Section 7 summarizes the Cove Mine Sites data quality objectives (DQOs), uncertainties, deviations, and data gaps.
- Section 8 summarizes the RSE investigation and provides conclusions.
- Section 9 provides references cited in this RSE Report.

[5] Subcontracted biological services switched from Hemlock Environmental Consultants LLC to Earth and Sky LLC in April 2019. The same biologist was subcontracted under these companies. This RSE Report will reference the biological services as being provided by Earth and Sky LLC.

2. Cove Mine Sites Description and Background

2.1 Site Description

The Cove Mine Sites are located in Cove Chapter of the Navajo Nation, in Apache County, Arizona, on Tribal Trust Land (Figure 1-1). The Cove Mine Sites are located near the top of several mesas in the Lukachukai Mountains in northeastern Arizona, approximately 5 miles southwest of Cove Chapter house. The Cove CD Mine Sites are as follows (Figure 1-2):

- Mesa III Northwest
- Frank No. 1
- Frank No. 2
- Mesa II 1/4 Mine (Mesa II 1/4)
- Mesa III West Mine (Mesa III West)
- Mesa IV 1/4 Mine (Mesa IV 1/4)
- NA-0316
- Cato No. 2
- Billy Topaha.

Eight of the Mine Sites are accessed via Indian Route 33 from Red Valley and an unnamed dirt road leading from Mesa V (referred to as the Main Mesa Road in this report). Billy Topaha is accessed from the east by taking unnamed dirt roads off of Indian Route 13 near Buffalo Pass. Large portions of the Mine Sites are inaccessible to field personnel because of steep cliffs, dense vegetation, and rugged terrain. Only areas that were safely accessible to field personnel were investigated. Because of the potential for impacts outside the mine boundary, a 100-foot-wide buffer was added to the Mine Sites for the RSE investigation. The buffer was added to each Mine Site to allow for investigation to occur beyond the mine boundary to delineate the potential extent of impacted material related to historical operations. Site-specific descriptions for each of the nine Cove Mine Sites are provided in Appendix A, and reclamation histories are provided in Appendix B.

2.2 Ownership and Access Agreements

Legal title to the 94 Mine Sites identified in the CD is held by the U.S. Government in trust for the Navajo Nation. Pursuant to the terms of the CD, the Navajo Nation Department of Justice (NNDOJ) designated Cyprus Amax as NNEPA's representative for the purposes of conducting RSE activities at the Mine Sites. This designation allows Cyprus Amax to access Navajo Trust lands to perform RSE activities. NNDOJ provided documentation of this designation in a letter dated October 16, 2017 (NNDOJ 2017; Appendix C).

As stated in Section VIII (Property Requirements) of the CD and Section 4 of the SOW, Cyprus Amax worked with local chapter officials to obtain access agreements from grazing permit holders before conducting fieldwork activities. In a letter to U.S. EPA and NNEPA dated September 5, 2017, Cyprus Amax provided documentation of its successful best effort to obtain permission to access the Group 1 Mine Sites (Appendix C), including the Cove Mine Sites (Cyprus Amax 2017).

2.3 Surrounding Land Use

Local land uses in Cove Chapter include farming, traditional gathering activities, grazing livestock, and hunting, but most residents work outside the community. The mesas of the Lukachukai Mountains provide grazing areas for local cattle and sheep, and residents often gather firewood in the summer and fall. Heavy snow accumulations generally prevent access to the Cove mesas in the winter months.

2.4 Historical Mining Practices, Reclamation History, and Investigations

The Cove Mine Sites include uranium and vanadium mines that were mined from the 1950s through the 1960s. Although some mining was conducted by surface stripping and open-pit methods, the majority of mining was by underground room and pillar methods or modifications of it (Chenoweth 1967). Access to underground portals was typically along narrow benches across steep cliff sides. Ore that met the minimum grade of uranium[6] set by the Atomic Energy Commission (AEC) was removed from the Mine Site in trucks to various mill sites or AEC buying stations (Chenoweth 1988). The remaining material, which consisted of overburden and waste rock with concentrations of uranium less than minimum grades set by the AEC, was left onsite[7]. Ethnographic surveys conducted as part of the cultural resource survey revealed that many of the mines operated 24 hours a day and that ore was brought out of the portals by hand in wheelbarrows and stockpiled until a tractor cleared it away (DCRM 2018b).

The Cove Mine Sites underwent multiple phases of reclamation by the Navajo Abandoned Mine Lands Program (NAML) from the 1990s through the 2000s. Appendix A summarizes site-specific mining backgrounds, practices, and reclamation histories for each of the Mine Sites; Appendix B includes additional reclamation history information for each Mine Site. Appendix A figures include historical mining features that were observed during RSE field activities and features from the Cove NAML Geodatabase digitized by Terra Spectra. The Cove NAML Geodatabase digitized by Terra Spectra was provided to Cyprus Amax in March 2018. Figures in Appendix B include historical mining features from the U.S. EPA Atlas with Geospatial Data (2007). Because of the age of the geospatial data collected during reclamation efforts, there is uncertainty in the data.

Previous investigations that focused on AUMs in the Cove area include a U.S. EPA aerial radiological survey, Airborne Spectral Photometric Environmental Collection Technology (ASPECT) survey (Figure 2-1) (CBRN CMAD 2018); U.S. EPA Abandoned Uranium Mine Site-Screening Reports (U.S. EPA 2010b through 2010l); Mine Category Assessment Protocol Report (U.S. EPA 2016); Cove Wash Watershed Assessment (U.S. EPA 2018a); Cove Biological Assessment (U.S. EPA 2015a); aerial radiological surveys conducted by the U.S. Department of Energy Remote Sensing Laboratory (DOE 2001; U.S. EPA 2007); Tronox Mine Site RSEs conducted by Tetra Tech, on behalf of the U.S. EPA (U.S. EPA 2019a); and a light detection and ranging survey (U.S. EPA 2019b). These previous investigations are discussed further in Appendix A as they relate to information pertinent to individual Mine Sites. The Cove Watershed Assessment is discussed in Section 2.5.6. The aerial radiological surveys conducted by the U.S. Department of Energy Remote Sensing Laboratory and RSE field activities conducted by Tetra Tech are discussed in the following paragraphs.

From 1994 to 1999, U.S. EPA Region 9 funded 41 aerial radiological surveys conducted by the U.S. Department of Energy Remote Sensing Laboratory (DOE 2001; U.S. EPA 2007). These aerial radiological surveys were conducted in support of the U.S. EPA's scientific study of AUMs to determine whether AUMs and related mine features posed a significant risk to human health and the environment. The surveys covered approximately 1,144 square miles within the Navajo Nation. The purpose of the aerial survey activities was to specifically identify areas of excess bismuth-214 (Bi-214) (surrogate for uranium) as an indicator of areas rich in uranium. Excess Bi-214 measurements were equated to ground-based exposure levels in microroentgen per hour (μR/hr). An excess ground exposure rate of 3.5 μR/hr identified areas that were either naturally rich in uranium or areas where anthropogenic activities had concentrated or exposed uranium (DOE 2001; U.S. EPA 2007). The surveys covered the Mine Sites and associated haul roads. The survey results of the Cove Mine Area are provided on Figure 2-2. The results of the survey as it relates to each Mine Site is discussed in Appendix A.

From March to October 2018, Tetra Tech, on behalf of the U.S. EPA, conducted RSE field activities at 38 AUM sites, 37 Target sites (Target sites included either sites related to AUM sites or sites identified by U.S. EPA as requiring additional characterization), 22 miles of drainages, nearly 10 miles of access roads, and 32 background areas to prepare the RSE Report (U.S. EPA 2019a). The Northern Agency Tronox RSE Report objective was to identify COPCs, delineate the lateral and vertical extents of mining-related contamination at the AUM and Target sites and along haul roads and drainages, and determine the volume of waste at the

[6] In the mining industry and as used in the *Atomic Energy Act*, the definition of "ore" is an economic one, and materials containing target metals that are not "ore" at one price may well become "ore" if the price or circumstances change in the future. The terminology used to refer to materials that do not contain the minimum grade varies but have been referred to as "protore/low-grade ore" or "waste rock" in different circumstances and contexts and depending on their grades.

[7] For additional information describing the AEC and uranium mining on the Navajo Nation, see *El Paso Natural Gas Co., LLC v. United States of America* (D. Ariz. 2019).

sites (including haul roads and drainages). As part of the Tronox RSE activities, data were collected at or near one of the CD Mine Sites (Frank No. 1), which will be evaluated using the multiple-lines-of-evidence approach during the risk assessment and EE/CA.

2.5 Physical Settings

2.5.1 Regional and Cove Mine Sites Physiography

Regionally, the Cove Mine Sites are 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 Colorado Plateau is bounded to the east and north by the Rocky Mountains in Colorado and Wyoming, to the west by the Basin and Range province in Utah and Nevada, and to the south by the Mogollon Rim in Arizona and the Rio Grande Rift in New Mexico. The Colorado River and its tributaries, including the Green, San Juan, and Little Colorado, drain the vast majority of the Colorado Plateau. The Colorado Plateau is typically high desert with scattered forests and varying topography. Incised drainages, canyons, volcanic intrusions, cliffs, buttes, and arroyos are common features of this uplifted, high-elevation, semi-arid plateau.

Locally, the Cove Mine Sites are in the Lukachukai Mountains, part of the Colorado Plateau physiographic province in Arizona. The Lukachukai Mountains are part of the Defiance Uplift and are the northwestern spur of the Chuska Mountain Range (Chenoweth 1967). The Lukachukai Mountains trend northwestward with bedrock stratigraphy sloping to the northeast. Except where the Lukachukai Mountains join the Chuska Mountains, the mountain slopes terminate as precipitous cliffs.

The elevation of the Lukachukai Mountains ranges from 6,300 feet above mean sea level (amsl) to over 9,000 feet amsl, and the Cove Mine Sites range in elevation from 7,200 to 7,700 feet (Chenoweth 1967). The elevations of the background reference areas (BRAs) range in elevation from 7,613 to 7,636 feet amsl (Morrison Formation), 7,128 to 7,157 feet amsl (Summerville Formation), and 6,164 to 6,198 feet amsl (Chinle Formation). Finger-like mesas and deep, steep-walled canyons combine to form very rugged topography. Pondarosa pine, aspen, and scrub oak are characteristic of this high-elevation forest. The summer months are defined by cooler temperatures than the lower-elevation slickrock and sage-brush terrain, and the winter snowpack can last into late spring.

2.5.2 Geologic Conditions

Geologic conditions regionally and on a Mine Site-specific basis are discussed in the following sections.

2.5.2.1 Regional Geology and Stratigraphy

The Lukachukai Mountains are approximately 110 miles long and 50 miles wide. To the west, the strata dips gently toward Black Mesa basin, which is separated from the Defiance uplift by several monoclines. To the east, strata dip steeply along the Defiance monocline into the San Juan Basin. The northeastern limit of the Defiance uplift is marked by the Toadlena anticline, which, in conjunction with the Chuska syncline on its southwestern flank, trends northwest for nearly 45 miles oblique to the long axis of the Defiance uplift. The Lukachukai Mountains lie in the northwestern part of the Chuska syncline. Few faults are present in the area surrounding the Lukachukai Mountains, and the Chuska syncline and Toadlena anticline are the dominant structural features of the Lukachukai Mountains area (Chenoweth 1967).

The bedrock stratigraphy observed in the Lukachukai Mountains ranges from Triassic-age to Tertiary-age, as well as unconsolidated Quaternary alluvial deposits (Figure 2-3). The exposed stratigraphy in the Lukachukai Mountains, from oldest to youngest, includes the Triassic Chinle Formation, Wingate Sandstone, and Kayenta Formation; the Jurassic Navajo Sandstone, Carmel Formation, Entrada Sandstone, Summerville Formation, and Morrison Formation; the Tertiary Chuska Sandstone and basalt flows; and Quaternary alluvium (Figure 2-3). The stratigraphic units expressed within the Cove Mine Sites investigation area are the Summerville Formation, the Morrison Salt Wash Member, and Quaternary deposits. The Morrison Salt Wash Member was the source of the ore-grade material extracted during mining.

Jurassic Strata

Summerville Formation

The Summerville Formation, which was deposited during the Middle Jurassic, is of marginal marine and tidal origin and is a major transgression of the Late Jurassic seaway. The Summerville is composed of reddish-brown, thinly bedded sandstone with interbedded siltstone, sandy silt stone, or mudstone. Sediments in the Summerville Formation often display thin red beds of rippled sandstones and mud cracks, which can be overprinted with secondary gypsum veins (University of Utah 2019).

Morrison Formation

The Salt Wash Member of the Morrison Formation is the only commercial ore-bearing unit (that contains uranium-vanadium deposits) in the Lukachukai district, and it crops out continuously around the perimeter of the mountains. The Salt Wash Member of the Morrison Formation is a sandstone with minor amounts of mudstone and siltstone, with the Salt Wash as a whole ranging in thickness from 100 to 180 feet (Chenoweth 1967). The sandstone is light red to pale gray, fine- to very fine-grained, and well-sorted, with rounded to sub-rounded quartz grains. The Salt Wash consists chiefly of imbricated lenses whose maximum thicknesses range up to 25 feet. The lenses can be well cemented with secondary calcite, and mudstone nodules are common throughout the sandstone lenses. The mudstone and siltstone lenses separating the sandstones range in thickness from a few inches up to 3 feet, and range in color from gray to greenish-gray to reddish-brown. The lenses are seldom longer than 200 to 300 feet and commonly pinch, swell, split, and coalesce along the bedding. Fossilized logs and carbonaceous materials are common throughout the Salt Wash Member of the Morrison Formation (Chenoweth 2013). The Salt Wash Member was deposited by an aggrading, braided stream system on an alluvial fan. The Salt Wash sediments were derived mainly from older sedimentary formations, and only minor contributions came from igneous and metamorphic rocks (Chenoweth 1967).

The base of the Salt Wash is marked by cut-and-fill–type bedding, and by 6 inches to 2 feet of white calcareous sandstone called the Bluff Sandstone over most of the area. While the significance and thickness of the Bluff Sandstone varies greatly regionally, it is relatively thin in the Lukachukai Mountains. O'Sullivan (1980) and Condon and Huffman (1988) argue that in this location, the Bluff Sandstone is the basal unit of the Morrison Formation, based on their observations of gradational contacts and intertonguing between the Bluff Sandstone and Salt Wash Member.

The other members of the Morrison Formation include the Recapture, Westwater Canyon, and Brushy Basin members. Locally, pre-Chuska erosion has removed these members from the area or they are poorly exposed in the Lukachukai Mountains (Chenoweth 1967). For the purposed of this RSE Report, the Recapture Member of the Morrison Formation was combined with the Salt Wash Member of the Morrison Formation. The remaining members are not observed to be within the investigation area of the Mine Sites.

Quaternary Alluvium

Quaternary-aged alluvial deposits are unconsolidated surficial sediments derived from a broad spectrum of depositional environments and source material. Alluvium is a general term describing colluvial and alluvial (soil and sediment) deposits. Source material for colluvial and alluvial deposits will reflect local geology and may include sediments from ore-bearing stratigraphy, such as the Morrison Formation.

2.5.2.2 Cove Mine Sites Geology and Stratigraphy

Historical mining activities in the Cove Mine Sites targeted the Salt Wash Member of the Morrison Formation, where ore bodies in the Lukachukai Mountains are primarily found (Figure 2-4). The stratigraphic position of ore-bearing units within the Salt Wash ranges from 30 to 80 feet above the Salt Wash-Summerville contact, roughly in the two middle quarters of the Salt Wash (Chenoweth 1967; Chenoweth and Malan 1973). The ore-bearing units range from 10 to 40 feet in thickness; are white, gray, limonitic brown, or red; and contain mud galls, claystone splits, and mudstone pebble conglomerate lenses. The ore-bearing sandstone changes from its normal color of pink or reddish brown to gray or tan near the ore bodies, which usually contain red, brown, and black stains (Chenoweth 1967).

In the Cove Mine Sites, the Bluff Sandstone was observed but was locally thin (6 inches to 2 feet). For the Cove Mine Sites assessment, the Bluff Sandstone was considered the basal unit of the Morrison Formation and was included as part of the Morrison Formation investigations.

Below the Salt Wash Member of the Morrison Formation is the Summerville Formation (Figure 2-4). According to field observations, the Summerville ranges from approximately 75 to 150 feet in thickness in the Cove mesas. At the Mine Sites, the Summerville Formation forms steep slopes and exposed cliffs, rendering the majority of the Mine Sites inaccessible and the Summerville Formation unable to be observed by field teams.

Mine Site field observations and soil sampling identified Quaternary soil and sediments overlying the Morrison Formation, and in some places, the Summerville Formation. Quaternary soil and sediment deposits are unconsolidated surficial sediments derived from a broad spectrum of depositional environments and source material. These Quaternary soils and sediments were most prevalent on the benches and haul roads where historical mining operations occurred. The Quaternary soil and sediments are generally shallow, averaging less than 3 feet in thickness over most the accessible terrain; however, greater thicknesses would be expected in drainages and alluvial fans present at the base of the cliffs.

2.5.3 Regional and Cove Mine Sites Climate

Climate data for the Mine Sites are available from a weather station near Lukachukai, Arizona (025129). Temperatures peak in July and trough in January. The maximum July temperature averages 86.5 degrees Fahrenheit (°F), whereas the minimum January temperature averages 18.6°F (WRCC 2019). Relative humidity of less than 10% may be recorded seasonally across much of the region. Lack of moisture in the air provides a limited heat reservoir and allows for large fluctuations in air temperatures. Daily temperature fluctuations of 25°F to 40°F are common.

Wind direction and magnitude in the region vary by location, season, and elevation. A wind rose from Lukachukai, Arizona, showing the number of hours per year the wind blows from a specific direction is shown on Figure 2-4 (Meteoblue 2019); the predominant wind direction is from the south to north, with secondary and tertiary directions from the southwest and west. These wind directions are consistent with field observations of wind direction at the Mine Sites. High wind is present seasonally, specifically mid-summer to early fall, with sustained wind speeds potentially reaching more than 40 miles per hour.

Precipitation is seasonally variable, with an average annual precipitation of 7.7 inches at the Lukachukai Weather Station (WRCC 2019). At higher elevations within the Lukachukai Mountains, precipitation is greater, with the average annual precipitation in the 12 to 16 inches per year range (U.S. EPA 2018a). Annual precipitation peaks in August during the summer monsoon season, and climatic cycles can lead to variable winter snowpack. The average annual pan evaporation rate from 1948 to 2005, as recorded at the Mexican Hat, Utah, weather station, located approximately 50 miles northwest of the Cove Mine Sites, is 86 inches (WRCC 2019), and the pan evaporation rates exceed precipitation every month except January. The highest pan evaporation rates occur from May through August, when pan evaporation exceeds 10 inches per month. The pan evaporation rate in Shiprock, New Mexico, located approximately 35 miles to the northeast of the Cove Mine Sites, is 70 inches per year (U.S. DOE 1999, 2002). The physiography in Mexican Hat, Utah, and Shiprock, New Mexico, is, however, more consistent with the land surrounding the Lukachukai Mountains than in the Cove Mine Sites, meaning that the pan evaporation rate in the Cove Mine Sites is less than the previously referenced values because of cooler temperatures associated with higher elevation.

2.5.4 Regional Hydrogeology and Hydrology

Surface drainage from the Lukachukai Mountains is part of the San Juan River watershed (WRRC 2010); however, groundwater resources derived from the Lukachukai Mountains are divided by drainages to the west into the Little Colorado River Plateau Basin (ADWR 2009) and drainages to the east into the San Juan River Basin. In the Lukachukai Mountains, the Cove Wash watershed mesas drain to the east into San Juan River

Basin (U.S. Geological Survey hydrologic unit code [HUC] sub-region 1408), which is part of the greater Upper Colorado River Basin (HUC Region 14) (Neptune and Terra Spectra 2018).

Several local and regional aquifers lie in the San Juan Basin. The aquifers consist of sedimentary formations of sandstone and limestone that are stacked on top of one another and generally separated by impermeable shales and siltstones. In descending order of depth, the regional aquifers are the D-, N-, and C-aquifers. Each aquifer has a large areal extent within the basin, but there is little vertical hydrologic connection between them (U.S. EPA 2014a).

Recharge of the San Juan Basin aquifers generally occurs in the topographically high outcroppings along the basin margin, such as the Lukachukai Mountains. Discharge occurs generally in the low elevations within the basin, specifically to regional rivers, such as the San Juan River. Because much of the groundwater is confined, precipitation must fall on the outcrop of the geologic unit and then travel downgradient to the saturated aquifer level for recharge to occur; therefore, groundwater recharge from precipitation is minimal, with models indicating recharge rates between 0.1 and 0.8 inch per year (Kernodle 1996).

The following subsections provide greater detail on the hydrostratigraphic units and aquifers in the San Juan Basins (Figure 2-4).

2.5.4.1 Alluvium

Quaternary deposits include stream-deposited alluvium and older terrace deposits, landslide deposits, and eolian sand. Most Quaternary and younger deposits are unconsolidated and form a thin covering over older bedrock sediments. Alluvium is present in drainages, and in the absence of other sources of water, alluvial deposits, where present, commonly are relied upon as a source of water for domestic and livestock use. Alluvial aquifers are typically thin and discontinuous perched aquifers along streams and alluvial channels. Reported alluvial well yields across the San Juan Basin range from less than 1 gallon per minute to as much as 1,100 gallons per minute (Kernodle 1996); however, water quality may be impacted in some areas by agricultural and industrial activities (ADWR 2009; ISC 2016). Alluvium near the Mine Sites in the Lukachukai Mountains is typically less than 100 feet in thickness (Stone et al. 1983).

2.5.4.2 Chuska Sandstone

The Chuska Sandstone is present across the San Juan Basin and locally present in the Lukachukai Mountains. The sandstone is recharged by leakage from the numerous lakes and potholes along the top of the Lukachukai Mountains, and springs are often identified at the base of the Chuska Sandstone. In addition to the discharge from springs, the sandstone loses water to the underlying Cretaceous and older sediments (Kernodle 1996).

2.5.4.3 D-Aquifer

The Morrison Formation and the Entrada Sandstone are part of a regionally significant aquifer called the D-Aquifer. Because the Summerville Formation lies between the Morrison Formation and the Entrada Sandstone, it is assumed locally to be part of the D-Aquifer (Kernodle 1996). Water quality in the D-Aquifer is generally considered marginal to unsuitable for domestic use because of high concentrations of dissolved solids (ADWR 2009); nevertheless, it is used in some areas for domestic use.

A groundwater study of the San Juan Basin conducted by Kernodle (1996) found that the Morrison Formation has a relatively low specific capacity, which limits usefulness for groundwater production. According to a study of 32 wells across the Navajo Nation, the average production rate was 0.42 gallon per minute per foot of drawdown. As a result of the low specific capacity, groundwater levels in the Morrison Formation located in the eastern agencies were significantly impacted by aquifer dewatering associated with historical uranium mining. Groundwater levels in the Morrison Formation declined as a result of increased mine dewatering during mining activities beginning in the 1940s; however, levels began to recover after mining activities ceased in the 1990s (mining in the Cove Mine Area ended in the 1960s). The Summerville Formation is usually regarded as a confining unit, although sands in the upper part of the unit might yield small quantities of water. Recharge to the unit is negligible. The Entrada Sandstone is similar to the Morrison Formation, yielding highly mineralized water. Well yields from the Entrada range from 3 to 200 gallons per minute, with an average of 40 gallons per minute (Kernodle 1996).

In the Cove mesas, intermittent and perennial springs and seeps emerge from the base of the Morrison Formation, Summerville Formation, and Entrada Sandstone (U.S EPA 2018a).

2.5.4.4 N-Aquifer

The Navajo Sandstone, Kayenta Formation, and Wingate Sandstone are part of another regionally significant aquifer called the N-Aquifer. The Navajo and Wingate Sandstones are the main water-bearing units in the N-Aquifer (ADWR 2009). The N-Aquifer is generally unconfined, and the water quality is generally good. The N-Aquifer serves as the primary domestic and agricultural water supply for portions of the Navajo Nation in Arizona and New Mexico (BOR 2006).

2.5.4.5 C-Aquifer

The lowest member of the Chinle Formation, the Shinarump Member, is part of a regionally significant aquifer called the C-Aquifer. Groundwater from the C-Aquifer is used primarily by industrial and municipal users located in urban areas to the south of the Lukachukai Mountains, such as Flagstaff, Winslow, and Holbrook (ADWR 2009). In the Cove Wash watershed (outside of the 1-mile radius from the Mine Sites), two shallow groundwater wells (less than 20 feet below ground surface [bgs]) are reportedly screened in the Chinle Formation (U.S. EPA 2018a); groundwater usage from these wells is unknown.

2.5.5 Cove Mine Sites Hydrogeology and Hydrology

Many of the CD Mine Sites and non-CD mine sites of the Lukachukai Mountains reside within the Cove Wash watershed (HUC 140801050903). Within this watershed, Cove Wash is the only named waterbody (Neptune and Terra Spectra 2018). The Cove Wash watershed is not a known drinking water source but may have been historically used by residents before drinking water was provided by a municipal source. It is not clear whether residents are currently using surface water or groundwater wells for drinking water (Neptune and Terra Spectra 2018; U.S. EPA 2018a); however, the Cove Wash watershed is used extensively for providing drinking water for grazing livestock and agriculture.

The pathway that precipitation (rain and snowmelt) takes to recharge water-bearing geologic units in the Lukachukai Mountains is dictated by the topography; the narrow ridges, sharp V-shaped canyons, and buttressed and recessed cliffs result in separated recharge and discharge pathways across the mesas (Cooley et al. 1969). Recharge occurs where the surfaces of the mesas have permeable rock, fractures, or both (Cooley et al. 1969). Much of the recharge moves downward and then discharges as springs, with some migrating downward to aquifer units, depending on the geologic units' permeability at the base of the mesas. Because springs furnish dependable water supplies, groundwater wells have typically not been drilled in the mountains.

Water used for grazing livestock is primarily from springs and seeps that emerge from the Chuska Sandstone, Morrison Formation, and most frequently, the Wingate Sandstone. Although these geologic units form laterally extensive regional aquifers while downgradient in the San Juan Basin, in the Lukachukai Mountains, water in these geologic units is unconfined and dissected by drainages, resulting in springs and seeps (Cooley et al. 1969). The extensive dissection of the Lukachukai Mountains will, in many cases, result in relatively short flow paths from areas of recharge to areas of discharge. It is assumed that many of the springs found at high elevations in the Lukachukai Mountains are thus supplied by localized recharge.

2.5.6 Surface Water

In 2018, U.S. EPA published the results of a 2-year assessment of the Cove Wash watershed that included the Cove mesas titled the *Final Assessment Report Cove Wash Watershed Assessment Site Navajo Nation, Cove Chapter, Arizona* (Watershed Assessment) (U.S. EPA 2018a). Weston collected sediment and surface water samples on behalf of U.S. EPA during four sampling events completed between 2015 and 2017

(U.S. EPA 2018a). Samples were taken under low-flow conditions (2015 and 2016 low flow) and high-flow conditions (2016 and 2017 spring snowmelt). Weston collected surface water and sediment samples to assess potential impacts of historical uranium mining from AUMs in the Cove Wash watershed. Weston also collected gamma scan measurements near the sampling locations during each sampling event.

Jacobs reviewed the data in the Watershed Assessment (U.S. EPA 2018a) that were pertinent to the CD Mine Sites. The drainages that were evaluated include the initial drainage downgradient of the Mine Site. Drainages farther downgradient that included non-CD mine sites were not evaluated. The drainages in the Cove Wash watershed that have CD Mine Sites located within the drainage boundaries are as follows (Figure 2-5):

- **Cove Wash North** – Cato No. 2 and multiple non-CD mine sites
- **Middle 1B** – Frank No. 1 (North Portal) and multiple non-CD mine sites
- **Middle 1C** – Frank No. 1 (East Portal) and Frank No. 2
- **Middle 1D** – Frank No. 1 (South Portal)
- **Middle 1E** – NA-0316 and Mesa IV 1/4
- **Middle 2A** – Mesa III Northwest, Mesa III West, and multiple non-CD mine sites
- **Middle 2C** – Mesa II 1/4
- Unnamed drainage spur in the upper reaches of **Middle 3A** – Billy Topaha

Surface water and sediment data from the Watershed Assessment (Tetra Tech 2019b) were compared with COPCs identified in the CD, which include mercury, molybdenum, selenium, uranium, vanadium, in sediment; and arsenic, molybdenum, mercury, selenium, thorium, uranium, Ra-226, Ra-228, gross alpha, antimony, barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, silver, thallium, and zinc in surface water. Sediment samples were compared to U.S. EPA RSLs for residential soil, and surface water was compared to the Navajo Nation Surface Water Quality Standard (NNSWQS). There is no U.S. EPA RSL for thorium or Ra-226 in sediment. Arsenic was not evaluated because the BTV is higher than the U.S. EPA RSL, and geology was not evaluated or designated in the drainages. For surface water, there is no NNSWQS for molybdenum, vanadium, Ra-226, or Ra-228; therefore, data were not evaluated. The summation of Ra-226 and Ra-228 results were evaluated. In addition, thorium was not analyzed in surface water samples collected during the Watershed Assessment (Tetra Tech 2019b). These analytes may be evaluated further once U.S. EPA and NNEPA decide on a common approach.

Figure 2-5 presents Watershed Assessment sample locations pertinent to the CD Mine Sites. The locations are color coded to show exceedances of the RSL for sediment or NNSWQS for surface water for the COPCs identified in the CD. Of the 59 sediment samples, sample locations CW-50 (2015 low-flow event; 17 milligrams per kilogram [mg/kg]) and CW-54 (2016 spring snowmelt; 65 mg/kg) exceeded the RSL (16 mg/kg) for uranium. CW-54 is downgradient of the Frank No. 1 Mine North Portal and three non-CD mine sites. CW-50 is located farther downgradient of CW-54 and is in the Middle 1 drainage, incorporating drainages Middle 1A and Middle 1G. No other sediment samples exceeded the RSL for the COPCs. In the *Cove Wash Watershed Assessment Report*, adjusted gross alpha exceedances were only found in the 2015 low-flow Background Location (CW-SW-04 [CW-04]; total 21.22 picocuries per liter [pCi/L]), the 2016 low-flow Dam Location (CW-SW-05-160627 [CW-05]; total 23.15 pCi/L) and the 2017 Spring Snowmelt Cove Wash Missile 2A Location (CW-SW-82-170424 [CW-82]; total 23.6 pCi/L). Figure 2-5 summarizes total and dissolved arsenic, thallium, uranium, and combined Ra-226 and Ra-228 COPCs exceeded the NNSWQS at select wells.

In general, the Watershed Assessment conducted by Weston concluded the following:

- Background locations had uranium RSL exceedances in water samples, which is a potential indication that naturally occurring uranium is present in the watershed; however, additional investigation may be warranted.
- Background concentrations showed variability, sometimes exceeding the screening level, suggesting that further investigation of naturally occurring uranium may be warranted.
- Uranium concentrations in surface water were lowest above the Morrison Formation and highest below the Morrison Formation, with decreasing concentrations downgradient from the Morrison Formation.

- Uranium is transported in the dissolved phase in surface waters throughout the watershed.
- The data suggest that uranium concentrations may be highest in surface waters during the low-flow season.

2.6 Biological and Cultural Assessment

This RSE Report seeks to consider the Diné Fundamental Law with respect to inherent beliefs of members of the Navajo Nation and considers traditional ecological knowledge, which may include understanding the importance of plants, animals, landscapes, and natural phenomena, when possible. Before beginning fieldwork at the Mine Sites, Cyprus Amax consulted with Navajo Nation governmental organizations responsible for stewardship of Navajo biological and cultural heritage, such as the Navajo Nation Historic Preservation Department (NNHPD) for cultural resources and the Navajo Nation Department of Fish and Wildlife (NNDFW) for biological resources.

2.6.1 Biological Assessment

Tronox Biological Clearance

U.S. EPA secured biological clearance for RSE work at Mine Sites in Cove Chapter mesas (including Tronox mine sites and Cyprus Amax Mines Sites) as part of the Tronox Settlement work. Cyprus Amax conducted RSE fieldwork in Cove under this biological clearance. U.S. EPA provided biological reports with relation to the Cove Mine Sites, including the *U.S. EPA Region 9 Tronox Radiological Survey and Cove Wash Investigation Biological Assessment Report* (U.S. EPA 2015a), *2016 Mexican Spotted Owl Survey Report* (Adkins and Weston 2016), *2019 Mexican Spotted Owl Survey Report* (Tetra Tech 2019a), *Biological Baseline Data and Geology of the Cove Region* (Clifford 2015), and the U.S. Fish and Wildlife Service letter of concurrence with the *Tronox Radiological Survey and Cove Wash Investigation Biological Assessment Report* sent to U.S. EPA (USFWS 2015) (Appendix C). Activities proposed in these reports included, but were not limited to, gamma scan surveys and surface water and sediment sampling in the Cove Wash watershed. The biological assessment reports identified possible sensitive species in the Cove Wash area from both the U.S. Fish and Wildlife Service and NNDFW (Tetra Tech 2019b). These reports support the conclusion that suitable habitat for the Mexican spotted owl (MSO) is present at the Mine Sites, and field activities may affect but are not likely to adversely affect the MSO, a federally threatened species (*Strix occidentalis lucida*); Navajo sedge, a sensitive species (*Carex specuicola*); and Zuni fleabane, a sensitive species (*Erigeron rhizomatus*) (USFWS 2015). Suitable habitat is not present on Cove Mine Sites for Navajo sedge or Zuni fleabane (USFWS 2015).

Figure 2-6 shows MSO are known to occur in the Cove Area. Results of the 2016, 2018, and 2019 MSO surveys (Adkins and Weston 2016; Tetra Tech 2019a). Eight of the nine Mine Sites were located in areas with fair to excellent MSO habitat, whereas one Mine Site (Billy Topaha) was located in an area with poor MSO habitat as indicated by color coding on Figure 2-6. Table 2-1 provides approximate distances, in miles, of MSO observations from each of the nine Cyprus Amax Cove Area Mine Sites and categorization of suitable MSO habitat. The distance of MSO observations from the nine Mine Sites is between 0.1 and 1.3 miles. No MSO were observed during RSE investigations, which typically took place in late summer and early fall.

