SKYLINE ABANDONED URANIUM MINE
WASTE PILE SITE
REMOVAL ACTION REPORT
NAVAJO NATION, SAN JUAN COUNTY, UTAH

TDD No.: TO-02-09-11-01-0006
PAN No.: 002693.2132.01RF

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Prepared for:

U.S. ENVIRONMENTAL PROTECTION AGENCY
Region 9

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List of Abbreviations and Acronyms

AML	Navajo Nation Abandoned Mine Lands Program
AML Repository	Existing repository area constructed by the AML program in the late 1990s
AOC	area of concern
ASTM	American Society for Testing and Materials
AUM	Abandoned Uranium Mine
bgs	below ground surface
cpm	counts per minute
Cs-137	Cesium-137
DAC	derived air concentration
DCGLw	derived concentration guideline level over a wide area
E & E	Ecology and Environment, Inc.
ERRS	Emergency and Rapid Response Services
ERS	Emergency Response Section
ft^2	square feet
GPS	Global Positioning System
HASL	US Department of Energy Health and Safety Laboratory
HDPE	high density polyethylene
kcpm	kilo-counts per minute
mil	thousands of an inch
MDCR	Minimum Detectable Count Rate
MSDA	Mesa Slope Decision Area
NaI	Sodium Iodide
NNAML	Navajo Nation Abandoned Mine Land Program
NNEPA	Navajo Nation Environmental Protection Agency
oz	ounce
pCi/g	picocuries per gram
psi	pounds per square inch

List of Abbreviations and Acronyms (cont.)

QC	quality control
R	Correlation Coefficient
R^2	Sum of Square Residuals
Ra-226	Radium-226
Ra-228	Radium-228
RAT	Rapid Assessment Tool
SAP	sampling and analysis plan
SMWP	Skyline AUM Waste Pile
START	Superfund Technical Assessment and Response Team
TDD	Technical Directive Document
Th-230	Thorium-230
TLDA	Transloading Decision Area
TRI	Texas Research International
TSDA	Talus Slope Decision Area
UA1	lower portion of unnamed arroyo
UA2	upper portion of unnamed arroyo
UI	laboratory data rejected due to low abundance
U.S. EPA	United States Environmental Protection Agency
yd^3	cubic yards
µCi	microcuries
µCi/cc	microcuries per cubic centimeter

1 Introduction

The United States Environmental Protection Agency (U.S. EPA) tasked Ecology and Environment, Inc.'s (E & E's) Superfund Technical Assessment and Response Team (START) to support a U.S. EPA-funded removal action at the former Skyline Abandoned Uranium Mine (AUM) Waste Pile Site (SMWP) located in the Oljato Chapter of the Navajo Nation (Navajo), Monument Valley, San Juan County, Utah. The location of the Skyline Mine is shown on Figure 1. Site features are depicted on Figure 2.

In July 2005, the Navajo Nation Environmental Protection Agency (NNEPA) identified multiple locations at the SMWP site with gamma radiation activity (gamma activity) counts more than two times above the background level. At the request of the NNEPA, the U.S. EPA and the START conducted several removal assessments from 2008 to 2011 at the SMWP. The soil sampling and gamma activity scans conducted during the removal assessments defined several areas at the SMWP where a removal action would be required to mitigate elevated contaminant concentrations in soil. Removal assessment work conducted prior to March 2010 is summarized in the *Skyline AUM Waste Pile Removal Assessment Report, Navajo Nation, San Juan County, Utah* (E & E 2010).

The purpose of this document is to summarize the soil removal action and the confirmation soil sampling conducted in the removal areas. This report also includes a description of assessment work performed between March 2010 and the start of the removal activities in March 2011. Removal assessment work described herein was performed by START under technical directive document (TDD) No. TO-02-09-08-11-0001.

The purpose of the removal work performed by START, the U.S. EPA, and the Emergency and Rapid Response Services (ERRS) contractor was to reduce elevated contaminant concentrations in soil; to confirm that residual Ra-226 concentrations in soils remaining after the removal action were below the site action levels; and to ensure that no off-site migration of airborne contaminants at unacceptable activity concentration levels occurred during the removal activities.

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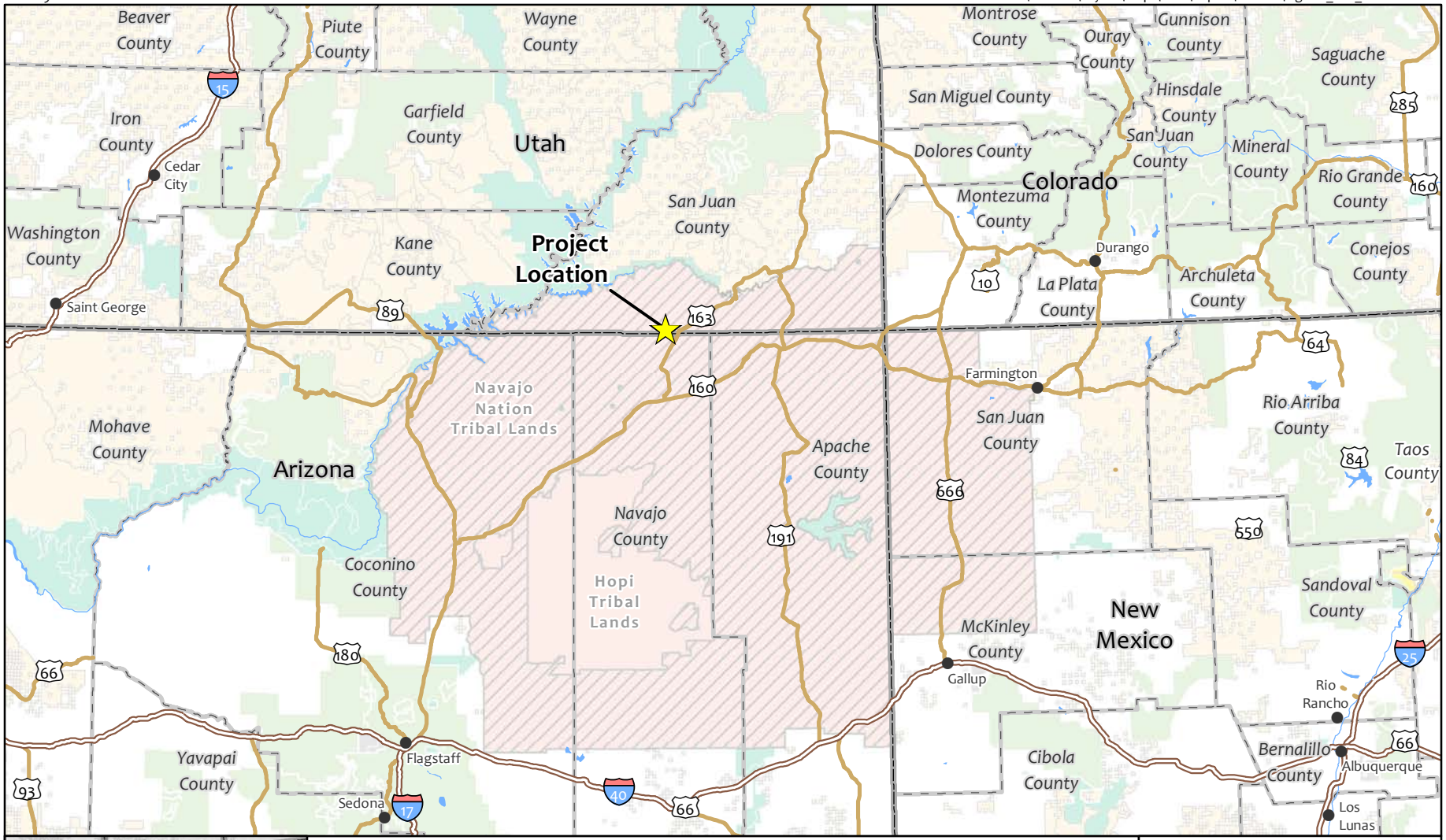

Figure 1
Site Location Map

Skyline AUM Waste Pile
Site Removal
San Juan County, Utah

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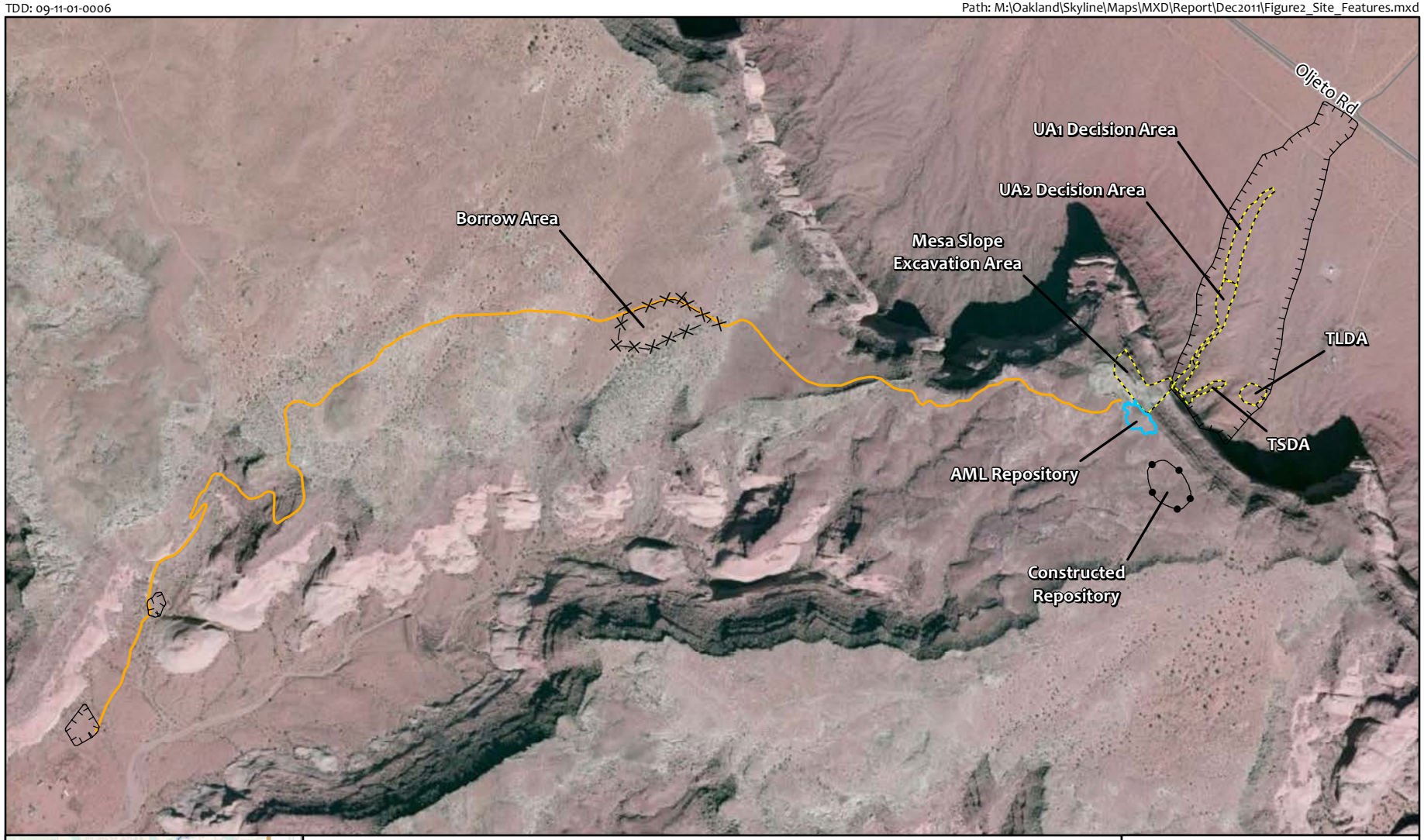

Legend

- Road
- Access Road
- Excavation Area
- Repository Area
- Existing AML Repository
- Soil Borrow Area
- Staging Area/Project Work Zone

N

0 500 1,000
Feet

Figure 2
Site Features Map

Skyline AUM Waste Pile
Site Removal
San Juan County, Utah

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2 Site Information

2.1 Site Location

The former Skyline AUM is located on top of Oljato Mesa (the mesa), approximately 1.5 miles northwest of Gouldings in Monument Valley, San Juan County, Utah. The SMWP site is located approximately 700 feet below and east of the former mine at the eastern base of the mesa at 37° 01' 13.99" north latitude, 110° 13' 50.97" west longitude.

2.2 Site Description

The areas of concern with regard to this report are the Skyline AUM, the SMWP site, and associated residential and pastoral areas east and downgradient from the foot of the mesa. Site features are depicted on Figure 2. Photographs of the Skyline AUM, the SMWP site, and related START assessment activities are included in Appendix A.

Approximately five homesites with residential structures are located between 600 feet and 1,800 feet east and northeast of the SMWP site. These residential properties are cross gradient to the waste piles, and runoff from the portions of the SMWP site that are impacted by mine waste does not flow through them. Land use in the project area is characterized by a low density of single-family residences surrounded by open grazing land. Areas near the foot of the mesa are characterized by talus slopes covered with waste rock and/or waste ore that was pushed over, or fell from, the top of the mesa where the operating mine was located. Portions of the cliff directly below the mine are visibly stained a grey-green color from this activity.

The road to the top of the mesa is in poor condition, and therefore access to the top of the mesa is generally limited to 4-wheel drive vehicles, all-terrain vehicles, or foot traffic. Other than several former uranium mine sites, miscellaneous barbed-wire fences, and one abandoned hogan, there is no known permanent infrastructure on the top of the mesa.

2.3 Site Background

Portions of the Navajo Nation are on geologic formations rich in radioactive uranium ores. Beginning in the 1940s, widespread mining and milling of uranium ore for national defense and energy purposes on Navajo tribal lands led to a legacy of abandoned uranium mines. The Skyline AUM is one of approximately 520 AUMs located on the Navajo Nation. During the late 1990s, portions of the Skyline AUM on top of the mesa were closed by the Navajo Nation Abandoned Mine Land (AML) program. This work focused on removing immediate physical hazards including sealing the mine portals, consolidating loose accessible mine waste, and capping it with uncontaminated fill material. However, due to the steep terrain, residual mine waste at the eastern edge of the mesa and the bottom of the mesa were not removed during mine closure activities.

As part of regular mining operations, a gondola was used to transport ore from the Skyline AUM to the foot of the mesa where it was loaded into trucks for transport to the mill. One area of documented elevated gamma activity was located approximately 500 feet southeast of the base of the stained areas of the cliff. This area may have been the transloading area where ore was transferred from ore cars to trucks for transport to a uranium mill.

According to NNEPA personnel, the top of the mesa and the SMWP area are used seasonally during the spring, summer, and fall by local residents as pastureland for grazing sheep, horses, and cattle and gathering traditional herbs and plants. Nearby residents have expressed concern to the NNEPA regarding the potential for wind-blown and water-borne radioactive particles to migrate from the site and impact their livestock and/or properties.

2.4 Previous Investigations

In 2001, the U.S. EPA Region 9 Emergency Response Section (ERS) demolished one structure constructed of radioactive stone and located in the residential area east of the SMWP site (E & E 2001).

During a site inspection performed by the NNEPA in July 2005, gamma radiation activity (gamma activity) counts greater than two times the background level were detected in approximately 80 locations at the SMWP site. The NNEPA requested assistance from the U.S. EPA in performing an investigation of the SMWP site and surrounding area to determine the nature and extent of the contamination and to mitigate any potential impacts to human health and/or the environment.

Because the uranium present in the mine waste is naturally occurring, it is expected to be in secular equilibrium with its daughter decay products. The radioisotope radium-226 (Ra-226) was selected for use as a proxy indicator for all radioisotopes in the uranium decay chain because it is the only radioisotope in the decay chain with well-established risk versus dose data.

In November 2008, START collected 28 surface soil samples for Ra-226 analysis from two areas of concern (AOCs) within the SMWP site and performed surface gamma activity scans at the SMWP site using the Rapid Assessment Tool (RAT) developed by the U.S. EPA. Each RAT unit was equipped with a Ludlum Model 2241-2 Digital Survey Ratemeter (2241) with a Ludlum Model 44-10 2-inch diameter sodium iodide (NaI) gamma scintillation detector (2x2), a Panasonic Toughbook® laptop computer, and a Trimble® Model GeoXT™ Global Positioning System (GPS) unit. The RAT software developed by the U.S. EPA allows the user to simultaneously collect and record gamma activity counts and their associated GPS locations and display this information in real time on the laptop computer.

As part of the removal assessment performed at the site in November 2008, a background area with similar geology and no known or suspected impacts from mining was also selected. Surface soil samples and gamma activity scan data were collected at 14 locations within the background area to allow for a comparison of Ra-226 concentrations and gamma activity counts in soils from the Skyline AUM. The average background area Ra-226 soil concentration for the 14 samples was 0.16 picocuries per gram (pCi/g).

The 28 soil samples collected in the two AOCs within the SMWP site during the November 2008 removal assessment activities documented the presence of mine waste that contained Ra-226 above background concentrations at both areas (E & E 2009). These locations were the suspected former transloading area, designated the transloading decision area (TLDA), and the top of the talus slope immediately below the mine, designated the talus slope decision area (TSDA).

START performed additional removal assessments in July 2009, August 2009, October 2009, and March 2010, collecting surface and subsurface soil samples for Ra-226 analysis and using the RAT to collect surface gamma activity measurements at various AOCs of the SMWP site (E & E 2010). Analysis of the 2008 through 2010 removal assessment data sets indicated that one-minute surface scans of gamma activity correlated strongly to Ra-226 concentrations in surface soil samples where Ra-226 concentrations and gamma activity counts were significantly above background levels. Based on the results of the previous removal assessments at the SMWP site, the following AOCs (Figure 2) were identified for a removal action: an unnamed arroyo flowing east and away from Oljato Mesa (Lower and Upper Portions of Unnamed Arroyo- UA1 and UA2); the TSDA and the TLDA at the base of the mesa; an existing mine waste repository at the top of the mesa (Existing Repository Area or AML Repository); and the slope of the mesa immediately below the mine and leading to the TSDA (Mesa Slope Area).

