Climax Transfer Station

Removal Site Evaluation Report

Final

July 2022

Cyprus Amax Minerals Company

Certification Page

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Jennifer Laggan

Cyprus Amax Minerals Company

Executive Summary

Introduction

The United States of America (U.S.) and the Navajo Nation entered into a Consent Decree (CD) with Cyprus Amax Minerals Company (Cyprus Amax)[1] 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 summarizes the results of investigations conducted to characterize chemical and radiological conditions at the Climax Transfer Station (Transfer Station). Site characterization data collected at the Transfer Station will be used to determine the volume of material impacted by ore-transfer activities, including technologically enhanced naturally occurring radioactive material (TENORM) in excess of the Investigation Levels (ILs) resulting from historical activities related to temporary storage of ore. 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, remedy evaluation through an engineering evaluation/cost analysis (EE/CA), or remedy implementation, is required.

Climax Transfer Station

The Transfer Station is located in the Shiprock Chapter of the Navajo Nation on Tribal Trust Land approximately 3 miles south of the Shiprock Chapter house, along U.S. Route 491 (Figure ES-1). The Transfer Station consists of 2.1 acres, plus a 100-foot-wide buffer around the boundary, for a total of 5.7 acres. The Transfer Station is located within Shiprock Chapter's commercial right-of-way along U.S. Route 491. Access to the Group 1 Mine Sites was submitted to U.S. EPA on September 5, 2017, and at that time, there were no individual members of Shiprock Chapter who have grazing permits or homesite leases where the Transfer Station is located (Brown 2017).

The Transfer Station was identified by U.S. EPA as one of 46 "Priority" abandoned uranium mine sites, as described in Section 1 of this RSE Report. The Transfer Station was identified as a priority Mine Site because of its proximity to potentially inhabited structures and gamma screening measurements that were elevated above background, as identified by U.S. EPA (U.S. EPA 2014). The Transfer Station is one of 94 Mine Sites identified in the CD (the Mine Sites), but it was not a mine. The Transfer Station was a location used to temporarily store ore before it was loaded and hauled to a mill for purchase and processing. No milling or processing of ore occurred on the Transfer Station.

In 2008, as part of the Morrison 1 contract, the Navajo Abandoned Mine Lands (NAML) Program removed 600 cubic yards of Class B material (soil having concentrations between 2 and 25 picocuries per gram [pCi/g] radium-226 [Ra-226]) and Class C material (soil having a concentration greater than 25 pCi/g Ra-226) from the Transfer Station and backfilled the area with locally sourced Class A material (less than 2 pCi/g Ra-226) (NAMLRP 2008, 2009). The removal area was approximately 0.5 acre and centered within the Transfer Station. NAML advised Cyprus Amax that the material was removed to the Vanadium Corporation of America Plot 3 Mine Site (NA-0806) in the Red Valley Area where it was consolidated, buried, and capped (NAMLRP 2018). A detailed summary of the NAML removal is presented in Appendix A.

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

Removal Site Evaluation Investigation (2017 to 2019)

Between September 2017 and September 2019, Jacobs[2] conducted field activities in accordance with the CD, the approved RSE Work Plan (CH2M 2017), and the approved RSE Work Plan Addendum (CH2M 2018), the latter two of which are collectively referred to hereafter as the Work Plans. Through this investigation, the following information was developed to assist in evaluating data quality objectives (DQOs):

1) Determine representative background threshold values (BTV) for the Transfer Station. (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 using site characterization data, including gamma count rate from walkover gamma scanning and from surface and subsurface soil and sediment sampling.
3) Statistically evaluate the relationship between concentrations of Ra-226 in surface soil and gamma count rates, as well as gamma count rates and dose rates.
4) Investigate whether ore-transfer activities, machine maintenance and refueling, and use of electrical equipment resulted in releases of petroleum hydrocarbons, or polychlorinated biphenyls (PCBs). Explosives, including perchlorate, were not analyzed as a secondary COPCs, because the Transfer Station was an ore-transfer station, and no blasting occurred at the Transfer Station.
5) Identify whether there is evidence that surface water or groundwater at the Transfer Station, if present and able to be sampled, have been impacted by ore-transfer-related activities.
6) Estimate the lateral and vertical extent of TENORM at the Transfer Station, including surface soil, subsurface soil, and sediment.

Findings and Discussion

Jacobs conducted field activities between September 2017 and September 2019 to address the DQOs (CH2M 2017, 2018; Jacobs 2019) and evaluate the extent of impacted material from ore-transfer activities, including TENORM and naturally occurring radioactive material (NORM) at the Transfer Station. The findings of the RSE are as follows:

1) DQO 1 was attained.
   - One background reference area (BRA) was selected based on the one predominant surficial geologic formation (Mancos Shale) at the Transfer Station. BTVs were calculated for gamma count rate and analytical concentrations for the primary COPCs at the BRA. BTVs, in addition to U.S. EPA Regional Screening Levels (RSL), if available, were used to derive ILs, which informed the evaluation of subsequent DQOs.
2) DQO 2 was attained with data gaps.
   - The type and extent of affected environmental media have been defined through gamma radiation survey, surface and subsurface soil sampling, and sediment sampling. Soil sampling was restricted along U.S. Route 491 and the gas line right-of-way running parallel to the highway.
3) DQO 3 was attained with data gaps.
   - The data were collected according to the Work Plan to determine whether a correlation existed between gamma count rate (counts per minute [cpm]) and Ra-226 surface soil concentrations (in picocuries per gram). The correlation was able to achieve the statistical performance criteria and

[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 RSE work, and Jacobs prepared this RSE Report. Jacobs and CH2M are referred to collectively as Jacobs.

model validation and is considered usable for estimating lateral extent of Ra-226 soil concentrations during an EE/CA.

   – The 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). Validation models indicate that predicted values consistently underestimate actual 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 the Group 2 Mine Sites.

4) DQO 4 was attained.

   – Data were collected in accordance with the Work Plan to evaluate whether ore-transfer activities released secondary COPCs into the environment. Transfer Station soil sampling data indicated that the secondary COPCs were below the ILs.

5) DQO 5 was attained.

   – During the RSE investigation, a review of available sources, including the U.S. Department of Energy database (DOE 2019a), identified four water wells within 1 mile of the Transfer Station. The four wells had insufficient water volume for sample collection. The DOE confirmed on June 8, 2021, by email that no historical groundwater samples had been collected from these wells, most likely because the wells were dry. No other ephemeral springs, streams, or ponds containing sampleable water were identified within a 1-mile radius of the Transfer Station; therefore, no water samples were collected.

6) DQO 6 was attained.

   – The volume of materials impacted by ore-transfer activities, including TENORM in excess of the ILs, was estimated to be 10,700 cubic yards.

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Acronyms and Abbreviations

°F	degree(s) Fahrenheit
µR/hr	microroentgen per hour
µrem/hr	microrem per hour
ANSI	American National Standards Institute
AUM	Abandoned Uranium Mine
bgs	below ground surface
BRA	background reference area
BTV	background threshold values
CD	Consent Decree
CERCLA	*Comprehensive Environmental Response Compensation and Liability Act of 1980*
CH2M	CH2M HILL Engineers, Inc.
COPC	contaminant of potential concern
cpm	counts per minute
Cyprus Amax	Cyprus Amax Minerals Company
DCRM	Dinétahdóó Cultural Resources Management
DOE	U.S. Department of Energy
DQO	data quality objective
DRO	diesel range organics
EE/CA	Engineering Evaluation Cost Analysis
ERG	Environmental Restoration Group
FESA	Federal Endangered Species Act
GIS	Geographic Information System
GPS	Global Positioning System
IL	investigation level
Jacobs	Jacobs Engineering Group Inc.
MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*
MBTA	Migratory Bird Treaty Act
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
mg/kg	milligram per kilogram
MSE	mean squared error
NaI	sodium iodide
NAML	Navajo Abandoned Mine Lands
NAMLRP	Navajo Abandoned Mine Lands Reclamation Program
NDWR	Navajo Nation Department of Water Resources

NESL	Navajo Endangered Species List
NNDFW	Navajo Nation Department of Fish and Wildlife
NNDOJ	Navajo Nation Department of Justice
NNEPA	Navajo Nation Environmental Protection Agency
NNHP	Navajo Natural Heritage Program
NNHPD	Navajo Nation Historic Preservation Department
No.	number
NORM	naturally occurring radioactive material
NTUA	Navajo Tribal Utility Authority
PCB	polychlorinated biphenyl
pCi/g	picocuries per gram
p-value	probability value
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
Ra-226	radium-226
ROW	right-of-way
RSE	Removal Site Evaluation
RSL	Regional Screening Level
SD	sediment
SOP	standard operating procedure
SOW	Statement of Work
SS	surface soil
TENORM	technologically enhanced naturally occurring radioactive materials
TPH	total petroleum hydrocarbons
Transfer Station	Climax Transfer Station
U.S. EPA	U.S. Environmental Protection Agency
USCS	Unified Soil Classification System
USGS	U.S. Geological Survey
USL	upper simultaneous limits
UTL	upper tolerance limits
VCA	Vanadium Corporation of America
Weston	Weston Solutions, Inc.
WRCC	Western Regional Climate Center
yd^3	cubic yard

1. Introduction

This Removal Site Evaluation (RSE) Report describes the activities and results of investigations to characterize chemical and radiological conditions at the Climax Transfer Station (Transfer Station). Jacobs Engineering Group Inc. (Jacobs)[1] performed the activities for Cyprus Amax Minerals Company (Cyprus Amax)[2] in accordance with the Consent Decree (CD) (United States of America and the Navajo Nation 2017) entered into by the United States of America (United States), Navajo Nation, Cyprus Amax, and Western Nuclear, Inc., with an effective date of May 22, 2017. Jacobs performed fieldwork according to the CD, the approved RSE Work Plan (CH2M 2017), and the approved RSE Work Plan Addendum (CH2M 2018), the latter two of 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), and May 31, 2018 (RSE Work Plan Addendum), before commencement of the RSE field activities. This RSE 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. Environmental Protection Agency (U.S. EPA) may determine that additional work, such as interim removal actions, risk assessment, remedy evaluation through an engineering evaluation/cost analysis (EE/CA), or remedy implementation, is required.

Consistent with the CD and discussions during the first (February 14, 2017) priority settings meeting, the Mine Sites listed in Attachment A of the Scope of Work (SOW) were divided into three groups for the purpose of conducting investigations (RSEs). Group 1 Mine Sites included 31 of the 94 Group 1 Mine Sites divided as follows: Climax Transfer Station (1 Transfer Station), Cove (9 Mine Sites), Tse Tah (18 Mine Sites), Monument No. 2 (1 Mine Site), Rock Door No. 1 (1 Mine Site), and Firelight No. 6 (1 Mine Site). During the 2020 Site Management Plan process, it was agreed that the King Tutt Point Mine Site (originally included as a Group 1 Mine Site) be moved to Group 2. Therefore, the RSE results for King Tutt Point Mine (1 Mine Site) will be combined with the RSE results for the remaining Group 2 Mine Sites.

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 1-1. 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 engineering evaluation/cost analysis (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 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 (Figure 1-2), 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

[1] 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.”

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

results (sihasin) (Figure 1-2)[3]. The stages of the Diné problem-solving process flows in an ongoing, circular clockwise direction (Sha Bikehgo) that begins in the east and moves through to the south, west, and north. Diné problem solving is ongoing with the application of mutual cooperation and kinship. The activities and results of the investigation to characterize chemical and radiological conditions at the Transfer Station, 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) prior to any necessary remedial or removal action for the Transfer Station.

The Transfer Station is located within the Shiprock Chapter of the Navajo Nation (Figure 1-3). This RSE Report describes activities performed and summarizes the results of the RSE investigation conducted to characterize chemical and radiological conditions at the Transfer Station. The Transfer Station was identified by U.S. EPA as a Priority Abandoned Uranium Mine Site (Priority Mine Site) located within the Navajo Nation. Priority designation was given because the Transfer Station is located near a potentially inhabited structure, and gamma screening measurements were elevated above background levels identified by U.S. EPA (U.S. EPA 2014). The Transfer Station area includes the site boundary from the U.S. EPA Atlas plus a 100-foot buffer surrounding the boundary to investigate areas offsite that could contain site-related contaminants. A 1-mile radius around the Transfer Station was considered for the evaluation of groundwater and surface water (Figure 1-4).

1.1 Objectives

The primary objective of completing the RSE at the Transfer Station was to provide data required to evaluate the site conditions and to estimate the volume and area of materials impacted by transfer activities, including technologically enhanced naturally occurring radioactive material (TENORM) above the established investigation levels (ILs). This RSE Report was not intended to establish cleanup levels, which may result in different volumes of materials impacted by ore-transfer activities, including TENORM, requiring remediation, or evaluate future potential remedies.

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 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.

To be called TENORM, U.S. EPA’s definition does not require a material’s radiological concentrations or properties to have actually been increased by human activity; 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

[3] The decision process uses the “traditional characteristics of each of the Four Directions: nitahakees, for intuition, discovery, and thinking of the East (2 N.N.C§110[N]); nahat’a, or planning (2 N.N.C.§110 [M]), and nahat’a or naat’aahji, or the talk of planning, or the South to carefully examine and involve all interests and knowledge holders in the process; jina’ to implement thought and consensual plans actively and for good results in the West (2 N.N.C§110[G]); and sihasin, or reflection and reconsideration, to assess the result of thinking, talking, planning and doing, of the North (2 N.N.C§110[T]), naabik’yai [2 N.N.C§110(M)]” (Roux Associates, Inc. 2015).

language that more clearly describes these materials, such as residual ore and materials impacted by ore transfer activities on the Transfer Station, haul roads, and drainages, etc.

1.2 Overview

On behalf of Cyprus Amax, Jacobs initiated RSE activities at the Transfer Station, following previous investigations by U.S. EPA. Specifically, U.S. EPA contracted with Weston Solutions, Inc. (Weston) to complete a site screening investigation in 2010 that found gamma radiation was present at the Transfer Station at measurements greater than an average background established for the area (U.S. EPA 2010a). The U.S. EPA prepared a site-specific screening report for the Transfer Station; the report is summarized in Section 2.4 of this RSE Report.

To perform the RSE, Jacobs conducted RSE investigations in accordance with the CD and the Work Plans, which included the following activities:

- Cultural resource surveys
- Biological surveys
- Site mapping to digitize and georeference the Transfer Station features and physical attributes
- Review of historical documents pertaining to the Transfer Station
- Gamma scan surveys of surface soils and sediments to determine the extent of historical ore transfer activities
- Surface and subsurface soil and sediment sampling to determine the lateral and vertical extents of contaminants of potential concern (COPCs) related to ore transfer activities, including TENORM
- Sampling of surface water and water from existing water supply wells within 1 mile of the Transfer Station
- 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 extent of materials impacted by ore-transfer activities, including TENORM
- Conclusions that indicate whether historical activities at the Transfer Station have potentially impacted nearby surface water and groundwater

The RSE Work Plans (CH2M 2017, 2018) define “impacts” to the Transfer Station as exceedances of COPCs compared with 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 either natural conditions or related to historical ore-transfer activities. Therefore, a multiple-lines-of-evidence approach has been developed for the Transfer Station to evaluate materials impacted by ore-transfer activities, including the designation of NORM and TENORM.

The RSE Report is not intended to establish cleanup levels or evaluate remedial alternatives. Following approval of the RSE Report, additional work at the Transfer Station may be required, which may include conducting a risk assessment and potential evaluation of remedial alternatives through performance of an EE/CA. Site-specific cleanup levels will be calculated during the risk assessment in the EE/CA, and the volume of materials affected by ore-transfer activities, including TENORM, may change.

1.3 Project Management and Organization

The Work Plans describe management and organization of the Climax Transfer Station RSE (CH2M 2017, 2018). A brief synopsis of the project's management and organization is 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 1-1 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[4] (Earth and Sky) performed the biological monitoring; Ground Penetrating Radar Systems performed utility locate services; Cascade Drilling provided subsurface drilling services; and ALS Environmental Laboratory in Fort Collins, Colorado, provided analytical laboratory services.

U.S. EPA Region 9 Remedial Project Managers were Ms. Linda Reeves through July 2021, and Mr. Kenyon Larsen through the date of this report. The NNEPA Remedial Project Managers were Mr. Binod Chaudhary through April 2019, Ms. Valinda Shirley through January 2020, Ms. Tennille Denetdeel through February 2022, and Ms. Dawn Begay through the date of this RSE Report.

1.4 Report Organization

This RSE Report documents the activities performed during the Transfer Station RSE. The Report is structured as follows:

- Section 1 summarizes the RSE investigation objectives, project management and organization, and report organization.
- Section 2 describes the Transfer Station, including operational and reclamation history, ownership, and land use, regional and site-specific geology, and hydrogeology, and summarizes the cultural and biological assessments.
- Section 3 summarizes RSE methodology.
- Section 4 includes results of RSE investigations, field activities, and radium-226 (Ra-226) correlation for surface soil.
- Section 5 provides the NORM and TENORM designations and area and volume estimate for materials impacted by ore-transfer activities, including TENORM.
- Section 6 summarizes the Transfer Station data quality objectives (DQOs), uncertainties, and data gaps.
- Section 7 provides an RSE investigation summary and conclusion.
- Section 8 provides references cited in this RSE Report.

[4] 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. Site Description and Background

2.1 Site Description

The Transfer Station is located in the Shiprock Chapter of the Navajo Nation, on Tribal Trust Land (Figure 1-3) and was identified by the U.S. EPA as a Priority Mine Site (U.S. EPA 2014). The Transfer Station was identified by the U.S. EPA as 1 of 46 Priority Mine Sites located within the Navajo Nation. As stated in Section 1 of this RSE Report, a designation of "Priority" is based on the Transfer Station's proximity to residences and gamma count rates elevated above an U.S. EPA-established background (U.S. EPA 2014).

The Transfer Station is located approximately 3 miles south of the Shiprock Chapter house, near U.S. Route 491 and U.S. Route 64. The Transfer Station is approximately 5,145 feet above mean sea level (amsl). The area of the Transfer Station given in the CD was 2.1 acres (United States of America and Navajo Nation 2017). Because of the potential for impacts beyond the Transfer Station boundary, a 100-foot-wide buffer was added to the boundary of the Transfer Station so that RSE investigations could delineate the potential extent of impacted environmental media related to historical ore-transfer activities. Therefore, the investigation area for the Transfer Station was approximately 5.7 acres, which included the inaccessible areas (Figure 2-1).

According to site visits, historical documentation, and information from the U.S. EPA Atlas (U.S. EPA 2007), there are three ephemeral drainages, four U.S. Department of Energy (DOE) wells within 1 mile, one former haul road, one access road, and an NAML excavation area at the Transfer Station (Figure 2-1).

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 94 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 (Appendix B).

As stated in Section VIII (Property Requirements) of the CD and Section 4 of the SOW, Cyprus Amax worked with local officials to obtain access agreements from grazing permit and homesite lease 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 Transfer Station (Appendix B).

The Shiprock Chapter of the Navajo Nation passed a resolution on November 20, 2016, to approve and support remediation of the Transfer Station as part of U.S. EPA and Navajo Nation comprehensive remediation efforts across the Navajo Nation (Appendix B).

2.3 Surrounding Land Use

The Transfer Station is located approximately 3 miles south of the Shiprock Chapter House within the Shiprock Chapter's commercial right-of-way (ROW) along U.S. Route 491; therefore, there are no individual members of the Shiprock Chapter who have grazing permits or homesite leases where the Climax Transfer Station is located. A fence is present along the western boundary of the Transfer Station that separates it from U.S. Route 491. A Navajo Tribal Utility Authority (NTUA) gas pipeline and 50-foot-wide ROW are located east of U.S. Route 491.

2.4 Historical Practices and Reclamation History

The Transfer Station provided a location to temporarily stockpile ore during the time period the Mine Sites were in operation (1950s and 1960s). Reportedly, ore from the Frank No. 1 Mine Site was stockpiled at the

Transfer Station prior to being transported to the Climax Uranium Mill in Grand Junction, Colorado (U.S. EPA 2007). No mining or processing of ore occurred at the Transfer Station.

From November through December 2008, Navajo Abandoned Mine Lands (NAML) performed reclamation activities at the Transfer Station under the Morrison 1 contract (NAMLRP 2008). NAML applied the site identification of NA-0829 to the Transfer Station. The removal area is shown on Figure 2-1, and further details regarding NAML's removal at the Transfer Station, including photographs, can be found in Appendix A. The work consisted of excavation and removal of approximately 600 cubic yards of Class B[7] and C material over an area of 0.5 acre near the center of the Transfer Station. Information regarding the depth to which NAML removed material is unknown; however, according to the information NAML did provide, Cyprus Amax estimates that material was removed to an average depth of approximately 0.75 foot. Actual excavation depths likely varied throughout the area. The removal area was capped with 25 cubic yards of Class A material (NAMLRP 2009). During an April 2018 site visit with Jacobs, NAML reported that the material was taken to Vanadium Corporation of America (VCA) Plot 3 (NA-0806), which is a Group 2 Mine Site covered by the CD in the Red Valley Area. NAML documented that the material was consolidated, buried, and capped on VCA Plot 3 Mine Site, as indicated in the Morrison 1 contract.

In 2010, U.S. EPA completed a site screening assessment of the Transfer Station (U.S. EPA 2010a). Weston conducted the site screening assessment on behalf of U.S. EPA and identified no observable mining or reclamation features present at the Transfer Station. Radiological measurements collected ranged from 10470 to 29170 counts per minute (cpm). Gamma count rates were elevated in the central portion of the Transfer Station as well as the northeastern and southeastern corners. U.S. EPA's assessment was completed after NAML performed reclamation activities. U.S. EPA indicated that the land where the Transfer Station is located is currently referred to locally as the "Proposed Fairgrounds" and "Shiprock New Fairgrounds" (U.S. EPA 2010a).

2.5 Review of Historical Aerial Photographs

As part of the RSE for the Transfer Station, a review of historical aerial imagery from 1954, 1965, 1978, 1997, and 2019 was conducted (Figures 2-2a through 2-2e). These aerial photographs reveal the following:

- The 1954 aerial image (Figure 2-2a) shows no discernable site features; however, the image quality is poor. U.S. Route 491 and drainages leading northeast and southeast from the Transfer Station are visible.
- The 1965 aerial image (Figure 2-2b) is of poor quality; however, Haul Road 1 is visible and bisects the Transfer Station.
- Because of the poor image quality of the 1978 aerial image (Figure 2-2c), no discernable site features can be observed except for U.S. Route 491.
- The 1997 and 2019 historical aerial images (Figure 2-2d and Figure 2-2e) show increased development near the Transfer Station. Specifically, U.S. Route 491 has been widened and the ROW for a gas line running parallel to the east of U.S. Route 491 is observed. In addition, buildings are apparent approximately to the north and west of the Transfer Station in 1997, and more development is apparent in the 2019 aerial image. Access Road 1 is visible traversing north from the Transfer Station.

2.6 Physical Setting

2.6.1 Regional and Site-specific Physiography

The Transfer Station is located within the Colorado Plateau physiographic province, which is an area of approximately 240,000 square miles in the Four Corners region of Utah, Colorado, Arizona, and New Mexico.

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[7] NAML had three different classifications of soil that were used during the reclamation process. Class A material was defined as having concentrations less than 2 picocuries per gram (pCi/g) radium-226 (Ra-226), Class B was defined as having concentrations between 2 pCi/g and 25 pCi/g Ra-226, and Class C material was defined as soil having a concentration greater than 25 pCi/g Ra-226 (NAML 2013).

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 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.

The San Juan River is located approximately 2 miles to the north of the Transfer Station. Land cover at the Transfer Station is relatively bare ground (weathered Mancos Shale) with sparse vegetation, which offers little break from the prevailing western winds (Figure 2-3).

Three incised drainages ranging up to approximately 6 feet deep transect the Transfer Station, providing contrasting topography to the otherwise flat terrain. The elevation of the Transfer Station is approximately 5,145 feet amsl with less than approximately 5 feet of elevation change across the Transfer Station (excluding the topographic relief from the locally incised drainages). The elevation of the BRA is approximately 5,151 feet amsl, with less than approximately 5 feet of elevation change. The Transfer Station and BRA have minor variations in surface topography, as shown in the topographic map presented on Figure 2-4.

2.6.2 Geologic Conditions

2.6.2.1 Regional Geology and Stratigraphy

The Transfer Station is located in the San Juan Basin, which is part of the Colorado Plateau and the dominant geologic feature in the northwestern part of New Mexico (Robertson et al. 2016). The San Juan Basin is a northwest-trending, asymmetric structural depression with an area of about 21,600 square miles at the eastern edge of the Colorado Plateau (Robertson et al. 2016). The basin formed during the Laramide orogeny in the Late Cretaceous to Early Tertiary periods and contains a thick sequence (more than 2.5 miles thick) of nearly horizontal sedimentary Paleozoic, Mesozoic, and Cenozoic rocks overlying a Precambrian basement complex (Robertson et al. 2016). The basin is bounded by the San Juan uplift, La Plata Mountains, and Sleeping Ute Mountain to the north; the Carrizo and Chuska Mountains and Defiance uplift to the west; the Zuni uplift to the south; the Lucero uplift and Ignacio monocline to the southeast; and the Nacimiento uplift and the Gallina-Archuleta arch to the east (Robertson et al. 2016).

The sedimentary strata of the San Juan Basin dip slightly down toward the center of the basin from the surrounding highlands. A stratigraphic column of the geologic units is presented on Figure 2-5. Older sedimentary and Precambrian rocks (1,500 to 1,750 million years old) are exposed in the uplifts on the outer boundary of the basin (Robertson et al. 2016; Brister and Hoffman 2002). Above the Precambrian rocks are the rocks of the lower Paleozoic. The rocks of the Triassic period (primarily the Chinle Group), overlying the Permian strata, were formed from deposits in various continental and fluvial environments and consist of variegated claystone and shale, siltstone, conglomerate, and limestone. Following deposition of Triassic sediments, erosion resulted in a widespread unconformity between the Triassic and Jurassic rocks. The lowermost Jurassic rocks, primarily the Entrada Sandstone, are sandstones that originated as dune fields. Uplift and volcanic activity to the southwest coincided with the deposition of the middle and upper Jurassic Morrison Formation. The Morrison Formation depositional environment was a vast plain with a variety of fluvial and lacustrine environments with evidence of volcanic debris. The Dakota Sandstone unconformably overlies the Morrison Formation throughout much of the basin and ranges from zero to about 500 feet thick, with 200 to 300 feet being the most common (Dam 1995). The Dakota Sandstone is conformably overlain by the Mancos Shale. The Mancos Shale was deposited during the Late Cretaceous (about 95 to 65 million years ago), when the western United States was dissected by the large Cretaceous Interior Seaway with a moving shoreline that deposited about 6,500 feet of marine, coastal plain, and nonmarine sediments, including shales, mudstones, limestones, sandstones, coal, and conglomerates (Robertson et al. 2016). The upper Cretaceous and Tertiary layers are absent in this part of the basin because of uplift and erosion (Robertson et al. 2016). The Mancos Shale is widely distributed throughout northwestern New Mexico, western Colorado, and eastern Utah.

The Mancos Shale has been documented as a natural source for uranium in the area (Robertson et al. 2016). The uranium is primarily from ash-fall deposits that fell into the Cretaceous Sea from regional volcanism. In a study of 16 sites in Colorado, Utah, Arizona, and New Mexico, the average uranium concentration in 102 samples of Mancos Shale was 3.7 milligrams per kilogram (mg/kg) and ranged from 0.9 to 12 mg/kg; 70% of the values were between 2 and 4 mg/kg. Of the 102 samples, 10 samples were collected 14 miles west of Shiprock, New Mexico; the average uranium concentration in these samples was 3.9 mg/kg and ranged from 1.5 to 5.5 mg/kg (Robertson et al. 2016). It is important to note that Ra-226 is a decay product of uranium and is therefore likely to be co-located throughout the Mancos Shale. In another study, average concentrations of thorium and uranium found in the Mancos shale were determined to be 10.2 and 3.7 mg/kg, respectively; the study also found that the concentrations of thorium decrease as uranium increases with distance from the upper Cretaceous shoreline. Laboratory studies found that uranium is present in the fine-grained primary reinstate minerals, and thorium occurs in fine-grained secondary resistate or fixed on clays (Pliler and Adams 1962).

2.6.2.2 Site-specific Geology and Stratigraphy

No site-specific stratigraphic information is available for the Transfer Station. However, approximately 2 miles north of the Transfer Station is the Shiprock Disposal Site (Figure 1-4), which is not associated with the Transfer Station. The Shiprock Disposal Site is managed by the DOE through the Uranium Mill Tailings Remedial Action Project (DOE 2019b). The stratigraphy underlying the Shiprock Disposal Site has been well-studied and is likely correlative to the stratigraphy underlying the Transfer Station based on close proximity. A lithologic log for an artesian well (Well 12T-520 shown on Figure 1-4), located just west of the Shiprock Disposal Site, records the area Site stratigraphy (Robertson et al. 2016; NDWR 2017). The well is completed as an open hole from 1,482 to 1,777 feet below ground surface (bgs). According to the lithologic log, there are 30 feet of alluvium (primarily weathered Mancos Shale) overlying 218 feet of the upper Mancos Shale. The upper Mancos Shale is underlain by 82 feet of Gallup Sandstone (intertongues with the Mancos Shale [Dam 1995]), which is underlain by 685 feet of the lower Mancos Shale. In total, approximately 900 feet of the Mancos Shale underlies the Shiprock Disposal Site (Robertson et al. 2016), and it is generally light gray to dark gray and calcareous throughout. Thin claystone layers (up to several inches thick) are common and are dark gray; they swell when brought to the surface and are considered excellent aquicludes (confining units) (Robertson et al. 2016). Underlying the Mancos Shale are 165 feet of Dakota Sandstone followed by the Morrison Formation from 1,180 to 1,760 feet bgs. The lithologic log identifies that the well has a total depth of 1,777 feet bgs; however, there is no information on the geology present for the deepest 17 feet bgs of the well.

According to observations made during RSE field work, the surficial geology underlying the Transfer Station is the Mancos Shale. It generally consists of organic-carbon and sulfide-enriched clayey to sandy to calcareous silt-shale with minor limestone, marlstone, bentonite, concretions, and sandstone (Robertson et al. 2016).

2.6.2.3 Regional and Site-specific Climate

Climate data for the Transfer Station were available from a weather station near Shiprock, New Mexico (WRCC 2019). Temperatures peak in July and trough in January. The maximum July temperature averages 94.6 degrees Fahrenheit (°F), whereas the minimum January temperature averages 15.7°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 varies by location, season, and elevation. A wind rose from Shiprock, New Mexico, showing the number of hours per year the wind blows from a specific direction, is shown on Figure 1-4 (Meteoblue 2019); the predominant wind direction is from west to east, consistent with field observations of wind direction at the Transfer Station. Although wind rose data indicate that westerly winds blow stronger than the east-northeasterly winds, winds from the east-northeast persist for a similar duration of the year. High wind is present seasonally, with sustained wind speeds potentially reaching more than 40 miles per hour.

A detailed literature review of studies characterizing deposition of windblown dust in arid regions of the southwestern United States indicate the extent to which observed downwind impacts of windblown dust can be affected by local topography, vegetation, and prevailing wind speeds and directions. Maximum coarse particle size deposition is mainly constrained to immediate tailings area because of the large size and fast settling times. Fine particles have smaller terminal velocity and are transported farther away and downwind. Particles 3 micrometers in size have a maximum deposition of approximately 300 meters from tailings, and smaller particles may travel farther. More importantly, there are slight variations in deposition patterns caused by the topography of the area (Stoven 2016).

Precipitation is seasonally variable, with an average annual precipitation of 7 inches, including rain and water-equivalent snow (WRCC 2019). Annual precipitation is greatest from July through September during the summer monsoon season. The average annual pan evaporation rate from 1926 to 2005 is 73.16 inches, as recorded at the Shiprock, New Mexico, weather station, located approximately 3 miles north of the Transfer Station (WRCC 2021). The highest average monthly rainfall occurs in August, with 1.01 inches and a pan evaporation rate of 10.80 inches (WRCC 2021).

2.6.3 Regional Hydrogeology and Hydrology

The major aquifers underlying this area are found in the Dakota Sandstone, the Morrison Formation, the Entrada Sandstone, and the San Andres and Glorieta Formations (Robertson et al. 2016; Dam 1995). The artesian well (Well 12T-520), located just west of the Shiprock Disposal Site (Figure 1-4), is screened in the Morrison Formation and produces free-flowing water at approximately 60 gallons per minute (Robertson et al. 2016). Thick shale beds of the Cretaceous and Triassic periods act as confining layers between these aquifers.

Vertical leakage between aquifers is thought to occur, but the magnitude is considered small (Dam 1995). Recharge to these regional aquifers occurs along the outcrops that form the structural boundaries of the San Juan Basin, and the general flow directions from these recharge points are to the San Juan River (Dam 1995). Water enters the groundwater system from precipitation on aquifer outcrops and from stream-channel loss as streams cross the outcrops (Robertson et al. 2016). The Mancos Shale is not generally considered an aquifer, because of its low hydraulic conductivity. The Mancos Shale is an aquiclude restricting the vertical flow of water to deeper geologic units. Waters associated with the Mancos Shale are typically described as occurring in an adjacent aquifer and infiltrating into the formation to a discrete depth (Robertson et al. 2016).

The Transfer Station is located in the Middle San Juan Watershed, located in southwestern Colorado, northwestern New Mexico, and northeastern Arizona, in the Four Corners Region. The Lukachukai and Chuska Mountains, along with most of the watershed, are formed by Cretaceous and Tertiary period sandstones, coal, mudstone, and shales, The National Hydrography Dataset identifies 5,596 miles of watercourse through the Middle San Juan River Watershed, the majority of which flow intermittently in summer months in periods of intense thunderstorms (USDS 2002).

2.6.4 Site-specific Hydrogeology and Hydrology

Surface drainage from the Transfer Station and surrounding area occurs through overland flow into incised drainage channels that flow eastward toward a network of dry arroyos. These arroyos converge outside the boundaries of the Transfer Station and flow into Many Devils Wash approximately 1 mile east of the Transfer Station (Figure 1-4). Many Devils Wash drains into the San Juan River, approximately 2 miles northeast of the Transfer Station. Surface flow in the Transfer Station drainage channels occurs intermittently, specifically during and after high rainfall and snowmelt events.

Jacobs evaluated three ephemeral drainages that convey runoff from the Transfer Station and are labeled Drainage 1, 2, and 3 (Figure 2-1). Drainage 1 originates in the center of the Transfer Station, continues to the northern portion of the Transfer Station, and conveys runoff to the northeast for 0.16 mile until it converges with Drainage 2. Drainage 2 begins in the center of the Transfer Station, continues to the northeastern corner of the Transfer Station, and also flows to the northeast. Drainage 3, in the southeastern corner of the Transfer

Station, begins in the center of the Transfer Station and conveys flow to the southeast. Approximately 1 mile from the eastern boundary of the Transfer Station, Drainage 2 and Drainage 3 converge into Many Devils Wash. Many Devils Wash flows to the north for approximately 1.25 miles from where Drainage 1 and 3 enter until it drains into the San Juan River. No water was observed flowing in the drainages at the Transfer Station during RSE activities. It is expected that water would only flow within the drainages during intense rainstorms.

Several databases were reviewed to identify groundwater sampling locations, including the *Navajo Nation Department of Water Resources Database* (NDWR 2017), the *Abandoned Uranium Mines and the Navajo Nation, Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data* (U.S. EPA 2007), and the *U.S. DOE Legacy Management Geospatial Environmental Mapping System* (GEMS) (DOE 2019a). No groundwater sampling locations were identified within the boundaries of the Transfer Station. From the GEMS database, four water wells were identified in Many Devils Wash, approximately 1 mile east of the Transfer Station boundary (DOE 2019a). Well identifications for these four wells are SHP02-1159, SHP02-1158, SHP02-1157, and SHP02-1156 (Figure 1-4). According to the well logs, the four wells are screened in alluvial sediments, with the borings terminating at the top of the Mancos Shale. The well screen intervals are 26.2 to 31.2 feet bgs for SHP02-1156, 26.7 to 31.7 feet bgs for SHP02-1157, 19.5 to 24.5 feet bgs for SHP02-1158, and 20.2 to 25.2 feet bgs for SHP02-1159 (Appendix C).

2.7 Biological and Cultural Assessments

This RSE Report seeks to consider the Fundamental Laws of the Diné 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 Transfer Station, 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.

2.7.1 Biological Assessment

Before beginning RSE fieldwork, Jacobs (on behalf of Cyprus Amax) consulted with NNDFW, which is responsible for stewardship of Navajo biological resources and heritage. NNDFW determined that the RSE sampling activities (hand tools, walking, and light-vehicle traffic) would have minimal disturbance. The activities were not considered development; therefore, NNDFW did not require formal consultation with a biological evaluation. Jacobs was required to obtain an annual biological investigation permit. The biological assessments conducted by Jacobs for the Climax Transfer Station and BRA were authorized by NNDFW under the following biological investigation permits and amendments (Appendix B):

1) Biological Investigation Permit Number 1095, issued June 16, 2017.
2) Amendment to Permit Number 1095, issued March 30, 2018, to add Dan Fillipi as a sub-permittee.
3) Biological Investigation Permit Number 1190, issued February 19, 2019.
4) Amendment to Permit Number 1190, issued September 9, 2019, to change permittee to Morgan King.
5) Biological Investigation Permit Number 1223 issued November 14, 2019.
6) Amendment to Permit Number 1223, issued February 7, 2020, to change name and title of principal from Stuart Brown to Jennifer Laggan.
7) Biological Investigation Permit Number 02172021 issued February 17, 2021. According to Jeff Cole, the permit number is the issue date.
8) Biological Investigation Permit Number 12312021 issued December 31, 2021.

