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Evaporation Pond Removal Excavation Control and Verification Report Durango, Colorado, Disposal Site

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U.S. DEPARTMENT OF ENERGY | Legacy Management

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Contents

Abbreviations ii
1.0 Introduction 1
1.1 Summary 1
1.2 Purpose and Scope 1
1.3 Background 1
1.4 Verification Criteria 4
2.0 Excavation Verification Process 5
2.1 Background Values 5
2.2 Liner Removal 5
2.3 Verification Survey and Sampling Protocol 7
2.4 Verification Definitions 7
2.5 Verification Method 7
2.6 Gamma Scintillometer Scans and Exposure Rate Measurements 7
2.7 Verification Soil Sampling Protocol 8
3.0 Data Results and Evaluation 8
3.1 Field Observations 8
3.2 Data Analysis 8
3.3 Sampling Results 11
3.4 Radium-226 11
3.5 Uranium 12
3.6 Thorium-230 13
3.7 Additional Analytes 13
4.0 Summary 13
5.0 References 15

Figures

Figure 1. Location of the Durango, Colorado, Disposal Site 2
Figure 2. Evaporation Pond at the Durango, Colorado, Disposal Site 3
Figure 3. Background Soil Sample Locations at the Durango, Colorado, Disposal Site 6
Figure 4. Durango Transient Drainage System Closure and Evaporation Pond Sampling Grid 9
Figure 5. ^{226}Ra Levels in Soil Samples 12
Figure 6. Uranium Levels in Soil Samples 12
Figure 7. ^{230}Th Levels in Soil Samples 13
Figure 8. Additional Analyte Levels in Soil Samples Versus Background 15
Figure 9. Vanadium Levels in Soil Samples Versus Background 15

Tables

Table 1. Background Values 5
Table 2. Supplemental Soil Analysis Results 11
Table 3. Supplemental Soil Analysis Results for Additional Analytes 14

Abbreviations

CFR	*Code of Federal Regulations*
cm	centimeter
cps	counts per second
DOE	U.S. Department of Energy
ft	feet
HDPE	high-density polyethylene
LM	Office of Legacy Management
m^2	square meters
mg/kg	milligrams per kilogram
mrem	millirem
NRC	U.S. Nuclear Regulatory Commission
OCS	opposed crystal system
pCi/g	picocuries per gram
PRB	permeable reactive barrier
Ra	radium
RBD	radium benchmark dose
RCT	radiological control technician
TEDE	total effective dose equivalent
Th	thorium
U	uranium

1.0 Introduction

1.1 Summary

The U.S. Department of Energy (DOE) removed the evaporation pond[1] that was used to collect and evaporate water conveyed from the Durango, Colorado disposal cell transient drainage system and from the decommissioned permeable reactive barrier (PRB) treatment system (DOE 1996). The verification sampling results demonstrated that the areas beneath the evaporation pond liner were free from contamination following removal.

1.2 Purpose and Scope

The purpose of this document is to describe the criteria and procedures that the DOE Office of Legacy Management (LM) used for excavation control and verification sampling following decommissioning of the evaporation pond at the Durango disposal site (Figure 1) and present the verification data.

The processes and sampling criteria defined in the *Durango Transient Drainage System Closure and Pond Removal Planning Documents, Durango, Colorado, Disposal Site* (DOE 2017) were followed to ensure that soils beneath the evaporation pond (Figure 2) that remained after removal are protective of human health and the environment. The verification criteria are based on the requirements of 40 *Code of Federal Regulations* 192.12 (40 CFR 192.12) and U.S. Nuclear Regulatory Commission (NRC) specifications.

1.3 Background

During construction of the Durango, Colorado disposal cell, seepage appeared on the slope of the cell. This observation warranted the installation of a transient drainage system and water management system to manage transient drainage from the disposal cell. This water management system gathered transient drainage and conveyed it to a double-lined evaporation pond and a PRB, which was constructed in 1995 to treat the water before it was conveyed to the evaporation pond.

The processes for operating and closing the transient drainage system and the evaporation pond were identified in the initial *Long-Term Surveillance Plan for the Bodo Canyon Disposal Site, Durango, Colorado* (DOE 1996). Criteria were established to determine when internal disposal cell conditions would allow for the permanent closure (sealing) of the transient drainage system.

Criteria for closure and removal, based on disposal cell water levels (as determined by pressure transducers placed within the cell), was satisfied in 2006. The PRB facility was removed in October 2010 (DOE 2011).

[1] In previous documents, the term “holding pond” has been used to describe this feature.