3 Summary of START Activities, March 2010 Through October 2011

The following sections describe field activities performed by the U.S. EPA, the ERRS contractor, and the START between March 2010 and October 2011. During the soil removal actions, confirmation soil sampling, associated one-minute gamma activity scans at the confirmation soil sample locations, and roving surface gamma activity scans of each excavated AOC were conducted to document that soils impacted with Ra-226 above the action levels had been effectively removed within the boundaries of the AOCs. Perimeter and work zone air monitoring were used to document that off-site migration of contaminants at unacceptable activity concentrations did not occur, and therefore, that there was no unacceptable exposure to nearby residents, workers, or the general public. Prior to each mobilization, the START updated the site-specific health and safety plan as needed.

3.1 Preconstruction Planning

3.1.1 Biological and Botanical Surveys

Biologists from E & E and Dodge Environmental LLC (Dodge) conducted biological surveys for special status species at five areas of the Skyline AUM site on February 24 and 25, 2011. The results of the survey were included in E & E's March 24, 2011, report titled, *Summary of Results of Biological Surveys for the Skyline Abandoned Uranium Mine Waste Pile Site Removal, Navajo Nation, San Juan County, Utah* (E & E 2011a). A copy of the report is included in Appendix B. The five areas that were surveyed were identified as Borrow Areas 1 and 2, Repository Area, Southwest Staging Area, Water Tank Area, and Northeast Area. The biologists verified the current land use for each area, mapped habitat and vegetation cover types, and recorded locations of potential special status species resources. No special status plant or animal species were observed during the field surveys; however, potential signs of two special status wildlife species, kit fox and banner-tailed kangaroo rat, were found during surveys. The potential kit fox signs that were found were a large burrow on the western side and potential kit fox tracks on the eastern side of the Borrow Areas 1 and 2. A potential burrow for banner-tailed kangaroo rats was found at the northern base of the talus slope in the Northeast Area. Additionally, potential habitat for Cronquist milkvetch was identified in the Northeast Area (E & E 2011a).

The report concluded that there was little evidence of sensitive plant and wildlife species within the project area and therefore limited expected impacts on individuals of any sensitive species. Limited impacts to sensitive wildlife species include temporary loss or disturbance of nesting and foraging habitat, although many species would be able to move into surrounding areas of the same habitat where activities are not occurring (E & E 2011a).

3.1.2 Cultural Resources Survey

On November 8 and 9, 2010; December 4, 6, and 29, 2010; and February 21 and 22, 2011, CSWTA, Inc. conducted a cultural resources inventory survey on approximately 142 acres of land for the Skyline AUM removal project. The results of the survey are in CSWTA Inc.'s May 12, 2011 report titled, "*A Cultural Resources Inventory Survey for the Existing Skyline AUM Site for Uranium Clean-Up in the Vicinity of Oljato, San Juan County, Utah*" (CSWTA, Inc. 2011). A copy of the report is included in Appendix C.

CSWTA, Inc. carefully examined all exposed ground surfaces and paid special attention to areas of erosion and deflation. The area was surveyed by sub-parallel pedestrian transects spaced 10-12 meters apart. No cultural resources, traditional cultural properties, or sacred places were inventoried during the survey. No collections were made during the survey (CSWTA, Inc. 2011).

3.1.3 Drawings and Specifications

E & E prepared construction drawings and specifications for each of the proposed excavation work areas and the repository construction at the Skyline AUM. As-built construction drawings of the repository and the specifications are included in Appendix D.

3.1.4 Sampling and Analysis Plan

Prior to and during mobilization activities, the START prepared the June 2011 Sampling and Analysis Plan (SAP) titled, "*Sampling and Analysis Plan, Skyline Abandoned Uranium Mine Waste Pile Site Removal Action, Navajo Nation, San Juan County, Ut*ah" (E & E 2011b). A copy of the SAP is included in Appendix E. The SAP described methods and procedures for collecting, analyzing, and evaluating air samples at the perimeter of work zones and confirmation soil samples in excavated areas.

3.2 Air Sampling

Prior to commencing dust-generating activities in the contaminated excavation areas, two air sampling pumps were set up at the perimeter of the work zone and run for approximately 8 to 10 hours (i.e., a standard work day) to establish background alpha and beta activity concentrations in ambient air. The background air samples were used to establish the COPC activity concentrations that are naturally occurring in the air unrelated to the removal activities occurring at the site.

Air sampling was performed during all activities that had the potential to generate dust containing radioisotopes. In general, three or four air sampling pumps were set up on the perimeter of each work zone that had the potential to generate contaminated dust. Pumps were located such that at least one pump was located in a downwind direction. Pumps were set up between the work zone and the homesites whenever contaminated soils were disturbed on the valley floor. In order to collect more representative data, the air sampling locations nearest the work zones were moved as the work area boundaries changed. The locations of various air monitoring stations are depicted on Figure 3. The dates indicated on Figure 3 correspond to when the sample assembly was put into service at that location.

In general, immediately prior to the start of work each day, a new 47-millimeter diameter borosilicate glass-fiber filter was installed in the sample pump. A calibrated flow measurement device was connected to the filter head. The pump was started and the initial flow rate and start time were recorded on the field log. After recording the flow, the flow-measurement device was removed and the sample head was set up to run normally. The sample pump and generator were periodically checked to ensure that the systems were operating and that loose dust was not accumulating on the surface of the filter. If dust was observed, the final flow rate was measured and recorded, the filter was collected for analysis, and a new filter was placed into service. If no loose dust was observed, the final flow rates were measured and the filters were collected daily at the completion of dust-generating activities.

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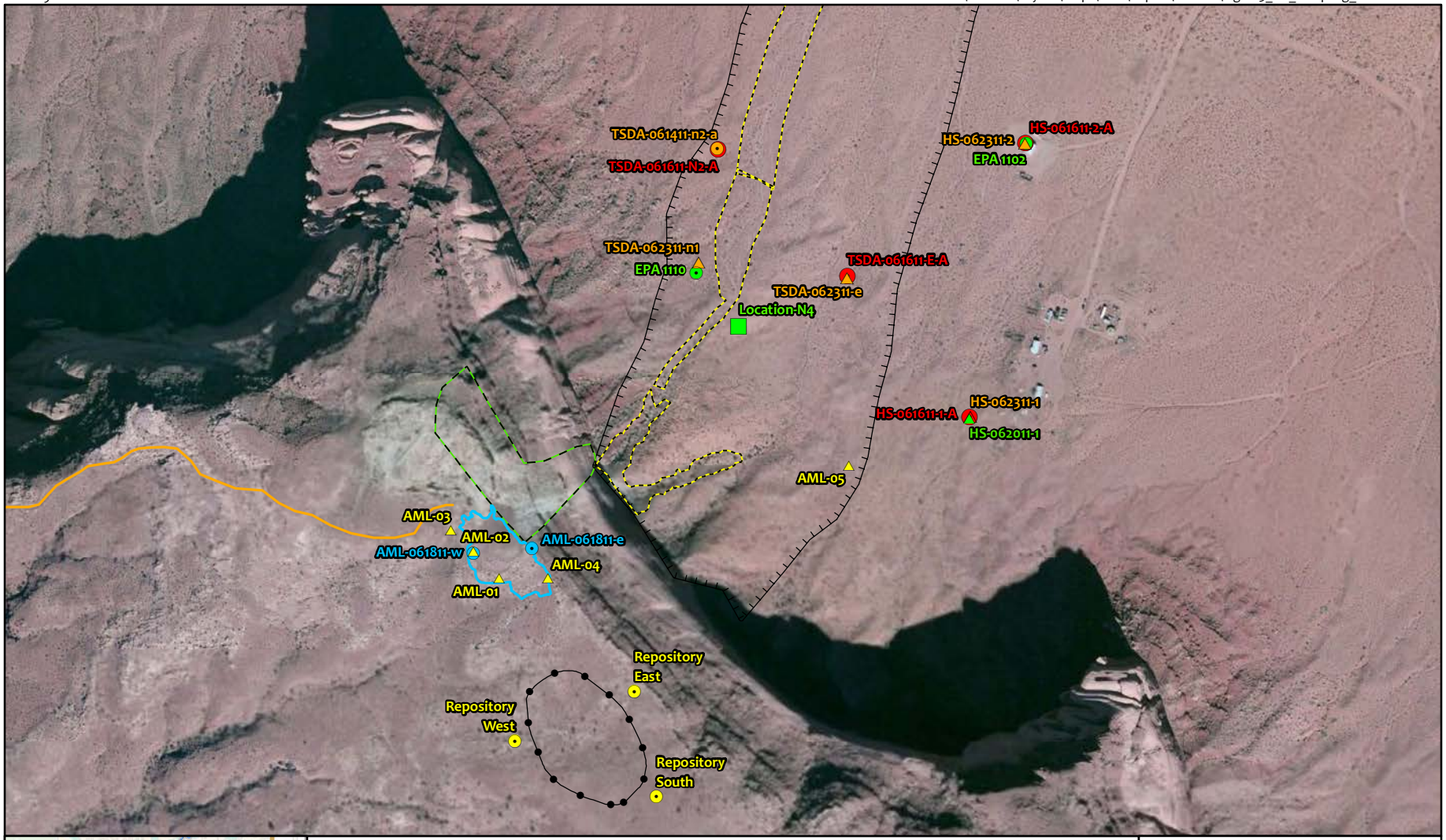

Legend

- Access Road
- Skyline Mine
- Excavation Area
- Existing Repository
- Repository Area
- Staging Area/ Project Work Zone

Air Sampling Location

- Air Sample - May 12, 2011
- Air Sample - June 7, 2011
- Air Sample - June 8, 2011
- Air Sample - June 14, 2011
- Air Sample - June 16, 2011
- Air Sample - June 18, 2011
- Air Sample - June 20, 2011
- Air Sample - June 23, 2011
- Air Sample - August 12, 2011

N

0 400 800
Feet

Figure 3
Air Sampling Locations

Skyline AUM Waste Pile Site Removal
San Juan County, Utah

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Air samples were analyzed in the field by counting the gross alpha and beta activity on each sample filter using a Ludlum Model 3030 Alpha/Beta Counter. The initial and final flow rates and the run time were used to calculate the total flow and subsequently, the estimated activity concentrations.

Alpha and beta activity concentrations were compared to the Nuclear Regulatory Commission's Derived Air Concentration (DAC) Annual Limits on Intake values as listed in Appendix B to 10 Code of Federal Regulations, Part 20. The DAC value is the allowable intake limit for a worker at a nuclear facility in a typical 2,000-hour work year. Depending on the amount of time that had elapsed between sample collection and sample analysis, alpha activity concentrations were variously compared to the values for Ra-226 and thorium-230 (Th-230). Each air sample was generally counted three times. The first count was typically performed immediately after sample collection, and the associated DAC from this measurement was compared to the DAC for Ra-226. Subsequent counts were respectively performed on the next two working days. The final count of alpha activity for each sample was compared to 10 percent of the DAC value for Th-230 of 3×10^{-12} microcuries per cubic centimeter (µCi/cc). The DAC for Th-230 was selected because it was the most conservative DAC value for any radioisotope expected to occur at detectable levels within the project site. Alpha activity concentrations did not exceed 10 percent of the DAC value, and no worker exceeded 2,000 hours on site. Final activity concentrations for beta radiation were within the range of background concentrations for all samples collected. The data indicated that no unacceptable exposures occurred either within or at the perimeter of the site, for either alpha or beta radiation. A graph of the estimated DAC based on the final alpha activity concentration for each sample is shown on Figure 4. Note that not all samples contained a detectable amount of alpha activity.

Air sampling was generally conducted in accordance with the SAP. One exception was that the initial sample count was occasionally delayed for up to 24 hours due to rain. The delay was necessary because the presence of moisture typically attenuates alpha activity on the air filters, which would bias the results low. Daily air sampling data (i.e., field data sheets) including flow rate and run time, estimated alpha activity concentrations in ambient air, and other pertinent data are included as Appendix F.

The air data were reviewed daily by START as part of the data validation process. Seven of the daily background quality control (QC) samples were slightly below the acceptable range for background beta activity. The lower limit on background beta concentrations for a minimum 4-hour sample run time was approximately 41 counts per minute (cpm) and was based on measurements of background beta activity at the site made prior to the start of contaminated soil excavation. Background values as low as 39 cpm were occasionally observed during daily instrument quality control checks. Because the background activity concentrations are subtracted from the sample beta activity concentrations as part of the estimate of airborne beta activity, the calculated sample results for beta activity may have been biased high. Thus, the air sample results are considered to be conservative estimates of alpha and beta activity at these locations.

In addition to the daily review by START personnel, personnel from the U.S. EPA's Environmental Response Team (ERT) in Las Vegas, Nevada, mobilized to the site from May 16 through May 19, 2011. ERT personnel inspected sampling equipment and procedures and

collected co-located duplicate samples as part of a quality assurance and quality control program intended to validate methods and procedures. No major exceptions to the SAP or problems with the air sampling program were noted. Two relatively minor suggestions were made and immediately implemented. The first recommendation was to not analyze wet samples, because the presence of moisture on the sample filter can attenuate alpha activity. The second recommendation was to determine the activity count per unit time (e.g., alpha count rates above 500 counts per minute for an eight-hour sampling period) that would indicate an actual or potential exceedance of the DAC for radon-222, Ra-226, or Th-230 and post the information in a prominent location near the samplers. It was also suggested that the contact information for the START and ERRS project managers and health and safety officers be posted on the same form with instructions to immediately notify those personnel if an exceedance occurred. The information was posted in the field laboratory.

3.3 Excavation Work

Excavation work began on March 28, 2011, and continued in various phases until September 20, 2011. Repository construction, final grading and capping, and restoration and stabilization activities continued until approximately October 15, 2011. Approximately 27,148 cubic yards (yd^3) of contaminated soil were excavated from the various decision areas and placed in the constructed repository. The estimated volume excavated from each decision area is included on Table 1. Approximately 20,000 yd^3 of the contaminated material was moved from the valley floor to the top of the mesa using a "skyline" system. The skyline system utilized a top-loading, bottom-dumping, pneumatically-activated, 4 yd^3-capacity hopper bucket suspended on steel cables (see photos in Appendix A). The skyline hopper bucket was able to move an average of approximately 380 yd^3 per day from the stockpile at the base of the mesa to trucks waiting at the top of the mesa.

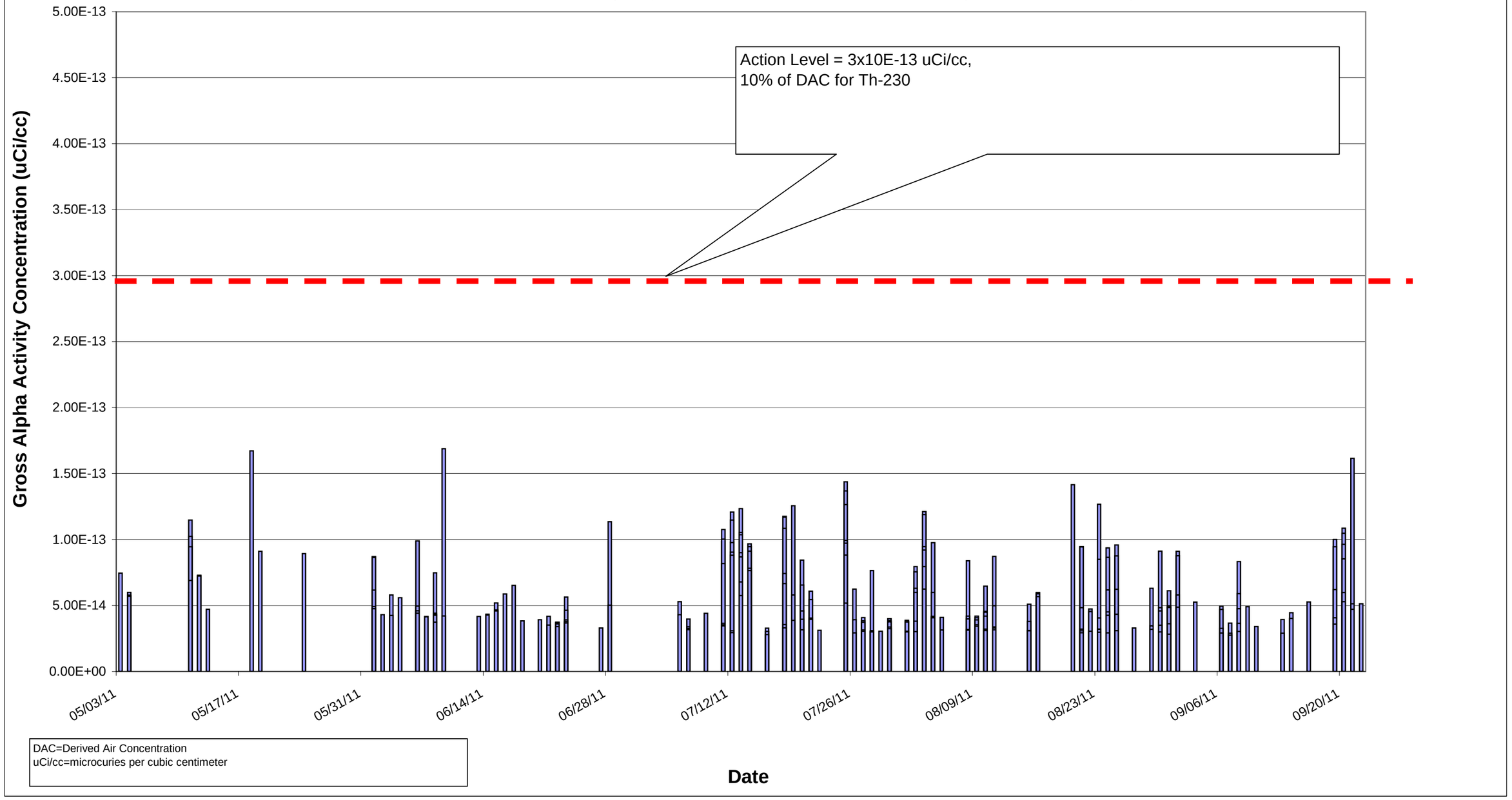
Table 1 Estimated Excavation Volumes, Skyline Mine Waste Pile Site Removal Action, San Juan County, Utah

E & E Project No. 002693.2132.01RF — TDD No. TO-02-09-11-01-0006

Excavation Source	Dates Material Transported to Repository	Estimated Excavation Volume (yd^3)
AML	6/1/11-6/9/11	4540
TLDA	7/25/11-9/20/11*	1800
TSDA	7/25/11-9/20/11*	4000
UA1 and UA2	7/25/11-9/20/11*	14612
Mesa Slope	6/20/11-7/21/11	2196
TOTAL		27148

Notes:
*Soil excavated from the TLDA, TSDA, UA1, and UA2 was stockpiled in the North Stockpile before being transported to the repository on the indicated dates.
yd^3 = cubic yards
AML = existing repository area
TLDA = transloading decision area
TSDA = talus slope decision area
UA1 = lower unnamed arroyo decision area
UA2 = upper unnamed arroyo decision area

Figure 4: Graph of Detected Final DAC Alpha Activity Values at Skyline AUM Waste Pile Site Removal Project, May through September 2011, Skyline AUM Waste Pile Site Removal, San Juan County, Utah



3.3.1 Borrow Area

Clean fill soil and rock used to construct and repair roads and the repository were excavated from a borrow area located approximately ½-mile north of the former mine site on top of Oljato Mesa (Figure 2). Approximately 35,000 yd^3 of material were excavated from the borrow area for use as bedding material, general fill, or rock armoring. A mechanical power-screen was used to segregate the appropriate gradation of rock or soil. Although originally proposed for use and included in the cultural resource and biological surveys, the potential borrow area located on the north side of the access road was not used or disturbed.