In accordance with the conditions of the biological investigation permit, biologists conducted a Navajo Natural Heritage Program (NNHP) resource review to identify special-status plant and wildlife species potentially present at the Transfer Station. 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 (NESL), and those species protected under the *Migratory Bird Treaty Act* (MBTA). The 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).

Prior to conducting RSE fieldwork, Jacobs and Earth and Sky biologists conducted pedestrian biological assessments of the Transfer Station and BRA with a focus on identifying potentially suitable habitat for special-status plant and wildlife species within the area. Surveys and biological monitoring of the Transfer Station and BRA were conducted in September and October 2017, April 2018, and September through November 2019. The results of the biological assessment are presented in Appendix B.

Observations made by the biologists during the biological investigation of the Climax Transfer Station and BRA are summarized as follows:

1) Vegetation
   - Botanists observed one vegetation type at the Transfer Station and BRA: Great Basin Desert Scrub.
2) Special-status Wildlife
   - Four burrowing owls (*Athene cunicularia),* U.S. Fish and Wildlife Service – bird of conservation concern, burrows were observed outside the Transfer Station and BRA, two inactive and two active. The owls and burrows were not disturbed during RSE activities.
   - No other FESA or NNDFW special-status species were observed, but potentially suitable foraging or nesting and denning habitat is present for golden eagle (*Aquila chrysaetos*), ferruginous hawk (*Buteo regalis*), mountain plover (*Charadrius montanus*), and kit fox (*Vulpes macrotis*).
3) Special-status Plants
   - Mesa Verde cacti (*Sclerocactus mesae-verdae*), a federal threatened species and Navajo endangered species, were identified at the Transfer Station. Avoidance buffers for soil sampling of 20 feet stipulated from NNDFW were established around the locations, and the plants were not disturbed during RSE investigations. Potentially suitable habitat for Mesa Verde cactus was present at the BRA site, but no individuals were observed. After consultation with NNDFW, signs were installed in four locations around the Transfer Station to deter nearby residents from accessing the Transfer Station and disturbing the nearby protected Mesa Verde cacti and habitat.
   - No other FESA or NNDFW special-status plants or potentially suitable habitats are present at the Transfer Station.
4) MBTA Protected Species
   - No active nests protected by MBTA were observed in the Transfer Station or BRA during RSE activities.
   - Burrowing owls are an MBTA-protected species. Their presence at the Transfer Station and BRA is discussed previously in the special-status wildlife section.

2.7.2 Cultural Resources Assessment

Before performing RSE field activities, DCRM, with Jacobs' oversight, assessed cultural resources at the Transfer Station and the associated BRA. DCRM conducted the cultural resources investigation in compliance with Section 106 of the National Historic Preservation Act, Title 36 of the Code of Federal Regulations Part 800.

The cultural resources assessment included an archival literature search and interviews with local residents, workers, and Shiprock 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 Transfer Station. DCRM conducted a Class III intensive cultural resources survey under Navajo Antiquities Permit Number B17648 to identify prehistoric and historical cultural resources. Fieldwork for the surveys was conducted between September 16 and 19, 2017. A crew of qualified archaeologists performed the field surveys by walking parallel transects, spaced at a maximum of 50-foot intervals through the Transfer Station, the Transfer Station buffer, and an additional 50-foot-wide buffer area. The crew surveyed drainages and the access road by walking two parallel transects, spaced 50 feet apart. DCRM prepared an archaeological inventory report and submitted it to NNHPD (DCRM 2018). The report detailed the results of the literature review and field survey and indicated that eight isolated occurrences were present at the Transfer Station, none of which were likely to be associated with any nearby archaeological sites. The Cultural Resource Compliance Form is presented in Appendix B.

Ethnographic surveys conducted as a part of the cultural resources assessment revealed that the Transfer Station was in existence before the Shiprock Mill and there may have been truck scales and an assay shed located onsite; however, it is unclear whether interviewees were talking about the Climax Transfer Station or another buying station in Shiprock. Ore that was staged at the Transfer Station was shipped to Durango (DCRM 2018).

3. Field Activities and Methods

Jacobs performed an RSE at the Transfer Station to provide information to evaluate the DQOs that were developed using the processes described in U.S. EPA's DQOs process, according to *Guidance on Systematic Planning Using the Data Quality Objectives Process* (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 comprises 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 was presented 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 and outlines 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 Transfer Station.
   – To evaluate this DQO, Jacobs identified one BRA for the Transfer Station, conducted gamma scanning 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 typical background concentrations. 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 samples at the Transfer Station, along associated drainages and in step-out areas, as needed. The access road was initially mis-identified as the haul road during the RSE field activities. Soil could not be sampled along the access road,

because it was within the 50-foot restricted area around a buried gas line. The actual haul road was evaluated as part of the Transfer Station because the limits were within the Transfer Station boundary. Step-out areas are defined as areas outside of the Transfer Station where gamma scans indicated count rates greater than the BTV. Data collection efforts included gamma scan surveys and collection of surface and 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 and Ra-226 surface soil samples from 15 correlation plots at the Transfer Station. The results were statistically analyzed to determine the relationships between concentrations of Ra-226 in soil and gamma count rates, as well as gamma count rates and dose rate.

4) Identify whether ore-handling activities, such as machine maintenance and refueling and use of electrical equipment, resulted in releases total petroleum hydrocarbons (TPH) or polychlorinated biphenyls (PCBs).

   – Jacobs evaluated evidence of ore-transfer-related activities at the Transfer Station by collecting a surface soil sample and a subsurface soil sample. One surface soil sample was analyzed for the secondary COPCs not in background (TPH and PCBs), and a subsurface soil sample was collected, because secondary COPCs were detected in the surface soil sample. As approved by U.S. EPA in the RSE Work Plans (CH2M 2017, 2018), explosive (including perchlorate) analysis was not performed, because the Transfer Station was a temporary storage location for transfer of ore between mines and milling sites, and therefore, no mining or blasting occurred at the Transfer Station.

5) Identify whether there is evidence that surface water and/or groundwater, if present and able to be sampled, has been impacted by ore-transfer-related activities.

   – Jacobs reviewed water well inventories, performed records search, and reviewed information provided by NNEPA. Two sources indicated that no surface water features were present within 1 mile of the Transfer Station (NDWR 2016; U.S. EPA 2007). The US DOE GEMS database identified four water monitor wells within 1 mile of the Transfer Station in Many Devils Wash (DOE 2019a). These four water wells were found to contain insufficient water volume and were unable to be sampled. The DOE confirmed on June 8, 2021, by email that no historical groundwater samples had been collected from these wells, most likely because the wells were dry (Kautsky 2021).

6) Estimate the area and volume of TENORM at the Transfer Station.

   – Multiple lines of evidence were obtained for the Transfer Station to evaluate the nature and extent of contamination, understand potential fate and transport pathways, and estimate the volume of materials impacted by ore-transfer activities, including TENORM. 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 transfer station operations; and conducting field investigation, including gamma scanning, along with surface and subsurface soil sample analysis.

3.2 Accessibility

The Transfer Station was accessed by vehicle during RSE activities by exiting U.S. Route 491 onto Access Road 1, 0.33 mile north of the Transfer Station (Figure 2-1). A fence line runs along the western side of the Transfer Station, preventing direct access from U.S. Route 491. Access Road 1 continues to parallel U.S. Route 491 south of the Transfer Station. An unnamed dirt road bisects the Transfer Station and continues east, where it connects with a network of trails leading to Many Devils Wash.

3.3 RSE Field Observations of Transfer Station

As part of RSE field activities, Jacobs performed, observed, and documented the following at the Transfer Station. A summary of these observations is provided in Section 3.3.1, except where noted.

- Verification of the location and attributes of historically documented transfer station features, such as ore stockpiles and haul roads. Many historical features were not able to be accurately located, because geographic information system (GIS) coordinates provided in historical documents have poor accuracy as a result of limitations of GIS technology (low resolution) at the time of collection. Additionally, natural erosional forces have contoured the Transfer Station, which may have obscured many features from being located. Additionally, NAML generally reclaimed features such that they blend in with the surrounding landscape; as such, field observations may not match with pre-reclamation NAML records.
- Current conditions at the Transfer Station, including transfer-related features, such as ore stockpiles and the haul road.
- Documentation of disturbed areas. Disturbed areas were documented as areas outside of known transfer station and reclamation areas. Areas associated with transfer-related or reclamation features, such as roads and residual ore piles, 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 aerial images and field observations. Shallow bedrock is defined as areas where bedrock is visually exposed at the surface and the soil mantle consists of less than 6 inches. A shallow bedrock map was not created for the Transfer Station, because there were no expressions of shallow bedrock.
- Geologic contacts.
- Interim actions. During the RSE investigation, an interim action was conducted to deter local residents from accessing the Transfer Station and disturbing the nearby protected Mesa Verde cacti and habitat. Additional information is provided in Section 3.4.
- Descriptions of Transfer Station-specific features.

3.3.1 Summary of RSE Field Observations

RSE activities conducted by Jacobs personnel from September 2017 through September 2019 included observations of transfer station and reclamation features at the Transfer Station. Field documentation of the features can be found in Appendix C. The observed features are presented on Figure 2-1 and discussed as follows:

- Jacobs observed the NAML excavation area and noted no visible residual ore. The NAML excavation area is considered a disturbed area.
- Three ephemeral drainages were observed at the Transfer Station. The three drainages originate from the center of the Transfer Station: Two of the drainages (Drainage 1 and Drainage 2) exited the Transfer Station from the north and drained to the northeast; one drainage (Drainage 3) exited the Transfer Station from the southeast and drained to the southeast. No water was observed in the drainages during RSE field work.
- One road (Access Road 1; used by NAML during reclamation activities) was initially identified as exiting the Transfer Station to the north and was mis-identified as a haul road as part of the RSE field activities. However, the aerial photo review indicates that the Transfer Station was not accessed from this road during historical ore-transfer activities but was likely accessed from U.S. Route 491 immediately to the west along the road that currently bisects the Transfer Station (Haul Road 1; used during ore-transfer activities). Once the highway was widened and a gas line installed, access to the Transfer Station was 0.33 mile to the north. Therefore, NAML would have used Access Road 1 during reclamation activities in 2008. Note that the field gamma scan logs use the incorrect descriptor Haul Road 1, when the work was

conducted on the access road. Haul Road 1 was evaluated as part of the Transfer Station since the limits were within the Transfer Station boundary.

3.4 Interim Actions

This section provides information regarding interim actions that may be required under the CD.

In October 2019, in accordance with the U.S. EPA letter dated October 11, 2019 (U.S. EPA 2019a), signs were installed at four locations around the Transfer Station to deter nearby residents from accessing the Transfer Station. Documentation of the completion of the sign installation was submitted to the U.S. EPA in a letter dated November 1, 2019, and is included in Appendix B (Jacobs 2019).

3.5 Background Reference Areas

Gamma scanning and soil characterization samples from one BRA were collected to determine background conditions for the Transfer Station. 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 being investigated but has not been affected by site activities." The BRA investigation was designed to evaluate the naturally occurring background of radiation and metals concentrations for comparison with the Transfer Station.

One BRA was selected for the Transfer Station, as described in the approved Work Plans (CH2M 2017, 2018), to characterize the predominant geologic formation from which gamma scanning and soil analytical samples were collected. The predominant geological formation is the Mancos Shale. The Mancos Shale BRA was selected based on U.S. Geological Survey (USGS) geologic maps and was verified in the field to be of similar geology and stratigraphic position to the Transfer Station, free of anthropogenic interference, and of relatively low topographic relief, thus subject to less interference by drainage and windblown dust. Additionally, the approximate elevation of the BRA is 5,155 feet amsl, whereas the approximate elevation of the Transfer Station is 5,145 feet amsl. The BRA was selected upgradient of prevailing wind from the Transfer Station. Figures 1-3 and 2-4 show the BRA location; the results of the BRA are presented in Section 4.

3.5.1 Gamma Scan Survey

In September 2017, Jacobs performed gamma scan surveys at the BRA to provide data to calculate BTVs for naturally occurring radiation in soils similar to those found at the Transfer Station. BTVs were used to establish the boundary of the scanned area at the Transfer Station. Before the field characterization work was performed, the approximately 2-acre BRA was 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 the 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 (keV), which includes gamma radiation emitted from bismuth-214 (Bi-214) and lead-214 (Pb-214), which are the primary gamma-emitting radionuclides in the uranium series. These radionuclides are a decay product of Ra-226.

Background gamma scan surveys were traversed at 7.5-foot transects at a rate of 2 to 3 feet per second, 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 personnel paused the gamma scanning and 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 scintillation detector under the conditions described is 1.58 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 MDCRSurveyor 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/microroentgens 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 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 C). 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.

3.5.2 Soil Sampling

BRA surface soil sampling was conducted in October 2017, and subsurface sampling was conducted in May 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 location safely accessible and where soil thicknesses were deep enough to allow for soil sampling. A dose rate measurement and a 1-minute static gamma count were also recorded at each surface soil sample location. 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 C. The static gamma count readings were performed for consistency with the Transfer Station 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, or hand-powered hammer drill, in accordance with the approved Work Plans (CH2M 2017, 2018). The soil samples were logged according to Unified Soil Classification System (USCS) methods (ASTM 2017) and Munsell color chart, then placed into new, unpreserved 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 Methods 6020 and 7471A. Soil samples were digested according to U.S. EPA Method 3050B prior to metal analysis by U.S. EPA Method 6020, and the analysis of mercury was performed after digestion of soil according to U.S. EPA Method 7471. Analytical results for the background surface soil samples were used to calculate BTVs for COPCs in soil. Analytical laboratory results are presented in Appendix D.

3.6 Background Threshold Values and Investigation Levels

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

3.6.1 Background Comparison Values

Because metals and Ra-226 are naturally present in soil, it is necessary to evaluate the concentrations of both 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 2015) recommends using the USL95 to estimate BTVs because it provides a proper balance between false positives and false negatives. However, USL95 should only be used when the raw background data represent a single environmental population without statistical outliers. The inclusion of multiple populations and statistical outliers tends to yield elevated values of USLs, which can result in substantial false negatives. UTL95-95 is alternatively recommended in cases with statistical outliers. Therefore, the following stepwise procedure is used to estimate BTV values for background data:

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 a goodness-of-fit test to characterize an appropriate distribution.
4) Two approaches (parametric and nonparametric procedures) were used 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 did not include statistical outliers, USL95 was used to determine BTVs; otherwise, UTL95-95 is used to estimate BTVs. Statistical documentation is outlined in Appendix E.

3.6.2 Investigation Levels

ILs for metals and Ra-226 are defined as the greater of the BTV or U.S. EPA RSLs. RSLs are not available 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. ILs were used to identify locations of “elevated” gamma count rates or soil COPC concentrations. For gamma scanning, the IL was used as a field screening level to inform the field team when to stop scanning or sampling. In accordance with the approved Work Plans (CH2M 2017, 2018), the IL for lateral extent was set at the applicable BTV plus 1500 cpm; for vertical extent, the IL was set at 2 times the applicable BTV.

ILs were developed to provide a preliminary evaluation of the investigation results and are not the levels that will define the extent of media to be cleaned up. The IL is not a definitive indicator of impacts from historical operations. The IL used to calculate the volume of media impacted by ore-transfer activities, including TENORM, may not accurately estimate the volume that would be subject to a removal action. Once the risk assessment is complete and cleanup values are determined, the volume of media impacted by ore-transfer activities, including TENORM, may change.

3.6.3 Transfer Station – Gamma Scan Surveys

Jacobs performed gamma scan surveys at the Transfer Station in September and October 2017 (Appendix C). Gamma scan surveys are used to determine the following:

- Lateral extent of elevated gamma count rates
- Locations where potential step-out gamma scanning and soil sampling was required
- Potential contaminant migration off the Transfer Station (for example, from runoff or wind)
- Locations of potential residual ore
- Areas with naturally occurring but elevated radiation levels
- Soil sampling locations

As with the BRA gamma scan surveys (September 2017), 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, was used to collect survey measurements; the equipment was inspected and calibrated by an accredited facility before use (Appendix C). Gamma scanning was conducted as described in Section 3.5.1, in accordance with approved Work Plans (CH2M 2017, 2018). Quality assurance/quality control (QA/QC) checks of each instrument were performed daily as described in Section 3.13. Multiple identical radiation detection systems were used for the surveys. The radiation detection equipment, while exhibiting some minor differences, was within the tolerances allowed under instrumentation calibration described in American National Standards Institute (ANSI) N323AB.

Gamma scan surveys were conducted along 15-foot transects over the Transfer Station, which included the buffer area. 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. If gamma count rates were above the IL at the edge of the Transfer Station buffer, then gamma scanning continued outside of the Transfer Station buffer until gamma count rates were consistently below the IL. The 15-foot transects are estimated to provide 40% coverage with the detector held at 18 inches above ground surface.

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. Drainage scanning started at the Transfer Station buffer and continued downstream until gamma count rates were consistently below the IL. If needed, step-out gamma scanning was completed outside the drainages until gamma count rates were consistently below ILs.

Haul Road 1 gamma scan surveys were collected with the Transfer Station gamma scan survey. Access Road 1 was collected along the shoulders, the centerline (sinusoidal wave pattern between the shoulders), and 8 feet away from each shoulder. The scanning of Access Road 1 started at the Transfer Station buffer and continued to the intersection with another roadway. No step-out gamma scanning was completed outside Haul Road 1 or Access Road 1.

3.7 Soil and Sediment Characterization

Soil and sediment sampling was performed according to the approved Work Plans (CH2M 2017, 2018). Gamma scanning and observed and reported feature locations were used to select surface soil and sediment sample locations to provide field information about the potential extent of COPCs at the Transfer Station. Following receipt of the surface soil and sediment soil laboratory data, which could take up to 2 months, the data were reviewed to determine where subsurface soil and sediment 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 collection of the subsurface soil and sediment samples.

Surface and subsurface soil and sediment sampling was conducted between October 2017 and September 2019 to characterize the extent of COPCs. Initial surface soil and sediment sampling were conducted in October 2017. The surface soil results were used to identify subsurface soil and sediment sampling locations, which were collected in June 2018. A third surface and subsurface soil sampling event was performed in September 2019.

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

3.7.1 Surface Soil and Sediment Sampling

Surface soil and sediment samples were characterized as being collected from 0 to 0.5 foot bgs. Samples collected from within drainages were designated as sediment samples. No observable features were identified at the Transfer Station; therefore, sampling locations were selected based on the gamma scan surveys conducted at the Transfer Station. Surface soil and sediment samples were placed in areas with gamma count rates greater than the IL, in areas downgradient of elevated gamma count rates, and in areas to provide adequate spatial coverage to identify the potential extent of COPCs at the Transfer Station. The gamma scan surveys were also used to determine acreage of accessible areas at the Transfer Station and drainages to calculate the total number of samples to be collected. Two surface soil samples were collected for each accessible acre within the Transfer Station and buffer area in accordance with the approved Work Plans (CH2M 2017, 2018). Likewise, for each accessible mile of drainage, 12 surface sediment samples were collected. The access road and haul road were not accessible for soil sampling because of the gas line.

At each soil sample location, a dose rate measurement and a 1-minute static gamma count were collected, recorded, and analyzed following the methods prescribed in Section 3.5.2. Each surface soil sample was analyzed for the primary COPCs. One location was selected for secondary COPC analysis, including TPH by U.S. EPA Method 8015 and PCBs by U.S. EPA Method 8082. 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. Because no portals existed at the Transfer Station, the area with the highest gamma count rate recorded during the gamma scan survey was chosen (CH2M 2017, 2018).

3.7.2 Subsurface Soil and Sediment Sampling

Subsurface soil and sediment samples were collected following the approved Work Plans (CH2M 2017, 2018). Surface soil and sediment sample locations with primary COPC concentrations that exceeded applicable ILs were identified as potential subsurface sampling locations and locations for additional step out samples to assess the horizontal and vertical delineation of potential impacts to soil and sediment. Identification of subsurface soil and sediment locations was further refined to delineate areas around higher concentrations of primary COPCs, detections of secondary COPCs, and if identified, areas around buried and exposed residual ore and other Transfer Station features, including locations downgradient of these areas (such as drainages). Subsurface soil and sediment sample locations were also selected to provide adequate spatial coverage of the Transfer Station.

Subsurface soil sampling was conducted using a drill rig because the Transfer Station was accessible to a drill rig and because some of the surface area of the transfer station had been previously reclaimed by NAML and there was a potential that residual ore was moved or buried. The drill rig used for sampling was a GeoProbe 6620DT direct-push rig with a MacroCore 2.00- or 2.25-inch-diameter core barrel with standard drive point and sand catchers. Drill rig cores were collected in clean, dedicated, acetate liners. Initial drill rig borings were pushed to 5 feet bgs unless refusal or bedrock was encountered. According to the approved Work Plans, borings continued until subsurface sample static gamma count rates were less than 2 times the BTV and no visible waste rock (that is, residual ore for the Transfer Station) was observed. The Work Plans (CH2M 2017, 2018) refer to waste rock; however, waste rock is not applicable at the Transfer Station, because only ore material was transferred and stockpiled, and therefore, only residual ore material is expected to be found at the Transfer Station.

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

Drill rig subsurface soil samples collected in 2018 spanned 0.5 foot; however, this interval was increased to 1 foot in 2019 to provide adequate sample volume for laboratory analysis. In 2019, drill rig samples were collected from 1 to 2 feet bgs and from 3 to 4 feet bgs. If the static gamma count rate at the 3- to 4-foot-bgs interval exceeded 2 times the IL, or residual ore was observed, soil sampling continued in 2-foot-depth intervals (5 to 6 feet bgs, 7 to 8 feet bgs, etc.) until the static gamma count rates were less than 2 times the IL and no residual ore was observed, or until bedrock or refusal was encountered.

Subsurface soil and sediment collection methods followed the approved Work Plans (CH2M 2017, 2018). Subsurface soil samples were logged according to USCS methods and Munsell color chart, and if observed, residual ore was recorded in the soil boring logs (Appendix C). A gamma scan measurement of the sample core was conducted approximately 1 inch above the sample at 6-inch intervals over the length of the core (drill rig sampling only). Professional judgment, either by geologist or other trained personnel, was used to identify residual ore during sampling. Visible residual ore was recorded in the field form. Visible residual ore typically presents as a fine-grained gray sand with elevated gamma count rates; however, visible residual ore can vary in appearance. Gamma scans measurements were conducted with the soil core on a level tailgate of the field truck or folding table in an area at or below background radiation levels, using a Ludlum Model 44-10 2-inch-by-2-inch NaI scintillation detector connected to a Ludlum Model 2221 scaler/ratemeter. The results of the gamma scan measurements were recorded in the soil boring logs in Appendix C.

The soil sample was 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 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 scan measurements recorded from subsurface soil samples with surface soil sample gamma scan measurements or gamma scan survey.

Photographs were taken of the drill core sample, filled sample jars, and the surrounding vicinity of the sample location. Submeter accuracy GPS coordinates were collected at the sample location and recorded. 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 in the surface sample, a subsurface soil sample was collected at 1.0 to 1.5 feet bgs at that location and analyzed for only for those secondary COPCs that were detected. A technical error caused the loss of a number of soil sampling forms, soil boring log forms, and photos; however, this did not result in data gaps.

3.8 Surface Water and Groundwater

Jacobs reviewed the Navajo Nation Department of Water Resources (NDWR) database (NDWR 2017), U.S. DOE Geospatial Environmental Mapping System (DOE 2019a), and U.S. EPA Atlas Geospatial Data (U.S. EPA 2007) to identify potential groundwater (wells) and surface water sampling locations. Four potential wells (SHP02-1156, SHP02-1157, SHP02-1158, and SHP02-1159) were identified within a 1-mile radius of the Transfer Station in Many Devils Wash. These monitor wells are part of the Shiprock Disposal Site monitoring well network managed by the U.S. DOE. However, during RSE field activities, Jacobs did not observe sufficient water volume to sample these wells. No sampleable ephemeral springs, streams, or ponds containing water were identified within a 1-mile radius of the Transfer Station, and none were observed in the field. There also was no evidence of water ponding on the Mine Site.

3.9 Correlation Studies

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

The purpose of the Ra-226 correlation was to provide a way for potential future removal or remedial action to estimate Ra-226 concentrations in surface soil by using walkover gamma count rate data in locations where soil or sediment samples were not collected. This estimate would then be used as a line of evidence to estimate the lateral extent of impacted areas. The relationship between the gamma count rate and Ra-226 surface soil concentrations can exhibit both linear and nonlinear characteristics depending on the site (Whicker et. al 2008). Therefore, a number of different regression models was assessed to determine which model was most representative of the conditions for the Transfer Station. The relationship can be skewed because of the heterogeneity of soil, instrumentation uncertainty, and input from other gamma-emitting radionuclides (for example, thorium or potassium-40) present in soil. Input from other sources can often 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 evaluation of Ra-226 concentration ranges useful for remedial decision making (estimated between 1 to 10 pCi/g).

The purpose of the dose rate correlation was not explicitly defined in the SOW and was developed at the request of 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 using an instrument that does not exhibit strong energy dependence provides a way to express gamma count rate 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 a radiation health physicist, selected 15 plots approximately 30 feet by 30 feet to focus 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 to achieve homogenous gamma count rates. Correlation plots were selected in areas with gamma homogeneity and away from geometric conditions, such as pits, holes, or trenches, that could skew the gamma count rates relative to Ra-226 concentrations in soil 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 (for example, 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 tolerance for variability, the correlation plot was discarded, and an additional plot was evaluated based on a review of field gamma scan measurements. To minimize inconsistencies between correlation plots, the same field operator and the same radiation detection equipment were used for each correlation plot at the Transfer Station. 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 of 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 other RSE gamma 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 Bicron 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 from 0 to 0.5 foot bgs and a 1-minute static gamma count were collected. The five aliquots were field composited (mixed and homogenized); from this, a surface soil sample was collected and analyzed using the same certified laboratory (ALS Environmental in Fort Collins, Colorado) and U.S. EPA Method 901.1 as other RSE soil analysis.

Data collected from the correlation plots were analyzed using both 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. 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 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 Transfer Station. Each surface soil sample location also included a 1-minute static gamma count and a dose rate per the RSE workplan. The validation studies 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 Transfer Station data points overlain by the regression equation. A quantitative validation was also performed by plotting observed versus predicted Ra-226 soil concentration values and performing regression analysis to determine the best data fit. The regression was compared with a 1:1 regression line to determine the degree of potential underprediction or overprediction.

3.10 Materials Impacted by Ore-Transfer Activities, Including TENORM Volume Calculations

The multiple-lines-of-evidence approach was used to determine the volume of materials impacted by ore-transfer activities, including TENORM and NORM. The multiple-lines-of-evidence approach involved evaluating the following:

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

For materials impacted by ore-transfer activities, including TENORM, a volume was calculated based on the lateral and vertical extent according to the multiple-lines-of-evidence approach. Field work was limited in restricted areas to minimize impacts to culturally or biologically sensitive resources or other areas where access is not allowed (for example, utility ROWs). These areas were included or excluded from the TENORM volume calculation based on surrounding data and professional judgment. The lateral extent (area) of materials affected by ore-transfer activities, 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 materials impacted by ore-transfer activities, including TENORM, was rounded up to the nearest 0.5 foot, and areas with similar depths were aggregated.

3.10.1 Impacted Areas

The following assumptions were used to calculate materials impacted by ore-transfer activities, including TENORM volumes. Please note that “elevated” includes actual (laboratory samples) radiological or metals concentrations above the IL and gamma scan data above ILs. Impacted areas include areas within the Transfer Station, drainages, and access road.

- Elevated unconsolidated material was considered material impacted by ore-transfer activities, including TENORM, if it met the multiple lines of evidence.
- Elevated unconsolidated material was considered NORM if it did not meet the multiple lines of evidence.

3.11 Health and Safety

The fieldwork at the Transfer Station was conducted in accordance with the health and safety plans submitted to the U.S. EPA with the 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 rate monitoring was performed for workers entering and leaving the Transfer Station areas. The results of radiation exposure rate monitoring indicated that no field staff were exposed to significant health risks.

3.12 Quality Assurance/Quality Control

The Quality Assurance Project Plan (QAPP) presents QA/QC procedures, policies, and requirements for data collection 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 use of a QAPP and standard operating procedures (SOPs) that included daily instrument calibration and checks and subcontractor oversight. Quality of laboratory data was confirmed by use of 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.

3.12.1 Field Data Quality

RSE activities included collecting large quantities of field screening data. SOPs were developed for the field activities, and contractor experience and credentials were verified before mobilization. Field staff checked the instrumentation calibration records, completed initial and daily source checks on the radiation equipment, verified compliance with SOPs, and reviewed preliminary data 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. The final quality-checked data are presented in this Report.

3.12.1.1 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 minimum 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 C contains copies of the calibration certificates and instrument source checks.

3.12.1.2 Field Confirmation

Field staff verified compliance with the SOPs and reviewed preliminary data during 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 the health physicist or trained personnel 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 audited before conducting gamma scan surveys to document adherence to the RSE Work Plans, including maintaining proper probe height and walking speed. Allowances were made for an 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 to verify data reports.

No significant deficiencies were observed.

3.12.2 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 2010b). 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 D.

3.13 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 auger, 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 bodies, 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 a radioactive contamination potentially 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 performed in accordance with the Health and Safety Plans (CH2M 2017, 2018).

No investigation-derived waste was produced as a result of these field efforts. Any sampled environmental media that were not required were returned to the location where they were obtained from or scattered at the Transfer Station in an area of similar radioactivity, as identified by previous gamma scans.

4. Investigation Results

This section presents the results of the background investigation, gamma scan surveys and surface and subsurface soil sampling, gamma count rate to Ra-226 surface soil and gamma count rate to dose rate correlations, and water sampling. Field investigations were limited to areas outside of inaccessible and restricted areas shown on Figure 2-1. Inaccessible areas were areas where health and safety concerns prevented access by field personnel; for example, the highway ROW. Restricted areas were locations with identified biological or culturally sensitive items. Buffer zones around biologically or culturally sensitive areas were set by the pertinent authority (either NNDFW or NNHPD), which also provided limitations on gamma scanning and soil sampling in these areas.

4.1 Background Assessment

As indicated in Section 3.5, one BRA was established for the Transfer Station (Mancos Shale). The investigation of this BRA provided data to assess background conditions by 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 presents the summary statistics of the gamma scan survey results for the Mancos Shale. The gamma scan survey data were plotted over an aerial image (Figure 4-1), with data color-coded based on gamma count rate ranges. The results are as follows:

- **Mancos Shale BRA**: The gamma count rates ranged from 8352 to 13890 cpm, with an average of 10848 cpm.

4.1.2 Background Reference Area Surface Soil Sampling Results

Table 4-1 summarizes statistics for metals and Ra-226 laboratory analytical results for surface soil samples collected within the Mancos Shale BRA. The metal concentrations detected within the BRA were typical of metals in non-ore-grade geologies, as expected for the Mancos Shale (less than 30 mg/kg for arsenic, mercury, and molybdenum, and less than 100 mg/kg for selenium, uranium, and vanadium) (USGS 1968; Myers 2010). Analytical laboratory results are summarized in Table 4-2. Field sampling forms are provided in Appendix C, laboratory reports are provided in Appendix D, and a detailed statistical analysis of background data is provided in Appendix E.

4.1.3 Background Reference Area Subsurface Soil Sampling Results

Three subsurface soil samples were collected at the BRA corresponding with locations containing the low, medium, and high concentrations of Ra-226 in surface soil (Figure 4-1). Concentrations of metals and Ra-226 in subsurface soil were comparable to surface soil concentrations. Table 4-2 presents the subsurface soil sample results collected at the Mancos Shale BRA.

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, a BTVs for the Mancos Shale for gamma count rate and primary COPC soil concentrations were based on the results obtained from the BRA investigation. An IL was derived from the BTV to allow for assessment of 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) that will 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, a U.S. EPA endorsed statistical computing software (R Core Team 2018), and ProUCL, a U.S. EPA-approved software (Version 5.1.00, U.S. EPA 2015) 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 E.

The BTVs were calculated using the following methods, as stipulated in the approved Work Plans (CH2M 2017, 2018).

- Gamma count rate and primary COPC concentrations – The BTV was set at the USL95 if no outliers were present in the data set. If outliers were present, they were evaluated to see whether they should be removed for reasons such as sample contamination, lab errors, etc. 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.
- Gamma Count Rate ILs were rounded to the nearest 100 from the calculated USL95.

The IL was calculated as follows, as approved by U.S. EPA in the Work Plans (CH2M 2017, 2018):

- Gamma count rate: The IL for the gamma scan was set at the BTV for this RSE Report. For field investigation gamma scanning, the IL was the BTV plus 1500 cpm; for vertical field delineation, the IL was 2 times the BTV.
- Primary COPC Concentrations: The IL equaled the greater of the BTV or U.S. EPA RSL. If no RSL was established, then the IL was the BTV.
- Secondary COPCs: Because these compounds are not naturally occurring, the IL was set at the U.S. EPA RSL.

BTVs and ILs are shown in Tables 4-3 and 4-4.

4.3 Gamma Scan Surveys

The gamma scan results for the Transfer Station were compared with the IL (Table 4-3). The IL for gamma count rate was used to evaluate the need for further lateral or vertical 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 presented the BTV and multiples of BTV used to analyze gamma count rate data. Initial gamma scan surveys were conducted from September to October 2017 and results are provided on Figures 4-2a, 4-2b, 4-2c, and 4-2d.

4.3.1 Gamma Scanning Results

- **Transfer Station:** The gamma scanning extended throughout the Transfer Station in areas that were accessible for walkover surveys. The terrain was accessible for scanning; however, a portion was inaccessible on the west side of the Transfer Station because it was on U.S. Route 491. The total scanned area was 5.4 acres.
  - Results from gamma scanning conducted on the Transfer Station are depicted in Figure 4-2a. Elevated gamma count rates were observed in the central portion of the Transfer Station with maximum values located within preferential overland flow pathways leading away from the NAML documented excavation area. Gamma count rates generally decreased to background values at the boundary of the Transfer Station. Gamma count rates at the Transfer Station buffer were less than the IL, except along the eastern buffer, where they were slightly elevated. Gamma scanning continued beyond the 100-foot-wide buffer to the east for approximately 125 to 150 feet, until gamma count rates were consistently less than the IL.
- **Drainages:** Three drainages were present at the Transfer Station, with flow patterns to the northeast and southeast. Gamma scanning was conducted along each drainage until gamma count rates were consistently less than the IL.
  - Drainage 1 was gamma scanned for approximately 0.16 mile. The centerline and banks of the drainage did not have gamma count rates greater than the IL (Figure 4-2b).
  - Drainage 2 was scanned for approximately 0.23 mile. The highest gamma count rates were found along the centerline of the drainage and were consistently higher than the surrounding soil on the top

of the banks, indicating localized transport from the Transfer Station (Figure 4-2b). Downgradient of this area, the results in the centerline of the drainage are consistent with surrounding soil on the top of the bank.

  - Drainage 3 was scanned for approximately 0.22 mile. Gamma count rates were highest at the boundary of the Transfer Station buffer and decreased with distance from the Transfer Station buffer (Figure 4-2c). At the Transfer Station boundary, the results in the centerline of the drainage were higher than the surrounding soil on the top of the bank, indicating very localized transport from the Transfer Station at that boundary. This transport appears to be limited to 180 feet from the buffer, because past that point, the gamma count rates were below the BTV.

- **Former Haul Road and Access Road:** Haul Road 1 is within the Transfer Station boundary and was gamma scanned as part of the Transfer Station until the inaccessible area was encountered. Gamma count rates were continually below the IL. Access Road 1 was gamma scanned from the Transfer Station to the north to the access point (break in the fence line) for U.S. Route 491, for a total distance of 0.31 mile. Gamma count rates along Access Road 1 were continually below the IL except for a few sporadic elevated gamma count rates (Figure 4-2d).

4.3.2 Gamma Scanning Investigation Level Exceedance Lateral Extent Mapping

According to the gamma scans in accessible areas described previously, the lateral extent of IL exceedances has been delineated. In accordance with the approved Work Plans, step-out gamma scanning was conducted if the area was not delineated by the field investigation gamma scanning IL (BTV plus 1500 cpm). The lateral extent of gamma exceedances was determined by drawing a polygon around multiple contiguous gamma scanned areas that exceeded the IL and calculating the area of the polygon. The lateral extent of IL exceedances across the Transfer Station, drainages, and access road is 2.38 acres, as shown on Figures 4-3a through 4-3d.

4.4 Soil Sampling Results

The following sections discuss the results of the soil and sediment sampling that was completed at the Transfer Station. Sampling locations are shown on Figures 4-2a through 4-2c, and the results are compared with the ILs that are presented in Tables 4-3 and 4-4. Sample descriptions are presented in Table 4-6, and analytical data are presented in Tables 4-7 and 4-8. Soil sample logs and soil boring logs are presented in Appendix C, laboratory analytical reports are provided in Appendix D, and descriptive statistics for soil sample data are provided in Appendix E.

Sample identifiers were in 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 ID, which was 01 for the Transfer Station.
- CC: The next two digits indicate the mine feature from which the sample was collected. For example, D1 would indicate the sample was collected from Drainage 1, whereas MS would indicate the sample was collected from the Mine Site.
- DDD: The next three digits indicate the sample number, numbered sequentially by order of collection.

Surface and subsurface soil samples may have been collected from the same sample location (CC-DDD). For subsurface soil samples, the sample number is followed by the sample interval. For example, SB-01-D1-001-1.0-1.5 would indicate a subsurface sample was collected at D1-001 from 1.0 to 1.5 feet below ground surface. The format for sample locations is AA-BB-CC described previously.

4.4.1 Soil and Sediment Sampling Frequency

Soil and sediment samples collected at the Transfer Station are summarized as follows and in Tables 4-6 and 4-7. Sampling locations are shown on Figures 4-2a, 4-2b, 4-2c, and 4-2d.

