Removal Assessment Report
Tronox AUM Sections 32 and 33
Eastern Agency
Prewitt, McKinley County, New Mexico

AUM Section 32
TDD No.: TO-02-09-11-10-0004
Project No.: EE-002693-2164-01TTO

AUM Section 33
TDD No.: TO-02-09-11-10-0005
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List of Abbreviations and Acronyms

AUM	Abandoned Uranium Mine
bgs	below ground surface
cpm	counts per minute
EML	Environmental Measurements Laboratory
ERT	Environmental Response Team
GIS	Geographical Information System
GPS	Global Positioning System
HASL	Health and Safety Laboratory
hr/day	hours per day
NNEPA	Navajo Nation Environmental Protection Agency
pCi/g	picocurie per gram
PIC	pressurized ionization chamber
PRG	Preliminary Remediation Goal
QC	quality control
Ra-226	Radium-226
Ra-226+D	Ra-226 and its radioactive decay chain products
rem	Roentgen equivalent man
r^2	coefficient of determination
SAP	Sampling and Analysis Plan
SD	standard deviation
sf	square feet
START	Superfund Technical Assessment and Response Team
USEPA	United States Environmental Protection Agency
Weston	Weston Solutions, Inc.

1 Introduction

The United States Environmental Protection Agency (USEPA) tasked Ecology and Environment, Inc.'s Superfund Technical Assessment and Response Team (START) to conduct a removal assessment at Tronox Abandoned Uranium Mine (AUM) Sections 32 and 33 located in Prewitt, McKinley County, New Mexico, in the Casamero Lake and Haystack Chapters of the Navajo Nation. AUMs 32 and 33 were part of the Five-Year Plan for cleaning up the legacy of abandoned uranium mining in the Navajo Nation (USEPA *et al.* 2008). The removal assessment included scanning gamma radiation activity in soil and waste piles, collecting samples from soil and waste piles, and assessing home sites near the AUMs. This report documents the field activities and results of the removal assessment.

2 Site Background

2.1 Site Location

AUM 32 is located approximately 1 mile east of County Road 19, Prewitt, McKinley County, New Mexico (Figure 2-1). AUM 32 is located in an Indian Allotment land which is part of the Casamero Lake Chapter of the Navajo Nation. The Chapter House is approximately 1.4 miles northwest of AUM 32. AUM 32 consists of a former mine area (Latitude: 35°29'26.7576"N, Longitude: -108°1'2.7798"W) and transfer area (Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W). The mine area is bordered to the east by AUM 33. The transfer area is located approximately 0.3 mile southwest of the mine area. AUM 32 is located in a range land.

AUM 33 is located immediately east of the AUM 32 mine area (Latitude: 35°29'26.1972"N, Longitude: -108°0'59.8583"W). AUM 33 is privately owned and is part of the Casamero Lake and Haystack Chapters of the Navajo Nation. AUM 33 is located in a range land.

Two home sites are located 0.5 mile west of AUMs 32 and 33 and were also included as part of this assessment.

2.2 Site Description

The AUM 32 mine area is approximately 365,005 square feet (sf) and contains an unsecured deep shaft located in the southeastern portion, and an undetermined extent of underground workings (Weston Solutions, Inc. [Weston] 2009). The mine area is relatively flat with sparse vegetation. Available geographical information show an ephemeral stream or river located north and south of the mine area and converges approximately 0.25 mile west of the mine area. A 10-foot deep ditch was observed to run from east to west and bounded the mine area to the north. The ditch connects to a pond located northwest of the mine area.

The AUM 32 transfer area is approximately 267,432 sf and contains a concrete pad and a sealed vent (Appendix A). The transfer area is located on a slight elevation with sparse vegetation. Evidence of past water flows toward a northwest direction was observed (Appendix A).

AUM 33 has an approximate area of 153,963 sf and contains waste piles, a wooden hopper located in the northeastern corner, and an undetermined extent of underground workings (Weston 2009). AUM 33 is relatively flat with sparse vegetation. Available geographical information show an ephemeral stream or river located north and south of AUM 33 which converges approximately 0.25 mile to the west, and two ponds located on the northeast. Evidence of water flowing through the AUM was observed. The two ponds were observed to be filled with water.

Groundwater depth and information on nearby water wells used for drinking water were not available. Soil borings during field activities detected bedrock at 3 feet below ground surface (bgs). No residences and public structures were found within 0.25 miles of AUMs 32 and 33. The nearest resident lives approximately 0.5 mile to the west. Agricultural food production such as livestock grazing or farming common in Navajo communities was not documented at or immediately adjacent to the AUMs; however, domestic pets, terrestrial wildlife, and animal droppings were observed.

The nearest residence consisted of two home sites. Home site CL-001 was composed of 3 structures (2 houses and a shed). Home site CL-002 was composed of 2 structures (a house and a hogan). Details on the home sites are provided in Appendix B.

2.3 Site History

According to USEPA, portions of the Navajo Nation are located 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 AUMs. Cobb Nuclear Company operated mines in the Casamero Lake Chapter area (Weston 2009).

AUMs 32 and 33 contained historical mines which were reportedly owned by Cobb Nuclear Company and were closed due to a fatality (Weston 2009). No other information on historical ownership of the mine and mining operations was available. No visible signs of reclamation were reported.

USEPA and Navajo Nation Environmental Protection Agency (NNEPA) interviewed a local resident who showed the location of a former transfer area southwest of the AUM 32 mine area. A concrete pad where a crane was reportedly mounted was located in the potential former transfer area. The resident had relatives who formerly worked for Cobb Nuclear Company and reported rail cars transported material from the mine area towards the south and southeast directions. The reported structures were not evident in historical aerial photographs available after the July 2012 USEPA-led field activities (Appendix C).