3.3.2 Repository Construction

Soils contaminated above the applicable action level were excavated and placed in a repository constructed on top of Oljato Mesa approximately 400 feet south of the former mine. As-built construction drawings for the repository, including survey drawings of the foundation's surface and the final surface, are included in Appendix D. Excavation for the repository foundation occurred from about April 4, 2011, until approximately May 19, 2011. Not all locations were excavated to the proposed depth due to the presence of hard rock in the bottom of the repository. Upon reaching final excavation depths, an 18-inch-thick layer of screened soil (bedding material) was placed on the bottom of the excavation. The material was compacted using a vibrating sheep's-foot compactor (grid-roller). In-place soil density and moisture testing using American Society for Testing and Materials (ASTM) D6938 was performed by Geomat Inc., Farmington, New Mexico, to ensure a minimum of 90 percent relative compaction was achieved. The density and moisture testing were also used to develop a method specification for watering and compaction that was subsequently used during placement of compactable fill materials (i.e., bedding material and general fill material). Copies of the geotechnical test data are included as Appendix G.

After installing the bedding material, Northwest Linings and Geotextile Products Inc., of Kent, Washington (Northwest Linings), mobilized to the site and began installing the lower geotextile membrane. The lower geotextile membrane (geomembrane) consisted of: 1) a bottom layer of 16-ounce (oz) per square yard geotextile fabric; 2) a middle layer of 60-thousandths of an inch (mil) thick high density polyethylene (HDPE) membrane textured on both sides; and 3) and an upper layer of 200-mil thick drainage layer. The drainage layer consisted of a plastic mesh covered on both sides with by an 8-oz per square yard geotextile fabric.

During the installation of the HDPE liner, trial seams were made and test coupons were cut from them. Destructive seam-strength testing was performed on at least four trial double-wedge welded seams prior to each shift and after lunch each day.

After installing the HDPE layer and prior to installing the drainage layer, all double-wedge welded seams were tested by sealing the seam, then pressurizing the interstitial space with air to a minimum of 40 pounds per square inch (psi) for at least five minutes in accordance with the construction specifications. Upon achieving a passing test result (i.e., less than 3 psi drop in five minutes), the opposite end of the seam was cut in the presence of the engineer. An immediate drop in pressure at the gauge end indicated the air channel in the seam was continuous. Extrusion welded seams were tested for leaks by brushing them with soapy water and then applying a vacuum using a standard vacuum box apparatus. After verifying that the seam was under a

minimum of 5 inches of mercury vacuum, Northwest Linings and START inspected the area for bubbles that would indicate leaks. In both of the above cases, small leaks were occasionally found, repaired, and retested until a passing result was achieved. Copies of the field testing forms and panel layout diagrams are included in Appendix H.

Destructive testing of the installed double-wedge welded seams was also performed. Northwest Linings cut 10 sections of seams selected at random and submitted them under chain-of-custody control to Texas Research International (TRI) for material and seam testing. Tests performed included: tensile strength by ASTM D638, thickness by ASTM D5994, puncture strength by ASTM D 4883, tear resistance by ASTM D 1004, and weld strength in peal and shear by ASTM D6932. All seams and materials exceeded the minimum construction specifications. Liner test data are included in Appendix H.

To prevent storm water runoff from eroding cover material and potentially exposing contaminated soils, an HDPE-lined drainage channel was constructed along the eastern and northeastern edge of the repository. The lined portion of the channel was approximately 450 feet long. The channel's location is depicted on Figure 5. Down gradient from the repository, the channel was excavated into native soil and rock in order to route runoff to an existing arroyo on the northwest side of the repository.

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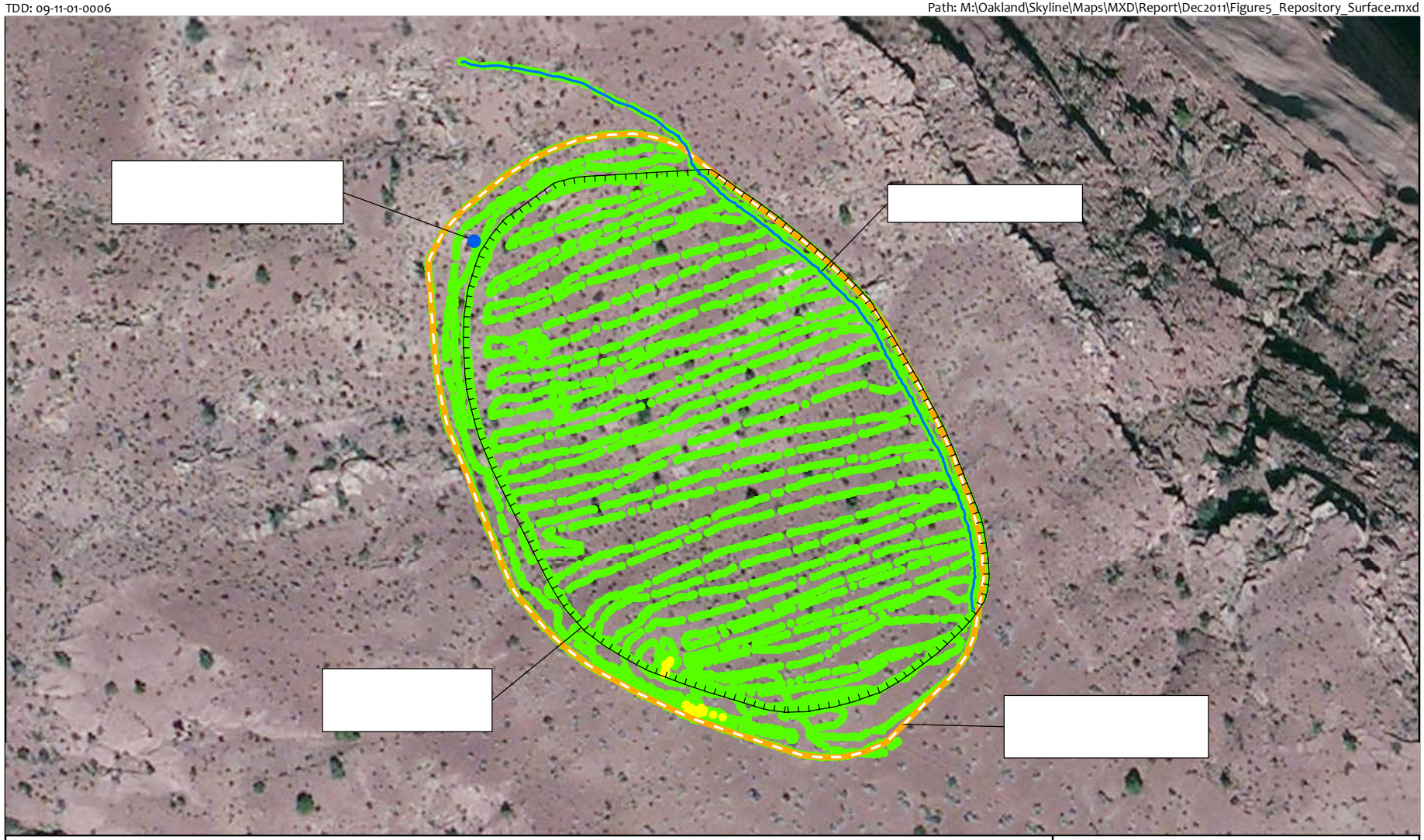

Legend

- Moisture Monitoring Pipe
- Constructed Channel
- Interior Perimeter of the Repository
- Approximate Extent of Repository Grading

Gamma Activity (Counts per Minute)

- 0 - 13140
- 13141 - 14845
- 14846 - 19960
- >19961

Ra-226 Concentration pCi/g - Picocuries per gram	Correlated Gamma Activity (Counts per Minute)
0-3.0	0-13140
3.0-3.5	13141-14845
3.5-5.0	14846-19960
>5.0	>19961

N

0 50 100

Feet

Figure 5
Repository Surface Gamma Activity and Site Features

Skyline AUM Waste Pile Site Removal
San Juan County, Utah

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After installing and testing the lower geomembrane layer, 4-inch-diameter 0.020-inch slotted Schedule 40 polyvinyl chloride pipe was installed parallel to the berm in the lowest (southwestern) portions of the repository. The slotted pipe was wrapped in a semi-permeable pipe-sleeve then connected to a solid pipe that penetrated the berm. All pipe connections were solvent-welded. A pipe-boot was manufactured from the 60-mil HDPE then installed and sealed around the pipe using butyl mastic, neoprene gaskets, and pipe clamps. The pipe-boot was subsequently extrusion-welded to the interior surface of the HDPE liner to form an integral, water-tight system. The extrusion welds were tested using the vacuum box method. Upon completion of the repository, a riser pipe, 4-inch diameter ball-valve, and threaded cap were installed on the pipe. An American Association of State and Highway Transportation Officials HS-20-rated utility vault was installed around the riser and valve assembly. Vaults that receive the HS-20 certification are rated to withstand loads up to 16,000 pounds with a tire contact area of 8 inches by 20 inches. The location of the utility vault and riser pipe are shown on Figure 5.

After completing the lower geomembrane layer and piping, a minimum of 18 inches of bedding material was placed and compacted onto the membrane. The thickness of the bedding layer was temporarily increased to 30 inches of cover in areas where haul trucks were operating. Once the bedding material was moisture-conditioned, graded, and compacted, approximately 27,000 yd^3 of impacted soils were placed and compacted into the repository in 12-inch to 18-inch-thick lifts.

Upon completion of contaminated soil excavation and disposal activities, an 18-inch-thick layer of bedding material was placed and compacted onto the repository surface. Northwest Linings then remobilized and installed the upper geomembrane layer. The upper geomembrane layer consisted of 16-oz-per-square-yard (16 oz) filter fabric, overlain by 60-mil textured HDPE, which was overlaid with 12 oz or 16 oz filter fabric.

The upper geomembrane layer was subjected to the same testing requirements used to assess the lower geomembrane layer. During the HDPE installation, trial seams were made at the beginning of each day and immediately after breaking for lunch. The seams were tested on site using a portable tensiometer. All installed seams were pressure or vacuum tested until there were no apparent leaks. Destructive seam tests were performed on 10 test patches submitted to TRI. Test results indicated all seams exceeded the minimum requirements. Copies of the test data and panel layout diagrams are included in Appendix H.

After completion of the liner testing, an 18-inch-thick layer of bedding material was placed, moisture-conditioned, and compacted into the surface. To prevent burrowing animals from potentially damaging the liner, a 1-foot-thick layer of 2-inch median diameter to 8-inch median diameter rock was placed on the bedding material. To limit gamma emissions from the impacted material and promote evapotranspiration, approximately 30 inches of general fill material was placed in lifts, moisture-conditioned, and compacted. To limit potential erosion, the drainage channel and the steeper exterior slopes on the west and northwest sides of the repository were armored with 4-inch-diameter to 8-inch-diameter rock.

A roving gamma activity scan was performed over the final repository surface using a Ludlum 2241 coupled with a 2-inch diameter NaI gamma-scintillation detector (2x2). The meter and detector were connected to a Trimble GPS unit and a Panasonic Toughbook® computer using the U.S. EPA's RAT software. Except for isolated areas in the southern portion of the repository

where liner repairs were in progress, elevated gamma activity greater than about two times background was not detected.

At the completion of site activities, all new roads constructed at the site were decommissioned, ripped, and seeded. The seed mix used for re-seeding the decommissioned roadways and the excavation and borrow areas is listed in Table 2.

Table 2 Restoration Seed Mix, Skyline Mine Waste Pile Site Removal Action, San Juan County, Utah

E & E Project No. 002693.2132.01RF TDD No. TO-02-09-11-01-0006

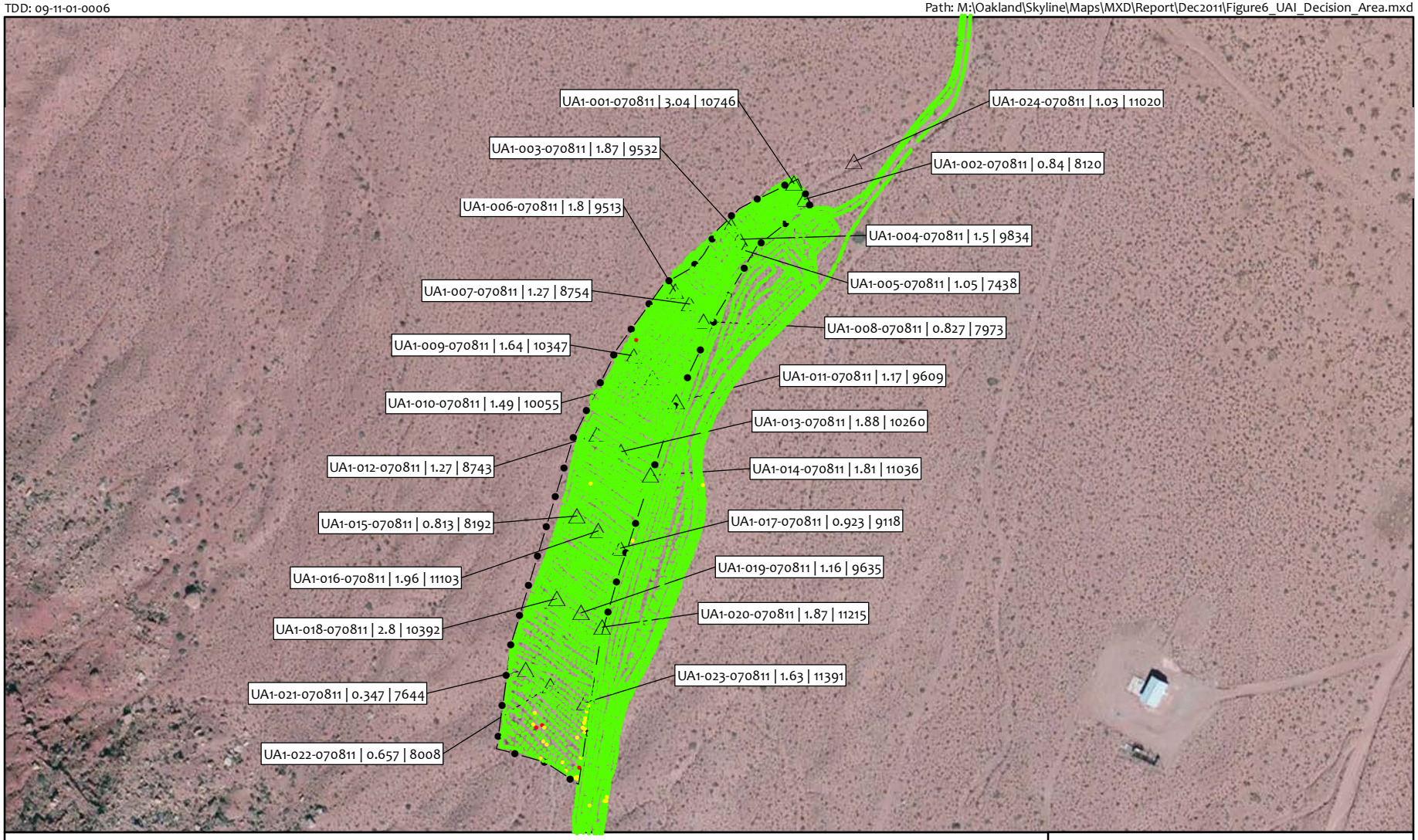
Seed	Percent
Berber or Palestine Orchard Grass	16
Slender Wheatgrass	28
Rose Clover	14
Sub Clover	14
Zorro Fescue	8
Ettlin's Wildflower Mix	20

3.3.3 Arroyo Excavation

The excavation area in the unnamed arroyo UA1 and UA2 decision areas extended for approximately 1,600 feet of the channel and varied from about 20 to 100 feet in width. Excavation depths in the UA1 decision area ranged between 1 foot and 4 feet below ground surface (bgs), but generally averaged 1 foot to 2 feet bgs. The excavation depth in the UA2 decision area was estimated to be approximately 2.5 feet to 4 feet bgs. Actual excavation depths exceeded 8 feet bgs in isolated locations in UA2 near the base of the talus slope, but generally averaged about 3 feet to 4 feet bgs at the upstream end and 1 foot to 3 feet bgs at the downstream end. A total of approximately 14,612 yd^3 of contaminated material was removed from the UA1 and UA2 decision areas and subsequently disposed of in the repository. The estimated volume excavated from each decision area is included on Table 1. After soil excavation was completed in the arroyo areas, confirmation soil samples were collected and the RAT unit was used to scan the final surface for elevated gamma activity. The approximate extents of the excavations in each decision area are respectively shown on Figure 6 and Figure 7.