- **Former Transfer Station:** A total of 5.4 acres of accessible area is present at the Transfer Station, which corresponded to a total of 11 surface soil samples to be collected. An additional 3 samples were collected for data gap analysis for a total of 14 surface soil samples. Ten locations were selected for subsurface soil sampling, co-located at surface soil sample locations that contained the highest concentration of Ra-226 or metals that were greater than the applicable IL.
- **Drainage:** Three drainages were present at the Transfer Station with an accessible mileage of 0.61 mile. Nine surface sediment samples were collected. One subsurface soil sample location was selected for Drainage 2, and three subsurface soil locations were selected at Drainage 3, based on elevated concentrations of Ra-226 and metals in surface soil samples.
- **Former Haul Road and Access Road:** Haul Road 1 with 0.31 accessible mile and Access Road 1 were present at the Transfer Station; however, soil samples were not collected, because the haul road was evaluated as part of the Transfer Station, since the limits were within the Transfer Station boundaries. The access road was within the ROW of an NTUA gas pipeline, and NTUA does not allow invasive sampling within 50 feet the gas pipeline.

4.4.2 Radium-226 in Soil

The data for Ra-226 are presented in Table 4-7 and shown on Figures 4-2a, 4-2b, and 4-2c.

- **Former Transfer Station:** Concentrations of Ra-226 in the 14 surface soil samples ranged from 1.82 to 61.8 pCi/g. The maximum concentration of 61.8 pCi/g for Ra-226 was collected from location 01-MS-007. Concentrations of Ra-226 exceeded the IL of 1.62 pCi/g in the 14 surface soil samples collected at the Transfer Station.

  Concentrations of Ra-226 in the 19 subsurface soil samples ranged from 0.99 to 1.96 pCi/g. Ra-226 exceeded the IL in 1 of the 19 subsurface soil samples collected. The 1- to 1.5-foot interval at location SB-01-MS-007 (1.96 pCi/g) exceeded the IL for Ra-226; however, in the 3- to 3.5-foot interval, Ra-226 did not exceed the IL. No residual ore was identified in subsurface soil borings within the Transfer Station.
- **Drainages:** Concentrations of Ra-226 in the 17 drainage samples ranged from 1.13 to 2.5 pCi/g. The maximum concentration of 2.5 pCi/g was detected in the sample collected at SD-01-D2-001. Ra-226 exceeded the IL in one surface soil sample collected at Drainage 2 (01-D2-001) and one surface soil sample collected at Drainage 3 (01-D3-003). Concentrations of Ra-226 in the 8 subsurface drainage samples did not exceed the IL for Ra-226. No residual ore was identified within soil borings collected along the drainages.

4.4.3 Radium-226 Investigation Level Exceedance Extent

The Ra-226 soil analytical concentrations exceeding the IL were not laterally bound by soil samples below the IL but were laterally bound by gamma scans less than the IL. The results of the Ra-226 surface and subsurface sampling results indicate that Ra-226 exceeds the IL around the NAML documented excavation area and in the topographically lower areas immediately downgradient of the NAML documented excavation area along Drainages 2 and 3 (Figures 4-2a, 4-2b, and 4-3b). The soil sampling results support the gamma scan conclusion that the transport of elevated materials down Drainage 2 and 3 is limited.

In accordance with the Work Plans, vertical delineation was investigated by subsurface sampling at locations with higher concentrations of primary COPCs, areas where residual ore could be buried or exposed, and locations downgradient of these areas. Subsurface soil sample locations were also selected to provide adequate spatial coverage at the Transfer Station; therefore, not all surface soil samples that exceeded the IL were selected for subsurface sampling. Subsurface soil samples were collected at 10 Mine Site locations and 4 drainage locations. The 10 Mine Site subsurface sample locations were vertically delineated at Ra-226 concentrations below the IL, and depths were generally limited to 0.5 foot bgs, except at sample 01-MS-007, which exceeded the IL to 1.5 feet bgs. The four drainage subsurface sample locations (01-D2-001, 01-D3-001, 01-D3-002, and 01-D3-003) were delineated at Ra-226 concentrations below the IL. IL exceedances in drainages were limited to 0.5 foot bgs.

4.4.4 Metals Results

The data for metals in soil and sediment are presented in Table 4-7 and shown on Figures 4-2a, 4-2b, and 4-2c. Metals concentrations plotted against depth for each respective subsurface soil sampling location are presented in Appendix E. Results are summarized as follows:

- **Former Transfer Station:** Thorium, uranium, and vanadium exceeded the ILs in one or more surface soil samples at the Transfer Station. One metal (thorium) also exceeded the IL in subsurface soil samples. Concentrations of arsenic, mercury, molybdenum, and selenium were less than the ILs in each surface and subsurface sample collected at the Transfer Station.
  - Thorium concentrations in the 14 surface soil samples ranged from 3.4 to 5.8 mg/kg. The maximum concentration of 5.8 mg/kg was collected at 01-MS-004, located to the northeast of the NAML excavation area and near Drainage 2. Concentrations of thorium in the 20 subsurface soil samples ranged from 3.9 to 6.0 mg/kg. The maximum concentration of 6.0 mg/kg was detected in the subsurface soil sample at location SB-01-MS-012. Seven subsurface soil samples contained thorium concentrations greater than the IL of 4.72 mg/kg. The extent of thorium in soils does not show a distinct pattern with depth or location (Appendix E).

    For comparison, the USGS performed a study of background concentrations of various metals in soil across the entire United States and regionally in the western states (Shacklette and Boerngen 1984). Surface soil was collected at depths of approximately 0.66 foot bgs from areas exhibiting natural conditions (away from roadcuts and fills). Thorium soil concentrations in the western states ranged from 2.4 to 31 mg/kg, with an average concentration of 9.1 mg/kg. The thorium data at the Transfer Station are less than the average in the Western States. Uranium concentrations in the 34 surface and subsurface soil samples ranged from 0.61 to 95 mg/kg. Surface soil exceeded the IL of 16 mg/kg in 3 of the 14 surface soil samples, with a maximum concentration of 95 mg/kg at 01-MS-007. The 20 subsurface samples (all depths) did not exceed the Uranium IL. Changes in concentrations of uranium with depth generally follow changes of Ra-226 and vanadium soil concentrations with depth (Appendix E).

    For reference, a regional study of the western U.S. documented uranium concentrations in soil that ranged from 0.68 to 7.9 mg/kg (Shacklette and Boerngen 1984). Uranium concentrations in soil at the Transfer Station exceeded the typical range of regional values in 7 of the 34 samples. Soil samples that exceeded the IL for uranium are also located where Ra-226 exceeds the IL.
  - Vanadium concentrations in the 14 surface soil samples ranged from 13 to 450 mg/kg. Surface soil exceeded the IL of 390 mg/kg in one sample, which was also the maximum concentration of 450 mg/kg collected at 01-MS-007. This was the only exceedance of the IL for vanadium. None of the 20 subsurface samples exceeded the IL. For reference, a regional study of the western U.S. documented vanadium concentrations in soil ranging from 7 to 500 mg/kg, with a mean value of 70 mg/kg (Table 2, Shacklette and Boerngen 1984). Vanadium concentrations in soil samples were within the typical range of regional concentrations in soil samples. In addition, changes in concentrations of vanadium with depth generally follow changes of Ra-226 and uranium soil concentrations with depth (Appendix E).

Drainages: Thorium was the only metal COPC to exceed the IL of 4.72 mg/kg in surface and subsurface drainage samples at the Transfer Station. Concentrations of thorium in the nine surface soil samples collected ranged from 3.9 to 5.9 mg/kg. The maximum concentration of thorium in surface soil was collected at SD-01-D3-002. Subsurface soil samples collected from 1.0 to 1.5 ft bgs and 3.5 to 3.5 ft bgs at SD-01-D3-002 reported concentrations less than the thorium IL. Three of the eight subsurface soil samples collected from the drainages had concentrations that exceeded the IL for thorium, ranging from 3.8 to 6.2 mg/kg. The maximum concentration of thorium was detected in the subsurface soil sample collected from 3 to 3.5 feet at SB-01-D2-001, although the surface sample concentration was lower than subsurface. Additionally, the concentrations are less than the western states' average concentration of 9.1 mg/kg (Shacklette and Boerngen 1984).

4.4.5 Metals Investigation Level Exceedance Extent

The IL exceedances in surface and subsurface soil for thorium, uranium, and vanadium are from sample locations on the eastern side of the Transfer Station (Figure 4-2a). This area is also near the NAML excavation area. Specific areas of metals IL exceedances are as follows:

- IL exceedances of metals on the Transfer Station are predominantly within the eastern half of the NAML excavation area and in the topographically lower areas immediately downgradient of the NAML documented excavation area along Drainages 2 and 3 (Figures 4-2a, 4-2b, and 4-3b). The soil sampling results support the gamma scan conclusion that the transport of elevated materials down Drainage 2 and 3 is limited.
- IL exceedances of uranium and vanadium were limited to surface soils samples with elevated Ra-226 concentrations. Uranium and vanadium IL exceedances were predominately within the eastern half of the NAML excavation area and topographically lower areas toward the buffer. There were no IL exceedances for uranium or vanadium within the drainages. For reference, vanadium was within the typical range of regional values for soil. In addition, changes in concentrations of uranium and vanadium with depth generally follow changes of Ra-226 soil concentrations with depth (Appendix F).
- Concentrations of IL exceedances for thorium are predominantly within the eastern half of the NAML excavation area and in the topographically lower areas immediately downgradient of the NAML documented excavation area along Drainages 2 and 3. Concentrations of thorium were less than the western states' average concentration of 9.1 mg/kg (Shacklette and Boerngen 1984).

In accordance with the Work Plans, vertical delineation was investigated by subsurface sampling at locations with higher concentrations of primary COPCs, areas where residual ore could potentially be buried or exposed, and locations downgradient of these areas. Subsurface soil sample locations were also selected to provide adequate spatial coverage at the Transfer Station; therefore, not all surface soil samples that exceeded the IL were selected for subsurface sampling. Subsurface soil samples were collected at 10 Mine Site locations and 4 drainage locations. Of the 10 Mine Sites sampled, 4 (01-MS-003, 01-MS-005, 01-MS-07, and 01-MS-012) were vertically delineated at bedrock ranging from 2.1 to 5 feet bgs and 6 (01-MS-001, 01-MS-009, 01-MS-010, 01-MS-0011, 01-MS-013, and 01-MS-014) were vertically delineated at metals concentrations less than the IL at 1.0 foot bgs. Of the 4 drainage sample locations, 2 sample locations (01-D2-001 and 01-D3-003) were delineated at bedrock at 3.5 feet bgs, and 1 sample location (01-D3-002) was delineated at metals concentrations less than the IL at 1.0 foot bgs. Uranium soil analytical concentrations were laterally bound by soil samples within the Transfer Station boundary and along Drainage 3 by soil samples below the IL (MS-002, MS-003, MS-005, MS-006, MS-008, MS-012, MS-013, and D3-001); vanadium IL exceedances were laterally bound within the Transfer Station boundary by soil samples less than the IL (MS-002, MS-003, MS-004, MS-005, MS-010, and MS-014). Thorium concentrations were not laterally delineated along the centerline of Drainage 3 by soil analytical concentrations below the IL.

4.4.6 Residual Ore Investigation

Visible residual ore was not identified in surface soil or soil borings collected from the Transfer Station or drainages. Table 4-6 notes that residual ore was not observed in soil borings.

4.4.7 Secondary Contaminants of Potential Concern in Soil

Jacobs evaluated evidence of ore-transfer activities at the Transfer Station by collecting a surface soil sample for secondary COPCs (TPH and PCBs); a subsurface soil sample was collected if secondary COPCs were detected in the surface soil sample. One surface soil sample was collected at 01-MS-007 and analyzed for secondary COPCs, including TPH and PCBs, at the Transfer Station (Table 4-8). Only TPH-diesel range organics (DRO) were detected in the surface soil sample; however, the concentration did not exceed the TPH IL of 96 mg/kg. In accordance with the Work Plans (CH2M 2017, 2018), subsurface soil samples were collected and analyzed for each secondary COPC that was detected in a surface soil sample. A subsurface soil sample was collected from 1.0 to 1.5 ft bgs at 01-MS-007 and analyzed for TPH-DRO. TPH-DRO was not detected in the subsurface soil sample 1.0 to 1.5 ft bgs.

In accordance with the Work Plan, samples were collected at the Transfer Station to evaluate whether ore-transfer activities released secondary COPCs into the environment. None of the secondary COPCs exceeded ILs.

4.5 Contaminants of Potential Concern

Soil samples at the Transfer Station were analyzed for the primary COPCs (COPCs in background), which included Ra-226, arsenic, mercury, molybdenum, selenium, thorium, uranium, and vanadium. According to the results presented in Section 4.4, concentrations of Ra-226, thorium, uranium, and vanadium in soil/sediment exceeded their respective ILs at the Transfer Station and therefore were confirmed as COPCs. No secondary COPCs (COPCs not in background) were confirmed as COPCs at the Transfer Station.

4.6 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 3.10. The correlation plot locations are presented on Figure 4-4. The purpose of the Ra-226 correlation is to provide a way for potential future removal or 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 method 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 Transfer Station gamma scans and soil/sediment analytical results. Details of the analyses of the data are provided in Appendix F.

4.6.1 Gamma Count Rate 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. An exponential regression model best represents the relationship in the correlation plot data between gamma count rate and Ra-226 surface soil concentration. The best fit regression equation to convert gamma count rate in cpm to predicted surface soil Ra-226 concentration in pCi/g for the Transfer Station is presented herein. Figure 4-5 graphically depicts the gamma count rate to Ra-226 surface soil concentration regression.

$$y = e^{-2.774+0.000266x}$$

Where:

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

x = gamma count rate (cpm)

Example correlation estimates:

- 12240 cpm correlates to 1.62 pCi/g of Ra-226 concentration (IL).
- 17170 cpm correlates to 6.00 pCi/g of Ra-226 concentration.
- 19090 cpm correlates to 10.00 pCi/g of Ra-226 concentration.
- 22160 cpm correlates to 22.70 pCi/g of Ra-226 concentration (maximum value correlation can be used).

The regression for gamma count rate (cpm) to Ra-226 surface soil concentration (pCi/g) resulted in a coefficient of determination (R-squared) value of 0.971. Therefore, the mean detector output was able to explain 97.1% of the observed variability in mean Ra-226 concentration. The equation produced a mean squared error (MSE) of 1.02, which describes the average error of the regression line from the individual data points. A probability value (p-value) of less than 0.001 suggests that the relationship between gamma count rate and Ra-226 surface soil concentration is significant and not due to chance.

A model validation study using data from surface soil sample locations collected across the Transfer Station was performed based on the methods presented in Section 3.10. Details of this analysis are described in Appendix F. The results of the validation indicated the chosen regression model can be used to predict Transfer Station Ra-226 surface soil concentrations. On average, the regression model exhibits a slight overprediction throughout the range of data. For example, a hypothetical surface soil sample with a measured Ra-226 concentration of 2.0 pCi/g would be predicted as 2.7 pCi/g, and a hypothetical surface soil sample with a measured Ra-226 concentration of 6.0 pCi/g would be predicted as 6.7 pCi/g.

In accordance with the work plan, sufficient data were collected to evaluate whether a correlation between gamma count rate and Ra-226 soil concentration is present at the Climax Transfer Station. This regression equation can be used to predict Ra-226 surface soil concentrations from gamma count rate only between the range of 10535 cpm and 22163 cpm, which is the range of values used to produce the regression. Predicted values outside of that range should be used qualitatively and with caution when making decisions. Detailed analysis of the correlation is found in Appendix F, including figures of estimated Ra-226 surface soil concentrations.

4.6.2 Gamma Count Rate and Dose Rate 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 naturally occurring radioactive materials. These systems, however, exhibit strong energy dependence and tend to over respond significantly to low-energy photons and under respond to high-energy photons. The data collected from these instruments, while useful for characterization, 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 ease of portability.

Analytical results of the dose rate data, in conjunction with the high-density gamma scan data, were used to develop the model. 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 Transfer Station is shown in the following equation. Figure 4-6 graphically depicts the gamma count rate to dose rate correlation.

$$y = 0.0008x + 0.534$$

Where:

y = dose rate (µrem/hr)
x = gamma count rate (cpm)

Example correlation estimates:

- 9540 cpm correlates to 8.00 µrem/hr.
- 12030 cpm correlates to 9.95 µrem/hr.
- 17060 cpm correlates to 13.90 µrem/hr.
- 22160 cpm correlates to 17.90 µrem/hr (maximum value correlation can be used).

The linear regression for gamma count rate (cpm) to dose rate (µrem/hr) resulted in an R-squared value of 0.590. Therefore, the mean detector output was able to explain 59% of the observed variability in dose rate. The equation produced an MSE of 2.25, which describes the average error of the regression line from individual data points. A p-value of less than 0.001 suggest that the relationship between gamma count rate and dose rate is significant and not due to chance. Because of weak statistics, the regression equation cannot be used to predict dose rate from gamma count rate. Detailed analysis is found in Appendix F.

A model validation study was performed using count rate and dose rate measurements collected at surface soil sample locations across the Transfer Station based on the methods described in Section 3.10. Details of this validation are described in Appendix F. None of these data were used to develop the correlation. 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 Transfer Station data was found to follow a nearly parallel slope but at lower dose rates than were found in the correlation plots. The variability in the data collected 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.
- Variation between like instruments. Calibration laboratories can allow +/- 20% difference between like instruments (ANSI 2013).
- Multiple Bicron MicroREM detectors were used in the field by multiple operators.

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 Transfer Station; however, Cyprus Amax is exploring additional methodologies for dose rate correlation at Group 2 Mines Sites.

4.7 Water Sampling Results

An attempt was made to sample four alluvial wells (SHP02-1156, SHP02-1157, SHP02-1158, and SHP02-1159) located in Many Devils Wash; however, they had insufficient water volume to sample. The alluvial wells are reportedly screened approximately between 20 and 30 feet bgs on top of the Mancos Shale. No other water wells, ephemeral springs, streams, or ponds were identified within a 1-mile radius of the Transfer Station. As such, no water samples were collected at the Transfer Station. Cyprus Amax requested available data from the DOE on these wells; the DOE confirmed on June 18, 2021, by email that no historical groundwater samples have been collected from these wells, presumably because the wells are dry (Kautsky 2021).

Using the multiple-lines-of-evidence approach, it appears that the Transfer Station is not impacting groundwater or surface water because of the following:

- Precipitation is the only water source at the Transfer Station.
- Infiltration is limited because of the pan evaporation rate (approximately 73 inches per year) and an average annual rainfall of 7 inches. The highest average monthly rainfall occurs in August with 1.01 inches and a pan evaporation rate of 10.80 inches. With an evaporation rate greater than rainfall, infiltration is expected to be minimal, stored in soil, and released through evaporation and transpiration without further, deeper, infiltration of water (Cadmus Group Inc. 2011).
- Surface water or ponding was not observed on the Transfer Station during RSE field activities, which were conducted during the monsoon season.
- Sediment samples above the IL are limited to surficial soils above bedrock (approximately 3.5 feet bgs).
- Transport of sediments above the IL are approximately 0.25 mile from the Transfer Station, with the nearest watercourse (Many Devils Wash) approximately 1 mile downgradient.

- Groundwater was not observed in the four DOE wells located in Many Devils Wash during multiple water sampling attempts conducted by DOE and Cyprus Amax. Absence of groundwater at the interface of the alluvium and Mancos Shale (approximately 20 to 30 feet bgs) indicates that surface water does not infiltrate and result in groundwater.
- According to literature reviews, the Mancos Shale acts as an aquiclude to prohibit vertical migration of groundwater flow at the Transfer Station (Robertson et al. 2016).

5. Areas of NORM and Materials Impacted by Ore-Transfer Activities, Including TENORM

The approximate lateral extent of gamma count rates and soil/sediment COPC concentrations that exceeded the IL is presented on Figures 5-1a through 5-1d. The multiple-lines-of-evidence approach was used to determine areas of NORM and historical ore-transfer impacts, including TENORM, as described in Section 3.11. The multiple lines of evidence included the evaluation of historical features, NAML reclamation activities, evaluation of historical and current aerial photographs; investigation reports; site geology, hydrology, and geomorphology; prominent wind direction; and site characterization data, such as field observations, gamma count rates, and analytical results from surface and subsurface soil sampling. From the multiple lines of evidence, polygons of materials impacted by ore-transfer activities, including TENORM, were derived and used to calculate volume.

5.1 Areas of Materials Impacted by Ore-Transfer Activities, Including TENORM

Investigated areas that had multiple lines of evidence indicating the area was affected by historical ore-transfer-related activities were designated as materials impacted by ore-transfer activities, including TENORM.

According to the multiple-lines-of-evidence approach, the areas of materials impacted by ore-transfer activities, including TENORM, are located in the following areas:

- The center portion of the Transfer Station around the NAML technical excavation location. This area was determined to be impacted by ore-transfer activities, including TENORM, through historical documentation, historical reclamation efforts, visual observation, information obtained from NAML staff and site characterization data (gamma scanning and surface and subsurface soil analysis).
  - During an April 2018 site visit, NAML reported the excavated material was removed from the NAML excavation area and taken to the VCA Plot 3 Mine Site buried and capped. No other areas of the Transfer Station were identified as impacted by ore-transfer-related activities.
  - NAML historical documentation identified an excavation area of an unknown depth in the center of the Transfer Station. The excavated area was capped with Class A (less than 2 pCi/g).
  - Visual observation of the NAML excavation area was conducted during the RSE field investigation; however, no residual ore was identified at the Transfer Station during the RSE field investigation. The excavation area was not identified in historical aerial photographs.
  - Surface and subsurface soil samples collected from and around the excavation area exceeded COPCs (Section 4.4). Additionally, elevated gamma count rates were observed in the central portion of the Transfer Station with maximum values located within preferential overland flow pathways leading away from the NAML documented excavation area.
- The eastern portion of the Transfer Station, buffer, and centerlines of Drainage 2 and 3 are considered to have impacts from ore-transfer activities, including TENORM, based on site hydrology, and field investigation, including site characterization data (gamma scanning and surface and subsurface soil sample analysis).
  - Information obtained from NAML staff, NAML historical documentation, and historical reclamation activities did not identify Transfer Station activities at the area near the eastern portion of the Transfer Station or near Drainage 2 and 3.
  - The surficial soil consists of weathered Mancos Shale, which is predominately interstitial shale fragments within a matrix of fine sand and clay. The permeability (that is, hydraulic conductivity) of this material is exceptionally low, ranging from 10-12 to 10-8 meters per second, compared with sands and gravel, which range from 10-6 to 1 meters per second. The primary mechanism for groundwater movement through the Mancos Shale is through fracture flow. Soil data collected from the Transfer Station do not show COPC exceedances greater than 3 feet bgs.

- The predominant wind direction in Shiprock, New Mexico, is from the western direction (Figure 1-4). The gamma scanning delineated exceedances on the eastern side of the Transfer Station. Therefore, wind transport of impacted material is not expected to have transported wind-blown sediments outside of the Site Buffer.
- A review of historical aerial photographs and RSE field observations did not observe disturbed vegetation along the eastern portion of the Transfer Station or Drainage 2 and 3.
- Soil samples within the Transfer Station that exceeded the IL were upgradient of Drainage 2 and 3; this soil may have contributed to exceedances downgradient within Drainages 2 and 3.
- Surface water is expected to flow from the Transfer Station to the east towards the Many Devils Wash (Figure 1-4). Elevated gamma scan measurements and COPC exceedances identified in surface and subsurface samples to the east are assumed to be attributed to the Transfer Station.
- Elevated gamma count rate and COPCs greater than the IL were located on the eastern portion of the Transfer Station and along the centerlines of Drainage 2 and Drainage 3 extending just beyond the Transfer Station buffer (Figure 5-1a, 5-1b, and 5-1c).
- The partition coefficient (K_d) for thorium is an indicator of how mobile a contaminant is in the environment and is the highest of the metals (ranging from 3,200 to 89,000 cubic centimeters per gram) (RESRAD Table E.3; Argonne National Laboratory 2001). The K_d value for thorium indicates that thorium would bind to soil and would therefore more likely be transported attached to sediment particles along the surface water flow path and less likely to be transported in the dissolved phase (U.S. EPA 1999). Low pH soil conditions resulting from acid rock drainage would alter this assumption. However, this condition was studied within the Northern Agency Tronox mines and was and found not to exist at any of the mine sites and non-AUM Target sites, including the Cove Transfer Station (U.S. EPA 2019b).

The extent of materials impacted by ore-transfer activities, including TENORM, at the Transfer Station was estimated to include 2.60 acres of the Transfer Station and drainages.

5.2 Areas of NORM

The multiple-lines-of-evidence approach was used to determine areas of NORM. Areas of NORM are described as follows:

- The area along Access Road 1 had gamma count rates less than the IL. No soil data were collected along Access Road 1, because of the gas line ROW. Access Road 1 is considered NORM (Figure 5-1d) for the following reasons:
  - Gamma count rates were not identified greater than the IL in any portion along Access Road 1 (Figure 4-2d). Information obtained from NAML staff, NAML historical documentation, and historical reclamation activities did not identify features or disturbances near Access Road 1.
  - NAML reclamation activities were performed from November through December 2008. NAML performed reclamation activities at the Transfer Station under the Morrison 1 contract (NAMLRP 2008). Technical specifications present Access Road 1 for access to the Transfer Station (Appendix A); therefore, Access Road 1 was likely used during reclamation activities.
  - Access Road 1 was not used during ore-transfer activities. The evaluation of historical and current aerial photographs does not identify Access Road 1 during the time where ore-transfer activities were expected to have occurred. The 1997 and 2019 historical aerial images (Figure 2-2d and Figure 2-2e) show increased development near the Transfer Station. Specifically, U.S. Route 491 has been widened, and the ROW for a gas line running parallel to the east of U.S. Route 491 is observed. In addition, buildings are apparent approximately to the north and west of the Transfer Station in 1997, and more development is apparent in the 2019 aerial image. Access Road 1 is visible traversing north from the Transfer Station.

- The predominant wind direction in Shiprock, New Mexico, is from the western direction (Figure 1-4). Therefore, wind transport of impacted material is not expected to be in the northern direction toward Access Road 1.
- Surface water is expected to flow from the Transfer Station to the east away from the direction of Access Road 1, based on topography (Figure 2-4).

5.3 Materials Impacted by Ore-Transfer Activities, Including TENORM Volume Estimate

The preliminary volume estimates of materials impacted by ore-transfer activities, including TENORM, is approximately 10,700 cubic yards (yd^3), as shown on Figures 5-2a, 5-2b, and 5-2c and presented in Table 5-1. This estimate was calculated according to the multiple-lines-of-evidence approach presented in Section 3.11. The multiple-lines-of-evidence approach was used to categorize the area as naturally occurring or the result of historical Transfer Station impacts, including TENORM. The intent of the RSE in the CERCLA process is to provide a conceptual estimate of the nature and extent of soil impacts and the volume of materials impacted by ore-transfer activities, including TENORM evaluation. The levels at which cleanup will be required will be determined during the risk assessment, after which, potential removal actions will be evaluated in the EE/CA. Once the cleanup level and a removal action is selected, additional sampling may be conducted to further refine the extent and volume of materials impacted by ore-transfer activities, including TENORM, either during the design or implementation stage.

6. Transfer Station DQO, Uncertainties, and Data Gap Summary

6.1 Data Quality Objectives

An evaluation of the DQOs is presented in Table 6-1. The DQOs have been met; however, there are some data gaps discussed in Section 6.3.

6.2 Deviations

Access Road 1 was initially identified as a haul road; however, after further historical review, it was identified to not be associated with ore-transfer activities. Evaluation of the access road, including the collection of gamma scan measurements, was a deviation from the Work Plan by collecting extra data.

Section 4.2.3 of the RSE Work Plan Addendum states that “Subsurface soil samples at the BRAs and Group 1 Mine Sites are expected to be collected using a combination of drilling and hand tool methods, depending on accessibility, potential biological impact, and depth to bedrock at each area." Table 4-3 of the Work Plan Addendum provided the anticipated method of sampling at the Transfer Station and noted that the final sampling method would be determined in the field. However, a deviation is noted from Section 4.2.2 of the Work Plan Addendum, which states that “Subsurface soil samples will be collected by a track-mounted drill rig where accessible, and by using hand tools in areas where a drill rig cannot access" Subsurface soil samples at the Mancos Shale background location were collected with hand tools, even though it was potentially accessible by drill rig.

6.3 Uncertainties

The following uncertainties and data gaps have been identified and may be considered during additional evaluations, including the risk assessment and EE/CA, if required. Some data gaps may be permanent and unable to be addressed during subsequent work at the Transfer Station.

Uncertainties and their significance to the RSE process include the following:

- An exceedance of the IL is not a definitive indicator of impacts from historical operations. Site-specific cleanup levels will be calculated during the risk assessment in the EE/CA, and the volume of materials impacted by ore-transfer activities, including TENORM, may change.
- 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 Transfer Station during the RSE phase of work; however, Cyprus Amax is exploring additional methodologies for dose rate correlation at the Group 2 Mine Sites.

6.4 Data Gaps

A data gap evaluation was conducted. Additional work to fill 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 unable to be addressed during subsequent work or assessment at the Transfer Station.

The following data gaps were identified:

- Concentrations of COPCs within restricted areas cannot be fully investigated because no intrusive activities are allowed within these areas.
  - The western edge of the buffer area could not be fully investigated, because it coincides with the expanded U.S. Route 491. The gamma scan count rates near the expanded U.S. Route 491 are less

than the IL, suggesting the area is not impacted by materials impacted by ore-transfer activities, including TENORM. If materials impacted by ore-transfer activities, including TENORM, exists below the roadbed of the expanded U.S. Route 491, exposure would be limited. A natural gas line ROW limited soil sampling along the western edge of the Transfer Station, Haul Road 1, and Access Road 1. Access Road 1 (along the natural gas ROW) was not used for transferring ore to and from the Transfer Station, and gamma count rates along Access Road 1 were less than IL levels.

- 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 Transfer Station; however, Cyprus Amax is exploring additional methodologies for dose rate correlation at the Group 2 Mine Sites.
- The nature and extent of thorium was not delineated in Drainage 3. Thorium speciation and secular equilibrium studies will occur as a part of the Group 2 RSE investigation and may be used as an additional line of evidence. Results of that investigation may be applied to the Climax Transfer Station if appropriate. Additional sampling to delineate exceedances may be conducted if needed during the EE/CA
- The lateral extent of Ra-226 soil analytical concentrations exceeding the IL were not laterally bound, because several areas were restricted for collection of soil samples, specifically, the western edge of the buffer area (because of the gas pipeline ROW and U.S. Route 491) and to the east (because of the restricted areas). However, gamma scans in these areas are less than the BTV, which provides a line of evidence that these areas may not be affected.

7. Transfer Station Summary and Conclusions

The Transfer Station RSE revealed the following:

- The Transfer Station is located in Shiprock Chapter of the Navajo Nation. The Transfer Station consists of 5.7 acres.
- The Transfer Station was a temporary stockpiling area for uranium ore before it was transported to offsite regional mills. No mining or ore processing occurred at the Transfer Station.
- In 2008, NAML removed 600 yd^3 of Class B and C material from the Transfer Station and backfilled with Class A material less than 2 pCi/g Ra-226 (in this RSE, the investigation level for Ra-226 is 1.62 pCi/g) (NAMLRP 2008, 2009). NAML reported that the removed material was taken to VCA Plot 3 (NA-0806) in the Red Valley Area and was consolidated, buried, and capped. The removal area is centered within the Transfer Station and is approximately 0.5 acre and estimated to have an average excavation depth of 0.75 foot.

The Transfer Station RSE investigation concludes the following:

- The Mesa Verde cactus, a federally threatened species and Navajo endangered species, was identified at the Transfer Station. A 20-foot buffer around each plant is required to protect the species. Cyprus Amax's delineation of materials impacted by ore-transfer activities, including TENORM, was not impacted by the presence of the Mesa Verde cactus at the Transfer Station.
- Four warning signs were erected to deter the public from accessing the Transfer Station and therefore reduce human exposure. These signs also may limit access near the Mesa Verde cactus and habitat.
- IL exceedances of gamma count rates and of Ra-226 and metals in soil samples at the Transfer Station were concentrated and highest in areas near the NAML excavation area and areas topographically downgradient of the excavation area. IL exceedances predominately decrease with distance from the excavation area.
- COPCs identified at the Transfer Station include Ra-226, uranium, vanadium, and thorium because they exceed the IL. Compared with the U.S. regional background data, thorium was less than the average and vanadium was greater than the average but within the typical range in one surface soil sample collected.
- No secondary COPCs exceeding ILs were observed at the Transfer Station. As such, it is assumed that the Transfer Station was not impacted by any historical releases from machine maintenance, refueling, or use of electrical equipment.
- Ore was brought to the Transfer Station by Haul Road 1, directly off of U.S. Route 491, west of the Transfer Station. The western portion of Haul Road 1 was obscured during the expansion of U.S. Route 491 and the construction of the gas pipeline between 1978 and 1997.
- Access Road 1 (used by NAML during reclamation activities) was not used to haul ore to and from the Transfer Station, because it did not appear in historical aerial photographs until sometime between 1978 and 1997, which is well after the Mine Sites were mined and the Transfer Station was used (the 1950s and 1960s).
- Surface water flows across the Transfer Station and excavation area through ephemeral drainages exiting to the east may be a transport mechanism for COPCs. However, surface water or ponding was not observed on the Transfer Station during RSE field activities, which were conducted during the monsoon season. Transport of sediments above the IL are approximately 0.25 mile from the Transfer Station, with the nearest watercourse (Many Devils Wash) approximately 1 mile downgradient.
- Infiltration is limited because of the pan evaporation rate (approximately 73 inches per year) and an average annual rainfall of 7 inches. The highest average monthly rainfall occurs in August, with 1.01 inches and a pan evaporation rate of 10.80 inches. With an evaporation rate greater than rainfall, infiltration is expected to be minimal, stored in soil, and released through evaporation and transpiration without further, deeper, infiltration of water (Cadmus Group Inc. 2011).

- Groundwater was not observed in the four DOE wells located in Many Devils Wash, located approximately 1 mile east of the Transfer Station. These wells are screened at the interface of the alluvium and Mancos Shale (approximately 20 feet bgs). Absence of groundwater at the interface indicates that surface water has not infiltrated and resulted in groundwater. According to literature reviews, the Mancos Shale acts as an aquiclude to prohibit vertical migration of groundwater flow in the Transfer Station area.
- Downgradient drainage locations with thorium exceedances will be further evaluated in the risk assessment.
- Offsite mobilization via wind is not a significant transport mechanism, because gamma scan measurements are near background levels surrounding the Transfer Station.
- The correlation between gamma count rate (cpm) and Ra-226 surface soil concentrations (pCi/g) 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 correlation between gamma count rate (cpm) and dose rate (µrem/hr) was unable to achieve acceptable statistical performance criteria, and model validation indicated that predicted values were not aligned with measured values. Therefore, the correlation may not be used for estimating dose rate from gamma count rates. Cyprus Amax is exploring additional methodologies for dose rate correlation at Group 2 Mine Sites.
- The total lateral extent of materials impacted by ore-transfer activities, including TENORM, is approximately 2.60 acres; the volume estimates of materials impacted by ore-transfer activities, including TENORM, was estimated to be 10,700 yd^3.

8. References

American National Standards Institute (ANSI). 2013. N323AB: Radiation Protection Instrumentation Test and Calibration—Portable Survey Instruments.

ASTM International (ASTM). 2017. *D2487-17, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*. ASTM International, West Conshohocken, PA. http://www.astm.org/cgi-bin/resolver.cgi?D2487.

Brister, B.S, and Hoffman, G.K., 2002. Fundamental Geology of San Juan Basin Energy Resources. *New Mexico's Energy, Present and Future: Policy, Production, Economics, and the Environment. Decision-Makers Field Conference 2002*, *New Mexico's Energy, present and future Decision-Makers Field Conference 2002*. Brian S. Brister and L. Greer Price. The New Mexico Bureau of Geology and Mineral Resources.

Brown, Stuart, Cyprus Amax. 2017. Personal communication (email) with Linda Reeves, U.S. EPA. September 5.

Cadmus Group Inc. 2011. *Modeling Water Balance Covers for Colorado Ecozones.* September 28.

CH2M HILL Engineers, Inc. (CH2M). 2017. *Removal Site Evaluation Work Plan for Consent Decree Sites*. October.

CH2M HILL Engineers, Inc. (CH2M). 2018. *Draft Addendum to Removal Site Evaluation Work Plan for Consent Decree Sites: Group 1 Mine Sites*. August.

Cyprus Amax Minerals Company (Cyprus Amax). 2017. *Re: 94 Mine Sites, Consent Decree, Case Nos. 2:17-CV-00140-DLR and 3:17-CV-08007-DLR, Demonstration of Best Efforts to Secure Access to Group 1 Mine Sites*. September 5.

Dam, William L. 1995. *Geochemistry of Ground Water in the Gallup, Dakota, and Morrison Aquifers, San Juan Basin, New Mexico*. U.S. Geological Survey Water-Resources Investigation Report 94-4253.

Dinétahdóó Cultural Resources Management (DCRM). 2018. *A Cultural Resource Inventory of the Climax Transfer Station Site in Shiprock Chapter, San Juan County, New Mexico for Jacobs.* August.

Jacobs Engineering Group Inc. (Jacobs). 2019 *Climax Transfer Station Sign Installation.* November 1.

Kautsky, Mark, U.S. DOE. 2021. Personal communication (email) with Gavin Wagoner, Jacobs. June 18.

Meteoblue. 2019. "Simulated historical climate & weather data for Shiprock." *Climate (modelled).* https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/shiprock_united-states-of-america_5491288. Accessed May 2019.

Myers, Gregory. 2010. *Technical Report of the Hosta Butte Property, McKinley County, New Mexico*. Prepared for Dauntless Capital Corporation. May 26.

Navajo Abandoned Mine Lands Reclamation Program (NAMLRP). 2008. *Morrison AML Maintenance Project, Proposal Documents.* July.