Materials from the mine potentially used as building materials for residential structures may expose residents to radiation. The nearest residents reportedly used some materials (tarps and lumber) obtained from the mine (Weston 2009).

2.4 Previous Investigation

A site screening was conducted at AUMs 32 and 33 which included collection of site information and gamma radiation survey data (Weston 2009). Gamma radiation activity was measured from surface soil along the initial boundary of the mine areas and along two diagonal intersecting transects from the mine areas' four corners. Gamma radiation activity measurements ranged from 10,689 to 180,367 counts per minute (cpm) at AUM 32; and 14,322 to 140,917 cpm at AUM 33. A rock from a waste pile at AUM 33 emitted over 800,000 cpm. Gamma radiation activity was also measured from a background location which was not identified in the report. The gamma radiation activity at the background location ranged from 16,630 to 17,128 cpm. The building materials in the nearest residence had gamma radiation measurements of approximately 12,000 cpm.

2.5 Removal Assessment Objective

The AUMs are accessible and unsecured. Gamma radiation activity in surface soil and waste piles at the AUMs and in residential structures at the home sites may pose an imminent and substantial threat to human health. USEPA led a removal assessment to define the lateral and vertical extent of gamma radiation levels in soil, gamma radiation levels in the waste piles, and presence of radiation in the residential structures to determine whether a removal action at the AUMs is necessary to protect human health.

START prepared Sampling and Analysis Plans (SAP) with the following specific objectives for the removal assessment (Appendix D).

1. Determine whether, and in what areas, concentrations of Radium-226 (Ra-226) in surface soil require removal, further assessment, or no further action.
   - Determine whether gamma radiation activity readings can be used to characterize the AUMs or if further sampling to characterize the AUMs is necessary.
   - Determine a suitable background location for collecting data to calculate a site-specific action level or identify an alternate means of setting an action level.
2. Determine whether concentrations of Ra-226 in subsurface soil at locations where the surface levels of Ra-226 are elevated require removal, further assessment, or no further action.
3. Determine radiation levels at the home site.
   - Determine gamma exposure levels inside residential structure require removal of the structure or no further action.
   - Determine whether gamma radiation activity in floor surfaces and/or surface soil around the home site require removal or no further action.

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Source: Aerial Photography - Bing Maps

LEGEND

Site area

Chapter boundary

N

0 1 2 3 4 Miles

Figure 2-1
Site Location Map
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

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3 START Field Activities

The field activities for the removal assessment consisted of two events. The first event was in June 2012 when START's planned activities included surface gamma radiation survey and sampling at AUM 32 mine area and AUM 33; and home site assessment. During the home site assessment, USEPA and NNEPA received information from the nearby resident about a potential former transfer area located southwest of the AUM 32 mine area. As a result, USEPA led an initial surface gamma radiation survey at the AUM 32 transfer area. The second event was in July 2012 when START conducted additional surface gamma radiation survey to delineate the AUM 32 transfer area and collected additional soil samples at the AUMs. Appendix A contains photographs of the field activities.

All field activities were conducted according to the SAP and SAP Addendum (Appendix D) except for subsurface sampling. During the June 2012 event, USEPA directed START to collect subsurface samples from one borehole instead of clustered boreholes because of soil conditions and feasibility in the field. During the July 2012 event, USEPA tasked START to collect additional subsurface samples at AUM 33 using a Geoprobe® system. The sample results are discussed in Section 4.0.

3.1 June 2012

START mobilized to the AUMs on June 11, 2012. The USEPA On-Scene Coordinator, USEPA Environmental Response Team (ERT), and NNEPA were also on site. Field activities included surface gamma radiation survey at the background area, AUM 32, and AUM 33; soil sampling for Ra-226 analysis at the background area and the AUM 32 mine area; soil and waste pile sampling for Ra-226 analysis at AUM 33; and home site assessment. START demobilized on June 16, 2012.

3.1.1 Surface Gamma Radiation Survey

A surface gamma radiation survey was conducted using a paired Ludlum Model 44-20 (3x3) detector and 2241 meter. Operational checks were conducted on the paired meter and detector before the field activities using a Spectrum Techniques check source with 1 microcurie of Cesium-137 based on previous AUM sites. The optimal high voltage setting for the instrument was set using a Fluke voltage meter. An operational check was also conducted before each survey day.

The VIPER system and geographical information system (GIS) were used for geospatial information collection and analysis. The survey meters were linked to the VIPER system which stored the data throughout the collection period. Survey data was downloaded from the VIPER system at the end of each day and processed using GIS.

Surface gamma radiation surveys were conducted in the background area, AUM 32 mine and transfer area, and AUM 33. The radiation survey equipment was mounted 6 inches from the ground surface to measure gamma radiation activity in surface soil The survey was conducted at transects 3 feet apart at a pace of 3 feet per second. Step-outs were conducted at transects up to 6 feet apart. The transect width was based on the field of view of the detector which was 3 to 6 feet in diameter.

3.1.1.1 Background Area

A background area was initially selected 600 feet southwest of AUM 32. After an interview with a nearby resident, a new background area was selected by the NNEPA and USEPA according to the *Background Location Selection Criteria* (NNEPA and USEPA 2010). The final background area was located 0.5 mile from AUMs 32 and 33 (Figure 3-1).

Gamma radiation activity was measured in the background area every day a survey was conducted at the AUMs or home sites according to the procedure outlined in the SAP (Appendix D). The mean and standard deviation (SD) of the gamma radiation activity measurements were calculated to determine if the background area was acceptable according to the SAP. The mean and SD were calculated and used to develop the investigation level. The investigation level was based on the mean plus 10 times the SD and was used to guide the field survey.