Project#: 002693.2132.01RF
TDD: 09-11-01-0006

Source: E&E 2011; Microsoft Virtual Earth 2011
Path: M:\Oakland\Skyline\Maps\MXD\Report\Dec2011\Figure6_UAI_Decision_Area.mxd



Legend

Soil Sample Location

Approximate UA1 Excavation Boundary

Gamma Activity (Counts per Minute)

- 0 - 13140
- 13141 - 14845
- 14846 - 19960
- >19961

N

0 100 200

Feet

Soil Sample ID	Ra-226 Activity Concentration (pCi/g)	Correlated Gamma Activity (Counts Per Minute)
UA1-003-070811	1.87	9532

Ra-226 Concentration pCi/g - Picocuries per gram	Correlated Gamma Activity (Counts per Minute)
0-3.0	0-13140
3.0-3.5	13141-14845
3.5-5.0	14846-19960
>5.0	>19961

Figure 6
Lower Unnamed Arroyo (UA1)
Confirmation Sample Locations
RA-226 in Surface Soils and
Associated Gamma Activity Count

Skyline AUM Waste Pile
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TDD: 09-11-01-0006

Source: E&E 2011; Microsoft Virtual Earth 2011
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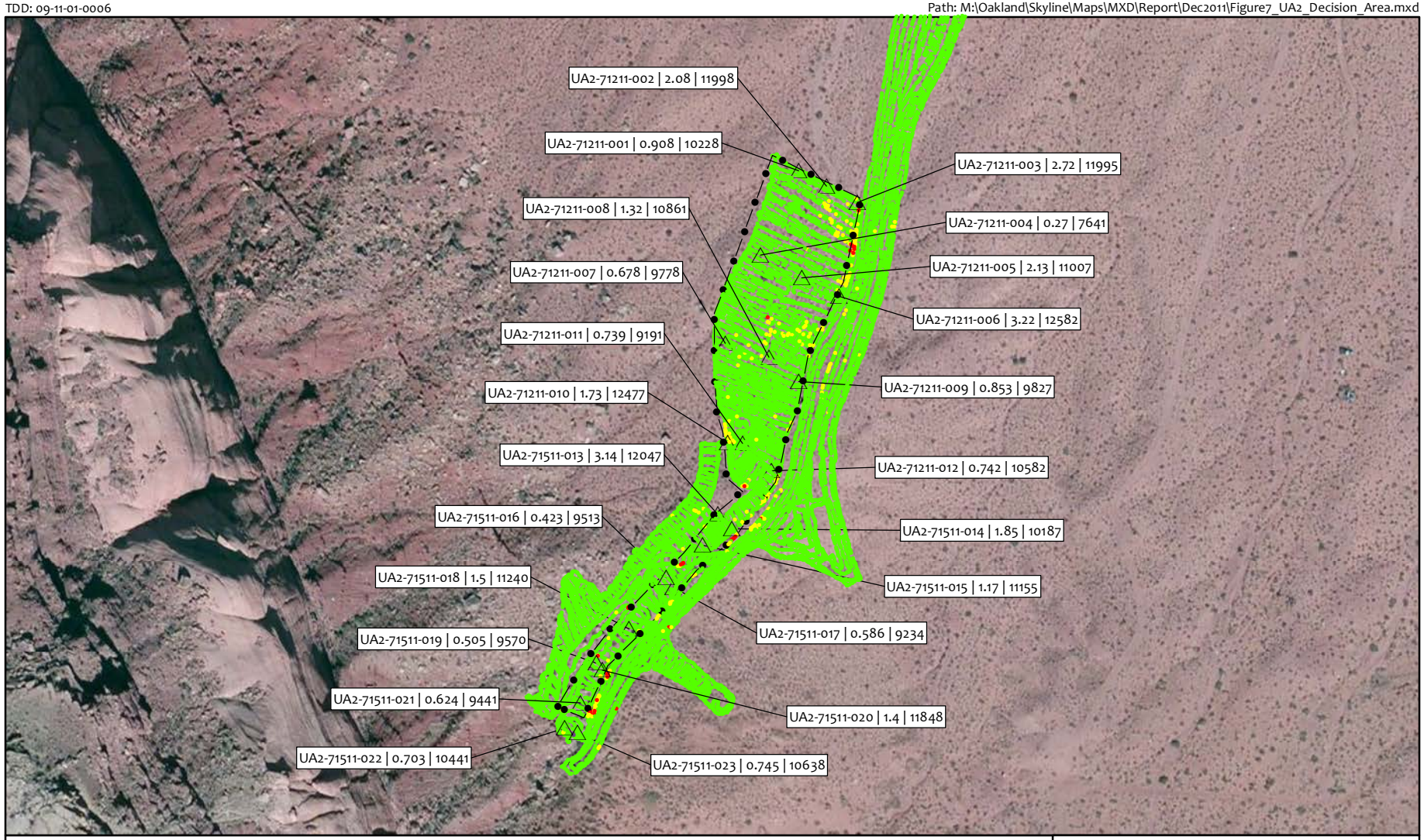

Legend

△ Soil Sample Location

Approximate UA2 Excavation Boundary

Gamma Activity (Counts per Minute)

- 0 - 13140
- 13141 - 14845
- 14846 - 19960
- >19961

Soil Sample ID	Ra-226 Activity Concentration (pCi/g)	Correlated Gamma Activity (Counts Per Minute)
UA2-71211-005	2.13	11007

N

0 100 200

Feet

Ra-226 Concentration pCi/g - Picocuries per gram	Correlated Gamma Activity (Counts per Minute)
0-3.0	0-13140
3.0-3.5	13141-14845
3.5-5.0	14846-19960
>5.0	>19961

Figure 7
Upper Unnamed Arroyo (UA2)
Confirmation Sample Locations
RA-226 in Surface Soils and
Associated Gamma Activity Count

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Site Removal
San Juan County, Utah

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3.3.4 TSDA Excavation

The excavation area for the TSDA was originally estimated to be approximately 16,000 square feet (ft^2) with an excavation depth of approximately 1.25 feet. During removal work, the TSDA was expanded both laterally and vertically due to the presence of residual mine waste. Final excavation depths at the top of the talus slope exceeded 8 feet below the original ground surface. The lateral boundaries were extended to include the upper 200 to 300 feet of the arroyos that drained the north and south side of the talus slope. The final excavation area was estimated to be 34,123 ft^2. The approximate extent of the TSDA excavation area is shown on Figure 8. Excavation depths within the TSDA typically did not exceed 6 to 8 feet before encountering bedrock or very large boulders. Some of the large boulders, competent native rock, and/or bedrock ore bodies in the uppermost portion of the Unnamed Arroyo (UA2) and on top of the talus slope exhibited relatively high gamma activity readings (up to approximately 145,000 cpm). Whenever possible, loose material was excavated and rock areas that appeared to be native material but still exhibited elevated gamma activity were covered with clean fill. Due to the steep terrain and the relative inaccessibility, portions of the elevated areas within the channels and at the top of the talus slope could not be completely covered. A total of approximately 4,000 yd^3 of contaminated material was removed from the TSDA and subsequently disposed of in the repository. The estimated volume excavated from each decision area is included on Table 1. After the initial soil removal action was completed, confirmation soil samples were collected and the RAT unit was used to perform roving and static gamma activity scans.

3.3.5 TLDA Excavation

The excavation area for the TLDA was originally estimated to be approximately 21,000 ft^2 with an excavation depth of approximately 1.25 feet. During removal work, the TLDA was expanded to adjacent areas on the north and northwest sides to include areas where contaminated material was stored and handled prior to being loaded into the skyline. The approximate extent of the TLDA excavation area is shown on Figure 9. A total of approximately 1,800 yd^3 of contaminated material was removed from the TLDA and subsequently disposed of in the repository. The estimated volume excavated from each decision area is included on Table 1. Upon completion of soil disposal activities and demobilization of the skyline system, additional surface soil sampling and gamma activity scans were performed in the newly included areas to confirm that material-handling operations had not adversely impacted them. After the soil removal action was completed, confirmation soil samples were collected and the RAT unit was used to perform roving and static gamma activity scans.

Project#: 002693.2132.01RF
TDD: 09-11-01-0006

Source: E&E 2011; Microsoft Virtual Earth 2011
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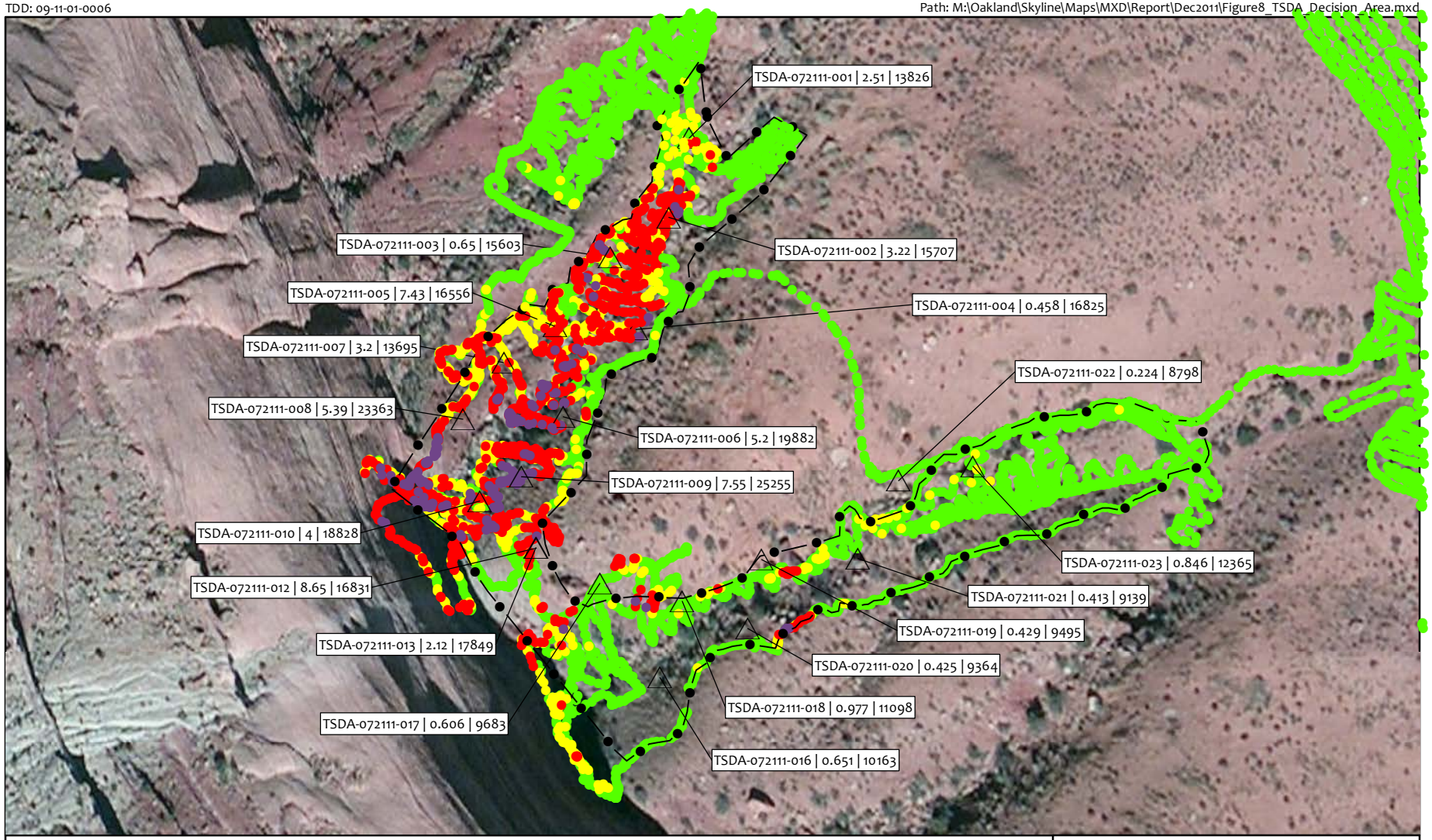

Legend

△ Soil Sample Location

Gamma Activity (Counts per Minute)

- 0 - 13140
- 13141 - 14845
- 14846 - 19960
- >19961

Approximate Talus Slope Decision Area Excavation Boundary

Soil Sample ID	Ra-226 Activity Concentration (pCi/g)	Correlated Gamma Activity (Counts Per Minute)
TSDA-072111-007	3.2	13695

N

0 50 100

Feet

Ra-226 Concentration pCi/g - Picocuries per gram	Correlated Gamma Activity (Counts per Minute)
0-3.0	0-13140
3.0-3.5	13141-14845
3.5-5.0	14846-19960
>5.0	>19961

Figure 8
Talus Slope Decision Area
Confirmation Sample Locations
RA-226 in Surface Soils and
Associated Gamma Activity Count

Skyline AUM Waste Pile
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San Juan County, Utah

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Project#: 002693.2132.01RF
TDD: 09-11-01-0006

Source: E&E 2011; Microsoft Virtual Earth 2011
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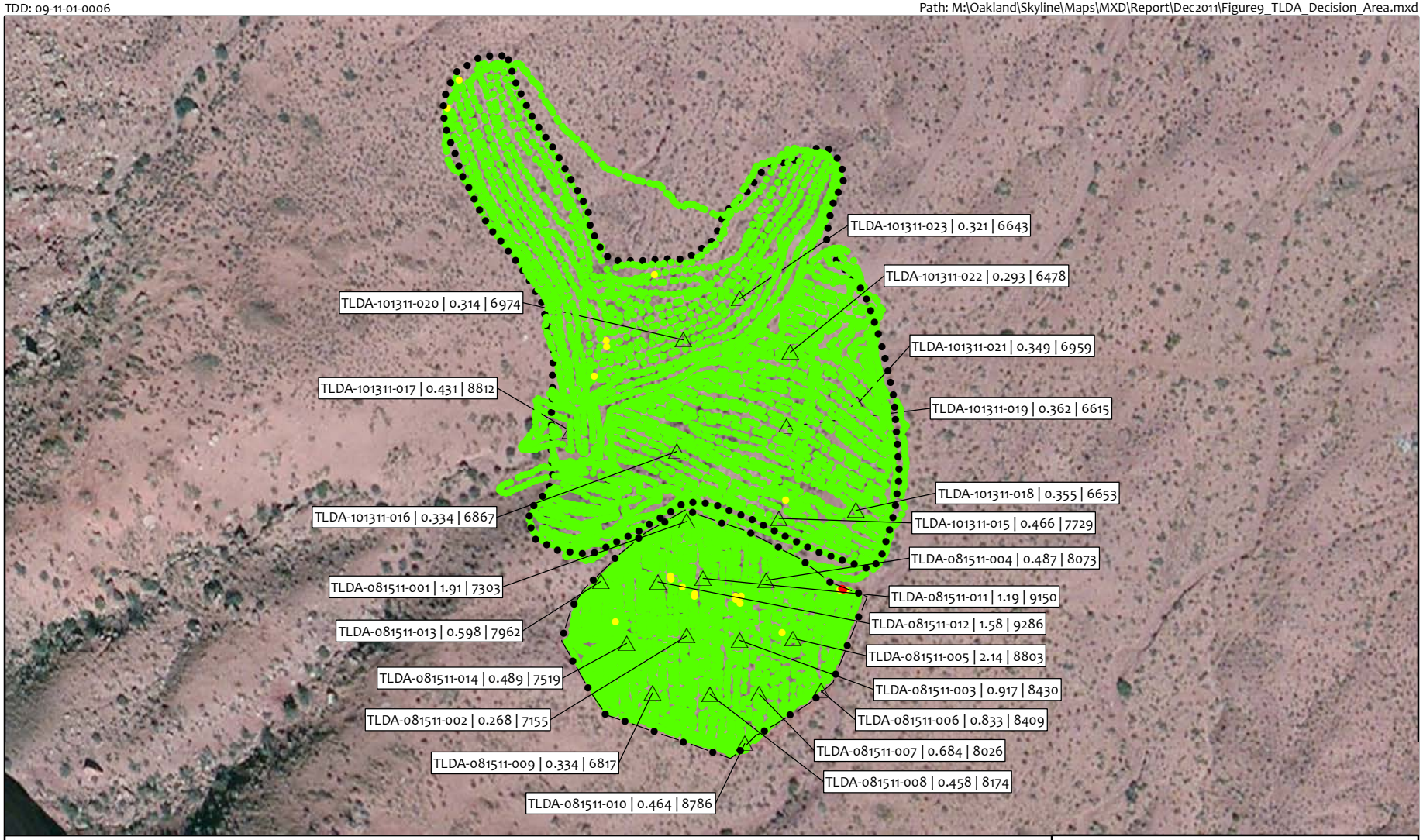

Legend

- Soil Sample Location
- Transloading Decision Area Excavation Boundary
- Material Stockpile Area

Gamma Activity (Counts per Minute)

- 0 - 11435
- 11436 - 13140
- 13141 - 19960
- >19961

N

0 100 200

Feet

Soil Sample ID	Ra-226 Activity Concentration (pCi/g)	Correlated Gamma Activity (Counts Per Minute)
TLDA-081511-002	0.268	7155

Ra-226 Concentration pCi/g - Picocuries per gram	Correlated Gamma Activity (Counts per Minute)
0-2.5	0-11435
2.5-3.0	11436-13140
3.0-5.0	13141-19960
>5.0	>19961

Figure 9
Transloading Decision Area Confirmation Sample Locations RA-226 in Surface Soils and Associated Gamma Activity Count

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3.3.6 AML Repository Excavation

Excavation activities within the AML Repository initially proceeded in 1-foot lifts. After each foot of soil was excavated or when visible mine waste appeared to have been removed, the excavated areas that could be safely accessed on foot were traversed by a START carrying the RAT in order to collect surface gamma activity measurements. Based on the results of the gamma activity scan, additional soils were excavated as necessary in 0.5- to 1-foot-thick increments. During excavation work, it became apparent that the amount of loose accessible mine waste buried in the AML Repository was less than the originally estimated 9,000 yd^3. Excavation depths within the AML Repository decision area typically did not exceed 4 to 5 feet before encountering bedrock. Portions of the bedrock appeared to be the topographical low end of the ore body and exhibited relatively high gamma activity readings (up to approximately 700,000 cpm). No attempt was made to remove the native bedrock/ore material. Instead, ERRS staff removed the remainder of the loose impacted material and then covered the ore bodies to the extent possible with a minimum of 3 feet of clean fill material. Due to the terrain (i.e., an overhanging rock shelf and nearly vertical slopes), some portions of the ore body were not able to be completely covered. A total of approximately 4,540 yd^3 of contaminated material was removed from the existing AML Repository and subsequently disposed of in the newly constructed repository. The estimated volume excavated from each decision area is included on Table 1. After soil excavation was concluded, confirmation soil samples were collected and the RAT unit was used to scan the final surface for elevated gamma activity. The approximate extent of the AML excavation and other site features are shown on Figure 10.