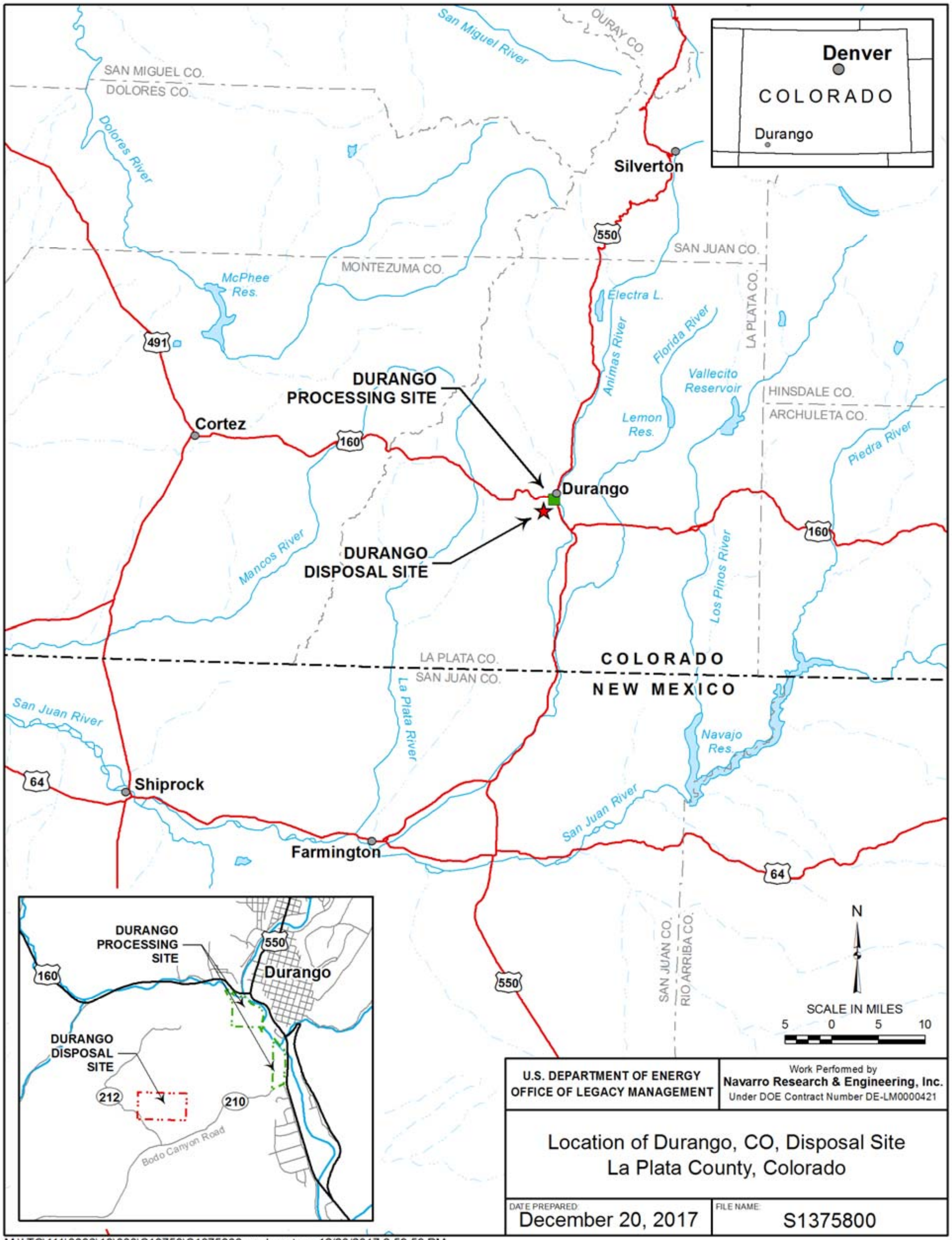

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Figure 1. Location of the Durango, Colorado, Disposal Site

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Figure 2. Evaporation Pond at the Durango, Colorado, Disposal Site

In 2016, a State of Colorado licensed Professional Engineer verified that criteria for closure and removal had been met, the seepage would not reappear, and no unacceptable pore pressure would develop on the slope of the disposal cell (Brennecke 2016). Closure of the transient drainage system and removal of the evaporation pond were completed during the summer of 2017.

1.4 Verification Criteria

Requirements for verifying the area beneath the evaporation pond liner was free of contaminants were based on the U.S. Environmental Protection Agency Uranium Mill Tailings Radiation Control Act standards for radium-226 (^{226}Ra) at mill sites and vicinity properties specified in 40 CFR 192. The standards specify criteria to 5 picocuries per gram (pCi/g) average concentration of ^{226}Ra above background for surface areas, and 15 pCi/g of ^{226}Ra above background for subsurface areas. Surface is defined as the top 15-centimeter (6-inch) layer averaged over 100 square meters (m^2). Subsurface is defined as any 15-centimeter (cm) layer below the surface averaged over 100 m^2.

Additionally, NRC requested that DOE follow NRC's guidance for radionuclides other than radium in soil (using the unity rule as presented in the radium benchmark dose [RBD] approach) to verify the area beneath the evaporation pond. The RBD approach is described in Appendix H of NUREG 1620, *Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites under Title II of the Uranium Mill Tailings Radiation Control Act of 1978* (NRC 2003).