3.1.1.2 AUM 32

The gamma radiation survey of surface soil at the mine area of AUM 32 consisted of 3-foot wide transects using a push cart covering 100 percent of the initial mine boundary and 6-foot wide transect step-outs until the gamma radiation activity level was below the investigation level. The step-outs extended to the west up to a dirt road running north to south and to the north up to a 10-foot deep ditch running east to west (Figure 3-1).

The gamma radiation survey of surface soil at the transfer area of AUM 32 consisted of 6-foot wide transects using a vehicle starting from the concrete pad and extending laterally in all directions until the gamma radiation activity level was below the investigation level.

3.1.1.3 AUM 33

The gamma radiation survey of surface soil at AUM 33 consisted of 3-foot wide transects using a push cart covering 100 percent of the initial mine boundary and 6-foot wide transect step-outs until the gamma radiation activity level was below the investigation level. The waste piles were scanned by holding the meter 6 inches from the surface of the waste pile and moving in a serpentine motion at a scan rate of 1 to 2 feet per second covering 100 percent of the waste pile.

3.1.2 Sampling for Ra-226 Analysis

Soil and waste pile samples were collected for Ra-226 analysis. Soil samples were collected from the background area, AUM 32 mine area, and AUM 33. Waste pile samples were collected from AUM 33. Surface static 1-minute gamma radiation activity was also measured at the soil sampling locations to determine the relationship between gamma radiation activity level and Ra-226 concentration in surface soil.

3.1.2.1 Background Area

Surface soil samples were collected from 0 to 2 inches bgs at random locations within the background area using a stainless steel trowel and placed in a 4-ounce plastic jar. The random locations were determined using Visual Sampling Plan software version 6.2 (Appendix D). Non-soil material including rocks larger than about ½-inch median diameter were removed from the soil sample. All sample locations were recorded in the field logbook. A total of 11 surface soil samples were collected from the background area.

3.1.2.2 AUM 32

Surface soil locations at the AUM 32 mine area were determined based on the results of the gamma radiation survey. Surface soil sample locations were located at the mine area using a Global Positioning System (GPS) unit pre-loaded with the GIS-assigned coordinates and marked with a flag. The surface soil locations are shown in Figure 3-1. Surface soil sampling procedures were similar to the background area. A total of 25 surface soil samples were collected from the AUM 32 mine area.

Subsurface soil samples were collected from locations of the highest gamma radiation activity results based on the 100 percent scan of the AUM 32 mine area. Subsurface soil sample locations were located at the mine area using a GPS unit pre-loaded with the GIS-assigned coordinates and marked with a flag. The subsurface soil locations are shown in Figure 3-1. Soil samples were collected at 1-foot depth intervals from the ground surface down to 3 feet bgs. Subsurface samples were collected using a hand auger and placed in a 4-ounce plastic jar. Non-soil material including rocks larger than about ½-inch median diameter were removed from the soil sample. All sample locations were recorded in the field logbook. A total of 27 subsurface soil samples were collected from the AUM 32 mine area.

3.1.2.3 AUM 33

Surface soil locations at AUM 33 were determined based on the results of the gamma radiation survey. Surface soil sample locations were located at AUM 33 using a GPS unit pre-loaded with the GIS-assigned coordinates and marked with a flag. The surface soil locations are shown in Figure 3-1. Surface soil sampling procedures were similar to the background area. A total of 16 surface soil samples were collected from AUM 33.

Subsurface soil samples were collected from locations of the highest gamma radiation activity results based on the 100 percent scan of AUM 33. Subsurface soil sample locations were located at AUM 33 using a GPS unit pre-loaded with the GIS-assigned coordinates and marked with a flag. The subsurface soil locations are shown in Figure 3-1. Soil samples were collected at 1-foot depth intervals from the ground surface down to 3 feet bgs except at AUM33-06 where the deepest sample was collected at 34 inches bgs due to refusal. Subsurface samples were collected using a hand auger and placed in a 4-ounce plastic jar. Non-soil material including rocks larger than about ½-inch median diameter were removed from the soil sample. All sample locations were recorded in the field logbook. A total of 21 subsurface soil samples were collected from AUM 33.

A surface sample (0 to 2 inches bgs) was collected from each waste pile to represent the lowest, middle of the range, and highest gamma radiation activity detected in the three waste piles. Surface waste pile samples were collected using a stainless-steel trowel and placed into a 4-ounce plastic jar. The waste pile samples were recorded and shipped with the soil samples. A total of 3 samples were collected from the waste piles.

3.1.2.4 Quality Control

Duplicate samples were collected from 10 percent of the total soil samples to assess sample variability (Appendix D). A total of eight duplicate samples were collected.

Sampling equipment was decontaminated after every sample. One rinsate sample was collected from each equipment at the end of each sampling day to assess field contamination. Six equipment rinsate samples and one sample of the distilled water used for the equipment rinsate were collected.

Sample jars were stored in a cooler according to the laboratory requirements and shipped at the end of field activities to GEL Laboratories, LLC located at 2040 Savage Road, Charleston, South Carolina. Chain-of-custody forms were completed and sent with the sample shipment. The samples were analyzed for Ra-226 by Environmental Measurements Laboratory (EML) Health and Safety Laboratory (HASL) 300 4.5.2.3 Method (Department of Energy 1990). Tier 1 data validation was conducted by the laboratory and Tier 2 data validation was performed by START according to the USEPA guidance (USEPA 1990 and 2001).

3.1.3 Home Site Assessment

Home site assessment was conducted at two home sites – CL-001 and CL-002. NNEPA and USEPA obtained access agreements from the residents. The home site assessment consisted of background measurements for each radiation instrument, surface gamma radiation survey inside and outside the structures, and gamma radiation exposure rate measurements inside the structures.