Navajo Abandoned Mine Lands Reclamation Program (NAMLRP). 2009. *Final Inspection and Close-out Meeting for Morrison Abandoned Mine Lands Maintenance Program*. April.

Navajo Abandoned Mine Lands Reclamation Program (NAMLRP). 2013. Navajo AML/UMTRA Department, USDOE/NAMLRP Meeting Presentation. May 30.

Navajo Abandoned Mine Lands Reclamation Program (NAMLRP). 2018. *Transfer Station Site Visit.* April.

Navajo Nation Department of Justice. 2017. Letter to Cyprus Amax Minerals Company: Access for Performing Environmental Work on Navajo Trust Lands. October 16.

Navajo Nation Department of Water Resources (NDWR). 2017. *Navajo Nation Department of Water Resources Database*.

Pliler, R., and J.A.S. Adams. 1962. *The Distribution of Thorium, Uranium, and Potassium in the Mancos Shale.* Elsevier Ltd.

R Core Team. 2018. R: A language and environment for statistical computing. The R Project for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Robertson, A.J., A.J. Ranalli, S.A. Austin, and B.R. Lawlis. 2016, *The source of groundwater and solutes to Many Devils Wash at a former uranium mill site in Shiprock, New Mexico*: U.S. Geological Survey Scientific Investigations Report 2016–5031, 54 p. http://dx.doi.org/10.3133/sir20165031.

Roux Associates, Inc. 2015. Initial White Paper on Cleanup Options for Navajo Abandoned Uranium Mines.

Shacklette, Hansford T. and Josephine G. Boerngen. 1984. *Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States*. U.S. Geological Survey Professional Paper 1270.

Stovern, Michael, Hector Guzman, Kyle P. Pine, Omar Félix, Matthew King, Wendell P. Ela, Eric A. Betterton, and Avelino Eduardo Sáez. 2016. *Windblown Dust Deposition Forecasting and Spread of Contamination around Mine Tailings.* https://www.researchgate.net/publication/292177430.

U.S. Department of Agriculture (USDA). 2002. *Rapid Watershed Assessment, Middle San Juan Watershed.* June.

U.S. Department of Energy (DOE). 2019a. *Legacy Management Geospatial Environmental Mapping System (GEMS)*. https://gems.lm.doe.gov/#. Accessed June 11, 2019.

U.S. Department of Energy (DOE). 2019b. Shiprock, New Mexico, Disposal Site. Fact Sheet. Accessed June 11, 2019. https://www.lm.doe.gov/Shiprock/ship_factsheet.pdf.

U.S. Environmental Protection Agency (U.S. EPA). 1999. “Understanding Variation in Partition Coefficient, Kd, Values.” *Volume II: Review of Geochemistry and Available Kd Values for Cadmium, Cesium, Chromium, Lead, Plutonium, Radon, Strontium, Thorium, Tritium (^{3}H), and Uranium*. EPA 402-R-99-004B. August.

U.S. Environmental Protection Agency (U.S. EPA). 2000. *Multi-Agency Radiation Survey and Site Investigation Manual.* EPA 402-R-97-016 rev 1, Rev 1. NUREG-1575. Prepared by U.S. Department of Energy, U.S. Environmental Protection Agency, Nuclear Regulatory Commission, and Department of Defense. August.

U.S. Environmental Protection Agency (U.S. EPA). 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process.* EPA QA/G-4. February.

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.

U.S. Environmental Protection Agency (U.S. EPA). 2010a. Navajo Abandoned Uranium Mine Site Screening Report, Climax Transfer Station AUM Site, Navajo AUM Northern Region. August.

U.S. Environmental Protection Agency (U.S. EPA). 2010b. *U.S. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review*. January.

U.S. Environmental Protection Agency (U.S. EPA). 2014. *Federal Actions to Address Impacts of Uranium Contamination in the Navajo Nation*. September.

U.S. Environmental Protection Agency (U.S. EPA) 2015. *ProUCL Version 5.1.002. Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations*. October.

U.S. Environmental Protection Agency (U.S. EPA). 2017. *Joint agency comments from U.S. EPA and NNEPA on the Group 1 RSE Work Plan received August 17, 2017.*

U.S. Environmental Protection Agency (U.S. EPA). 2018. *Technical Specifications, Shiprock AML Reclamation, Morrison Project Shiprock, New Mexico, Project No. NA-0829*. March.

U.S. Environmental Protection Agency (U.S. EPA). 2019a. *Climax Transfer Station Signs.* October 11, 2019.

U.S. Environmental Protection Agency (U.S. EPA). 2019b. Northern Agency Tronox Mines Draft Final Removal Site Evaluation Report. July

U.S. Fish and Wildlife Service (USFWS) 1998. *Final Endangered Species Act (ESA) Section 7 Consultation Handbook*. March. https://www.fws.gov/endangered/esalibrary/pdf/esa_section7_handbook.pdf.

U.S. Geological Survey (USGS). 1968. *Geology and Ground-Water Occurrence in Southeastern McKinley County, New Mexico*. Technical Report 35, New Mexico State Engineer. J. B. Cooper and E. E.

United States of America and the Navajo Nation. 2017. *Consent Decree.* Cyprus Amax Minerals Company and Western Nuclear, Inc. (defendants). United States District Court for the District of Arizona, Case 2:17-cv-00140-MHB. May 22.

Western Regional Climate Center (WRCC). 2019. *New Mexico Climate Summaries.* https://wrcc.dri.edu/summary/climsmnm.html.

Western Regional Climate Center (WRCC). 2021. *Evaporation Stations*. https://wrcc.dri.edu/Climate/comp_table_show.php?stype=pan_evap_avg

Whicker, R., P. Cartier, J. Cain, K. Milmine, and M. Griffin. 2008. “Radiological Site Characterizations: Gamma Surveys, Gamma/Radium-226 Correlations, and Related Spatial Analysis Techniques.” *Health Physics Journal*. S180. November.

Tables

Table 1-1. Jacobs Project Management Team

Climax Transfer Station 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
J.D. = Juris Doctor
M.S. = Master of Science
PMP = Project Management Professional

Table 4-1. Summary of Background Statistics
Climax Transfer Station Removal Site Evaluation Report

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)
Distribution	Lognormal	Normal	Lognormal	Lognormal	Normal	Normal	Lognormal	Normal	None
Minimum	3.1	0.0083	0.71	0.87	3	0.51	10	0.95	8352
Maximum	5.7	0.02	1.2	1.1	4.5	0.75	16	1.6	13890
Mean	4.1	0.0131	0.906	0.97	3.66	0.63	12.2	1.182	10848
Standard Deviation	0.606	0.00251	0.124	0.0661	0.397	0.0619	1.848	0.163	844
Outlier	No	No	No	No	No	No	No	No	No
95-95 UTL	5.63	0.020	1.22	1.13	4.57	0.78	16.9	1.56	12340
95% USL	5.93	0.020	1.28	1.16	4.72	0.8	17.9	1.62	13890

Notes:

Statistics were calculated using ProUCL Version 5.1 (U.S. EPA released 2015).
cpm = count(s) per minute
mg/kg = milligram(s) per kilogram
pCi/g = picocurie(s) per gram
U.S. EPA = U.S. Environmental Protection Agency
USL = upper simultaneous limit
UTL = upper tolerance limit

Table 4-2. Soil Sample Laboratory Results - Background Reference Area
Climax Transfer Station Removal Site Evaluation Report

Mine Site	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)	
Climax Transfer Station	SS-CT-B1-001-10082017	0	0.5	Mancos Shale	Hand Tools	-108.707041	36.737615	10/09/2017	9803	6	3.9		0.82		0.96	J	3.2		0.63		12		0.012	J	0.98	
Climax Transfer Station	SS-CT-B1-002-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706815	36.73761	10/09/2017	10156	6	3.6		0.84		0.96	J	3.3		0.55		10		0.016	J	1.29	
Climax Transfer Station	SS-CT-B1-003-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706585	36.737671	10/09/2017	10117	6	3.8		0.83		0.89	J	3.4	J	0.57		12		0.014	J	1.07	
Climax Transfer Station	SS-CT-B1-004-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706464	36.737654	10/09/2017	10289	6	5.2		0.86		0.98	J	3.9		0.58		15		0.012	J	1.6	
Climax Transfer Station	SB-CT-B1-004-1.0-1.5-05082018	1	1.5	Mancos Shale	Hand Tools	-108.706464	36.737654	05/08/2018	10889	6	3.9	J	0.57	J	1	J	3.6	J	0.77	J	18	J	0.01	J	1.04	
Climax Transfer Station	SS-CT-B1-005-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706272	36.737618	10/09/2017	10549	8	3.9		0.82		0.94	J	3.5		0.56		12		0.011	J	1.22	
Climax Transfer Station	SS-CT-B1-006-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706151	36.737767	10/09/2017	10297	6	3.7		0.71		0.89	J	3.4		0.51		11		0.012	J	0.99	
Climax Transfer Station	SS-CT-B1-007-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706398	36.737826	10/09/2017	9541	5	4.1		0.86		0.94		3.5		0.7		14		0.014	J	1.13	
Climax Transfer Station	SS-CT-B1-008-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706582	36.737825	10/09/2017	10376	7	4.2		0.93		1.1		3.8		0.64		13		0.0088	J	1.12	
Climax Transfer Station	SS-CT-B1-009-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706809	36.737792	10/09/2017	9464	8	3.2		0.75		0.87	J	3		0.6		10		0.012	J	1.22	
Climax Transfer Station	SS-CT-B1-010-10082017	0	0.5	Mancos Shale	Hand Tools	-108.707012	36.737854	10/09/2017	9641	6	3.1		0.75		0.87	J	3.1		0.6		10		0.0083	J	1.11	
Climax Transfer Station	SS-CT-B1-011-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706982	36.737974	10/09/2017	9416	8	4.1		0.92		1		4		0.67		13		0.012	J	1.4	
Climax Transfer Station	SS-CT-B1-012-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706813	36.737959	10/09/2017	9635	5	3.8		0.88		0.92	J	3.5		0.7		11		0.014	J	1	
Climax Transfer Station	SS-CT-B1-013-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706627	36.737943	10/09/2017	9807	5	4.9		1.1		1.1	J	4.1		0.7		14		0.014	J	1.4	
Climax Transfer Station	SS-CT-B1-014-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706407	36.737982	10/09/2017	10495	7	4.3		0.83		1	J	3.7		0.56		13		0.016	J	1.09	
Climax Transfer Station	SS-CT-B1-015-10082017	0	0.5	Mancos Shale	Hand Tools	-108.70621	36.737943	10/09/2017	10377	6	5.1		1.1		1.1		4.5		0.63		16		0.012	J	1.26	J
Climax Transfer Station	SS-CT-B1-016-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706163	36.738108	10/09/2017	10263	6	4		1.1		0.98	J	3.5		0.68		10		0.0092	J	1.14	
Climax Transfer Station	SS-CT-B1-017-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706393	36.738165	10/09/2017	10641	5	3.6		0.9		0.97	J	3.5		0.65		10		0.014	J	0.95	
Climax Transfer Station	SB-CT-B1-017-1.0-1.5-05082018	1	1.5	Mancos Shale	Hand Tools	-108.706393	36.738165	05/08/2018	11434	7	3.5		1		0.96		3.1		0.74		10		0.0087	J	1.14	
Climax Transfer Station	SS-CT-B1-018-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706659	36.738181	10/09/2017	10338	6	4.2		0.88		0.98	J	4.1		0.57		14		0.012	J	1.34	J
Climax Transfer Station	SS-CT-B1-019-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706863	36.738114	10/09/2017	9668	6	3.9		0.84		0.89	J	3.3		0.67		11		0.016	J	1.21	
Climax Transfer Station	SS-CT-B1-020-10082017	0	0.5	Mancos Shale	Hand Tools	-108.707053	36.738148	10/09/2017	9478	6	5.7		1.2		1		4.4		0.75		16		0.02	J	1.37	J
Climax Transfer Station	SS-CT-B1-021-10082017	0	0.5	Mancos Shale	Hand Tools	-108.707033	36.738329	10/09/2017	10414	7	3.8		0.9		0.9	J	3.5		0.67		11		0.014	J	1.24	
Climax Transfer Station	SS-CT-B1-022-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706795	36.738284	10/09/2017	10776	8	4.3		0.93		1		4.2		0.69		13		0.013	J	1	
Climax Transfer Station	SS-CT-B1-023-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706574	36.738301	10/09/2017	10656	7	3.8		0.95		0.99		3.6		0.68		11		0.014	J	1.2	
Climax Transfer Station	SB-CT-B1-023-1.0-1.5-05082018	1	1.5	Mancos Shale	Hand Tools	-108.706574	36.738301	05/08/2018	11746	8	3.7		1.2		1.4		3.6		0.86		9.9		0.012	J	1.23	
Climax Transfer Station	SS-CT-B1-024-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706425	36.738304	10/09/2017	10880	7	4.6		1.1		1	J	4		0.71		11		0.015	J	1.26	
Climax Transfer Station	SS-CT-B1-025-10082017	0	0.5	Mancos Shale	Hand Tools	-108.706219	36.738335	10/09/2017	10169	5	3.8		0.86		0.95	J	3.5		0.6		12		0.013	J	0.97	
Quality Control Samples [e]																										
Climax Transfer Station	SS-CT-B1-003-10082017-DUP	0	0.5	Mancos Shale	Hand Tools	-108.706585	36.737671	10/09/2017	----	----	3.9		0.84		0.88	J	3.5		0.59		12		0.015	J	1.21	
Climax Transfer Station	SB-CT-B1-004-1.0-1.5-05082018-DUP	1	1.5	Mancos Shale	Hand Tools	-108.706464	36.737654	05/08/2018	----	----	3.8		0.6		0.87	J	3.4		0.69		16		0.01	J	0.97	
Climax Transfer Station	SS-CT-B1-013-10082017-DUP	0	0.5	Mancos Shale	Hand Tools	-108.706627	36.737943	10/09/2017	----	----	4.0		0.84		0.97	J	3.7		0.61		12		0.011	J	1.19	
Climax Transfer Station	SS-CT-B1-023-10082017-DUP	0	0.5	Mancos Shale	Hand Tools	-108.706574	36.738301	10/09/2017	----	----	4.0		0.99		0.93	J	3.7		0.69		11		0.015	J	1.47	

Notes:

[a] Location coordinates are in geographic coordinate system WGS 84, decimal degrees. West longitudes are designated as negative.
[b] Gamma count rate from 1 minute static reading from Ludlum 2221 2×2 NaI detector from one inch above the sample jar for subsurface soil.
[c] Gamma count rate from 1 minute static reading from Ludlum 2221 2×2 NaI detector from a height of 18 inches above ground prior to sample collection for surface soil.
[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 to 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.
μrem/hr = microrem per hour
cpm = count(s) per minute
J = Estimated. This qualifier indicates that the analyte was detected, but should be considered estimated.
mg/kg = milligram(s) per kilogram
NaI = sodium iodide
pCi/g = picocurie(s) per gram
U.S. EPA = U.S. Environmental Protection Agency
WGS = World Geodetic System

Table 4-3. Investigation Levels for Primary COPCs in Surface and Subsurface Soil
Climax Transfer Station Removal Site Evaluation Report

Criteria	Primary COPCs[a,b]								Gamma Count Rate[d] (cpm)
	Arsenic (mg/kg)	Mercury (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Thorium (mg/kg)	Uranium (mg/kg) [c]	Vanadium (mg/kg)	Ra-226 (pCi/g)	
Regional Screening Level[c]	0.68	**11.00**	**390.00**	**390.00**	- -	**16.00**	**390.00**	- -	- -
Background Threshold Values - Mancos Shale	**5.93**	0.02	1.28	1.16	**4.72**	0.80	17.90	**1.62**	13900

Notes:

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

[b] Results rounded to two significant figures

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

[d] Based on U.S. EPA RSLs for residential soil (June 2017) and a target hazard quotient of 1.0

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

- - = not applicable

BTV = background threshold value

COPC = contaminant of potential concern

cpm = count(s) per minute

mg/kg = milligram(s) per kilogram

pCi/g = picocurie(s) per gram

RSL = regional screening level

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

Table 4-4. Investigation Levels for Secondary COPCs in Surface and Subsurface Soil
Climax Transfer Station Removal Site Evaluation Report

Analyte[a]	Unit	Investigation Level[b]	Reporting Limit
TPH-Purgable (gas range organics)	mg/kg	82	1
TPH-Extractable (diesel range organics)	mg/kg	96	10
TPH-Extractable (motor oil range)	mg/kg	2500	20
Aroclor-1016	µg/kg	4100	0.033
Aroclor-1221	µg/kg	200	0.033
Aroclor-1232	µg/kg	170	0.033
Aroclor-1242	µg/kg	230	0.033
Aroclor-1248	µg/kg	230	0.033
Aroclor-1254	µg/kg	240	0.033
Aroclor-1260	µg/kg	240	0.033

Notes:

[a] U.S. EPA Method SW8015B and SW8082

[b] Based on U.S. EPA regional screening levels for residential soil (June 2017)

COPC = contaminant of potential concern

µg/kg = microgram(s) per kilogram

mg/kg = milligram(s) per kilogram

TPH = total petroleum hydrocarbons

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

Table 4-5. Gamma Scan Bin Ranges
Climax Transfer Station Removal Site Evaluation Report

Level	Geology	Mancos Shale
1	BTV	0 to 13900 cpm
2	BTV to IL	13901 to 15400 cpm
3	IL to 2 times BTV	15401 to 27800 cpm
4	2 to 5 times BTV	27801 to 69500 cpm

Notes:

BTV = background threshold value

cpm = count(s) per minute

IL = Investigation Level

Table 4-6. Sample Descriptions
Climax Transfer Station Removal Site Evaluation Report

Sample Location Identification	Sample Depths (feet)	Maximum Boring Depth (feet)	Reason for Boring Termination	Presence of Residual Ore
01-D1-001	0.0–0.5	0.5	Surface sample only	No residual ore observed
01-D1-002	0.0–0.5	0.5	Surface sample only	No residual ore observed
01-D2-001	0.0–0.5, 1.0–1.5, 3.0–3.5	3.5	Bedrock	No residual ore observed
01-D2-002	0.0–0.5	0.5	Surface sample only	No residual ore observed
01-D2-003	0.0–0.5	0.5	Surface sample only	No residual ore observed
01-D2-004	0.0–0.5	0.5	Surface sample only	No residual ore observed
01-D3-001	0.0–0.5, 1.0–1.5, 2.4–2.9	3.0	Bedrock	No residual ore observed
01-D3-002	0.0–0.5, 1.0–1.5, 3.0–3.5	3.5	Gamma count less than 2× BTV	No residual ore observed
01-D3-003	0.0–0.5, 1.0–1.5, 2.5–3.0	3.0	Bedrock	No residual ore observed
01-MS-001	0.0–0.5, 1.0–1.5, 3.0–3.5	4.0	Bedrock	No residual ore observed
01-MS-002	0.0–0.5	0.5	Surface sample only	No residual ore observed
01-MS-003	0.0–0.5. 1.0–1.5, 1.5–2.0	2.1	Bedrock	No residual ore observed
01-MS-004	0.0–0.5	0.5	Surface sample only	No residual ore observed
01-MS-005	0.0–0.5, 1.0–1.5, 3.0–3.5	3.6	Bedrock	No residual ore observed
01-MS-006	0.0–0.5	0.5	Surface sample only	No residual ore observed
01-MS-007	0.0–0.5, 1.0–1.5, 3.0–3.5	3.5	Bedrock	No residual ore observed
01-MS-008	0.0–0.5	0.5	Surface sample only	No residual ore observed
01-MS-009	0.0–0.5, 1.0–1.5, 2.5–3.0	3.0	Bedrock	No residual ore observed
01-MS-010	0.0–0.5, 1.0–1.5, 1.9–2.4	2.5	Bedrock	No residual ore observed
01-MS-011	0.0–0.5, 1.0–1.5, 3.0–3.5	3.5	Bedrock	No residual ore observed
01-MS-012	0.0–0.5, 1.0–2.0, 3.0–4.0, 4.0–5.0	5.0	Bedrock	No residual ore observed
01-MS-013	0.0–0.5, 1.0–2.0	2.3	Bedrock	No residual ore observed
01-MS-014	0.0–0.5, 1.0–2.0, 3.0–3.5	3.5	Bedrock	No residual ore observed

Notes:

2× = two times

BTV = background threshold value

Table 4-7. Laboratory Results for Primary COPCs in Surface and Subsurface Soil

Climax Transfer Station Removal Site Evaluation Report

Mine Site	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)[e]	Arsenic		Mercury		Molybdenum		Selenium		Thorium		Uranium		Vanadium		Radium-226	
											(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(pCi/g)	
										IL[d]	5.93		11.00		390.00		390.00		4.72		16.00		390.00		1.62	
										BTV	5.93		0.02		1.28		1.16		4.72		0.80		17.90		1.62	
Climax Transfer Station	SD-01-D1-001-01082018	0.0	0.5	Mancos Shale	Hand Tools	-108.700562	36.747641	01/08/2018	8258	7.0	3.7		0.013	J	0.94		**1.3**		4.2		**0.87**		12		1.39	
Climax Transfer Station	SD-01-D1-002-01082018	0.0	0.5	Mancos Shale	Hand Tools	-108.699392	36.747814	01/08/2018	13761	8.0	3.7		0.013	J	1.1		**1.2**		4.0		0.8		11		1.34	
Climax Transfer Station	SD-01-D2-001-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.700722	36.747148	10/21/2017	13588	7.0	3.2		0.011	J	0.93		1.0	J	4.0		**2.2**		**20**		**2.5**	
Climax Transfer Station	SB-01-D2-001-1.0-1.5-06062018	1.0	1.5	Mancos Shale	Drill Rig	-108.700743	36.747145	06/06/2018	8207	9.0	5.4		**0.05**	J	**1.3**		**1.2**		**5.9**		**0.96**		11		1.24	
Climax Transfer Station	SB-01-D2-001-3.0-3.5-06062018	3.0	3.5	Mancos Shale	Drill Rig	-108.700743	36.747145	06/06/2018	8546	11	5.1		**0.053**	J	1.2		**1.2**		**6.2**		**0.87**		12		1.29	
Climax Transfer Station	SD-01-D2-002-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.699924	36.747473	10/21/2017	12362	5.0	4.0		0.013	J	1.1		0.93	J	4.5		0.73		14		1.13	
Climax Transfer Station	SD-01-D2-003-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.697893	36.747787	10/21/2017	13037	6.0	4.0		0.014	J	**1.3**		1.1		4.4		**1.2**		14		1.53	
Climax Transfer Station	SD-01-D2-004-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.697375	36.747679	10/21/2017	12701	7.0	3.6		0.014	J	1.2		1.0	J	4.0		0.76		11		1.2	
Climax Transfer Station	SD-01-D3-001-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.701293	36.745322	10/21/2017	11902	5.0	3.6		0.012	J	1.0		0.95	J	4.1		**1.4**		14		1.62	
Climax Transfer Station	SB-01-D3-001-1.0-1.5-06052018	1.0	1.5	Mancos Shale	Drill Rig	-108.701305	36.745328	06/05/2018	- -	- -	2.2		**0.021**	J	1.1		**1.3**		3.8		**2.3**		6.6		1.29	
Climax Transfer Station	SB-01-D3-001-2.4-2.9-06052018	2.4	2.9	Mancos Shale	Drill Rig	-108.701305	36.745328	06/05/2018	- -	- -	2.9		**0.025**	J	0.99		1.1		4.2		**0.89**		7.2		1.37	
Climax Transfer Station	SD-01-D3-002-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.699367	36.743182	10/21/2017	11359	6.0	5.0		**0.027**	J	**1.3**		1.1		**5.9**		**1.4**		14		1.32	
Climax Transfer Station	SB-01-D3-002-1.0-1.5-06052018	1.0	1.5	Mancos Shale	Drill Rig	-108.69938	36.743194	06/05/2018	- -	- -	3.3		0.0082	J	0.95		1.0		4.0		0.66		11		1.25	
Climax Transfer Station	SB-01-D3-002-3.0-3.5-06052018	3.0	3.5	Mancos Shale	Drill Rig	-108.69938	36.743194	06/05/2018	- -	- -	3.1		0.0093	J	1.0		**1.5**		3.9		0.67		10		0.99	
Climax Transfer Station	SD-01-D3-003-06052018	0.0	0.5	Mancos Shale	Hand Tools	-108.700431	36.744738	06/05/2018	- -	- -	3.2		0.017	J	0.95		0.93	J	3.9		**0.9**		11		**1.64**	
Climax Transfer Station	SB-01-D3-003-1.0-1.5-06052018	1.0	1.5	Mancos Shale	Drill Rig	-108.700431	36.744738	06/05/2018	- -	- -	3.0		0.02	J	1.0		**1.2**		4.0		**1.1**		11		1.03	
Climax Transfer Station	SB-01-D3-003-2.5-3.0-06052018	2.5	3.0	Mancos Shale	Drill Rig	-108.700431	36.744738	06/05/2018	- -	- -	4.7		**0.047**	J	**1.7**		**1.2**		**5.2**		**0.88**		11		1.53	
Climax Transfer Station	SS-01-MS-001-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.702499	36.746634	10/21/2017	15325	7.0	2.8		0.012	J	0.94		1.0		3.8		**5.8**		**47**		**6.64**	
Climax Transfer Station	SB-01-MS-001-1.0-1.5-06052018	1.0	1.5	Mancos Shale	Drill Rig	-108.702499	36.746641	06/05/2018	- -	- -	2.4		0.019	J	0.87		0.9	J	4.4		**2.6**		7.5		1.06	
Climax Transfer Station	SB-01-MS-001-3.0-3.5-06052018	3.0	3.5	Mancos Shale	Drill Rig	-108.702499	36.746641	06/05/2018	- -	- -	2.5		**0.032**	J	0.94		1.0	J	4.1		0.66		7.1		1.12	
Climax Transfer Station	SS-01-MS-002-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.702342	36.746827	10/21/2017	14019	7.0	3.4		0.017	J	0.93		**1.2**		4.1		**1.9**		13		**1.82**	
Climax Transfer Station	SS-01-MS-003-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.701937	36.747045	10/21/2017	19374	9.0	4.3		0.019	J	0.95		**1.2**		4.5		**12**	J	**63**		**6.75**	
Climax Transfer Station	SB-01-MS-003-1.0-1.5-06062018	1.0	1.5	Mancos Shale	Drill Rig	-108.701962	36.747043	06/06/2018	7920	10	3.6		**0.039**	J	1.2		1.1		4.7		**1.9**	J	8.7		1.07	
Climax Transfer Station	SB-01-MS-003-1.5-2.0-06062018	1.5	2.0	Mancos Shale	Drill Rig	-108.701962	36.747043	06/06/2018	8429	11	4.8		**0.039**	J	**1.4**		1.1		**5.3**		0.79		9.3		1.44	
Climax Transfer Station	SS-01-MS-004-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.701507	36.746878	10/21/2017	15267	7.0	5.7		**0.033**	J	1.0		**1.3**		**5.8**		**2.0**		**26**		**2.39**	
Climax Transfer Station	SS-01-MS-005-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.701341	36.746677	10/21/2017	15049	10	3.8		0.018	J	1.0		**1.2**		4.5		**5.4**		**44**		**4.82**	
Climax Transfer Station	SB-01-MS-005-1.0-1.5-06062018	1.0	1.5	Mancos Shale	Drill Rig	-108.701341	36.746691	06/06/2018	8126	12	4.4		**0.049**	J	**1.3**		**1.2**		**4.9**		**1.9**		10		1.25	
Climax Transfer Station	SB-01-MS-005-3.0-3.5-06062018	3.0	3.5	Mancos Shale	Drill Rig	-108.701341	36.746691	06/06/2018	7437	12	5.0		**0.046**	J	**1.6**		**1.6**		**5.1**		0.73		10		1.39	
Climax Transfer Station	SS-01-MS-006-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.701496	36.746199	10/21/2017	16525	7.0	3.4		0.016	J	0.94		0.92	J	4.3		**3.7**		**23**		**2.77**	
Climax Transfer Station	SS-01-MS-007-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.701965	36.746683	10/21/2017	59522	35	2.8		0.0094	J	0.83		**3.2**		3.4		**95**		**450**		**61.8**	
Climax Transfer Station	SB-01-MS-007-1.0-1.5-06062018	1.0	1.5	Mancos Shale	Drill Rig	-108.701969	36.746691	06/06/2018	7992	12	4.9		**0.038**	J	**1.3**		**1.3**		**5.8**		**8.2**		**30**		**1.96**	
Climax Transfer Station	SB-01-MS-007-3.0-3.5-06062018	3.0	3.5	Mancos Shale	Drill Rig	-108.701969	36.746691	06/06/2018	8006	12	4.3		**0.042**	J	**1.4**		**1.2**		**5.5**		**0.92**		11		1.4	
Climax Transfer Station	SS-01-MS-008-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.702118	36.746178	10/21/2017	16839	11	3.6		0.02	J	0.91		1.1		**4.8**		**7.0**		**43**		**5.81**	
Climax Transfer Station	SS-01-MS-009-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.702563	36.746312	10/21/2017	14951	7.0	2.9		0.014	J	0.98		**1.4**		3.5		**9.7**		**49**		**5.15**	
Climax Transfer Station	SB-01-MS-009-1.0-1.5-06052018	1.0	1.5	Mancos Shale	Drill Rig	-108.702569	36.746321	06/05/2018	- -	- -	3.1		**0.026**	J	1.2		1.1		4.7		**2.4**		8.0		1.49	
Climax Transfer Station	SB-01-MS-009-2.5-3.0-06052018	2.5	3.0	Mancos Shale	Drill Rig	-108.702569	36.746321	06/05/2018	- -	- -	2.3		**0.021**	J	0.88		0.86	J	3.7		0.61		6.4		1.27	
Climax Transfer Station	SS-01-MS-010-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.701682	36.745724	10/21/2017	20494	10	3.2		0.013	J	0.97		**1.2**		4		**23**		**98**		**11.2**	
Climax Transfer Station	SB-01-MS-010-1.0-1.5-06062018	1.0	1.5	Mancos Shale	Drill Rig	-108.701679	36.745728	06/06/2018	9469	14	2.4		**0.03**	J	1.1		1.1		3.9		**1.4**		7.3		1.26	
Climax Transfer Station	SB-01-MS-010-1.9-2.4-06062018	1.9	2.4	Mancos Shale	Drill Rig	-108.701679	36.745728	06/06/2018	9351	14	2.8		**0.031**	J	1.2		0.91	J	3.9		**1.4**		7.9		1.17	
Climax Transfer Station	SS-01-MS-011-10212017	0.0	0.5	Mancos Shale	Hand Tools	-108.701226	36.746964	10/21/2017	17128	10	4.1		0.017	J	0.99		**1.2**		**5**		**3.7**		**31**		**3.7**	
Climax Transfer Station	SB-01-MS-011-1.0-1.5-06062018	1.0	1.5	Mancos Shale	Drill Rig	-108.701227	36.746968	06/06/2018	8116	11	2.6		**0.022**	J	1.1		0.96	J	3.9		**1.7**		7.5		0.99	
Climax Transfer Station	SB-01-MS-011-3.0-3.5-06062018	3.0	3.5	Mancos Shale	Drill Rig	-108.701227	36.746968	06/06/2018	7842	12	3.2		**0.027**	J	**1.3**		1.1		4.6		0.74		**8.2**		1.3	
Climax Transfer Station	SS-01-MS-012-09272019	0.0	0.5	Mancos Shale	Hand Tools	-108.702263	36.746317	09/27/2019	19526	7	2.4		0.0086	J	0.77		**1.3**		3.8		**11**		**61**		**7.23**	
Climax Transfer Station	SB-01-MS-012-1.0-2.0-09272019	1.0	2.0	Mancos Shale	Drill Rig	-108.702263	36.746317	09/27/2019	12863	- -	2.6		0.015	J	0.74		**1.3**		4.4		0.74		11		1.25	
Climax Transfer Station	SB-01-MS-012-3.0-4.0-09272019	3.0	4.0	Mancos Shale	Drill Rig	-108.702263	36.746317	09/27/2019	13318	- -	4.9		**0.041**		0.93		**1.5**		**6**		**0.94**		14		1.52	
Climax Transfer Station	SB-01-MS-012-4.0-5.0-09272019	4.0	5.0	Mancos Shale	Drill Rig	-108.702263	36.746317	09/27/2019	13368	- -	4.0		0.029	J	1.2		**1.5**		**5.3**		**0.85**		13		1.31	
Climax Transfer Station	SS-01-MS-013-09272019	0.0	0.5	Mancos Shale	Hand Tools	-108.702329	36.746545	09/27/2019	15480	5	2.4		0.0086	J	0.83		**1.2**		4		**4**		**25**		**2.77**	
Climax Transfer Station	SB-01-MS-013-1.0-2.0-09272019	1.0	2.0	Mancos Shale	Drill Rig	-108.702329	36.746545	09/27/2019	13088	- -	2.4		0.012	J	0.7		1.1		4.4		0.72		10		1.35	
Climax Transfer Station	SS-01-MS-014-09272019	0.0	0.5	Mancos Shale	Hand Tools	-108.702129	36.746546	09/27/2019	19671	7	2.6	J	0.01	J	0.92		**1.7**		3.8		**45**		**290**		**13.7**	
Climax Transfer Station	SB-01-MS-014-1.0-2.0-09272019	1.0	2.0	Mancos Shale	Drill Rig	-108.702129	36.746546	09/27/2019	12991	- -	2.6		0.014	J	0.86		1.1		4.1		0.7		9.5		1.02	
Climax Transfer Station	SB-01-MS-014-3.0-3.5-09272019	3.0	3.5	Mancos Shale	Drill Rig	-108.702129	36.746546	09/27/2019	13320	- -	3.3		0.012	J	1.1		**1.2**		4.4		0.73		11		1.23	
Quality Control Samples [f]																										
Climax Transfer Station	SD-01-D2-003-10212017-DUP	0.0	0.5	Mancos Shale	Hand Tools	-108.697893	36.747787	10/21/2017	13037	- -	3.7		0.014	J	1.2		1.2		4.2		1.1		12		1.38	
Climax Transfer Station	SB-01-D3-001-1.0-1.5-06052018-DUP	1.0	1.5	Mancos Shale	Drill Rig	-108.701305	36.745328	06/05/2018	- -	- -	2.3		0.024	J	1.3		1.7		3.7		1.8		7		1.23	
Climax Transfer Station	SB-01-MS-003-1.0-1.5-06062018-DUP	1.0	1.5	Mancos Shale	Drill Rig	-108.701962	36.747043	06/06/2018	7920	- -	3.7		0.034	J	1.3		1.2		4.8		2.1		9		0.95	
Climax Transfer Station	SS-01-MS-003-10212017-DUP	0.0	0.5	Mancos Shale	Hand Tools	-108.701937	36.747045	10/21/2017	19374	- -	3.6		0.012	J	0.89		1.3		4.2		13		87		10.1	
Climax Transfer Station	SB-01-MS-009-1.0-1.5-06052018-DUP	1.0	1.5	Mancos Shale	Drill Rig	-108.702569	36.746321	06/05/2018	- -	- -	3.0		0.026	J	1.1		0.93	J	4.6		2.1		7.9		1.77	
Climax Transfer Station	SS-01-MS-011-10212017-DUP	0.0	0.5	Mancos Shale	Hand Tools	-108.701226	36.746964	10/21/2017	17128	- -	3.8		0.017	J	0.96		1.2		4.7		4.1		29		4.05	
Climax Transfer Station	SS-01-MS-014-09272019-DUP	0.0	0.5	Mancos Shale	Hand Tools	-108.702129	36.746546	09/27/2019	19671	- -	2.7		0.0078	J	0.99		2.4		3.8		65		290		21.1	

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 and for subsurface soil, the measurement is the on-contact sample jar reading, as collected from Ludlum 2221 2×2 NaI detector.

[c] Gamma radiation measurement from collimated 1 minute static reading from Ludlum 2221 2×2 NaI detector at 6 inches above ground prior to collection.

[d] The investigation level for each analyte is the higher of the U.S. EPA RSL and calculated background threshold value. For analytes in which there was no applicable RSL, the investigation level is equal to the background threshold value.

[e] 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.

[f] Quality Control samples were collected for field quality assurance and quality control and are not compared to investigation levels or background threshold values.

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.

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

Bold Data = Analytical detections exceeding the background threshold values

Bold Grey Data = Analytical detections exceeding the investigation level

- - = Not analyzed

µrem/hr = microrem per hour

BTV = Background Threshold Value

COPC = contaminant of potential concern

cpm = count(s) per minute

IL = investigation level

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

mg/kg = milligram(s) per kilogram

NaI = sodium iodide

pCi/g = picocurie(s) per gram

RSL = U.S. EPA Regional Screening Levels are based on a hazard quotient of 1.0 and a residential exposure scenario (June 2017)

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

WGS = The World Geodetic System

Table 4-8. Laboratory Results for Secondary COPCs in Surface and Subsurface Soil

Climax Transfer Station Removal Site Evaluation Report

									TPH by U.S. EPA Method SW8015				PCBs by U.S. EPA Method SW8082													
									Diesel Range Organics		Gasoline Range Organics		Aroclor 1016		Aroclor 1221		Aroclor 1232		Aroclor 1242		Aroclor 1248		Aroclor 1254		Aroclor 1260	
								U.S. EPA RSL[b]	(mg/kg)		(mg/kg)		(µg/kg)		(µg/kg)		(µg/kg)		(µg/kg)		(µg/kg)		(µg/kg)		(µg/kg)	
								-->	96		82		4100		200		170		230		230		240		240	
Mine Site	Sample Identification	Top of Sample Interval (feet)	Bottom of Sample Interval (feet)	Geologic Unit	Sample Method	Longitude[a]	Latitude[a]	Sample Date																		
Climax Transfer Station	SS-01-MS-007-10212017	0	0.5	Mancos Shale	Hand Tools	-108.701965	36.746683	10/21/2017	1.8	J	0.47	U	17	U	17	U	17	U	17	U	17	U	17	U	17	U
Climax Transfer Station	SB-01-MS-007-1.0-1.5-06062018	1	1.5	Mancos Shale	Drill Rig	-108.701969	36.746691	06/06/2018	5.2	U	- -		- -		- -		- -		- -		- -		- -		- -	
<u>Quality Control Samples [c]</u>																										
Climax Transfer Station	SB-01-MS-007-1.0-1.5-06062018-DUP	1	1.5	Mancos Shale	Hand Tools	-108.701969	36.746691	06/06/2018	5.1	U	- -		- -		- -		- -		- -		- -		- -		- -	
Climax Transfer Station	SS-01-MS-007-10212017-DUP	0	0.5	Mancos Shale	Drill Rig	-108.701965	36.746683	10/21/2017	5.6		0.48	U	17	U	17	U	17	U	17	U	17	U	17	U	17	U

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

[b] U.S. EPA RSLs are based on a Hazard Quotient of 1.0, a 1 × 10-6 target risk, and a residential exposure scenario (http://www.epa.gov/region9/superfund/prg/).