The results of the RBD analysis (SHB Inc. 2017) were accepted by the NRC (Whited 2017) as the verification criteria and are as follows:

1. The total effective dose equivalent (TEDE) received from 15 pCi/g ^{226}Ra in 15 cm soil horizon under 15 cm of clean fill is 20.6 millirem (mrem). This is the RBD.
2. The equivalent natural uranium concentration, i.e., the concentration of uranium in the 15 cm soil horizon under 15 cm of clean fill that results in the RBD (same dose as from the 15 pCi/g of ^{226}Ra) of 2395 pCi/g and, similarly, the equivalent concentration for thorium-230 (^{230}Th) is 42.9 pCi/g.
3. The RBD for this site represents an annual dose of 1.9×10^{-02} mrem to a receptor, standing on the remediated pond area for 8 hours per day per year.

2.0 Excavation Verification Process

2.1 Background Values

Prior to the start of excavation activities, background values for the Durango, Colorado disposal site were established. Three upgradient locations, 0801, 0802, and 0803, within the site boundary and beyond the influence of the evaporation pond and disposal cell, were selected for the measurement of background values and were sampled on May 23, 2017 (Figure 3). At these locations, gamma readings in counts per second (cps) were collected using Mount Sopris SC-132 crutch scintillometers; dose rates were measured using a Thermo Scientific BICRON Micro Rem/Sievert Tissue-Equivalent Survey Meter; soil samples were collected for ^{226}Ra determination using an opposed crystal system (OCS). These results are presented in Table 1. Soil samples were also collected using a hand auger for analytical laboratory analysis of ^{226}Ra, ^{230}Th, uranium, and supplemental analyte concentrations. Results of this analysis are presented in Section 3.0.

Table 1. Background Values

Background Location	Gamma Range (cps)	Dose Range (µR/h)	OCS (pCi/g)
0801	90–100	18–20	1.1
0802	80–100	20–22	1.1
0803	80–100	18–20	2.9

Abbreviation:
µR/h = microroentgens per hour

2.2 Liner Removal

The evaporation pond measured 90 × 110 feet (ft) across the surface and could hold up to approximately 320,000 gallons. The evaporation pond was lined with a 2-foot-thick compacted clay liner and two 40-millimeter-thick high-density polyethylene (HDPE) liners, with drainage nets placed in between the liners.

The evaporation pond liner removal procedure and sampling protocol was defined in the *Durango Transient Drainage System Closure and Pond Removal Planning Documents, Durango, Colorado, Disposal Site* (DOE 2017). The removal was conducted in a manner that minimized damage to the bottom HDPE liner before all of the contaminated materials above the liner were removed and before the condition of the liner could be documented.

Once the top liner was removed, the second liner was visually inspected, before the underlying clay layer was exposed. Radiological measurements and inspection of the clay beneath the liner did not identify any areas with elevated radiological readings or wetness, discoloration, or salt deposits associated with the pond contents.