A background measurement for each radiation instrument was collected prior to commencing the home site assessment. Three sample locations generally located within 20 feet of each other were selected and marked at the background area. At each location, a General Electric Reuter-Stokes High Pressurized Ionization Chamber RSS 131 (PIC) was used to measure and record the gamma radiation exposure rate in milliRoentgen per hour once per second for approximately 5 minutes. The PIC measurements were collected to determine the average exposure rate within a background area. To allow the instrument to reach its full-scale measurement range, and to account for the period when personnel were near the machine (i.e., turning the PIC on or off), data collected in the first or last 90 seconds of the 5 minute PIC sample period was not used. The PIC sampling method was based on recommendations from the manufacturer to: (1) minimize movement around the instrument during sampling to help prevent undesirable changes in the static radiation field; and, (2) omit instrument fluctuations at the beginning and end of a sampling period; and was consistent with previous Navajo home site assessments. After omitting the approximate first 90 measurements, the next 120 measurements were used to calculate the average exposure rate at each location which was used to estimate the average background exposure rate. Background measurements were performed for the gamma radiation survey equipment by scanning the perimeter of the background area for a minimum of 3 minutes to collect at least 180 data points.

START conducted gamma radiation survey of surface soil similar to the procedures in Section 3.1.1 around each structure covering 100 percent of the property. Gamma radiation activity was also measured inside each structure using a paired Ludlum Model 44-20 (3x3) detector and 2241 meter held 6 inches above the floor, and moved in a serpentine motion at a scan rate of 1 to 2 feet per second. Transects were surveyed from one wall to the opposite wall until 100 percent of the accessible areas were scanned. Objects encountered during the survey were not moved, and the survey was performed around the object. The extent of the elevated measurements was determined and the dimensions of the elevated area were documented on a sketch of the area on a structure diagram. The approximate average gamma radiation activity was recorded for each room in the structure. All measurements were documented on a survey form. Static exposure rate measurements were collected inside each room of every accessible structure. In the center of each room, or closest location if obstructed, a PIC was placed 1 meter above the floor, and measurements were collected every second and logged for 5 minutes. The PIC measurements were collected to represent the statistically-based average exposure rate in each room. The exposure rate was used to determine the dose to a resident if the room were occupied, for comparison to dose risk ranges. Each structure was photographed and included in the home site packet (Appendix B).

3.2 July 2012

START re-mobilized to the AUMs on July 16, 2012 to further assess the AUM 32 transfer area. START's planned field activities included additional surface gamma radiation survey and soil sampling for Ra-226 analysis at the transfer area at AUM 32. During the field activities, USEPA directed START to collect additional subsurface soil samples for Ra-226 analysis at AUMs 32 and 33 using a Geoprobe® system. START demobilized on July 20, 2012.

3.2.1 Surface Gamma Radiation Survey

An additional gamma radiation survey of surface soil at the AUM 32 transfer area was conducted. Operational checks were performed similar to the June 2012 event. The same paired Ludlum Model 44-20 (3x3) detector and 2241 meter were used with the VIPER and GIS systems. According to the SAP Addendum (Appendix D) the survey equipment was mounted 6 inches from the ground surface on a vehicle and transects were conducted 3 to 5 feet apart at a pace of 3 feet per second at all accessible areas. The transect width was based on the field of view of the detector which was 3 to 6 feet in diameter. Step-outs were conducted until readings were below the investigation level.

3.2.2 Sampling for Ra-226 Analysis

Soil samples were collected at the AUM 32 transfer area for Ra-226 analysis. Additional subsurface samples were collected from the AUM 32 and AUM 33 mine areas. Surface static 1-minute gamma radiation activity was also measured at the soil sampling locations as additional data for determining the relationship between gamma radiation activity level and Ra-226 concentration in surface soil.

3.2.2.1 AUM 32

Sampling locations were determined based on the results of the gamma radiation survey (Figure 3-1). Sampling locations were marked and surface soil was sampled similar to the June 2012 event. A total of 24 surface soil samples were collected from the AUM 32 transfer area.

Subsurface samples were collected at the AUM 32 transfer area using a Geoprobe® system according to the SAP Addendum (Appendix D). Navajo Tribal Utility Authority cleared the area of known utilities. In addition, utility location was conducted at all of the boring locations by Pacific Coast Locators, Inc. on July 17, 2012. All locations were cleared within an 8- by 8-foot area and down to 6 feet bgs for drilling. A continuous core was extracted down to 3 feet bgs. Soil boring logs were documented by the START geologist. Subsurface samples from one location (AUM32-49) were collected using a hand auger down to 24 inches bgs due to refusal. A total of 46 subsurface soil samples were collected from the AUM 32 transfer area.

Additional subsurface soil samples were collected from the AUM 32 mine area at locations where previous Ra-226 concentrations detected at 3 feet bgs exceeded the action level. AUM32-01, -08, and -09 were cleared by the utility locator and samples were collected at 3 and 4 feet bgs from the soil core extracted using a Geoprobe® system. A total of 6 additional subsurface soil samples were collected from the AUM 32 mine area.

3.2.2.2 AUM 33

Additional sampling at AUM 33 using a Geoprobe® system was tasked by USEPA during the field activities for AUM 32. The utility locator cleared 3 boring locations within an 8- by 8- foot area down to 6 feet bgs for drilling. Only one location was accessible with the Geoprobe® truck. A continuous core was extracted down to 4 feet bgs from AUM33-07 (Figure 3-1). Soil boring logs were documented by the START geologist. A soil sample was collected at 3 and 4 feet bgs from the soil core. A total of 2 additional subsurface soil samples were collected from AUM 33.

3.2.2.3 Quality Control

Duplicate samples were collected from 10 percent of the total soil samples to assess sample variability (Appendix D). A total of seven duplicate samples were collected.