Cyprus Amax Habitat Assessments

Before beginning of the RSE fieldwork, Jacobs (on behalf of Cyprus Amax) discussed proposed field activities with NNDFW. NNDFW determined that the RSE sampling activities (hand tools, walking, and light vehicle traffic) would have minimal disturbance; therefore, those activities were not considered development, and RSE fieldwork could occur year-round. NNDFW did not require formal consultation with a biological evaluation but did require Jacobs to obtain an annual biological investigation permit. RSE activities were authorized by NNDFW under the following biological investigation permits and amendments (Appendix C):

- Biological Investigation Permit Number 1095, issued June 16, 2017
- Amendment to Permit Number 1095, issued March 30, 2018, to add Dan Fillipi as a sub-permittee

- Biological Investigation Permit Number 1190, issued February 19, 2019
- Amendment to Permit Number 1190, issued September 9, 2019, to change permittee to Morgan King
- Biological Investigation Permit Number 1223 issued November 14, 2019
- Amendment to Permit Number 1223, issued February 7, 2020, to change name and title of principal from Stuart Brown to Jennifer Laggan
- Biological Investigation Permit Number 02172021 issued February 17, 2021
- Biological Investigation Permit Number 12312021 issued December 31, 2021

In accordance with the conditions of the biological investigation permit, Jacobs and Earth and Sky biologists conducted a Navajo Natural Heritage Program resource review to identify special-status plant and wildlife species potentially present at the Mine Sites. Special-status species are defined as those listed by the federal *Endangered Species Act* (FESA) of 1973, as amended (FESA; 16 U.S. Code §1531 *et seq.)* or those listed by NNDFW Navajo Endangered Species List, and those species protected under the *Migratory Bird Treaty Act* (MBTA). FESA requires that federal agencies seek to conserve endangered species, threatened species, and critical habitat, and through consultation with U.S. Fish and Wildlife Service, the primary implementing agency for FESA, ensure action does not jeopardize the continued existence of species and their habitat (USFWS 1998).

As part of the RSE process, biologists performed general habitat assessments and identified disturbed areas during RSE field activities in fall 2017, fall 2018, and fall 2019 (Appendix D). Results for each of the Cove Mine Sites are summarized in Appendix A. As stated earlier, RSE field activities were characterized as having minimal disturbance and could occur year-round.

Observations made by Jacobs biologists during the biological investigation of the BRAs are summarized as follows:

- Vegetation
  - During reconnaissance-level vegetation classification, several types of vegetation were observed at the Mine Sites; disturbed scrub shrub habitat, Gambel oak (*Quercus gambelii*) shrub, mixed conifer forest, pinyon-juniper woodland, and ponderosa pine (*Pinus ponderosa*) forest. See Appendix D for Biological Observation Log field form with a representative photograph of the Mine Site.
- Special-status Wildlife
  - The reports in Appendix C concluded that the Mine Sites were located within excellent, good, fair, or poor-quality suitable habitat for MSO (Strix occidentalis lucida). The distance of MSO observations from the Mine Sites is between 0.1 and 1.3 miles. No MSO were observed during RSE investigations.
  - The Navajo Natural Heritage Program query identified several additional special-status species that are known to occur in the vicinity, including golden eagle (*Aquila chrysaetos*), northern goshawk (*Accipiter gentilis*), northern pygmy-owl (*Glaucidium gnoma*), peregrine falcon (*Falco peregrinus*), northern leopard frog (*Lithobates pipiens*), and Rocky Mountainsnail (*Oreohelix strigosa*), but none were observed at the Mine Site.
  - No other FESA or NNDFW special-status species were observed.
- Special-status Plants
  - No FESA or NNDFW special-status plants or potentially suitable habitat is present at the Mine Site. On several Mine Sites, the Navajo Natural Heritage Program query identified one special-status plant species that is known to occur in the vicinity: Sivinski's Fleabane (*Erigeron sivinskii*).
- MBTA-protected Species
  - No active nests protected by the MBTA were observed at the Mine Site.

Observations made by biologists during the biological investigation at the Cove Mines Sites are discussed in Appendix A.

2.6.2 Cultural Resource Assessment

Before performing RSE activities, DCRM, with Jacobs' oversight, assessed cultural resources at the Mine Sites and associated BRAs. DCRM conducted the cultural resources investigation in a manner sufficient to meet federal standards for compliance with Section 106 of the *National Historic Preservation Act, 36 Code of Federal Regulations 800*.

The cultural resources assessment included an archival literature search and interviews with residents, workers, and Cove Chapter officials, as well as a field survey. DCRM conducted a Class I literature search using archives of the NNHPD in Window Rock, Arizona, to capture previous survey data and previously recorded resources within 1 mile of the Mine Sites. DCRM conducted a Class III intensive cultural resources survey for the Cove Mine Sites under Navajo Antiquities Permit Number B17648 to identify prehistoric and historical cultural resources. Fieldwork for the surveys was conducted from September 2017 through September 2018. A crew of qualified archaeologists performed the field surveys by walking accessible areas of the Mine Sites in parallel transects spaced at a maximum of 15-meter intervals through the Mine Site, Mine Site buffer, and an additional 50-foot-wide buffer area. The crew surveyed drainage channels and haul roads by walking two parallel transects. Areas deemed as inaccessible were not field surveyed, because of safety concerns for field staff. DCRM prepared an archaeological inventory report detailing the results of the literature review and field survey and submitted it to NNHPD (DCRM 2018a). The report indicated that two archaeological sites and eight isolated occurrences were present in the Cove Mine Sites. A Cultural compliance form is provided for the Cove Mine Sites in Appendix C.

Ethnographic surveys conducted as a part of the cultural resource survey revealed that ore was brought out of portals and piled until a tractor came and cleared the ore away. Ore was often hauled by hand in wheel barrels, and interviewees indicated the mines may have operated 24 hours a day (DCRM 2018b).

3. Field Activities and Methods

Jacobs performed an RSE at the Cove Mine Sites to provide information to evaluate the DQOs that were developed using the processes described in U.S. EPA's DQO process, according to *Guidance on Systematic Planning Using the Data Quality Objectives Process U.S. EPA QA/G-4* (U.S. EPA 2006) and following DQO guidance from the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (U.S. EPA 2000). The DQO process is a series of logical and iterative steps that guide the plan for acquisition of environmental data. It is composed of the following steps:

1) **State the problem**. Define the problem to be studied. Review prior studies and existing information to gain an understanding sufficient to define the problem. Prepare problem statements.
2) **Identify the goal of the study**. Define the decisions to be made. Describe how environmental data will be used in meeting objectives and solving the problem, identify study questions, define what actions may result from each decision, and develop decision statements.
3) **Identify the information inputs**. Identify the data that must be obtained and the measurements that must be taken to answer the decision statements.
4) **Define the boundaries of the study**. Define the target population and characteristics of interest. Specify the temporal and spatial boundaries for which decisions will apply.
5) **Develop the analytical approach**. Define the parameter of interest, specify the project screening criteria, and develop the logic for drawing conclusions from findings.
6) **Develop performance criteria for data being collected**. Define tolerable decision error rates based on a consideration of the consequences of making an incorrect decision.
7) **Optimize sampling design**. Evaluate information from the previous steps and develop the sampling design that meets the decision statements.

A further explanation of the DQO process and how it was used to develop the methodology for performing RSE activities is in the RSE Work Plans (CH2M 2017, 2018).

The following section presents DQOs that were developed for the RSE. It also describes the type and quality of data that were collected to inform the DQOs and future environmental decisions as well as the methods for collecting and assessing those data.

3.1 Data Quality Objectives

The DQOs of the RSE work and the methodology used to evaluate each DQO, as described in the RSE Work Plans (CH2M 2017, 2018), include the following:

1) Identify the background level of radiation and metal concentrations from naturally occurring materials at the Mine Sites.
   - To evaluate this DQO, Jacobs identified three BRAs for the Cove Mine Sites, conducted gamma scan surveys at the BRAs to assess surface gamma count rates, and collected surface and subsurface soil samples for laboratory analysis of the primary COPCs, including arsenic, molybdenum, mercury, Ra-226, selenium, thorium, uranium, and vanadium. BTVs were calculated for gamma count to represent a typical background count rate and the primary COPCs to represent a typical background concentration. Actual background conditions may vary based on the heterogeneity of the natural environment.
2) Determine the type and extent of affected environmental media, including surface soil, subsurface soil, and sediment.
   - Jacobs evaluated this DQO by collecting soil and sediment data at the Mine Sites, associated haul roads and drainages, and in step-out areas, as needed. Step-out areas are defined as areas outside of the Mine Sites where gamma scans indicated count rates greater than the BTV. Data collection efforts included gamma scan surveys and collecting surface soil, subsurface soil, and sediment

samples for laboratory analysis of the primary COPCs. Surface soil was defined as 0 to 0.5 foot bgs, and subsurface soil was defined as below 0.5 foot bgs.

3) Determine whether there is a correlation between Ra-226 soil concentration in surface soil with gamma count rate and dose rate following the methods presented in this RSE Report.

   – Jacobs evaluated this DQO by collecting gamma count rates, dose rates, and Ra-226 surface soil samples from 19 correlation plots at the Cove Mine Sites and statistically evaluating the results to determine the relationships between concentrations of Ra-226 in soil and gamma count rate, as well as gamma count rate and dose rate.

4) Identify whether mining-related activities, machine maintenance and refueling, or use of electrical equipment resulted in releases of explosives (including perchlorate), total petroleum hydrocarbons (TPH), or polychlorinated biphenyls (PCBs).

   – Jacobs evaluated evidence of mining-related activities at the Mine Sites by collecting surface and subsurface soil samples. One surface soil sample was analyzed for the secondary COPCs not in background (explosives, including perchlorate, TPH, and PCBs), and a subsurface sample was collected if secondary COPCs were detected in the surface soil sample.

5) Identify evidence that surface water or groundwater has been impacted by mining-related activities, if present and able to be sampled.

   – Jacobs reviewed groundwater well inventories, performed a records search, reviewed information provided by NNEPA and U.S. EPA's Cove Wash Watershed Report, and conducted field reconnaissance to evaluate potential sources of groundwater and surface water and their suitability for sampling. Four potential springs and troughs were identified; however, only three of these features met the sampling criteria set forth in the RSE Work Plans (CH2M 2017, 2018) and contained sufficient water volume for sample collection. Jacobs collected samples at these three features (Spring 1, Spring 2, and Livestock Trough) and analyzed them for the primary COPCs and additional analytes requested by U.S. EPA (2018b).

6) Estimate the area and volume of TENORM present at the Mine Sites.

   – Multiple lines of evidence were obtained for the Mine Sites to determine the nature and extent of contamination, understand potential fate and transport pathways, and estimate the volume of mining-impacted material, including TENORM, on the Mine Sites. The multiple lines of evidence include reviewing historical activities, including reclamation; conducting interviews with residents and consultation with NAML staff; reviewing historical and current aerial photographs; analyzing geologic stratigraphy, hydrogeology, and hydrology; identifying prominent wind direction; conducting visual observations of disturbed areas for evidence of historical mining operations; and conducting a field investigation, including gamma scanning and surface and subsurface soil sample analysis.

3.2 Description of Mine Site Features and Characteristics

As part of RSE field activities, Jacobs performed, observed, and documented the following at each Mine Site:

- Verification of the location and attributes of historically documented mine features, such as portals, shafts, and vents. Many historical mine features could not be accurately located because the geographic information system (GIS) coordinates provided in historical documents have poor accuracy as a result of GIS technology limitations (low resolution) at the time of collection. Additionally, natural erosional forces have contoured the Mine Sites, which may have obscured many of these features from being located.
- Current conditions at the Mine Site, including mine-related features, such as portals, waste rock piles, and haul roads.
- Documentation of historical reclamation activities. In general, NAML reclaimed mine features such that they blend in with the surrounding landscape; as such, field observations may not match with pre-reclamation NAML records.

- Documentation of visual waste rock. Waste rock was visually identified in the field during RSE field activities. Waste rock typically resembled a gray, fine-grained sand with elevated gamma scan measurements.
- Documentation of disturbed areas. Disturbed areas were documented as areas outside of known mining and reclamation areas. Areas associated with historical mining or reclamation, such as roads, waste rock piles, and portals, were considered to be disturbed and were not separately documented as such.
- Surface water flow pathways, including drainages.
- Areas of shallow bedrock. Shallow bedrock mapping was conducted using a combination of field observations and aerial images. Shallow bedrock is defined as areas where bedrock is visually exposed at the surface and the soil mantle consists of less than 6 inches. Mine Site-specific maps are shown in Appendix A. Shallow bedrock maps were not created for Mine Sites that did not have shallow bedrock expressions.
- Geologic contacts were mapped, where they were visible.
- Interim actions. During the RSE investigation at Frank No. 2, an eroded portal that was previously closed by NAML needed repair to address the physical safety hazard. An interim action was conducted to address the physical hazard and is discussed further in Appendix A-3.

Descriptions of Mine Site-specific features, including waste rock, are included in Appendix A. Feature Observation Forms summarizing observations and data collected by Jacobs (including photographs) are presented in Appendix D.

3.3 Background Reference Areas

Gamma scanning and soil characterization samples from three BRAs were collected to determine background conditions for the Mine Sites. Section 2.2 of MARSSIM (U.S. EPA 2000) defines a BRA as "a geographical area from which representative reference measurements are collected for comparison with measurements performed in specific survey units. The BRA is defined as an area that has similar physical, chemical, radiological, and biological characteristics as the survey unit(s) being investigated but has not been affected by site activities." BRA investigations were designed to evaluate the naturally occurring background radiation and metals concentrations for comparison to the Mine Sites.

Three BRAs were selected for the Cove Mine Sites as described in the approved Work Plans (CH2M 2017, 2018) to characterize the predominant geologic formation from which field gamma scanning and soil analytical samples were collected. The Morrison Formation, Summerville Formation, and Chinle Formation were selected as the BRAs for the Cove Mine Sites, based on a desktop review of U.S. Geological Survey geologic maps and aerial photos. BRAs were verified in the field to be of similar geology and stratigraphic position to the Mine Sites, free of anthropogenic interference and at a higher elevation than the Mine Sites with relatively low topographical relief where it would be subject to less interference by drainages and windblown dust. The Chinle Formation background was chosen during an initial desktop review for the Mine Sites; however, the Chinle Formation was not observed at the Mine Sites and therefore was not used during the RSE investigation. Figure 1-2 shows the BRA locations.

The geologic map (Figure 2-4) provides a general sense of the large-scale geology of the Cove Area and should not be used for fine-scale interpretation. Geologic maps were created based on professional large-scale approximation of geologic units, contacts, and structures by the map authors (Cooley et al. 1969), which are accurate for use at the scale (1:125,000) the map is published. However, the geologic boundaries become more qualitative when the area to be investigated has not been extensively mapped or field validated. Jacobs field crews performed BRA field verification before evaluation.

3.3.1 Gamma Scan Survey

In September 2017, Jacobs performed gamma scan surveys in the BRAs to provide data to calculate BTVs for naturally occurring radiation in soils similar to those found at the Mine Sites. BTVs were used to establish the boundary of the scanned area at the Mine Sites. Before the field characterization work was performed, the approximately 2-acre BRAs were selected, and a grid separating the area into 25 predetermined, equally sized cells was uploaded to the Environmental Restoration Group (ERG) Model 105G handheld global positioning system (GPS) system.

Gamma scan surveys were performed in accordance with the RSE Work Plans (CH2M 2017, 2018). For the gamma scan surveys, a Ludlum Model 44-10 2-inch-by-2-inch sodium iodide (NaI) gamma scintillation detector connected to a Ludlum Model 2221 scaler/ratemeter, coupled with an ERG Model 105G handheld GPS system for automated data logging, was used to collect survey measurements. Gamma scan geolocation data were collected in a Universal Transverse Mercator Zone 12 North coordinate system.

The Ludlum Model 44-10 detects gamma radiation in the soil from approximately 50 to 3,000 kiloelectron volts, which includes gamma radiation emitted from Bi-214 and lead-214, which are the primary gamma-emitting radionuclides in the uranium series. These radionuclides are decay products of Ra-226.

Background gamma scan surveys were traversed at 7.5-foot transects at a rate of 2 to 3 feet per second, while holding the detector 18 inches above the ground surface with the detector in a vertical position pointing toward the ground. Individual gamma count rate measurements and associated geolocations were recorded once every second. If obstructions or inaccessible areas were encountered, field personal paused the gamma scanning or walked around the obstacle and continued gamma scanning on the other side.

Guidance from MARSSIM (U.S. EPA 2000) and NUREG-1507 (U.S. Nuclear Regulatory Commission 1995) were used to establish a scan minimum detectable concentration (MDC) for the NaI detection system. The approximate detection sensitivity for Ra-226 with a 2-inch-by-2-inch NaI gamma scintillation detector under the conditions described is 1.58 picocuries per gram (pCi/g) as calculated in the RSE Work Plans (CH2M 2017, 2018). The 2-inch-by-2-inch NaI detector was used on this project as an investigation tool to measure gamma radiation levels relative to background. Additionally, an estimate of the minimum detectable count rate (MDCR) and scan MDC in pCi/g in soil is provided as follows:

The MARSSIM framework is used to calculate the *a priori* MDCR and scan MDC using the following equations:

$$MDCR = S_i\left(\frac{60}{i}\right)$$

$$S_i = d'\sqrt{b_i}$$

Where:

MDCR = minimum detectable count rate (counts per minute [cpm])

S_i (counts) = the minimal number of net source counts required for a specified level of performance for the counting interval *i* (seconds)

i = counting or observation interval, equal to 1 second for this calculation

d′ = the index of sensitivity, equal to 1.38 for a true positive rate of 0.95 and a false positive rate of 0.60 (from MARSSIM Table 6.5)

b_i = the number of background counts, taken from the mean value of the representative BRAs (that is, Morrison Formation) measured in the Cove Draft RSE (Jacobs 2019a, Table 4-1) in the 1-second interval (approximately 2 to 3 feet per second scan speed), equal to 10967 cpm or 182.8 counts per second

Therefore, the MDCR is calculated as follows:

$$MDCR = d'\sqrt{b_i}\left(\frac{60}{i}\right) = 1.38\sqrt{(182.8)}\left(\frac{60}{1}\right) = 1{,}119\ cpm$$

The $MDCR_{Surveyor}$ is then calculated using the following equation to account for potential surveyor error in survey performance:

$$MDCR_{Surveyor} = \frac{MDCR}{\sqrt{p}}$$

Where:

MDCR = minimum detectable count rate (cpm)

p = surveyor efficiency, estimated in MARSSIM to be between 0.5 and 0.75, but the detection capability of a GPS-based scan system for each 1-second counting interval is statistically equivalent to “ideal observer” performance as described by MARSSIM in terms of Type I and Type II decision errors (Alecksen and Whicker 2016).

Therefore, the $MDCR_{Surveyor}$ is calculated as follows:

$$MDCR_{Surveyor} = \frac{MDCR}{\sqrt{p}} = \frac{1{,}119}{0.9} = 1{,}180\ cpm$$

To determine the scan MDC in units of pCi/g, the relationship of count rate to exposure rate for the detector must first be established. MARSSIM Table 6.7 identifies the ratio of 760 cpm/microroentgen per hour (μR/hr) for a 2-inch-by-2-inch NaI detector for measurement of Ra-226 in equilibrium in progeny. The minimum detectable exposure rate (MDER) is then calculated as follows:

$$MDER = \frac{MDCR_{Surveyor}}{Count\ Rate\ to\ Exposure\ Rate\ Ratio} = \frac{1{,}180\ cpm}{760\,\frac{cpm}{\mu R/hr}} = 1.55\ \mu R/hr$$

According to these calculations, the scan MDC can be calculated as follows using a conversion factor from pCi/g to μR/hr of 1.017 from Microshield (a photon/gamma ray shielding and dose assessment computer program) as recommended by *NUREG 1507* (NRC 1998):

$$Scan\ MDC = MDER \times Conversion\ Factor = 1.55\ \mu R/hr \times 1.017\frac{pCi/g}{\mu R/hr} = 1.58\ pCi/g$$

Gamma scanning logs captured the location, date and time, personnel, and equipment serial number used for scanning (Appendix D). Gamma scanning continued until the full background area was completed, and the results were used to calculate gamma count rate BTVs. Gamma scan data were uploaded daily to a computer and secure server.

3.3.2 Soil Sampling

BRA surface soil sampling was conducted in September and October 2017, and subsurface sampling was conducted in May and June 2018. BRA surface soil (0 to 0.5 foot bgs) sample locations were selected in real-time by field sampling personnel at a frequency of one location within each of the predetermined 25 cells. The sample location was selected within each of the 25 grids at a safely accessible location and where soil thicknesses were deep enough to allow for soil sampling. At each soil sample location, a dose rate measurement (surface soil samples only) and a 1-minute static gamma count were also recorded. Dose rate measurements were collected at 3 feet above ground surface, whereas the static gamma count was collected at 18 inches above ground surface. Dose rates were recorded with a Bicron Micro Rem tissue-equivalent plastic scintillation detector, and the static gamma count was recorded with a Ludlum Model 44-10 2-inch-by-2-inch NaI scintillation detector. The detector was connected to a Ludlum Model 2221 scaler/ratemeter. Readings are included in the characterization surface soil sampling logs in Appendix D. The static gamma counts were performed for consistency with the Mine Site soil samples and provide general information on the radiological conditions at each sample location; however, these field measurements were not used to develop a BTV or for any other purpose at this time.

Three subsurface soil samples were collected from areas that corresponded with the minimum, maximum, and mean concentrations of Ra-226 in surface soil, as determined by analytical laboratory data. BRA surface soil samples were collected using a hand trowel, whereas subsurface soil sampling was conducted using hand tools, including hand trowels, shovel, hand auger, post hole digger, and hand-powered hammer drill, in accordance with the approved Work Plans (CH2M 2017, 2018). Soil samples were logged according to Unified Soil Classification System methods (ASTM 2017) and Munsell color chart, placed into unpreserved and unused sample jars, and labeled with the sample identification, date, and time.

Additionally, photographs were taken of the filled sample jars and the surrounding vicinity, and submeter accuracy GPS coordinates were collected at the sample location. Filled soil samples were packaged and shipped to ALS Environmental Laboratories in Fort Collins, Colorado, under appropriate chain of custody. Each surface and subsurface soil sample was analyzed for the primary COPCs, which included Ra-226 by U.S. EPA Method 901.1 and metals (arsenic, vanadium, molybdenum, selenium, thorium, uranium, and mercury) by U.S. EPA Method 6020/7471. Soil samples were digested according to U.S. EPA Method 3050B before the metals analysis by U.S. EPA Method 6020, and mercury analysis was performed after soil digestion according to U.S. EPA Method 7471 (this involves a series of steps with strong acids and oxidizers). Analytical results for the background surface soil samples were used to calculate BTVs for COPCs in soil. The soil sampling laboratory results are presented in Appendix E.

3.4 Background Threshold Values and Investigation Levels

The methodology for calculating BTVs and ILs was set forth in the approved Work Plans (CH2M 2017, 2018) and are discussed in the following subsections.

3.4.1 Background Threshold Values

Because metals and Ra-226 are naturally present in soil, it is necessary to evaluate the concentrations in naturally occurring environmental media so that an evaluation of potential impacts from historical mining activities can be quantified. Both the upper tolerance limits (UTL95-95) and the upper simultaneous limits (USL95) were used to estimate potential BTVs. The ProUCL Technical Guide (U.S. EPA 2015b) recommends using the USL95 to estimate BTVs because it provides a proper balance between false positives and false negatives. However, USL95 should be used only when the raw background data set represents a single environmental population without statistical outliers. The inclusion of multiple populations or statistical outliers tends to yield elevated values of USL, which can result in substantial false negatives. The UTL95-95 is alternatively recommended in cases with statistical outliers. Therefore, the following stepwise procedure was used to estimate BTV values for a given background data set:

1) Conduct exploratory data analyses using background data while confirming statistical independency and no significant spatial variability.
2) Identify potential outliers and conduct confirmatory outlier tests using both parametric and nonparametric methods.
3) Conduct goodness-of-fit test to characterize an appropriate distribution.
4) Choose one of two approaches (parametric and nonparametric procedures) to determine BTVs based on the distributional characteristics of a given background data set. If the background data can be characterized by a well-known distribution, use a parametric method to estimate BTVs; otherwise, use a nonparametric method to estimate BTVs.

If the raw background data set is free from statistical outliers, USL95 is used to determine BTVs; otherwise, UTL95-95 is used to estimate BTVs. Statistical documentation is outlined in Appendix F.

3.4.2 Investigation Levels

Investigation levels (ILs) were developed to facilitate a preliminary evaluation of the RSE results. ILs for metals and Ra-226 were defined as the greater of the BTV or U.S. EPA RSLs. U.S. EPA had not published RSLs for Ra-226 and thorium; therefore, the BTVs for these contaminants were used as the ILs. For secondary COPCs, the ILs were set at the U.S. EPA RSLs because these constituents are not naturally found in the environment and, therefore, have no background value.

The IL is not a definitive indicator of impacts from historical operations. The IL, used as one part of the multiple lines of evidence to calculate the volume of media impacted by mining impacts, including TENORM, may not accurately estimate the volume that would be subject to a removal action. Once the risk assessment is complete and cleanup levels are determined, the volume of mining-impacted material, including TENORM, may change.

3.5 Mine Sites – Gamma Scan Surveys

Jacobs performed gamma scan surveys at the Mine Sites in November and December 2017 and in May 2018. Gamma scan surveys were used to determine the following:

- The lateral extent of elevated count rates exceeding the ILs
- Locations where potential step-out gamma scanning and soil sampling were required
- Potential contaminant migration off the Mine Sites (for example, from runoff or wind)
- Potential waste rock locations
- Soil sampling locations

As with the BRA gamma scan surveys, survey measurements were collected with a Ludlum Model 44-10 2-inch-by-2-inch NaI gamma scintillation detector connected to a Ludlum Model 2221 scaler/ratemeter, coupled with an ERG Model 105G handheld GPS system for automated data logging; the equipment was inspected and calibrated by an accredited facility before use (Appendix D). Gamma scanning was conducted as described in Section 3.3.1 and according to the approved Work Plans (CH2M 2017, 2018). Quality assurance (QA)/quality control (QC) checks of each instrument were performed daily as described in Section 3.11. Multiple identical radiation detection systems were used for the surveys performed. The radiation detection equipment, while exhibiting some minor differences, were within the tolerances allowed under instrumentation calibration described in American National Standards Institute (ANSI) N323AB. Sources contributing to uncertainty between like detection systems include minor differences in equipment manufacture, different instrument operators, calibration conditions, and environmental factors. The uncertainty between radiation detection instruments was within the +/- 20% tolerance allowed under instrumentation calibration described in ANSI N323AB. The radiation detection instruments were also verified within this tolerance during daily instrument response checks (see Appendix D).

Gamma scan surveys were conducted along 15-foot transects over accessible areas of the Mine Sites (including buffer). The 15-foot transects were laid out in GIS and were loaded onto the ERG Model 105G handheld GPS system for field personnel to follow while conducting the gamma scan survey. The 15-foot transects were estimated to provide 40% coverage with the detector held at 18 inches above ground surface.

A screening level for field gamma scans was developed for field personnel to determine the extent of area horizontally and vertically outside of each Mine Site to be evaluated. In accordance with the approved Work Plans (CH2M 2017, 2018), the field screening level[8] for horizontal continuous gamma scans was set at the applicable BTV plus 1500 cpm; for vertical extent, the static field screening level was set at 2 times the applicable BTV.

If gamma count rates were greater than the field screening level at the edge of the Mine Site buffer, then gamma scanning continued outside the Mine Site buffers until gamma count rates were consistently less than field screening level or it was determined that naturally occurring materials were biasing the gamma count rates, such as slopes or drainages with eroded and weathered ore-bearing bedrock.

For drainages, gamma scan surveys were performed along each side of the drainage, along the centerline of the drainage in a sinusoidal wave pattern, and approximately 8 feet away from both sides of the drainage.

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[8] In the Work Plans, this value was called the IL; however, it is referred to as a field screening level in this report to avoid confusion.

Drainage scanning started at the Mine Site buffer and continued downstream until gamma count rates were consistently less than the field screening level. If needed, step-out gamma surveys were completed outside the drainages until gamma count rates were consistently less than the field screening level or it was determined that naturally occurring materials were biasing gamma count rates, such as drainage geometry or eroded and weathered ore-bearing bedrock.

At the former haul roads, gamma scan surveys were conducted along the shoulders, centerline (sinusoidal wave pattern between the shoulders), and 8 feet away from each shoulder. Scanning started at the Mine Sites' buffer and continued up to the intersection with another roadway or another Mine Site boundary (if applicable). If needed, step-out gamma scanning was completed outside the former haul road until gamma count rates were consistently less than the field screening level or it was determined that naturally occurring materials were biasing the gamma scan measurements, such as the presence of ore-bearing bedrock.

3.6 Soil and Sediment Characterization

Soil sampling was performed according to the approved Work Plans (CH2M 2017, 2018). Gamma scanning and observed and reported mine feature locations were used to select surface soil and sediment sample locations to provide field information about the extent of radiological impacts at the Mine Sites. Following receipt of the surface soil and sediment laboratory data, which could take up to 2 months, the data were reviewed to determine where subsurface soil samples would be collected to define the vertical extent of potentially impacted soil. The approved RSE Work Plan Addendum (CH2M 2018) summarized the plan for collecting subsurface soil and sediment samples.

Surface and subsurface soil and sediment sampling was conducted between September 2017 and October 2019 to characterize the extent of COPCs. The results were used to develop the sampling methodology for collecting subsurface soil and sediment samples. Subsurface soil and sediment samples were collected in May and June 2018 and in October 2019. Soil sampling forms are included in Appendix D. A technical error caused the loss of several soil sampling forms, which could not be recovered.

The following subsections summarize the field sample methods, soil screening readings, and laboratory analysis.

3.6.1 Surface Soil and Sediment Sampling

Surface soil and sediment samples were collected according to the approved Work Plans (CH2M 2017, 2018). Surface soil samples were characterized as being collected from 0 to 6 inches bgs. Samples collected from within drainages were designated as sediment samples. Sampling locations were selected based on the gamma scan surveys conducted at the Mine Sites. Surface soil and sediment samples were placed in areas with gamma count rates greater than the IL, in downgradient areas of elevated gamma count rates, and in areas to provide adequate spatial coverage. The gamma scan surveys also were used to determine the acreage of accessible areas at the Mine Sites, drainages, and former haul roads, which was used to calculate the total number of samples to be collected. In accordance with the approved Work Plans, for each accessible acre within the Mine Site and buffer, two surface soil samples were collected (CH2M 2017, 2018). Likewise, for each accessible mile of drainage, 12 surface soil samples were collected. During the RSE process, U.S. EPA and NNEPA requested that additional samples be added to the sampling plan.

At each soil sample location, a dose rate measurement (surface soil samples only) and a 1-minute static count were collected, recorded, and analyzed following the methods prescribed in Section 3.3.2. Each surface soil sample was analyzed for the primary COPCs, and one location was selected for secondary COPC analysis, including TPH by U.S. EPA Method 8015; PCBs by U.S. EPA Method 8082; and perchlorate by U.S. EPA Method SW6850. As described in the approved Work Plans, the secondary COPC soil sample location was selected at the observed portal with the highest recorded static gamma count (CH2M 2017, 2018). If no portals were observed on the site, then the area on the site with the highest gamma count rate recorded during the gamma scan survey was chosen.

3.6.2 Subsurface Soil Sampling

Subsurface soil samples were collected following the approved Work Plans (CH2M 2017, 2018). Surface soil sample locations with primary COPC concentrations that exceeded applicable ILs were identified as potential subsurface sampling locations to meet the DQO for horizontal and vertical delineation of potential impacts to soil. Identification of subsurface soil locations was further refined to delineate areas around higher concentrations of primary COPCs and areas around buried and exposed waste rock and other mine features, including locations downgradient of these areas (such as drainages). Subsurface soil sample locations also were selected to provide adequate spatial coverage over the Mine Sites.

Subsurface soil sampling was conducted entirely using hand tools because of the Mine Site's inaccessibility to drill rigs. Hand tools included hand augers, shovels, breaker bars, hand-operated hammer drills, and hand trowels.

Subsurface soil samples generally were co-located at previously collected surface soil locations; however, if a surface soil or sediment sample was not collected previously at a location, a surface soil or sediment sample also was collected from 0 to 0.5 foot bgs. Subsurface soil samples were collected from intervals of 1.0 to 1.5 feet bgs and 3.0 to 3.5 feet bgs unless refusal was encountered. If refusal was encountered, up to two additional borings within 2 feet of the original location were attempted to reach the target sample depth. Where bedrock or refusal was encountered, samples were collected from the 0.5-foot-bgs interval directly above bedrock or refusal unless that interval was previously sampled. If the static gamma count rates at the 3.0- to 3.5-foot-bgs interval exceeded 2 times the IL, or waste rock was observed, soil sampling continued in 2-foot intervals (5 to 5.5 feet bgs, 7 to 7.5 feet bgs, etc.) until the static gamma count rates were less than 2 times the IL and no waste rock was observed, or when bedrock or refusal was encountered.

Subsurface soil collection methods followed the approved Work Plans (CH2M 2017, 2018). Subsurface samples were logged according to Unified Soil Classification System methods and Munsell color chart. If waste rock was observed by field staff, it was recorded in the soil boring logs (Appendix D). Subsurface soil samples were scanned in an area where radiation levels were at or less than the gamma IL, using a Ludlum Model 44-10 2-inch-by-2-inch NaI scintillation detector connected to a Ludlum Model 2221 scaler/ratemeter. This subsurface soil gamma count rates are recorded in the soil boring logs in Appendix D.

The samples were placed into new, unpreserved sample jars and labeled with the sample identification, date, and time. A 1-minute static gamma count was conducted on filled sample jars in an area where radiation levels were at or less than the gamma IL. Measurements were performed by removing the sample jar lid and holding the sample jar approximately 3 feet above ground surface with the Ludlum Model 44-10 2-inch-by-2-inch NaI scintillation detector approximately 1 inch above the sample. Because of the different collection methods, it is not appropriate to compare gamma count rates recorded from subsurface soil samples with surface soil sample gamma count rates or gamma scan survey results.

Photographs were taken of the filled sample jars and surrounding vicinity from where the sample was collected. Submeter accuracy GPS coordinates were collected at the sample location and recorded. Soil samples were packaged and shipped to ALS Environmental Laboratories in Fort Collins, Colorado, for analysis. Each surface soil or sediment sample was analyzed for the primary COPCs. If secondary COPCs were detected at the one surface soil location where they were collected, a subsurface soil sample was collected at 1.0 to 1.5 feet bgs at that location and analyzed only for those secondary COPCs that were detected in the surface soil sample.

3.7 Surface Water and Groundwater

Four potential surface water sampling locations were identified in a 1-mile radius of the Cove Mine Sites in the Navajo Nation Department of Water Resources Database (NNDWR 2017). The four locations are presented in Table 3-1 and on Figure 1-2. During the RSE field investigation, reconnaissance was conducted of accessible Mine Site drainages to identify additional surface water sampling locations or springs/seeps within the Cove Mine Sites and the Cove Wash watershed; however, additional water sampling locations were not identified because of inaccessibility or the ephemeral nature of the water sources. No groundwater wells were identified within the 1-mile radius of the Mine Sites.