3.3.5 Mesa Slope Excavation

The Mesa Slope Decision Area (MSDA) included the steeply sloped areas with residual mine waste located east and northeast of and below the former mine area and AML repository. Soils were removed from this area using either a long-reach excavator or a 1-yd^3-capacity drag bucket that was operated using a skyline system. The skyline system was used to scrape ore from the Mesa Slope area from about June 20 through July 23, 2011. After July 23, 2011, the bucket on the skyline system was replaced with a large 4-yd^3-capacity bottom-dump (hopper) bucket, and the skyline system was used to haul soil from the valley floor to the AML repository. Approximately 2,196 yd^3 of impacted material were removed from the slope and hauled to the repository for disposal. The estimated volume excavated from each decision area is included on Table 1. The approximate lateral extent of the excavated area is depicted on Figure 10. Due to the extremely steep slopes (approximately 50 to 60 degrees), uneven terrain, and adjacent vertical cliff face, not all visible mine waste was removed from this area. Due to concerns for worker safety, no attempt was made to scan or sample the MSDA; however, based on visual evidence, an estimated 85 to 90 percent of the original volume of mine waste was removed.

Project#: 002693.2132.01RF
TDD: 09-11-01-0006

Source: E&E 2011; Microsoft Virtual Earth 2011
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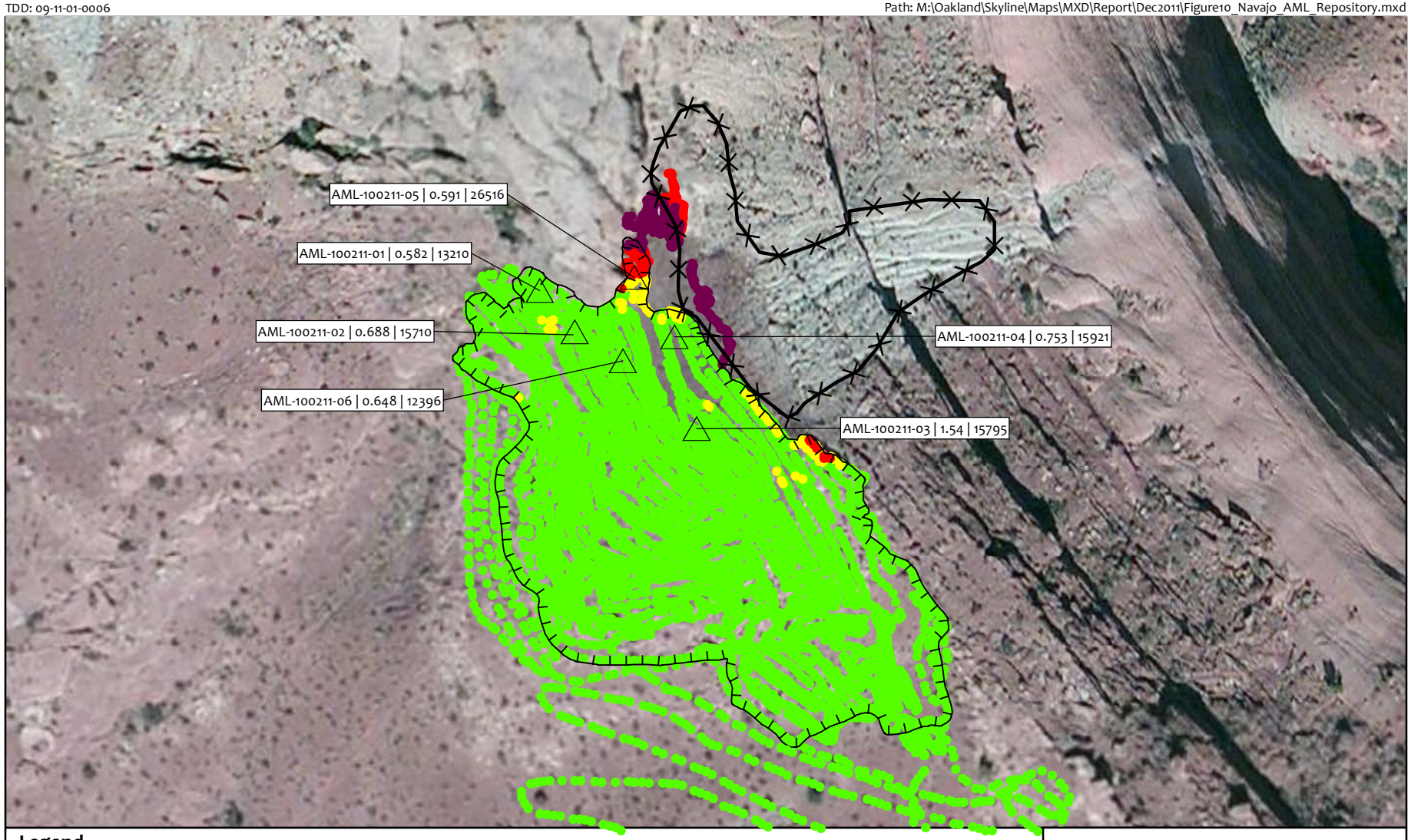

Legend

- Soil Sample Location
- Approximate Perimeter of the Navajo Nation Abandoned Mine Lands Program Repository Excavation
- Mesa Slope Decision Area (MSDA) Approximate Excavation Boundary

Gamma Activity (Counts per Minute)

- 0 - 19960
- 19961 - 30000
- 30001 - 100000
- >100000

N

0 50 100

Feet

Soil Sample ID	Ra-226 Activity Concentration pCi/g - Picocuries per gram	Correlated Gamma Activity (Counts Per Minute)
AML-100211-02	0.688	15710

Figure 10
Former Navajo AML Repository
Surface Gamma Activity and
Mesa Slope Excavation Boundary

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San Juan County, Utah

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4 Laboratory Results and Gamma Activity Scan Data

Soil samples collected were analyzed by General Engineering Laboratories (GEL), Charleston South Carolina, for Ra-226 by gamma spectroscopy with ingrowth by U.S. Department of Energy Health and Safety Laboratory (HASL) Method 300.4.5.2.3, a modification of EPA Method 901.1. Surface soil gamma activity was measured in the field using a RAT equipped with a Ludlum Model 2241 or 2221 meter and a Ludlum Model 44-10 2x2 detector.
Soil samples were collected and analyzed in accordance with the SAP. Disposable soil sampling equipment was used to collect the samples; therefore, equipment rinse blanks were not collected. All data were validated by a qualified chemist and, except where noted in the specific cases discussed herein, found to be suitable for the uses intended. Excluding duplicates, a total of 102 surface soil samples were collected and analyzed. The chemist noted the presence of relatively low concentrations of radium-228 (Ra-228) in approximately 54 soil samples and cesium-137 (Cs-137) in approximately 10 samples. The presence of Ra-228 is likely a decay product of naturally occurring thorium-232 and attributable to natural sources. Detected concentrations of Ra-228 ranged from 0.016 pCi/g to a maximum of 1.5 pCi/g and were greatest in the samples collected from the former AML Repository area. Detected concentrations of Cs-137 ranged from 0.016 to 0.11 pCi/g. The presence of Cs-137 in surface soils is most likely attributable to historic fallout from above-ground atomic weapons testing conducted by the United States Military at either the Nevada Test Site or in New Mexico.

4.1 Background Sampling

4.1.1 Soil Sampling

During the November 2008 and August 2009 removal assessment activities, the START performed one-minute gamma activity counts and collected co-located soil samples from the surface and at 1 foot bgs at 14 locations within a background area with similar geology to the Skyline AUM site and no known or suspected impacts from mining. A summary of the Ra-226 concentrations in surface soil and associated surface gamma activities from November 2008 and August 2009 are summarized in the *Skyline AUM Waste Pile Removal Assessment Report, Navajo Nation, San Juan County, Utah,* dated May 25, 2010, and prepared by Ecology and Environment, Inc. (E & E 2010). The average concentration of Ra-226 in surface soil samples from the background area was 0.16 pCi/g during the 2008 surface soil sampling event and 0.260 pCi/g during the 2009 subsurface soil sampling event (E & E 2010).

4.2 Correlation Study Between Ra-226 Activity Concentrations in Surface Soils and Co-located One-Minute Gamma Activity Counts

As part of the data evaluation process, detected Ra-226 soil activity concentrations between 2 pCi/g and 5.35 pCi/g and their associated one-minute gamma activity counts were selected for use in a correlation study. Except where field notes suggested an obvious bias due to sample geometry, all samples in the selected range were used in the study. The purpose of the study was to develop an equation that allows the user to predict the surface soil Ra-226 activity concentration based on roving gamma activity scan data. The range of sample concentrations was selected because it bounds the applicable range of project-specific action levels (i.e., action

levels ranged from 2.5 to 5.0 pCi/g). The purpose of selecting this range is to promote a higher degree of confidence in the correlation between observed gamma activity and Ra-226 at concentrations near the action levels. It was not considered necessary or useful to have strong correlations between data sets for observed gamma activity levels or activity concentrations that are obviously well below or well above the action level. The selected samples and the associated gamma count data are listed in Table 3. A graph of the correlation between data sets is shown on Figure 11. As shown on the table, the correlation coefficient (R) between data sets was 0.913, suggesting a strong positive correlation between data sets at activity concentrations near the action levels. Similarly, the sum of the squared residuals (R^2) was calculated from the trend-line equation in Figure 11. The calculated R^2 value of 0.833 also suggests good correlation between the data sets and is above the typical U.S. EPA acceptance criteria of 0.70. The trend-line equation shown on Figure 11 was subsequently used to develop the relationship between gamma activity and Ra-226 activity concentrations in surface soil that is shown on figures depicting RAT data for the UA1, UA2, TSDA, and TLDA Decision Areas (Figures 6 – 9). Although no surface soil samples were collected from the newly constructed repository, this relationship was also used to estimate Ra-226 concentrations in surface soils in that area (Figure 5).

Table 3 Correlated Radium 226 Concentrations in Surface Soil and Gamma Activity Measurement Data, UA1, UA2, TLDA, and TSDA, Skyline Mine Waste Pile Site Removal Action, San Juan County, Utah[1]

E & E Project No. 002693.2132.01RF TDD No. TO-02-09-11-01-0006

Sample ID	Radium 226 (pCi/g)	Associated Gamma Activity Count (one-minute count)
UA2-71211-002	2.08	11998
UA2-71211-005	2.13	11007
TLDA-081511-005	2.14	8803
TSDA-072111-001	2.51	13826
UA2-71211-003	2.72	11995
UA1-018-070811	2.80	10392
UA1-001-070811	**3.04**	10746
UA2-71511-013	**3.14**	12047
TSDA-072111-007	**3.20**	13695
TSDA-072111-002	**3.22**	15707
UA2-71211-006	**3.22**	12582
TSDA-072111-010	**4.00**	18828
TSDA-072111-006	**5.20**	19882
TSDA-072111-906	**5.35**	19758
TSDA-072111-008	**5.39**	23363
R-Correlation Coefficient		0.913
R^2-Sum of Squared Residuals		0.834

Notes:pCi/g – picocuries per gram
1. Correlation data includes one-minute gamma activity measurements and corresponding surface soil concentrations (by HASL method 300.4.5.2.3) for samples with detected activity concentrations between 2 and 5.35 pCi/g.
Bold –Indicates the detected concentration was above the respective action level
UA1-Lower Unnamed Arroyo Decision Area; UA2-Upper Unnamed Arroyo Decision Area
TLDA-Transloading Decision Area; TSDA-Talus Slope Decision Area

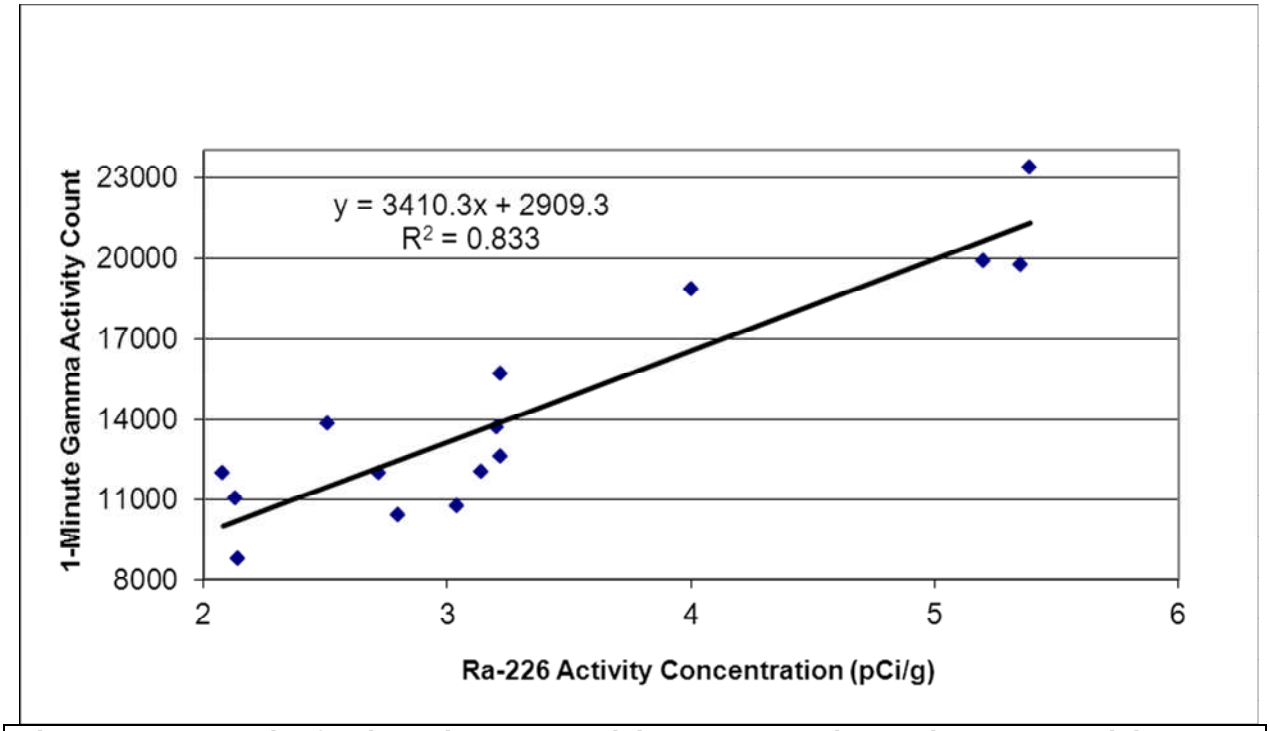

Figure 11 **Graph of Selected Ra-226 Activity Concentration and Gamma Activity Count Correlation Data, Skyline AUM Waste Pile Site Removal Action, San Juan County, Utah**

Notes: Ra-226 – radium 226
pCi/g – picocuries per gram
TDD No. TO-02-09-11-01-0006 E & E Project No. 002693.2132.01RF

4.2.1 Detection Limit Study

To determine the approximate effective area of detection of the 2x2 gamma detector used to perform the confirmation surveys, START performed one-minute gamma activity counts using Cs-137 gamma radiation check sources with stated activities of 1 microcurie (µCi) and 5 µCi. One-minute gamma activity counts were performed at 1-foot incremental distances (0 to 10 feet) from the check source in each cardinal direction until observed gamma activity levels could not be distinguished from measured background activity. Background gamma radiation levels were measured in the same fashion at 2-foot intervals. Based on observed data, the effective range of detection for gamma radiation in the 1 to 5 µCi range was between 3 and 5 feet. In order to be conservative, START used 3 feet as the estimated radius of detection (i.e., 6-foot diameter). Based on this study, all figures depicting RAT gamma scan data show a 6-foot diameter colored circle to depict the measured gamma activity.

Roving gamma activity scan data were used in conjunction with the correlation equation to estimate the Ra-226 concentrations in surface soils in each decision area after excavation. Statistics for the UA1, UA2, TSDA, and TLDA decision areas are shown below in Table 4.