Sampling equipment was decontaminated after every sample. One rinsate sample was collected from each equipment at the end of the sampling day to assess field contamination. Five equipment rinsate samples and one sample of the distilled water used for the equipment rinsate were collected.

Sample jars were stored in a cooler according to the laboratory requirements and shipped at the end of field activities to GEL Laboratories, LLC. Chain-of-custody forms were completed and sent with the sample shipment. The samples were analyzed for Ra-226 by EML HASL 300 4.5.2.3 Method (Department of Energy 1990). Tier 1 data validation was conducted by the laboratory and Tier 2 data validation was performed by START according to USEPA guidance (USEPA 1990 and 2001).

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Source: Aerial Photography - Bing Maps

LEGEND

Gamma activity levels in kilo counts per minute

- Less than or equal to Investigation Level (0 - 40)
- Greater than Investigation Level (40.1 - 50)
- Greater than 2x Background Level (50.1 - 240)
- Greater than 10x Background Level (>240)

Sample location type

- Subsurface
- Surface
- Background area

- Initial mine area
- Transfer area
- Homesite
- Chapter boundary

N

0 400 800 Feet

Figure 3-1
Soil Sampling Location Map
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

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Ecology & Environment, Inc. GIS Department Project: L:\Oakland\Tronox\Maps\MXDs\Old\Figure_3-1_Viper_activity_scan_sample_locs_poster.mxd Date: 9/20/2012

4 Results

The results of the surface gamma radiation survey, soil and waste pile sampling, and home site assessment are presented below. The relationship between surface soil Ra-226 sample results and co-located 1-minute gamma radiation activity measurements and proposed removal areas are also presented in this section.

4.1 Surface Gamma Radiation Survey

4.1.1 Background Area

The results of the surface gamma radiation survey in the background area are shown in Figure 3-1. The background area had a low daily mean and SD and was considered acceptable according to the SAP (Appendix D). The calculated mean background gamma radiation activity ranged from 23,706 to 23,870 cpm and the SD ranged from 141 to 330 cpm. The highest investigation level developed using the daily mean and SD of the gamma radiation activity measured in the background area was 27,011 cpm which was used as the initial investigation level in the field. A new investigation level was developed based on the relationship between surface soil Ra-226 sample results and co-located 1-minute gamma radiation activity measurements (Section 4.4).

4.1.2 AUM 32

The results of the surface gamma radiation survey at the AUM 32 mine area are shown in Figure 4-1. Gamma radiation activity ranged from 38,560 to 962,400 cpm. Rocks and potential buried rocks had gamma radiation activity over 500,000 cpm.

Step-outs of the gamma radiation survey was conducted in all directions of the initial mine boundary except for the eastern boundary which was immediately bordered by AUM 33. An open shaft located in the southeastern portion of the mine area was demarcated at least 10 feet around the opening and not surveyed for protection of health and safety. The gamma radiation survey extended 200 feet north of the initial mine boundary up to a 10-foot deep ditch. A hand-scan of the bottom of the ditch did not indicate elevated levels. The gamma radiation survey extended 100 feet south and 1,000 feet west of the initial mine boundary. The total mine area surveyed was 489,851 sf.

The results of the surface gamma radiation survey at the AUM 32 transfer area are shown in Figure 4-2. Gamma radiation activity ranged from 16,880 to above 1,000,000 cpm. The highest reading recorded by the VIPER system was 24,000,000 cpm. The total transfer area surveyed was 2,010,910 sf.

4.1.3 AUM 33

The result of the surface gamma radiation survey at AUM 33 is shown in Figure 4-3. Gamma radiation activity ranged from 33,410 to above 1,000,000 cpm. The highest reading recorded by the VIPER system was 4,221,540 cpm. The total area surveyed was 173,956 sf.

4.2 Sampling for Ra-226 Analysis

All analytical results were validated and found to be acceptable to meet project objectives for use as definitive-level data without qualification. Validated analytical results are included in Appendix E.

4.2.1 Background Area

Surface soil samples were collected from random locations within the background area. The sample results and co-located 1-minute gamma radiation activity measurements are presented in Table 4-1. The background Ra-226 concentrations ranged from 0.592 to 0.900 picocuries per gram (pCi/g). The highest Ra-226 background concentration of 0.900 pCi/g was used to calculate the action level for the AUMs.

The action level for Ra-226 was based on the sum of the highest background concentration of Ra-226 and the USEPA Preliminary Remediation Goal (PRG) of 1.21 pCi/g (USEPA 2010). The action level for Ra-226 in soil at the AUMs is 2.11 pCi/g.

4.2.2 AUM 32

The sample results (AUM32-01 through -25) and co-located 1-minute gamma radiation activity measurements from the AUM 32 mine area are presented in Table 4-2. Ra-226 concentrations in surface soil at the mine area ranged from 1.19 to 37.3 pCi/g. Ra-226 concentrations detected down to 4 feet bgs in subsurface soil ranged from 0.797 to 112 pCi/g. AUM32-01, -08, and -09 contained elevated concentrations of Ra-226 at 3 feet bgs and were re-sampled at 3 and 4 feet bgs using a Geoprobe® system. The results from samples obtained using a hand auger decreased by an average of 79% when samples were collected using a Geoprobe®. The Geoprobe® method is considered to collect more representative samples at each depth; therefore, the Geoprobe® results were used. The soil depths of Ra-226 concentrations exceeding the action level are shown in Figure 4-1. Soil around the open shaft in the mine area contained Ra-226 concentrations above the action level down to depths of 2 to 3 feet bgs. The remainder of the mine area showed Ra-226 concentrations above the action level in surface soil and down to depths of 1 to 2 feet bgs except for AUM-32-04 which slightly exceeded the action level at 3 feet bgs.