Field visits were made to each of the four surface water sampling locations to determine sampling viability. Three of the locations were confirmed to be viable water sampling locations, meeting the requirements for sampling under the Work Plans (CH2M 2017, 2018). The fourth water sampling location did not meet the sampling criteria because the location was inaccessible. Additionally, water was not observed to be flowing in the accessible area downgradient of the spring near the Mine Site. Additional details describing the four locations are described as follows:

- Spring 1 was located below a cliff along a topographic bench approximately 0.6 mile east and 700 feet higher in elevation than the Billy Topaha Mine Site. The location was a small catchment below a highly sloped drainage. Because of heavy vegetation and steep slopes, the source of the water entering the catchment could not be identified. No CD Mine Sites were upgradient of Spring 1. No CD Mine Sites were downgradient from Spring 1 because this location drains to Middle 3E drainage (Figure 2-4). Spring 1 was designated CO-SW-001 for sampling purposes.
- A Livestock Trough was located along the Main Mesa Road between Mesa III and IV, approximately 0.5 mile south of NA-0316. The source for the Livestock Trough is unknown. CD Mine Sites Na-0316, Frank No. 2, and Frank No. 2 are downgradient from the Livestock Trough. There were no CD Mine Sites upgradient from the Livestock Trough. The Livestock Trough was designated CO-SW-002 for sampling purposes.
- Spring 2 was located below a cliff along a topographic bench approximately 0.7 mile east and 700 feet higher in elevation than the Billy Topaha Mine Site. The location was a small catchment below a highly sloped drainage. Because of heavy vegetation and steep slopes, the source of the water entering the catchment could not be identified. No CD Mine Sites were upgradient of Spring 1. No CD Mine Sites were downgradient from Spring 1 because this location drains to Middle 3E drainage (Figure 2-4). Spring 2 was designated SW-CO-Spring02 for sampling purposes.
- The Nez Spring was located approximately 0.4 mile northwest and 800 feet higher in elevation than the Mesa IV 1/4 Mine Site. The Nez Spring was not accessible to field personnel, because of steep slopes and heavy vegetation. According to a topographic map (Figure 2-4), discharge from the spring would flow over land until it intersected an unnamed upper reach of the Middle 1E drainage. This upper reach of the Middle 1E drainage would intersect the Main Mesa Road and then flow through the Mesa IV 1/4 Mine Site. However, during any RSE field events, no water was observed to flow across the Main Mesa Road at this location, and no water was observed flowing through the Mine Site. Therefore, no sample was collected, and no Jacobs sampling nomenclature was assigned to the Nez Spring.

Spring 1 and the Livestock Trough were sampled in June 2018, and Spring 2 was sampled in October 2019. Water samples were collected according to the methodology in the approved Work Plans. Each sample location was surveyed by using a handheld submeter accuracy GPS unit.

The samples were analyzed for the primary water COPCs specified in the CD, which include arsenic, molybdenum, mercury, selenium, thorium, uranium, vanadium, Ra-226, Ra-228, gross alpha, antimony, barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, silver, thallium, and zinc. The surface water samples also were analyzed for total dissolved solids, anions (carbonate, bicarbonate, chloride, and sulfate), cations (sodium and calcium), and field parameters, including pH, conductivity, turbidity, temperature, salinity, and oxidation-reduction potential as required under the CD. As stated in the Work Plans, at the request of U.S. EPA, nitrates were removed from the water COPC list (U.S. EPA 2018b). The water samples were analyzed for alkalinity, radiochemistry (uranium isotopes, potassium-40 and lead-210) and both total and dissolved metals, including aluminum, boron, iron, lithium, manganese, magnesium, potassium, phosphorous, and strontium. The field parameters were collected by using a portable multi-parameter water quality meter. Field parameters included pH, conductivity, turbidity, temperature, salinity, and oxidation-reduction potential. Salinity was not analyzed in the field because the portable multi-parameter water quality meter did not analyze for salinity. Instead, salinity was calculated using specific conductance and temperature (Fofonoff and Millard 1983), which is a deviation from the Work Plan.

3.8 Correlation Studies

A correlation study was performed at the Cove Mine Sites by collecting dose rate measurements (in microrem per hour [µrem/hr]), gamma count rate measurements (in cpm), and soil Ra-226 activity concentration (in pCi/g) in soil at each correlation plot. From these data, two correlations were derived. One correlation compared gamma count rates with Ra-226 concentrations (Ra-226 correlation); the other correlation compared gamma count rates with dose rates (dose rate correlation).

The purpose of the Ra-226 correlation was to provide a way for potential future removal/remedial actions to estimate Ra-226 concentrations in surface soil using walkover gamma count rate data in locations where soil or sediment samples were not collected. This estimate would then be used as one line of evidence to estimate the lateral extent of impacted areas. The relationship between the gamma count rates and Ra-226 surface soil concentrations can exhibit both linear and nonlinear characteristics depending on the site (Whicker et al. 2008). Therefore, several different regression models were assessed to determine which model was most representative of the Mine Site conditions. The relationship can be skewed because of the soil heterogeneity, instrumentation uncertainty, and input from other gamma-emitting radionuclides (thorium, potassium-40) present in soil. Input from other sources often can disproportionately influence the correlation at the lowest range of activities because the ratio of gamma radiation from other sources is higher in relation to gamma from Ra-226 in soil. Jacobs designed the correlation to target lower gamma count rates (typically between background and approximately 25000 cpm) to allow for Ra-226 evaluation at concentration ranges useful for remedial decision making (estimated at between 1 to 10 pCi/g).

The purpose of the dose rate correlation was not explicitly defined in the SOW and was developed at U.S. EPA's request (U.S. EPA 2017). The dose rate correlation could be used to allow a common, instrument-independent basis of comparison for evaluations with future gamma scanning, which may use different gamma survey instruments, configurations, or measurement technologies. Gamma count rates measured by NaI detectors are highly energy dependent. A correlation against an instrument that does not exhibit strong energy dependence provides a way to express gamma count rate data in terms of dose rate. A Bicron MicroREM meter was used for the dose rate correlation.

To perform the correlations, the field team, in consultation with the radiation health physicist, selected 19 plots. In accordance with the Work Plan, correlation plots were to be 30 feet by 30 feet. Because of steep terrain, however, plot sizes often needed to be much smaller and vary in dimensions. U.S. EPA representatives were in the field when the initial correlation plots were laid out and concurred with the modification of size and dimensions. Correlation plots focused on low (close to background) and medium gamma count rates to represent the desired Ra-226 concentrations. However, the exact shape and size of each correlation plot was determined in the field in order to achieve homogenous gamma count rates. Correlation plots were selected in areas with gamma homogeneity and away from geometric conditions (for example, pits, holes, or trenches) that could skew gamma count rates relative to soil Ra-226 concentrations and dose rate. As a preliminary indication of homogeneity, five equally spaced points were selected within the plot, and a 1-minute static gamma count was collected at each point. If the variability of the static counts was narrow (that is, less than approximately 3000 cpm), the correlation plot was determined usable, soil samples were collected, and a gamma scan of the plot was conducted. A higher tolerance for variability (for example, less than approximately 5000 cpm) was allowed for correlation plots in the higher range of gamma count rates. If the range of the static counts exceeded the range, the correlation plot was discarded, and an additional plot was evaluated based on a review of field gamma measurements. To minimize inconsistencies between correlations plots, the same field operator and same radiation detection equipment were used for each correlation plot. U.S. EPA representatives were present in the field during correlation fieldwork and closely observed and approved selection of plot locations and field methodology.

The following data were collected at each correlation plot:

1) A continuous gamma scan survey consisting of consecutive 1-second integrated counts was conducted for the correlation plot area. The gamma scan survey was performed with approximately 3-foot transects to provide high-density measurements. The same scanning speed of 2 to 3 feet per second and average height geometry of 18 inches above ground surface used for all other RSE gamma scan surveys was

maintained. The average of the gamma count rate from the survey was computed and reported as a single value for each plot.

2) A single dose rate measurement consisting of a user-interpreted reading of the analog dial of the microRem meter was performed at the center of the five-point dice pattern to obtain a dose rate representative of the plot area. The measurement was performed with the waist-height geometry of 3 feet above ground surface.

3) At each of the five locations, a surface soil aliquot was collected from 0 to 0.5 foot bgs and a 1-minute static gamma count was collected. The five aliquots were field composited (mixed and homogenized), and from this, a surface soil sample was collected and analyzed in the laboratory for Ra-226.

Data collected from the correlation plots were analyzed using qualitative and quantitative statistical methods to identify data distribution and outliers. Outliers identified during analysis were not removed from the data set unless laboratory error, sample contamination, or collection errors were identified that could compromise the data. These conditions did not occur for any correlation plots and no outliers were removed. Regression modeling was then used to identify the best relationship between the average gamma count rates from the gamma scan survey and the surface soil Ra-226 concentrations in pCi/g. In addition, a correlation between gamma count rate (cpm) and dose rate (μrem/hr) was developed at U.S. EPA's request. For both the correlations, the DQO was to determine whether a correlation was present between gamma count rate and concentrations of Ra-226 in surface soil and sediment, as well as between gamma count rate and dose rate.

Validation studies were performed for both correlation studies to assess how well the chosen correlation models predict Ra-226 surface soil concentrations and dose rate. Validation studies were performed using data collected across the Mine Sites. Each surface soil sample location also included a 1-minute static gamma count and a dose rate measurement in accordance with the RSE Work Plan. The validation study attempted to locate sample locations that resembled the conditions required for the correlation plots. Validation studies were performed for both correlation models to assess how well those models predicted Ra-226 surface soil concentrations and dose rate. RSE surface soil sample data were used to perform these validations. However, only RSE data that were representative of the conditions at the correlation plots were used for the validation studies. As such, only RSE data that fell within the range of the correlation plot gamma count rates were used and were further refined to include only those samples away from pits, holes, or trenches, which could skew the gamma count rates and dose rates. Validation was assessed by qualitatively observing Mine Site data points overlain by the regression equations. A quantitative validation was also performed by plotting observed versus predicted Ra-226 soil concentration values and performing regression analysis to determine data fit. This regression was compared with a 1:1 regression line to determine the degree of any underprediction or overprediction.

3.9 Mining-impacted Material, Including TENORM Volume Calculations

To determine the volume of mining-impacted material, including TENORM related to historical mining activities, a multiple-lines-of-evidence approach was used. The Cove Mine Area was historically mined based on the presence of elevated concentrations of NORM in the local geology; therefore, some amount of elevated natural uranium and daughter products are present at the Mine Sites. Gamma scan measurements can be biased high by surrounding naturally occurring sources of radiation (that is, shallow bedrock). Therefore, in order to determine whether an exceedance was attributed to NORM or TENORM, a multiple-lines-of-evidence approach was used. The multiple-lines-of-evidence approach evaluated the following:

- Interviews with residents and information obtained during consultation with NAML staff
- Historical documentation on mining and past NAML reclamation activities
- Historical and current aerial photographs
- Geologic stratigraphy, hydrogeology, and hydrology
- Prominent wind direction
- Visual observations of disturbed areas for evidence of historical mining operations
- A field investigation, including gamma scans and surface and subsurface soil sample analysis

For mining-impacted material, including TENORM, a volume was calculated based on the lateral and vertical extents according to the multiple-lines-of-evidence approach. Fieldwork is limited in restricted areas to minimize impacts to culturally or biologically sensitive resources or other areas where access is not allowed (for example, utility rights-of-way). These areas were included or excluded from the TENORM volume calculation based on surrounding data and professional judgment. The lateral extent (area) of mining-impacted material, including TENORM, was calculated using GIS software. The vertical extent was determined by subsurface soil data or depth-to-encountered bedrock. Minor variations in the surface topography of potentially impacted areas are assumed to be accounted for in the horizontal and vertical extent estimates because the maximum depth of a given area was used. For each sample location, the depth of mining-impacted material, including TENORM, was rounded up to the nearest 0.5 foot, and areas with similar depths were aggregated.

Sections 3.8.1 through 3.8.3 present assumptions used to calculate mining-impacted material, including TENORM volumes. Note that "elevated" includes actual (laboratory samples) radiological or metals concentrations greater than the IL.

3.9.1 Waste Rock Piles

- Visible waste rock within a pile, regardless of gamma scan measurements or analytical soil data, was considered TENORM.
- Former waste rock piles were considered disturbances.
- Cover material on top of visible waste rock was included in the volume calculation because of the impracticality of segregating this material in the field.
- The vertical dimension of the waste rock pile was defined at the depth at which bedrock was encountered or soil analytical data were less than ILs.
- The mining-impacted material, including TENORM volume, in inaccessible waste rock piles was estimated using visual observations, subsurface soil borings in accessible portions of the waste rock piles extrapolated into the inaccessible area, aerial photographs, and professional judgment.

3.9.2 Other Impacted Areas

Other impacted areas include Mine Sites, drainage, and haul roads.

- Elevated unconsolidated material was considered TENORM after reviewing multiple lines of evidence.
- Elevated unconsolidated material was considered NORM if it did not meet the criteria after reviewing multiple lines of evidence.

3.9.3 Bedrock

Elevated in situ bedrock that was exposed as a result of natural weathering and erosion is considered NORM. Elevated in situ bedrock exposed because of historical mining-related activities was defined as TENORM. However, no volume was calculated.

3.10 Health and Safety

Fieldwork at the Mine Sites was conducted in accordance with the health and safety plans included in the approved RSE Work Plans (CH2M 2017, 2018), which identified and outlined necessary safety precautions and nearby medical facilities and resources. Daily safety briefings were conducted with field staff. In addition to routine safety precautions for heavy equipment operation and rugged field conditions, radiation exposure monitoring was performed for workers entering and leaving mine feature areas. The results of radiation exposure monitoring indicated that no field staff were exposed to significant health risks.

3.11 Quality Assurance/Quality Control

The Quality Assurance Project Plan (QAPP) presents QA/QC procedures, policies, and requirements for collecting data that are scientifically valid and defensible. The QAPP was included in the approved RSE Work Plans (CH2M 2017, 2018).

Quality of field data collection was confirmed by using a QAPP and standard operating procedures (SOPs) that included daily instrument calibration and checks and subcontractor oversight. Quality of laboratory data was confirmed by using the QAPP, which specifies analytical methods, laboratory instrument checks, QC sampling, and reporting limits. In accordance with the QAPP (Appendix C of the Work Plan), 90% of laboratory analytical data underwent a Level 3 validation, and 10% of the laboratory analytical data underwent a Level 4 validation by an experienced chemist.

3.11.1 Field Data Quality

RSE activities included collection of large quantities of field screening data as well as media samples for analytical evaluation. SOPs were developed for the field activities, and contractor experience and credentials were verified before mobilization. Field staff checked instrumentation calibration records, completed initial and daily source checks on the radiation equipment, verified compliance with SOPs, and reviewed preliminary field screening data collected during the field activities. The data collected from field activities were documented and preserved for archives. The data were reviewed for completeness, errors, and accuracy. Only the final validated analytical data are presented in this report.

3.11.1.1 Field Instrumentation Calibration and Checks

The field instruments were maintained and operated in accordance with their respective technical manuals and approved operating procedures. Each detector and scaler/ratemeter set was calibrated at least every 12 months in accordance with ANSI N323AB: *Radiation Protection Instrumentation Test and Calibration—Portable Survey Instruments* (ANSI 2013). The field survey instruments used to collect survey data were required to operate within acceptable tolerances and in accordance with the SOPs. Each survey instrument was required to pass a daily QC check. Failure of any of these daily checks would result in removal of the equipment from service until the equipment operated within acceptable tolerances or could be fixed. Appendix D contains copies of the calibration certificates and instrument source checks.

3.11.1.2 Field Confirmation

Field staff verified compliance with the SOPs and reviewed preliminary data during the field activities. Field staff were experienced and versed in the use of field equipment. The following QA/QC practices were performed by field oversight staff:

1) Field equipment was inspected by a health physicist or personnel trained by a health physicist during mobilization and initiation of fieldwork. At this time, equipment calibration logs were reviewed and confirmed. The source was confirmed to be of appropriate type and energy.
2) Transect survey areas were verified by GPS and field maps. Area boundaries were marked with flagging and other markers.
3) Field staff were inspected before conducting gamma walkover surveys to confirm adherence to the RSE Work Plans and conditions, including maintaining proper probe height and walking speed. Allowances were made for uneven ground.
4) Preliminary field data were observed and checked on a data logger intermittently.
5) Static gamma counts were collected and recorded on separate GPS devices and field logbooks for verification of subcontractor data reports.

No significant deficiencies were observed.

3.11.2 Laboratory Data Quality

RSE activities included collecting soil samples for laboratory analysis. The QAPP was provided to the analytical laboratory. The reported data were evaluated according to QAPP requirements, U.S. EPA method guidance, and the *U.S. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review* (U.S. EPA 2010a). The QAPP identifies the method-specific QC requirements for each analytical parameter and matrix and defines a plan to test that the correct sampling, analytical, and data-reduction procedures were followed. The Data Quality Evaluation Summary Report is included in Appendix E.

3.12 Decontamination, Investigation-derived Waste, and Personal Monitoring

Decontamination procedures were designed to minimize health risk for field staff, minimize the spread and transport of radioactive material, and prevent cross-contamination of samples. Non-disposable field sampling equipment and radiation meters were decontaminated. Decontamination was performed on reusable personal protective equipment and field equipment not used for sampling and field measurements to mitigate the transport of, and minimize exposure to, dust and soil with potentially elevated levels of radioactive material. Soil sampling equipment, such as hand augers, trowels, and scoops that contacted soils, were decontaminated before sampling, between each sample location, and daily after sampling in accordance with the approved SOPs. Sampling equipment was thoroughly decontaminated by removing sediment and dust with decontamination wipes and disposable towels, and equipment blanks were collected to demonstrate effective decontamination processes.

Field staff performed personal monitoring of their body, including personal clothing, exposed skin, and equipment, as well as reusable personal protective equipment, such as boots and hardhats. Personal monitoring was performed during breaks before handling or consuming food, when field staff exited areas where the potential for radioactive contamination existed, and at the end of the workday. Personal monitoring was performed with a Ludlum Model 12 equipped with a 44-9 Geiger-Mueller detector. If any locations exceeded 2 times the detector background measurement, decontamination activities were to be performed in accordance with the Health and Safety Plan (CH2M 2017, 2018).

No investigation-derived waste was produced as a result of these field efforts. Environmental media that was not sent for analytical analysis was returned to the location where it was sampled from or at the Mine Sites in an area of similar radioactivity, as identified by previous gamma scans.

4. Investigation Results

This section presents the results of the background investigation (DQO 1); Mine Site-specific results for gamma scan surveys and surface and subsurface soil sampling are presented in Appendix A (DQOs 2 and 4); Ra-226 and dose rate correlation study (DQO 3); and water sampling within 1 mile of the Cove Mine Sites (DQO 5).

Field investigations were limited to areas outside of inaccessible and restricted areas. Inaccessible areas were areas where health and safety concerns prevented access by field personnel (because of steep slopes or cliff ledges, for example). Restricted areas were locations of identified biologically or culturally sensitive items. Buffer zones around biologically or culturally sensitive areas were set by the pertinent authority (either NNDFW or NNHPD), which also may have limited gamma scanning or soil sampling in these areas.

4.1 Background Assessment

As indicated in Section 3.3, three BRAs were established for the Cove Mine Sites (Morrison Formation, Summerville Formation, and Chinle Formation). The investigation of these BRAs provided data to assess background conditions using gamma scan surveys and surface soil concentrations for Ra-226 and metals.

4.1.1 Background Reference Area Gamma Scan Survey Results

Table 4-1 summarizes the gamma scan survey results statistics for the Morrison, Summerville, and Chinle BRAs. The gamma scan survey data were plotted over an aerial image for each BRA (Figures 4-1 through 4-3), with the data color coded based on gamma count rate ranges. The results are summarized as follows:

1) **Morrison BRA:** Gamma count rates ranged from 8977 to 13228 cpm.
2) **Summerville BRA:** Gamma count rates ranged from 7194 to 10610 cpm.
3) **Chinle BRA:** Gamma count rates ranged from 9611 to 14570 cpm.

4.1.2 Background Reference Area Surface Soil Sampling Results

Table 4-1 summarizes the statistics for metals and Ra-226 laboratory analytical results for soil samples collected within the three BRAs. Laboratory analytical results are summarized in Table 4-2. Field sampling forms are provided in Appendix D, laboratory reports are provided in Appendix E, and detailed statistical analysis of background data is presented in Appendix F.

4.1.3 Background Reference Area Subsurface Soil Sampling Results

Three subsurface soil samples were collected at each BRA corresponding with locations containing the minimum, median, and maximum Ra-226 concentrations in surface soil. Mean concentrations of metals and Ra-226 in subsurface soil were comparable to concentrations in surface soil. Table 4-2 presents the subsurface soil sample results collected at the three BRAs.

4.2 Background Threshold Values and Preliminary Investigation Levels

Background concentrations in nature typically vary and can span a range of values. For the purpose of the RSE investigation, BTVs were calculated for the each of the three BRAs for gamma count rate and primary COPC soil concentrations based on the results from the BRA investigations. An IL was derived from the BTV to assess the extent of field scanning and the type and extent of potentially impacted environmental media. ILs are not the same as the preliminary remediation goals (cleanup goals) to be defined during the risk assessment and EE/CA, if one is required. The method used for calculating the BTV is described as follows.

R (U.S. EPA-endorsed statistical computing software) (R Core Team 2018) and ProUCL Version 5.1 (U.S. EPA-approved software) (U.S. EPA 2015b) were used to evaluate the data and calculate required values. BTVs and ILs were set as follows, and documentation of statistical methods, assumptions, and calculations are provided in Appendix F.

The BTVs were calculated using the following method, as stipulated in the Work Plans (CH2M 2017, 2018). Background statistics used to calculate the BTVs are presented in Table 4-1.

- Gamma count rate and primary COPC concentrations: The BTV was set at the USL95 if no outliers were present in the data set; the BTV was calculated this way for arsenic (except for the Summerville Formation), mercury, molybdenum, selenium, thorium, uranium, vanadium, Ra-226, and gamma count rate for the Morrison, Summerville, and Chinle Formations. If outliers were present, they were evaluated to see whether they should be removed for reasons such as sample contamination or lab errors. If there was no reason to remove the outliers, then they were not removed from the data set, and the UTL95-95 was used as the BTV. The BTV for arsenic was calculated this way in the Summerville Formation.
- Gamma Count Rate ILs were rounded to the nearest 100 from the calculated USL95.
- The IL equaled the greater of the BTV or the U.S. EPA RSL. If no RSL had been established by U.S. EPA, then the IL was the BTV, as approved by U.S. EPA in the Work Plans (CH2M 2017, 2018). ILs are listed in Tables 4-3 and 4-4. For field investigation gamma count rate, the IL was the BTV plus 1500 cpm; for vertical field delineation, the IL was 2 times the BTV. For analytical data, the IL was set as follows:
- U.S. EPA RSL was greater than the BTV for mercury, molybdenum, selenium, uranium, and vanadium; therefore, the IL was set at the U.S. EPA RSL.
- BTV was greater than the U.S. EPA RSL for arsenic; therefore, the IL was set at the BTV.
- No U.S. EPA RSL was established for gamma count rate, Ra-226, and thorium; therefore, the BTV was used as the IL.
- Secondary COPCs: Because these compounds are not naturally occurring, the IL was set at the U.S. EPA RSL.

4.3 Gamma Scan Surveys

Gamma scan results for the Mine Sites and mine features were compared to the IL (Table 4-3). The IL for gamma count rate was used to evaluate the need for further lateral scanning or sampling in the field, to inform locations of surface soil samples, and as a preliminary tool to indicate areas of potentially elevated radioactivity. Table 4-5 presents the BTV and multiple of the BTV used to analyze the gamma count rate. Although a BTV for the Chinle Formation was calculated, none of the Mine Sites had Chinle Formation present and it was not used or presented in Table 4-5.

Gamma scan summaries for the Mines Sites are presented in the site-specific Mine Site summaries in Appendix A. These summaries include evaluation of gamma scan measurements on the Mine Site, drainages, and haul roads.

4.4 Soil Sampling Results

The soil sampling results for the site-specific Mine Sites are presented in Appendix A. The results are compared with the IL and multiple lines of evidence. Sample descriptions, gamma scan measurements, and laboratory analytical results for primary and secondary COPCs are summarized in site-specific tables in Appendix A. Soil sample logs and soil boring logs are presented in Appendix D, and laboratory analytical reports are provided in Appendix E.

Sample identifiers were based on the following format:

AA-BB-CC-DDD

- AA: The first two digits indicate the sample media, such as SD for sediment, SS for surface soil, or SB for subsurface soil.

- BB: The next two digits indicate the Mine Site identification. Waste rock pile locations have four letter spaces, which are named with Navajo Nation Waste Rock Pile (NNWP) or Cyprus Amax Waste rock pile (CAWP), and include a 2-digit waste rock pile designation.
- CC: The next two digits indicate the mine feature from which the sample was collected. For example, MS would indicate the sample was collected from the Mine Site, whereas H1 would indicate the sample was collected from Former Haul Road 1.
- DDD: The next three digits indicate the sample number, numbered sequentially by order of collection.

The site-specific soil sampling summary in Appendix A includes evaluation of soil sampling frequency, Ra-226, metals and secondary COPCs on the Mine Site, haul roads, drainages, and waste piles.

4.5 Secondary Contaminants of Potential Concern

Jacobs evaluated evidence of mining-related activities at the Mine Sites by collecting a surface soil sample, and a subsurface soil sample if the surface soil sample exceeded the IL. The samples were analyzed for the secondary COPCs (TPH, explosives, perchlorate, and PCBs). Secondary COPC samples were collected from each of the nine Mine Sites, and no IL exceedances were recorded. Sample results from seven of the Mine Sites had detections of diesel-range organics, and one had a detection of gasoline-range organics. The secondary COPC results are summarized in Table 4-6.

In accordance with the Work Plan, a sufficient number of soil and sediment samples was collected at the Mine Sites for secondary COPC analysis to evaluate whether mining-related activities released secondary COPCs into the environment. None of the secondary COPCs exceeded ILs. Because secondary COPCs did not exceed the IL, there is no evidence to suggest that historical mining activities resulted in release of explosives, TPH, or PCBs. According to this information, historical mining activities did not result in a release of secondary COPCs.

4.6 Contaminants of Potential Concern

For each of the Mine Sites, site-specific COPCs were determined based on the IL exceedances. These COPCs are detailed for each Mine Site in Appendix A. At eight of the Mine Sites, Ra-226, arsenic, thorium, uranium, and vanadium in soil exceeded their respective ILs and therefore were confirmed as Mine Site COPCs. In the one remaining Mine Site (Mesa III West), Ra-226, arsenic, thorium, and uranium in soil exceeded their respective ILs and were confirmed as Mine Site COPCs.

4.7 Correlation Studies

Correlation studies were performed for both gamma count rate (in cpm) and Ra-226 surface soil concentration (in pCi/g), and for gamma count rate (in cpm) and dose rate (in μrem/hr). Correlation data were acquired according to the methodology described in Section 3.8. The correlation plot locations are presented on Figure 4-4. The purpose of the Ra-226 correlation is to inform future potential removal/remedial actions to estimate Ra-226 concentrations in surface soils using walkover gamma scans in locations where soil samples are not collected for laboratory analysis. The purpose of the dose rate correlation is to provide a way to convert gamma count rate from an energy-dependent detector to dose rate from a detector that is largely energy independent over a broad energy range. The Ra-226 surface soil correlation was not used for the site characterization, which relied instead on the gamma scans and soil/sediment analytical results. Details of the analyses performed are provided in Appendix G.

4.7.1 Gamma Count and Radium-226 Surface Soil Concentration Correlation

Analytical results of the correlation sample data in conjunction with the high-density gamma scan data were used to develop the regression equation. Linear regression analysis under log transformation was the model found that best represents the relationship in the correlation plot data between gamma count rate and Ra-226 soil concentration for the Cove Mine Sites. The best fit regression equation to convert gamma measurements in cpm to predicted surface soil Ra-226 concentrations in pCi/g for the Cove Mine Sites is presented. Figure 4-5 depicts the gamma count rate to Ra-226 soil concentration correlation.

$$y = 0.4856e^{0.0001x}$$

Where:

y = Ra-226 soil concentration (pCi/g)

x = Gamma radiation measurement (cpm)

Example Correlation Estimates

- 9426 cpm correlates to 1.28 pCi/g Ra-226 concentration.
- 17755 cpm correlates to 3.0 pCi/g Ra-226 concentration.
- 20560 cpm correlates to 4.0 pCi/g Ra-226 concentration.
- 29494 cpm correlates to 10.0 pCi/g Ra-226 concentration.

The regression statistics demonstrate that a statistical relationship exists between gamma count rate (cpm) and Ra-226 concentrations in surface soil at the Cove Mine Sites but did not meet the Work Plan requirements of an R-squared value greater than or equal to 0.8. Therefore, the mean detector output was able to explain 60.5% of the observed variability in mean Ra-226 concentration. The equation produced a mean squared error of 2.89, which describes the average error of the regression line from the individual data points. A regression probability value (p-value) of less than 0.001 suggests that the relationship between gamma count rate and Ra-226 soil concentration is significant and not because of chance. These regression statistics demonstrate that a statistical relationship exists between gamma count rate and Ra-226 concentrations in surface soil at the Cove Mine Sites.

A model validation study using data from surface soil samples collected across the nine Cove Mine Sites was performed based on the methods presented in Section 3.8. Details of this analysis are described in Appendix G. The validation results indicated that the chosen regression model can be used to predict Mine Site Ra-226 surface soil concentrations. The regression model exhibits a slight overprediction less than 4.5 pCi/g and a slight underprediction greater than 4.5 pCi/g. For example, a hypothetical surface soil sample with a measured Ra-226 concentration of 2.0 pCi/g would be predicted as 2.14 pCi/g, and a hypothetical surface soil sample with a measured Ra-226 concentration of 6.0 pCi/g would be predicted as 5.90 pCi/g.

Sufficient data were collected to evaluate whether a correlation between gamma count rate and Ra-226 soil concentration is present at the Cove Mine Sites. This regression equation can be used to predict Ra-226 soil concentrations only for gamma values between the range of 9426 cpm to 36468 cpm. The regression equation is statistically valid only when used to predict soil concentration values within the range of values that was used to produce it. Predicted values outside of that range should be used qualitatively and with caution when making decisions. Detailed analysis is found in Appendix G.

4.7.2 Gamma Count Rate and Dose Rate Data Correlation

NaI detection systems used for this RSE are commonly used to scan and characterize radiological conditions at a site. These types of instruments are a widely accepted tool for characterization of spatial distributions of gamma radiation caused by NORM. These systems, however, exhibit strong energy dependence and tend to over respond significantly to low-energy photons and under respond to high-energy photons. While the data collected from these instruments are useful for characterization, they cannot be used to assess radiation doses to potential workers or the public. To mitigate the drawbacks of the energy-dependent system, a site-specific dose correlation to normalize NaI detector measurements to a less energy-dependent instrument was performed. A Bicron MicroREM instrument was chosen for this study for its relative energy independence across a broad range of photon energies and its ease of portability.

Analytical results of the correlation dose rate data in conjunction with the high-density gamma scan data were used to develop the regression equation. Linear regression analysis was used to perform the analysis. The regression equation to convert gamma count rate in cpm to predicted dose rate in µrem/hr for the Mine Site is presented as follows. Figure 4-6 depicts the gamma count to dose rate correlation.

$$y = 0.00043x + 4.091$$

Where:

y = Dose rate (µrem/hr)

x = Gamma radiation measurement (cpm)

Example Correlation Estimates

- 9426 cpm correlates to 8.1µrem/hr (minimum value predicted).
- 13742 cpm correlates to 10 µrem/hr.
- 25370 cpm correlates to 15 µrem/hr.
- 36468 cpm correlates to 19.8 µrem/hr (maximum value predicted).

The linear regression for gamma count rate (cpm) to dose rate (µrem/hr) resulted in an R-squared value of 0.613. Therefore, the mean detector output was able to explain 61.3% of the observed variability in dose rate. The equation produced a mean squared error of 2.64, which describes the average error of the regression line from the individual data points. A regression probability value (p-value) of less than 0.001 suggests that the relationship between gamma count rate and dose rate is significant and not because of chance. These regression statistics demonstrate that a statistical relationship exists between gamma count rate and dose rate at the Cove Mine Area.

A model validation study was performed using count rate and dose rate measurements collected at surface soil sample locations across all nine Cove Mine Sites, based on the methods described in Section 3.8. Details of this validation are described in Appendix G. Large variability was found to exist in the predicted versus measured dose rates, particularly in the low range. Lack of measurement precision of the dose rate instrument when performing measurements at low ranges is considered a significant factor. The trend in the Mine Site data was found to follow a slightly different slope than was found in the correlation plots. The variability in the collected Mine Site data is due to the following factors:

- The Bicron MicroREM has significant uncertainty when measurements are collected at low-dose-rate conditions (less than approximately 15 µrem/hr) and relies on analog interpretation by the field operator. This uncertainty is greatest at radiation levels that are at or near background.
- Multiple Bicron MicroREM detectors were used in the field by multiple operators.
- Variation between like instruments. Calibration laboratories typically allow +/- 20% difference between like instruments (ANSI 2013).

The validation model indicates that dose rates are not well predicted by the regression equation. The model requires further investigation before it can be considered usable during a potential remedial action for estimating dose rate from gamma count rates. No further correlation sampling will be conducted at the Cove Mine Sites; however, Cyprus Amax is exploring additional methodologies for dose rate correlation at Group 2 Mines Sites.

5. Cove Mine Sites Water Summary

5.1 Spring/Seeps

Four springs were identified within a 1-mile radius of the Cove Mine Sites as potential surface water sampling locations. Of the four locations, three were sampled (Spring 1, Spring 2, and the Livestock Trough) and one was not observed to be flowing through the downgradient Mine Site (Nez Spring). The IL exceedances for Ra-226/228 and adjusted gross alpha were observed at Spring 1 (Table 5-1 and Figure 5-1). No IL exceedances were reported from samples collected at Livestock Trough or Spring 2.