Table 4 Statistics for Post-Excavation Radium 226 Concentrations Based on Correlated Gamma Scan Data for UA1, UA2, TSDA, and TLDA, Skyline Mine Waste Pile Site Removal Action, San Juan County, Utah

E & E Project No. 002693.2132.01RF — TDD No. TO-02-09-11-01-0006

Statistics	UA1	UA2	TSDA	TLDA
Number of Measurements	8068	20950	19030	8036
Mean Correlated Residual Ra-226 Concentration (pCi/g)	1.96	1.90	2.31	1.46
Standard Deviation (pCi/g)	0.36	0.54	1.63	0.28
Mean plus 3x Standard Deviation	3.03	3.51	7.2	2.29
DCGLw (pCi/g)	3.0	3.0	3	2.5
No of Measurements Above DCGLw	30	446	4042	23
Estimated Excavation Area (Square Feet)	103788	61957	34123	47017
Minimum (pCi/g)	0.94	0.48	0.73	0.73
Maximum (pCi/g)	3.87	5.83	41.7	4.31
Median (pCi/g)	1.96	1.87	1.9	1.43
Range (pCi/g)	2.93	5.35	40.9	3.58
Quartile 25% (pCi/g)	1.70	1.55	1.46	1.26
Quartile 50% (pCi/g)	1.96	1.87	1.9	1.43
Quartile 75% (pCi/g)	2.20	2.26	2.78	1.62
Quartile 100% (pCi/g)	3.87	5.83	41.7	4.31

pCi/g = picocuries per gram
DCGLw = derived concentration guideline level for a wide area
UA1-Lower Unnamed Arroyo Decision Area; UA2-Upper Unnamed Arroyo Decision Area
TLDA-Transloading Decision Area; TSDA-Talus Slope Decision Area

4.3 Unnamed Arroyo Confirmation Surface Soil Sampling and Gamma Activity Measurements

4.3.1 Lower Portion of Unnamed Arroyo – UA1

On July 8, 2011, the START collected confirmation surface soil samples from the lower portion (UA1) of the unnamed arroyo that receives runoff from the Skyline AUM. Locations for surface soil samples collected from the UA1 are shown on Figure 6. A summary of the analytical data for surface soil samples collected from the UA1 is included on Table 5.

Table 5 Summary of Surface Soil Sample Results for Radium 226 and Associated Gamma Activity Counts, Lower Arroyo (UA1) Decision Area, Skyline Mine Waste Pile Site Removal Action, San Juan County, Utah

E & E Project No. 002693.2132.01RF TDD No. TO-02-09-11-01-0

Sample ID	Radium 226 (pCi/g)	Method Detection Limit	Associated One-Minute Gamma Activity Count (cpm)
UA1-001-070811	**3.04**	0.164	10746
UA1-002-070811	0.840	0.144	8120
UA1-003-070811	1.87	0.126	9532
UA1-004-070811	1.50	0.114	9834
UA1-005-070811	1.05	0.172	7438
UA1-905-070811	0.810	0.0907	7438
UA1-006-070811	1.80	0.133	9513
UA1-007-070811	1.27	0.0869	8754
UA1-008-070811	0.827	0.0929	7973
UA1-009-070811	1.64	0.108	10347
UA1-010-070811	1.49	0.0818	10055
UA1-011-070811	1.17	0.104	9609
UA1-012-070811	1.27	0.147	8743
UA1-013-070811	1.88	0.133	10260
UA1-014-070811	1.81	0.102	11036
UA1-015-070811	0.813 UJ	0.274	8192
UA1-915-070811	0.714	0.109	7059
UA1-016-070811	1.96	0.178	11103
UA1-017-070811	0.923	0.0829	9118
UA1-018-070811	2.80	0.155	10392
UA1-019-070811	1.16	0.0958	9635
UA1-020-070811	1.87	0.120	11215
UA1-021-070811	0.347	0.0958	7644
UA1-022-070811	0.657	0.101	8008
UA1-023-070811	1.63	0.114	11391
UA1-923-070811	1.77	0.152	11565
UA1-024-070811	1.03 UJ	0.377	11020
MINIMUM (Ra-226)	0.347		7,644
MAXIMUM (Ra-226)	3.04		10,746
AVERAGE	1.41	pCi/g	9,472
STANDARD DEVIATION	0.6	pCi/g	1,379
R-Correlation coefficient			0.721
R^2 Sum of squared Residual			0.524

Notes:
Radium 226 concentrations by EML HASL 300, 4.5.2.3
Gamma activity counts by Ludlum Measurements Inc. Model 2241 Ratemeter and Detector Model 44-10 2"x2" NaI Gamma Scintillator
pCi/g = picocuries per gram cpm = counts per minute
UJ= data value qualified due to low abundance (i.e not detected at the indicated method detection limit)
Results above the area-specific action levels are indicated in bold.

The START collected confirmation soil samples, including three duplicate samples, at 24 discrete locations in the UA1. The sample locations were distributed in a series of linear transects oriented perpendicular to the arroyo channel, with the exception of soil sample location UA1-024, which was situated in undisturbed soils downgradient of the channel excavation. One-minute gamma activity measurements were performed at each surface soil sampling location. The results are included in Table 5.

Ra-226 concentrations in surface samples collected in the UA1 ranged from 0.347 pCi/g to 3.04 pCi/g. A graph of these data is shown on Figure 12. The average concentration for the sample set was 1.41 pCi/g. One sample (UA1-001-070811) exceeded the site-specific action level of 3 pCi/g with a concentration of 3.04 pCi/g.. Surface one-minute gamma activity counts at the 24 surface soil sample locations ranged from 7.059 kilo-counts per minute (kcpm) to 11.565 kcpm, with an average of 9.472 kcpm. The correlation coefficient for the Ra-226 laboratory analytical data for the soil samples and the field-measured gamma activity counts was 0.724 and the R^2 value was 0.524, indicating a relatively weak positive correlation between the measurements. The exact reason for the relatively weak correlation was not evaluated, but previous correlation studies performed at the site indicate that correlation between Ra-226 concentration and associated gamma activity data sets is poor when detected activity concentrations of Ra-226 are less than about 1.5 pCi/g (E&E 2010). At UA1, 15 of the 24 surface soil samples used in the decision area correlation had measured concentrations of less than 1.5 pCi/g. Although a qualitative study was not performed, it is hypothesized that the effects of small changes in topography, solar radiation, and detector geometry have an influence on measured gamma activity, and thus introduce an unknown amount of error to each measurement. While these errors occur at both high and low concentrations/gamma activities, their influence is much greater at low concentrations; the magnitude of the error becomes negligible in comparison to the stronger gamma field produced by soils with higher (i.e., greater than about 1.5 pCi/g) Ra-226 concentrations.

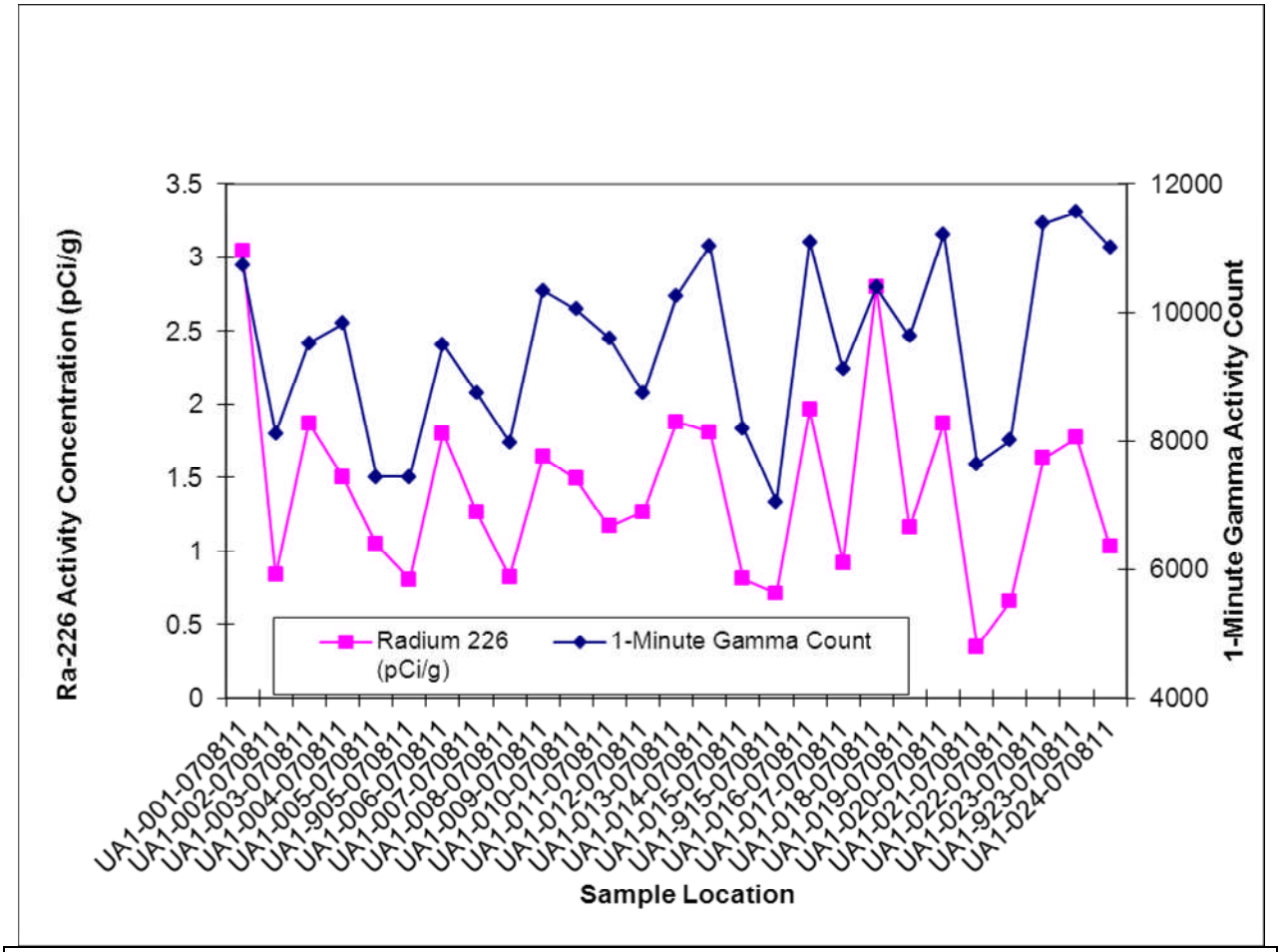

Figure 12 **Graph of Surface Soil Ra-226 Activity Concentration and Associated One-Minute Gamma Activity Count, Lower Arroyo (UA1) Decision Area, Skyline AUM Waste Pile Site Removal Action, San Juan County, Utah**

Notes: Ra-226 – radium 226
pCi/g – picocuries per gram
TDD No. TO-02-09-11-01-0006 E & E Project No. 002693.2132.01RF

The laboratory data were reviewed by qualified chemists as part of the data validation process. Samples UA1-015-070811 and UA1-024-070811 were qualified due to low abundance and therefore labeled with the data qualifier UJ. According to GEL's acceptance criteria, all data except for one sample met their data quality objectives and were considered to be acceptable for use according to their criteria. Sample UA1-003-070811 and its laboratory duplicate were outside the laboratory's range of the acceptable relative percent difference (RPD) requirement of 0 to 20 percent, with a value of 21.9 percent; however, the samples did meet the laboratory's 0 to 3 relative error ratio requirement with a value of 2.04, and the project SAP criteria of within 35 percent RPD. Data were also validated by a qualified START chemist. All data met the acceptance criteria stated in the project SAP. Laboratory analytical reports and data validation reports are included in Appendix I.

After excavation work was completed, the START also traversed the entire area on approximately 4-foot-wide transects carrying the RAT in order to measure and record surface

gamma activity at one-second intervals. The correlation equation shown on Figure 11 was used to estimate the post-excavation residual concentration of Ra-226 in surface soils based on the roving gamma activity scan data. Based on the observed gamma activity in UA1, the estimated median and mean values of Ra-226 were both 1.96 pCi/g and the standard deviation was 0.36 pCi/g. The mean and the median values were approximately equal, suggesting the data are not skewed. Statistical data for gamma activity results and correlated Ra-226 values are shown in Table 4. The histogram of the gamma data and the associated estimated Ra-226 concentrations are included in Appendix J. Gamma activity data collected using the RAT system are included in tabular form in Appendix K. The histogram supports the conclusion that the data are not skewed and are approximately normally distributed. Based on the histogram, the minimum detectable count rate (MDCR) above background is approximately 6.90 kcpm, which corresponds to a Ra-226 concentration of 1.17 pCi/g. Of the 8,068 sample measurements collected, 30 correspond to Ra-226 concentrations above 3.0 pCi/g, with a predicted maximum of 3.87 pCi/g. Of the 30 measurements above the action level, 19 of them correspond to concentrations between 3.0 and 3.3 pCi/g.

Based on Figure 6, there was no obvious pattern of elevated activity distribution, although elevated readings occurred with greater frequency in the southern portion of the decision area. During the scan work, operators were directed to try to laterally define areas of elevated gamma activity. In practice this meant that scanning measurements in more contaminated areas were more tightly spaced and occurred at a higher density and frequency than scanning measurements made in non-impacted areas with the typical scanning frequency. A preliminary review of the gamma scan data indicated that measurements tended to be grouped around elevated areas with greater frequency, suggesting the tabular data, including the mean and median values, and the total number of elevated measurements for each data set, were likely biased high. START notes that although it is appropriate for the situation, the practice of defining the lateral extent of the elevated areas will generally bias the gamma scan statistical data slightly higher, since more points are collected from contaminated areas. Additionally, due to the steep uneven terrain, it was not always possible to perform evenly spaced transects when conducting gamma scans, especially in the TSDA and the upper portion of the UA2 decision area. It is possible that repeatedly traversing a small contaminated area because accessibility to other areas was not possible may also have biased measurements. Because of these potential biases, the actual size of the elevated measurement area is not considered equivalent to the product of the detector area and the number of elevated measurements, as Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidance suggests (MARSSIM 2000). No attempts were made to estimate or otherwise account for the suspected biases.

4.3.2 Upper Portion of Unnamed Arroyo-UA2

On July 15, 2011, the START collected confirmation surface soil samples from the upper portion (UA2) of the Unnamed Arroyo that receives runoff from the Skyline AUM. Locations for surface soil samples collected from the UA2 are shown on Figure 7. A summary of the analytical data for surface soil samples collected from the UA2 is included on Table 6.

The START collected confirmation soil samples, including four duplicate samples, at 23 discrete locations in the UA2 distributed in a series of linear transects perpendicular to the arroyo channel. One-minute gamma activity scans were collected at each of the surface soil sampling locations.

Ra-226 concentrations in surface samples collected in the UA2 ranged from 0.27 pCi/g to 3.22 pCi/g. The average concentration for the sample set was 1.26 pCi/g. Two samples (UA2-071211-006 and UA2-71211-013) exceeded the site-specific action level of 3 pCi/g at concentrations of 3.22 and 3.14 pCi/g, respectively. Surface one-minute gamma activity counts at the 23 surface soil sample locations ranged from 7.641 kcpm to 12.582 kcpm, with an average of 10.558 kcpm. The correlation coefficient for the Ra-226 laboratory analytical data for the soil samples and the field-measured gamma activity counts was 0.793 and the R^2 value was 0.629, indicating a relatively weak positive correlation between the measurements. The reason for the poor correlation is likely attributable to the large proportion of detected sample concentrations that were less than 1.5 pCi/g. A graph of these data is shown on Figure 13.

The data were reviewed by a qualified chemist at GEL as part of the data validation process. Except for three samples, all data met the laboratory's data quality objectives. Samples UA2-071211-904, UA2-071211-011, and UA2-071511-016 were qualified as estimated due to low abundance and were labeled with the data qualifier UJ. All QC samples met laboratory acceptance criteria. Data were also validated by a qualified START chemist. All data met the acceptance criteria stated in the SAP and were considered to be acceptable for the intended use. Laboratory analytical reports and data validation reports are included in Appendix I.

After excavation work was completed, the START also traversed the entire area on approximately 4-foot-wide transects carrying the RAT to measure and record surface gamma activity at one-second intervals. The gamma activity measurements were used to estimate Ra-226 concentrations using the correlation equation shown on Figure 11. A histogram of the gamma activity and estimated Ra-226 concentration data is included in Appendix J. A tabular summary of the gamma activity scan data from the UA2 is included in Appendix K.

The median (1.87 pCi/g) and mean (1.90 pCi/g) estimated Ra-226 concentrations calculated from the gamma scan data were less than the removal action level of 3.0 pCi/g. The mean and the median values were approximately equal, indicating the data were not skewed. Statistical data for estimated Ra-226 values are shown in Table 4. The histogram of the gamma activity and associated estimated Ra-226 concentration data (Appendix J) supports the conclusion that the data are not skewed and are approximately normally distributed. Based on the histogram, the MDCR above background is approximately 6.90 kcpm, which corresponds to a Ra-226 concentration of approximately 1.17 pCi/g. Of the 20,950 sample measurements collected, 446 corresponded to Ra-226 concentrations above 3.0 pCi/g, with a predicted maximum of 5.83 pCi/g. Of the 446 elevated measurements, 68 were greater than 3.5 pCi/g.

Similar to the data for UA1, an informal observation of the coordinates of the elevated measurements suggested they tended to be grouped around contaminated areas, supporting the hypothesis that the gamma data may be biased slightly high. As an example, the 14 highest gamma activity readings corresponded to Ra-226 concentrations ranging from 4.40 pCi/g to the maximum of 5.83 pCi/g. Of those 14 measurements, 13 were collected within 1 foot of each other, suggesting the operator was attempting to bound an isolated occurrence of elevated material (e.g., a chunk of ore). Because of this bias, the actual size of the elevated measurement area is not considered equivalent to the product of the detector area and the number of elevated measurements. No attempt was made to estimate or otherwise account for the suspected bias.

Based on Figure 7, there was no obvious pattern of distribution, although elevated readings occurred with slightly greater frequency in the northern and eastern portions of the UA2 decision area.