The sample results (AUM32-26 through -49) and co-located 1-minute gamma radiation activity measurements from the AUM 32 transfer area are presented in Table 4-2. Ra-226 concentrations in surface soil at the transfer area ranged from 0.789 to 300 pCi/g. Ra-226 concentrations detected down to 3 feet bgs in subsurface soil ranged from 0.544 to 94.8 pCi/g. The soil depths of Ra-226 concentrations exceeding the action level are shown in Figure 4-2. Soil in the area with gamma radiation activity of above 1 million cpm during the survey contained Ra-226 concentrations of 237 to 300 pCi/g in surface soil as detected in sampling locations AUM32-27, -28, and -29. Ra-226 concentrations in sampling locations AUM32-27 and -28, were above the action level down to 1 foot bgs. AUM32-29 had elevated levels of Ra-226 down to 3 feet bgs. AUM32-49 located between the mine and transfer areas contained 108 pCi/g of Ra-226 in surface soil and concentrations exceeding the action level down to 2 feet bgs where refusal was met using a hand auger. Except for these four sampling locations, elevated levels of Ra-226 in the transfer area were limited to surface soil (0 to 2 inches bgs). The southern portion of the transfer area was bounded by Ra-226 concentrations below the action level.

4.2.3 AUM 33

The sample results (AUM33-01 through -16) and co-located 1-minute gamma radiation activity measurements from AUM 33 are presented in Table 4-3. Ra-226 concentrations in surface soil at AUM 33 ranged from 0.996 to 76.1 pCi/g. Ra-226 concentrations detected down to 3 feet bgs in subsurface soil ranged from 0.816 to 35.4 pCi/g. The soil depths of Ra-226 concentrations exceeding the action level are shown in Figure 4-3. AUM33-02, -04, and -07 contained elevated concentrations of Ra-226 at 3 feet bgs based on hand-augered samples (Table 4-3). Only

AUM33-07 was accessible with the Geoprobe® truck and was re-sampled at 3 and 4 feet bgs. The results from samples obtained using a hand auger decreased by 70% when samples were collected using a Geoprobe®. The Geoprobe® method is considered to collect more representative samples at each depth; therefore, the Geoprobe® results were used. Ra-226 concentrations detected at areas with gamma radiation activity above twice the background level exceeded the action level. All the waste pile samples (AUM33-WP-01, -02, and -03) exceeded the action level. Ra-226 concentrations detected around the waste piles were above the action level down to a depth of 2 feet bgs. The eastern and southern portions of AUM 33 were bounded by Ra-226 concentrations below the action level.

4.3 Soil Geology

Soil borings using a Geoprobe® showed that, in general, soil at the AUMs consisted of clayey and sandy silt overlying shallow bedrock. Bedrock, as observed in most of the borings, consisted of weathered sandy siltstone and weathered siltstone at depths of 1 to 7.5 feet below bgs. Bedrock was not encountered at the total explored depth of four feet bgs at boring locations AUM32-01, AUM32-08, AUM32-09, AUM32-30, and AUM32-37. Obvious fill was noted at boring locations AUM32-01 and AUM32-08, where mine waste was observed at the ground surface. The total thickness of mine waste at boring locations AUM32-01 and AUM32-08 was observed to be 1 foot and 3 feet, respectively. Logs of soil stratigraphy for soil borings collected in July 2012 are included in Appendix F.

4.4 Relationship between Gamma Radiation Activity and Ra-226 Concentration

The relationship between surface soil Ra-226 sample results and co-located 1-minute gamma radiation activity measurements was evaluated to determine if gamma radiation activity measurements can be used as a field screening tool to estimate Ra-226 concentrations. Gamma radiation activity can be measured in real-time in the field while Ra-226 concentrations are determined by laboratory analysis which takes months after sampling.

Correlation analysis measures the strength of association between the paired quantitative variables in the form of a correlation coefficient. The value of a correlation coefficient ranges from -1 for perfect negative correlation, to zero for no correlation at all, to +1 for a perfect positive correlation. The equation for the correlation coefficient is:

$$Correl(X,Y) = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}}$$

Where:

x,y is the paired (co-located) 1-minute gamma radiation activity measurement and Ra-226 sample result from surface soil

$\bar{x}$ is the mean of the 1-minute gamma radiation activity measurements

$\bar{y}$ is the mean of the Ra-226 sample results

The correlation coefficient calculated from all surface soil data using Excel (Microsoft 2010) was 0.77 (Table 4-4). The data was further divided into subsets to refine the correlation. The results indicate correlation increased based on data less than 60,000 cpm, equipment used, and absence of subsurface gamma radiation activity. The highest correlation coefficient was 0.92 which was calculated from the gamma radiation activity measurements using equipment A1.

Linear regression analysis was also conducted to determine if the relationship between co-located 1-minute gamma radiation activity and Ra-226 concentration in surface soil may be predicted by the linear equation $y=mx+b$.

Where:

y is the predicted Ra-226 concentration
m is the slope of the line
x is the measured 1-minute gamma radiation activity
b is the y-intercept of the line

Linear regression analysis was conducted using Excel (Microsoft 2010) which determined the linear least squares curve that best fits the paired data and calculated the coefficient of determination (r^2). The r^2 compares estimated and actual y values, and ranges in value from 0 to 1. If $r^2=1$, there is a perfect correlation in the sample; i.e., there is no difference between the estimated y value and the actual y value. If $r^2=0$, the regression equation is not helpful in predicting a y value. Similar to the correlation coefficient, the r^2 was calculated for each data set (Table 4-4). The highest r^2 was 0.84 which was calculated from the gamma radiation activity measurements using equipment A1. Figure 4-4 shows the predicted Ra-226 concentration based on the best-fit linear equation ($r^2=0.84$) and the measured Ra-226 concentration from the soil samples. Ra-226 concentrations cannot be predicted by the measured co-located 1-minute gamma radiation activity based on a linear trend.