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

- - = Not analyzed

µg/kg = microgram(s) per kilogram

COPC = contaminant of potential concern
J = Estimated. This qualifier indicates that the analyte was detected, but should be considered estimated.
mg/kg = milligram(s) per kilogram
PCB = polychlorinated biphenyl
RSL = regional screening level
TPH = total petroleum hydrocarbons
U = The analyte was not detected above the indicated method detection limit.
U.S. EPA = U.S. Environmental Protection Agency
WGS = The World Geodetic System

Table 5-1. Mining Impacted Material or TENORM Volume Estimate Summary

Climax Transfer Station Removal Site Evaluation Report

TENORM Areas greater than the IL	Area (acres)	Depth (feet below ground surface)	Volume (cubic yards)
Area A	1.05	0.0 -1.0	1,700
Area B	0.1	0.0-2.0	300
Area C	1.25	0.0-3.5	7,100
Area D	0.2	0.0-5.0	1,600
Total	**2.6**	**N/A**	**10,700**

Notes:

IL = investigation level

N/A = Not applicable.

TENORM = technologically enhanced naturally occurring radioactive materials

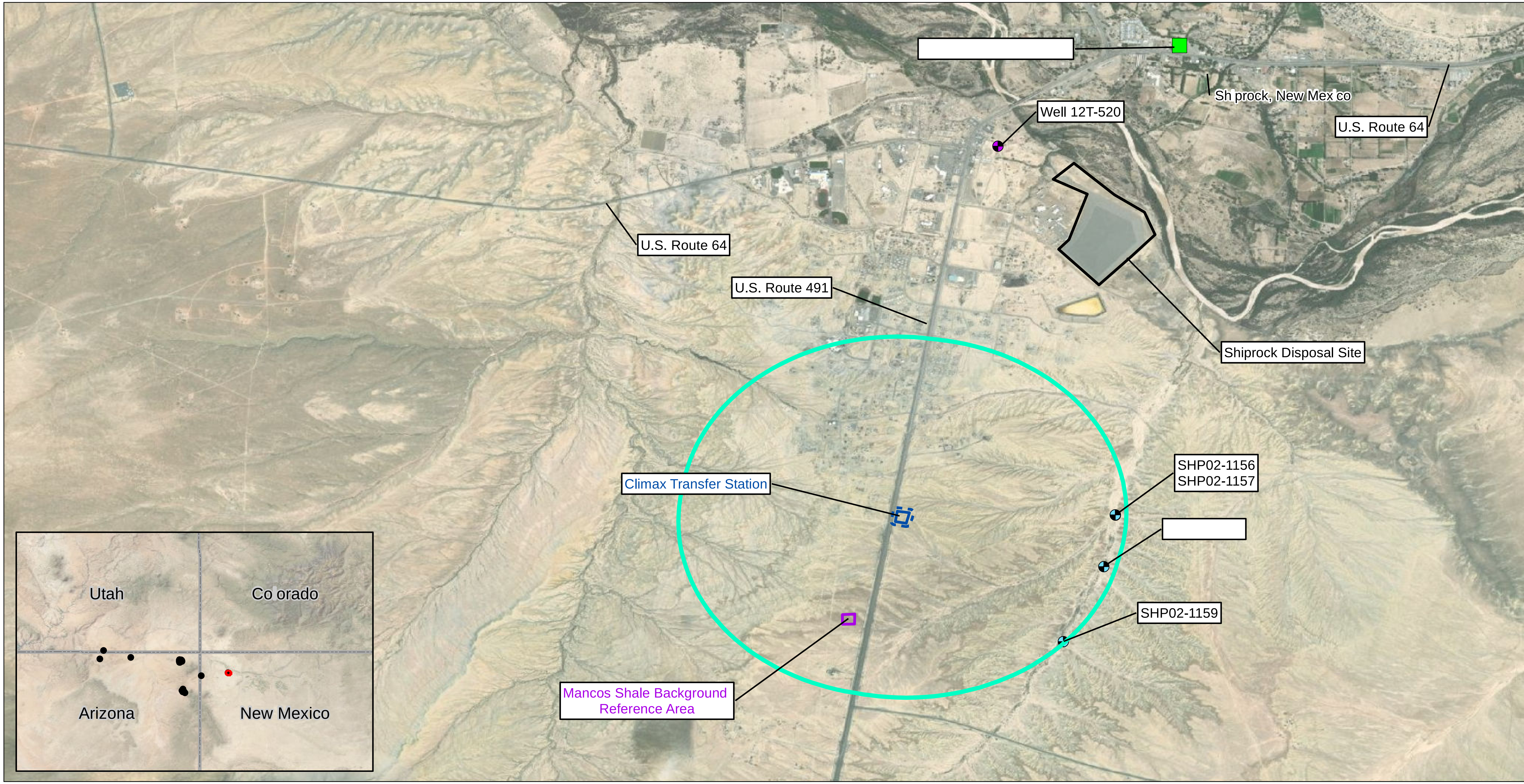
Table 6-1. Data Quality Objectives
Climax Transfer Station Removal Site Evaluation Report

DQO Number	Data Quality Objective	Data Quality Objective Met?	Supporting Information
1	Identify the background level of radiation and metal concentrations from naturally-occurring materials at the transfer station.	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 background reference area.	Section 4 presents the background investigation data and analysis. Table 4-1, 4-2 and 4-3 lists the background comparison values for the gamma count rate and the primary COPCs. Figure 4-1 shows the radiation survey results in the background reference area.
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. The type and extent of affected environmental media has been defined through gamma radiation survey, surface and subsurface soil sampling, and sediment sampling. Areas along U.S. Highway 491 and the Natural Gas Line right of way were restricted to soil sampling.	Results are presented in Table 4-7 and in Figures 4-2a through 4-2d. A discussion of type and extent is presented as part of Section 4. Data gaps are presented in Section 6.3.
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. Data was collected in accordance with the Work Plan to determine if a correlation existed between gamma count rate and Radium-226 and between gamma count rate and dose rate. The gamma/Radium-226 correlation is usable for estimating Radium-226 concentrations at the Mine Site within the data range used to create it. The gamma/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 4.6 and on Figures 4-4 through 4-6. Appendix F contains a detailed analysis of the correlations.
4	Identify if ore-transfer related activities such as blasting, machine maintenance and refueling, and use of electrical equipment result in releases of TPH, or PCBs.	This DQO has been met because sufficient data were collected in accordance with the Work Plan to evaluate if ore transfer activities released secondary COPCs into the environment. Trasfer Station soil sampling data indicated that all secondary COPCs were below the IL. Explosives, including perchlorate, were not sampled because this was an ore transfer station and no blasting occurred.	Results are presented in Section 4; Table 4-4 and 4-8 list the investigation levels 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. No ephemeral springs, streams or ponds within a 1-mile radius of the transfer station were identified in the Navajo Nation Department of Water Resources Database (NDWR 2017) or the U.S. EPA Atlas with Geospatial Data (U.S. EPA 2007). The DOE Legacy Management Geospatial Environmental Mapping System (DOE 2019) database identified four alluvial wells located in Many Devils Wash, approximately 1 mile east of the Climax Transfer Station boundary. During the RSE investigation, these wells were identified as dry and no samples were collected.	Groundwater data are presented and discussed in Section 4.7.
6	Estimate the volume of waste rock and impacted materials present at the transfer station.	This DQO has been met. The volume of TENORM has been estimated for the Transfer Station. The area and volume of TENORM was delineated using multiple lines of evidence, including historical information, vegetation disturbance mapping, geology and hydrology analysis, and site characterization data. The estimated area is 2.6 acres; the estimated volume is 10,700 cubic yards.	TENORM volume estimations are presented in Section 5.3. Areas and depths of TENORM volume estimations are presented in Figures 5-1a through 5-1d and Figure 5-2a through 5-2c.

Notes:

COPC = contaminant of potential concern
DOE = U.S. Department of Energy
DQO = data quality objective
NDWR = Navajo Nation Department of Water Resources
PCB = polychlorinated biphenyl
RSE = Removal Site Evaluation
TENORM = Technologically-enhanced naturally occurring radioactive material
TPH = total petroleum hydrocarbons
U.S. EPA = U.S. Environmental Protection Agency

Figures



LEGEND

- Shiprock Chapter House
- U.S. DOE Well Database Location Meeting RSE Work Plan Sampling Criteria
- Well Location Not Meeting RSE Work Plan Sampling Criteria
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary
- Background Reference Area
- 1-mile radius around Site
- Shiprock Disposal Site

Notes:
Water wells meeting the RSE Work Plan sampling criteria (CH2M, 2017) are shown in blue and sampling was attempted.
CH2M = CH2M HILL Engineers, Inc.
RSE = removal site evaluation
U.S. DOE = United States Department of Energy

0 1,500 3,000 6,000
Feet
1:36,000
1 inch = 3,000 feet
N

Sources:
1. CH2M, 2017. *Removal Site Evaluation Work Plan for Consent Decree Sites*. October.
2. U.S. DOE Legacy Management Geospatial Environmental Mapping System (GEMS). Accessed online May 2019.

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. Transfer Station Location Map
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE ES-1_TRANSFERSTATIONLOCATIONMAP.MXD CPOITRAS 4/6/2022 08:11:55

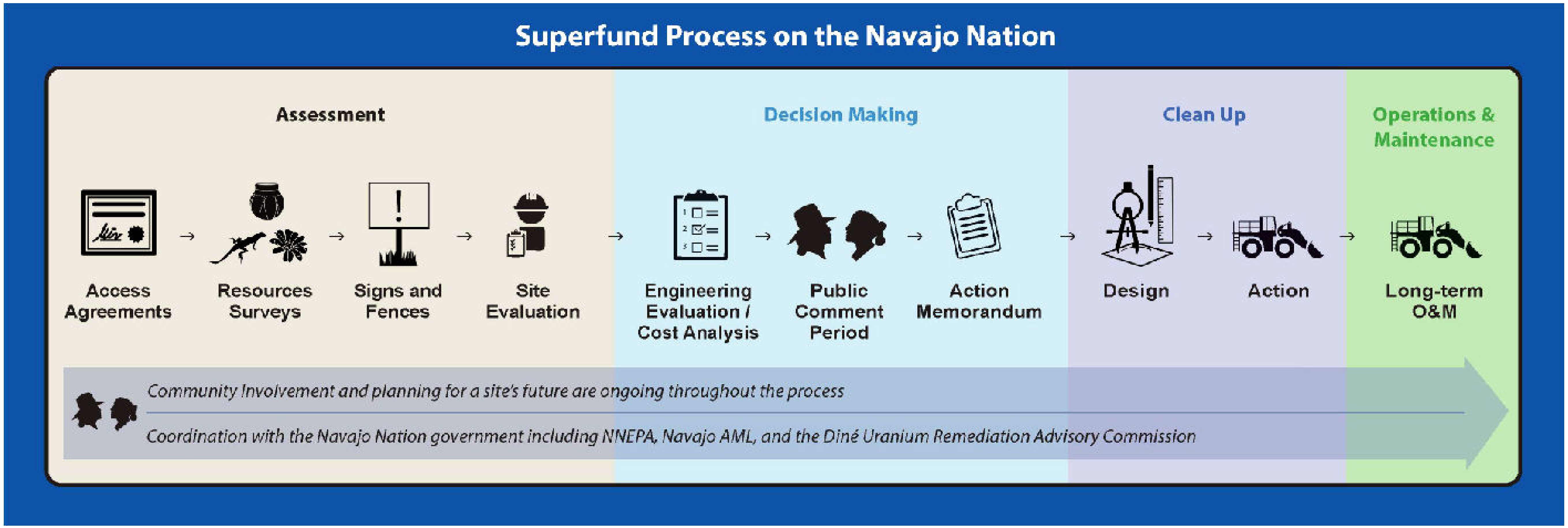
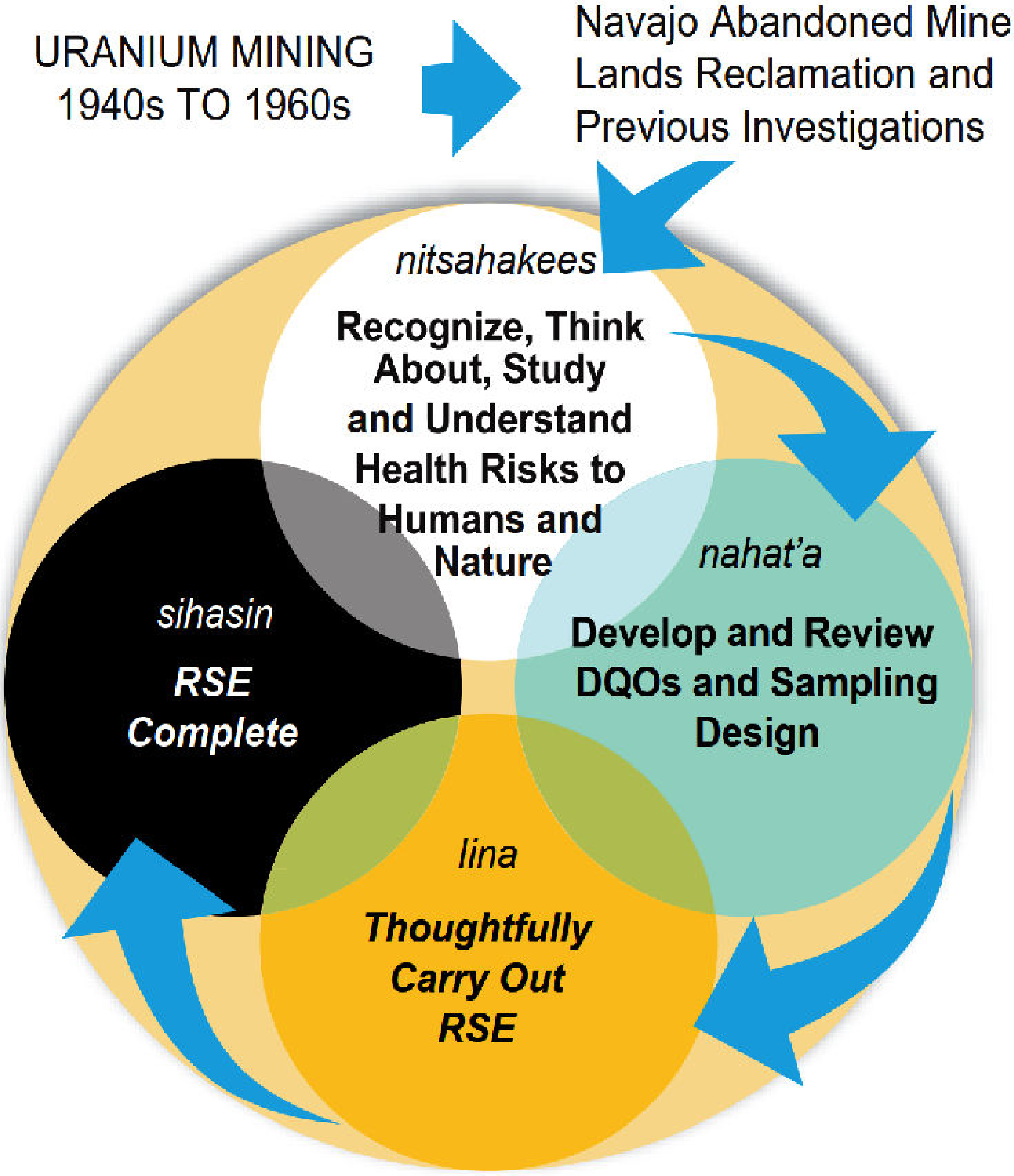


Figure 1-1. Superfund Process on the Navajo Nation
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

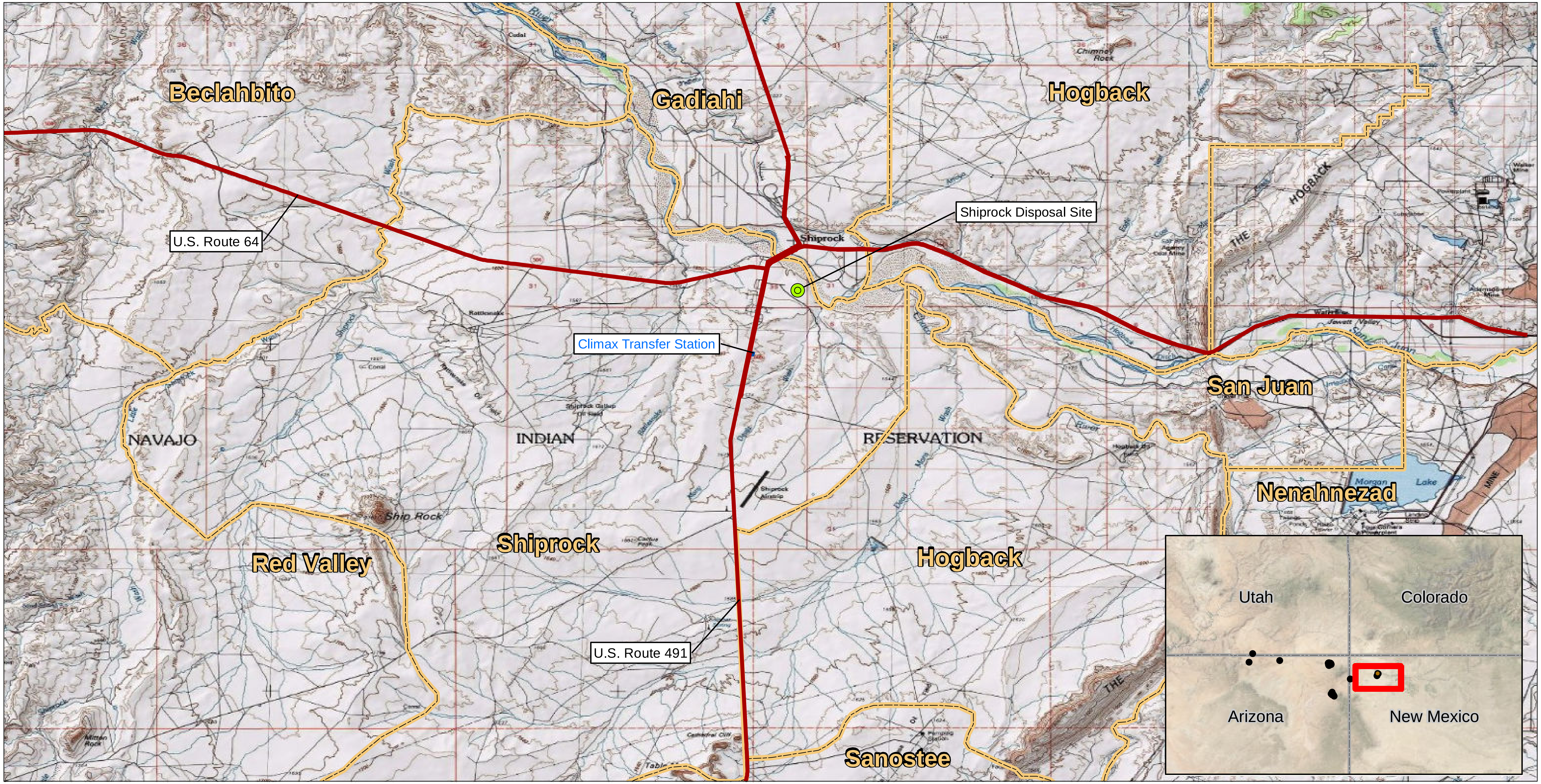
SLC W:\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\CLIMAXTRANSFERSTATION_MAINTEXTFIGURES\CLIMAXTRANSFERSTATION_MAINTEXTFIGURES.APRX CPOITRAS 6/17/2022 10:53:11



Notes:
DQO = Data Quality Objectives
RSE = Removal Site Evaluation

Figure 1-2. Decision Process
Climax Transfer Station
Removal Site Evaluation Report

JACOBS



LEGEND

Shiprock Disposal Site

Major Roads

Navajo Nation Chapter 2015

Group One Transfer Station Boundary

0 6,500 13,000 26,000
Feet

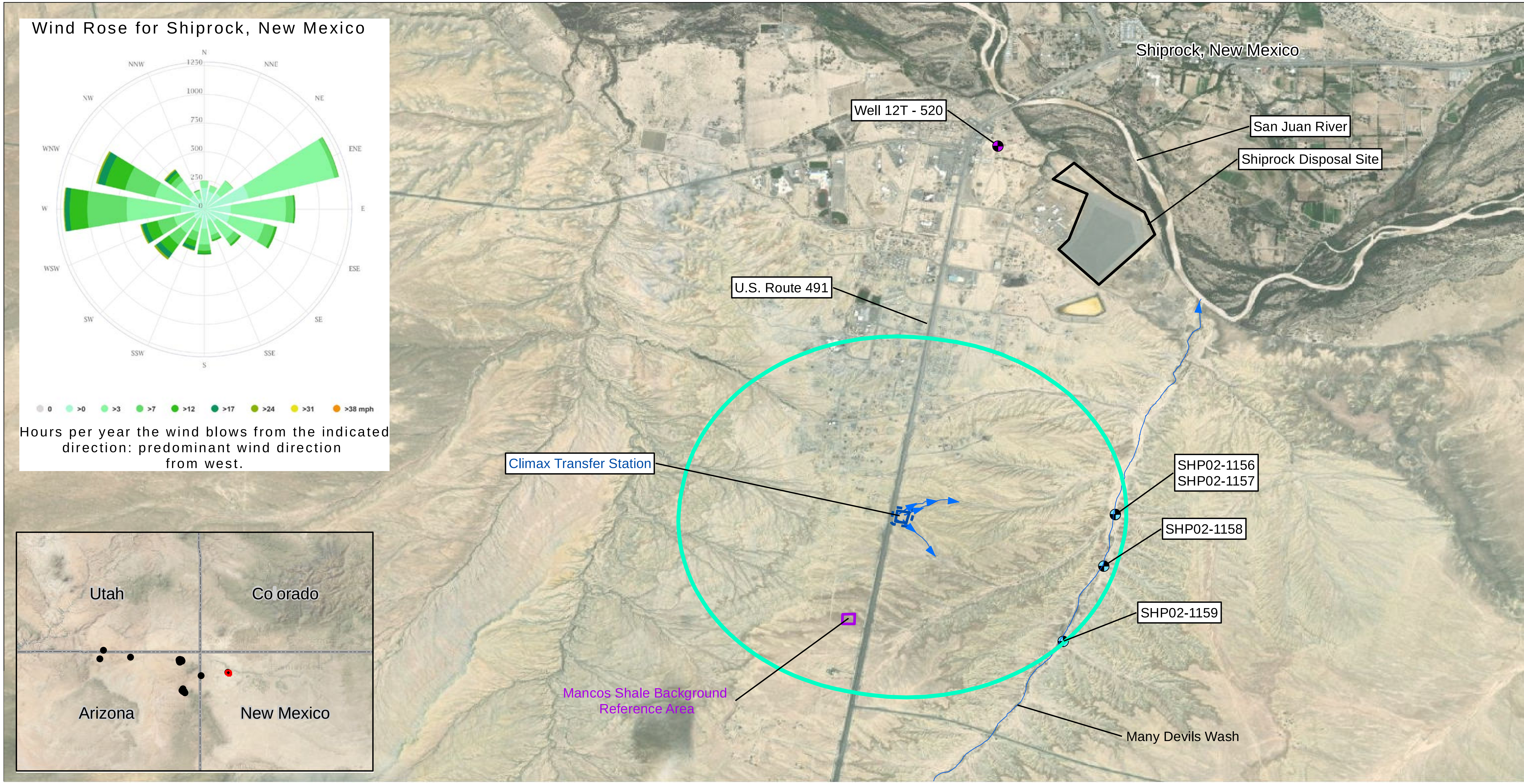
1:156,000 1 inch = 13,000 feet

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 1-3. Regional Location Map
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

SLC W:\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE 1-3_REGIONALLOCATIONMAP.MXD CPOITRAS 6/17/2022 10:47:05



LEGEND

- U.S. DOE Well Database Location Meeting RSE Work Plan Sampling Criteria
- Well Location Not Meeting RSE Work Plan Sampling Criteria
- Drainage
- Estimated Extent of Drainages (Not Field Verified)
- NHD Drainage Flowline
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary
- Background Reference Area
- 1-mile radius around Site
- Shiprock Disposal Site

Notes:
Water wells meeting the RSE Work Plan sampling criteria (CH2M, 2017) are shown in blue and sampling was attempted.
CH2M = CH2M HILL Engineers, Inc.
RSE = removal site evaluation
U.S. DOE = United States Department of Energy

Sources:
1. CH2M, 2017. *Removal Site Evaluation Work Plan for Consent Decree Sites*. October.
2. U.S. DOE Legacy Management Geospatial Environmental Mapping System (GEMS). Accessed online May 2019.
3. Wind Rose Source: https://www.meteoblue.com/en/weather/forecast/modelclimate/shiprock_united-states-of-america_5491288

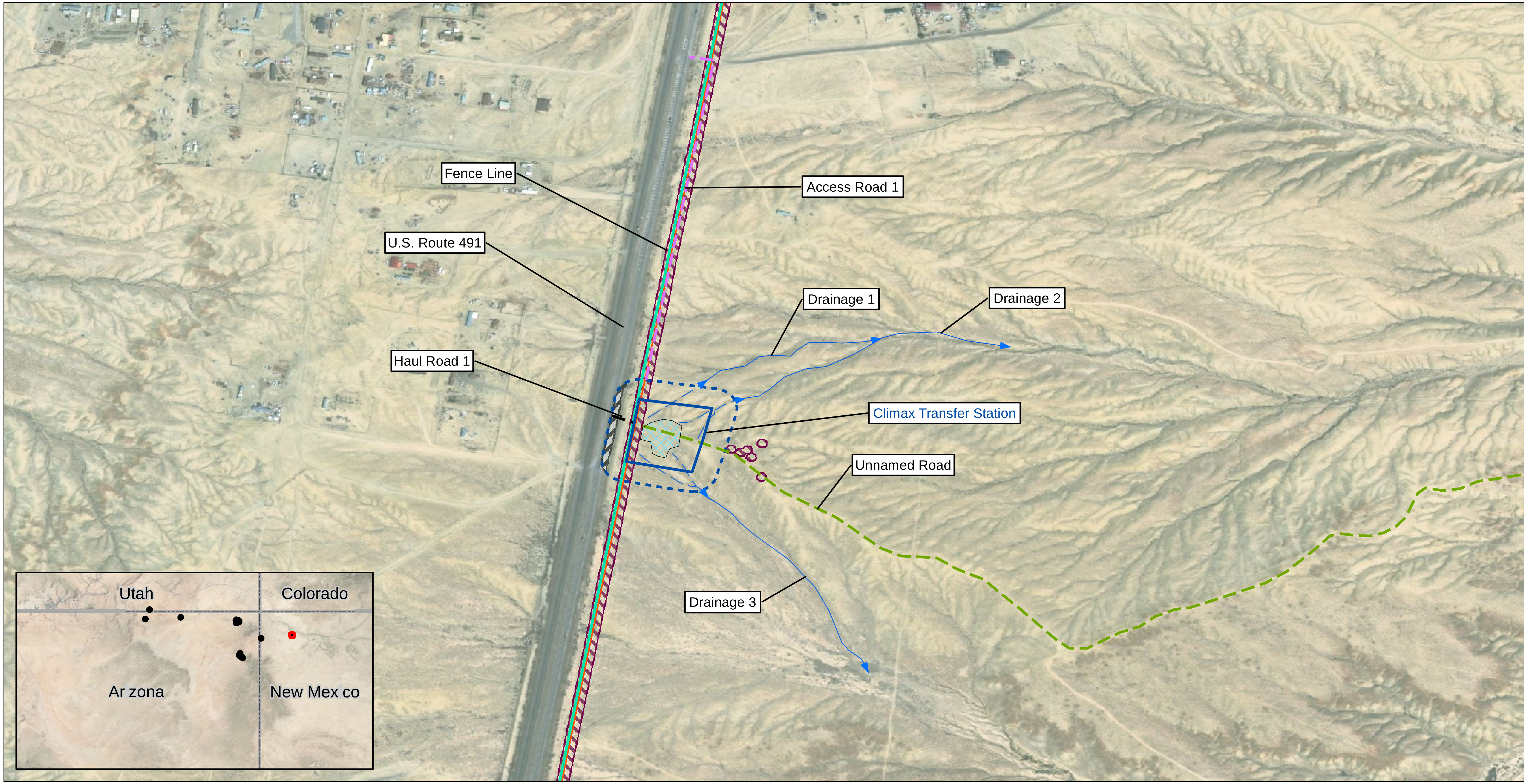
0 1,500 3,000 6,000
Feet
1:36,000
1 inch = 3,000 feet
N

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 1-4. General Location Map
Climax Transfer Station
Removal Site Evaluation Report

JACOBS®

SLC W:\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE 1-4_GENERALLOCATIONMAP.MXD CPOITRAS 6/17/2022 10:48:31



LEGEND

- Climax Transfer Station
- Drainage
- Estimated Extent of Drainages (Not Field Verified)
- Access Road
- Former Haul Road
- Unnamed Road
- Fence Line
- Gas Pipeline
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary
- NAML Technical Specifications of Excavation Disturbed Area
- Restricted Area
- Inaccessible Area

Notes:
NAML = Navajo Abandoned Mine Lands

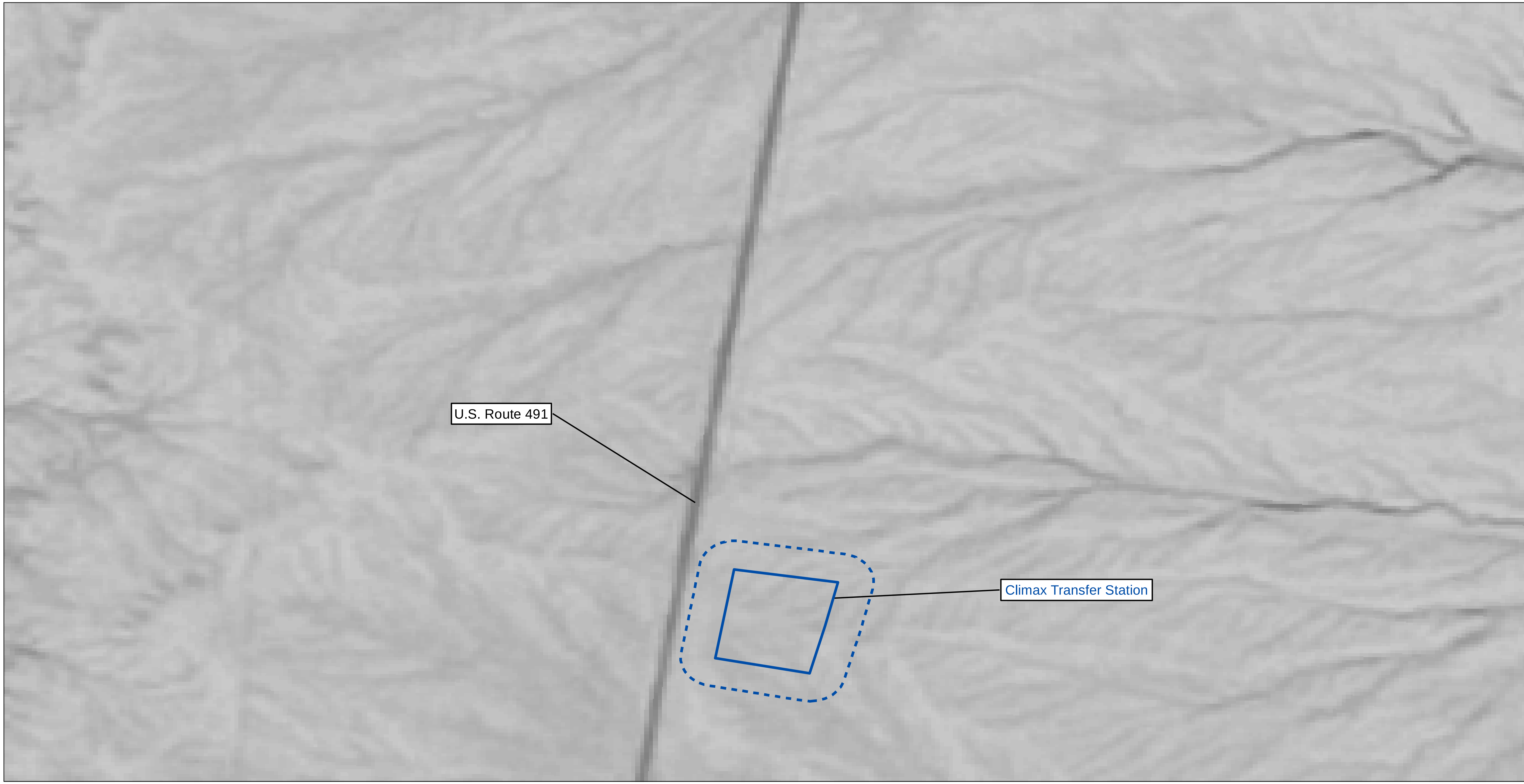
N
0 250 500 1,000
Feet
1:6,000 1 inch = 500 feet

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 2-1. Transfer Station Layout
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE 2-1_CLIMAX_TRANSFER_STATION_SITE_LAYOUT.MXD CPOITRAS 4/6/2022 08:36:32



LEGEND

100-foot Transfer Station Buffer

Group One Transfer Station Boundary

0 175 350 700
Feet
1:4,200 1 inch = 350 feet

Figure 2-2a. Historical Aerial Photo from 1954
Climax Transfer Station
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: United States Geological Survey 2018

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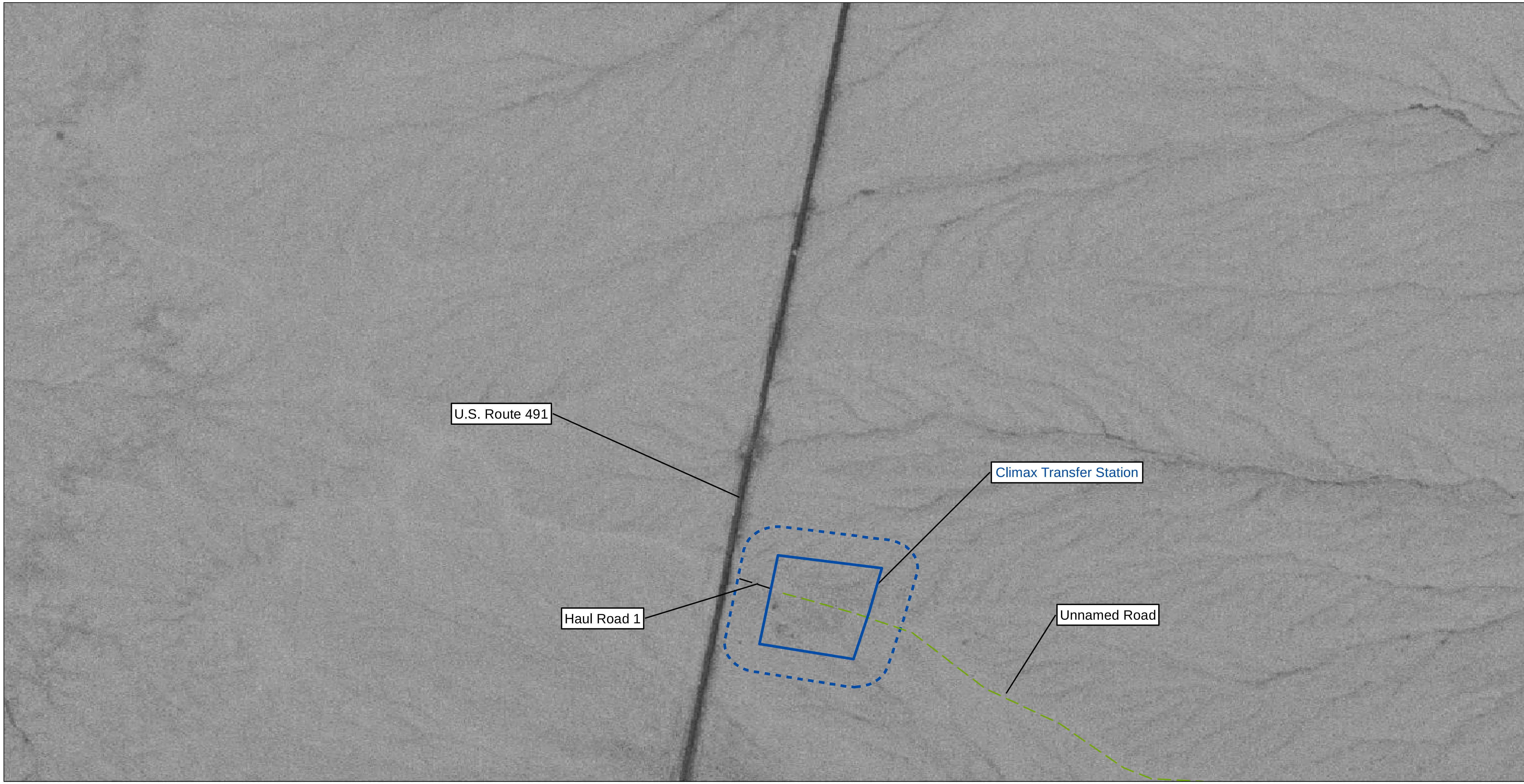
SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE 2-2A_CTS_HISTORICAL_MAP_1954.MXD CPOITRAS 1/21/2022 11:48:17