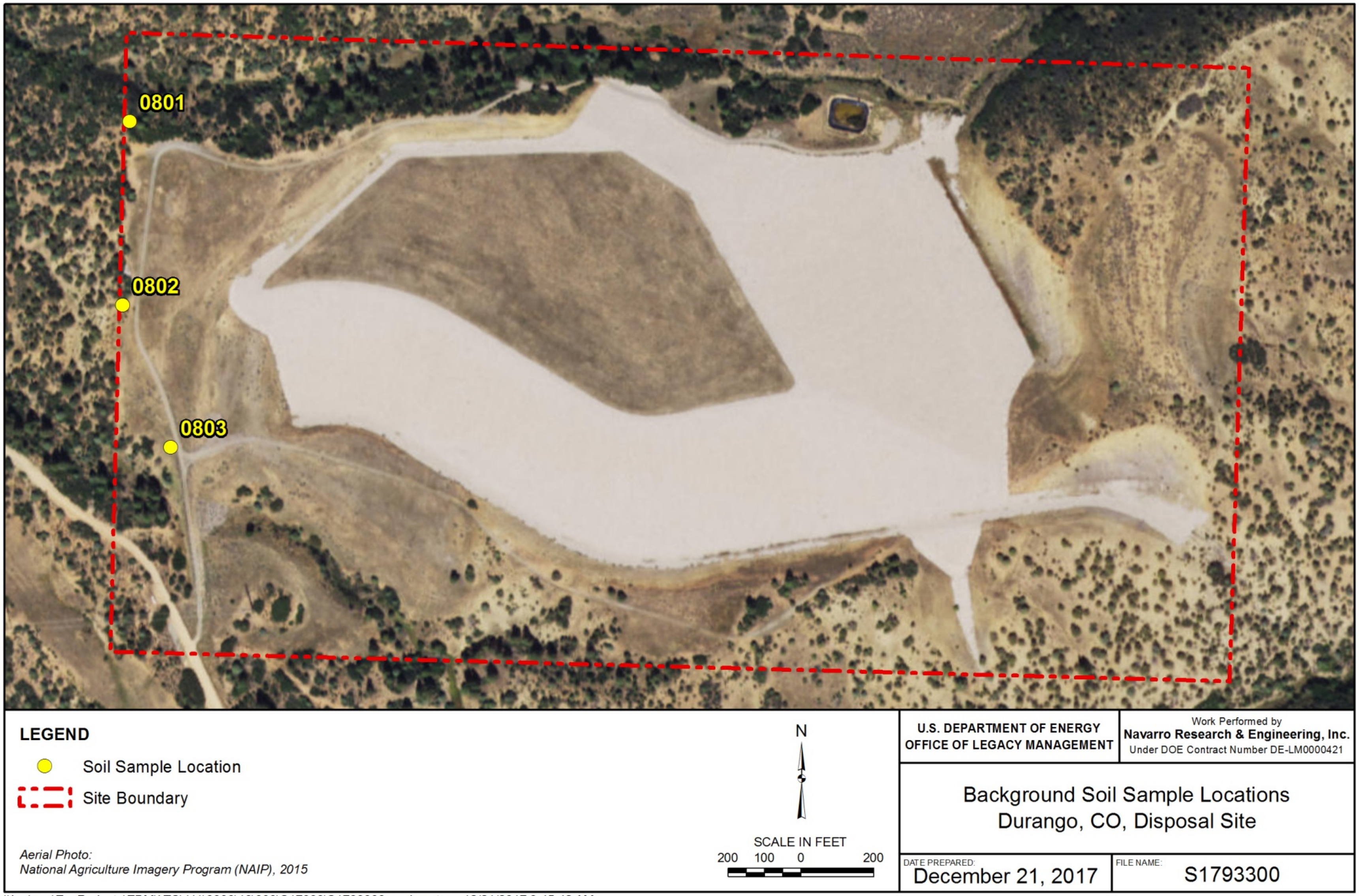

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Figure 3. Background Soil Sample Locations at the Durango, Colorado, Disposal Site

2.3 Verification Survey and Sampling Protocol

Verification surveys were performed to confirm that remaining soils in disturbed areas met the soil standards specified in 40 CFR 192.12 and criteria derived from NRC's guidance for radionuclides. Gamma scanning, exposure rates, and soil samples were used to document the post-remediation radiological condition of the property.

2.4 Verification Definitions

Verification definitions are given below.

- ***Aliquots*:** Aliquots are individual samples collected from a grid block within a V-area.
- ***Standard verification*:** Standard verification is a soil verification method based on subdividing a V-area of approximately 100 m^2 into 3.3 × 3.3 m grid blocks. An aliquot was taken from the center of each grid block and one to nine aliquots are combined to form the verification samples (Figure 4).
- ***Sample identification number*:** Samples were identified and labeled to identify the V-area grid location from which they were collected, as shown in Figure 4.
- ***V-areas*:** V-areas are verification areas documented on the verification map (Figure 4) as V-1 through V-12. The excavated portions of the property were divided into approximately 100 m^2 areas and numbered appropriately. Verification soil samples were then collected from the V-areas, as required.
- ***Verification soil samples*:** Verification soil samples were collected to demonstrate compliance with the appropriate soil criteria.

2.5 Verification Method

The area of the evaporation pond below the liners was divided into twelve 100 m^2 areas (V-areas). The 100 m^2 V-area were subdivided into nine 3.3 × 3.3 m grids (Figure 4). Each 100 m^2 V-area was gamma scanned, and the range and average of scintillometer readings was recorded on the field verification map. The gamma range of the excavated area was determined by observing the high and low gamma scintillometer readings; the average is the gamma reading most commonly observed during the scan of the excavation. Composite soil samples were taken from the V-area to verify compliance with the established criteria.

2.6 Gamma Scintillometer Scans and Exposure Rate Measurements

Scintillometers and exposure rate meters used for gamma-scan surveys had current calibration and daily operational checks performed. The excavated areas were gamma scanned using handheld Mount Sopris SC-132 crutch scintillometers or equivalent field operable instrumentation. The range and average of scintillometer readings were recorded on the field verification map.

An average count rate in the excavation was determined by hand scanning the excavated area and recording the low and high gamma readings observed in the excavation on the field verification map. The most commonly observed gamma readings in the excavation were considered the excavation's average gamma reading. Gamma counts ranged 100–130 cps, and averaged approximately 110 cps.

The exposure rate for the location where each soil aliquot was collected was measured and recorded on the field verification map. These rates are provided in Figure 4.

2.7 Verification Soil Sampling Protocol

For each V-area, a composite sample was collected consisting of one aliquot from each grid block. Aliquots were taken from the approximate geometric center of each 3.3 m × 3.3 m cell and represent a 6-inch (15-centimeter) depth interval. Verification soil samples were analyzed for ^{226}Ra concentrations using the OCS.

Supplemental soil samples were collected as grab samples (not composited) from five locations with the highest radiological readings in accordance with the verification sampling plan. All soil samples were analyzed for molybdenum, ^{226}Ra/^{228}Ra, selenium, ^{230}Th/^{232}Th, uranium-234/235/238 (^{234}U/^{235}U/^{238}U), and vanadium. All locations where soil samples were collected were documented on the field verification map.