The Mine Sites are hydraulically downgradient from the four springs (and thus not the source for any elevated radioactivity) for the following reasons:

1) Groundwater flow in the Cove Mine Sites is assumed to follow topography, and the terrain in the Cove Mine Sites is heavily dissected by multiple deep drainages (Cooley et al. 1969). The topography therefore creates significant drainage boundaries between the spring locations and CD Mine Sites. Because springs furnish a dependable supply of water, groundwater wells have typically not been drilled in the Lukachukai Mountains. A summary of the absence of hydraulic connections between the Mine Sites and surface water locations is as follows:
    a) The Livestock Trough is upgradient of the Mine Sites and drainage below NA-0316, Frank No. 1, and Frank No. 2.
    b) Spring 1 and Spring 2 are not hydraulically connected to the CD Mine Sites. Topographically, the springs flow to an upper reach of the Middle 3E drainage (Figure 2-5).
2) Stratigraphically, Spring 1 and Spring 2 are located near the contact between the Chuska Sandstone and the Recapture Member of the Morrison Formation, and the Livestock Trough emerges from a pipe of unknown source (Figure 2-3). As shown on Figure 2-4, the Chuska Sandstone and Recapture member of the Morrison Formation are stratigraphically higher than the historical mining unit at the Mine Sites (the Salt Wash Member of the Morrison Formation).
3) Topographically, Spring 1 and Spring 2 are approximately 700 feet higher in elevation than the nearest mine features (that is, the observed waste rock pile at the Billy Topaha Mine Site). The Livestock Trough is approximately 400 feet higher in elevation than the closest CD Mine Site.

Additionally, Spring 1 is located near the Chuska Sandstone-Recapture Member contact. While the Recapture Member of the Morrison Formation is generally not considered an economically viable mining deposit, it does contain uranium deposits, which may explain the presence of metals, uranium decay products, and elevated adjusted gross alpha measurements.

6. Cove Mine Sites Mining-impacted Material, Including TENORM, Summary

Table 6-1 summarizes the Cove Mine Site TENORM area and volume estimates of mining-impacted material. TENORM was calculated per the methods in Section 3.9. Development of these estimates for each Cove Mine Site is detailed in the site-specific Mine Site technical memoranda in Appendix A. A summary of those results are as follows:

- Cato No. 2: The RSE results found an estimated 14,900 cubic yards of mining-impacted material, including TENORM, present across 2.22 acres at the Mine Site.
- Frank No. 1: The RSE results found an estimated 61,900 cubic yards of mining-impacted material, including TENORM, present across 15.35 acres at the Mine Site.
- Frank No. 2: The RSE results found an estimated 3,900 cubic yards of mining-impacted material, including TENORM, present across 1.28 acres at the Mine Site.
- NA-0316: The RSE results found an estimated 11,400 cubic yards of mining-impacted material, including TENORM, present across 2.81 acres at the Mine Site.
- Mesa IV 1/4: The RSE results found an estimated 8,300 cubic yards of mining-impacted material, including TENORM, present across 2.08 acres at the Mine Site.
- Mesa III Northwest: The RSE results found an estimated 3,600 cubic yards of mining-impacted material, including TENORM, present across 0.57 acre at the Mine Site.
- Mesa III West: The RSE results found an estimated 3,600 cubic yards of mining-impacted material, including TENORM, present across 0.75 acre at the Mine Site.
- Mesa II 1/4: The RSE results found an estimated 9,500 cubic yards of mining-impacted material, including TENORM, present across 1.87 acres at the Mine Site.
- Billy Topaha: The RSE results found an estimated 5,000 cubic yards of mining-impacted material, including TENORM, present across 0.77 acre at the Mine Site.

7. Mine Site DQO, Uncertainties, and Data Gap Summary

7.1 Data Quality Objectives

An evaluation of the DQOs for the Mine Sites is summarized in Table 7-1. The DQOs have been met; however, there are some data gaps discussed in Section 7.4. Site-specific Mine Site details are presented in Appendix A.

7.2 Deviations from the Work Plans

The following items were identified:

- Salinity was calculated and not measured. Salinity was not analyzed in the field, because the portable multi-parameter water quality meter did not analyze for salinity. Instead, salinity was calculated using specific conductance and temperature (Fofonoff and Millard 1983), which is a deviation from the Work Plan.
- Dose rate measurements were not collected at correlation Plot 15, Plot 18, and Plot 19, which is a deviation from the Work Plan.

7.3 Uncertainties

The following uncertainties have been identified and may be considered during additional evaluations, including the risk assessment and EE/CA, if required. Some uncertainties may be permanent and nonaddressable during subsequent work at the Mine Sites.

Uncertainties and their significance to the RSE process are as follows:

- An exceedance of the IL is not a definitive indicator of impacts from historical operations. The IL used as a part of the multiple lines of evidence to calculate the volume of mining impacts, including TENORM, may not accurately estimate the volume that is subject to a removal action. Once the risk assessment is complete and cleanup values are determined, the volume of mining impacts, including TENORM, may change.
- Areas without data that were inaccessible for health and safety reasons encountered during field investigations could contain impacted material, including TENORM. These areas may require cleanup and, as a result, change the estimated volume that is subject to a removal action.
- Cyprus Amax acknowledges that the correlations between gamma count rate (cpm) and dose rate (μrem/hr) have significant uncertainties associated with the instrumentation and the narrow range of data collected. No further correlation sampling will be conducted at the Mine Sites during the RSE phase of work; however, Cyprus Amax is exploring additional methodologies for dose rate correlation at the Group 2 Mine Sites.

7.4 Data Gaps

A data gap evaluation was conducted. Additional work to fill the data gaps may be considered during additional evaluations, including the risk assessment and EE/CA, if required. However, some data gaps may be permanent and nonaddressable during subsequent work at the Mine Sites. Mine Site-specific data gaps are discussed in Appendix A. Data gaps and their significance to the RSE process are discussed in the following sections herein.

The following data gaps have been identified:

- Large portions of the Mine Sites were not evaluated, because of inaccessibility caused by steep terrain and heavy vegetation. Gamma scanning and soil sampling were conducted only on accessible portions of the Mine Sites. In addition, most drainages downgradient of the Mine Sites were not accessible for the same reasons and therefore could not be evaluated.

- Vertical extent of mining-impacted material, including TENORM, was not delineated at some of the Mine Sites (Appendix A). Subsurface sampling was conducted in accordance with the Work Plans (CH2M 2017, 2018); however, refusal was encountered before sample collection less than the IL for some analytes in each of these borings. Once a cleanup level for COPCs is determined, additional deeper soil sampling at the Mine Sites may be required. Collection of deeper soil samples at these locations may not be feasible because of site conditions.
- The lack of precision of the dose rate instrument when performing measurements at low ranges is considered a significant factor; additionally, the instrument relies on analog interpretation by field personnel, so the dose rate correlation cannot be used. No further correlation sampling will be conducted at the Mine Site; however, Cyprus Amax is exploring additional methodologies for dose rate correlation at the Group 2 Mine Sites.

8. Cove Mine Sites Summary and Conclusions

The following is a general summary of the Cove Mine Sites:

The Cove Mine Sites are located on Tribal Trust Land in Cove Chapter of the Navajo Nation in Apache County, Arizona. Nine of the 94 Mine Sites listed in the CD are located in Cove. The nine Mine Sites in the Cove Area are as follows:

- Cato No. 2
- Frank No. 1
- Frank No. 2
- NA-0316
- Mesa IV 1/4
- Mesa III Northwest
- Mesa III West
- Mesa II 1/4
- Billy Topaha

The Mine Sites were mined in the 1950s through 1960s, with production totals varying among the Mine Sites.

- Mining of the Cove Mine Sites targeted uranium ore deposits in the Salt Wash Member of the Morrison Formation. Uranium ore deposits in the Salt Wash Member of the Morrison Formation are generally located in the lower third of the geologic unit, which overlies the cliff-forming Summerville Formation. Since the Salt Wash Member of the Morrison Formation contains naturally occurring uranium minerals, some amount of natural uranium and uranium daughter products are present at the Mine Sites.
- In the early 2000s, as part of the Northern Navajo Abandoned Mine Lands Reclamation Project, NAML conducted reclamation activities at many of the Cove mines, including most of the nine CD Mine Sites. Mine Site reclamation activities included waste rock consolidation and burial, scarification and blocking access to Mine Site access roads, and backfilling and closing mine portals and highwalls.

The RSE investigation, in summary, concluded the following:

- IL exceedances of gamma count rates and Ra-226 and metals concentrations in soil samples were primarily located within relatively short distances from historical mine features (that is, portals, prospects, waste rock piles, and haul roads). In some cases, inaccessible areas near these features prevented investigations farther away.
- COPCs identified at eight of the Mine Sites include Ra-226, uranium, vanadium, arsenic, and thorium. COPCs identified at the remaining Mine Site (Mesa III West) include Ra-226, uranium, arsenic, and thorium.
- Secondary COPCs did not exceed their respective ILs at any of the Cove Mine Sites. Using multiple lines of evidence, it is assumed that the Mine Sites were not impacted by any historical releases from blasting, machine maintenance, refueling, or use of electrical equipment.
- The water data collected from locations within 1 mile of the Cove Mine Sites were from surface water features that were hydraulically and topographically upgradient of the Mine Sites and were therefore not impacted by mining-related activities. Water data from the bottom of the drainages were not collected, because of inaccessibility. No water was observed at the Mine Sites during RSE activities.
- Data collected by U.S. EPA at high-flow and low-flow conditions over 2 years (Weston 2015 to 2017) indicated impacts to surface water and sediments in the Cove drainages along which the CD Mine Sites are located. However, additional data are necessary to fully understand the contributions from naturally occurring ore-bearing formations and individual Mine Sites.
- The Ra-226 correlation achieved acceptable statistical performance criteria and model validation. The correlation may be used for estimating the lateral extent of Ra-226 soil concentrations during an EE/CA.

- The dose rate correlation could not achieve acceptable statistical performance criteria and model validation, which indicates that predicted values are not aligned with measured values. Therefore, the correlation may not be used during an EE/CA for estimating dose rate from gamma count rates. Cyprus Amax is exploring additional methodologies for dose rate correlation at Group 2 Mine Sites.
- An interim action was conducted at Frank No. 2 to repair an eroded portal previously closed by NAML to address the physical safety hazard. No other mining features requiring interim action were observed at the Cove Mine Sites.
- The total lateral extent of mining-impacted material, including TENORM, across the nine Mine Sites covers approximately 27.66 acres; the volume estimates of mining-impacted material, including TENORM, for the nine Mine Sites is approximately 121,900 cubic yards. Site-specific, mining-impacted material, including TENORM volumes, greater than the ILs are presented in Table 6-1.

Summaries and conclusions specific to each Mine Site are provided in the site-specific reports in Appendix A.

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Tables

Table 1-1. Consent Decree Mine Sites: Cove Mine Site List

Cove Mine Area Removal Site Evaluation Report

Mine Site Number	Mine Claim All Site IDs	Mine Name	State	Chapter	Surface Area Acres (rounded)	Underground Area Acres (rounded)	AEC Records of Ore Production (tons)	Years Active According to U.S. EPA Atlas	Latitude (north)	Longitude (west)	Priority Mine	Proximate Mine
3	422	Billy Topaha Mine	Arizona	Cove	4.4	0.0	703	1959-1960	36.5005295341	-109.2253065200		
4	104	Cato No. 2	Arizona	Cove	6.5	0.0	52	1953-1954	36.5480201387	-109.2498938690		
5	106	South Portal, Frank No. 1 Mine	Arizona	Cove	12.0	1.1	75,739	1951-1967	36.5304430903	-109.2545655060		
	505	North Portal, Frank No. 1 Mine	Arizona	Cove	0.9	1.3			36.5366909246	-109.2556406100		
	509	East Portal, Frank No. 1 Mine	Arizona	Cove	10.2	2.5			36.5331690026	-109.2518936640		
6	510	Frank No. 2	Arizona	Cove	3.9	0.3	N/A	0	36.5321226646	-109.2529084440		
7	96	Mesa II 1/4 Mine	Arizona	Cove	2.2	0.3	725	1963-1966	36.5151713703	-109.2343637110		
8	424	Mesa III, Northwest Mine	Arizona	Cove	7.3	0.1	735	1957	36.5195447407	-109.2477979150	yes	
9	417	Mesa III, West Mine	Arizona	Cove	6.6	0.0	N/A	1966	36.5146359700	-109.2507121510		
10	415	Mesa IV 1/4 Mine	Arizona	Cove	6.0	0.3	344	1965-1968	36.5282303341	-109.2611541410		
11	107	NA-0316	Arizona	Cove	1.6	0.0	N/A	0	36.5293472379	-109.2571912820		yes

Notes:

AEC = Atomic Energy Commission

ID = identification

N/A = not applicable

RSE = removal site evaluation

U.S. EPA = United States Environmental Protection Agency

VCA = Vanadium Corporation of America

Table 1-2. Jacobs Project Management Team

Cove Mine Area Removal Site Evaluation Report

Name	Title	Education/Credentials
Dawn Townsen	Project Manager	M.S., Hydrology; B.S., Biology and Chemistry
Kira Aiello	Senior Technical Consultant	M.S., Environmental Engineering and Radiation Health Physics, B.S., Nuclear Engineering
Gavin Wagoner	Field Investigation Task Manager	B.S., Geological Sciences, with Environmental Science minor
Eric Packard	Radiation Safety Officer	B.S., Radiation Health Physics; American Board of Health Physics, Certification #6036
George Tangalos	Senior Geologist	Professional Geologist, Utah; M.S., Geology and Geophysics; B.A., Geology with Biochemistry minor
Jon Russ	Risk Assessor, Quality Assurance Manager	B.S., Wildlife Sciences; Certified Hazardous Materials Manager.
Aditya Tyagi	Statistician	Ph.D., Biosystems Engineering; M.S., Environmental Engineering; B.S., Civil Engineering; Professional Engineer, Texas, Certification #92042
Joshua Painter	Health and Safety Officer	B.S., Environmental Remediation and Hazardous Waste Management; Certified Safety Professional, Certification #18665

Notes:

= Number

B.A. = Bachelor of Arts

B.S. = Bachelor of Science

M.S. = Master of Science

Table 2-1. Mexican Spotted Owl Habitat and Observations
Cove Mine Area Removal Site Evaluation Report

Mine Site[a]	Suitable MSO Habitat Category[b, c]	MSO Observations 2016 (approximate miles)	MSO Observations 2018 (approximate miles)	MSO Observations 2019 (approximate miles)
Cato No. 2	Excellent	0.1	0.1	0.8
Frank No. 1 North Portal	Fair	0.5	0.4	0.6
Frank No. 1 South Portal	Fair	0.5	0.3	0.5
Frank No. 1 East Portal	Fair	0.3	0.1	0.3
Frank No. 2	Fair	0.4	0.2	0.4
NA-0316	Good	0.7	0.5	0.8
Mesa III Northwest	Fair	1.0	0.6	0.5
Mesa III West	Fair	1.3	0.8	0.1
Mesa II ¼	Fair	0.4	0.4	0.4
Mesa IV ¼	Good	0.9	0.7	1.0
Billy Topaha	Poor	1.1	1.1	1.2

Notes:

[a] Figure 2-5 shows the location of Cove Area Mine Sites in relation to suitable habitat and observation locations.

[b] MSO suitable habitat categories (excellent, good, fair, and poor) were adapted by Adkins and Weston (2016) and based on suitable habitat definitions provided in MSO Recovery Plan (USFWS 2012).

[C] Mine Sites may be entirely or partially within suitable habitat as delineated by 2016 Mexican Spotted Owl Survey Report (Adkins and Weston, 2016) and Mexican Spotted Owl Survey Report 2019 Season (Tetra Tech, 2019), and shown on Figure 2-5.

MSO = Mexican Spotted Owl

Sources:

1. Adkins Consulting, Inc. and Weston Solutions, Inc. (Adkins and Weston). 2016. *2016 Mexican Spotted Owl Survey Report* . November.

2. Tetra Tech Inc. (Tetra Tech). 2019. *Northern Agency Tronox Mines Engineering Evaluation/Cost Analysis Mexican Spotted Owl Survey Report 2019 Nesting Season* . Submitted to U.S. Environmental Protection Agency. August.

3. U.S. Fish and Wildlife Service (USFWS). 2012. *Final Recovery Plan for Mexican Spotted Owl (Strix occidentalis lucida)* . First Revision. Albuquerque, New Mexico. 413 pages.

Table 3-1. Surface Water and Groundwater Sample Location Summary
Cove Mine Area Removal Site Evaluation Report

Mine Site Area	NNDWR Well Database Location	NNDWR Northing (Zone 12 S)	NDWR Easting (Zone 12 S)	Cyprus Amax Observed Northing if Different from NNDWR	Cyprus Amax Observed Easting if Different from NNDWR	Cyprus Amax Location Notes	Well Water or Surface Water Sample Locations	Location to be Sampled (yes or no)	Comments
Cove Mine Area	Nez Spring	36.531726	-109.267981	NA	NA	NA	Surface water	No	The Nez Spring has not been observed to be flowing through the Mine Site during Cyprus Amax field visits. The drainage downgradient from the spring was dry during the investigation on 6/21/18.
	Spring 1	36.501239	-109.211988	NA	NA	NA	Surface water	Yes; sampled 6/20/2018	None
	Spring 2	36.500850	-109.213728	NA	NA	NA	Surface water	Yes, sampled 10/3/2019	The spring was dry during investigation on 6/20/18 and 9/21/18. The spring was sampled on a return visit during the Removal Site Evaluation data gaps investigation.
	Livestock Trough	36.521797	-109.257887	NA	NA	NA	Surface water	Yes, sampled 6/21/2018	None

Notes:

Cyprus Amax = Cyprus Amax Minerals Company

NA = not applicable

NNDWR = Navajo Nation Department of Water Resources

Table 4-1. Summary of Background Statistics
Cove Mine Area Removal Site Evaluation Report

Background Reference Area	Statistic	Arsenic (mg/kg)	Mercury (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Thorium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium 226 (pCi/g)	Gamma Count Rate (cpm)
Morrison Formation	Distribution	Normal	Lognormal	Normal	DQR[a]	Lognormal	Normal	Normal	Normal	None
	Minimum	1.0	0.0039	0.12	NA	2.1	0.34	7.9	0.42	8977
	Maximum	2.2	0.031	0.22	NA	3.6	1.5	13	1.32	13228
	Mean	1.66	0.01	0.17	NA	2.57	0.77	10.51	0.96	10967
	Standard Deviation	0.28	0.01	0.03	NA	0.36	0.29	1.42	0.22	533
	Outlier	No	No	No	No	No	No	No	No	No
	95-95 UTL	2.31	0.034	0.23	DQR[a]	3.46	1.44	13.8	1.45	11896
	95% USL	2.41	0.042	0.24	DQR[a]	3.64	1.54	14.3	1.53	**13228**
Summerville Formation	Distribution	Box-Cox Transformation	Lognormal	Normal	Normal	Lognormal	Normal	Lognormal	Kaplan Meier (KM) Censored Method[c]	None
	Minimum	0.98	0.0016	0.07	0.23	1.1	0.19	4.8	0.35	7194
	Maximum	3.2	0.013	0.17	0.53	2.3	0.59	19	0.94	10610
	Mean	1.39	0.01	0.11	0.37	1.56	0.34	7.99	0.544	8937
	Standard Deviation	0.43	0	0.02	0.1	0.37	0.1	3	0.188	573
	Outlier	Yes	No	No	No	No	No	No	No	No
	95-95 UTL	3.02	0.016	0.17	0.59	2.58	0.56	15.5	0.97	9868
	95% USL	4.82	0.019	0.18	0.62	2.81	0.60	17.5	1.04	**10610**
Chinle Formation	Distribution	Box-Cox Transformation	Normal	Normal	Normal	Box-Cox Transformation	Lognormal	None	Normal[b]	None
	Minimum	1.6	0.0048	0.066	0.52	2.7	0.33	9.4	0.85	9611
	Maximum	2.7	0.014	0.15	0.83	4.2	0.47	13	1.24	14570
	Mean	1.96	0.01	0.1	0.65	3.59	0.38	10.34	1.03	11799
	Standard Deviation	0.26	0	0.02	0.070	0.39	0.03	0.97	0.11	581
	Outlier	No	No	No	No	No	No	No	No	No
	95-95 UTL	3.05	0.014	0.15	0.81	4.25	0.45	13.0	1.29	12659
	95% USL	3.51	0.014	0.16	0.83	4.32	0.46	13.0	1.34	**14570**

Notes:
Statistics were calculated using ProUCL Version 5.1 (U.S. EPA 2015).
Highlighted values indicate the selected BTV.

[a] If a constituent is not detected in any of the background samples, the DQR is used. Under this rule, if there are two consecutive detections in a GU for a constituent, it is an SSI for that GU-constituent pair. According to U.S. Environmental Protection Agency Guidance (2009), "A confirmed exceedance is registered if any GU-constituent pair in the '100% non-detect' group exhibits quantified measurements (i.e., at or above the reporting limit [RL]) in two consecutive sample and resample events."

[b] Data could not be transformed. Actual confidence coefficient achieved by UTL is 72.3%, because at least 59 observations are needed to achieve 95% coverage.

[c] Kaplan Meier Censored Method for adjusting mean and standard deviation for UTL and USL.

If no significant outlier is present, the USL95 is used as the BTV. Otherwise, the 95%/95% UTL is used as the BTV.
BTV = Background Threshold Value
cpm = counts per minute
DQR = Double Quantification Rule
GU = geological unit
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram
SSI = statistically significant increase
USL = upper simultaneous limit
UTL = upper tolerance limit

Table 4-2. Soil Sample Laboratory Results – Background Reference Areas
Cove Mine Area Removal Site Evaluation Report

Mine Area	Sample Identification	Top of Sample Interval (feet)	Bottom of Sample Interval (feet)	Geologic Unit	Sample Method	Longitude[a]	Latitude[a]	Sample Date	Gamma Count Rate (cpm)[b,c]	Dose Rate (µRem/hr)[d]	Arsenic (mg/kg)		Molybdenum (mg/kg)		Selenium (mg/kg)		Thorium (mg/kg)		Uranium (mg/kg)		Vanadium (mg/kg)		Mercury (mg/kg)		Radium 226 (pCi/g)	
Cove	SS-CO-B1-001-10142017	0	0.5	Morrison	Hand Tools	-109.257437	36.531151	10/14/2017	9288	7	1.7		0.16	J	0.43	U	2.5		0.42		8.6		0.017	J	0.42	
Cove	SS-CO-B1-002-10142017	0	0.5	Morrison	Hand Tools	-109.257363	36.531268	10/14/2017	10528	7	1.4		0.15	J	0.37	U	2.7		0.61		10		0.0073	J	1.04	
Cove	SS-CO-B1-003-10142017	0	0.5	Morrison	Hand Tools	-109.257483	36.531292	10/14/2017	10615	7	1.7		0.18	J	0.45	U	2.7	J	0.71		11		0.0071	J	1.11	
Cove	SS-CO-B1-004-10142017	0	0.5	Morrison	Hand Tools	-109.257608	36.531268	10/14/2017	10283	6	2		0.21		0.54	U	2.5		0.88		12		0.017	J	1.23	
Cove	SS-CO-B1-005-10142017	0	0.5	Morrison	Hand Tools	-109.257781	36.531312	10/14/2017	10225	7	1.9		0.18	J	0.65	U	2.7		0.55		11		0.014	J	0.77	
Cove	SS-CO-B1-006-10142017	0	0.5	Morrison	Hand Tools	-109.25785	36.531428	10/14/2017	9971	8	1.7		0.17	J	0.54	U	2.7		0.51		9.9		0.016	J	0.75	
Cove	SS-CO-B1-007-10142017	0	0.5	Morrison	Hand Tools	-109.257712	36.531441	10/14/2017	10943	6	2		0.19	J	0.58	U	3.6		0.62		12		0.0098	J	0.91	
Cove	SS-CO-B1-008-10142017	0	0.5	Morrison	Hand Tools	-109.257549	36.5314	10/14/2017	10942	7	2.2		0.22		0.58	U	3.2		0.85		13		0.01	J	1.16	
Cove	SS-CO-B1-009-10142017	0	0.5	Morrison	Hand Tools	-109.257371	36.53138	10/14/2017	10806	7	1.8		0.19	J	0.66	U	2.9		0.82		13		0.0089	J	1.32	
Cove	SS-CO-B1-010-10142017	0	0.5	Morrison	Hand Tools	-109.257334	36.53154	10/14/2017	10519	7	1.5		0.15	J	0.45	U	2.6		0.67		9.7		0.03	J	0.8	
Cove	SS-CO-B1-011-10142017	0	0.5	Morrison	Hand Tools	-109.257525	36.531584	10/14/2017	10462	7	1.7		0.16	J	0.51	U	2.5		0.92		10		0.0096	J	0.82	
Cove	SS-CO-B1-012-10142017	0	0.5	Morrison	Hand Tools	-109.257689	36.531578	10/14/2017	10622	5	1.7		0.18	J	0.41	U	2.7		0.79		11		0.0086	J	1.1	
Cove	SS-CO-B1-013-10142017	0	0.5	Morrison	Hand Tools	-109.257879	36.53159	10/14/2017	10405	4	1.6		0.16	J	0.47	U	2.3	J	0.48	J	9.3		0.0094	J	0.86	
Cove	SS-CO-B1-014-10142017	0	0.5	Morrison	Hand Tools	-109.257898	36.531674	10/14/2017	10371	7	1.2		0.12	J	0.34	U	2.1		0.34		8.1		0.004	J	0.76	
Cove	SS-CO-B1-015-10142017	0	0.5	Morrison	Hand Tools	-109.257694	36.531661	10/14/2017	10528	6	1.7		0.17	J	0.49	U	2.3		0.88		11		0.014	J	1.26	
Cove	SS-CO-B1-016-10142017	0	0.5	Morrison	Hand Tools	-109.25751	36.53165	10/14/2017	10660	7	1.5		0.16	J	0.39	U	2.2		1.4		11		0.01	J	1.15	
Cove	SS-CO-B1-017-10142017	0	0.5	Morrison	Hand Tools	-109.257342	36.531671	10/14/2017	10268	7	1.2		0.12	J	0.3	U	2.3		1.1		9.6		0.004	J	0.89	
Cove	SS-CO-B1-018-10142017	0	0.5	Morrison	Hand Tools	-109.257396	36.53182	10/14/2017	10268	7	1.8		0.17	J	0.44	U	3.1		0.95		11		0.0077	J	1.07	
Cove	SS-CO-B1-019-10142017	0	0.5	Morrison	Hand Tools	-109.257435	36.532042	10/14/2017	10377	4	1.4		0.17	J	0.4	U	2.4		0.96		10		0.011	J	0.88	
Cove	SS-CO-B1-020-10142017	0	0.5	Morrison	Hand Tools	-109.257564	36.531938	10/14/2017	10503	8	1		0.12	J	0.26	U	2.2		0.38		7.9		0.0039	J	0.63	
Cove	SS-CO-B1-021-10142017	0	0.5	Morrison	Hand Tools	-109.257753	36.531889	10/14/2017	9763	5	1.9		0.2	J	0.56	U	2.1		1.5		13		0.031	J	1.06	J
Cove	SS-CO-B1-022-10142017	0	0.5	Morrison	Hand Tools	-109.257864	36.53193	10/14/2017	10936	6	1.6		0.14	J	0.46	U	2.5		0.42		9.2		0.0078	J	0.76	
Cove	SS-CO-B1-023-10142017	0	0.5	Morrison	Hand Tools	-109.257849	36.531794	10/14/2017	10607	7	1.8		0.16	J	0.54	U	2.4		0.85		11		0.01	J	1.12	
Cove	SS-CO-B1-024-10142017	0	0.5	Morrison	Hand Tools	-109.257661	36.531822	10/14/2017	10510	6	2		0.21		0.53	U	2.8		0.82		11		0.016	J	0.97	
Cove	SS-CO-B1-025-10142017	0	0.5	Morrison	Hand Tools	-109.257582	36.531786	10/14/2017	10510	6	1.4		0.15	J	0.37	U	2.2		0.85		9.4		0.011	J	1.1	
Cove	SB-CO-B1-001-1.0-1.5-05112018	1	1.5	Morrison	Hand Tools	-109.257456	36.531164	05/11/2018	9168	--	1.4		0.13	J	0.87	J	2		0.19		6.5		0.0097	J	0.46	UJ
Cove	SB-CO-B1-007-1.0-1.5-05112018	1	1.5	Morrison	Hand Tools	-109.257720	36.531458	05/11/2018	8256	--	1.5		0.16	J	0.69	J	2.9		0.45		11		0.011	J	0.88	
Cove	SB-CO-B1-009-1.0-1.5-05112018	1	1.5	Morrison	Hand Tools	-109.257373	36.531411	05/11/2018	8846	--	1.5		0.17	J	0.76	J	3		0.58		11		0.0096	J	0.94	
Cove	SS-CO-B2-001-09252017	0	0.5	Summerville	Hand Tools	-109.237579	36.542425	09/28/2017	8457	5	1.3		0.12	J	0.39	J	1.6		0.31		9		0.0043	J	0.68	
Cove	SS-CO-B2-002-09252017	0	0.5	Summerville	Hand Tools	-109.237741	36.542438	09/28/2017	8481	7	1.4		0.12	J	0.42	J	1.7		0.34		8.2		0.0093	J	0.68	J
Cove	SS-CO-B2-003-09252017	0	0.5	Summerville	Hand Tools	-109.237931	36.542442	09/28/2017	7927	6	1.1	J	0.1	J	0.26	J	1.3		0.3	J	6.5	J	0.0028	J	0.35	J
Cove	SS-CO-B2-004-09252017	0	0.5	Summerville	Hand Tools	-109.238003	36.542565	09/28/2017	8834	6	1.3		0.11	J	0.36	J	1.7		0.33		7.9		0.0054	J	0.66	J
Cove	SS-CO-B2-005-09252017	0	0.5	Summerville	Hand Tools	-109.237861	36.542525	09/28/2017	8165	5	1.3		0.12	J	0.36	J	1.5		0.37		7.5		0.004	J	0.6	
Cove	SS-CO-B2-006-09252017	0	0.5	Summerville	Hand Tools	-109.23769	36.542508	09/28/2017	7706	6	1.2		0.099	J	0.3	J	1.3		0.4		7.3		0.0046	J	0.36	U
Cove	SS-CO-B2-007-09252017	0	0.5	Summerville	Hand Tools	-109.237596	36.542503	09/28/2017	8215	7	1.3		0.084	J	0.42	J	1.7		0.3		5.6		0.0022	J	0.66	
Cove	SS-CO-B2-008-09252017	0	0.5	Summerville	Hand Tools	-109.237502	36.542576	09/28/2017	8234	4	3.2		0.17	J	0.45	J	2.2		0.59		19		0.0055	J	1.04	UJ

Table 4-2. Soil Sample Laboratory Results – Background Reference Areas
Cove Mine Area Removal Site Evaluation Report