LEGEND

- Former Haul Road
- Unnamed Road
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary

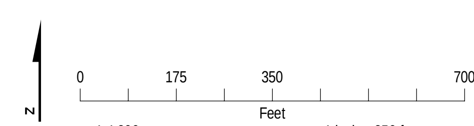
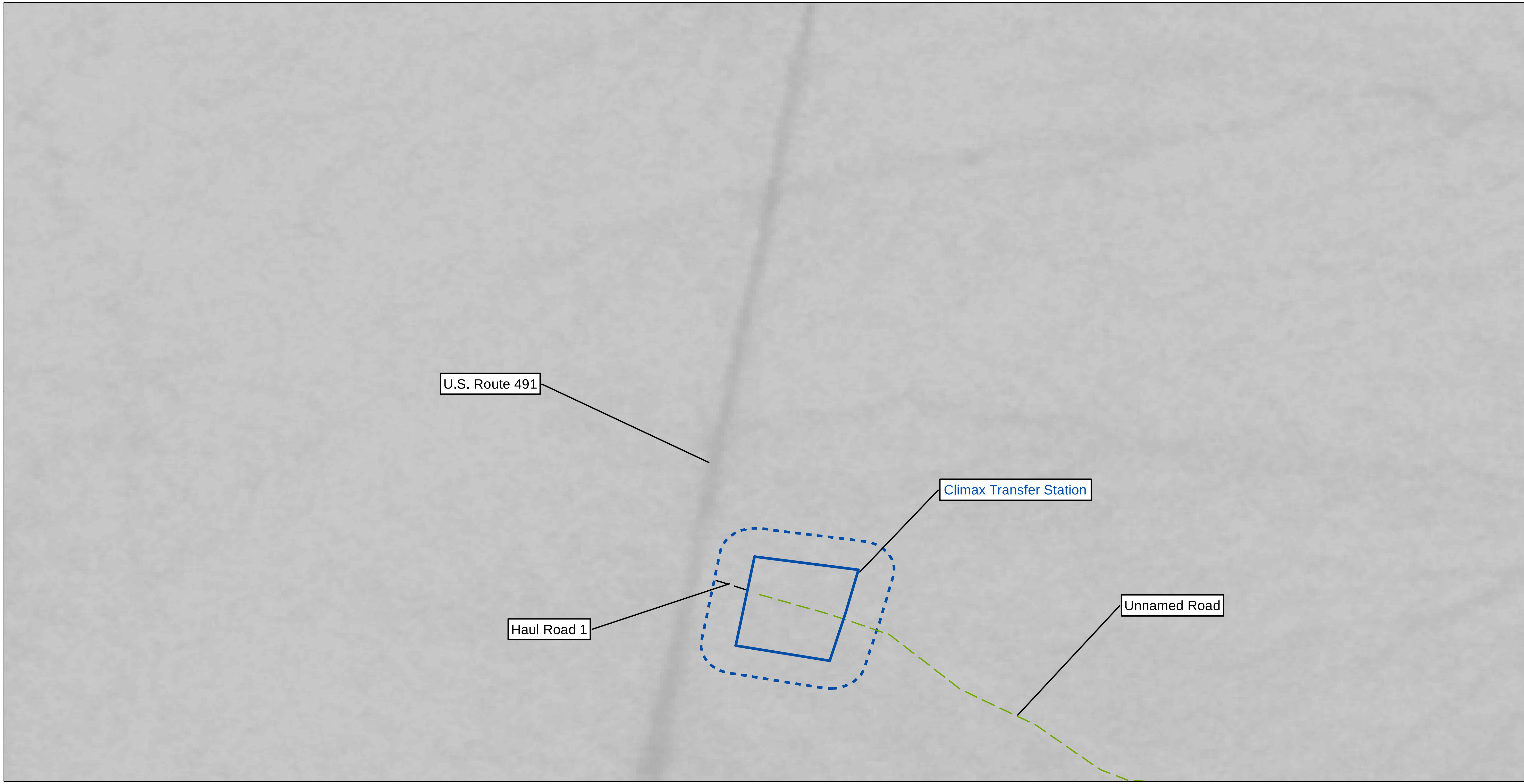


Figure 2-2b. Historical Aerial Photo from 1965
Climax Transfer Station
Removal Site Evaluation Report

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: United States Geological Survey 2018

JACOBS

SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE 2-2B_CTS_HISTORICAL_MAP_1965.MXD CPOITRAS 1/21/2022 11:39:41



LEGEND

- Former Haul Road
- Unnamed Road
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary

N

0 175 350 700

Feet

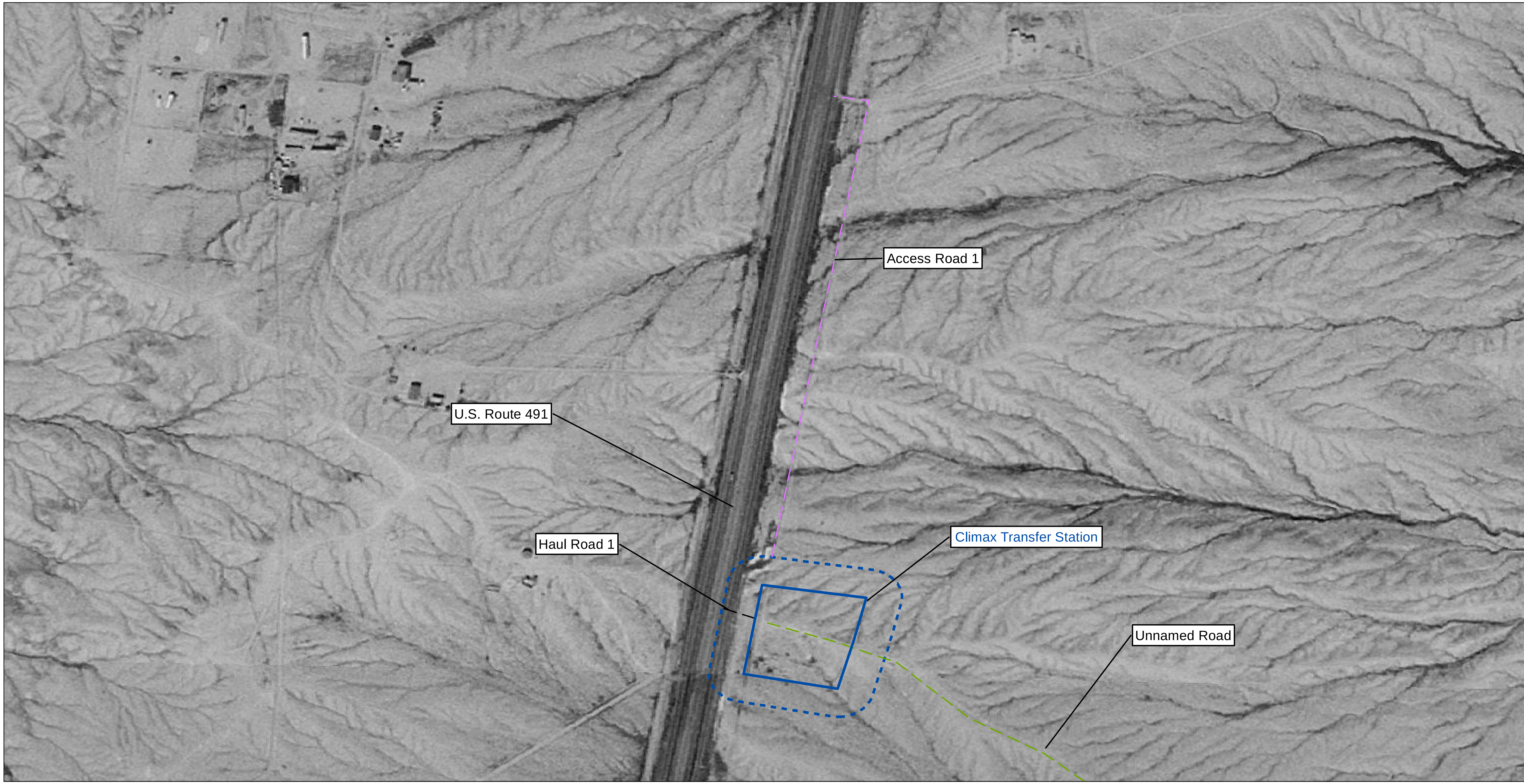
1:4,200 1 inch = 350 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: United States Geological Survey 2018

Figure 2-2c. Historical Aerial Photo from 1978
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE 2-2C_CTS_HISTORICAL_MAP_1978.MXD CPOITRAS 1/21/2022 11:53:33



LEGEND

- Access Road
- Former Haul Road
- Unnamed Road
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary

0 175 350 700
Feet
1:4,200 1 inch = 350 feet

Figure 2-2d. Historical Aerial Photo from 1997
Climax Transfer Station
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: United States Geological Survey 2018

JACOBS

SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE 2-2D_CTS_HISTORICAL_MAP_1997.MXD CPOITRAS 1/21/2022 11:55:34

LEGEND

- Access Road
- Former Haul Road
- Unnamed Road
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary

N

0 175 350 700

Feet

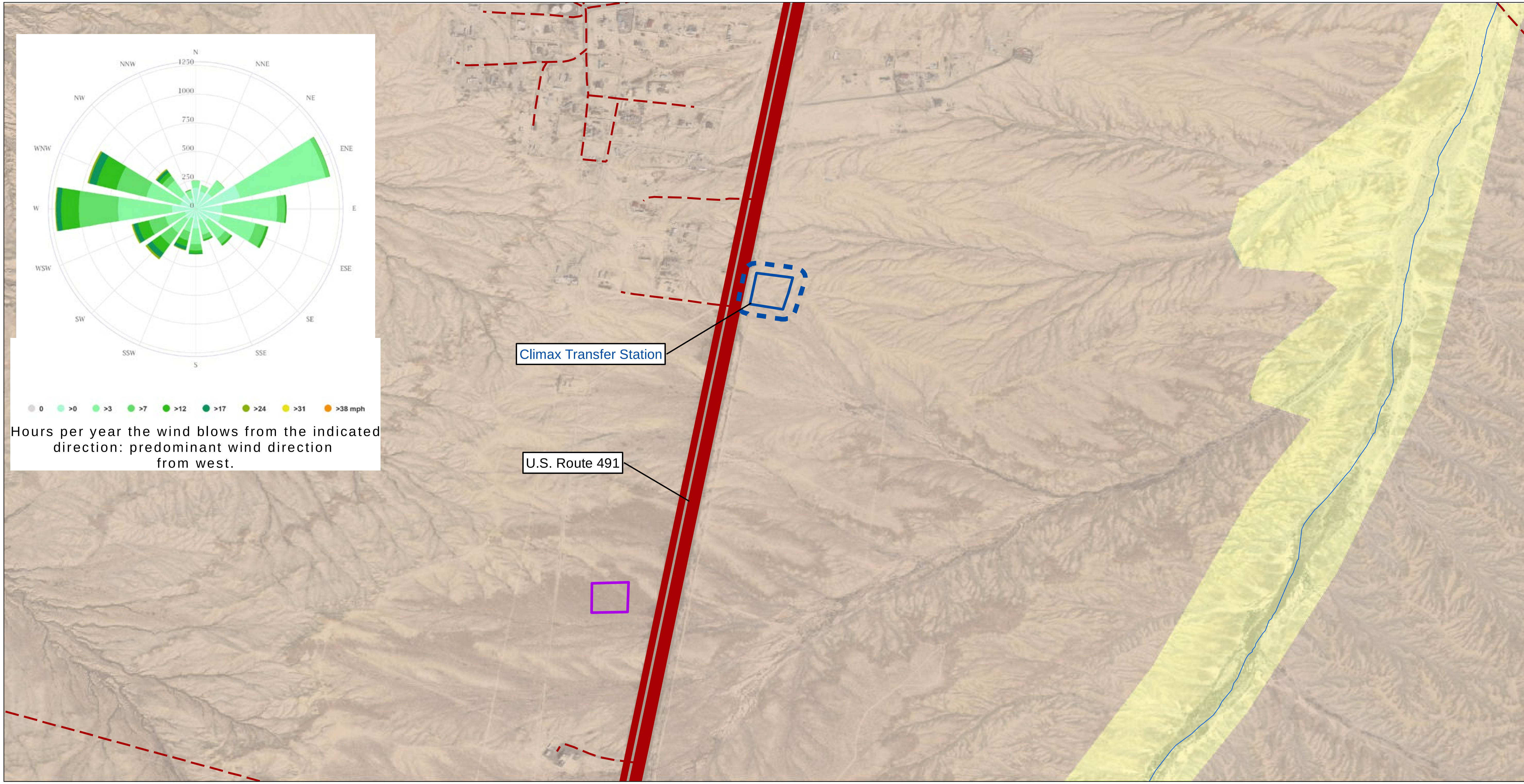
1:4,200 1 inch = 350 feet

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 2-2e.
Satellite Imagery from 2019
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE 2-2E_CTS_HISTORICAL_MAP_2019.MXD CPOITRAS 1/21/2022 11:45:21



LEGEND

- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary
- Background Reference Area
- Major Road
- Unpaved / Local Road
- Watercourse

SITE GEOLOGY

HOLOCENE

Qa: Eolian deposits. Loess and well-sorted sand; locally includes small dune areas.

CRETACEOUS

Km: Mancos shale. Light- to dark-gray marine shale with minor tan fine-grained sandstone and siltstone; marl beds near base. Thin sandstone beds form ledges in otherwise smooth shale slopes.

Sources:
1. Geology adapted from O'Sullivan, R.B. and Beikman, H.M. 1963. Geology, Structure and Uranium Deposits of the Shiprock Quadrangle, New Mexico and Arizona. U.S. Geological Survey Miscellaneous Geologic Investigations Map I-345. 1:250,000. https://ngmdb.usgs.gov/Prodesc/proddesc_1389.htm
2. Wind Rose Source: https://www.meteoblue.com/en/weather/forecast/modelclimate/shiprock_united-states-of-america_5491288

N

0 500 1,000 2,000

Feet

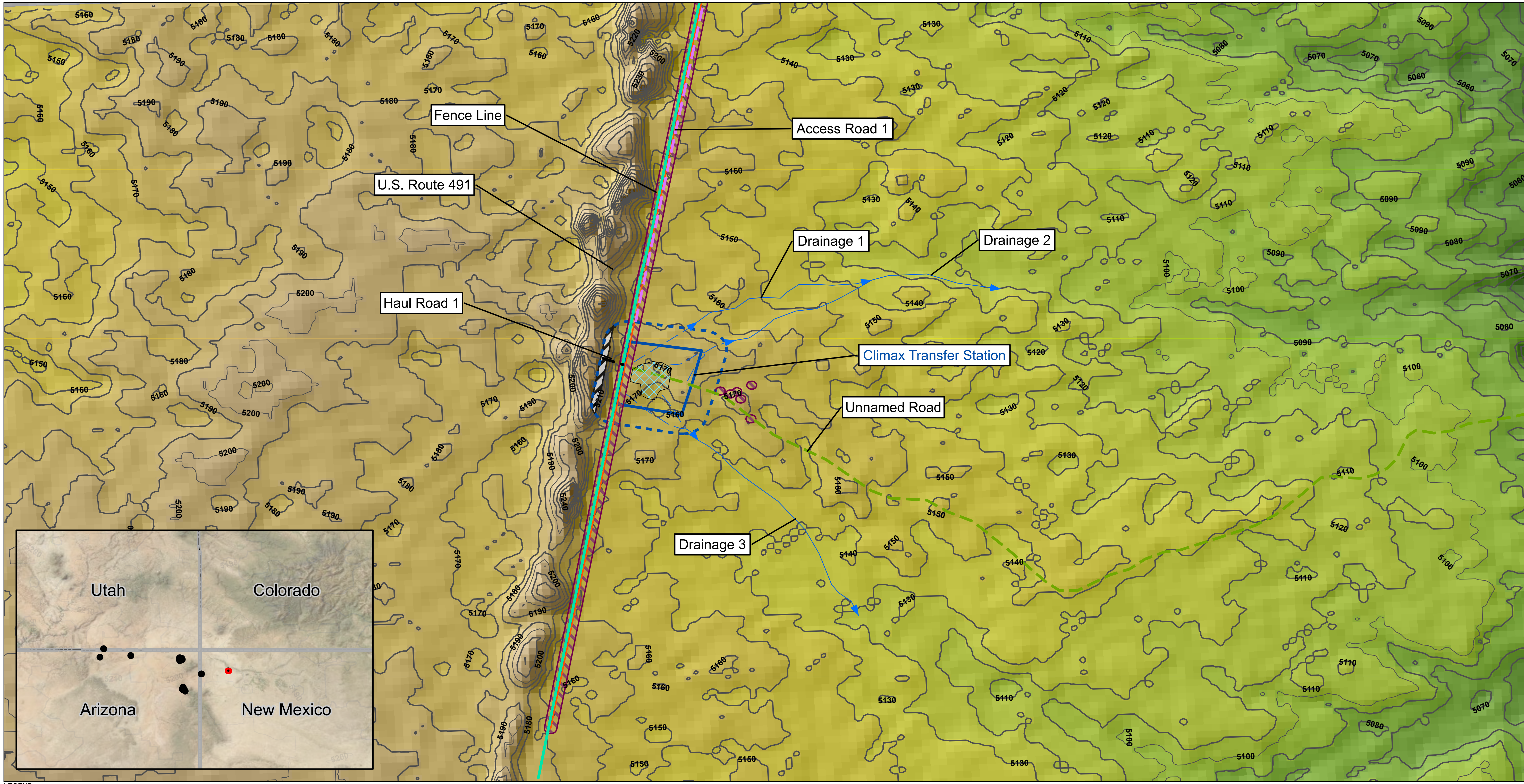
1:12,000 1 inch = 1,000 feet

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 2-3. Geologic Map with Wind Direction
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE 2-3_GEOLOGICMAP_WINDDIRECTION.MXD CPOITRAS 1/21/2022 12:13:48



LEGEND

- Drainage
- Estimated Extent of Drainages (Not Field Verified)
- Access Road
- Former Haul Road
- Unnamed Road
- Fence Line
- Gas Pipeline
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary
- NAML Technical Specifications of Excavation Disturbed Area
- Restricted Area
- Inaccessible Area

Elevation in feet

- 5,030 - 5,040
- 5,040 - 5,050
- 5,050 - 5,060
- 5,060 - 5,070
- 5,070 - 5,080
- 5,080 - 5,090
- 5,090 - 5,100
- 5,100 - 5,110
- 5,110 - 5,120
- 5,120 - 5,130
- 5,130 - 5,140
- 5,140 - 5,150
- 5,150 - 5,160
- 5,160 - 5,170
- 5,170 - 5,180
- 5,180 - 5,190
- 5,190 - 5,200
- 5,200 - 5,210
- 5,210 - 5,220
- 5,220 - 5,230
- 5,230 - 5,240
- 5,240 - 5,250
- 5,250 - 5,260
- 5,260 - 5,270

SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\CTS_TOPO_MAP.APRX TARROWOO 4/14/2022 16:18:25

Notes:
NAML = Navajo Abandoned Mine Lands

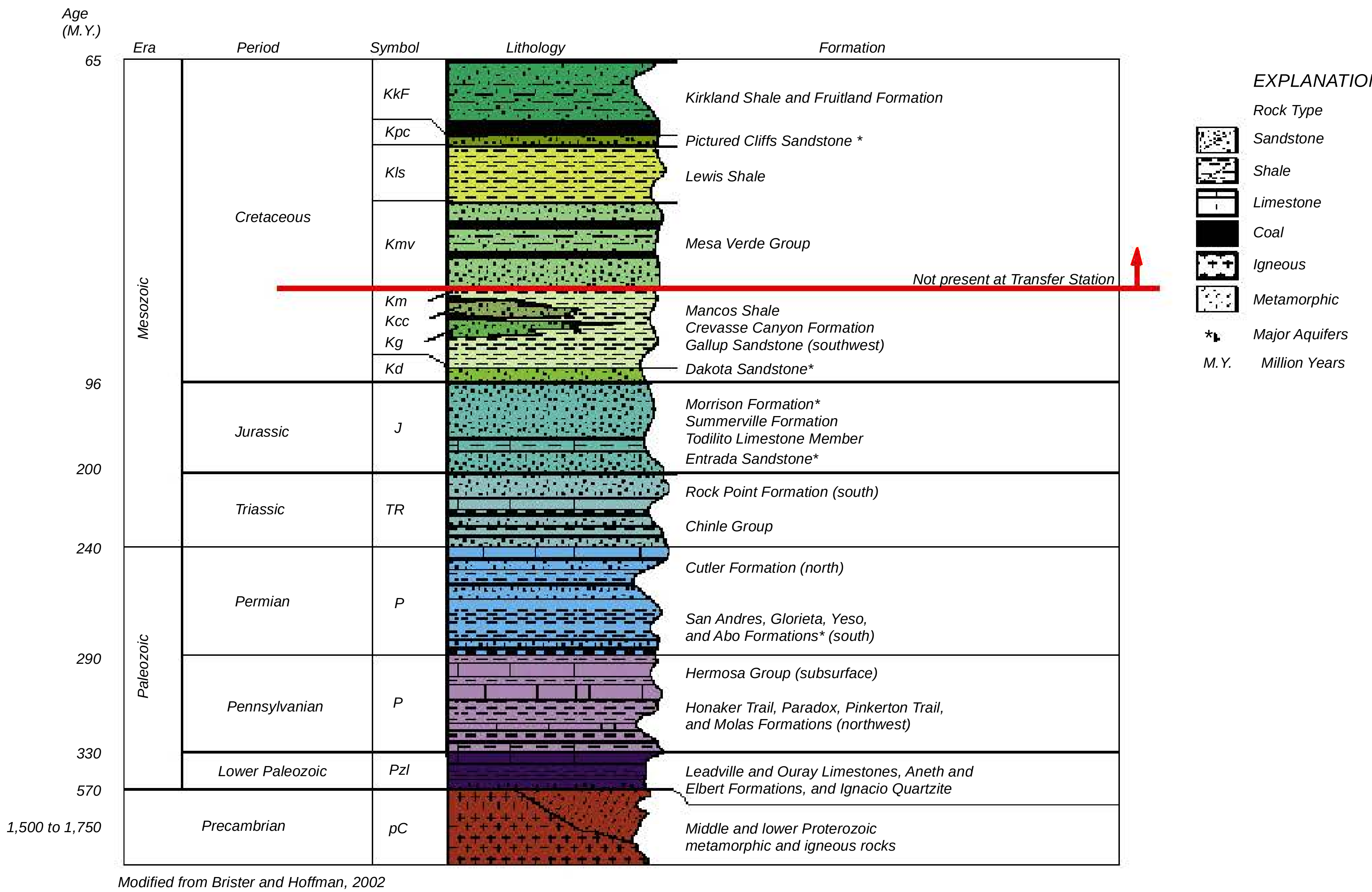
N

0 250 500 1,000
Feet
1:6,000 1:6,000

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 2-4. Transfer Station Topographic Background
Climax Transfer Station
Removal Site Evaluation Report

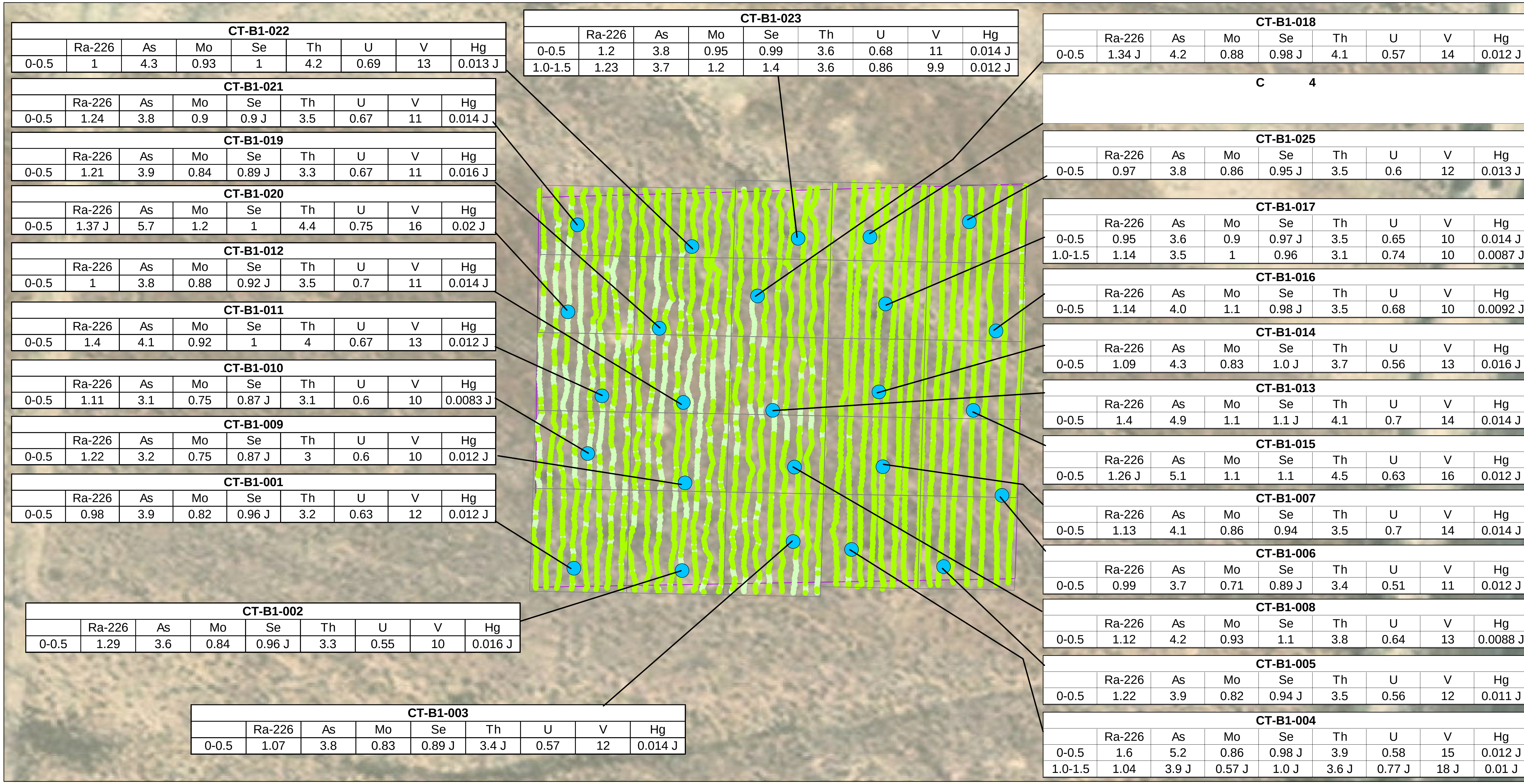
JACOBS



Source:
Modified from Brister and Hoffman, 2002
and Robertson et al. 2016.
1. Mancos Shale is present at the Transfer Station

Figure 2-5. Startigraphic Column of the
San Juan Basin, New Mexico
Climax Transfer Station
Removal Site Evaluation Report

JACOBS



CT-B1-022

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1	4.3	0.93	1	4.2	0.69	13	0.013 J

CT-B1-021

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.24	3.8	0.9	0.9 J	3.5	0.67	11	0.014 J

CT-B1-019

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.21	3.9	0.84	0.89 J	3.3	0.67	11	0.016 J

CT-B1-020

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.37 J	5.7	1.2	1	4.4	0.75	16	0.02 J

CT-B1-012

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1	3.8	0.88	0.92 J	3.5	0.7	11	0.014 J

CT-B1-011

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.4	4.1	0.92	1	4	0.67	13	0.012 J

CT-B1-010

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.11	3.1	0.75	0.87 J	3.1	0.6	10	0.0083 J

CT-B1-009

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.22	3.2	0.75	0.87 J	3	0.6	10	0.012 J

CT-B1-001

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	0.98	3.9	0.82	0.96 J	3.2	0.63	12	0.012 J

CT-B1-002

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.29	3.6	0.84	0.96 J	3.3	0.55	10	0.016 J

CT-B1-003

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.07	3.8	0.83	0.89 J	3.4 J	0.57	12	0.014 J

CT-B1-023

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.2	3.8	0.95	0.99	3.6	0.68	11	0.014 J
1.0-1.5	1.23	3.7	1.2	1.4	3.6	0.86	9.9	0.012 J

CT-B1-018

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.34 J	4.2	0.88	0.98 J	4.1	0.57	14	0.012 J

C 4

CT-B1-025

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	0.97	3.8	0.86	0.95 J	3.5	0.6	12	0.013 J

CT-B1-017

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	0.95	3.6	0.9	0.97 J	3.5	0.65	10	0.014 J
1.0-1.5	1.14	3.5	1	0.96	3.1	0.74	10	0.0087 J

CT-B1-016

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.14	4.0	1.1	0.98 J	3.5	0.68	10	0.0092 J

CT-B1-014

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.09	4.3	0.83	1.0 J	3.7	0.56	13	0.016 J

CT-B1-013

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.4	4.9	1.1	1.1 J	4.1	0.7	14	0.014 J

CT-B1-015

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.26 J	5.1	1.1	1.1	4.5	0.63	16	0.012 J

CT-B1-007

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.13	4.1	0.86	0.94	3.5	0.7	14	0.014 J

CT-B1-006

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	0.99	3.7	0.71	0.89 J	3.4	0.51	11	0.012 J

CT-B1-008

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.12	4.2	0.93	1.1	3.8	0.64	13	0.0088 J

CT-B1-005

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.22	3.9	0.82	0.94 J	3.5	0.56	12	0.011 J

CT-B1-004

	Ra-226	As	Mo	Se	Th	U	V	Hg
0-0.5	1.6	5.2	0.86	0.98 J	3.9	0.58	15	0.012 J
1.0-1.5	1.04	3.9 J	0.57 J	1.0 J	3.6 J	0.77 J	18 J	0.01 J

LEGEND

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

Gamma cpm

- 0 - 10000
- 10001 - 13890

	Mancos Shale IL
Radium (Ra)-226	1.62 pCi/g
Arsenic (As)	5.93 mg/kg
Mercury (Hg)	11 mg/kg
Molybdenum (Mo)	390 mg/kg
Selenium (Se)	390 mg/kg
Thorium (Th)	4.72 mg/kg
Uranium (U)	16 mg/kg
Vanadium (V)	390 mg/kg
Gamma BTV	13900

Notes:
1. Background reference area is 2.0 acres
2. Ra-226 is reported in pCi/g; metals are reported in mg/kg.
3. Gamma BTV is the 95% USL, BTV = 13900 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

Notes: continued
pCi/g = picocuries per gram
USL = upper simultaneous limit

Figure 4-1. Mancos Shale Background Reference Area Gamma Scan Survey and Soil Sampling Results
Climax Transfer Station
Removal Site Evaluation Report

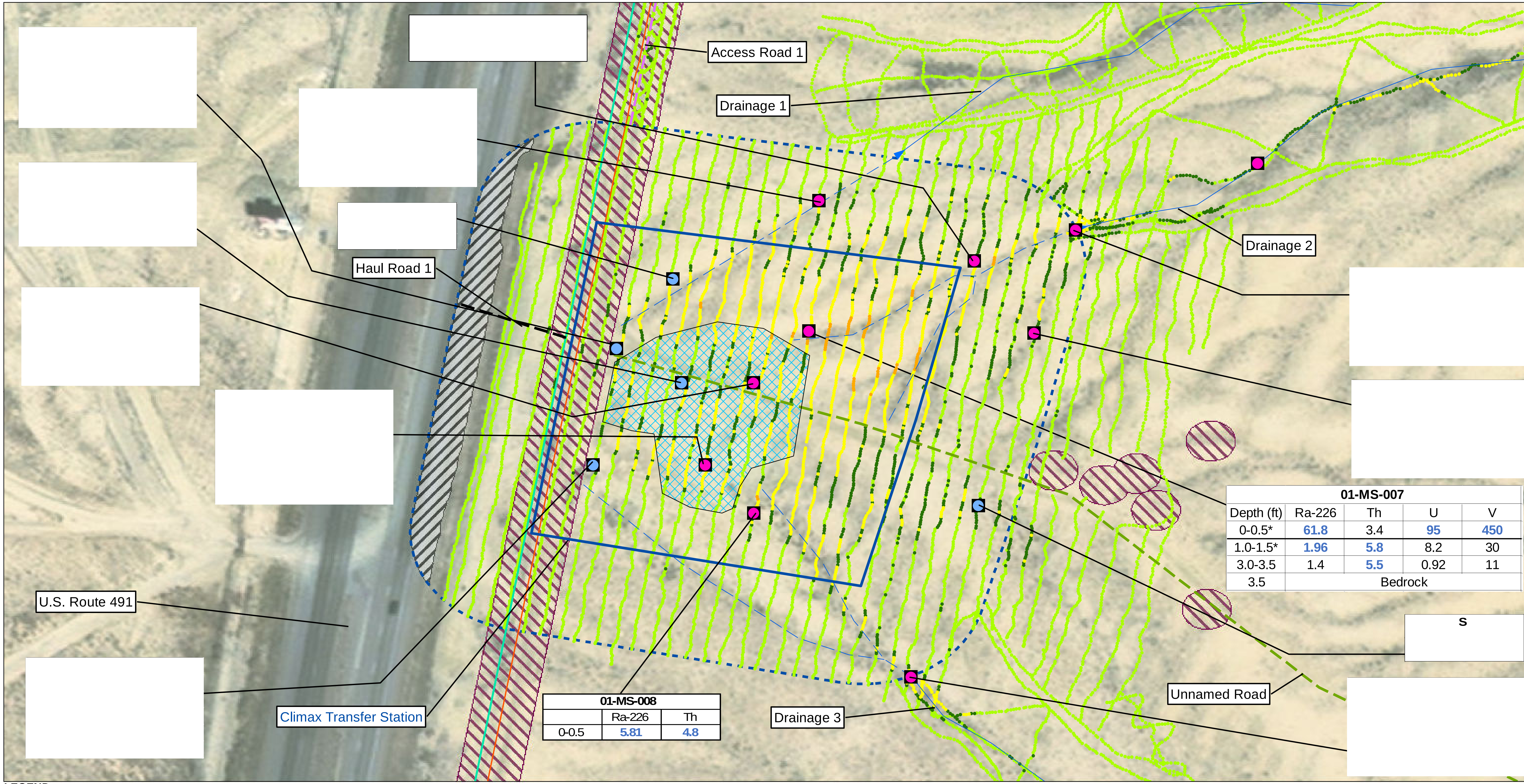
N

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

JACOBS

SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE_4-1_MANCOS_SHALE_BACKGROUND_REFERENCE_AREA_RESULTS.MXD CPOITRAS 1/21/2022 14:00:40



01-MS-007				
Depth (ft)	Ra-226	Th	U	V
0-0.5*	**61.8**	3.4	**95**	**450**
1.0-1.5*	**1.96**	**5.8**	8.2	30
3.0-3.5	1.4	**5.5**	0.92	11
3.5	Bedrock			

01-MS-008		
	Ra-226	Th
0-0.5	**5.81**	**4.8**

LEGEND

Sample Location

- Ra-226 exceedance
- Metals and Ra-226 exceedance
- Exceeds BTV
- Drainage
- Estimated Extent of Drainages (Not Field Verified)
- Access Road
- Former Haul Road
- Unnamed Road
- Fence Line
- Gas Pipeline
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary
- NAML Technical Specifications of Excavation Disturbed Area
- Inaccessible Area
- Restricted Area

Mancos Shale Gamma Scan (cpm)

- 9047 - 13900
- 13901 - 15400
- 15401 - 27800
- 27801 - 57836

	Mancos Shale IL
Radium (Ra)-226	1.62 pCi/g
Arsenic (As)	5.93 mg/kg
Mercury (Hg)	11 mg/kg
Molybdenum (Mo)	390 mg/kg
Selenium (Se)	390 mg/kg
Thorium (Th)	4.72 mg/kg
Uranium (U)	16 mg/kg
Vanadium (V)	390 mg/kg
Gamma BTV	13900

Notes:
1. Results are only shown for those COPCs that have at least one exceedance of the IL in the given boring.
2. Ra-226 is reported in pCi/g; metals are reported in mg/kg.
3. Blue and Bold = Exceedance of IL
4. Nomenclature for Surface Soil (0.0-0.5) samples includes an SS at the beginning of the Sample ID
5. Nomenclature for Subsurface Soil (>0.5) samples includes an SB at the beginning of the Sample ID
6. Former waste rock piles are not identified as disturbed vegetation because previous NAML reclamation efforts established sufficient vegetative cover in these areas, consistent with nearby native vegetation. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
7. Mine site accessible area = 5.4 acres
8. Distance of former haul roads surveyed = 0.31 miles
9. Secondary COPCs collected at 01-MS-007 were less than RSLs and therefore are not presented in the figure.