3.0 Data Results and Evaluation

3.1 Field Observations

Both liners were thoroughly examined, and the removal process was documented using photographs. The top liner had evidence of a breach leaking onto the drainage nets and second liner. No cuts or tears were identified in the second liner and it appeared to retain moisture. While removing the second liner, the clay layer beneath became wet from significant rainfall, however, it was evident the moisture was new and not a result of seepage through the liner system. A certified radiological control technician (RCT) was on location and scanned the entire area. Scintillometer readings ranged from 100 to 130 cps, which are comparable to background values for the area.

3.2 Data Analysis

Background soil samples 0801, 0802, and 0803 were collected on May 3, 2017. Samples were shipped overnight for laboratory analysis from Grand Junction, Colorado, to Reston Stable Isotope Laboratory in Reston, Virginia, and GEL Laboratories in Charleston, South Carolina, on May 8, 2017.

Supplemental verification grab and composite samples V1–V12 were collected on August 4, August 9, and August 10, 2017. Samples were shipped overnight for laboratory analysis from Grand Junction, Colorado, to the ALS laboratory, Ft. Collins, Colorado, on August 14, 2017.

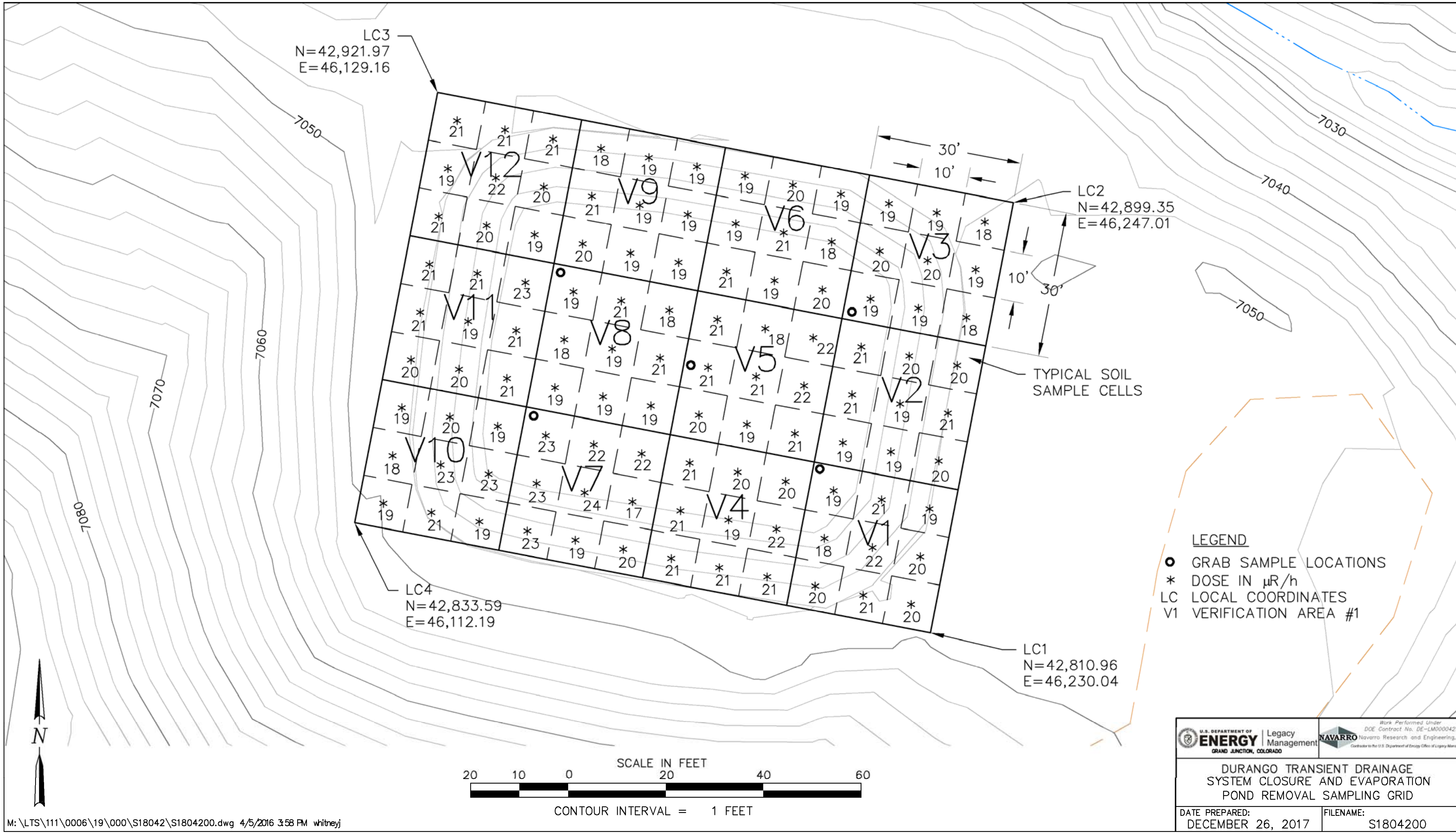

Figure 4. Durango Transient Drainage System Closure and Evaporation Pond Sampling Grid

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3.3 Sampling Results

The analytical results of the supplemental soil samples are reported in comparison to the background samples for ^{226}Ra, natural uranium, and ^{230}Th, and are presented in Table 2. Supplemental soil samples were also analyzed for molybdenum, ^{228}Ra, selenium, ^{232}Th, ^{234}U/^{235}U/^{238}U, and vanadium. The results for these additional analytes are presented in Section 3.7.