Mine Area	Sample Identification	Top of Sample Interval (feet)	Bottom of Sample Interval (feet)	Geologic Unit	Sample Method	Longitude[a]	Latitude[a]	Sample Date	Gamma Count Rate (cpm)[b,c]	Dose Rate (µRem/hr)[d]	Arsenic (mg/kg)		Molybdenum (mg/kg)		Selenium (mg/kg)		Thorium (mg/kg)		Uranium (mg/kg)		Vanadium (mg/kg)		Mercury (mg/kg)		Radium 226 (pCi/g)	
Cove	SS-CO-B2-009-09252017	0	0.5	Summerville	Hand Tools	-109.237486	36.542661	09/28/2017	8178	5	1.7		0.11	J	0.48	J	1.6		0.35		12		0.0043	J	0.76	J
Cove	SS-CO-B2-010-09252017	0	0.5	Summerville	Hand Tools	-109.237576	36.542689	09/28/2017	7571	5	1.3		0.14	J	0.36	J	1.7		0.27		9.6		0.0077	J	0.94	J
Cove	SS-CO-B2-011-09252017	0	0.5	Summerville	Hand Tools	-109.237759	36.542637	09/28/2017	8382	4	1.4		0.13	J	0.53	J	1.9		0.37		9.7		0.005	J	0.55	J
Cove	SS-CO-B2-012-09252017	0	0.5	Summerville	Hand Tools	-109.237476	36.542728	09/28/2017	7595	5	1.4		0.12	J	0.35	J	1.5		0.45		7.6		0.01	J	0.61	
Cove	SS-CO-B2-013-09252017	0	0.5	Summerville	Hand Tools	-109.237888	36.542653	09/28/2017	7269	6	1		0.071	J	0.23	J	1.1		0.19		5.1		0.0016	J	0.48	UJ
Cove	SS-CO-B2-014-09252017	0	0.5	Summerville	Hand Tools	-109.23804	36.542647	09/28/2017	7999	4	0.98		0.09	J	0.28	J	1.2		0.32		6.4		0.0047	J	0.43	UJ
Cove	SS-CO-B2-015-09252017	0	0.5	Summerville	Hand Tools	-109.23804	36.542796	09/28/2017	7489	4	1		0.07	J	0.24	J	1.1		0.25		4.8		0.0037	J	0.37	U
Cove	SS-CO-B2-016-09252017	0	0.5	Summerville	Hand Tools	-109.237845	36.542775	09/28/2017	8158	5	1.3		0.11	J	0.44	J	1.6		0.27		7.4		0.0051	J	0.53	UJ
Cove	SS-CO-B2-017-09252017	0	0.5	Summerville	Hand Tools	-109.237729	36.542807	09/28/2017	8781	5	1.7		0.12	J	0.53	J	2.3		0.43		8.3		0.0044	J	0.52	UJ
Cove	SS-CO-B2-018-09252017	0	0.5	Summerville	Hand Tools	-109.237641	36.542749	09/28/2017	8043	5	1.6		0.14	J	0.48	J	2.3		0.53		12		0.013	J	0.93	J
Cove	SS-CO-B2-019-09252017	0	0.5	Summerville	Hand Tools	-109.237616	36.542834	09/28/2017	8025	5	1.6		0.15	J	0.43	J	1.6		0.45		9.2		0.012	J	0.68	J
Cove	SS-CO-B2-020-09252017	0	0.5	Summerville	Hand Tools	-109.237959	36.542919	09/28/2017	8445	5	1.7		0.12	J	0.5	J	2		0.4		6.4		0.0076	J	0.66	
Cove	SS-CO-B2-021-09252017	0	0.5	Summerville	Hand Tools	-109.237916	36.542927	09/28/2017	7551	4	1.2		0.1	J	0.27	J	1.2		0.31		6.8		0.0056	J	0.66	
Cove	SS-CO-B2-022-09252017	0	0.5	Summerville	Hand Tools	-109.238034	36.543025	09/28/2017	7088	6	1.1		0.09	J	0.26	J	1.3		0.19		4.8		0.0075	J	0.35	U
Cove	SS-CO-B2-023-09252017	0	0.5	Summerville	Hand Tools	-109.238048	36.543129	09/28/2017	7495	5	1.3		0.097	J	0.28	J	1.1		0.24	J	5.9		0.0066	J	0.39	UJ
Cove	SS-CO-B2-024-09252017	0	0.5	Summerville	Hand Tools	-109.237825	36.543024	09/28/2017	7689	5	1.3		0.11	J	0.26	J	1.1		0.36		6.6		0.0046	J	0.55	U
Cove	SS-CO-B2-025-09252017	0	0.5	Summerville	Hand Tools	-109.237727	36.542957	09/28/2017	7697	5	1.1		0.12	J	0.29	J	1.3		0.3		6.2		0.0043	J	0.43	J
Cove	SB-CO-B2-005-1.0-1.5-05092018	1	1.5	Summerville	Hand Tools	-109.237769	36.542549	05/09/2018	9168	--	1.2		0.1	J	0.63	J	1.8		0.24		7.5		0.0066	J	0.56	U
Cove	SB-CO-B2-010-1.0-1.5-05092018	1	1.5	Summerville	Hand Tools	-109.237631	36.542755	05/09/2018	9203	--	2.4		0.1	J	0.66	J	2.7		0.62		17		0.0025	J	0.9	
Cove	SB-CO-B2-022-1.0-1.5-05112018	1	1.5	Summerville	Hand Tools	-109.237910	36.543047	5/11/2018	8256	--	1.1		0.073	J	0.42	J	1.3	J	0.18		4.7		0.0023	J	0.56	UJ
Cove	SS-CO-B3-001-09252017	0	0.5	Chinle	Hand Tools	-109.203592	36.577422	09/25/2017	11818	6	2.7		0.12	J	0.83	J	3.7		0.42		13		0.0083	J	1.24	J
Cove	SS-CO-B3-002-09252017	0	0.5	Chinle	Hand Tools	-109.203449	36.577382	09/25/2017	12079	5	1.8		0.096	J	0.58	J	3.8		0.39		9.5		0.0093	J	1.1	
Cove	SS-CO-B3-003-09252017	0	0.5	Chinle	Hand Tools	-109.203322	36.577367	09/25/2017	12031	6	1.8		0.11	J	0.67	J	3.9	J	0.38		10		0.012	J	1.15	
Cove	SS-CO-B3-004-09252017	0	0.5	Chinle	Hand Tools	-109.20325	36.577277	09/25/2017	12114	7	2.1		0.13	J	0.76	J	3.9		0.38		10		0.012	J	0.92	
Cove	SS-CO-B3-005-09252017	0	0.5	Chinle	Hand Tools	-109.203177	36.577229	09/25/2017	12099	7	2		0.11	J	0.69	J	3.9		0.38		10		0.01	J	0.93	
Cove	SS-CO-B3-006-09252017	0	0.5	Chinle	Hand Tools	-109.203637	36.577263	09/25/2017	11939	7	1.7		0.086	J	0.52	J	3.4		0.35		9.8		0.0051	J	1	
Cove	SS-CO-B3-007-09252017	0	0.5	Chinle	Hand Tools	-109.203618	36.577063	09/25/2017	11940	7	1.9		0.12	J	0.65	J	3.4		0.38		9.6		0.014	J	1.2	
Cove	SS-CO-B3-008-09252017	0	0.5	Chinle	Hand Tools	-109.203544	36.577017	09/25/2017	11915	6	2		0.1	J	0.69	J	4.2		0.38		10		0.0079	J	1.02	
Cove	SS-CO-B3-009-09252017	0	0.5	Chinle	Hand Tools	-109.203384	36.576984	09/25/2017	12165	8	1.8		0.13	J	0.58	J	3.4		0.36		11		0.0088	J	1.07	
Cove	SS-CO-B3-010-09252017	0	0.5	Chinle	Hand Tools	-109.203245	36.576896	09/25/2017	12104	6	1.7		0.083	J	0.6	J	3.8		0.39		10		0.006	J	0.89	
Cove	SS-CO-B3-011-09252017	0	0.5	Chinle	Hand Tools	-109.203784	36.576788	09/25/2017	11657	6	1.9		0.087	J	0.66	J	4		0.36		9.7		0.0082	J	1.11	
Cove	SS-CO-B3-012-09252017	0	0.5	Chinle	Hand Tools	-109.203698	36.576868	09/25/2017	12155	8	2		0.1	J	0.59	J	3.9		0.4		9.5		0.01	J	1.23	
Cove	SS-CO-B3-013-09252017	0	0.5	Chinle	Hand Tools	-109.203642	36.576705	09/25/2017	12021	7	2.3		0.097	J	0.75	J	3.9		0.4		10		0.01	J	1.07	
Cove	SS-CO-B3-014-09252017	0	0.5	Chinle	Hand Tools	-109.203511	36.576648	09/25/2017	11731	8	1.8		0.11	J	0.66	J	3.8		0.4		9.4		0.0076	J	0.85	
Cove	SS-CO-B3-015-09252017	0	0.5	Chinle	Hand Tools	-109.203336	36.576584	09/25/2017	12169	7	1.8		0.094	J	0.53	J	3		0.33		10		0.0067	J	0.88	
Cove	SS-CO-B3-016-09252017	0	0.5	Chinle	Hand Tools	-109.203416	36.576408	09/25/2017	Not available	Not available	1.8		0.11	J	0.6	J	3.4		0.37		11		0.0083	J	1	
Cove	SS-CO-B3-017-09252017	0	0.5	Chinle	Hand Tools	-109.203595	36.576445	09/25/2017	11986	6	1.9		0.095	J	0.63	J	3.8		0.38		9.7		0.0091	J	1.03	
Cove	SS-CO-B3-018-09252017	0	0.5	Chinle	Hand Tools	-109.20376	36.576482	09/25/2017	11503	7	2		0.066	J	0.61	J	3.1		0.4		9.6		0.0048	J	0.89	
Cove	SS-CO-B3-019-09252017	0	0.5	Chinle	Hand Tools	-109.2039	36.576446	09/25/2017	12157	6	2		0.08	J	0.65	J	3.8		0.47		9.7		0.0092	J	1.01	
Cove	SS-CO-B3-020-09252017	0	0.5	Chinle	Hand Tools	-109.203987	36.57647	09/25/2017	11963	6	1.8		0.1	J	0.63	J	3.6		0.36		9.9		0.009	J	0.98	

Table 4-2. Soil Sample Laboratory Results – Background Reference Areas
Cove Mine Area Removal Site Evaluation Report

Mine Area	Sample Identification	Top of Sample Interval (feet)	Bottom of Sample Interval (feet)	Geologic Unit	Sample Method	Longitude[a]	Latitude[a]	Sample Date	Gamma Count Rate (cpm)[b,c]	Dose Rate (µRem/hr)[d]	Arsenic (mg/kg)		Molybdenum (mg/kg)		Selenium (mg/kg)		Thorium (mg/kg)		Uranium (mg/kg)		Vanadium (mg/kg)		Mercury (mg/kg)		Radium 226 (pCi/g)	
Cove	SS-CO-B3-021-09252017	0	0.5	Chinle	Hand Tools	-109.203976	36.576303	09/25/2017	Not available	Not available	2.6		0.14	J	0.65	J	2.7		0.34		12		0.0088	J	0.98	
Cove	SS-CO-B3-022-09252017	0	0.5	Chinle	Hand Tools	-109.203683	36.576218	09/25/2017	11157	8	2.2		0.14	J	0.72	J	2.8		0.36		12		0.011	J	0.96	
Cove	SS-CO-B3-023-09252017	0	0.5	Chinle	Hand Tools	-109.20358	36.576041	09/25/2017	11934	8	2		0.15	J	0.61	J	3.3		0.38		11		0.0096	J	1.16	
Cove	SS-CO-B3-024-09252017	0	0.5	Chinle	Hand Tools	-109.203855	36.576148	09/25/2017	12274	7	1.6		0.077	J	0.67	J	3.9		0.4		12		0.0078	J	0.97	
Cove	SS-CO-B3-025-09252017	0	0.5	Chinle	Hand Tools	-109.204159	36.576182	09/25/2017	11819	8	1.9		0.09	J	0.66	J	3.3		0.37		10		0.007	J	1.17	
Cove	SB-CO-B3-001-1.0-1.5-06202018	1	1.5	Chinle	Hand Tools	-109.203601	36.577425	06/20/2018	7975	--	2.1		0.12	J	0.88	J	3.6	J	0.41		11		0.000059	UJ	1.13	
Cove	SB-CO-B3-014-1.0-1.5-06202018	1	1.5	Chinle	Hand Tools	-109.20356	36.576632	06/20/2018	7961	--	1.6		0.083	J	0.67	J	3.8		0.33		7.4		0.000062	UJ	1.05	
Cove	SB-CO-B3-017-1.0-1.5-06202018	1	1.5	Chinle	Hand Tools	-109.20361	36.576461	06/20/2018	7881	--	1.4		0.076	J	0.71	J	2.9		0.31		6.5		0.000057	UJ	1.08	
Quality Control Samples[e]																										
Cove	SB-CO-B1-001-1.0-1.5-05112018-DUP	1	1.5	Morrison	Hand Tools	-109.257456	36.531164	05/11/2018	--	--	1.3		0.14	J	0.83	J	1.9		0.21		6.4		0.010	J	0.52	
Cove	SS-CO-B1-003-10142017-DUP	0	0.5	Morrison	Hand Tools	-109.257483	36.531292	10/14/2017	--	--	1.8		0.19	J	0.57	U	2.9		0.59		12		0.0069	J	0.86	
Cove	SS-CO-B1-013-10142017-DUP	0	0.5	Morrison	Hand Tools	-109.257879	36.53159	10/14/2017	--	--	1.8		0.18	J	0.54	U	2.6		0.57		11		0.0082	J	0.72	
Cove	SS-CO-B1-023-10142017-DUP	0	0.5	Morrison	Hand Tools	-109.257849	36.531794	10/14/2017	--	--	1.9		0.15	J	0.54	U	2.7		0.74		11		0.0099	J	1.26	
Cove	SS-CO-B2-003-09252017-DUP	0	0.5	Summerville	Hand Tools	-109.237931	36.542442	09/28/2017	--	--	1.0		0.11	J	0.3	J	1.2		0.27		6.3		0.0053	J	0.57	J
Cove	SS-CO-B2-013-09252017-DUP	0	0.5	Summerville	Hand Tools	-109.237888	36.542653	09/28/2017	--	--	0.96		0.083	J	0.19	J	0.84		0.17		4.6		0.0012	J	0.36	UJ
Cove	SS-CO-B2-022-1.0-1.5-05112018-DUP	1	1.5	Summerville	Hand Tools	-109.237910	36.543047	5/11/2018	--	--	1.3		0.093	J	0.55	J	1.6		0.24		5.2		0.0023	J	0.46	
Cove	SS-CO-B2-023-09252017-DUP	0	0.5	Summerville	Hand Tools	-109.238048	36.543129	09/28/2017	--	--	1.4		0.11	J	0.29	J	1.1		0.43		6.7	J	0.0064	J	0.62	J
Cove	SB-CO-B3-001-1.0-1.5-06202018-DUP	1	1.5	Chinle	Hand Tools	-109.203601	36.577425	06/20/2018	--	--	2.1		0.12	J	0.86	J	3.4		0.4		11		0.000062	UJ	1.07	
Cove	SS-CO-B3-003-09252017-DUP	0	0.5	Chinle	Hand Tools	-109.203322	36.577367	09/25/2017	--	--	1.9		0.13	J	0.61	J	4		0.44		10		0.0095	J	1.14	
Cove	SS-CO-B3-013-09252017-DUP	0	0.5	Chinle	Hand Tools	-109.203642	36.576705	09/25/2017	--	--	2.2		0.088	J	0.67	J	3.9		0.39		10		0.0098	J	1.06	
Cove	SS-CO-B3-023-09252017-DUP	0	0.5	Chinle	Hand Tools	-109.20358	36.576041	09/25/2017	--	--	2.1		0.15	J	0.63	J	3		0.39		11		0.014	J	1.06	

Notes:

[a] Location coordinates are in geographic coordinate system WGS 84, decimal degrees. West longitudes are designated as negative.

[b] For surface soil data, the measurement is the surface radiation reading; for subsurface soil, the measurement is the on-contact sample jar reading, as collected from Ludlum 2221 2x2 NaI detector.

[c] Gamma radiation measurement from 1-minute static reading from Ludlum 2221 2x2 NaI detector at 18 inches above ground prior to collection.

[d] Dose rate measurements were collected at waist height (36 inches) using a Bicron MicroRem meter with a tissue-equivalent plastic scintillator. The Bicron MicroREM instrument used for dose rate measurements does not have the resolution required for measurements at low-dose-rate conditions (less than approximately 15 µrem/hr) and requires reliance on analog interpretation by the field operator. This instrument is appropriate only for its intended use as a health and safety tool.

[e] Quality Control samples were collected for field quality assurance and quality control and are not compared with investigation levels.

U.S. EPA laboratory analytical method SW846 6020 was used to analyze samples for metals, arsenic, molybdenum, selenium, uranium, and vanadium. U.S. EPA Method SW846 7471A was used for mercury analysis. U.S. EPA Method 901.1 was used for Radium-226 analysis.

- - = Not analyzed

µRem/hr = microrem per hour

cpm = counts per minute

J = Estimated. This qualifier indicates that the analyte was detected but should be considered estimated.

mg/kg = milligrams per kilogram

NaI = sodium iodide

U = The analyte was not detected above the indicated method detection limit.

UJ = The analyte was not detected above the indicated estimated method detection limit.

U.S. EPA = U.S. Environmental Protection Agency

Table 4-3. Investigation Levels for Primary COPCs in Surface and Subsurface Soil
Cove Mine Area Removal Site Evaluation Report

Criteria	Primary COPCs[a]								Gamma Count Rate (cpm)
	Arsenic (mg/kg)	Mercury (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Thorium (mg/kg)	Uranium (mg/kg) [c]	Vanadium (mg/kg)	Radium 226 (pCi/g)	
Regional Screening Level[b]	0.68	**11**	**390**	**390**	---	**16**	**390**	---	---
Background Threshold Values - Morrison	**2.41**	0.042	0.24	---	**3.64**	1.54	14.3	**1.53**	**13200**
Background Threshold Values - Summerville	**3.02**	0.019	0.175	0.624	**2.81**	0.600	17.5	**1.04**	**10600**
Background Threshold Values - Chinle	**3.51**	0.014	0.162	0.834	**4.32**	0.46	13.0	**1.34**	**14600**

Notes:

[a] The investigation level for each primary COPC is bolded and defined as the higher of the RSL or the calculated BTV for each analyte.

[b] According to U.S. EPA RSLs for residential soil (June 2017) and a target hazard quotient of 1.0.

[c] The residential RSL for uranium has been modified to 16 mg/kg.

Bold = The investigation level for each analyte is the higher of the U.S. EPA RSL or calculated BTV. For analytes in which there was no applicable RSL, the investigation level is equal to the BTV.

--- = not applicable

BTV = background threshold value

COPC = contaminant of potential concern

mg/kg = milligrams per kilogram

RSL = Regional Screening Level

Table 4-4. Investigation Levels for Secondary COPCs in Surface and Subsurface Soil
Cove Mine Area Removal Site Evaluation Report

Analyte[a]	Unit	Investigation Level[b]	Reporting Limit
TPH-Purgeable (gas range organics)	mg/kg	82	1
TPH-Extractable (diesel range organics)	mg/kg	96	10
TPH-Extractable (motor oil range)	mg/kg	2,500	20
Aroclor-1016	µg/kg	4.1	0.033
Aroclor-1221	µg/kg	0.2	0.033
Aroclor-1232	µg/kg	0.17	0.033
Aroclor-1242	µg/kg	0.23	0.033
Aroclor-1248	µg/kg	0.23	0.033
Aroclor-1254	µg/kg	0.24	0.033
Aroclor-1260	µg/kg	0.24	0.033
Perchlorate	µg/kg	55	0.004
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	mg/kg	3,900	0.5
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	mg/kg	6.1	0.5
1,3,5-Trinitrobenzene	mg/kg	2,200	0.5
1,3-Dinitrobenzene	mg/kg	6.3	0.5
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	mg/kg	160	0.5
Nitrobenzene	mg/kg	5.1	0.5
2,4,6-Trinitrotoluene	mg/kg	21	0.5
4-Amino-2,6-dinitrotoluene	mg/kg	150	0.5
2-Amino-4,6-dinitrotoluene	mg/kg	150	0.5
2,4-Dinitrotoluene	mg/kg	1.7	0.5
2,6-Dinitrotoluene	mg/kg	0.36	0.5
2-Nitrotoluene	mg/kg	3.2	0.5
3-Nitrotoluene	mg/kg	6.3	0.5
4-Nitrotoluene	mg/kg	34	0.5

Notes:

[a] U.S. EPA Methods SW8015B, SW6850, SW8082, and SW8330B.

[b] According to U.S. EPA RSLs Residential Soil (June 2017).

µg/kg = micrograms per kilogram

TPH = total petroleum hydrocarbons

Table 4-5. Gamma Scan Bin Ranges by Geologic Unit
Cove Mine Area Removal Site Evaluation Report

Bin	Geology	Morrison Formation	Summerville Formation
1	BTV	0 to 13200 cpm	0 to 10600 cpm
2	BTV to IL	13201 to 14700 cpm	10601 to 12100 cpm
3	IL to 2 times BTV	14701 to 26400 cpm	12101 to 21200 cpm
4	2 to 5 times BTV	26401 to 66000 cpm	21201 to 53000 cpm
5	5 to 10 times BTV	66001 to 132000 cpm	53001 to 106000 cpm
6	>10 times BTV	>132001 cpm	>106001 cpm

Notes:

> = greater than

BTV = background threshold value

cpm = counts per minute

IL = Investigation Level

Table 4-6. Laboratory Results for Secondary COPCs in Surface and Subsurface Soil
Cove Mine Area Removal Site Evaluation Report

Mine Site	Sample Identification	Top of Sample Interval (feet)	Bottom of Sample Interval (feet)	Longitude[b]	Latitude[b]	Sample Date	U.S. EPA Method SW6850: Perchlorate (µg/kg)		TPH by U.S. EPA Method SW8015: Diesel Range Organics (mg/kg)		TPH by U.S. EPA Method SW8015: Gasoline Range Organics (mg/kg)		PCBs by U.S. EPA Method SW8082[d]: Aroclor 1016 (µg/kg)		PCBs by U.S. EPA Method SW8082[d]: Aroclor 1221 (µg/kg)		PCBs by U.S. EPA Method SW8082[d]: Aroclor 1232 (µg/kg)		PCBs by U.S. EPA Method SW8082[d]: Aroclor 1242 (µg/kg)		PCBs by U.S. EPA Method SW8082[d]: Aroclor 1248 (µg/kg)		PCBs by U.S. EPA Method SW8082: Aroclor 1254 (µg/kg)		PCBs by U.S. EPA Method SW8082: Aroclor 1260 (µg/kg)		Explosives by U.S. EPA Method SW8330B: 1,3,5-Trinitrobenzene (mg/kg)		Explosives by U.S. EPA Method SW8330B: 1,3-Dinitrobenzene (mg/kg)		Explosives by U.S. EPA Method SW8330B: 2,4,6-Trinitrotoluene (mg/kg)		Explosives by U.S. EPA Method SW8330B: 2,4-Dinitrotoluene (mg/kg)	
						U.S. EPA RSL[c] -->	55		96		82		4100		200		170		230		230		240		240		2200		6.3		21		1.7	
Billy Topaha	SS-03-MS-002-11102017	0	0.5	-109.224709	36.500105	11/10/2017	2	U	5.2	U	0.46	U	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	0.2	U	0.2	U	0.2	U	0.2	U
Cato No. 2	SS-04-MS-001-10192017	0	0.5	-109.25036	36.5482	10/19/2017	2	U	4.3	J	0.49	U	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	0.2	UJ	0.2	UJ	0.2	UJ	0.2	UJ
Cato No. 2	SB-04-MS-001-1.0-1.5-09202018	1	1.5	-109.250364	36.548203	09/20/2018	- -		4.1	U	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Frank No. 1	SS-05-MS-008-10252017	0	0.5	-109.255232	36.530845	10/25/2017	2.1	U	3.4	J	0.52	U	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	0.2	U	0.2	U	0.2	U	0.2	U
Frank No. 1	SS-05-MS-013-10252017	0	0.5	-109.253892	36.533133	10/25/2017	2.1	U	4.2	J	0.5	U	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	0.2	U	0.2	U	0.2	U	0.2	U
Frank No. 1	SB-05-MS-013-1.0-1.5-09172018	1	1.5	-109.253891	36.533124	09/17/2018	- -		3.7	J	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Frank No. 1	SS-05-MS-024-10252017	0	0.5	-109.255615	36.536817	10/25/2017	2.1	U	9.6		0.53	U	17	U	17	U	17	U	17	U	17	U	17	U	17	U	0.2	U	0.2	U	0.2	U	0.2	U
Frank No. 1	SB-05-MS-024-1.0-1.5-10062018	1	1.5	-109.255131	36.536961	10/06/2018	- -		2.5	J	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Frank No. 2	SS-06-MS-003-10252017	0	0.5	-109.253424	36.532049	10/25/2017	2.1	UJ	5.1	U	0.47	U	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	0.2	U	0.2	U	0.2	U	0.2	U
Mesa II ¼	SS-07-MS-002-10202017	0	0.5	-109.234323	36.515299	10/20/2017	2.1	U	1.8	J	0.49	U	18	U	18	U	18	U	18	U	18	U	18	U	18	U	0.2	U	0.2	U	0.2	U	0.2	U
Mesa II ¼	SB-07-MS-002-1.0-1.5-10102018	1	1.5	-109.234332	36.515305	10/10/2018	- -		8.2	J	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Mesa III, Northwest Mine	SS-08-MS-003-10202017	0	0.5	-109.2477	36.519314	10/20/2017	2	U	6		0.43	U	17	U	17	U	17	U	17	U	17	U	17	U	17	U	0.2	U	0.2	U	0.2	U	0.2	U
Mesa III, Northwest Mine	SB-08-MS-003-1.0-1.5-06082018	1	1.5	-109.2477	36.519318	06/08/2018	- -		7.9	J	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Mesa III, West	SS-09-MS-005-10232017	0	0.5	-109.250684	36.514556	10/23/2017	2.1	U	3.7	J	0.44	U	17	U	17	U	17	U	17	U	17	U	17	U	17	U	0.2	U	0.2	U	0.2	U	0.2	U
Mesa III, West	SB-09-MS-005-1.0-1.5-10152018	1	1.5	-109.250696	36.514565	10/15/2018	- -		3.3	J	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Mesa IV ¼	SS-10-MS-003-10232017	0	0.5	-109.260613	36.527956	10/23/2017	2.2	U	1.6	J	0.5	U	19	U	19	U	19	U	19	U	19	U	19	U	19	U	0.2	U	0.2	U	0.2	U	0.2	U
Mesa IV ¼	SB-10-MS-003-1.0-1.5-10162018	1	1.5	-109.260612	36.527974	10/16/2018	- -		2.4	J	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
NA-0316	SS-11-MS-005-10242017	0	0.5	-109.257471	36.529241	10/24/2017	2.1	U	62		0.6		18	UJ	18	UJ	18	UJ	18	UJ	18	UJ	18	UJ	18	UJ	0.2	U	0.2	U	0.2	U	0.2	U
NA-0316	SB-11-MS-005-1.0-1.5-10122018	1	1.5	-109.257461	36.529241	10/12/2018	- -		7.5		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Quality Control Samples [c]																																		
Billy Topaha	SS-03-MS-002-11102017-DUP	0	0.5	-109.224709	36.500105	11/10/2017	2	U	5.1	U	0.48	U	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	0.2	U	0.2	U	0.2	U	0.2	U
Cato No. 2	SB-04-MS-001-1.0-1.5-09202018-DUP	1	1.5	-109.250364	36.548203	09/20/2018	- -		4.1	U	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Frank No. 1	SS-05-MS-008-10252017-DUP	0	0.5	-109.255232	36.530845	10/25/2017	2.1	U	8.1		0.49	U	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	0.2	U	0.2	U	0.2	U	0.2	U
Frank No. 1	SS-05-MS-013-10252017-DUP	0	0.5	-109.253892	36.533133	10/25/2017	2.1	U	2.7	J	0.47	U	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	0.2	U	0.2	U	0.2	U	0.2	U
Frank No. 1	SB-05-MS-024-1.0-1.5-10062018-DUP	1	1.5	-109.255131	36.536961	10/06/2018	- -		5.3	U	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Frank No. 1	SS-05-MS-024-10252017-DUP	0	0.5	-109.255615	36.536817	10/25/2017	2.1	U	16		0.49	U	18	U	18	U	18	U	18	U	18	U	18	U	18	U	0.2	U	0.2	U	0.2	U	0.2	U
Frank No. 2	SS-06-MS-003-10252017-DUP	0	0.5	-109.253424	36.532049	10/25/2017	2.1	U	5.1	U	0.48	U	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	0.2	U	0.2	U	0.2	U	0.2	U
Mesa II ¼	SB-07-MS-002-1.0-1.5-10102018-DUP	1	1.5	-109.234332	36.515305	10/10/2018	- -		6.7	J	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Mesa II ¼	SS-07-MS-002-10202017-DUP	0	0.5	-109.234323	36.515299	10/20/2017	2.1	U	2.7	J	0.5	U	17	U	17	U	17	U	17	U	17	U	17	U	17	U	0.2	U	0.2	U	0.2	U	0.2	U
Mesa III, Northwest Mine	SB-08-MS-003-1.0-1.5-06082018-DUP	1	1.5	-109.2477	36.519318	06/08/2018	- -		3.5	J	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Mesa III, Northwest Mine	SS-08-MS-003-10202017-DUP	0	0.5	-109.2477	36.519314	10/20/2017	2	U	4.6	J	0.42	U	17	U	17	U	17	U	17	U	17	U	17	U	17	U	0.2	U	0.2	U	0.2	U	0.2	U
Mesa III, West	SDUPB-09-MS-005-1.0-1.5-10152018-D	1	1.5	-109.250696	36.514565	10/15/2018	- -		4.1	J	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Mesa III, West	SS-09-MS-005-10232017-DUP	0	0.5	-109.250684	36.514556	10/23/2017	2.1	U	4	J	0.5	U	16	U	16	U	16	U	16	U	16	U	16	U	16	U	0.2	U	0.2	U	0.2	U	0.2	U
Mesa IV ¼	SB-10-MS-003-1.0-1.5-10162018-DUP	1	1.5	-109.260612	36.527974	10/16/2018	- -		2.6	J	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Mesa IV ¼	SS-10-MS-003-10232017-DUP	0	0.5	-109.260613	36.527956	10/23/2017	2.2	U	17		0.54	U	19	U	19	U	19	U	19	U	19	U	19	U	19	U	0.2	U	0.2	U	0.2	U	0.2	U
NA-0316	SB-11-MS-005-1.0-1.5-10122018-DUP	1	1.5	-109.257461	36.529241	10/12/2018	- -		7		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
NA-0316	SS-11-MS-005-10242017-DUP	0	0.5	-109.257471	36.529241	10/24/2017	2.1	U	65		0.33	J	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	0.2	U	0.2	U	0.2	U	0.2	U

Notes:

[a] Secondary COPC samples were collected via hand tools and were within the Morrison geologic unit.
[b] Location coordinates are in geographic coordinate system WGS 84, decimal degrees. West longitudes are designated as negative.
[c] U.S. EPA RSLs are
[d] Quality Control samples were collected for field quality assurance and quality control and are not compared with investigation levels.
- - = Not analyzed
J = Estimated. This qualifier indicates that the analyte was detected but should be considered estimated.
HMX = octogen
PCB = polychlorinated biphenyls
RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine
TPH = total petroleum hydrocarbons
U = The analyte was not detected above the indicated method detection limit.
UJ = The analyte was not detected above the indicated estimated method detection limit.

Table 4-6. Laboratory Results for Secondary COPCs in Surface and Subsurface Soil
Cove Mine Area Removal Site Evaluation Report

Mine Site	Sample Identification	Top of Sample Interval (feet)	Bottom of Sample Interval (feet)	Longitude[b]	Latitude[b]	Sample Date	Explosives by U.S. EPA Method SW8330B																			
						U.S. EPA RSL[c] -->	2,6-Dinitrotoluene (mg/kg) 0.36		2 Amino-4,6 Dinitrotoluene (mg/kg) 150		2 Nitrotoluene (mg/kg) 3.2		3 Nitrotoluene (mg/kg) 6.3		4 Amino-2,6 Dinitrotoluene (mg/kg) 150		4 Nitrotoluene (mg/kg) 34		HMX (mg/kg) 3900		Nitrobenzene (mg/kg) 5.1		RDX (mg/kg) 6.1		Trinitro-phenylmethyl-nitramine (Tetryl) (mg/kg) 160	
Billy Topaha	SS-03-MS-002-11102017	0	0.5	-109.224709	36.500105	11/10/2017	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	UJ
Cato No. 2	SS-04-MS-001-10192017	0	0.5	-109.25036	36.5482	10/19/2017	0.2	UJ	0.2	UJ	0.2	UJ	0.2	UJ	0.2	UJ	0.2	UJ	0.2	UJ	0.2	UJ	0.2	UJ	0.2	UJ
Cato No. 2	SB-04-MS-001-1.0-1.5-09202018	1	1.5	-109.250364	36.548203	09/20/2018	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Frank No. 1	SS-05-MS-008-10252017	0	0.5	-109.255232	36.530845	10/25/2017	0.2	U	0.2	U	0.2	UJ	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	U
Frank No. 1	SS-05-MS-013-10252017	0	0.5	-109.253892	36.533133	10/25/2017	0.2	U	0.2	U	0.2	UJ	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	UJ
Frank No. 1	SB-05-MS-013-1.0-1.5-09172018	1	1.5	-109.253891	36.533124	09/17/2018	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Frank No. 1	SS-05-MS-024-10252017	0	0.5	-109.255615	36.536817	10/25/2017	0.2	U	0.2	U	0.2	UJ	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	U
Frank No. 1	SB-05-MS-024-1.0-1.5-10062018	1	1.5	-109.255131	36.536961	10/06/2018	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Frank No. 2	SS-06-MS-003-10252017	0	0.5	-109.253424	36.532049	10/25/2017	0.2	U	0.2	U	0.2	UJ	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	U
Mesa II ¼	SS-07-MS-002-10202017	0	0.5	-109.234323	36.515299	10/20/2017	0.2	U	0.2	U	0.2	UJ	0.2	U	0.2	U	0.2	U	0.2	U	0.2	UJ	0.2	U	0.2	U
Mesa II ¼	SB-07-MS-002-1.0-1.5-10102018	1	1.5	-109.234332	36.515305	10/10/2018	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Mesa III, Northwest Mine	SS-08-MS-003-10202017	0	0.5	-109.2477	36.519314	10/20/2017	0.2	U	0.2	U	0.2	UJ	0.2	U	0.2	U	0.2	U	0.2	U	0.2	UJ	0.2	U	0.2	UJ
Mesa III, Northwest Mine	SB-08-MS-003-1.0-1.5-06082018	1	1.5	-109.2477	36.519318	06/08/2018	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Mesa III, West	SS-09-MS-005-10232017	0	0.5	-109.250684	36.514556	10/23/2017	0.2	U	0.2	U	0.2	UJ	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	U
Mesa III, West	SB-09-MS-005-1.0-1.5-10152018	1	1.5	-109.250696	36.514565	10/15/2018	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Mesa IV ¼	SS-10-MS-003-10232017	0	0.5	-109.260613	36.527956	10/23/2017	0.2	U	0.2	U	0.2	UJ	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	U
Mesa IV ¼	SB-10-MS-003-1.0-1.5-10162018	1	1.5	-109.260612	36.527974	10/16/2018	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
NA-0316	SS-11-MS-005-10242017	0	0.5	-109.257471	36.529241	10/24/2017	0.2	U	0.2	U	0.2	UJ	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	U
NA-0316	SB-11-MS-005-1.0-1.5-10122018	1	1.5	-109.257461	36.529241	10/12/2018	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Quality Control Samples [c]																										
Billy Topaha	SS-03-MS-002-11102017-DUP	0	0.5	-109.224709	36.500105	11/10/2017	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	UJ
Cato No. 2	SB-04-MS-001-1.0-1.5-09202018-DUP	1	1.5	-109.250364	36.548203	09/20/2018	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Frank No. 1	SS-05-MS-008-10252017-DUP	0	0.5	-109.255232	36.530845	10/25/2017	0.2	U	0.2	U	0.2	UJ	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	U
Frank No. 1	SS-05-MS-013-10252017-DUP	0	0.5	-109.253892	36.533133	10/25/2017	0.2	U	0.2	U	0.2	UJ	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	U
Frank No. 1	SB-05-MS-024-1.0-1.5-10062018-DUP	1	1.5	-109.255131	36.536961	10/06/2018	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Frank No. 1	SS-05-MS-024-10252017-DUP	0	0.5	-109.255615	36.536817	10/25/2017	0.2	U	0.2	U	0.2	UJ	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	U
Frank No. 2	SS-06-MS-003-10252017-DUP	0	0.5	-109.253424	36.532049	10/25/2017	0.2	U	0.2	U	0.2	UJ	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	U
Mesa II ¼	SB-07-MS-002-1.0-1.5-10102018-DUP	1	1.5	-109.234332	36.515305	10/10/2018	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Mesa II ¼	SS-07-MS-002-10202017-DUP	0	0.5	-109.234323	36.515299	10/20/2017	0.2	U	0.2	U	0.2	UJ	0.2	U	0.2	U	0.2	U	0.2	U	0.2	UJ	0.2	U	0.2	U
Mesa III, Northwest Mine	SB-08-MS-003-1.0-1.5-06082018-DUP	1	1.5	-109.2477	36.519318	06/08/2018	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Mesa III, Northwest Mine	SS-08-MS-003-10202017-DUP	0	0.5	-109.2477	36.519314	10/20/2017	0.2	U	0.2	U	0.2	UJ	0.2	U	0.2	U	0.2	U	0.2	U	0.2	UJ	0.2	U	0.2	U
Mesa III, West	SDUPB-09-MS-005-1.0-1.5-10152018-D	1	1.5	-109.250696	36.514565	10/15/2018	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Mesa III, West	SS-09-MS-005-10232017-DUP	0	0.5	-109.250684	36.514556	10/23/2017	0.2	U	0.2	U	0.2	UJ	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	U
Mesa IV ¼	SB-10-MS-003-1.0-1.5-10162018-DUP	1	1.5	-109.260612	36.527974	10/16/2018	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Mesa IV ¼	SS-10-MS-003-10232017-DUP	0	0.5	-109.260613	36.527956	10/23/2017	0.2	U	0.2	U	0.2	UJ	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	U
NA-0316	SB-11-MS-005-1.0-1.5-10122018-DUP	1	1.5	-109.257461	36.529241	10/12/2018	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
NA-0316	SS-11-MS-005-10242017-DUP	0	0.5	-109.257471	36.529241	10/24/2017	0.2	U	0.2	U	0.2	UJ	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	UJ	0.2	U	0.2	U

Notes:

[a] Secondary COPC samples were collected via hand tools and were within the Morrison geologic unit.