The mean Ra-226 concentrations detected in surface soil within 5,000 cpm range increments of gamma radiation activity measurements were plotted per equipment to determine if gamma radiation activity measurements from each equipment pair can be used to determine if co-located Ra-226 concentrations are below the action level of 2.11 pCi/g (Figure 4-5). The graph shows the mean Ra-226 concentrations for co-located 1-minute gamma radiation activity measurements below 40,000 cpm using equipment A1 was below the action level. The 95% confidence interval of the mean calculated using Excel (Microsoft 2010) was 1.23 to 1.81 pCi/g.

The results indicate there is a correlation between surface soil Ra-226 sample results and co-located 1-minute gamma radiation activity measurements; however, gamma radiation activity measurements may be affected by equipment used, subsurface radiation activity, and other factors that result in a non-linear relationship with Ra-226 concentrations in surface soil. Locations with gamma radiation activity measurements below 40,000 cpm using equipment A1 will likely have mean surface soil concentrations of Ra-226 below the action level of 2.11 pCi/g.

4.5 Home Site Assessment

The average exposure rate at the background area and the PIC measurements from each room in the structures at CL-001 and CL-002 are presented in Tables 4-5 and 4-6, respectively. Because the PIC only measures gamma radiation, a 1:1 conversion factor was assumed when converting the PIC measurements from Roentgen to a dose number, Roentgen equivalent man (rem), to estimate the average annual gamma radiation dose rate to a person spending 24 hours per day (hr/day) in the background area. Based on USEPA guidance, an excess cancer risk of $3\text{x}10^{-4}$ was used to calculate the acceptable dose above background. This calculation assumed that persons are occupying the room being assessed (and thus being exposed) for 24 hr/day, 365.25 days per year, for 30 years. The risk calculation is based on a risk conversion factor of 7% cancer incidence per 100 rem of exposure and comes from the National Academy of Sciences report on the Health Effects of Biological Exposure to Low Levels of Ionizing Radiation (National Research Council 1990). Based on this excess cancer rate, the allowable difference between the annual background dose rate and the annual dose rate for a person in the room being assessed was calculated as 15 mrem/yr. This calculated dose rate is consistent with Navajo projects in USEPA Region 9.

The difference between the background dose rate and the measured dose rate in each room in the structures at CL-001 and in the living room of structure B at CL-002 was negative (i.e. the resident would receive a greater dose in the background area). This result suggests that in most cases the structure is shielding the occupant from naturally-occurring background radiation. The difference between the background dose rate and the measured dose rate in the remaining rooms measured at CL-002 did not exceed 15 mrem/yr.

Results of the gamma radiation survey inside the structures and of surface soil outside the structures within the property were below the investigation level or twice the background level.

The results of the home site assessment were summarized in a home site packet which contained a table of interior measurements accompanied by a figure(s) with a scaled illustration of the structure and radiation measurements within the structures, a figure showing the results of the gamma radiation survey of surface soil around the structures and within the property, and a photographic log for each structure. The home site packet is included as Appendix B.

4.6 Proposed Removal Areas

The results of the removal assessment defined areas of AUMs 32 and 33 for further action such as soil removal to protect human health. The proposed lateral extent of soil for removal was determined based on the surface gamma radiation activity levels and surface soil sample results exceeding the action level. Subsurface soil sample results exceeding the action level were used to determine the vertical extent of soil for removal. As directed by USEPA, the proposed removal areas were based on the most conservative estimate. The proposed removal areas for AUM 32 mine area are shown in Figure 4-6, AUM 32 transfer area in Figures 4-7 and 4-8, and AUM 33 in Figure 4-9. Table 4-7 presents the estimated soil excavation volumes by removal area. At AUM 32, a total of 27,009 cubic yards of soil was calculated for removal at the mine area and 18,043 cubic yards of soil was calculated for removal at the transfer area. A total of 18,556 cubic yards of soil was calculated for removal at AUM 33 excluding the waste piles. The proposed removal areas at the AUMs have a total excavation volume of 63,608 cubic yards of soil.

Project # EE-002693-2164-01TTO
TDD# TO-02-09-11-10-0004

Source: Aerial Photography - Bing Maps

LEGEND

Gamma activity levels in kilo counts per minute

- Less than or equal to Investigation Level (0 - 40)
- Greater than Investigation Level (40.1 - 50)
- Greater than 2x Background Level (50.1 - 240)
- Greater than 10x Background Level (>240)

Ra-226 Concentration in Surface Soil (0 to 2 inches bgs)

- Less than or equal to Action Level (2.11 pCi/g)
- Greater than Action Level
- Chapter boundary

Note:

Sample depths were measured in feet below ground surface (bgs).
NE = Not applicable or not evaluated.
Radium-226 (Ra-226) concentrations in picocuries per gram (pCi/g).

N

0 100 200 300 400 Feet

Figure 4-1
Gamma Radiation Activity and Ra-226 Soil Concentrations at AUM 32 Mine Area
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

ecology and environment, inc.
International Specialists in the Environment

Ecology & Environment, Inc. GIS Department Project: L:\Oakland\Tronox\Maps\MXDs\Figure 4-1_Radium226_Soil_Concentration_AUM_32_V3.mxd Date: 8/30/2012

Project # EE-002693-2164-01TTO
TDD# TO-02-09-11-10-0004

Source: Aerial Photography - Bing Maps

LEGEND

Gamma activity levels in kilo counts per minute

- Less than or equal to Investigation Level (0 - 40)
- Greater than Investigation Level (40.1 - 50)
- Greater than 2x Background Level (50.1 - 240)
- Greater than 10x Background Level (>240)

Ra-226 Concentration in Surface Soil (0 to 2 inches bgs)

- Less than or equal to Action Level (2.11 pCi/g)
- Greater than Action Level
- Chapter boundary

Note:

Sample depths were measured in feet below ground surface (bgs).
NE = Not applicable or not evaluated.
Radium-226 (Ra-226) concentrations in picocuries per gram (pCi/g).