Table 6 Summary of Surface Soil Sample Results for Radium 226 and Associated Gamma Activity Counts, Upper Arroyo (UA2) Decision Area, Skyline Mine Waste Pile Site Removal Action, San Juan County, Utah

E & E Project No. 002693.2132.01RF TDD No. TO-02-09-11-01-0006

Sample ID	Radium 226 (pCi/g)	Method Detection Limit	Associated One-Minute Gamma Activity Count (cpm)
UA2-71211-001	0.908	0.102	10228
UA2-71211-002	2.08	0.160	11998
UA2-71211-003	2.72	0.0952	11995
UA2-71211-004	0.270	0.0906	7641
UA2-71211-904	0.397 UJ	0.242	7851
UA2-71211-005	2.13	0.109	11007
UA2-71211-006	**3.22**	0.104	12582
UA2-71211-007	0.678	0.103	9778
UA2-71211-008	1.32	0.166	10861
UA2-71211-009	0.853	0.113	9827
UA2-71211-010	1.73	0.133	12477
UA2-71211-011	0.739 UJ	0.320	9191
UA2-71211-012	0.742	0.0965	10582
UA2-71211-912	0.818	0.0813	10454
UA2-71511-013	**3.14**	0.134	12047
UA2-71511-014	1.85	0.125	10187
UA2-71511-015	1.17	0.0909	11155
UA2-71511-915	1.38	0.116	11343
UA2-71511-016	0.423 UJ	0.123	9513
UA2-71511-017	0.586	0.0827	9234
UA2-71511-018	1.50	0.103	11240
UA2-71511-019	0.505	0.155	9570
UA2-71511-020	1.40	0.141	11848
UA2-71511-920	1.46	0.0961	11928
UA2-71511-021	0.624	0.136	9441
UA2-71511-022	0.703	0.0998	10441
UA2-71511-023	0.745	0.102	10638
MINIMUM	0.27		7,641
MAXIMUM	3.22		12,582
AVERAGE	1.26	pCi/g	10,558
STANDARD DEVIATION	0.82	pCi/g	1,295
R-CORRELATION COEFFICIENT			0.793
R^2-SUM OF SQUARED RESIDUALS			0.629

Notes:
Radium 226 concentrations by EML HASL 300, 4.5.2.3
Gamma activity counts by Ludlum Measurements Inc. Model 2241 Ratemeter and Detector Model 44-10 2"x2" NaI Gamma Scintillator
pCi/g = picocuries per gram cpm = counts per minute
UJ = qualified as estimated due to low abundance (i.e. not detected at the method detection limit)
Results above the area-specific action levels are indicated in bold.

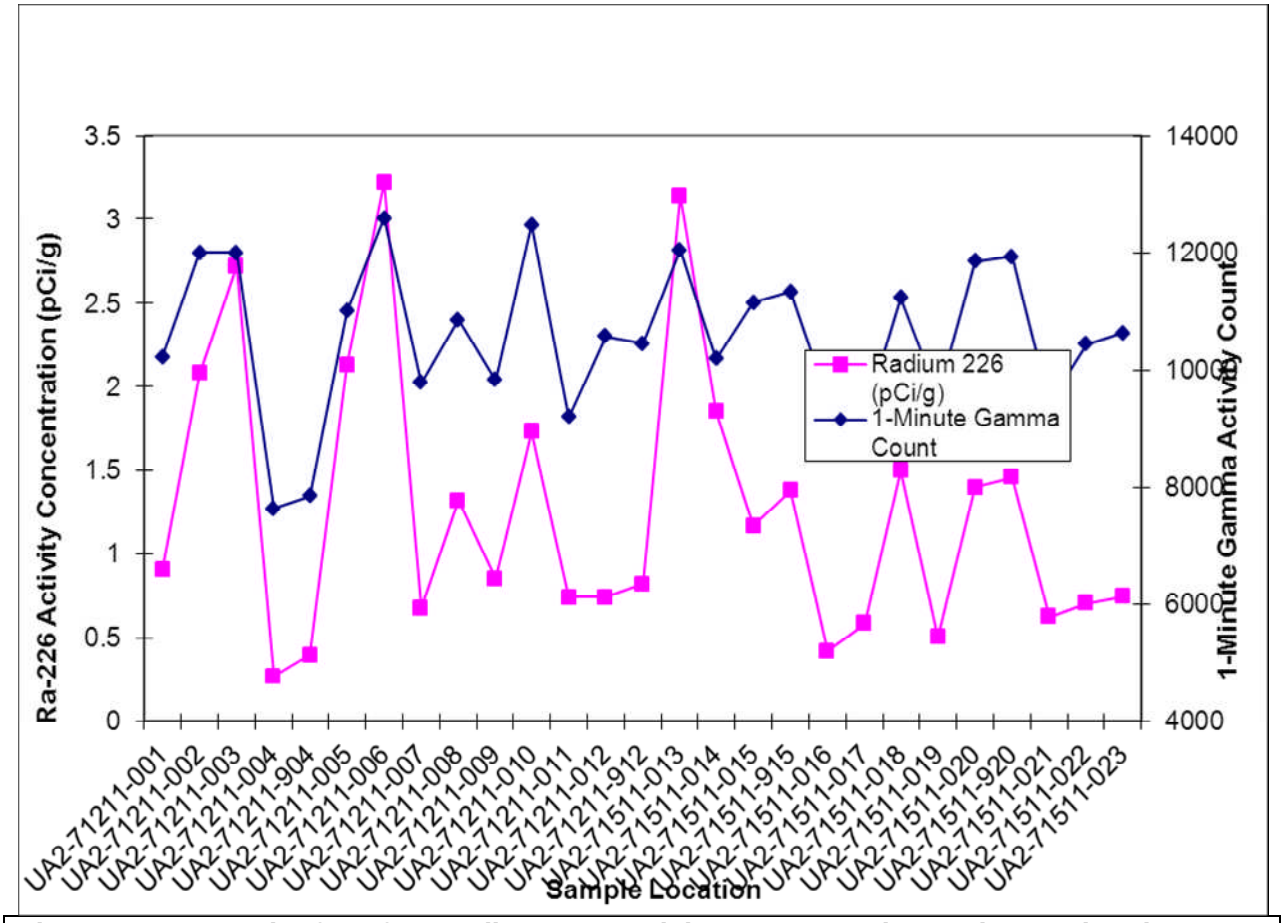

Figure 13 **Graph of Surface Soil Ra-226 Activity Concentration and Associated One-Minute Gamma Activity Count, Upper Arroyo (UA2) Decision Area, Skyline AUM Waste Pile Site Removal Action, San Juan County, Utah**

Notes: Ra-226 – radium 226
pCi/g – picocuries per gram
TDD No. TO-02-09-11-01-0006 E & E Project No. 002693.2132.01RF

4.4 TSDA Surface Soil Sampling and Gamma Activity Measurements

On July 21, 2011, the START collected confirmation surface soil samples from the TSDA. Locations for surface soil samples collected from the TSDA are shown on Figure 8. A summary of the analytical data for surface soil samples collected from the TSDA is included on Table 7.

The START collected confirmation soil samples, including three duplicate samples, at 23 discrete locations distributed in a grid pattern within the TSDA. One-minute gamma activity scans were collected at each of the surface soil sampling locations. Radium-226 concentrations in surface samples collected in the TSDA ranged from 0.224 pCi/g to 8.65 pCi/g. The average concentration for the sample set was 2.43 pCi/g. Eight sample locations (including one duplicate sample) exceeded the site-specific action level of 3 pCi/g, with exceedances ranging from 3.22 pCi/g to 8.65 pCi/g. Surface one-minute gamma activity counts at the 23 surface soil sample locations ranged from 8.798 kcpm to 25.255 kcpm, with an average of 14.075 kcpm. The correlation coefficient between the Ra-226 laboratory analytical data for the soil samples and the field-measured gamma activity counts was 0.789, and the R^2 value was 0.62, indicating a

relatively weak positive correlation between the measurements. The reason for the poor correlation is likely attributable to the large proportion of detected sample concentrations that were less than 1.5 pCi/g. As discussed previously, the observed correlation is poor at low concentrations and gamma activity levels. A graph of these data is shown on Figure 14.

Table 7 Summary of Surface Soil Sample Results for Radium 226 and Associated Gamma Activity Counts, Talus Slope Decision Area (TSDA), Skyline Mine Waste Pile Site Removal Action, San Juan County, Utah

E & E Project No. 002693.2132.01RF TDD No. TO-02-09-11-01-0006

Sample ID	Radium 226 (pCi/g)	Method Detection Limit	Associated One-Minute Gamma Activity Count (cpm)
TSDA-072111-001	2.51	0.105	13826
TSDA-072111-002	**3.22**	0.134	15707
TSDA-072111-003	0.650	0.0948	15603
TSDA-072111-004	0.458	0.0977	16825
TSDA-072111-005	**7.43**	0.158	16556
TSDA-072111-006	**5.20**	0.160	19882
TSDA-072111-906	**5.35**	0.153	19758
TSDA-072111-007	**3.20**	0.120	13695
TSDA-072111-008	**5.39**	0.166	23363
TSDA-072111-009	**7.55**	0.185	25255
TSDA-072111-010	**4.00**	0.130	18828
TSDA-072111-011	0.504	0.162	10357
TSDA-072111-012	**8.65**	0.156	16831
TSDA-072111-013	2.12	0.126	17849
TSDA-072111-014	0.730	0.106	12022
TSDA-072111-015	0.571	0.107	10045
TSDA-072111-016	0.651	0.0908	10163
TSDA-072111-916	0.623	0.126	10191
TSDA-072111-017	0.606	0.103	9683
TSDA-072111-018	0.977	0.105	11098
TSDA-072111-019	0.429	0.179	9495
TSDA-072111-020	0.425 UJ	0.246	9364
TSDA-072111-021	0.413 UJ	0.219	9139
TSDA-072111-921	0.418 UJ	0.103	9250
TSDA-072111-022	0.224	0.213	8798
TSDA-072111-023	0.846	0.105	12365
MINIMUM	0.224		8,798
MAXIMUM	8.65		16,831
AVERAGE	2.429	pCi/g	14,075
STANDARD DEVIATION	2.616	pCi/g	4,712
R-CORRELATION COEFFICIENT			0.789
R^2-SUM OF SQUARED RESIDUALS			0.623

Notes:
Radium 226 concentrations by EML HASL 300, 4.5.2.3
Gamma activity counts by Ludlum Measurements Inc. Model 2241 Ratemeter and Detector Model 44-10 2"x2" NaI Gamma Scintillator
pCi/g = picocuries per gram cpm = counts per minute
UJ = qualified as estimated due to low abundance (i.e. not detected at the method detection limit)
Results above the area-specific action levels are indicated in bold.

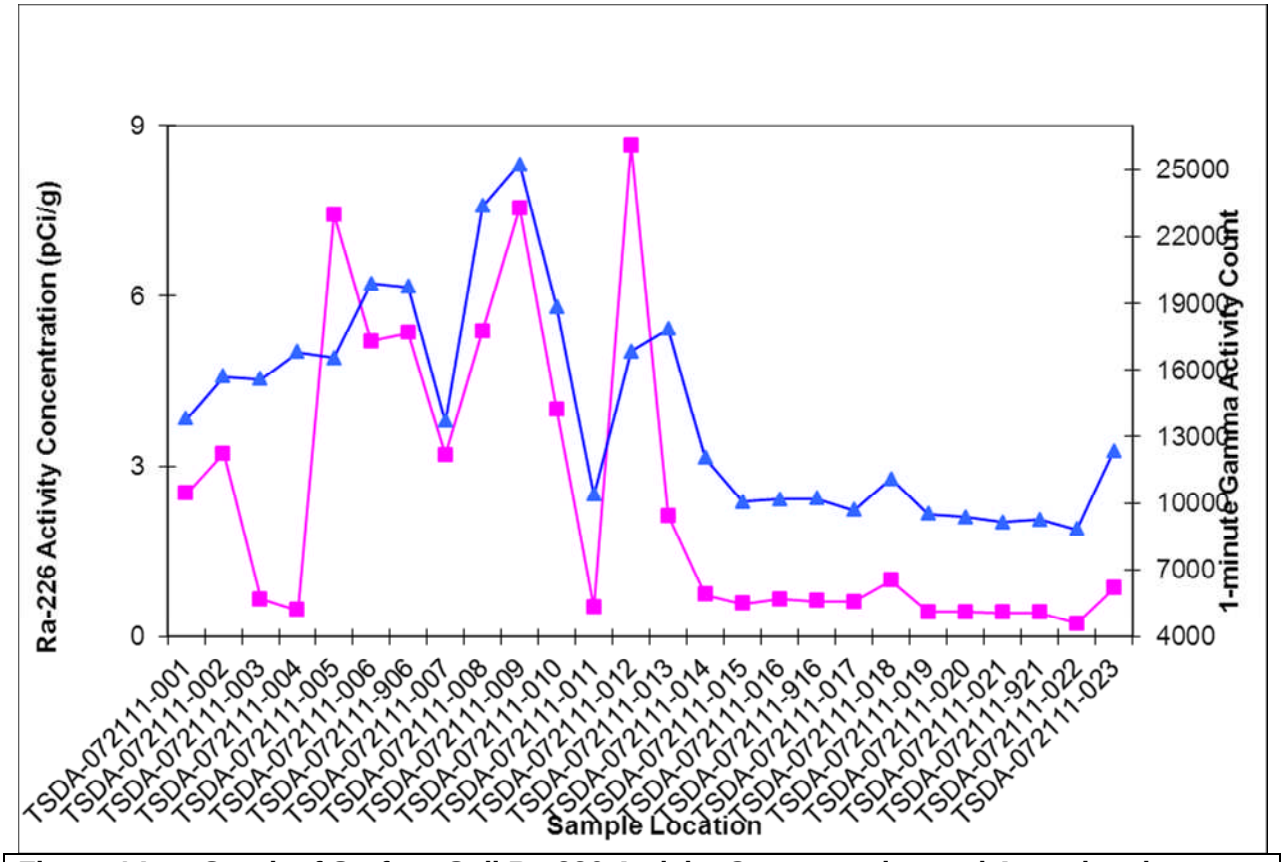

Figure 14 **Graph of Surface Soil Ra-226 Activity Concentration and Associated One-Minute Gamma Activity Count, Talus Slope Decision Area (TSDA), Skyline AUM Waste Pile Site Removal Action, San Juan County, Utah**

Notes: Ra-226 – radium 226
pCi/g – picocuries per gram
TDD No. TO-02-09-11-01-0006 E & E Project No. 002693.2132.01RF

The laboratory soil sampling data were reviewed by a qualified START chemist as part of the data validation process. All sample results and procedures met data quality objectives and were considered to be acceptable for use as stated in the SAP. Samples TSDA-0721-020, TSDA-0721-021, and TSDA-0721-022 were qualified as estimated due to low abundance and were labeled with the data qualifier UJ. All QC samples met laboratory acceptance criteria. Laboratory analytical reports and data validation reports are included in Appendix I.

After excavation work was completed, the START traversed the area on approximately 4-foot-wide transects carrying the RAT in order to collect surface gamma activity measurements. Due to the steep, rocky uneven terrain in the TSDA, not all areas could be sampled or scanned. Additionally, poor geometry between the GPS unit and the associated satellites prevented the collection of spatial data (coordinates) at some locations close to the mesa. However, because the sampler was within the boundary of the decision area at the time, these data were collected and included in the data set. Gamma activity scan data from the TSDA are depicted on Figure 8. The gamma activity measurements were used to estimate Ra-226 concentrations using the correlation equation shown on Figure 11. A histogram of the gamma activity and associated Ra-226 concentration data is included in Appendix J. A tabular summary of the gamma activity scan data

from the TSDA is included in Appendix K. Statistical data for estimated Ra-226 values are shown in Table 4.

As discussed in Section 3.3.4, the ERRS contractor was unable to excavate all impacted material above the 3.0 pCi/g action level for Ra-226 due to the presence of large, competent, native ore-bearing rock or bedrock and/or steep topography. In general, although concentrations decreased by approximately 80 percent, surface Ra-226 concentrations remain above the action level in the western and northern portions of the TSDA, including the uppermost reaches of UA2 (Figure 9). The size of this post-excavation residual elevated area was estimated at 18,750 ft^2. Smaller isolated areas of elevated activity were also present in the arroyo that drains the south side of the talus slope.

Of the 19,030 gamma activity sample measurements collected, 4,042 corresponded to Ra-226 concentrations above 3.0 pCi/g, with an estimated maximum of 41.67 pCi/g. Of the 4,042 samples that corresponded to values above 3 pCi/g, 2,511 were less than 4.0 pCi/g and 3,527 were less than 5.0 pCi/g, suggesting that most of the values were only slightly above the action level and, based on previous modeling data, unlikely to significantly increase risks to human health or the environment (E & E, 2010). The median (1.90 pCi/g) and mean (2.31 pCi/g) Ra-226 concentrations calculated from the gamma scan data were less than the removal action level of 3.0 pCi/g. The mean value was slightly greater than the median value, suggesting a possible bias or skew. The histogram of the gamma activity and associated Ra-226 concentration data (Appendix J) supports the hypothesis that the data are slightly skewed towards the higher concentrations. There are several potential reasons for the observed skew. The most likely reason is the bias in the measurement method that was previously discussed. As discussed, once sample collection personnel observed elevated gamma activity, they spent more time in the elevated areas relative to other areas in order to define the boundaries of the elevated gamma activity. For example in the TSDA, 48 of the 53 highest gamma readings were all collected within 1-foot of each other. These measurements included every estimated Ra-226 activity concentration value between 14 pCi/g and 41.67 pCi/g. This suggests that one isolated location in the western portion of the TSDA had material with residual Ra-226 concentrations in the 40 pCi/g range, while all other areas were less than 14 pCi/g. Based on the histogram, the MDCR was approximately 6.90 kcpm, which corresponds to a Ra-226 concentration of approximately 1.17 pCi/g.