Table 2. Supplemental Soil Analysis Results

Sample	Sample Type	^{226}Ra (pCi/g)	^{230}Th (pCi/g)	Uranium (mg/kg)	Uranium (pCi/g)[a]
V1	Composite	1.48	1.03	1.1	0.7
V1	Grab	1.3	1.01	1.3	0.9
V2	Composite	1.51	1.06	4	2.7
V3	Composite	1.45	0.978	8	5.4
V3	Grab	1.45	0.965	4.4	3.0
V4	Composite	1.31	1.07	3.2	2.2
V5	Composite	1.2	1.01	1	0.7
V5	Grab	1.43	0.997	0.57	0.39
V6	Composite	1.33	1.08	1.3	0.9
V7	Composite	1.41	1.05	0.69	0.47
V7	Grab	1.35	0.994	0.48	0.32
V8	Composite	1.52	1.02	0.73	0.49
V8	Grab	1.49	1.18	1.1	0.7
V9	Composite	1.63	1.04	1.8	1.2
V10	Composite	1.52	1.12	0.65	0.44
V11	Composite	1.29	1	1.1	0.7
V12	Composite	1.28	1.11	2.2	1.5
Background 0801	Grab	0.874	0.958	0.575	0.389
Background 0802	Grab	0.784	1.29	0.343	0.232
Background 0803	Grab	1.27	1.23	0.487	0.329

Note:
[a] Conversion for natural uranium in soil is 1 mg/kg = 0.6757 pCi/g.

Abbreviation:
mg/kg = milligrams per kilogram

3.4 Radium-226

The standards in 40 CFR 192 specify criteria of 15 pCi/g average concentration of ^{226}Ra above background for subsurface areas. The ^{226}Ra sampling results (Figure 5) were within 1 pCi/g of background values from locations 0801, 0802, and 0803, below the established criteria.

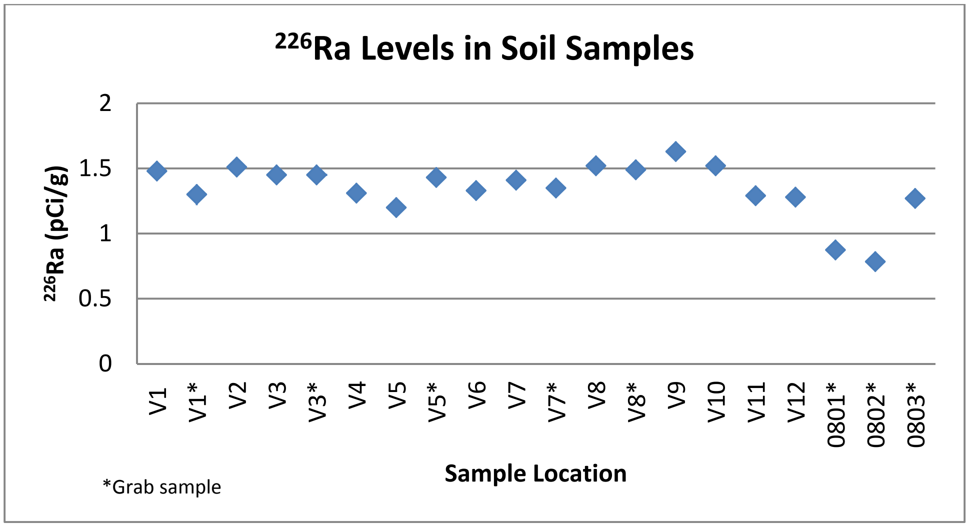

Figure 5. ^{226}Ra Levels in Soil Samples

3.5 Uranium

The NRC criteria for the equivalent natural uranium concentration for the subsurface (i.e., same dose as from the 15 pCi/g of ^{226}Ra) was accepted at 2395 pCi/g. The uranium sampling results (Figure 6) were below the established criteria and within 6 pCi/g of background values from locations 0801, 0802, and 0803. The pCi/g values were converted from the reported values in milligram per kilogram (mg/kg) (Table 2) using the conversion for natural uranium in soil (1 mg/kg = 0.6757 pCi/g).