Notes: continued
10. Distance of drainage surveyed = 0.61 miles
> = greater than
BTV = background threshold value
COPCs = contaminants of potential concern
cpm = counts per minute
IL = Investigation Level

Notes: continued
mg/kg = milligrams per kilogram
NAML = Navajo Abandoned Mine Lands
pCi/g = picocuries per gram
RSLs = regional screening levels
* = Secondary COPCs analyzed in the following sample interval Sample Location
ft = feet

N

0 50 100 200
Feet
1:1,200 1 inch = 100 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 4-2a. Transfer Station Gamma Scan Survey and Soil Sampling Results Map
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

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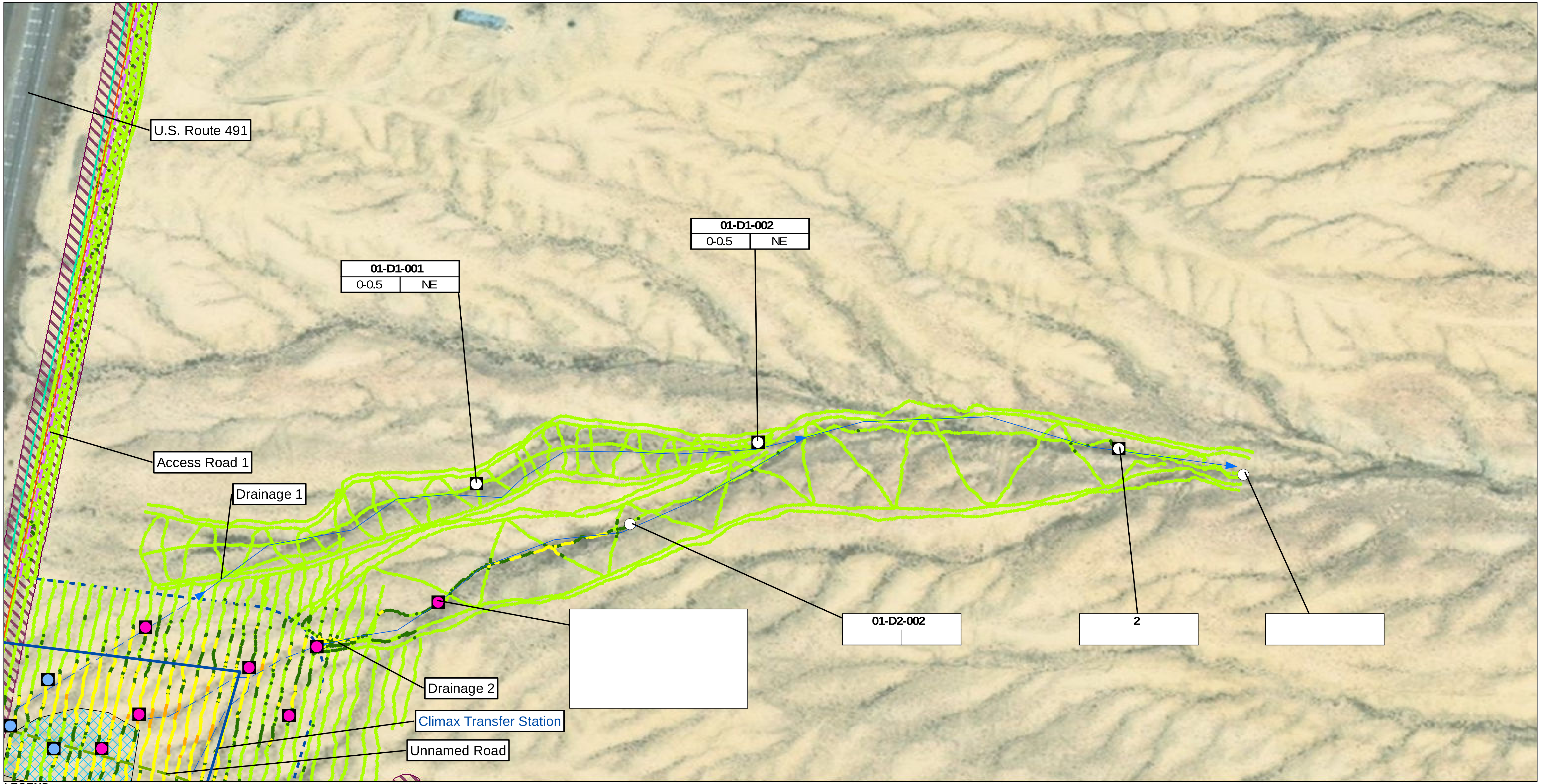

LEGEND

Sample Location
- Ra-226 exceedance
- Metals and Ra-226 exceedance
- No exceedance
- Exceeds BTV
- Drainage
- Estimated Extent of Drainages (Not Field Verified)
- Access Road
- Unnamed Road
- Fence Line
- Gas Pipeline

Mancos Shale Gamma Scan (cpm)
- 0 - 13900
- 13901 - 15400
- 15401 - 27800
- 27801 - 57836

- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary
- NAML Technical Specifications of Excavation Disturbed Area
- Restricted Area

	Mancos Shale IL
Radium (Ra)-226	1.62 pCi/g
Arsenic (As)	5.93 mg/kg
Mercury (Hg)	11 mg/kg
Molybdenum (Mo)	390 mg/kg
Selenium (Se)	390 mg/kg
Thorium (Th)	4.72 mg/kg
Uranium (U)	16 mg/kg
Vanadium (V)	390 mg/kg
Gamma BTV	13900

Notes:
1. Results are only shown for those COPCs that have one exceedance in a boring.
2. Ra-226 is reported in pCi/g; metals are reported in mg/kg.
3. Gamma BTV for Mancos Shale is 13900 cpm.
4. Blue and Bold = Exceedance of IL
5. Nomenclature for Surface Soil (0.0-0.5) samples includes an SS at the beginning of the Sample ID
6. Nomenclature for Subsurface Soil (>0.5) samples includes an SB at the beginning of the Sample ID
7. Former waste rock piles are not identified as disturbed vegetation because previous NAML reclamation efforts established sufficient vegetative cover in these areas, consistent with nearby native vegetation. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
8. Mine site accessible area = 5.4 acres
9. Distance of former haul roads surveyed = 0.31 miles

Notes: continued
10. Distance of drainage surveyed = 0.61 miles
> = greater than
BTV = background threshold value
COPCs = contaminants of potential concern
cpm = counts per minute
IL = Investigation Level

Notes: continued
mg/kg = milligrams per kilogram
NAML = Navajo Abandoned Mine Lands
NE = No Exceedence
pCi/g = picocuries per gram

0 75 150 300
Feet
1:1,800 1 inch = 150 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 4-2b. Drainage 1 and Drainage 2 Gamma Scan Survey and Soil Sampling Results Map
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

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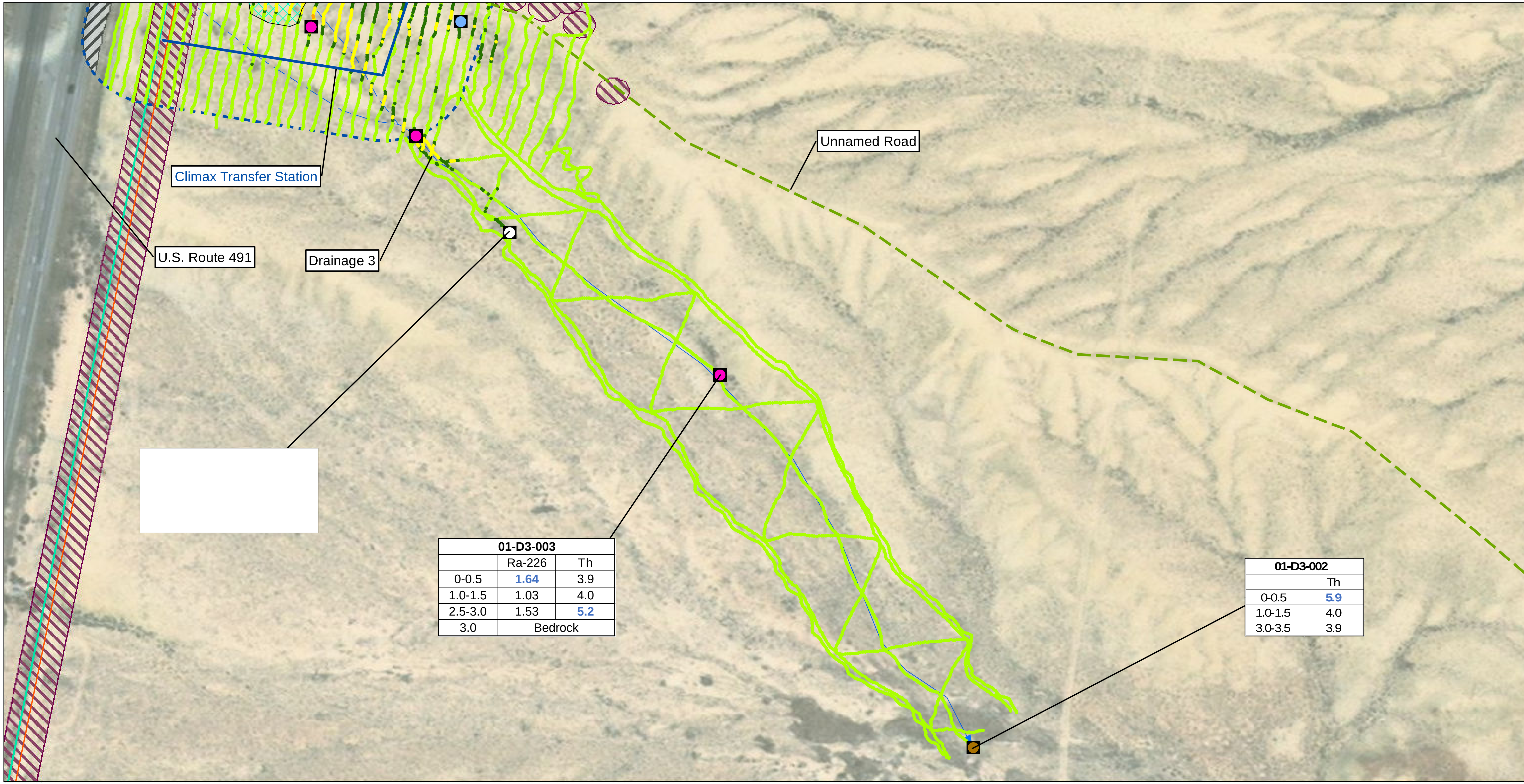

01-D3-003		
	Ra-226	Th
0-0.5	**1.64**	3.9
1.0-1.5	1.03	4.0
2.5-3.0	1.53	**5.2**
3.0	Bedrock	

01-D3-002	
	Th
0-0.5	**5.9**
1.0-1.5	4.0
3.0-3.5	3.9

LEGEND

Sample Location
- Ra-226 exceedance
- Metals exceedance
- Metals and Ra-226 exceedance
- No exceedance
- Exceeds BTV

Mancos Shale Gamma Scan (cpm)
- 0 - 13900
- 13901 - 15400
- 15401 - 27800
- 27801 - 57836
- Drainage
- Estimated Extent of Drainages (Not Field Verified)
- Unnamed Road

- Fence Line
- Gas Pipeline
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary
- NAML Technical Specifications of Excavation Disturbed Area
- Inaccessible Area
- Restricted Area

	Mancos Shale IL
Radium (Ra)-226	1.62 pCi/g
Arsenic (As)	5.93 mg/kg
Mercury (Hg)	11 mg/kg
Molybdenum (Mo)	390 mg/kg
Selenium (Se)	390 mg/kg
Thorium (Th)	4.72 mg/kg
Uranium (U)	16 mg/kg
Vanadium (V)	390 mg/kg
Gamma BTV	13900

Notes:
1. Results are only shown for those COPCs that have one exceedance in a boring.
2. Ra-226 is reported in pCi/g; metals are reported in mg/kg.
3. Gamma BTV for Mancos Shale is 13900 cpm.
4. Blue and Bold = Exceedance of IL
5. Nomenclature for Surface Soil (0.0-0.5) samples includes an SS at the beginning of the Sample ID
6. Nomenclature for Subsurface Soil (>0.5) samples includes an SB at the beginning of the Sample ID
7. Former waste rock piles are not identified as disturbed vegetation because previous NAML reclamation efforts established sufficient vegetative cover in these areas, consistent with nearby native vegetation. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
8. Mine site accessible area = 5.4 acres
9. Distance of former haul roads surveyed = 0.31 miles

Notes: continued
10. Distance of drainage surveyed = 0.61 miles
> = greater than
BTV = background threshold value
COPCs = contaminants of potential concern
cpm = counts per minute
IL = Investigation Level

Notes: continued
mg/kg = milligrams per kilogram
NAML = Navajo Abandoned Mine Lands
NE = No Exceedence
pCi/g = picocuries per gram

N

0 75 150 300
Feet
1:1,800 1 inch = 150 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 4-2c. Drainage 3 Gamma Scan Survey and Soil Sampling Results Map
Climax Transfer Station
Removal Site Evaluation Report

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LEGEND

- Drainage
- Access Road
- Fence Line
- Gas Pipeline
- 100-foot Transfer Station Buffer
- Inaccessible Area
- Restricted Area

Mancos Shale Gamma Scan (cpm)

- 0 - 13900
- 13901 - 15400
- 15401 - 27800

Notes:
1. A haul road sample was not collected because the road is located near a gas line.
2. Gamma BTV for Mancos Shale is 13900 cpm.
3. Former waste rock piles are not identified as disturbed vegetation because previous NAML reclamation efforts established sufficient vegetative cover in these areas, consistent with nearby native vegetation. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
4. Mine site accessible area = 5.4 acres
5. Distance of former haul roads surveyed = 0.31 miles
6. Distance of drainage surveyed = 0.61 miles

BTV = background threshold value
cpm = counts per minute

Notes: continued
mg/kg = milligrams per kilogram
NAML = Navajo Abandoned Mine Lands
NE = No Exceedence
pCi/g = picocuries per gram

N

0 62.5 125 250
Feet
1:1,500 1 inch = 125 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 4-2d. Access Road Gamma Scan Survey Map
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

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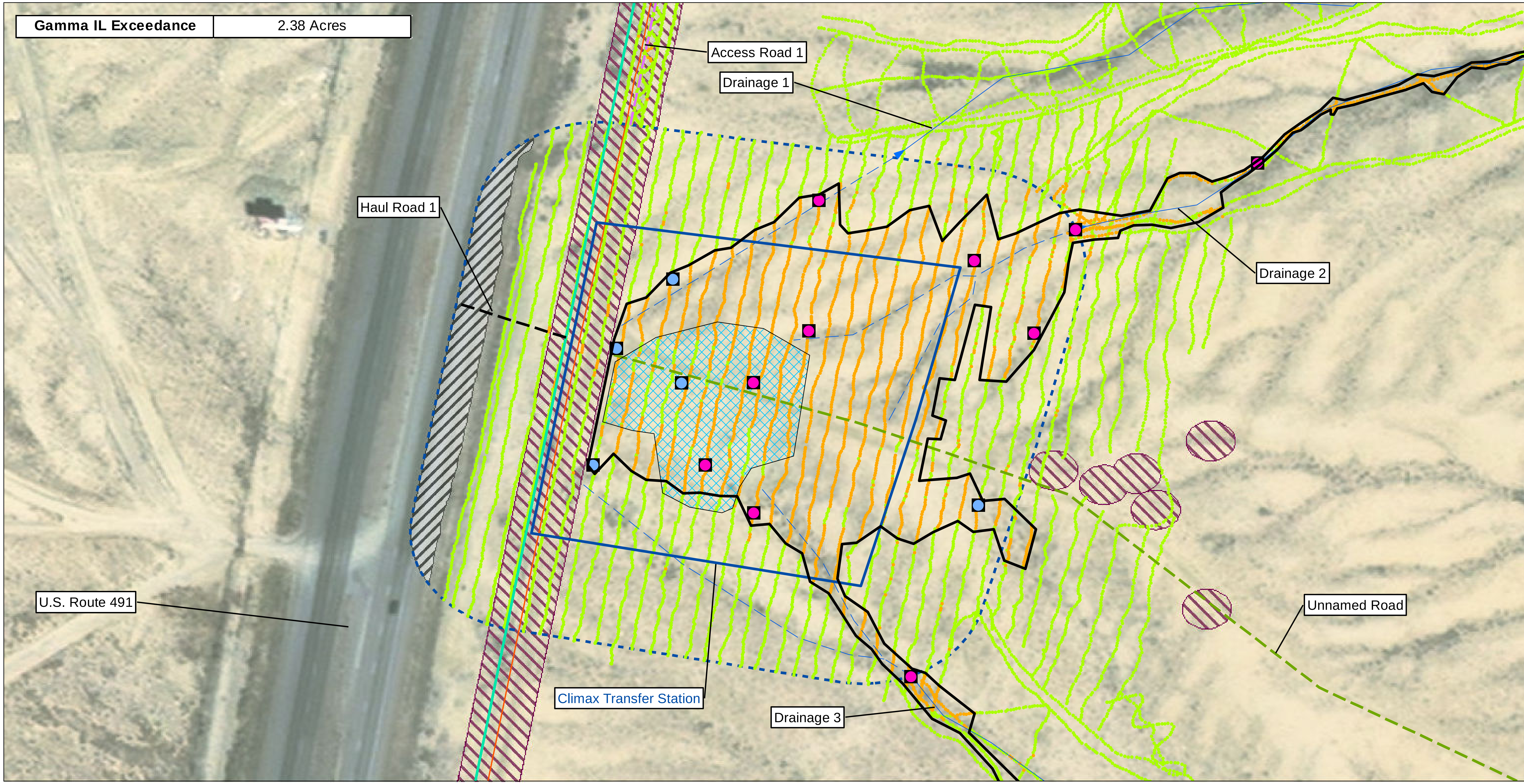

LEGEND

- Drainage
- Estimated Extent of Drainages (Not Field Verified)
- Access Road
- Former Haul Road
- Unnamed Road
- Fence Line
- Gas Pipeline

Sample Location
- Ra-226 exceedance
- Metals and Ra-226 exceedance
- Exceeds BTV
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary
- NAML Technical Specifications of Excavation Disturbed Area

- Inaccessible Area
- Restricted Area
- Gamma Exceedence

Mancos Shale Gamma Scan (cpm)
- 0 - 13900
- 13901 - 57836

Notes:
1. BTV and IL for Mancos Shale gamma scan data is 13900 cpm.
2. Former waste rock piles are not identified as disturbed vegetation because previous NAML reclamation efforts established sufficient vegetative cover in these areas, consistent with nearby native vegetation. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
3. Calculated area that exceeds the IL includes mine site, haul roads, and drainages.

BTV = background threshold value
cpm = counts per minute
IL = Investigation Level
NAML = Navajo Abandoned Mine Lands

N
0 50 100 200
Feet
1:1,200 1 inch = 100 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 4-3a. Transfer Station
Gamma Exceedance Area Map
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

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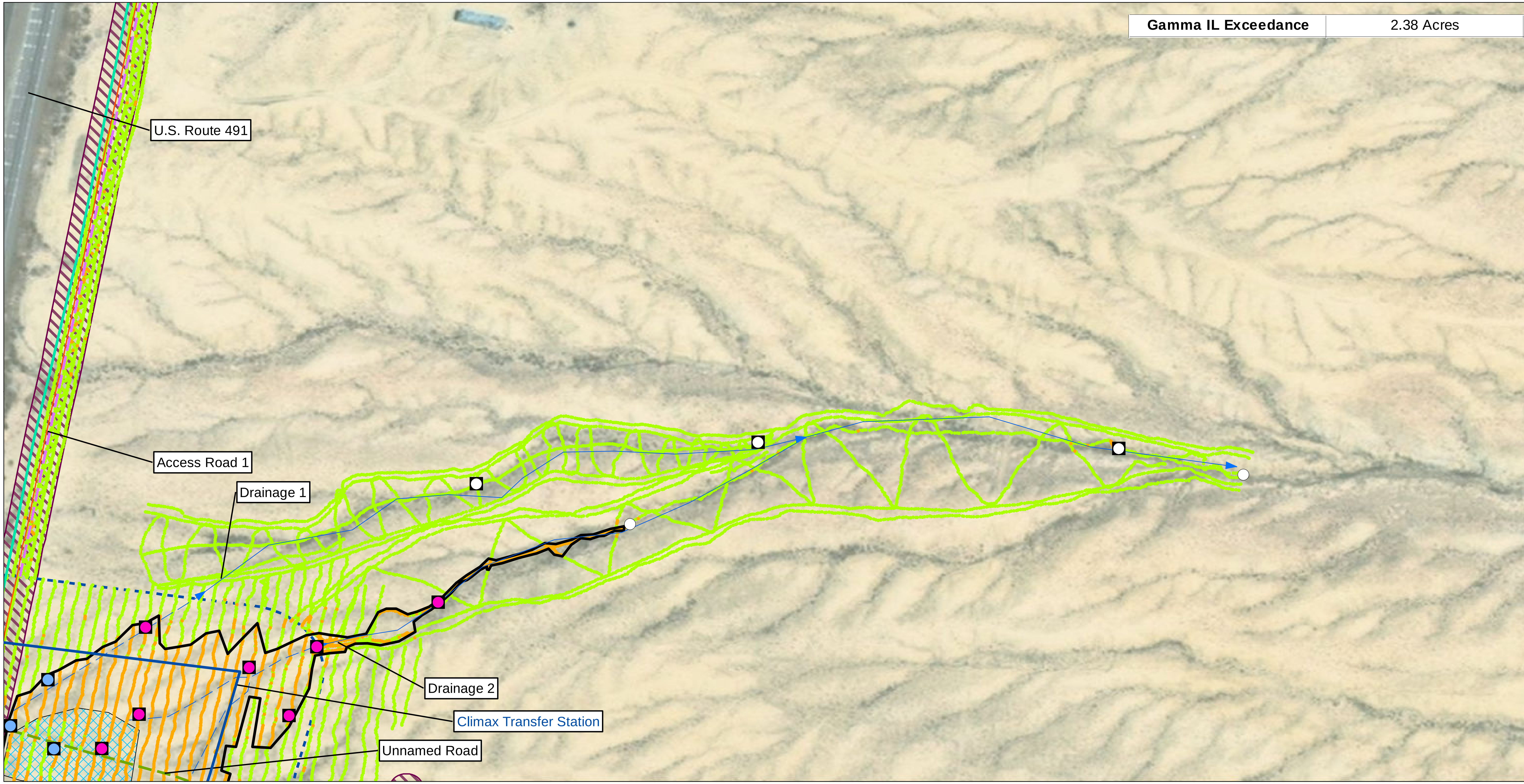

LEGEND

Sample Location
- Ra-226 exceedance
- Metals and Ra-226 exceedance
- No exceedance
- Exceeds BTV
- Drainage
- Estimated Extent of Drainages (Not Field Verified)

- Access Road
- Unnamed Road
- Fence Line
- Gas Pipeline
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary

- Gamma Exceedence
- NAML Technical Specifications of Excavation Disturbed Area
- Restricted Area

Mancos Shale Gamma Scan (cpm)
- 0 - 13900
- 13901 - 57836

Notes:
1. BTV and IL for Mancos Shale gamma scan data is 13900 cpm.
2. Former waste rock piles are not identified as disturbed vegetation because previous NAML reclamation efforts established sufficient vegetative cover in these areas, consistent with nearby native vegetation. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
3. Calculated area that exceeds the IL includes mine site, haul roads, and drainages.
BTV = background threshold value
cpm = counts per minute
IL = Investigation Level
NAML = Navajo Abandoned Mine Lands

0 75 150 300
Feet
N
1:1,800 1 inch = 150 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 4-3b. Drainage 1 and Drainage 2 Gamma Exceedance Area Map
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

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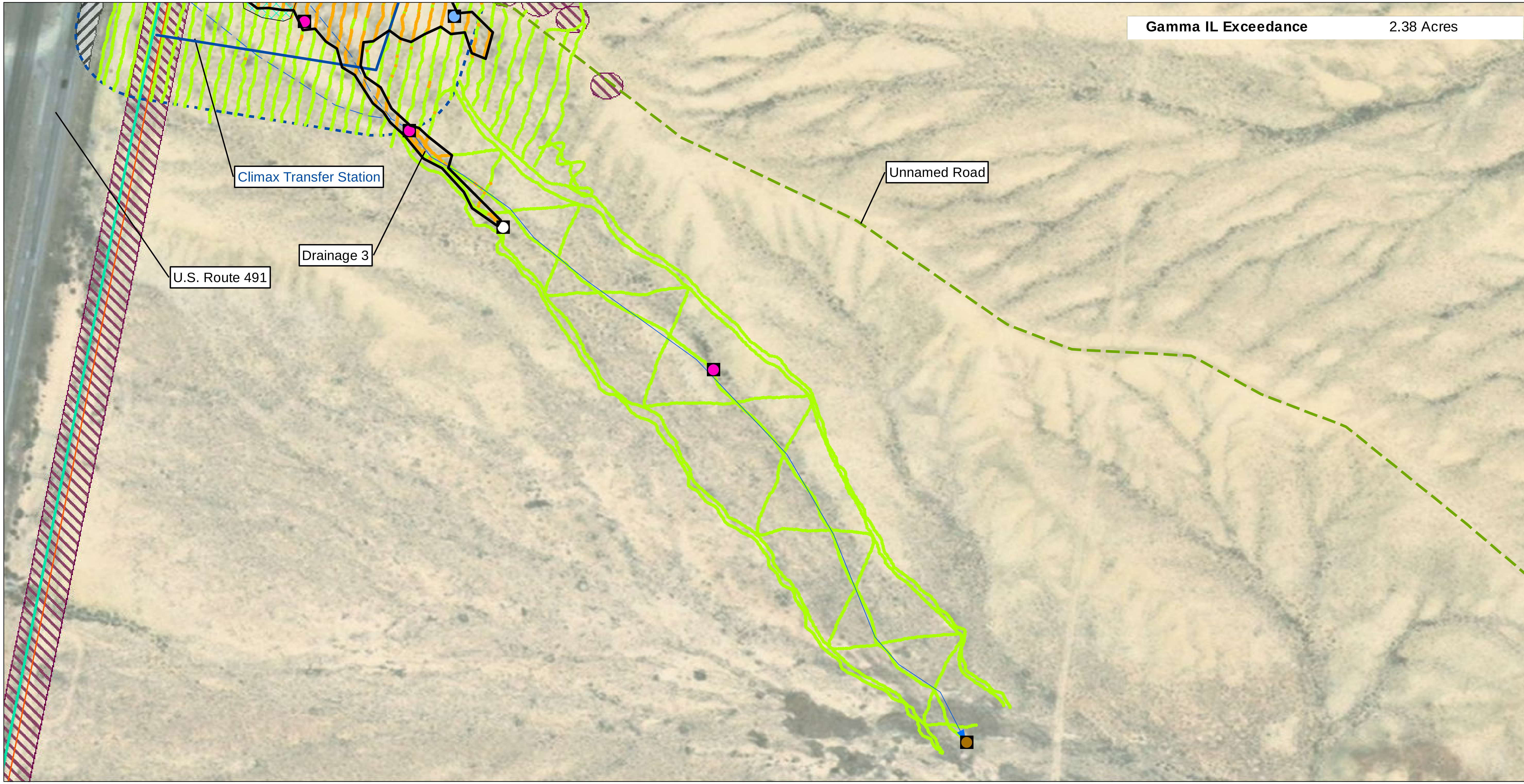

LEGEND

- Drainage
- Estimated Extent of Drainages (Not Field Verified)
- Unnamed Road
- Fence Line
- Gas Pipeline

Sample Location

- Ra-226 exceedance
- Metals exceedance
- Metals and Ra-226 exceedance
- No exceedance
- Exceeds BTV

- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary
- Inaccessible Area
- Restricted Area

- NAML Technical Specifications of Excavation Disturbed Area
- Gamma Exceedence

Mancos Shale Gamma Scan (cpm)

- 0 - 13900
- 13901 - 57836

Notes:
1. BTV and IL for Mancos Shale gamma scan data is 13900 cpm.
2. Former waste rock piles are not identified as disturbed vegetation because previous NAML reclamation efforts established sufficient vegetative cover in these areas, consistent with nearby native vegetation. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
3. Calculated area that exceeds the IL includes mine site, haul roads, and drainages.
BTV = background threshold value
cpm = counts per minute
IL = Investigation Level
NAML = Navajo Abandoned Mine Lands

0 75 150 300
Feet
1:1,800 1 inch = 150 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 4-3c. Drainage 3
Gamma Exceedance Area Map
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

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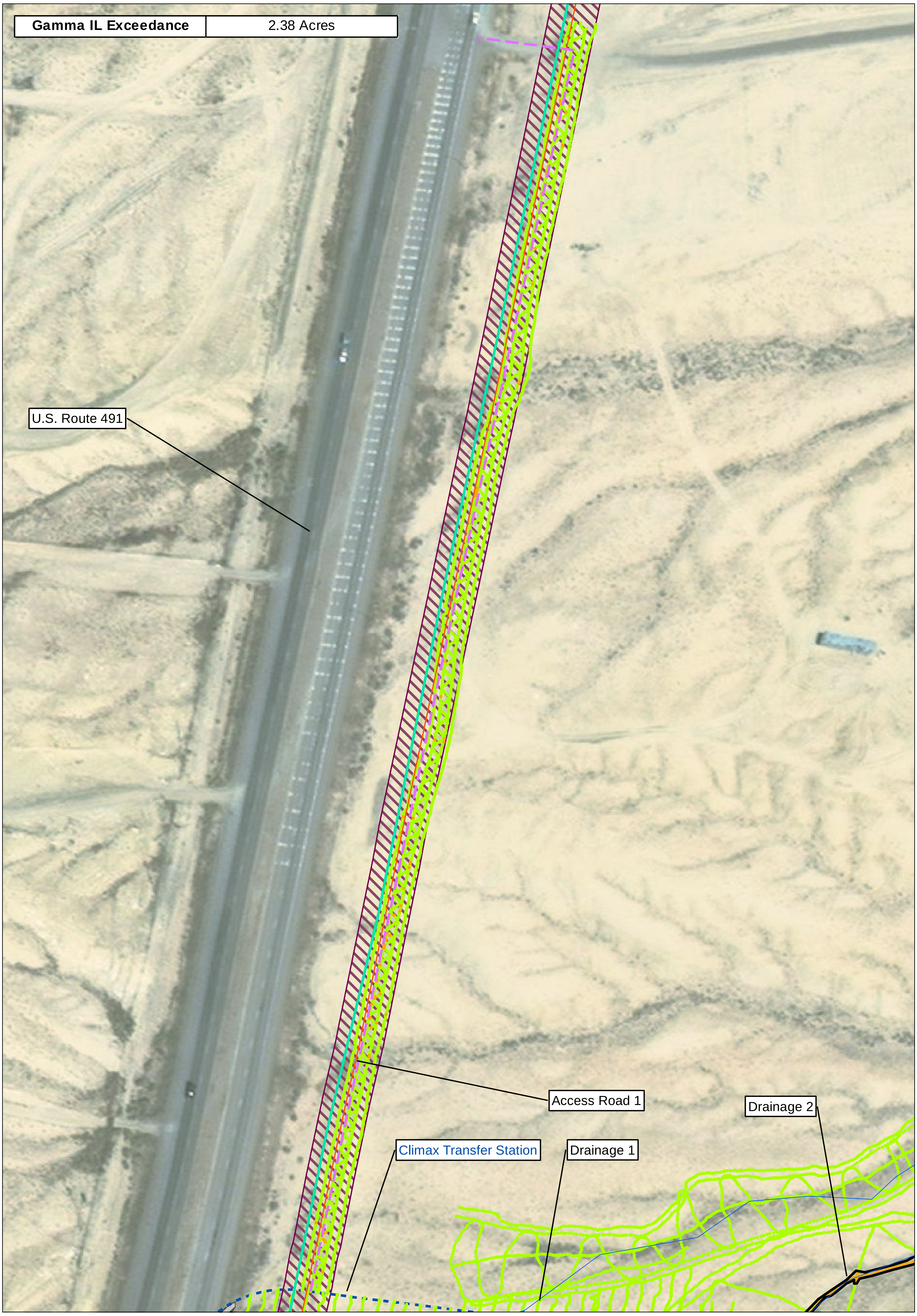

LEGEND

- Drainage
- Access Road
- Fence Line
- Gas Pipeline
- 100-foot Transfer Station Buffer
- Inaccessible Area
- Restricted Area
- Gamma Exceedence

Mancos Shale Gamma Scan (cpm)

- 0 - 13900
- 13901 - 57836

Notes:
1. A haul road sample was not collected because the road is located near a gas line.
2. BTV and IL for Mancos Shale gamma scan data is 13900 cpm.
3. Former waste rock piles are not identified as disturbed vegetation because previous NAML reclamation efforts established sufficient vegetative cover in these areas, consistent with nearby native vegetation. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
4. Calculated area that exceeds the IL includes mine site, haul roads, and drainages.

BTV = background threshold value
cpm = counts per minute

Notes: continued
mg/kg = milligrams per kilogram
NAML = Navajo Abandoned Mine Lands
NE = No Exceedence
pCi/g = picocuries per gram

N

0 62.5 125 250
Feet
1:1,500
1 inch = 125 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 4-3d. Access Road Gamma Exceedance Area Map
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

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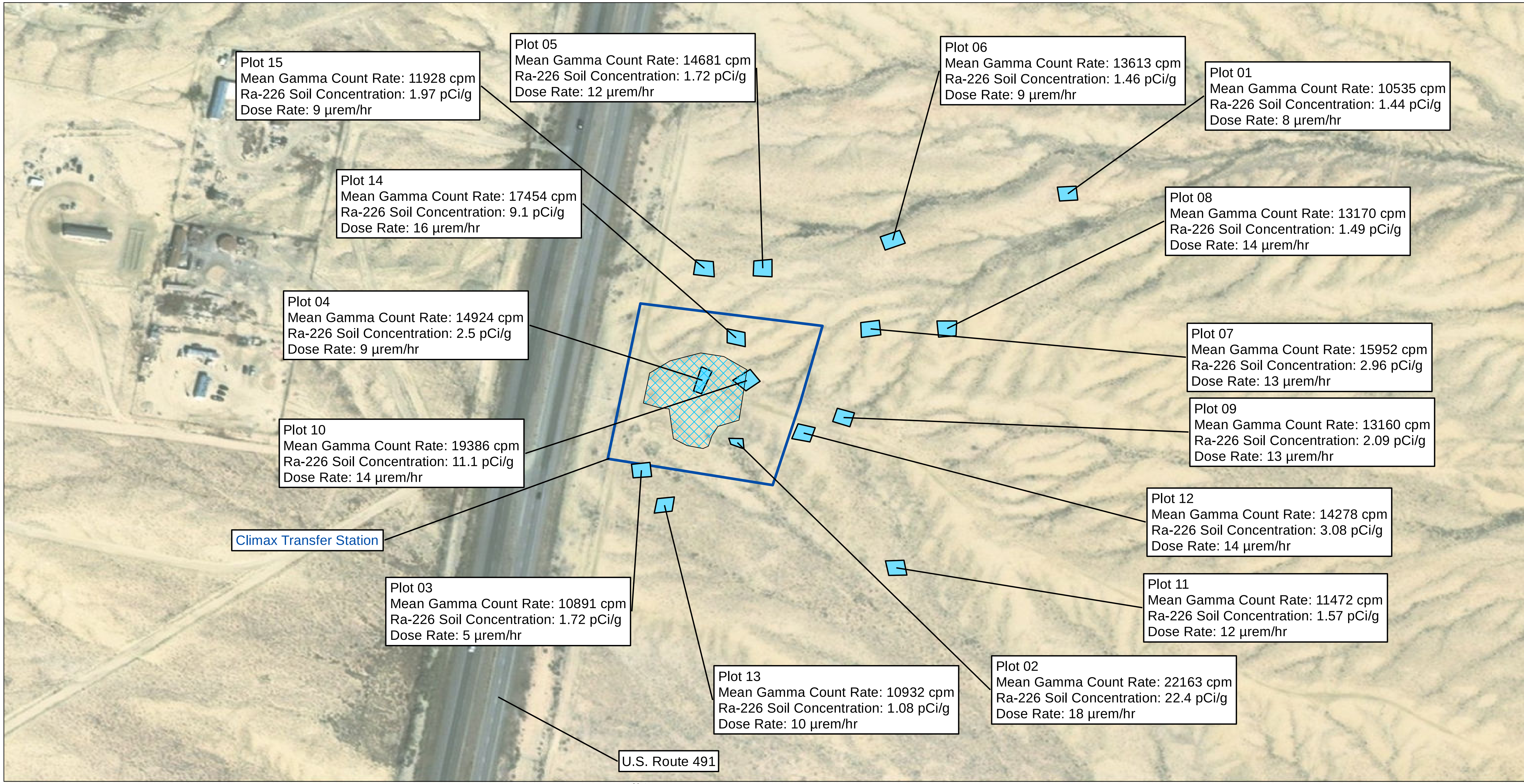


LEGEND

- NAML Technical Specifications of Excavation Disturbed Area
- Correlation Plots
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary

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 = microrems per hour
NAML = Navajo Abandoned Mine Lands
pCi/g = picocuries per gram
Ra = Radium