[b] Location coordinates are in geographic coordinate system WGS 84, decimal degrees. West longitudes are designated as negative

[c] U.S. EPA RSLs are

[d] Quality Control samples were collected for field quality assurance and quality control and are not compared with investigation levels

- - = Not analyzed
J = Estimated. This qualifier indicates that the analyte was detected but should be considered estimated.
HMX = octogen
PCB = polychlorinated biphenyls
RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine
TPH = total petroleum hydrocarbons
U = The analyte was not detected above the indicated method detection limit.
UJ = The analyte was not detected above the indicated estimated method detection limit.

Table 5-1. Surface Water Sample Laboratory Results
Cove Mine Area Removal Site Evaluation Report

Analyte	Unit	Surface Water Project Screening Criteria [b]: U.S. EPA Maximum Contaminant Level	Surface Water Project Screening Criteria [b]: Navajo Nation Surface Water Quality	Cove		Cove		Cove		Cove		Cove	
			NNDWR Well Database Location	Spring 1		Livestock Trough		Spring 2		Spring 2		Livestock Trough	
			Sample Identification	CO SW 001-06202018		CO SW 002-06212018		SW CO Spring02-10032019		SW CO Spring02-10032019-DUP [f]		CO SW 002-06212018-DUP [f]	
			Sample Method	Dip Sampler		Dip Sampler		Peristaltic Pump		Peristaltic Pump		Dip Sampler	
			Longitude [a]	109.2137217		109.2578870		109.2119817		109.2119817		109.2578870	
			Latitude [a]	36.5008579		36.5217970		36.5012451		36.5012451		36.5217970	
			Sample Date	06/20/2018		06/21/2018		2019-10-03		2019-10-03		06/21/2018	
Metals by SW6010 / SW6020 / SW7470A													
Aluminum, Total	mg/L	- -	- -	13		0.073	U	0.047	J	0.042	U	0.01	U
Aluminum, Dissolved	mg/L	- -	- -	0.85		0.02	J	0.016	J	0.014	J	0.014	J
Antimony, Total	mg/L	0.006	0.0056	0.00027	J	0.00012	U	0.00012	U	0.0001	U	0.0001	U
Antimony, Dissolved	mg/L	0.006	0.0056	0.00012	U	0.00012	U	0.00012	U	0.0001	U	0.0001	U
Arsenic, Total	mg/L	0.010	0.01	0.0096		0.0029		0.0007	J	0.0007	J	0.003	
Arsenic, Dissolved	mg/L	0.010	0.01	0.0023		0.0026		0.00082	J	0.0006	J	0.003	
Barium, Total	mg/L	2.0	1.0	0.41		0.3		0.017		0.017		0.29	
Barium, Dissolved	mg/L	2.0	1.0	0.094		0.29		0.017		0.017		0.29	
Beryllium, Total	mg/L	0.004	0.004	0.003		0.000054	U	0.000054	U	0.00005	U	0.00005	U
Beryllium, Dissolved	mg/L	0.004	0.004	0.00011	J	0.000054	U	0.000054	U	0.00005	U	0.00005	U
Boron, Total	mg/L	- -	0.63	0.071	U	0.024	U	0.014	J	0.009	J	0.0013	U
Boron, Dissolved	mg/L	- -	0.63	0.035	J	0.023	J	0.009	J	0.006	J	0.033	J
Cadmium, Total	mg/L	0.005	0.005	0.0009	J	0.000083	U	0.000083	U	0.00008	U	0.00008	U
Cadmium, Dissolved	mg/L	0.005	0.005	0.000083	U	0.000083	U	0.000083	U	0.00008	U	0.00008	U
Calcium, Total	mg/L	- -	- -	180		66		40		41		63	
Chromium, Total	mg/L	0.1	0.1	0.0089	U	0.0022	U	0.00046	U	0.0005	U	0.0005	U
Chromium, Dissolved	mg/L	0.1	0.1	0.0014	J	0.001	J	0.00059	J	0.0009	J	0.001	J
Cobalt, Total	mg/L	- -	1.0	0.0069		0.00011	U	0.00012	J	0.0001	U	0.0001	U
Cobalt, Dissolved	mg/L	- -	1.0	0.00044	J	0.00011	U	0.00012	J	0.0001	J	0.0001	U
Copper, Total	mg/L	1.3	1.3	0.012	J	0.00073	J	0.00039	J	0.0003	U	0.0004	J
Copper, Dissolved	mg/L	1.3	1.3	0.002	J	0.00032	J	0.0014	J	0.002	J	0.001	J
Iron, Total	mg/L	- -	- -	15		0.17		0.093	J	0.033	U	0.15	
Iron, Dissolved	mg/L	- -	- -	0.69		0.031	J	0.027	J	0.11		0.031	J
Lead, Total	mg/L	0.015	0.015	0.014		0.0001	J	0.00016	J	0.00008	U	0.0001	J
Lead, Dissolved	mg/L	0.015	0.015	0.0017	J	0.000079	U	0.000080	J	0.0001	J	0.00008	J
Lithium, Total	mg/L	- -	- -	0.06		0.012	U	0.006	J	0.006	J	0.0003	U
Lithium, Dissolved	mg/L	- -	- -	0.014	J	0.011	J	0.0067	J	0.006	J	0.012	J
Magnesium, Total	mg/L	- -	- -	19		6.8		3.0		2.9		6.6	
Magnesium, Dissolved	mg/L	- -	- -	6.7		6.8		3.0		2.8		6.5	
Manganese, Total	mg/L	- -	- -	0.54		0.016	U	0.016		0.016		0.0004	U
Manganese, Dissolved	mg/L	- -	- -	0.088		0.013		0.015		0.019		0.013	
Mercury, Total	mg/L	0.002	0.002	0.00018	J	0.00006	U	0.00006	U	0.00006	U	0.00006	U
Mercury, Dissolved	mg/L	0.002	0.002	0.00006	U	0.00006	U	0.00006	U	0.00006	U	0.00006	U
Molybdenum, Total	mg/L	- -	- -	0.0006	J	0.00024	J	0.00024	J	0.0002	J	0.0003	J
Molybdenum, Dissolved	mg/L	- -	- -	0.00047	J	0.00032	J	0.00022	J	0.0002	J	0.0003	J
Nickel, Total	mg/L	- -	0.61	0.013	J	0.00092	U	0.00092	U	0.0009	U	0.0009	U
Nickel, Dissolved	mg/L	- -	0.61	0.0018	J	0.00092	U	0.001	J	0.009	J	0.0009	U
Phosphorus, Total	mg/L	- -	- -	4.6		0.094	J	0.0053	U	0.059	J	0.092	J
Phosphorus, Dissolved	mg/L	- -	- -	0.74		0.076	J	0.072	J	0.073	J	0.076	J
Potassium, Total	mg/L	- -	- -	27		1.0		1.3		1.3		1	
Potassium, Dissolved	mg/L	- -	- -	20		1.1		1.4		1.3		1	
Selenium, Total	mg/L	0.05	0.05	0.0015	J	0.00065	U	0.00065	U	0.0007	U	0.0007	J
Selenium, Dissolved	mg/L	0.05	0.05	0.00065	U	0.00074	J	0.00065	U	0.0007	U	0.0008	J
Silver, Total	mg/L	- -	0.035	0.000029	U	0.000029	U	0.000029	U	0.00003	U	0.00003	U
Silver, Dissolved	mg/L	- -	0.035	0.000029	U	0.000029	U	0.000029	U	0.00003	U	0.00003	U
Sodium, Total	mg/L	- -	- -	7.3		5.8		3.9		3.9		5.6	
Strontium, Total	mg/L	- -	- -	0.46		0.32		0.12		0.12		0.3	
Strontium, Dissolved	mg/L	- -	- -	0.22		0.31		0.12		0.12		0.3	
Thallium, Total	mg/L	0.002	0.002	0.0001		0.0000041	U	0.0000041	U	0.000004	U	0.000004	U
Thallium, Dissolved	mg/L	0.002	0.002	0.0000041	U	0.0000041	U	0.0000041	U	0.000004	U	0.000004	U
Uranium, Total	mg/L	0.03	0.03	0.0018		0.0032		0.00011		0.0001		0.003	
Uranium, Dissolved	mg/L	0.03	0.03	0.0012		0.0031		0.00011		0.0001		0.003	
Vanadium, Total	mg/L	- -	- -	0.092		0.0037	J	0.001	J	0.001	J	0.004	J
Vanadium, Dissolved	mg/L	- -	- -	0.0075		0.0035	J	0.00096	J	0.001	J	0.003	J
Zinc, Total	mg/L	- -	2.1	0.098	J	0.022	J	0.0019	J	0.0014	U	0.006	J
Zinc, Dissolved	mg/L	- -	2.1	0.015	J	0.0019	J	0.01	J	0.005	J	0.004	J
General Chemistry by E300 / SM2320B / SM2540C													
Chloride	mg/L	- -	- -	8.4		6.4		1.2		1.1		6.3	
Sulfate	mg/L	- -	- -	2.1		6.9		1.0	U	1.0	U	6.8	
Alkalinity, Bicarbonate (as $CaCO_3$)	mg/L	- -	- -	330		210		140		140		210	
Alkalinity, Carbonate (as $CaCO_3$)	mg/L	- -	- -	20	U	20	U	20	U	20	U	208	U
Alkalinity, Total (as $CaCO_3$)	mg/L	- -	- -	330		210		140		140		210	
Total Dissolved Solids	mg/L	- -	- -	420		260		180		180		270	
Radiochemistry by E900.0 / E901.1 / E903.0 / E904.0 / D3972 / ALS704													
Lead-210	pCi/L	- -	- -	5.3		0.22	U	0.36	U	0.53		-0.22	U
Potassium-40	pCi/L	- -	- -	83	U	-25	U	112	U	142	U	40	U
Radium-226	pCi/L	- -	- -	3.3		0.18	U	0.35	U	0.42	U	0.3	J
Radium-228	pCi/L	- -	- -	5.7		-0.02	U	0.75	U	0.72	U	0.26	U
Radium-226 + Radium-228	pCi/L	5	5	**9**		0.16	U	1.1	U	1.14	U	0.56	J
Uranium, Total	pCi/L	- -	- -	10.9		1.41		0.17		0.13		1.06	
Uranium-234	pCi/L	- -	- -	13.6		2.64		0.31		0.28		2.47	
Uranium-235	pCi/L	- -	- -	0.43		0.14		0.08	U	36	U	0.16	
Uranium-238	pCi/L	- -	- -	10.9		1.41		0.17		0.133		1.06	
Alpha Gross	pCi/L	- -	- -	221		2.6		1.92	U	1.93	U	3.6	
Adjusted Gross Alpha[c,d]	pCi/L	15	15	**196.1**		0.0		1.36		0		0	
Field Parameters													
Turbidity	NTU	--	--	10000		4.85		5.01		5.01		4.85	
Temperature	ºC	--	--	13.68		20.95		4.4		4.4		20.95	
Salinity[e]	PSU	--	--	0.41		0.20		0.187		0.187		0.20	
Specific Conductivity	mS/cm	--	--	0.653		0.374		0.239		0.239		0.374	
Dissolved Oxygen	percent	--	--	186.4		179.9		- -		- -		179.9	
Dissolved Oxygen	mg/L	--	--	18.73		14.68		4.3		4.3		14.68	
pH	standard units	--	--	6.55		7.01		6.64		6.64		7.01	

Notes:
[a] Location coordinates are in geographic coordinate system WGS 84, decimal degrees. West longitudes are designated as negative.
[b] According to Navajo Nation Surface Water Quality Standards, 2015.
[c] The project screening criteria for gross alpha are adjusted gross alpha after removal of uranium content.
[d] Because of differences in analytical technique, removal of isotopic uranium content may result in negative values. A zero value is reported in this scenario.
[e] Salinity was calculated from specific conductivity and temperature (Fofonoff 1983)
[f] Quality control samples were collected for field quality assurance and quality control and are not compared with investigation levels.

Bold gray data = Analytical detections exceeding the screening criteria

- - = Not analyzed or not available

Laboratory Analytical Qualifiers:

J = Estimated. This qualifier indicates that the analyte was detected but should be considered estimated.
U = The analyte was not detected above the indicated method detection limit.

Acronyms and Abbreviations:

°C = degree(s) Celsius
$CaCO_3$ = calcium carbonate
mg/L = milligrams per liter
NTU = Nephelometric Turbidity Units
PSU = Practical Salinity Unit
mS/cm = milliSiemens per centimeter
pCi/L = picocuries per liter

Table 6-1. Mining-impacted Material, Including TENORM Volume Estimate Summary
Cove Mine Area Removal Site Evaluation Report

Mine Site	Area (acres)	Volume (cubic yards)
Cato No. 2	2.22	14,900
Frank No. 1	15.35	61,900
Frank No. 2	1.28	3,900
NA-0316	2.81	11,400
Mesa IV ¼	2.04	8,300
Mesa III Northwest	0.57	3,600
Mesa III West	0.75	3,600
Mesa II ¼	1.87	9,500
Billy Topaha	0.77	5,000
TOTAL	**27.66**	**122,100**

Note:

TENORM = Technologically Enhanced Naturally Occurring Radioactive Material

Table 7-1. Data Quality Objectives
Cove Mine Area Removal Site Evaluation Report

DQO Number	Data Quality Objective	Data Quality Objective Status	Supporting Information
1	Identify the background level of radiation and metal concentrations from naturally occurring materials at the Mine Site.	This DQO has been met because background level radiation and metal concentrations were defined through field investigations, including gamma radiation surveys and soil analytical samples collected from the BRA.	Section 4 of the RSE Report presents the background investigation data and analysis. Tables 4-1, 4-2, and 4-3 in the RSE Report list the background threshold values for the gamma count rate and the primary COPCs. Figures 4-1, 4-2, and 4-3 of the RSE Report show the radiation survey results in the BRAs.
2	Determine the type and extent of affected environmental media, including surface soil, subsurface soil, and sediment.	This DQO has been met with data gaps because the type and extent of affected environmental media in accessible areas has been defined through gamma radiation survey, surface and subsurface soil sampling, and sediment sampling. The inaccessible areas have not been evaluated and vertical delineation has not been achieved at some of the Mine Sites.	Results are presented in Section 2 of the site-specific appendices of Appendix A.
3	Determine the correlation between gross gamma radiation levels and concentrations of Radium-226 in surface soil and sediment, as well as the correlation between gross gamma radiation levels and dose rate.	This DQO has been met with data gaps. Samples were collected according to the Work Plan to assess the relationship between gamma count rate and radium-226. Data was collected according to the Work Plan to assess the relationship between gamma count rate and dose rate. Additional data needs to be collected at higher count rate/dose rates to better assess the relationship; however, no further sampling will be conducted as a part of this RSE at the Cove Mine Sites. The radium-226 correlation is usable for estimating radium-226 concentrations at the Mine Site within the data range used to create it. The dose rate correlation is not usable because the Bicron MicroRem instrument is analog and has significant uncertainty for measurements collected at low dose rate conditions.	Results of the correlations are presented in Section 4.5 and on Figures 4-4 through 4-6 of the RSE Report. Appendix G contains a detailed analysis of the correlations.
4	Identify if mining-related activities, such as blasting, machine maintenance and refueling, and use of electrical equipment, result in releases of explosives (including perchlorate), TPH, or PCBs.	This DQO has been met because sufficient data were collected in accordance with the Work Plan to evaluate if mining-related activities released secondary COPCs into the environment. Mine Site soil sampling data indicated that all secondary COPCs were less than the IL.	Results are presented in Section 2 of the site-specific appendices of Appendix A. Tables 4-4 and 4-6 in the RSE Report list the ILs and laboratory results for the secondary COPCs .
5	Identify evidence that surface water and/or groundwater has been impacted by mining-related activities, if present and able to be sampled.	This DQO has been met with data gaps. Water collected within 1 Mile of the Mine Site was hydraulically and topographically upgradient of the Mine Sites and not impacted by mining activities. Additional data may be collected to evaluate if surface water and/or groundwater has been impacted by mining-related activities.	A review of the Cove Mine Area springs and hydrology is provided in Section 2.5.5 to 2.5.6 and Section 5 of the RSE Report. The spring sampling analytical data is presented in Table 5-1 of the RSE Report.
6	Estimate the volume of waste rock and impacted materials present at the Mine Site.	This DQO has been met. The volume of TENORM has been estimated for each Cove Mine Area Mine Site using multiple lines of evidence.	Section 3 of the site-specific appendices of Appendix A contains the detailed volume estimation process for each Mine Site. Section 6 and Table 6-1 of the RSE Report summarizes the Mine Site volume estimates.

Notes:

BRA = background reference area

COPC = contaminant of potential concern

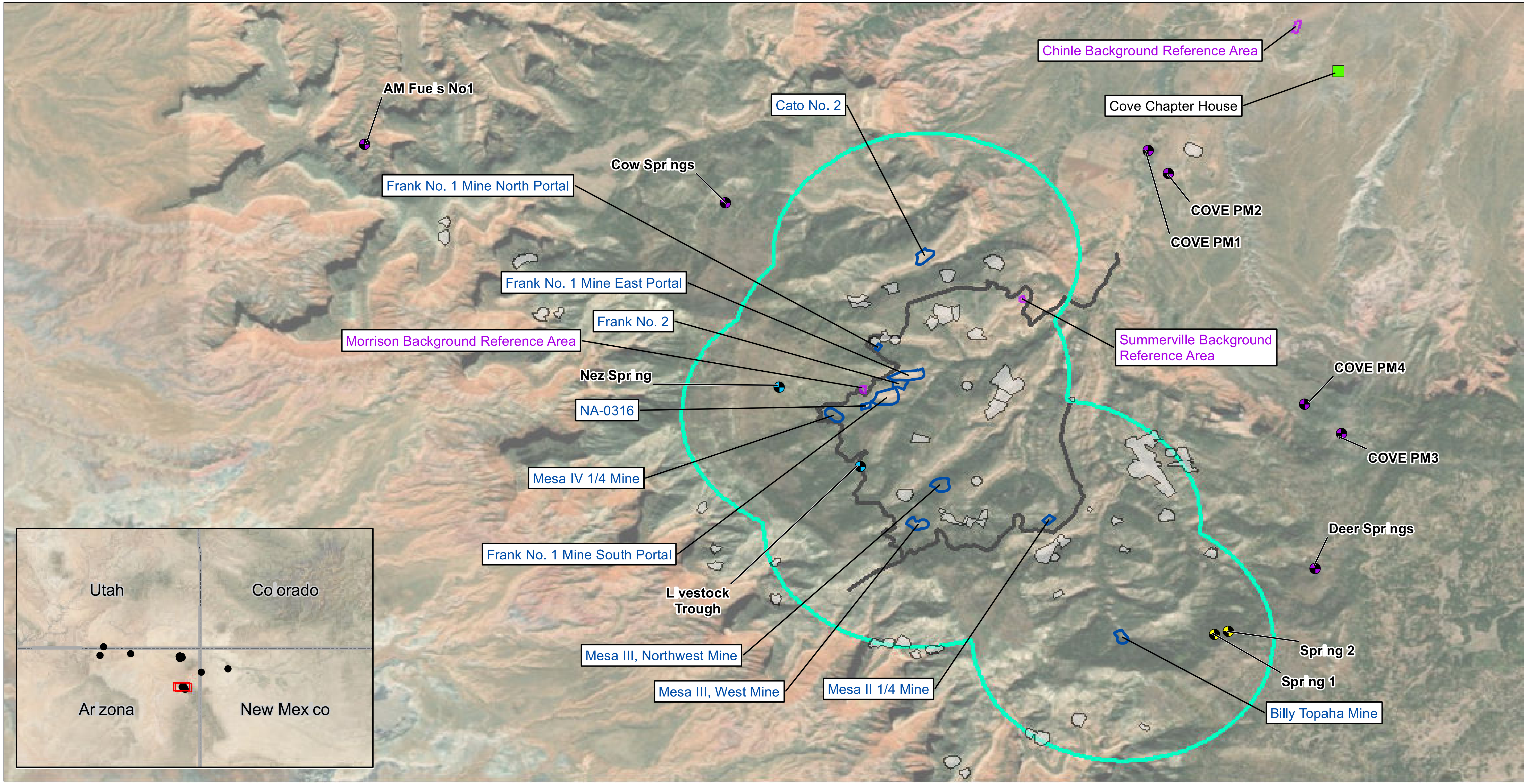
DQO = data quality objective

IL = investigation level

PCB = polychlorinated biphenyls

RSE = Removal Site Evaluation

Figures



LEGEND

- Cove Chapter House
- NDWR Well Database Location Not Meeting RSE Work Plan Sampling Criteria
- NDWR Well Database Location Meeting RSE Work Plan Sampling Criteria
- Water Sampling Location Meeting RSE Work Plan Sampling Criteria
- Group One Mine Boundary
- Non-Consent Decree Mine Boundary
- Background Reference Area
- 1-mile radius around Mine Site
- Main Mesa Road

Notes:
Water wells and surface water features meeting the RSE Work Plan sampling criteria (CH2M, 2017) are shown in blue and sampling was attempted.
CH2M = CH2M HILL Engineers, Inc.
NDWR = Navajo Nation Department of Water Resources
RSE = removal site evaluation

Sources:
1. Navajo Nation Department of Water Resources Water Management Branch Well Database. Accessed online August 2017.
2. CH2M, 2017. *Removal Site Evaluation Work Plan for Consent Decree Sites*. October.

N

0 2,250 4,500 9,000
Feet
1:54,000 1 inch = 4,500 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure ES-1. Mine Site Location Map
Cove Mine Area
Removal Site Evaluation Report

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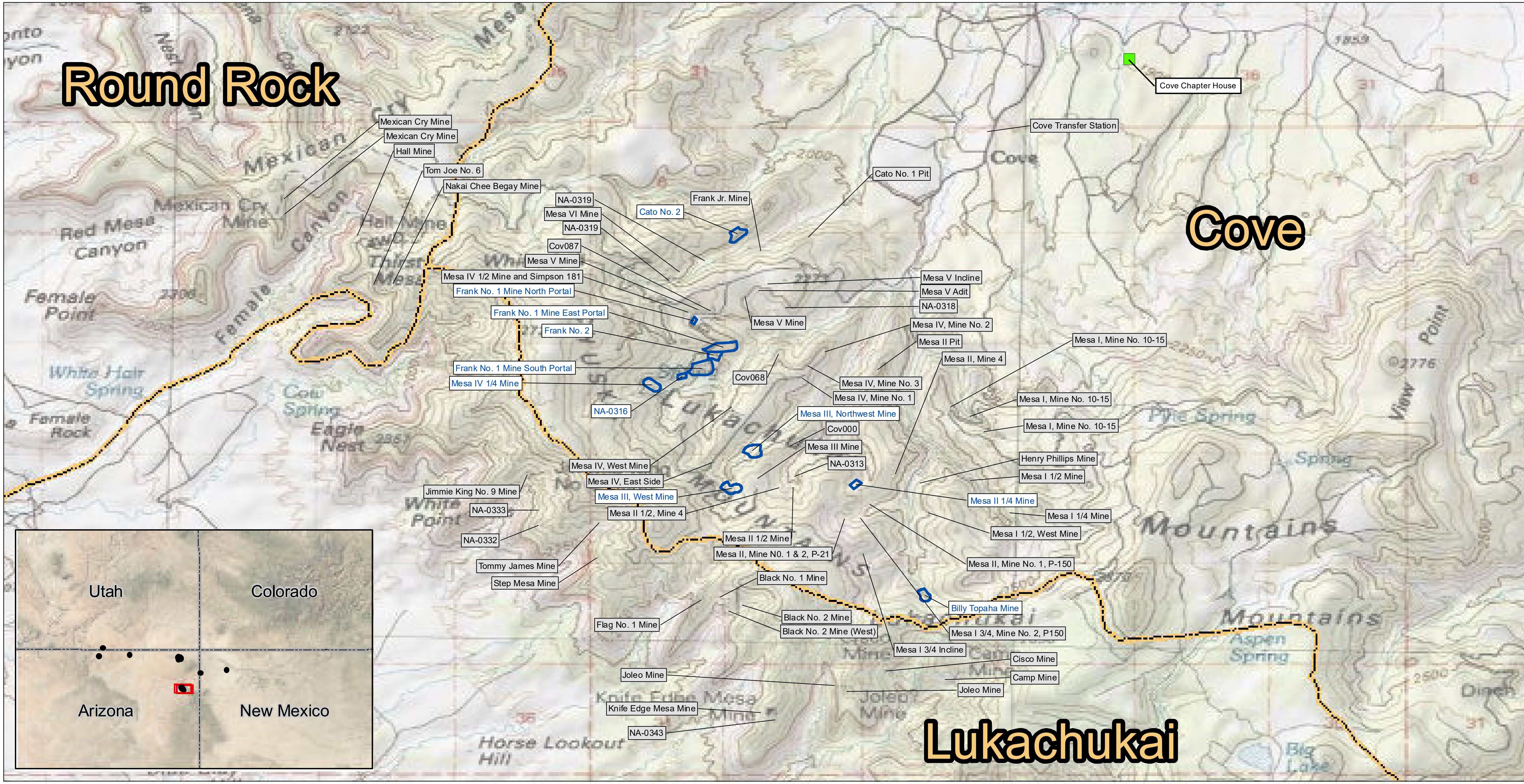


LEGEND

- Cove Chapter House
- Group One Mine Boundary
- Non-Consent Decree Mine Boundary
- Navajo Nation Chapter 2015

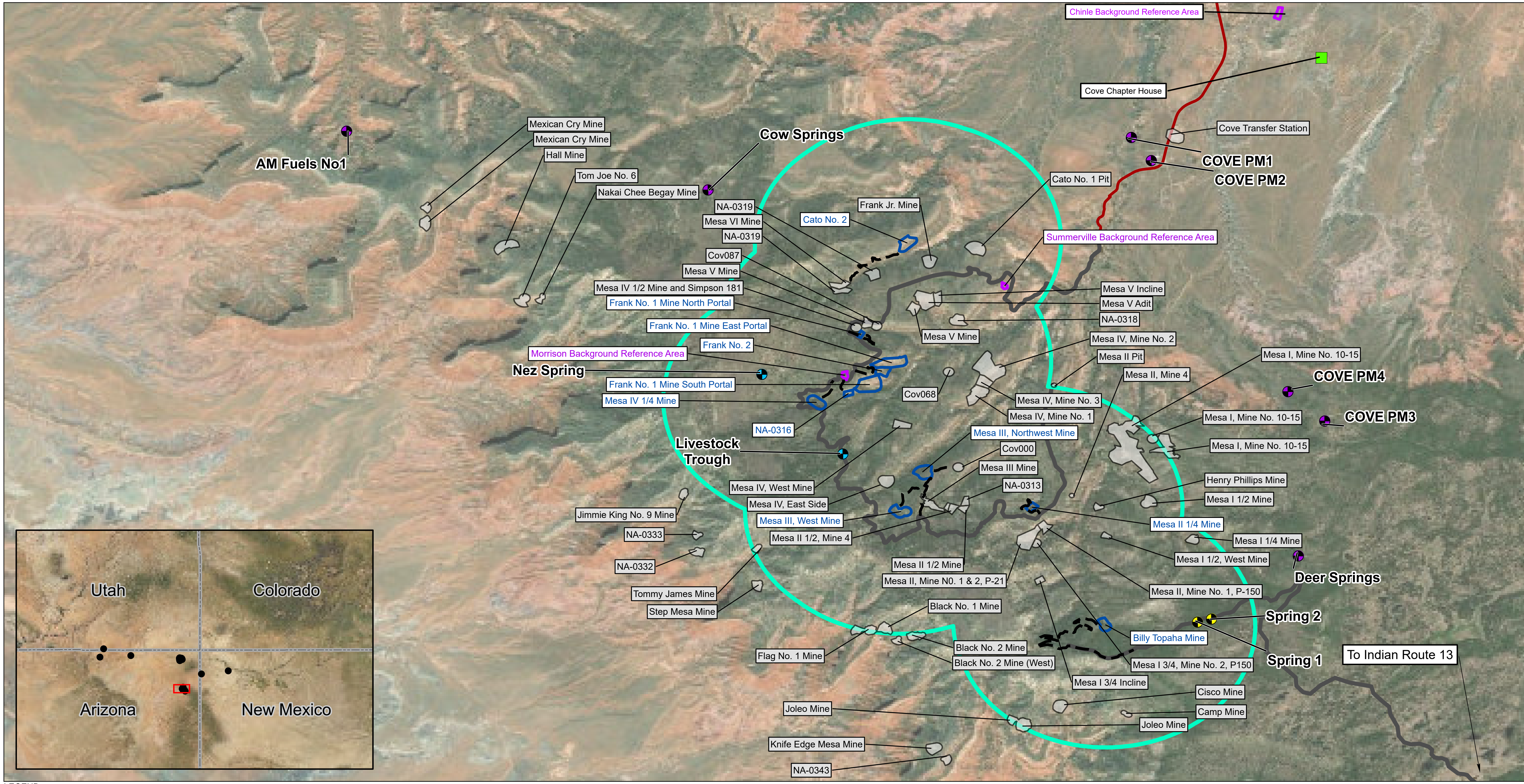
SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\COVE\RSE_REPORT_FIGURES\FIGURE 1-2_COVE_REGIONAL.MXD TARROWOO 9/27/2022 23:12:22

N

0 2,375 4,750 9,500
Feet
1:57,000 1 inch = 4,750 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 1-1. Regional Location Map
Cove Mine Area
Removal Site Evaluation Report



LEGEND

- Cove Chapter House
- NDWR Well Database Location Meeting RSE Work Plan Sampling Criteria
- Water Sampling Location Meeting RSE Work Plan Sampling Criteria
- NDWR Well Database Location Not Meeting RSE Work Plan Sampling Criteria
- Group One Mine Boundary
- Non-Consent Decree Mine Boundary
- Background Reference Area
- 1-mile radius around Mine Site
- Main Mesa Road and Access Roads
- Former Haul Road
- Indian Route 33

Notes:
Water wells and surface water features meeting the RSE Work Plan sampling criteria (CH2M, 2017) are shown in blue and sampling was attempted.
CH2M = CH2M HILL Engineers, Inc.
NDWR = Navajo Nation Department of Water Resources
RSE = removal site evaluation

Sources:
1. Navajo Nation Department of Water Resources Water Management Branch Well Database. Accessed online August 2017.
2. CH2M, 2017. *Removal Site Evaluation Work Plan for Consent Decree Sites*. October.

N

0 2,250 4,500 9,000
Feet

1:54,000 1:54,000

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 1-2. Regional Location Map
Cove Mine Area
Removal Site Evaluation Report

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SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\COVE\RSE_REPORT_FIGURES\FIGURE 1-4_COVE_GENERALLOCATION\FIGURE 1-4_COVE_GENERALLOCATION.APRX TARROWOO 10/26/2022 11:57:30

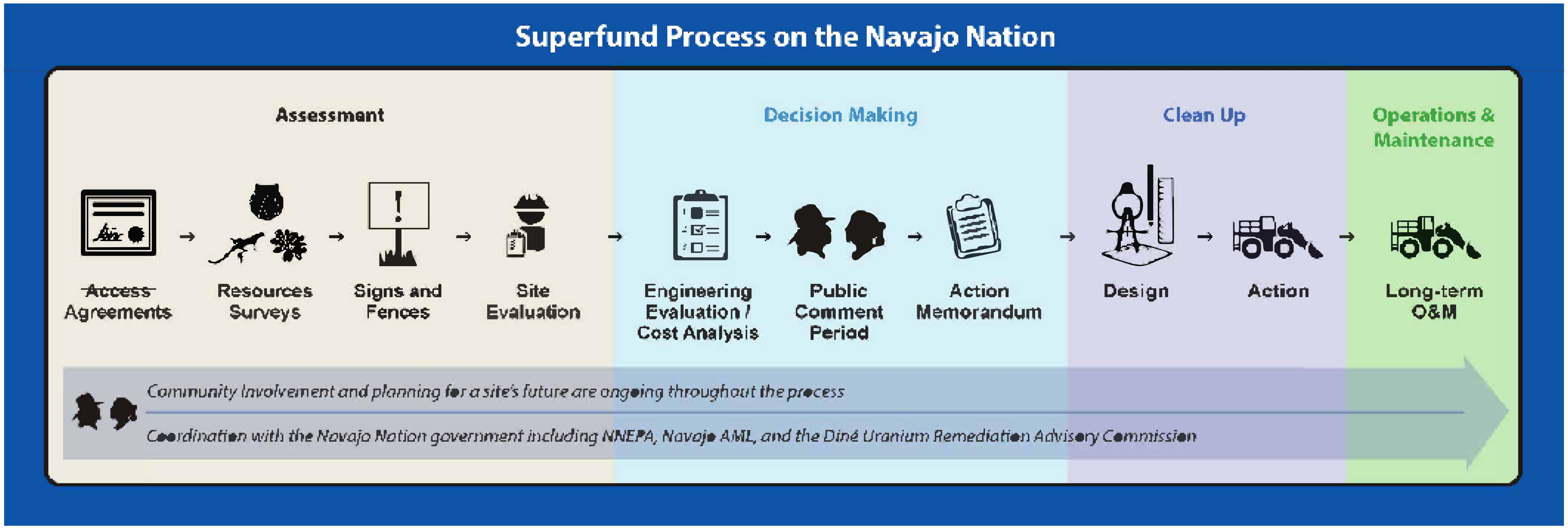

Figure 1-3. Superfund Process on the Navajo Nation
Cove Mine Area
Removal Site Evaluation Report

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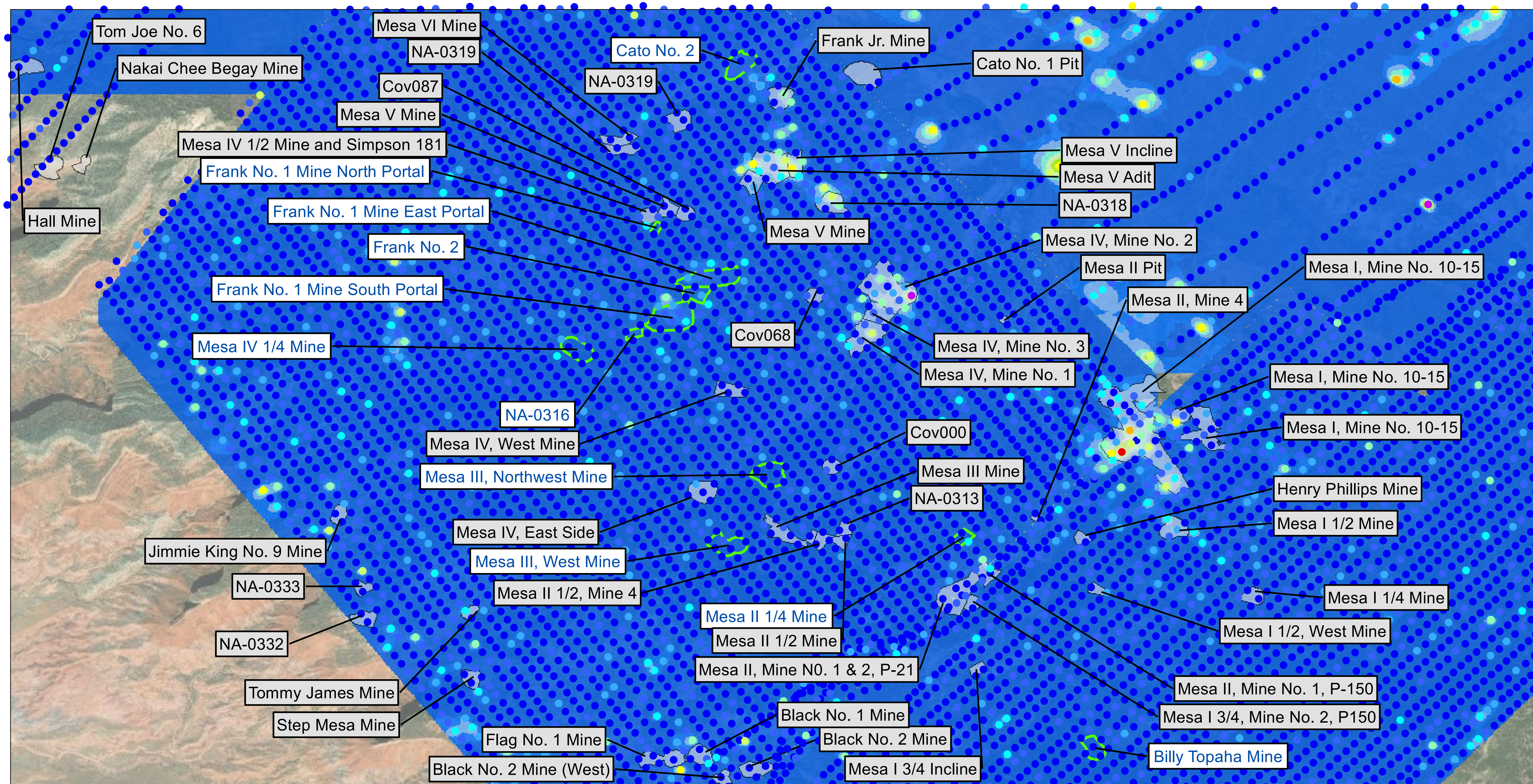

LEGEND

- Group One Mine Boundary
- Non-Consent Decree Mine Boundary

Polygon Surface of ASPECT Net eU

< 9.5	27.5 - 32
9.5 - 14	32 - 36.5
14 - 18.5	36.5 - 41
18.5 - 23	41 - 45.5
23 - 27.5	> 45.5

ASPECT Net eU

< 9.5	27.6 - 32.0
9.6 - 14.0	32.1 - 36.5
14.1 - 18.5	36.6 - 41.0
18.6 - 23.0	41.1 - 45.5
23.1 - 27.5	> 45.6

Notes:
1. Net eU is estimated using bismuth-214
> = greater than
< = less than
ASPECT = Airborne Spectral Photometric Environmental Collection Technology
eU = equivalent uranium
USEPA = United States Environmental Protection Agency
Source:
US EPA ASPECT data collected in 2014 and 2015 for the EPA.
ASPECT database file was provided by the EPA on November 2nd, 2018.