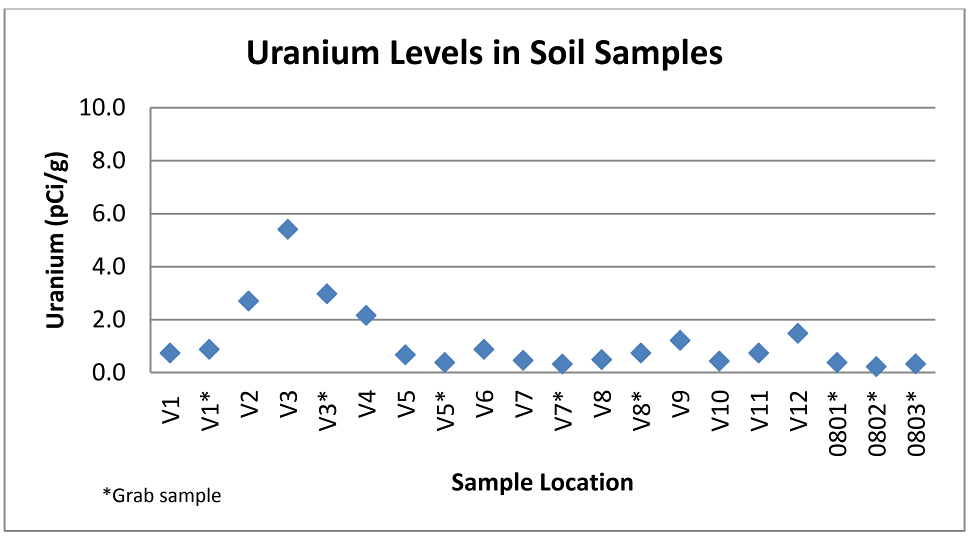

Figure 6. Uranium Levels in Soil Samples

3.6 Thorium-230

The NRC criteria for the equivalent thorium-230 concentration for the subsurface (i.e., same dose as from the 15 pCi/g of ^{226}Ra) was accepted at 42.9 pCi/g. The ^{230}Th sampling results (Figure 7) were similar to the background value from location 0801 and lower than background values from locations 0802 and 0803. All ^{230}Th levels and were below the established criteria.

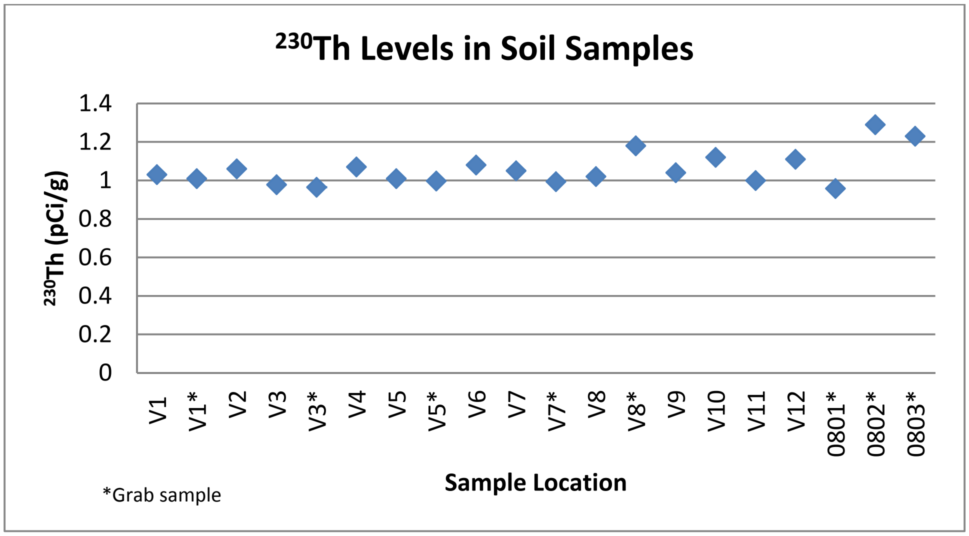

Figure 7. ^{230}Th Levels in Soil Samples

3.7 Additional Analytes

Supplemental soil samples were analyzed for molybdenum, ^{228}Ra, selenium, ^{232}Th, ^{234}U/^{235}U/^{238}U, and vanadium (Table 3). These results are compared to background levels in Figure 8. Due to differences in scale, vanadium results are presented separately in Figure 9.

The reported values were consistent with or below background levels, with no significant outliers.

4.0 Summary

The verification sampling results of all analytes were below the established criteria based on the requirements of 40 CFR 192.12 and additional criteria set by NRC. These results, along with field observations confirm no evidence of contamination in remaining soils.

Table 3. Supplemental Soil Analysis Results for Additional Analytes

Sample	Sample Type	Molybdenum (mg/kg)	^{228}Ra (pCi/g)	Selenium (mg/kg)	^{232}Th (pCi/g)	^{234}U (pCi/g)	^{235} (pCi/g)	^{238}U (pCi/g)	Vanadium (mg/kg)
V1	Composite	0.64	1.77	0.99	1.02	1.17	0.0256	1.05	15
V1	Grab	0.65	1.84	0.94	1.07	1.12	0.0537	1.2	15
V2	Composite	1.8	1.08	0.96	1.01	1.85	0.109	2.13	21
V3	Composite	1.4	1.5	0.98	1.05	5.26	0.276	4.93	30
V3	Grab	1.1	1.56	0.9	1.09	2.13	0.088	2.06	17
V4	Composite	0.87	1.68	1	1.02	1.33	0.0484	1.29	25
V5	Composite	0.69	1.19	0.89	1.03	0.827	0.0472	1.02	14
V5	Grab	0.59	1.09	0.95	1.03	1.52	0.041	1.5	14
V6	Composite	0.69	1.86	1	1.12	1.3	0.0682	1.25	16
V7	Composite	0.6	1.52	1.1	1.16	1.05	0.0452	0.944	15
V7	Grab	0.59	1.53	0.92	1.09	0.839	0.0576	0.939	11
V8	Composite	0.62	2.05	0.95	1.04	0.958	0.064	1.08	15
V8	Grab	0.6	1.77	1	1.11	0.944	0.0763	1.04	15
V9	Composite	0.86	1.45	0.98	1.03	1.37	0.051	1.26	16
V10	Composite	0.66	2.34	0.93	1.12	0.968	0.021	0.927	14
V11	Composite	0.74	1.45	0.93	1.06	0.97	0.0968	1.21	14
V12	Composite	0.69	1.01	1	1.08	1.77	0.11	1.83	15
Background 0801	Grab	0.459	1.23	1.19	1.18	1.18	0.168	1.29	35.6
Background 0802	Grab	0.416	1.41	1.31	1.4	0.96	0.217	1.48	18.1
Background 0803	Grab	0.626	1.2	1.16	1.17	1.67	0.295	1.05	16.1