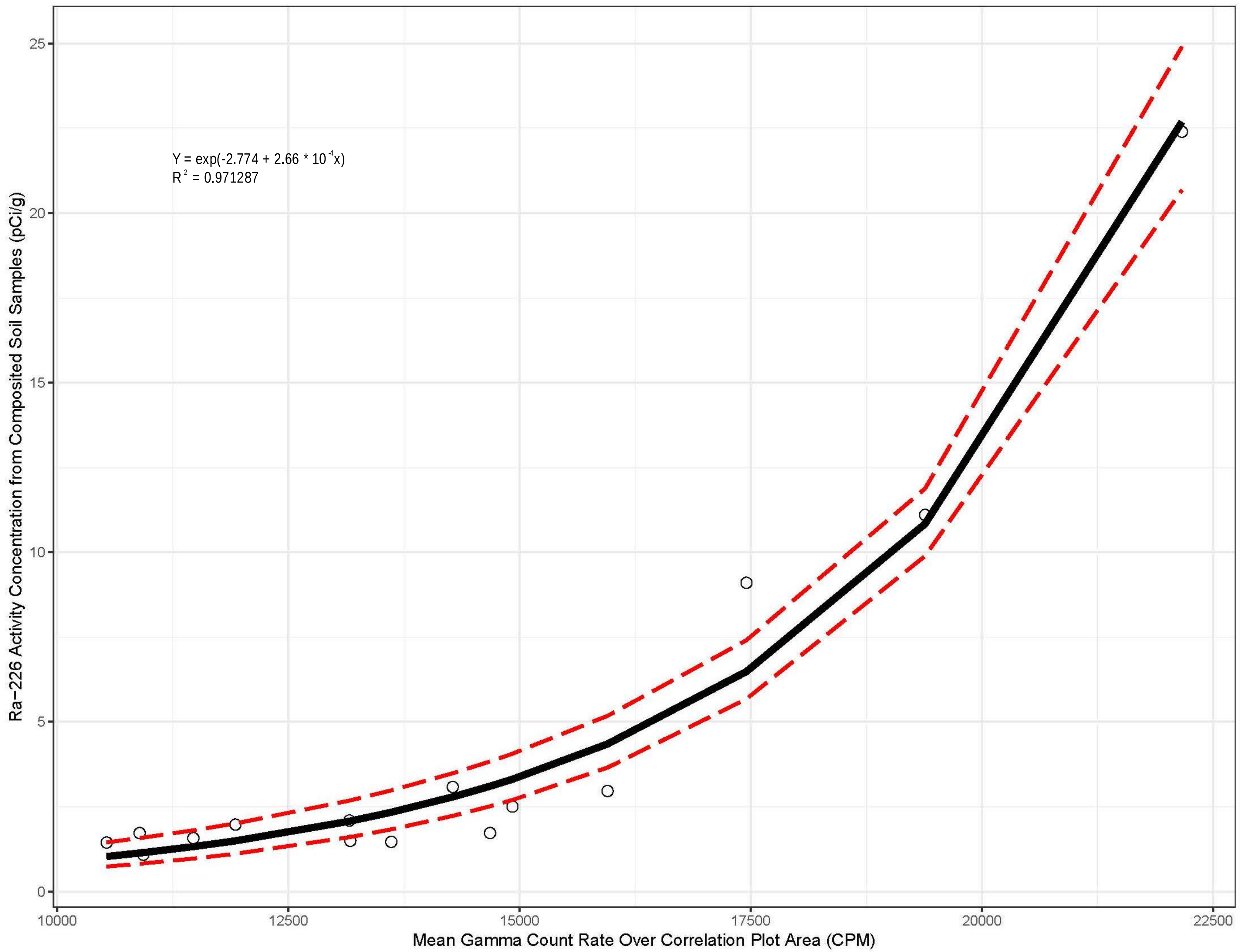
N | 0 100 200 400 Feet | 1:2,400 | 1 inch = 200 feet

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
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE_4-4_CLIMAX_TRANSFER_STATION_CORRELATION_PLOT_MAP.MXD CPOITRAS 1/22/2022 03:41:22



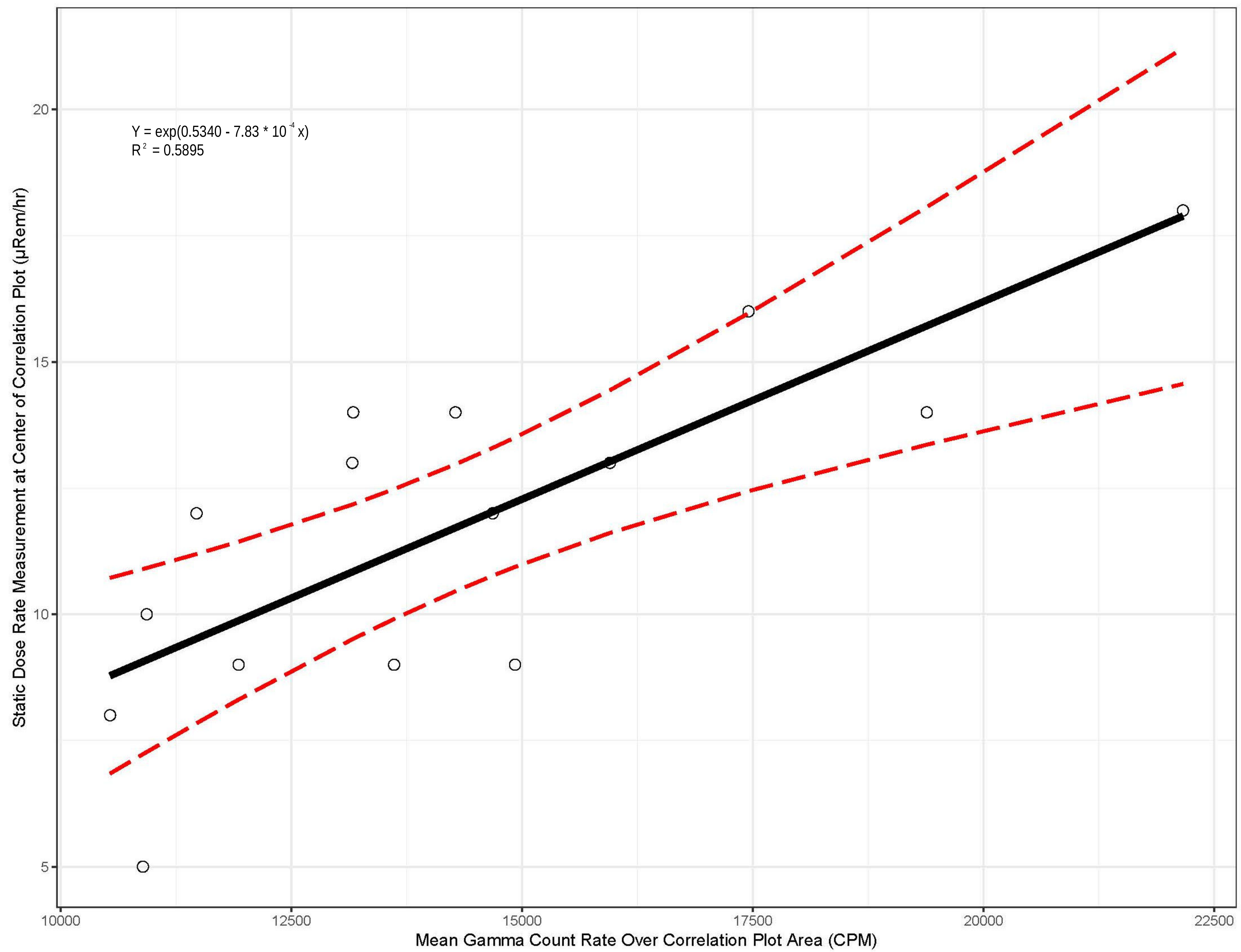
LEGEND

- 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)
Climax Transfer Station
Removal Site Evaluation Report

SLC Z:\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE_4-5_CLIMAX_TRANSFER_STATION_CORRELATION_GCRTOSC.MXD CPOITRAS 3/13/2020 09:15:55



LEGEND

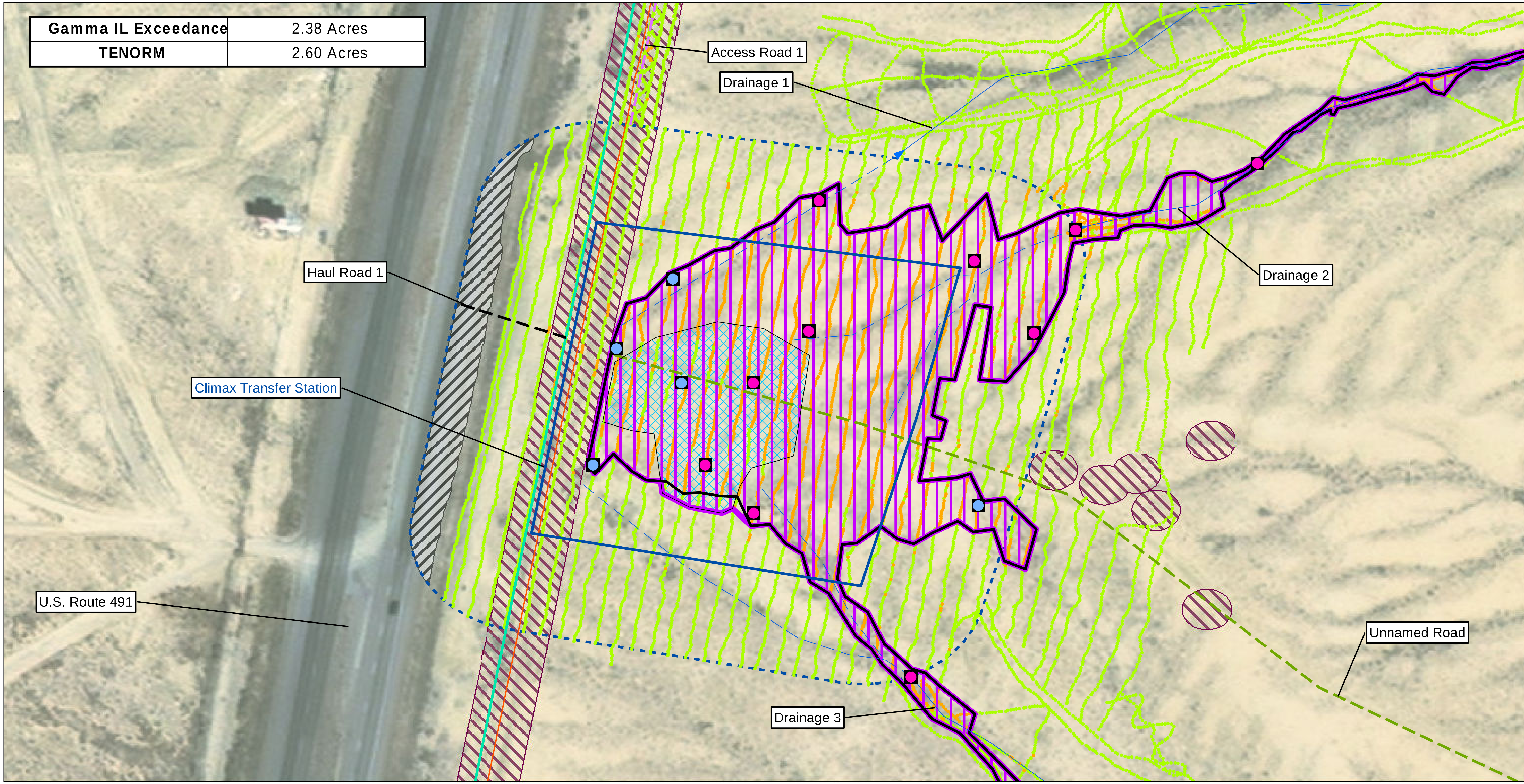
- Sample Location
- Predicted pCi/g
- 95% Confidence interval

Notes:
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)
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE_4-7_CLIMAX_TRANSFER_STATION_CORRELATION_GCRTODR.MXD CPOITRAS 5/20/2022 07:24:14



Gamma IL Exceedance	2.38 Acres
TENORM	2.60 Acres

LEGEND

Sample Location
- Ra-226 exceedance
- Metals and Ra-226 exceedance
- Exceeds BTV
- Drainage
- Estimated Extent of Drainages (Not Field Verified)
- Access Road
- Former Haul Road
- Unnamed Road
- Fence Line
- Gas Pipeline
- Gamma Exceedance
- TENORM Area
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary
- NAML Technical Specifications of Excavation Disturbed Area
- Inaccessible Area
- Restricted Area

Mancos Shale Gamma Scan (cpm)
- 0 - 13900
- 13901 - 57836

Notes:
1. BTV and IL for Mancos Shale gamma scan data is 13900 cpm.
2. Former waste rock piles are not identified as disturbed vegetation because previous NAML reclamation efforts established sufficient vegetative cover in these areas, consistent with nearby native vegetation. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
3. Calculated area that exceeds the IL includes mine site, haul roads, and drainages.

BTV = background threshold value
IL = Investigation Level
NAML = Navajo Abandoned Mine Lands
CPM = counts per minute
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

N

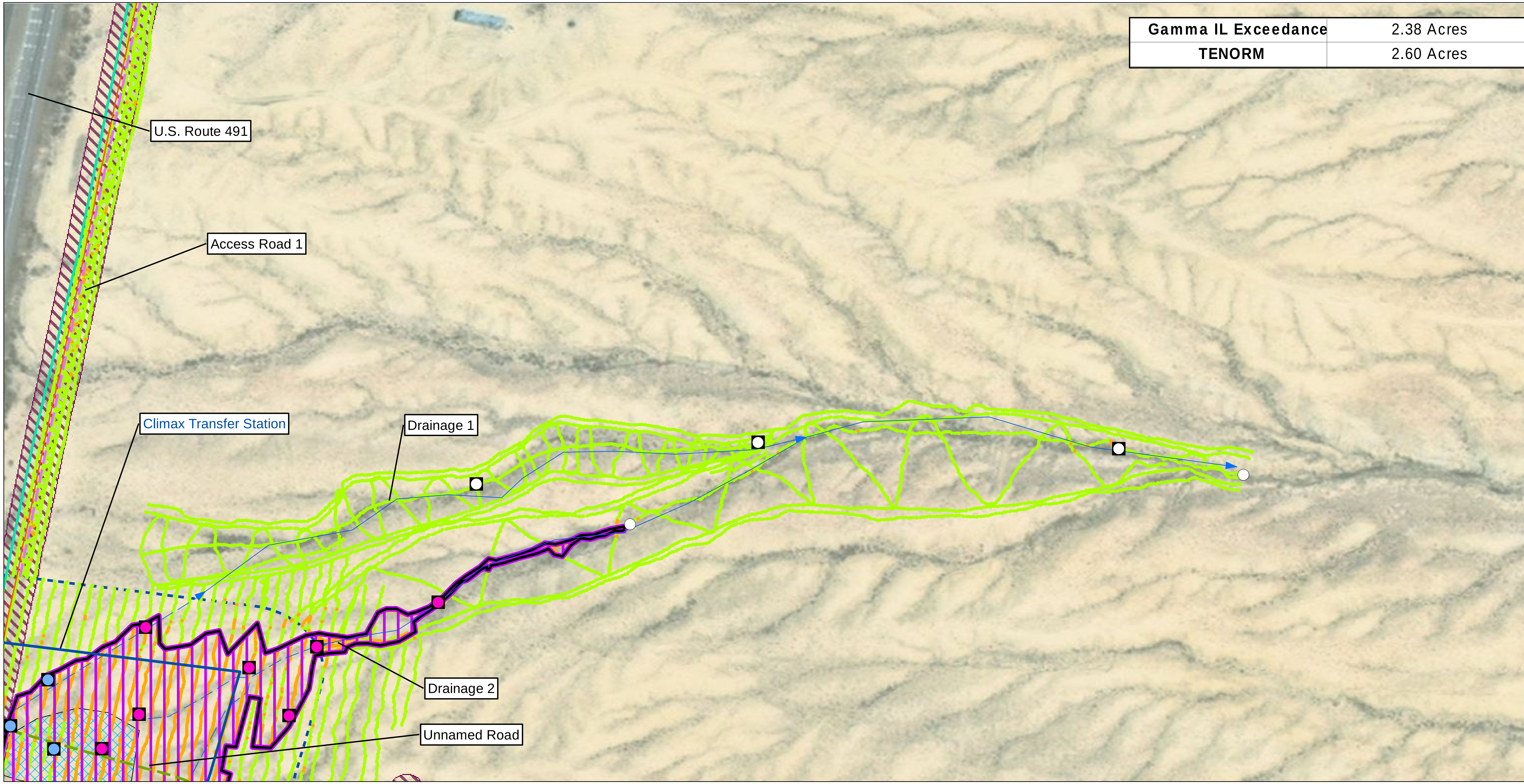
0 50 100 200
Feet
1:1,190 1 inch = 99.2 feet

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 5-1a. Transfer Station Gamma Exceedance and TENORM Area Map
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE_5-1A_CLIMAX TRANSFER_STATION_NORM_MINE_SITE.MXD CPOITRAS 1/22/2022 06:31:34



LEGEND

Sample Location
- Ra-226 exceedance
- Metals and Ra-226 exceedance
- No exceedance
- Exceeds BTV
- Drainage
- Estimated Extent of Drainages (Not Field Verified)

- Access Road
- Unnamed Road
- Fence Line
- Gas Pipeline

- Gamma Exceedence
- TENORM Area
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary
- NAML Technical Specifications of Excavation Disturbed Area
- Restricted Area

Mancos Shale Gamma Scan (cpm)
- 0 - 13900
- 13901 - 57836

Notes:
1. BTV and IL for Mancos Shale gamma scan data is 13900 cpm.
2. Former waste rock piles are not identified as disturbed vegetation because previous NAML reclamation efforts established sufficient vegetative cover in these areas, consistent with nearby native vegetation. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
3. Calculated area that exceeds the IL includes mine site, haul roads, and drainages.

BTV = background threshold value
IL = Investigation Level
NAML = Navajo Abandoned Mine Lands
CPM = counts per minute
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

0 75 150 300
Feet
1:1,800 1 inch = 150 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 5-1b. Drainage 1 and Drainage 2
Gamma Exceedance and TENORM Area Map
Climax Transfer Station
Removal Site Evaluation Report

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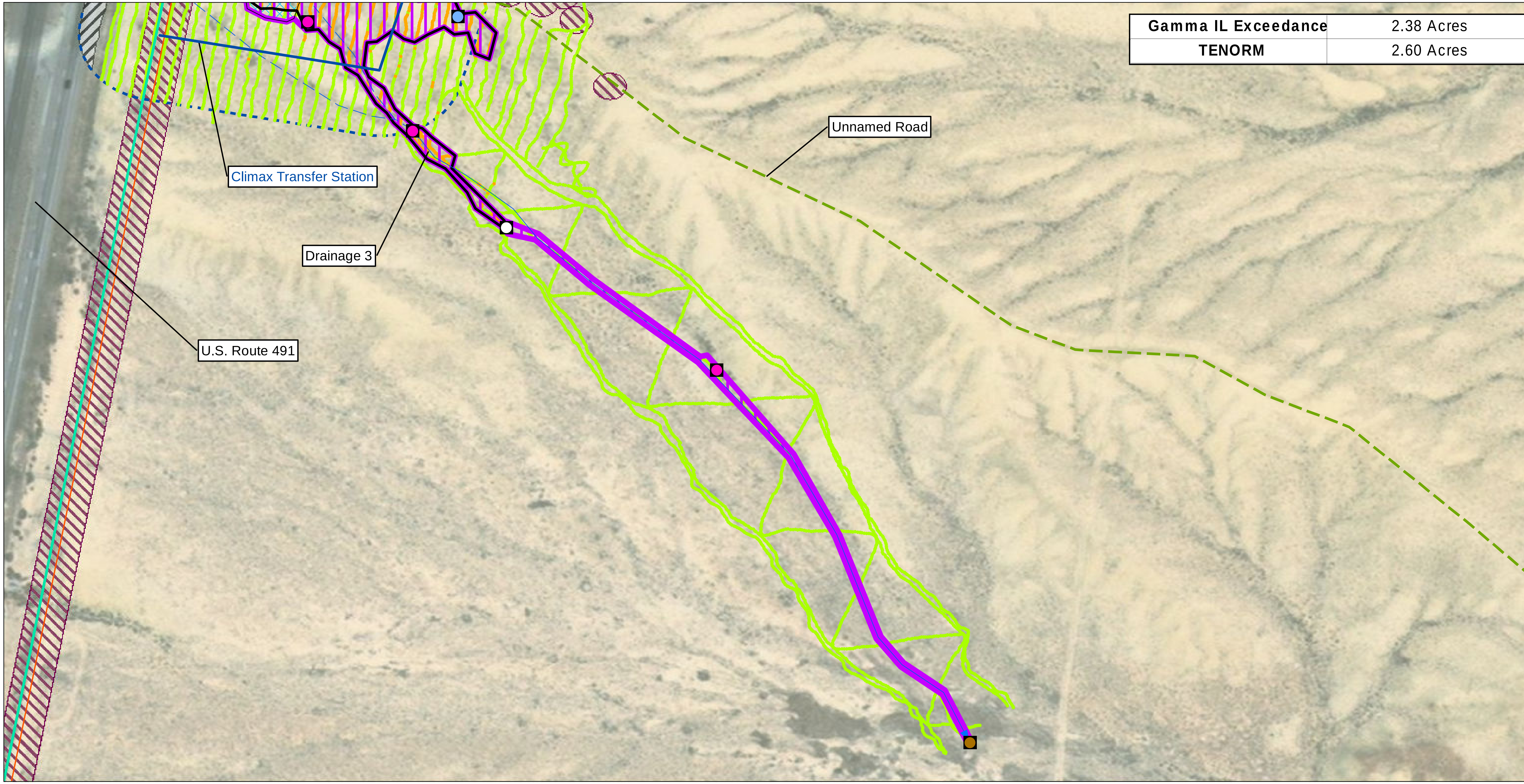

LEGEND

Sample Location
- Ra-226 exceedance
- Metals exceedance
- Metals and Ra-226 exceedance
- No exceedance
- Exceeds BTV
- Drainage
- Estimated Extent of Drainages (Not Field Verified)

- Unnamed Road
- Fence Line
- Gas Pipeline
- Gamma Exceedence
- TENORM Area
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary

- NAML Technical Specifications of Excavation Disturbed Area
- Restricted Area
- Inaccessible Area

Mancos Shale Gamma Scan (cpm)
- 0 - 13900
- 13901 - 57836

Notes:
1. BTV and IL for Mancos Shale gamma scan data is 13900 cpm.
2. Former waste rock piles are not identified as disturbed vegetation because previous NAML reclamation efforts established sufficient vegetative cover in these areas, consistent with nearby native vegetation. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
3. Calculated area that exceeds the IL includes mine site, haul roads, and drainages.
BTV = background threshold value
IL = Investigation Level
NAML = Navajo Abandoned Mine Lands
CPM = counts per minute
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

0 75 150 300
Feet
1:1,800 1 inch = 150 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 5-1c. Drainage 3
Gamma Exceedance and TENORM Area Map
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

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LEGEND

Sample Location

- No exceedance
- Exceeds BTV
- Drainage
- Access Road
- Fence Line
- Gas Pipeline
- 100-foot Transfer Station Buffer
- Restricted Area
- Gamma Exceedence
- TENORM Area

Mancos Shale Gamma Scan (cpm)

- 0 - 13900
- 13901 - 57836

Notes:
1. BTV and IL for Mancos Shale gamma scan data is 13900 cpm.
2. Former waste rock piles are not identified as disturbed vegetation because previous NAML reclamation efforts established sufficient vegetative cover in these areas, consistent with nearby native vegetation. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
3. Calculated area that exceeds the IL includes mine site, haul roads, and drainages.

Notes continued:
BTV = background threshold value
IL = Investigation Level
NAML = Navajo Abandoned Mine Lands
CPM = counts per minute
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

N

0 62.5 125 250
Feet
1:1,500 1 inch = 125 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 5-1d. Access Road
Gamma Exceedance Area Map
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

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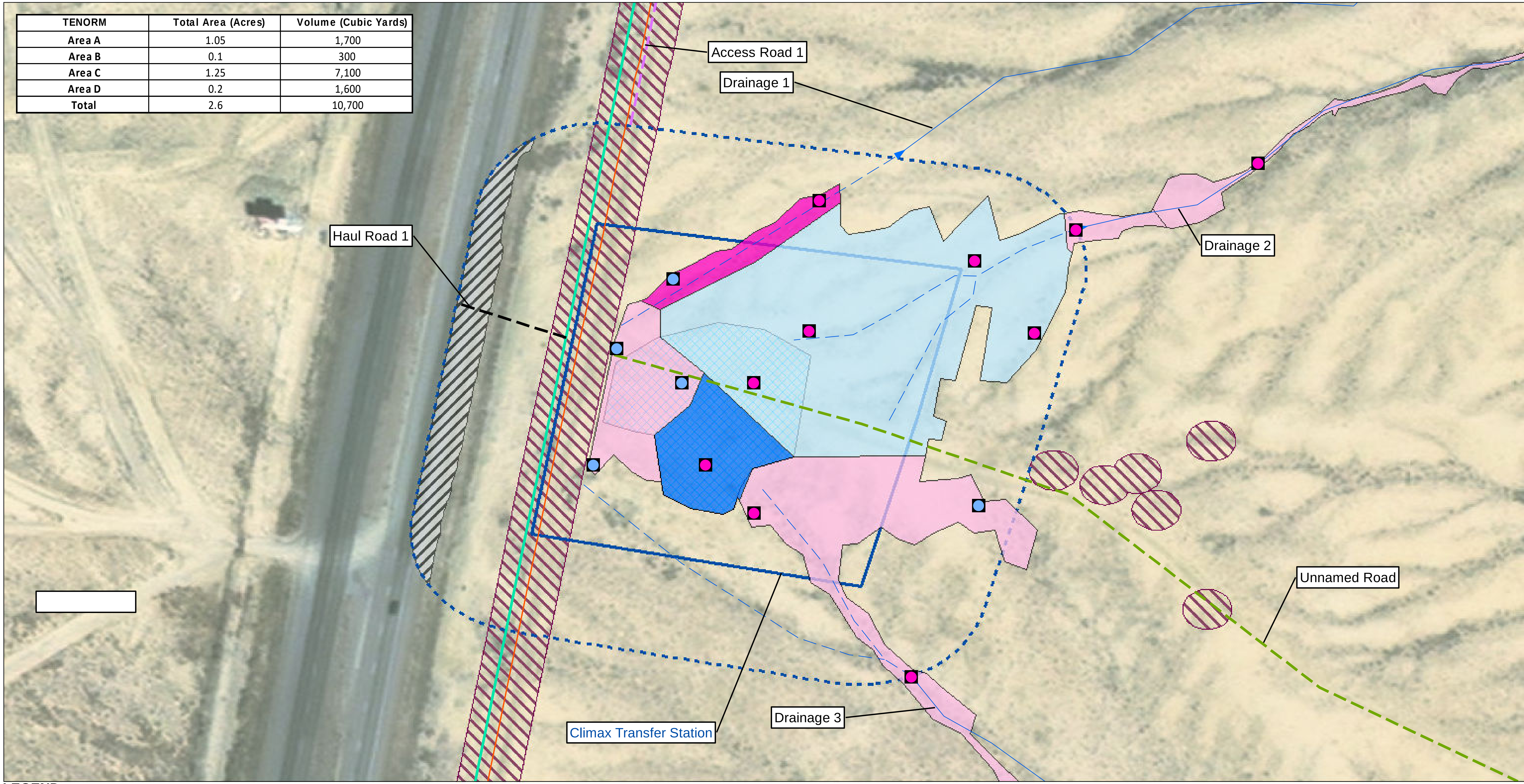

TENORM	Total Area (Acres)	Volume (Cubic Yards)
Area A	1.05	1,700
Area B	0.1	300
Area C	1.25	7,100
Area D	0.2	1,600
Total	2.6	10,700

LEGEND

Sample Location
- Ra-226 exceedance
- Metals and Ra-226 exceedance
- Exceeds BTV
- Drainage
- Estimated Extent of Drainages (Not Field Verified)

- Access Road
- Former Haul Road
- Unnamed Road
- Fence Line
- Gas Pipeline

- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary
- NAML Technical Specifications of Excavation Disturbed Area
- Inaccessible Area
- Restricted Area

TENORM Areas with Depth
- Area A - TENORM 0 -1.0 ft bgs
- Area B - TENORM 0 -2.0 ft bgs
- Area C - TENORM 0 -3.5 ft bgs
- Area D - TENORM 0 -5.0 ft bgs

Notes:
1. Former waste rock piles are not identified as disturbed vegetation because previous NAML reclamation efforts established sufficient vegetative cover in these areas, consistent with nearby native vegetation. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
BTV = background threshold value
NAML = Navajo Abandoned Mine Lands
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

N

0 50 100 200
Feet
1:1,200 1 inch = 100 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 5-2a. Transfer Station
TENORM Depth and Area Map
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

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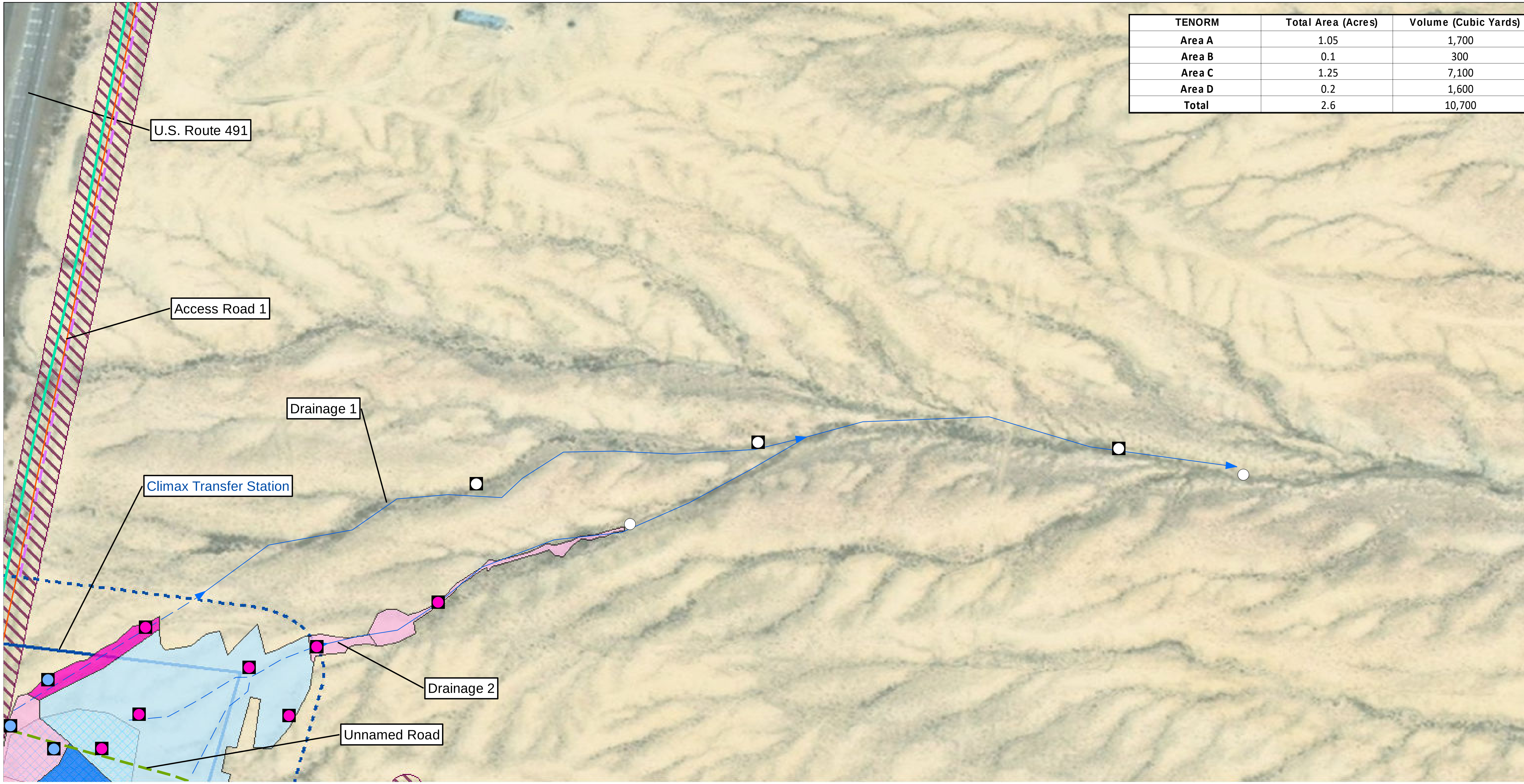


TENORM	Total Area (Acres)	Volume (Cubic Yards)
Area A	1.05	1,700
Area B	0.1	300
Area C	1.25	7,100
Area D	0.2	1,600
Total	2.6	10,700

LEGEND

Sample Location
- Ra-226 exceedance
- Metals and Ra-226 exceedance
- No exceedance
- Exceeds BTV
- Drainage
- Estimated Extent of Drainages (Not Field Verified)
- Access Road
- Unnamed Road
- Fence Line
- Gas Pipeline
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary
- NAML Technical Specifications of Excavation Disturbed Area
- Restricted Area

TENORM Areas with Depth
- Area A - TENORM 0 -1.0 ft bgs
- Area B - TENORM 0 -2.0 ft bgs
- Area C - TENORM 0 -3.5 ft bgs
- Area D - TENORM 0 -5.0 ft bgs

Notes:
1. Former waste rock piles are not identified as disturbed vegetation because previous NAML reclamation efforts established sufficient vegetative cover in these areas, consistent with nearby native vegetation. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
BTV = background threshold value
NAML = Navajo Abandoned Mine Lands
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

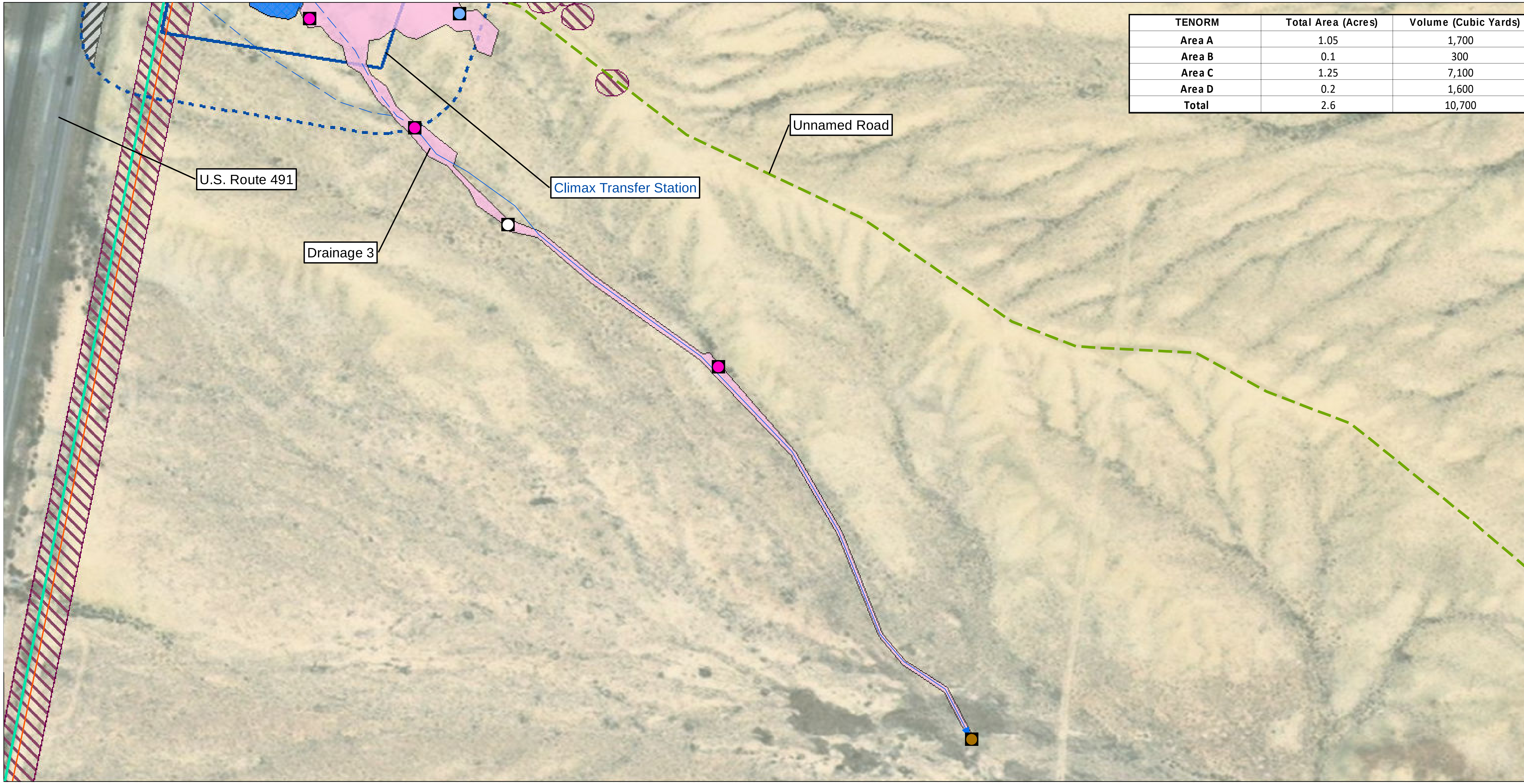
0 75 150 300
Feet
1:1,800 1 inch = 150 feet
N

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 5-2b. Drainage 1 and Drainage 2
TENORM Depth and Area Map
Climax Transfer Station
Removal Site Evaluation Report

JACOBS

SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE_5-2B_CLIMAX TRANSFER_STATION_TENORM_DRAINAGE_1_2.MXD CPOITRAS 1/22/2022 07:00:00



TENORM	Total Area (Acres)	Volume (Cubic Yards)
Area A	1.05	1,700
Area B	0.1	300
Area C	1.25	7,100
Area D	0.2	1,600
Total	2.6	10,700

LEGEND

Sample Location
- Ra-226 exceedance
- Metals exceedance
- Metals and Ra-226 exceedance
- No exceedance
- Exceeds BTV

- Drainage
- Estimated Extent of Drainages (Not Field Verified)
- Unnamed Road
- Fence Line
- Gas Pipeline
- 100-foot Transfer Station Buffer
- Group One Transfer Station Boundary

- NAML Technical Specifications of Excavation Disturbed Area
- Inaccessible Area
- Restricted Area

TENORM Areas with Depth
- Area A - TENORM 0 -1.0 ft bgs
- Area D - TENORM 0 -5.0 ft bgs

Notes:
1. Former waste rock piles are not identified as disturbed vegetation because previous NAML reclamation efforts established sufficient vegetative cover in these areas, consistent with nearby native vegetation. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
BTV = background threshold value
NAML = Navajo Abandoned Mine Lands
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

0 75 150 300
Feet
N
1:1,800 1 inch = 150 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 5-2c. Drainage 3
TENORM Depth and Area Map
Climax Transfer Station
Removal Site Evaluation Report

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SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\CLIMAX_TRANSFER_STATION\RSE_REPORT_FIGURES\FIGURE_5-2C_CLIMAX TRANSFER_STATION_TENORM_DRAINAGE_3.MXD CPOITRAS 1/22/2022 07:00:30