4.5 TLDA Surface Soil Sampling and Gamma Activity Measurements

On August 15, 2011, and October 13, 2011, the START collected confirmation surface soil samples from the TLDA, located at the foot of the mesa. Locations for surface soil samples collected from the TLDA are shown on Figure 10. Note that the soil sampling decision area was expanded to include portions of the material stockpile area located north of the TLDA. This area was graded and used to stockpile contaminated soil during the removal effort; therefore, it was included in final confirmation sampling and gamma scanning activities. A summary of the analytical data for surface soil samples collected from the TLDA is included on Table 8.

Table 8 Summary of Surface Soil Sample Results for Radium 226 and Associated Gamma Activity Counts, Transloading Decision Area (TLDA), Skyline Mine Waste Pile Site Removal Action, San Juan County, Utah

E & E Project No. 002693.2132.01RF TDD No. TO-02-09-11-01-0006

Sample ID	Radium 226 August 2010 (pCi/g)	Radium 226- November 2008 & August 2009[1] (pCi/g)	Method Detection Limit	Associated One-Minute Gamma Activity Count (cpm)
TLDA-081511-001	1.91	0.562	0.116	7303
TLDA-081511-002	0.268	21.0	0.060	7155
TLDA-081511-003	0.917	24.8	0.0806	8430
TLDA-081511-004	0.487	3.43	0.0616	8073
TLDA-081511-005	2.14	28.1	0.122	8803
TLDA-081511-006	0.833	0.782	0.0782	8409
TLDA-081511-906[2]	1.04	N/A	0.101	8333
TLDA-081511-007	0.684	1.7	0.103	8026
TLDA-081511-008	0.458	1.6	0.0797	8174
TLDA-081511-009	0.334	2.66	0.075	6817
TLDA-081511-010	0.464	0.974	0.0794	8786
TLDA-081511-011	1.19	8.56	0.0723	9150
TLDA-081511-012	1.58	2.19	0.0947	9286
TLDA-081511-013	0.598	1.05	0.113	7962
TLDA-081511-014	0.489	2.67	0.0652	7519
TLDA-101311-015	0.466	N/A	0.115	7729
TLDA-101311-016	0.334	N/A	0.0983	6867
TLDA-101311-017	0.431 UJ	N/A	0.135	8812
TLDA-101311-018	0.355	N/A	0.0903	6653
TLDA-101311-918[2]	0.389	N/A	0.0785	6595
TLDA-101311-019	0.362	N/A	0.0757	6615
TLDA-101311-020	0.314 UJ	N/A	0.187	6974
TLDA-101311-021	0.349	N/A	0.0802	6959
TLDA-101311-022	0.293	N/A	0.102	6478
TLDA-101311-023	0.321	N/A	0.0695	6643
MINIMUM	0.268	0.562	pCi/g	6,478
MAXIMUM	2.14	28.1	pCi/g	9,286
AVERAGE	0.68	7.15	pCi/g	7,702
STANDARD DEVIATION	0.5	9.8	pCi/g	898
R-CORRELATION COEFFICIENT				0.565
R^2- SUM OF SQUARED RESIDUALS				0.319

Notes: UJ = qualified as estimated due to low abundance (i.e. not detected at the method detection limit)
Radium 226 concentrations by EML HASL 300, 4.5.2.3
Gamma activity counts by Ludlum Measurements Inc. Model 2241 Ratemeter and Detector Model 44-10 2"x2" NaI Gamma Scintillator
pCi/g = picocuries per gram cpm = counts per minute N/A = not applicable
Results above the area-specific action levels are indicated in bold.
1. Data reported in Ecology and Environment's *Skyline AUM Waste Pile Site Removal Assessment Report* dated May 25, 2010.

The START collected confirmation soil samples, including two duplicate samples, at 23 discrete locations distributed in a roughly triangular grid pattern within the TLDA. In accordance with the SAP, 14 of the samples were collected from the same geographic locations as the surface and subsurface samples that were collected during the November 2008 and August 2009 removal assessments (E & E 2010). The Ra-226 surface activity concentrations as detected during that previous assessment work are included in Table 8 for comparison. Ra-226 concentrations in surface samples collected from the TLDA in 2011 ranged from 0.268 pCi/g to 2.14 pCi/g. The average concentration for the sample set was 0.68 pCi/g. None of the samples exceeded the site-specific action level of 2.5 pCi/g. The minimum, maximum, and average concentrations decreased from 0.562, 28.1, and 7.15 pCi/g, respectively, in 2008/2009 to the 2011 concentrations of 0.268, 2.14, and 0.68 pCi/g, respectively.

The soil data were reviewed by a qualified START chemist as part of the data validation process. Except for two samples, all data met data quality objectives and were considered to be acceptable for use as stated in the SAP. Samples TLDA-101311-017 and TLDA-101311-020 were qualified as estimated due to low abundance and labeled with the data qualifier UJ. All QC samples met laboratory and START acceptance criteria. Laboratory analytical reports and data validation reports are included in Appendix I.

One-minute gamma activity scans were collected at each of the surface soil sampling locations. A summary of the one-minute gamma activity counts from the TLDA is included on Table 8. Surface one-minute gamma activity counts at the 23 surface soil sample locations ranged from 6.478 kcpm to 9.286 kcpm, with an average of 7.702 kcpm. The correlation coefficient for the Ra-226 laboratory analytical data for the soil samples and the field-measured gamma activity counts was 0.57 and the R^2 was 0.32, suggesting a poor positive correlation between the measurements. The reason for the poor correlation between Ra-226 concentrations and surface gamma activity is unclear but, as previously discussed, most likely due to the frequent detection of relatively low gamma activity and Ra-226 activity concentrations in soil. A graph of these data is shown on Figure 15.

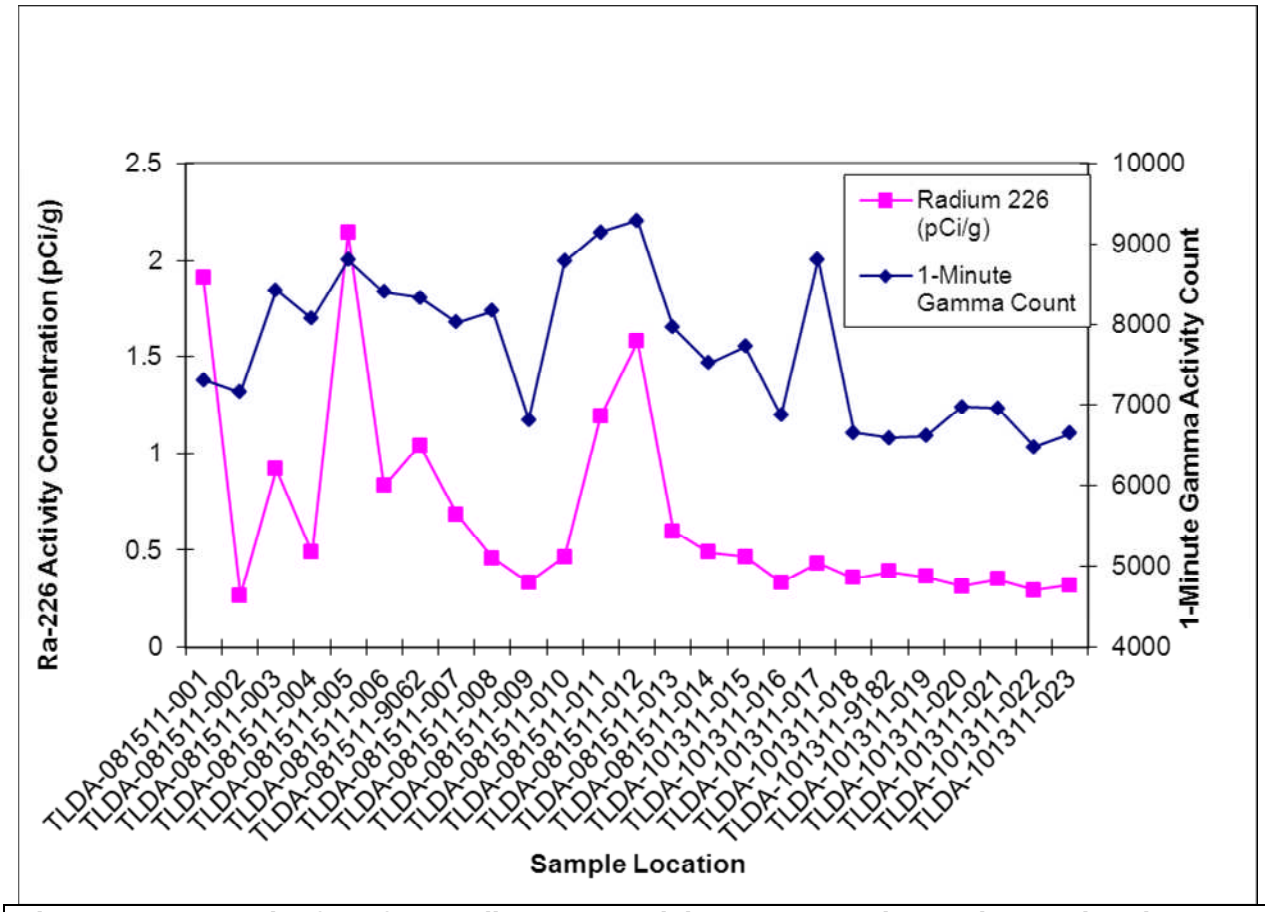

Figure 15 **Graph of Surface Soil Ra-226 Activity Concentration and Associated One-Minute Gamma Activity Count, Transloading Decision Area (TLDA), Skyline AUM Waste Pile Site Removal Action, San Juan County, Utah**

Notes: Ra-226 – radium 226
pCi/g – picocuries per gram
TDD No. TO-02-09-11-01-0006 E & E Project No. 002693.2132.01RF

After excavation work was completed, the START traversed the entire area on approximately 4-foot-wide transects carrying the RAT system to measure and record surface gamma activity at one-second intervals. The gamma activity measurements were used to estimate Ra-226 concentrations using the correlation equation shown on Figure 11. A histogram of the gamma activity and associated Ra-226 concentration data is included in Appendix J. A tabular summary of the gamma activity scan data from the TLDA is included in Appendix K.

The median (1.43 pCi/g) and mean (1.46 pCi/g) estimated Ra-226 concentrations calculated from the gamma scan data were less than the removal action level of 2.5 pCi/g. The mean and the median values were approximately equal, indicating the data were not skewed. Statistical data for estimated Ra-226 values are shown in Table 4. The histogram of the gamma activity and associated Ra-226 concentration data (Appendix J) supports the conclusion that the data are not skewed and are approximately normally distributed. Based on the histogram, the MDCR above background is approximately 6.50 kcpm, which corresponds to a Ra-226 concentration of approximately 1.1 pCi/g. Of the 8,036 sample measurements collected, 23 correspond to Ra-226 concentrations above 2.5 pCi/g, with an estimated maximum of 4.31 pCi/g.

4.6 AML Surface Soil Sampling and Gamma Activity Measurements

On October 2, 2011, the START collected confirmation surface soil samples after excavation was concluded at the existing repository (AML) at the top of the mesa. Locations for surface soil samples collected from the AML are shown on Figure 10. A summary of the analytical data for surface soil samples collected from the AML is included on Table 9.

Table 9 Summary of Surface Soil Sample Results for Radium 226 and Associated Gamma Activity Counts, Existing Repository Area (AML), Skyline Mine Waste Pile Site Removal Action, San Juan County, Utah

E & E Project No. 002693.2132.01RF TDD No. TO-02-09-11-01-0006

Sample ID	Radium 226 (pCi/g)	Method Detection Limit	Associated One-Minute Gamma Activity Count (cpm)
AML-100211-01	0.582	0.0965	13210
AML-100211-02	0.688	0.0929	15710
AML-100211-03	1.54	0.110	15795
AML-100211-04	0.753	0.0952	15921
AML-100211-904	0.731	0.138	15663
AML-100211-05	0.591	0.118	26516
AML-100211-06	0.648	0.0877	12396
MINIMUM	0.582	pCi/g	12,396
MAXIMUM	1.54	pCi/g	26,516
AVERAGE	0.79	pCi/g	16,459
STANDARD DEVIATION	0.34	pCi/g	4,657
R-CORRELATION COEFFICIENT			-0.117
R^2- SUM OF SQUARED RESIDUALS			0.014

Notes:
Radium 226 concentrations by EML HASL 300, 4.5.2.3
Gamma activity counts by Ludlum Measurements Inc. Model 2241 Ratemeter and Detector Model 44-10 2"x2" NaI Gamma Scintillator
pCi/g = picocuries per gram
cpm = counts per minute
Results above the area-specific action levels are indicated in bold.

The START collected confirmation soil samples, including one duplicate sample, at six discrete locations distributed in a triangular grid pattern within the AML. This number was reduced from the 14 samples originally proposed in the SAP. The sample frequency was reduced for two reasons. First, not all contaminated soils were excavated. Some areas were obviously part of the ore body and/or were indurated native sandstones that exhibited elevated gamma activity levels. As previously discussed, whenever possible these areas were covered with clean fill imported from the borrow area. Based on U.S. EPA guidance in the field, it was not considered necessary to sample imported materials at the same frequency as was proposed in the SAP. However, it was determined that some sampling was necessary to show that surface soils are not contaminated and that elevated gamma readings are related to the material beneath or near them. This would not have been possible using only gamma activity scan data.

The soil sampling data were reviewed by a qualified START chemist as part of the data validation process. All data met data quality objectives and were considered to be acceptable for use as stated in the SAP. No data were qualified and no problems or exceptions were noted. All QC samples met laboratory acceptance criteria. Laboratory analytical reports and data validation reports are included in Appendix I.

Radium-226 concentrations in surface samples collected in the AML cover material ranged from 0.582 pCi/g to 1.54 pCi/g. The average concentration for the sample set was 0.79 pCi/g. None of the samples exceeded the site-specific action level of 5 pCi/g. One-minute gamma activity counts were performed at each of the surface soil sampling locations. Surface one-minute gamma activity counts at the six soil sample locations ranged from 12.396 kcpm to 26.516 kcpm, with an average of 16.459 kcpm. The maximum gamma activity readings occurred in the northern portion of the decision area, near an exposed outcropping of ore. This ore body was immediately south of the mine portals and beneath an overhanging rock. Due to the overhanging rock, not all of the ore was covered with fill material.

The correlation coefficient for the Radium-226 laboratory analytical data for the soil samples and the field-measured one-minute gamma activity counts was -0.117 with an R^2 of 0.014, indicating a very weak negative correlation between the measurements. This result was expected, because laboratory analysis of the soil samples collected at the ground surface detects the radioactivity in the actual soil sample, while surface gamma activity scans are capable of detecting buried radioactive materials in the repository, and/or exposed outcroppings of ore, thus producing gamma activity counts that are biased high.

After excavation work was completed, the START also traversed the entire area on approximately 4-foot-wide transects carrying the RAT in order to collect a 100 percent surface gamma activity scan. Some areas on steep uneven terrain could not be scanned to concerns about worker safety. Residual areas of elevated gamma activity corresponding to Ra-226 concentrations above 5.0 pCi/g were present in the northern and northeastern portions of the AML decision area, near ore bodies adjacent to the mesa slope excavation area and the former mine portals.

5 Discussion

Daily perimeter and work zone air sampling performed during the excavation work indicated that gross alpha and beta radiation activity concentrations in air did not exceed allowable levels and no unacceptable exposures occurred.

One confirmation surface soil sample collected from the lower portion of the unnamed arroyo (UA1) exceeded the site-specific action level of 3 pCi/g with a concentration of 3.04 pCi/g. Two confirmation soil samples collected from the upper portion of the unnamed arroyo (UA2) exceeded the site-specific action level of 3 pCi/g with concentrations of 3.14 and 3.22 pCi/g, respectively. Based on gamma activity scan data, the average estimated Ra-226 activity concentration in UA1 is 1.96 pCi/g, and the average in UA2 is 1.90 pCi/g. Relatively small isolated areas of higher gamma activity that correspond to Ra-226 concentrations up to 3.87 pCi/g are present in UA1, and similar isolated areas corresponding to Ra-226 concentrations up to 5.83 pCi/g are present in UA2.

Eight confirmation soil samples collected from the TSDA exceeded the site-specific action level of 3 pCi/g, with exceedances ranging from 3.22 pCi/g to 8.65 pCi/g. Elevated Ra-226 concentrations are present in the northern and western portions of the TSDA, in the steep rocky areas near the base of the mesa. In general, the ERRS contractor removed loose accessible material to the extent possible using conventional excavation techniques. Residual concentrations above the site-specific action level either represent background concentrations of radioactive materials at the site or were mine waste that could not be excavated because of the steep inaccessible terrain.

None of the confirmation surface soil samples collected from the TLDA exceeded the site-specific action level of 2.5 pCi/g. RAT gamma activity data indicate an average surface Ra-226 activity concentration of 1.46 pCi/g, with an isolated maximum of 4.31 p/Ci/g.

None of the confirmation surface soil samples collected from the existing repository (AML) exceeded the site-specific action level of 5 pCi/g. Portions of this area were filled with 3 to 8 feet of clean fill material. However, vertically-oriented native ore bodies remain partially exposed near the mine portals. Similarly, although the mass of contaminated soils in the mesa slope Excavation Area was greatly reduced, residual amounts of ore and/or waste rock remain on the steep slope below the mine portals.

6 References

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Appendix A
Site Photographs

Appendix B
Biological Survey Report

Appendix C
Cultural Resources Report

Appendix D
Drawings and Specifications

Appendix E
Sampling and Analysis Plan, Skyline AUM Waste Pile Site Removal Action, April 2011

Appendix F
Air Sampling Data

Appendix G
Geotechnical Testing Data

Appendix H
Liner Testing Documents

Appendix I
Laboratory Analytical Reports and Data Validation Reports for July through October 2011 Soil Sampling Data

Appendix J
Histograms of Correlated Ra-226 and Gamma Activity Scan Data

Appendix K
Gamma Activity Scan Data and Correlated Ra-226 Concentrations for UA1, UA2, TLDA, and TSDA