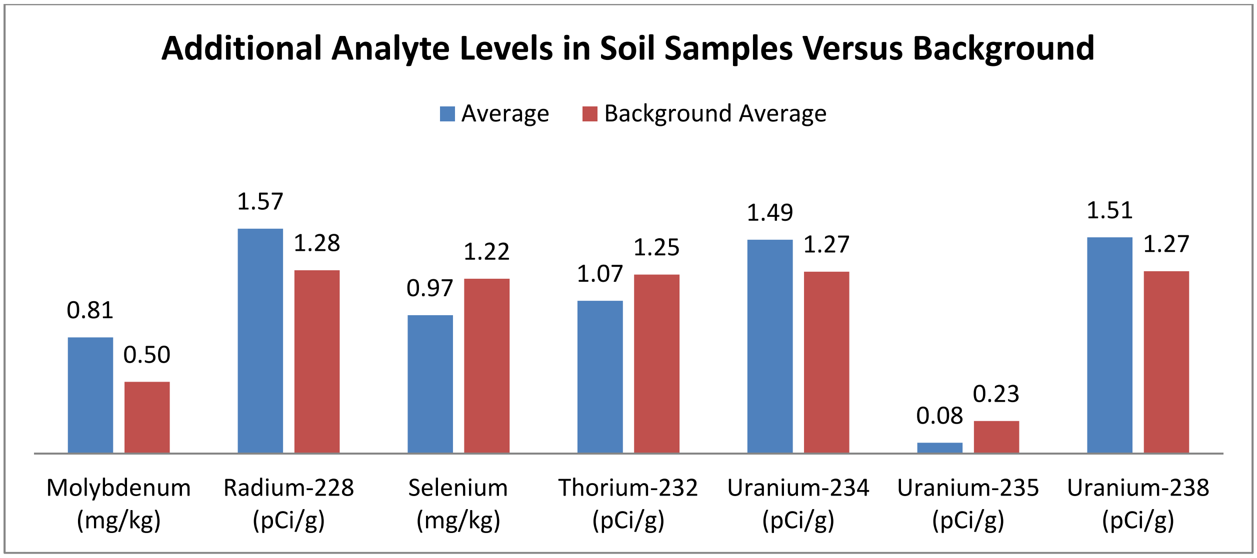

Figure 8. Additional Analyte Levels in Soil Samples Versus Background

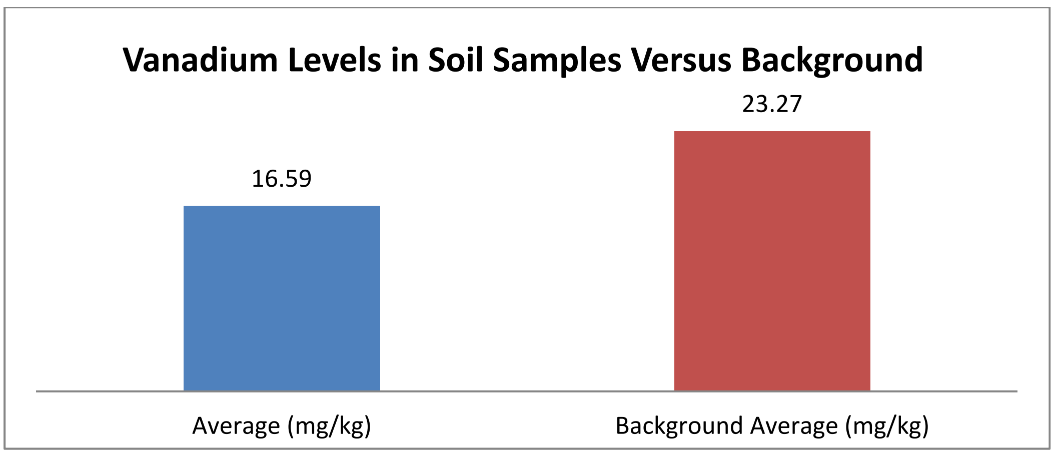

Figure 9. Vanadium Levels in Soil Samples Versus Background

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