N

0 1,250 2,500 5,000
Feet
1:30,000 1 inch = 2,500 feet

Figure 2-1. ASPECT Map
Cove Mine Area
Removal Site Evaluation Report

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

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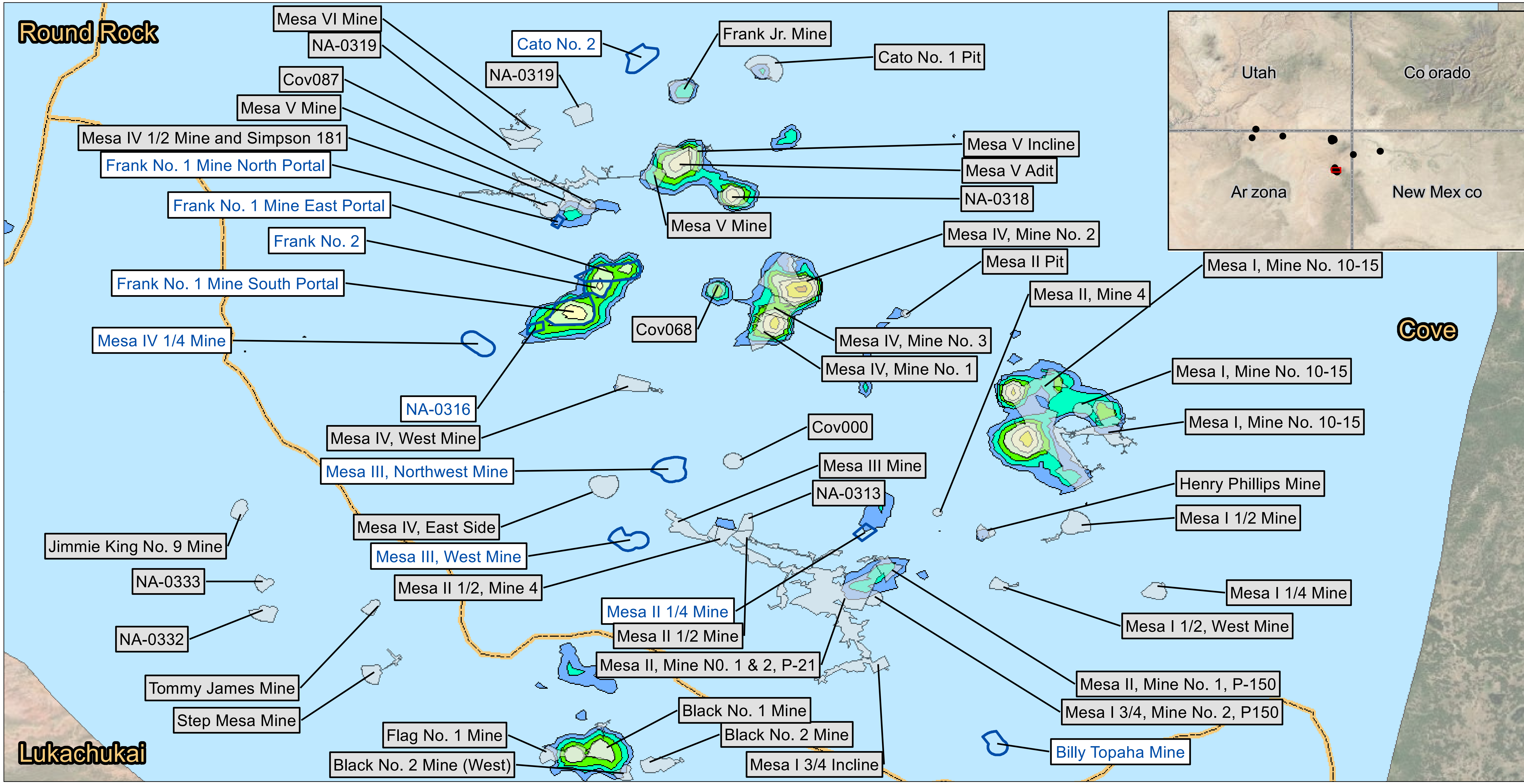
SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\COVE\RSE_REPORT_FIGURES\FIGURE 2-1_COVE_ASPECT.MXD TARROWOO 6/28/2022 17:00:09



LEGEND

- Group One Mine Boundary
- Non-Consent Decree Mine Boundary
- Navajo Nation Chapter 2015

Ground Surface Exposure Rate (in μR/h)

- 0 - 2.4
- 2.4 - 3.5
- 3.5 - 5.2
- 5.2 - 7.4
- 7.4 - 10.9
- 10.9 - 16.2
- 16.2 - 23.6
- 23.6 - 34.9
- 34.9 - 52.4
- >52.5

Notes:
1. US EPA Region 9 and US Department of Energy excess bismuth-214 data collected from October 1994 to October 1999.
2. Ground surface exposure rate is estimated from excess bismuth-214 readings in counts per minute based upon the 1764keV photopeak. Bismuth-214 is based upon measured minus expected bismuth-214 times a per flight determined constant equal to a ratio of statistically most likely values.
μR/hr = microroentgen per hour
AUM = Abandoned Uranium Mines
USEPA = United States Environmental Protection Agency

N

0 1,250 2,500 5,000
Feet
1:30,000 1 inch = 2,500 feet

Source:
1. U.S. Environmental Protection Agency (U.S. EPA). 2007. Abandoned Uranium Mines and the Navajo Nation, Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data. August.

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 2-2. Regional Ground Surface Exposure Rate Map
Cove Mine Area
Removal Site Evaluation Report

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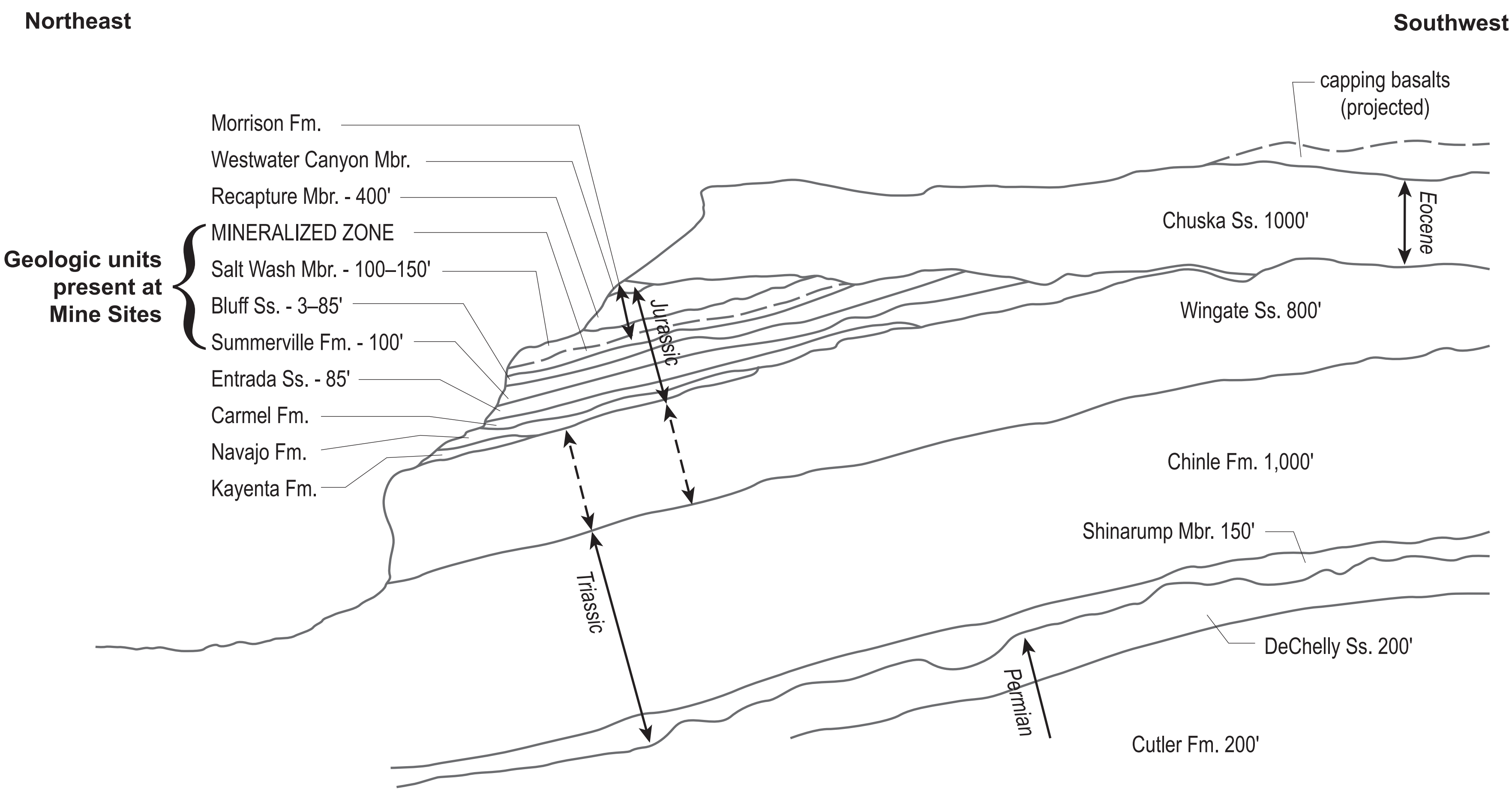
SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\COVE\RSE_REPORT_FIGURES\FIGURE 2-2_COVE_REGIONAL_ATLAS_EXPOSURE_RATE_MAP.MXD TARROWOO 6/28/2022 16:13:52



Generalized Geologic Cross Section of Cove Mine Area and Lukachukai Mountains

Notes:
150' = 150 feet thick
Fm. = Formation
Mbr. = Member
Ss. = Sandstone

Adapted from:
Scarborough, Robert B. 1981. Radioactive Occurrences and Uranium Production in Arizona Final Report. Arizona Bureau of Geology and Mineral Technology Geological Survey Branch, Tucson, Arizona, May 1981.

Figure 2-3.
Cove Mine Area Stratigraphy
Cove Mine Area
Removal Site Evaluation Report

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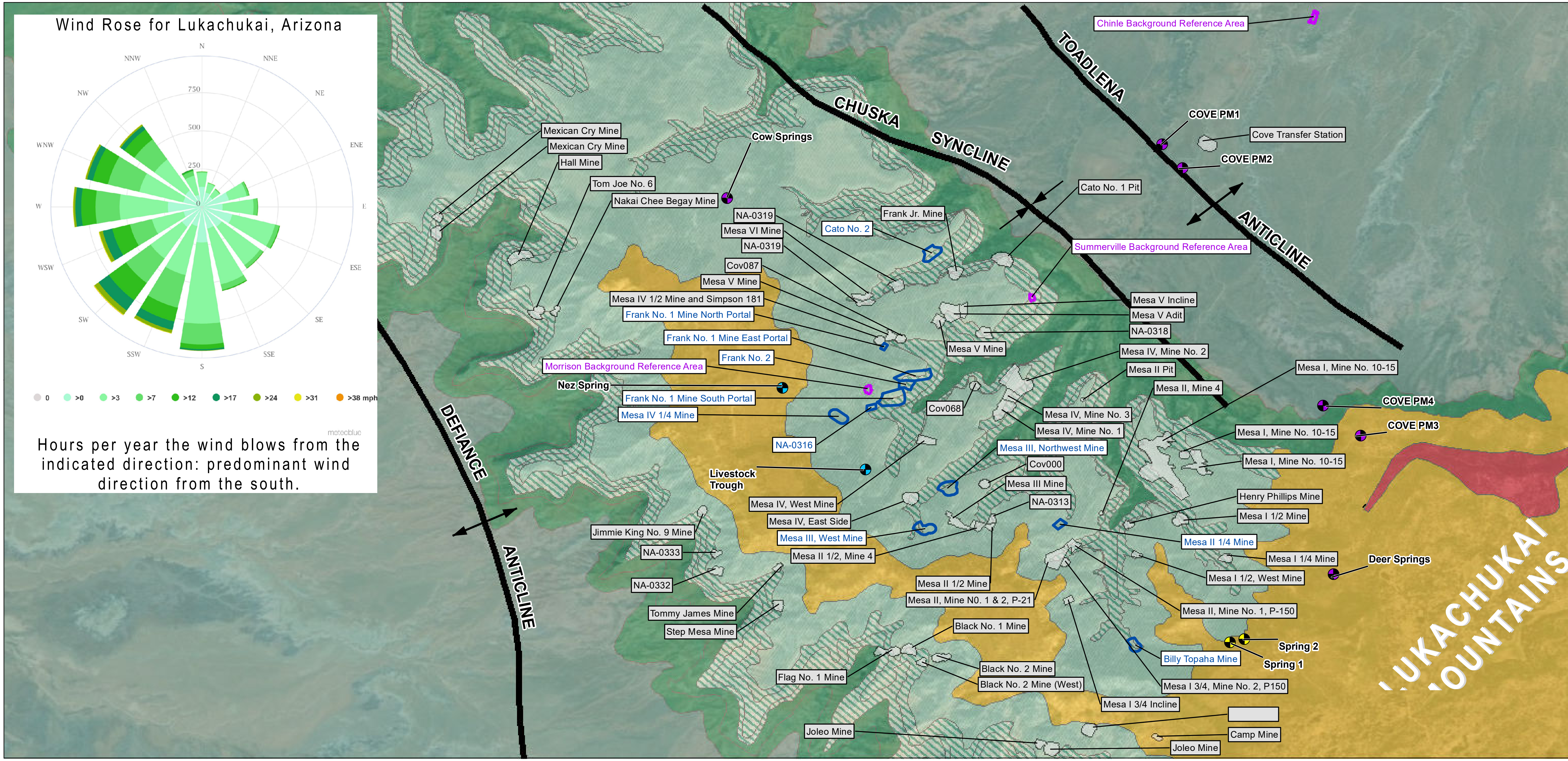

LEGEND

- Group One Mine Boundary
- Non-Consent Decree Mine Boundary
- Group One Background Area
- Syncline
- Anticline
- NDWR Well Database Location Not Meeting RSE Work Plan Sampling Criteria
- NDWR Well Database Location Meeting RSE Work Plan Sampling Criteria
- Water Sampling Location Meeting RSE Work Plan Sampling Criteria

SITE GEOLOGY

TERTIARY

- Tc: Chuska sandstone. Light-brown to yellowish-gray to white cross-bedded sandstone, with minor interbedded reddish-brown siltstone and shale.
- Ti: Intrusive igneous rocks.

JURASSIC

Morrison Formation

- Jmw: Westwater Canyon Member. Yellowish-gray sandstone containing conglomeratic lenses and dark reddish-brown siltstone.
- Jmr: Recapture Member. White to brown fine- to medium-grained sandstone, siltstone, and conglomerate.
- Jms: Salt Wash member. White to moderately orange very fine- to medium-grained sandstone, grayish-red shale, and gray limestone. Uranium ore-bearing unit

JURASSIC (cont.)

Summerville Formation, Entrada Sandstone, Carmel Formation Undifferentiated

- Js: Summerville Formation. Reddish-orange to reddish-brown, fine-grained, well-sorted sandstone, siltstone, sandy siltstone, and mudstone; ripple marks, small-scale trough crossbeds, and wavy, subparallel laminations common.
- Je: Entrada Sandstone. Reddish-brown massive bedded fine-grained sandstone and siltstone.
- Jc: Carmel Formation. Reddish-orange to brown to buff siltstone with interbedded reddish-orange sandstone layers.

N

0 2,250 4,500 9,000

Feet

1:54,000 1 inch = 4,500 feet

TRIASSIC

Glen Canyon Group Undifferentiated

- JTRn: Navajo Sandstone. Light-brown fine to medium-grained, massive crossbedded eolian sandstone.
- TRk: Kayenta Formation. Light red to reddish-brown lenticular, sandstone, siltstone and conglomerate with minor limestone.
- TRwl: Wingate Sandstone. Lukachukai Member. Reddish-brown fine-grained, massive crossbedded eolian sandstone.
- TRwr: Wingate Sandstone. Rock Point Member. Reddish-brown siltstone.

Chinle Formation

- TRcco: Church Rock and Owl Rock Members. Reddish-brown siltstone and silty sandstone; light gray and grayish-pink interbedded limestone and calcareous siltstone, respectively.
- TRcpu, TRcps, TRcpl: Upper, Middle and Lower units of the Sonsela Sandstone Bed. Light-gray sandstone and conglomerate.

Figure 2-4. Geologic Map with Wind Direction

Cove Mine Area

Removal Site Evaluation Report

Sources:

1. Geology adapted from Cooley, M.E., Harshbarger, J.W., Akers, J.p, Hardt, W.F, and Hicks, O.N. 1969. Geologic map of the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah in Regional hydrogeology of the Navajo and Hopi Indian reservations, Arizona, New Mexico, and Utah, with a section on vegetation. U.S. Geological Survey Professional Paper 521-A, Plate 1, Sheet 5. Scale 1:125,000. https://pubs.er.usgs.gov/publication/pp521A
2. Wind Rose Source: https://www.meteoblue.com/en/weather/forecast/modelclimate/lukachukai_united-states-of-america_5303304

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Geologic Map: USGS National Geologic Map Database 1969

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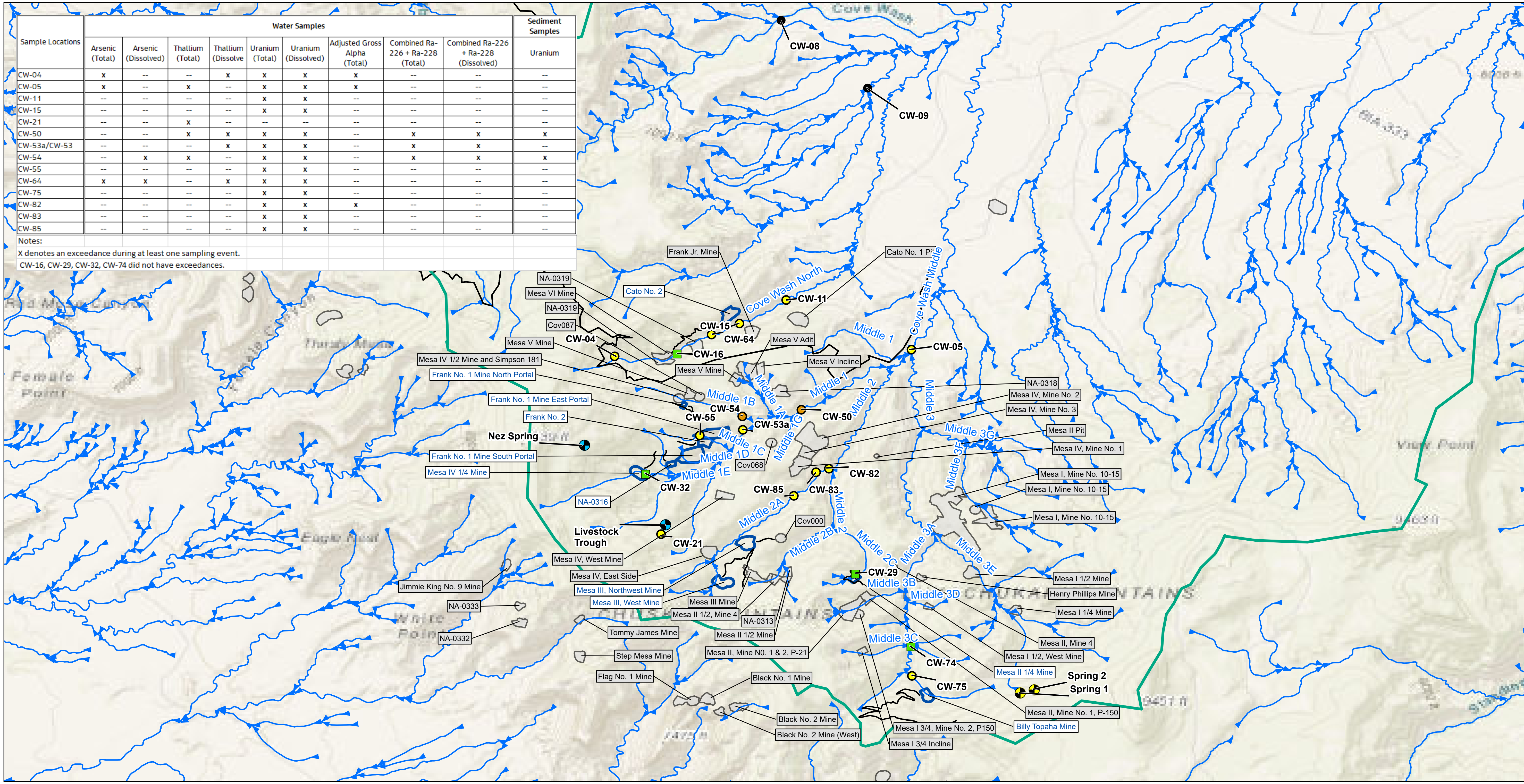
SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\COVE\RSE_REPORT_FIGURES\FIGURE 2-4_COVE_GEOLOGIC_WINDDIRECTION.MXD TARROWOO 7/27/2022 13:48:51

Sample Locations	Water Samples									Sediment Samples
	Arsenic (Total)	Arsenic (Dissolved)	Thallium (Total)	Thallium (Dissolve	Uranium (Total)	Uranium (Dissolved)	Adjusted Gross Alpha (Total)	Combined Ra-226 + Ra-228 (Total)	Combined Ra-226 + Ra-228 (Dissolved)	Uranium
CW-04	x	--	--	x	x	x	x	--	--	--
CW-05	x	--	x	--	x	x	x	--	--	--
CW-11	--	--	--	--	x	x	--	--	--	--
CW-15	--	--	--	--	x	x	--	--	--	--
CW-21	--	--	x	--	--	--	--	--	--	--
CW-50	--	--	x	x	x	x	--	x	x	x
CW-53a/CW-53	--	--	--	x	x	x	--	x	x	--
CW-54	--	x	x	--	x	x	--	x	x	x
CW-55	--	--	--	--	x	x	--	--	--	--
CW-64	x	x	--	x	x	x	--	--	--	--
CW-75	--	--	--	--	x	x	--	--	--	--
CW-82	--	--	--	--	x	x	x	--	--	--
CW-83	--	--	--	--	x	x	--	--	--	--
CW-85	--	--	--	--	x	x	--	--	--	--

Notes:
X denotes an exceedance during at least one sampling event.
CW-16, CW-29, CW-32, CW-74 did not have exceedances.



LEGEND

Weston (2018) Sediment Only Sampling Locations
- No Exceedance

Weston (2018) Sediment and Surface Water Sampling Locations
- Exceedance for Groundwater
- Exceedance for Groundwater and Sediment
- Weston Sample Location
- Water Sampling Location Meeting RSE Work Plan Sampling Criteria
- NDWR Well Database Location Meeting RSE Work Plan Sampling Criteria
- Cove Wash Watershed Drainage Boundary
- Drainage from EPA Database
- Mine Boundary
- Non-Consent Decree Mine Boundary

Notes:
1) Water wells and surface water features meeting the RSE Work Plan sampling criteria (CH2M, 2017) are shown in blue and sampling was attempted.
2) Water samples were compared to the NNWQS
3) Sediment samples were compared to the RSLs
4) Sediment and surface water samples were collected by Weston on behalf of U.S. EPA during four sampling events completed between 2015 and 2017 (U.S. EPA 2018b). Samples were taken under low-flow conditions (2015 and 2016 low flow) and high-flow conditions (2016 and 2017 spring snowmelt).
CH2M = CH2M HILL Engineers, Inc.
EPA = Environmental Protection Agency
NDWR = Navajo Nation Department of Water Resources
NNWQS = Navajo Nation Water Quality Standard
Ra = Radium
RSE = removal site evaluation
RSL = regional screening level

Sources:
1. Navajo Nation Department of Water Resources Water Management Branch Well Database. Accessed online August 2017.
2. CH2M, 2017. *Removal Site Evaluation Work Plan for Consent Decree Sites*. October.
3. U.S. Environmental Protection Agency (U.S EPA). 2018. Final Assessment Report Cove Wash Watershed Assessment Site Navajo Nation, Cove Chapter, Arizona. Prepared by Weston Solutions, Inc. (Weston). April.
4. EPA drainage database file was provided by the EPA on June 29th, 2018.

N
0 2,250 4,500 9,000
Feet
1:54,000
1 inch = 4,500 feet

Figure 2-5. U.S. EPA (2018) Sediment and Surface Water Sampling Locations in Cove Wash Watershed
Cove Mine Area
Removal Site Evaluation Report

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

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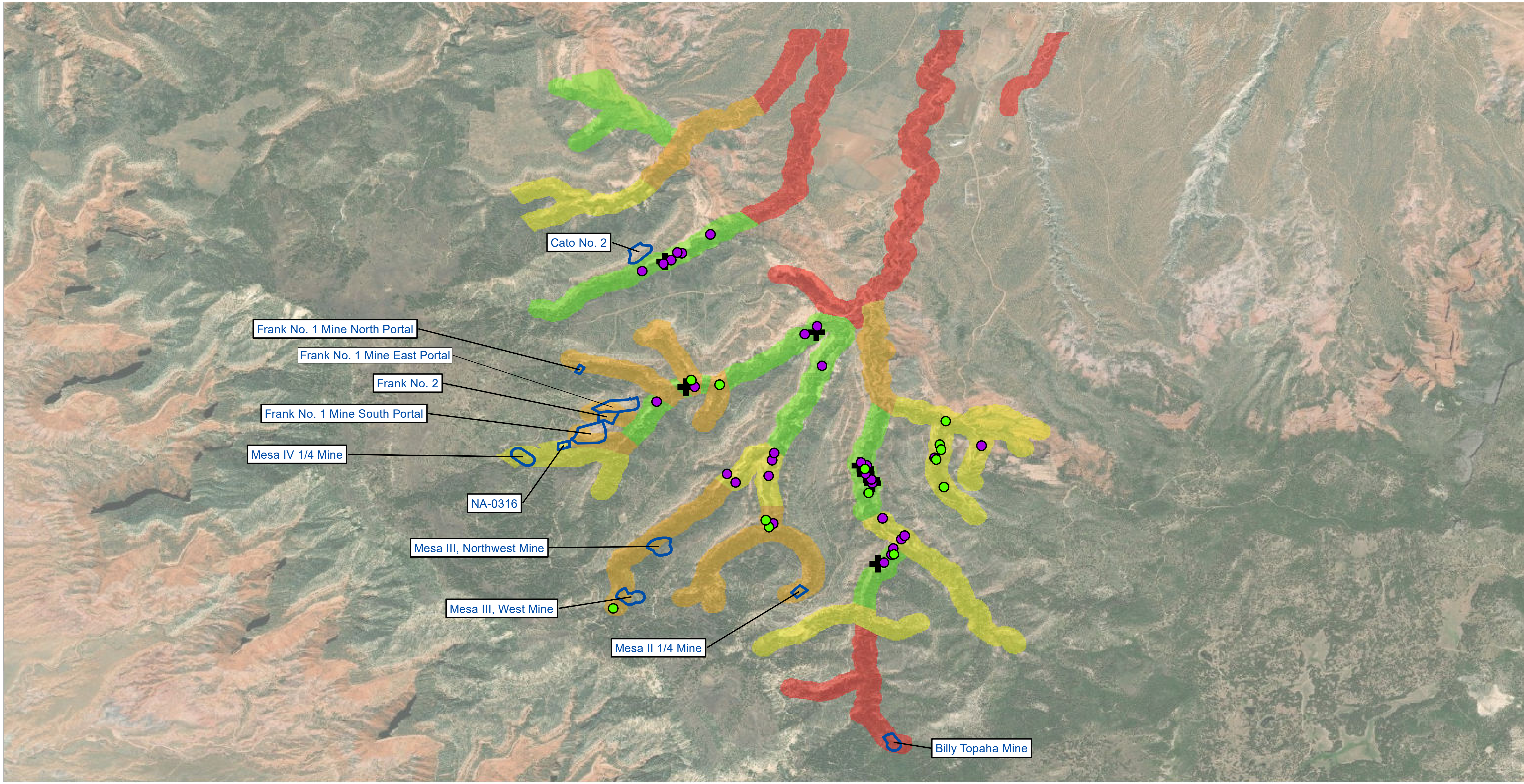
SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\COVE\RSE_REPORT_FIGURES\COVE_MAINTEXTFIGURES\COVE_MAINTEXTFIGURES.APRX TARROWOO 9/29/2022 11:33:38



LEGEND

- 2019 MSO Observations
- 2018 MSO Observations
- 2016 MSO Observations
- Group One Mine Boundary
- Excellent Mexican Spotted Owl Habitat
- Good Mexican Spotted Owl Habitat
- Fair Mexican Spotted Owl Habitat
- Poor Mexican Spotted Owl Habitat

Notes:
This data was digitized from two reports:
2016 Mexican Spotted Owl Survey Report (Adkins and Weston, 2016) and
Mexican Spotted Owl Survey Report 2019 Season (Tetra Tech, 2019).
MSO = Mexican Spotted Owl

Sources:
1. Adkins Consulting, Inc. and Weston Solutions, Inc. (Adkins and Weston). 2016. 2016 Mexican Spotted Owl Survey Report. November.
2. Tetra Tech Inc. (Tetra Tech). 2019. Northern Agency Tronox Mines Engineering Evaluation/Cost Analysis Mexican Spotted Owl Survey Report 2019 Nesting Season. Submitted to U.S. Environmental Protection Agency. August.

N

0 1,200 2,400 4,800
Feet
1:42,000
1 inch = 3,500 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 2-6. Mexican Spotted Owl Suitable Habitat and Known Locations
Cove Mine Area
Removal Site Evaluation Report

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SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\COVE\RSE_REPORT_FIGURES\FIGURE 2-6_MEXICANSPOTTEDOWL_COVE.MXD TARROWOO 7/6/2022 10:34:01

CO-B1-007	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.91	2	0.0098 J	0.19 J	0.58 *U*	3.6	0.62	12
1.0-1.5	0.88	1.5	0.011 J	0.16 J	0.69 J	2.9	0.45	11

CO-B1-006	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.75	1.7	0.016 J	0.17 J	0.54 *U*	2.7	0.51	9.9

CO-B1-005	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.77	1.9	0.014 J	0.18 J	0.65 *U*	2.7	0.55	11

CO-B1-020	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.63	1	0.0039 J	0.12 J	0.26 *U*	2.2	0.38	7.9

CO-B1-025	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1.1	1.4	0.011 J	0.15 J	0.37 *U*	2.2	0.85	9.4

CO-B1-010	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.8	1.5	0.03 J	0.15 J	0.45 *U*	2.6	0.67	9.7

CO-B1-009	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1.32	1.8	0.0089 J	0.19 J	0.66 *U*	2.9	0.82	13
1.0-1.5	0.94	1.5	0.0096 J	0.17 J	0.76 J	3.0	0.58	11

CO-B1-003	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1.11	1.7	0.0071 J	0.18 J	0.45 *U*	2.7 J	0.71	11

CO-B1-002	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1.04	1.4	0.0073 J	0.15 J	0.37 *U*	2.7	0.61	10

CO-B1-001	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.42	1.7	0.017 J	0.16 J	0.43 *U*	2.5	0.42	8.6
1.0-1.5	0.46 UJ	1.4	0.0097 J	0.13 J	0.87 J	2	0.19	6.5

C 4

LEGEND

- Sample Location for Primary COPC
- Background Reference Area
- Background Sampling Grid

Gamma cpm
- 0 - 10000
- 10001 - 13228

Notes:
1. Background reference area is 1.3 acres
2. Ra-226 is reported in pCi/g; metals are reported in mg/kg.
3. Metals analyzed: arsenic, mercury, molybdenum, selenium, thorium, uranium, and vanadium.
4. Gamma BTV is the 95% USL, BTV = 13200 cpm.

BTV = background threshold value
COPCs = contaminants of primary concern
cpm = counts per minute
IL = Investigation Level
J = estimated concentration

Notes: continued
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram
U = non-detect
UJ = estimated concentration below detection limit
USL = upper simultaneous limit

0 25 50 100
Feet
1:600 1 inch = 50 feet
N

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 4-1. Morrison Background Reference Area—Gamma Scan Survey and Soil Sampling Results
Cove Mine Area
Removal Site Evaluation Report

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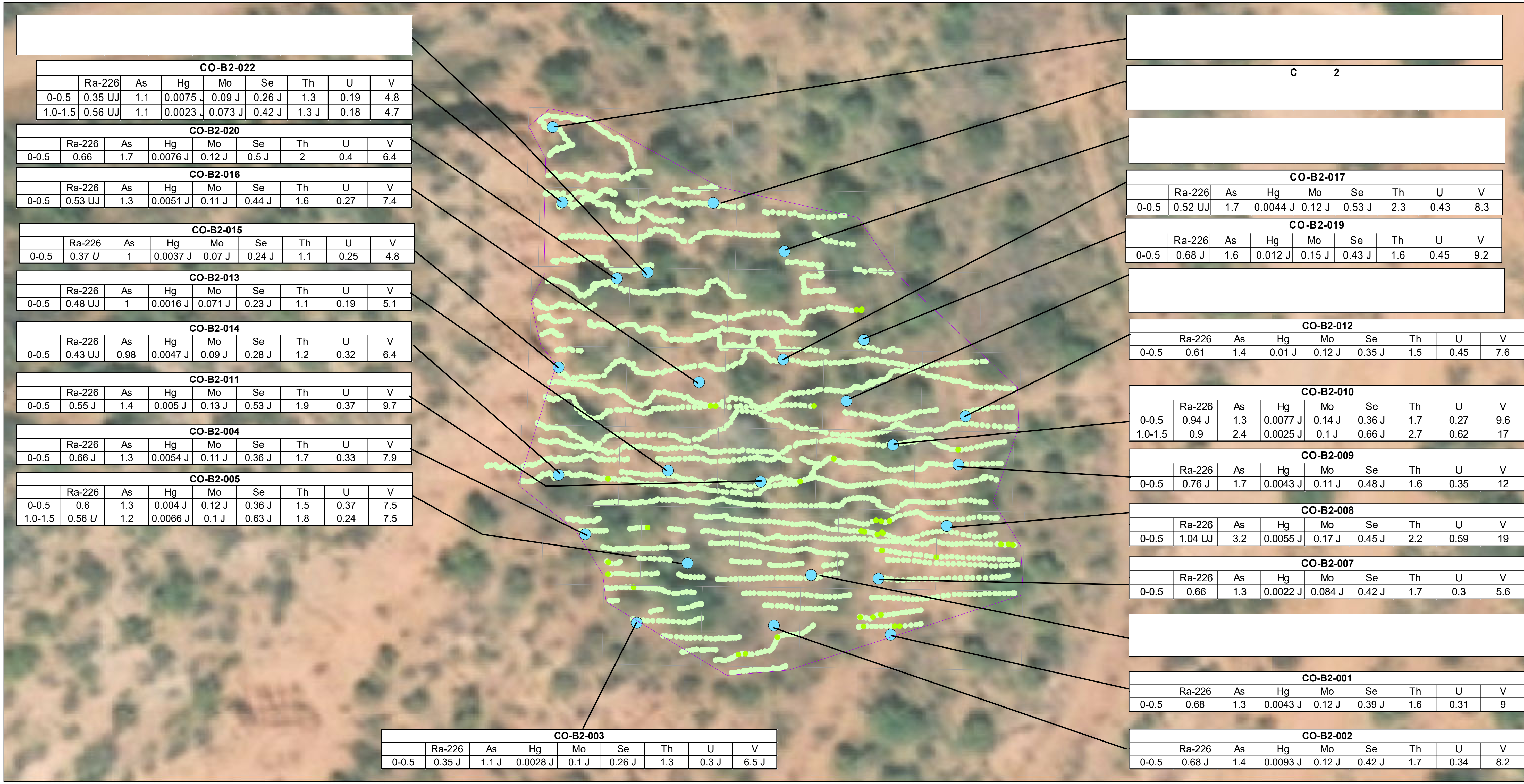
SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\COVE\RSE_REPORT_FIGURES\FIGURE 4-1_MORRISON_BACKGROUND_REFERENCE_AREA_RESULTS.MXD TARROWOO 7/27/2022 15:20:53



CO-B2-022								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.35 UJ	1.1	0.0075 J	0.09 J	0.26 J	1.3	0.19	4.8
1.0-1.5	0.56 UJ	1.1	0.0023 J	0.073 J	0.42 J	1.3 J	0.18	4.7

CO-B2-020								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.66	1.7	0.0076 J	0.12 J	0.5 J	2	0.4	6.4

CO-B2-016								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.53 UJ	1.3	0.0051 J	0.11 J	0.44 J	1.6	0.27	7.4

CO-B2-015								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.37 *U*	1	0.0037 J	0.07 J	0.24 J	1.1	0.25	4.8

CO-B2-013								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.48 UJ	1	0.0016 J	0.071 J	0.23 J	1.1	0.19	5.1

CO-B2-014								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.43 UJ	0.98	0.0047 J	0.09 J	0.28 J	1.2	0.32	6.4

CO-B2-011								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.55 J	1.4	0.005 J	0.13 J	0.53 J	1.9	0.37	9.7

CO-B2-004								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.66 J	1.3	0.0054 J	0.11 J	0.36 J	1.7	0.33	7.9

CO-B2-005								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.6	1.3	0.004 J	0.12 J	0.36 J	1.5	0.37	7.5
1.0-1.5	0.56 *U*	1.2	0.0066 J	0.1 J	0.63 J	1.8	0.24	7.5

CO-B2-017								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.52 UJ	1.7	0.0044 J	0.12 J	0.53 J	2.3	0.43	8.3

CO-B2-019								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.68 J	1.6	0.012 J	0.15 J	0.43 J	1.6	0.45	9.2

CO-B2-012								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.61	1.4	0.01 J	0.12 J	0.35 J	1.5	0.45	7.6

CO-B2-010								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.94 J	1.3	0.0077 J	0.14 J	0.36 J	1.7	0.27	9.6
1.0-1.5	0.9	2.4	0.0025 J	0.1 J	0.66 J	2.7	0.62	17

CO-B2-009								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.76 J	1.7	0.0043 J	0.11 J	0.48 J	1.6	0.35	12

CO-B2-008								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1.04 UJ	3.2	0.0055 J	0.17 J	0.45 J	2.2	0.59	19

CO-B2-007								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.66	1.3	0.0022 J	0.084 J	0.42 J	1.7	0.3	5.6

CO-B2-001								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.68	1.3	0.0043 J	0.12 J	0.39 J	1.6	0.31	9

CO-B2-002								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.68 J	1.4	0.0093 J	0.12 J	0.42 J	1.7	0.34	8.2

CO-B2-003								
	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.35 J	1.1 J	0.0028 J	0.1 J	0.26 J	1.3	0.3 J	6.5 J

LEGEND

- Sample Location for Primary COPC
- Background Reference Area
- Background Sampling Grid

Gamma cpm

- 0 - 10000
- 10001 - 10610

	Summerville IL
Radium (Ra)-226	1.04 pCi/g
Arsenic (As)	3.02 mg/kg
Mercury (Hg)	11 mg/kg
Molybdenum (Mo)	390 mg/kg
Selenium (Se)	390 mg/kg
Thorium (Th)	2.81 mg/kg
Uranium (U)	16 mg/kg
Vanadium (V)	390 mg/kg

Notes:
1. Background reference area is 0.9 acres
2. Ra-226 is reported in pCi/g; metals are reported in mg/kg.
3. Gamma BTV is the 95% USL, BTV = 10600 cpm.
BTV = background threshold value
COPCs = contaminants of primary concern
cpm = counts per minute
IL = Investigation Level
J = estimated concentration
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram

Notes: continued
U = non-detect
UJ = estimated concentration below detection limit
USL = upper simultaneous limit

N

0 25 50 100
Feet
1:600 1 inch = 50 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 4-2. Summerville Background Reference Area— Gamma Scan Survey and Soil Sampling Results
Cove Mine Area
Removal Site Evaluation Report

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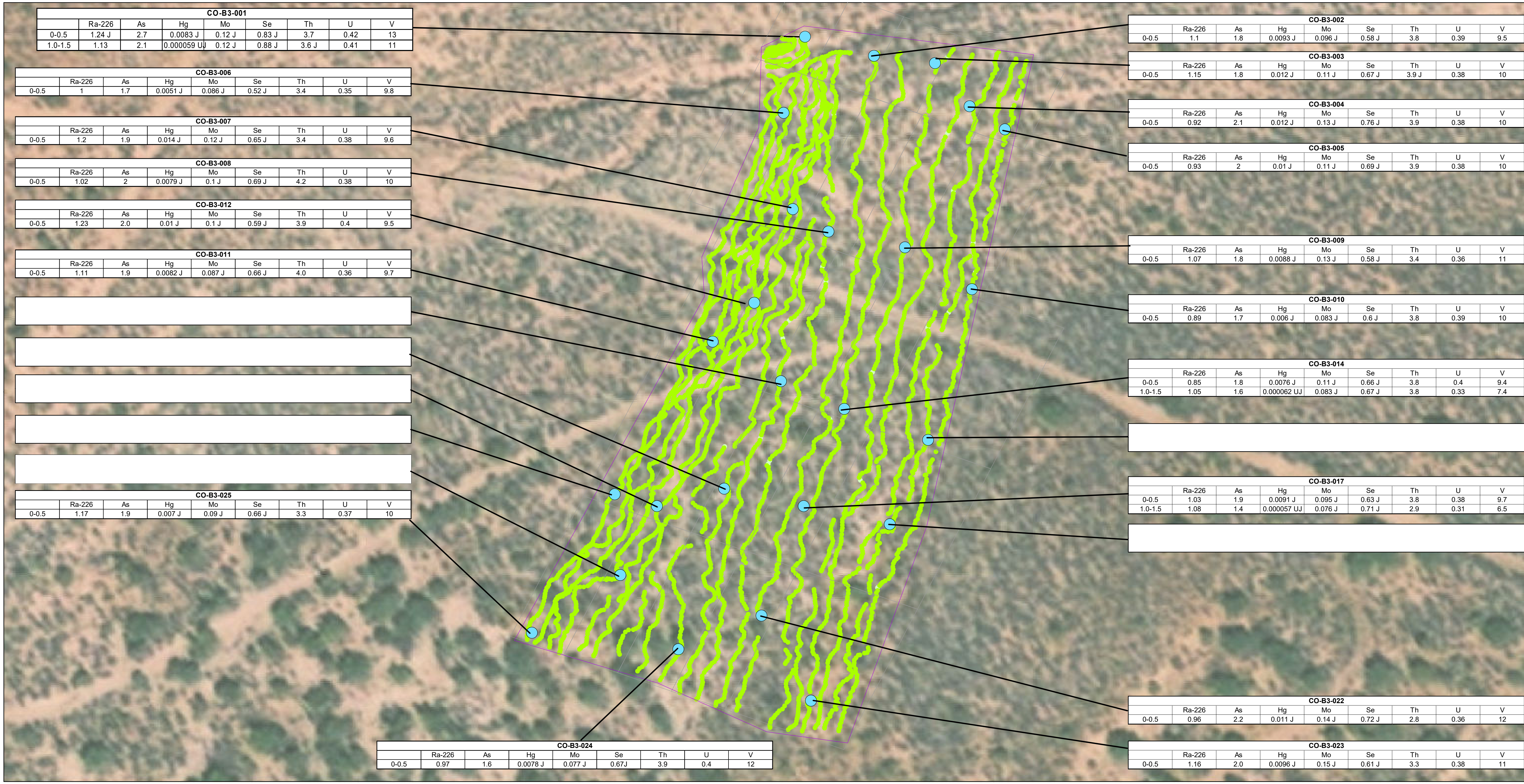
SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\COVE\RSE_REPORT_FIGURES\FIGURE 4-2_SUMMERVILLE_BACKGROUND_REFERENCE_AREA_RESULTS.MXD TARROWOO 7/27/2022 15:20:38



CO-B3-001

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1.24 J	2.7	0.0083 J	0.12 J	0.83 J	3.7	0.42	13
1.0-1.5	1.13	2.1	0.000059 UJ	0.12 J	0.88 J	3.6 J	0.41	11

CO-B3-006

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1	1.7	0.0051 J	0.086 J	0.52 J	3.4	0.35	9.8

CO-B3-007

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1.2	1.9	0.014 J	0.12 J	0.65 J	3.4	0.38	9.6

CO-B3-008

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1.02	2	0.0079 J	0.1 J	0.69 J	4.2	0.38	10

CO-B3-012

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1.23	2.0	0.01 J	0.1 J	0.59 J	3.9	0.4	9.5

CO-B3-011

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1.11	1.9	0.0082 J	0.087 J	0.66 J	4.0	0.36	9.7

CO-B3-025

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1.17	1.9	0.007 J	0.09 J	0.66 J	3.3	0.37	10

CO-B3-002

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1.1	1.8	0.0093 J	0.096 J	0.58 J	3.8	0.39	9.5

CO-B3-003

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1.15	1.8	0.012 J	0.11 J	0.67 J	3.9 J	0.38	10

CO-B3-004

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.92	2.1	0.012 J	0.13 J	0.76 J	3.9	0.38	10

CO-B3-005

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.93	2	0.01 J	0.11 J	0.69 J	3.9	0.38	10

CO-B3-009

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1.07	1.8	0.0088 J	0.13 J	0.58 J	3.4	0.36	11

CO-B3-010

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.89	1.7	0.006 J	0.083 J	0.6 J	3.8	0.39	10

CO-B3-014

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.85	1.8	0.0076 J	0.11 J	0.66 J	3.8	0.4	9.4
1.0-1.5	1.05	1.6	0.000062 UJ	0.083 J	0.67 J	3.8	0.33	7.4

CO-B3-017

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1.03	1.9	0.0091 J	0.095 J	0.63 J	3.8	0.38	9.7
1.0-1.5	1.08	1.4	0.000057 UJ	0.076 J	0.71 J	2.9	0.31	6.5

CO-B3-022

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.96	2.2	0.011 J	0.14 J	0.72 J	2.8	0.36	12

CO-B3-023

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	1.16	2.0	0.0096 J	0.15 J	0.61 J	3.3	0.38	11

CO-B3-024

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.97	1.6	0.0078 J	0.077 J	0.67J	3.9	0.4	12

LEGEND

- Sample_Locations
- Sample Location for Primary COPC
- Background Reference Area
- Background Sampling Grid

Gamma cpm

- 0 - 10000
- 10001 - 14570

	Chinle IL
Radium (Ra)-226	1.34 pCi/g
Arsenic (As)	3.51 mg/kg
Mercury (Hg)	11 mg/kg
Molybdenum (Mo)	390 mg/kg
Selenium (Se)	390 mg/kg
Thorium (Th)	4.32 mg/kg
Uranium (U)	16 mg/kg
Vanadium (V)	390 mg/kg

Notes:
1. Background reference area is 2.1 acres
2. Ra-226 is reported in pCi/g; metals are reported in mg/kg.
3. Gamma BTV is the 95% USL, BTV = 14600 cpm.

BTV = background threshold value
COPCs = contaminants of primary concern
cpm = counts per minute
IL = Investigation Level
J = estimated concentration
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram

Notes: continued
U = non-detect
UJ = estimated concentration below detection limit
USL = upper simultaneous limit

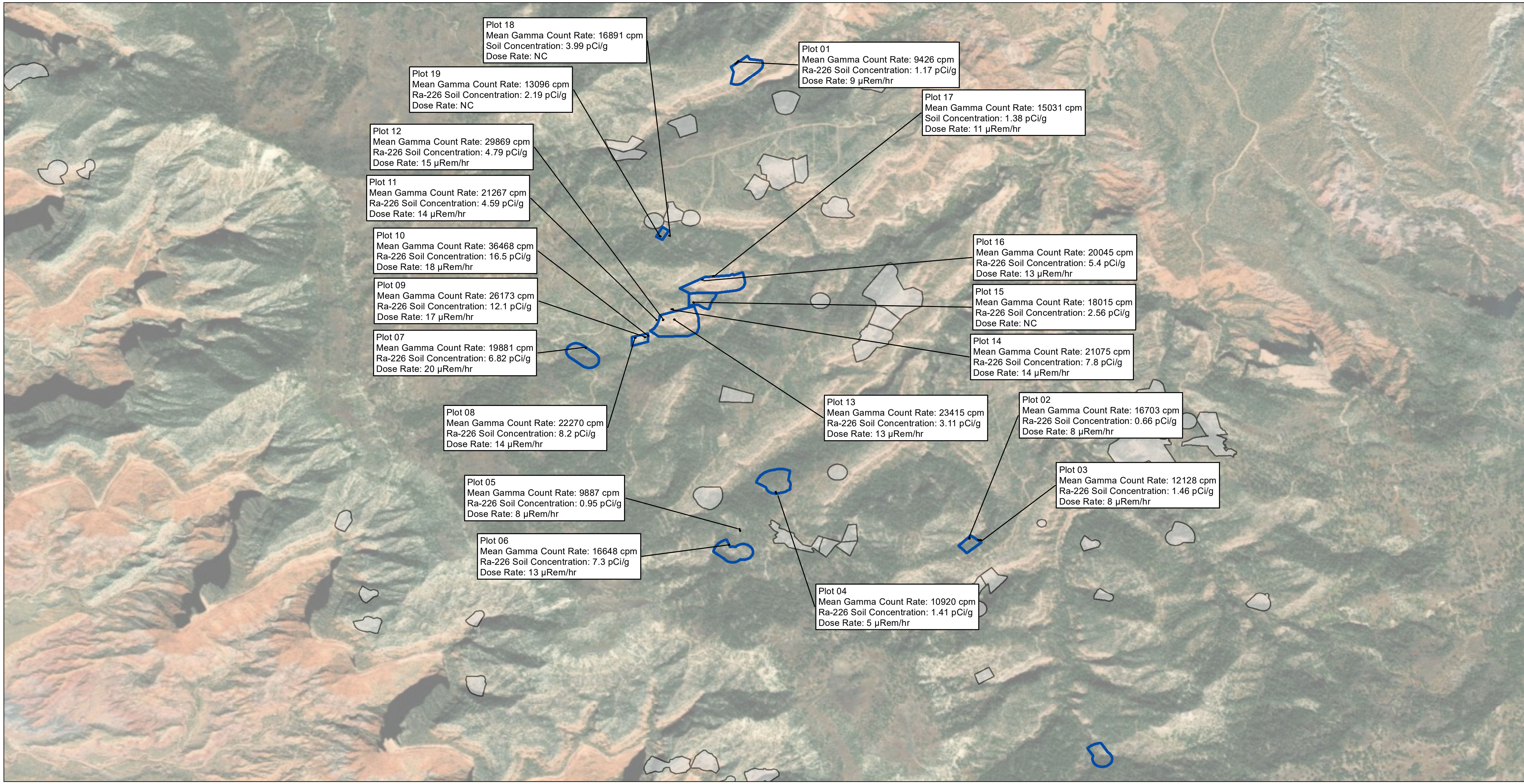
N

0 37.5 75 150
Feet
1:900 1 inch = 75 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 4-3. Chinle Background Reference Area— Gamma Scan Survey and Soil Sampling Results
Cove Mine Area
Removal Site Evaluation Report

JACOBS



LEGEND

Group One Mine Boundary

Non-Consent Decree Mine Boundary

Notes:
The Bicron MicroREM instrument used for dose rate measurements does not have the resolution required for measurements at low dose rate conditions (less than approximately 15 μRem/hr) and requires reliance on analog interpretation by the field operator.
This instrument is appropriate only for its intended use as a health and safety tool.
cpm = counts per minute
μRem/hr = microrems per hour
NC = not collected
pCi/g = picocuries per gram
Ra = Radium

N

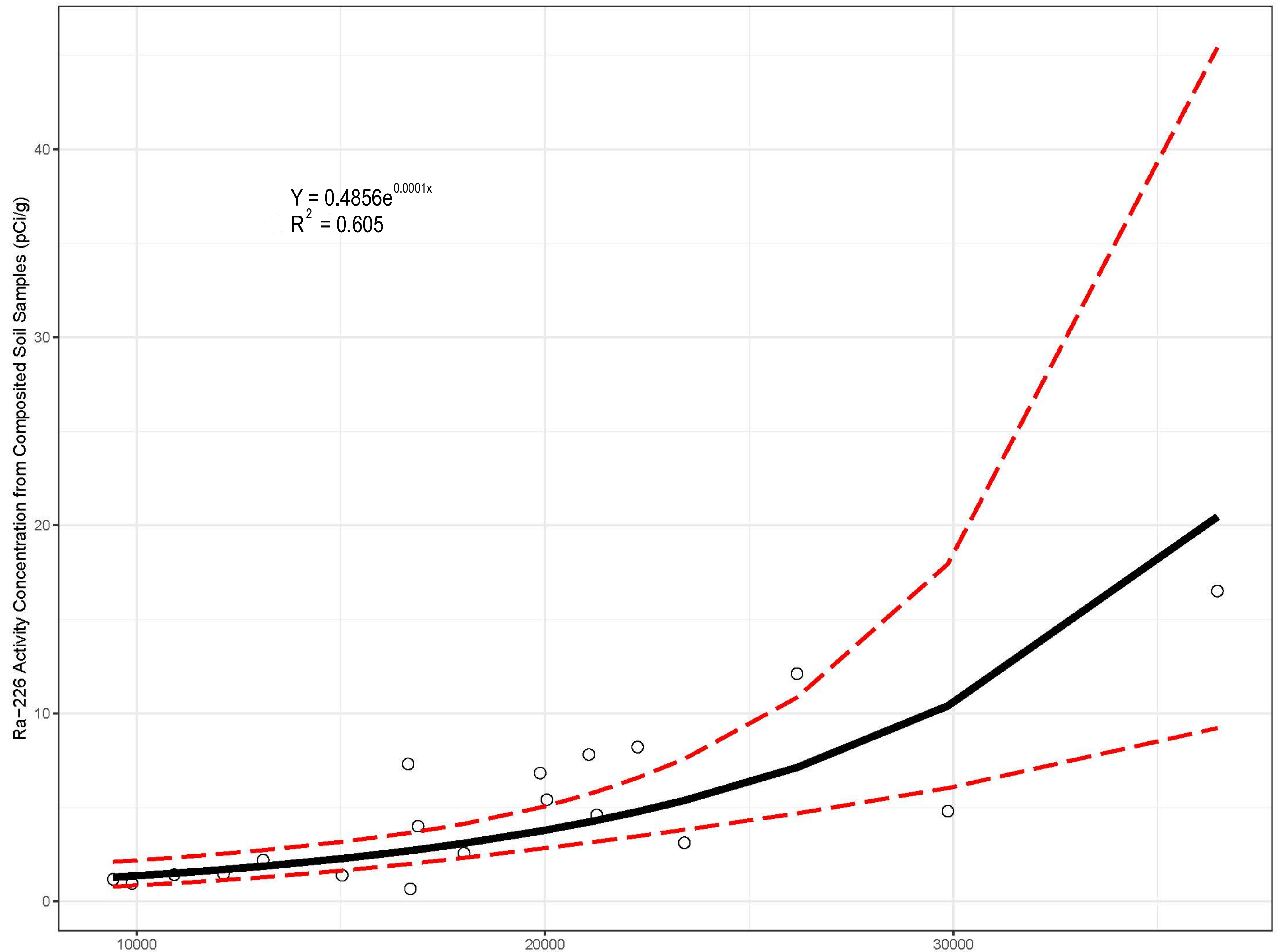
0 1,250 2,500 5,000
Feet
1:30,000 1 inch = 2,500 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 4-4. Correlation Plot Map
Cove Mine Area
Removal Site Evaluation Report

JACOBS

SLC Y:\MAPFILES\SITESPECIFIC\COVE\RSE_REPORT_FIGURES\FIGURE_4-4_COVE_CORRELATION_PLOTS_MAP.MXD CPOITRAS 5/6/2020 10:46:08



LEGEND

Sample Location

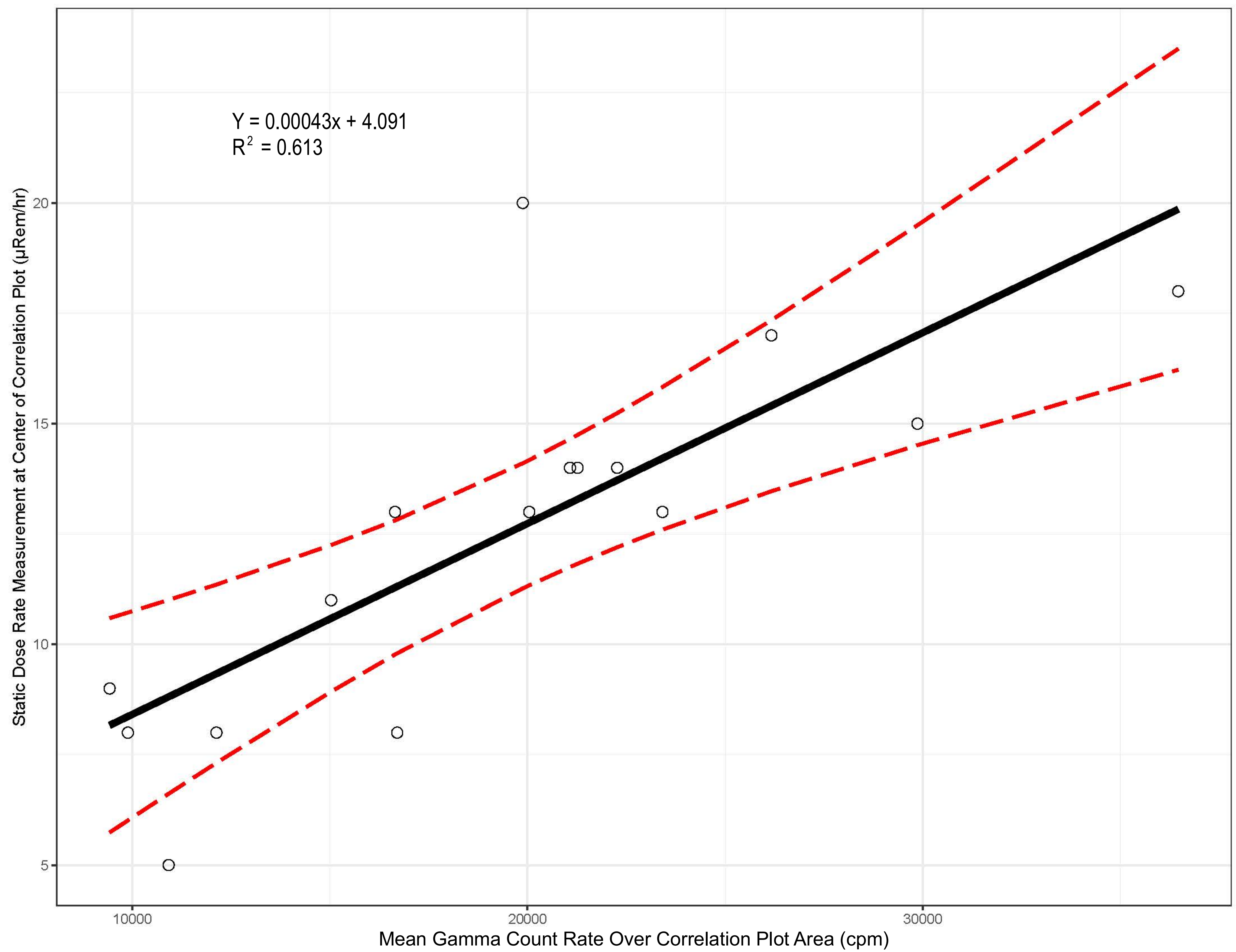
Predicted pCi/g

95% Confidence interval

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

Figure 4-5. Correlation of Mean Gamma Count Rate (cpm) to Ra-226 Soil Concentration (pCi/g)
Cove Mine Area
Removal Site Evaluation Report

JACOBS



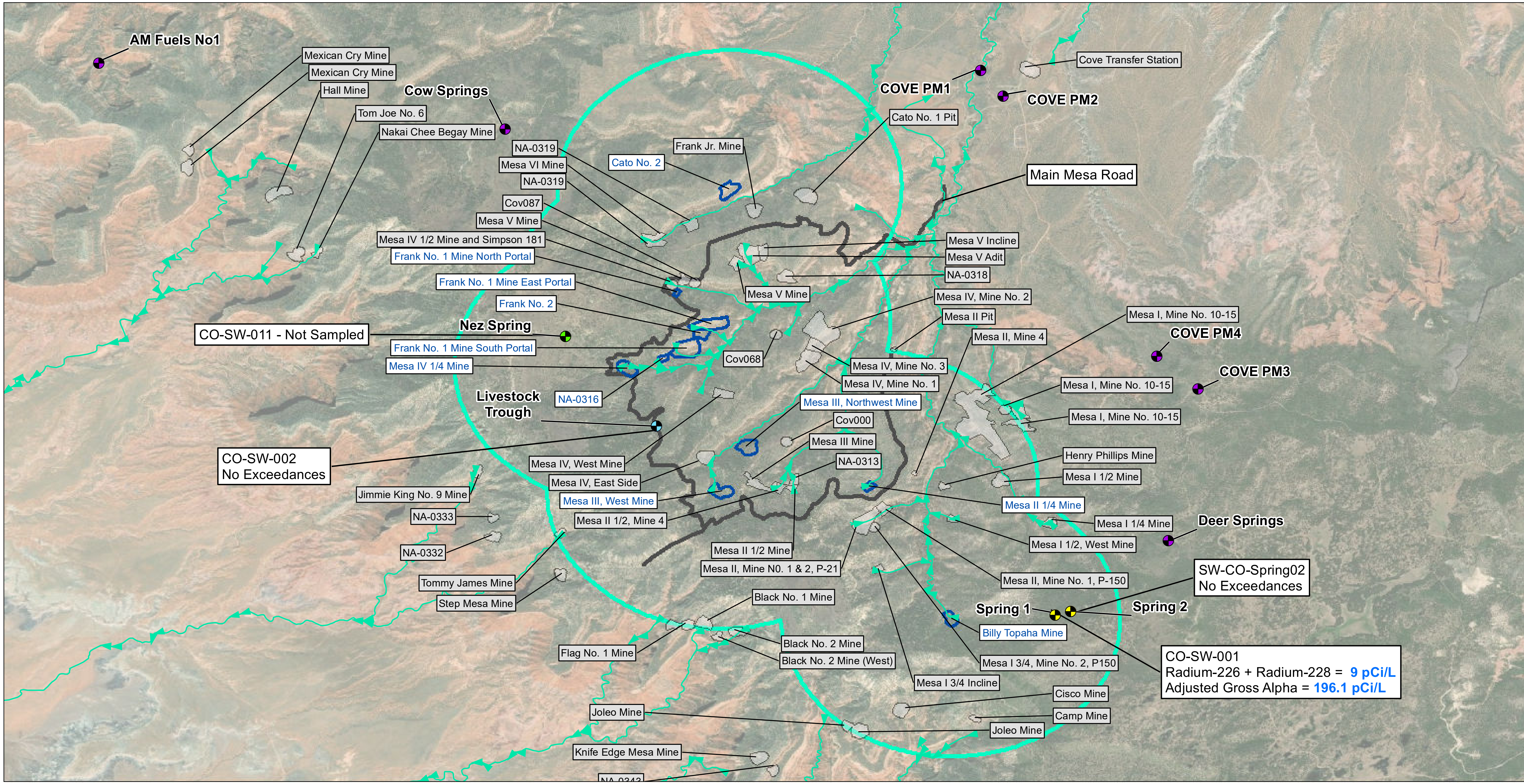
LEGEND

- ○ Sample Location
- —— Predicted pCi/g
- – – 95% Confidence interval

Notes:
1. The Bicron MicroREM instrument used for dose rate measurements does not have the resolution required for measurements at low dose rate conditions (less than approximately 15 µRem/hr) and requires reliance on analog interpretation by the field operator. This instrument is appropriate only for its intended use as a health and safety tool.
cpm = counts per minute
µRem/hr = microrem per hour
Ra = Radium

Figure 4-6. Correlation of Mean Gamma Count Rate (cpm) to Dose Rate (µRem/hr)
Cove Mine Area
Removal Site Evaluation Report

JACOBS



LEGEND

- NDWR Well Database Location Meeting RSE Work Plan Sampling Criteria- Sampled
- Water Sampling Location Meeting RSE Work Plan Sampling Criteria- Sampled
- NDWR Well Database Location Meeting RSE Work Plan Sampling Criteria- Not Sampled
- NDWR Well Database Location Not Meeting RSE Work Plan Sampling Criteria
- Group One Mine Boundary
- Non-Consent Decree Mine Boundary
- 1-mile radius around Mine Site
- Drainage from EPA Database
- Main Mesa Road

Notes:
1. Drainages are based on the EPA database (U.S. EPA Atlas with Geospatial Data 2007) and were not located
2. Water wells and surface water features meeting the RSE Work Plan sampling criteria (CH2M, 2017) are shown in blue and green, and sampling was attempted. Water wells and surface water features not meeting the sampling criteria were not sampled and are shown in purple.
3. Blue and Bold values exceed the surface water screening criteria. Table 5-1
CH2M = CH2M HILL Engineers, Inc.
EPA = Environmental Protection Agency
NDWR = Navajo Nation Department of Water Resources
pCi/L = picocuries per liter
RSE = removal site evaluation

Sources:
1. Navajo Nation Department of Water Resources Water Management Branch Well Database. Accessed online August 2017.
2. CH2M, 2017. *Removal Site Evaluation Work Plan for Consent Decree Sites*. October.
3. EPA drainage database file was provided by the EPA on June 29th, 2018.

N
0 2,000 4,000 8,000
Feet
1:48,000
1 inch = 4,000 feet

Figure 5-1. Water Well and Surface Water Results Map
Cove Mine Area
Removal Site Evaluation Report

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Topographic map: ESRI ArcGIS online

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SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\COVE\RSE_REPORT_FIGURES\FIGURE_5-1_WATER_WELL_AND_SURFACE_WATER_RESULTS_MAP.MXD TARROWOO 7/6/2022 17:56:33