N

0 100 200 300 400 Feet

Figure 4-2
Gamma Radiation Activity and Ra-226 Soil Concentrations at AUM 32 Transfer Area
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

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Ecology & Environment, Inc. GIS Department Project: L:\Oakland\Tronox\Maps\MXDs\Figure_4-2_Radium226_Soil_Concentration_AUM_32_V3.mxd Date: 8/30/2012

Project # EE-002693-2165-01TTO
TDD# TO-02-09-11-10-0005

Source: Aerial Photography - Bing Maps

LEGEND

Gamma activity levels in kilo counts per minute

- Less than or equal to Investigation Level (0 - 40)
- Greater than Investigation Level (40.1 - 50)
- Greater than 2x Background Level (50.1 - 240)
- Greater than 10x Background Level (>240)

Ra-226 Concentration in Surface Soil (0 to 2 inches bgs)

- Less than or equal to Action Level (2.11 pCi/g)
- Greater than Action Level
- Chapter boundary

Note:

Sample depths were measured in feet below ground surface (bgs).
NE = Not applicable or not evaluated.
Radium-226 (Ra-226) concentrations in picocuries per gram (pCi/g).

N

0 100 200 300 400 Feet

Figure 4-3
Gamma Radiation Activity and Ra-226 Soil Concentrations at AUM 33
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

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Table 4-1
Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity
Tronox AUM Sections 32 and 33 Background Area
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004
TO-02-09-11-10-0005

Project No.: EE-002693-2164-01TTO
EE-002693-2165-01TTO

Sample ID[a]	Ra-226 Concentration[b] (pCi/g)	Surface Gamma Radiation Activity[c] (cpm)	
		Radiation Survey Equipment[d]	
		A1	B2
Tronox - BKG2 - 01	0.666	24,087	24,000
Tronox - BKG2 - 02	0.592	23,534	23,892
Tronox - BKG2 - 03	0.801	23,497	23,719
Tronox - BKG2 - 04	0.900		
Tronox - BKG2 - 05	0.648		
Tronox - BKG2 - 06	0.740		
Tronox - BKG2 - 07	0.701		
Tronox - BKG2 - 08	0.722		
Tronox - BKG2 - 09	0.728		
Tronox - BKG2 - 10	0.698		
Tronox - BKG2 - 11	0.626		

Notes:

a All background samples were collected from the surface (0 to 2 inches below ground surface).

b Concentrations shown in **bold** exceed the action level of 2.11 pCi/g

c Static 1-minute measurement at sampling location

d Paired radiation survey equipment which consisted of Ludlum Model 44-20 (3x3) detector and 2241 meter:
Equipment A1 consisted of a Ludlum 2241-3 meter (Serial No. 256844) and an Alpha Spectra detector (Serial No. 121611BP).
Equipment B2 consisted of a Ludlum 2241-3 meter (Serial No. 256852) and an Alpha Spectra detector (Serial No. 121611BQ).

AUM Abandoned uranium mine
cpm Counts per minute
pCi/g Picocuries per gram
Ra-226 Radium-226

Table 4-2
Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity
Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Sample ID[a]	Ra-226 Concentration[b] (pCi/g)	Surface Gamma Radiation Activity[c] (cpm)	Radiation Survey Equipment[d]
Mine Area [e]			
AUM32-01-02	**10.2**		
AUM32-01-12	**8.86**		
AUM32-01-24	**4.50**		
AUM32-01-36	**6.18**		
AUM32-01-36 (G)	1.35		
AUM32-01-48 (G)	1.24		
AUM32-02-02	**2.89**	42,213	B2
AUM32-02-12	2.09		
AUM32-02-24	**2.47**		
AUM32-02-36	1.98		
AUM32-102-36	**2.51**		
AUM32-03-02	**8.21**	54,245	B2
AUM32-03-12	**2.94**		
AUM32-103-12	**2.67**		
AUM32-03-24	1.98		
AUM32-03-36	1.40		
AUM32-04-02	**12.4**	73,533	B2
AUM32-04-12	**2.58**		
AUM32-04-24	1.45		
AUM32-04-36	**2.15**		
AUM32-05-02	2.07	74,440	B2
AUM32-05-12	**2.12**		
AUM32-05-24	1.39		
AUM32-05-36	1.42		
AUM32-06-02	**22.2**	104,554	B2
AUM32-06-12	1.14		
AUM32-06-24	1.62		
AUM32-106-24	2.01		
AUM32-06-36	1.49		
AUM32-07-02	1.65	106,041	B2
AUM32-07-12	**12.8**		
AUM32-07-24	**31.0**		
AUM32-07-36	**40.7**		
AUM32-08-02	**37.3**	492,811	B2
AUM32-08-12	**112**		
AUM32-08-24	**9.78**		
AUM32-08-36	**10.8**		

Table 4-2
Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity
Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Sample ID[a]	Ra-226 Concentration[b] (pCi/g)	Surface Gamma Radiation Activity[c] (cpm)	Radiation Survey Equipment[d]
AUM32-08-36 (G)	**2.45**		
AUM32-08-48 (G)	1.07		
AUM32-09-02	**2.41**	183,333	B2
AUM32-09-12	**50.7**		
AUM32-09-24	**57.1**		
AUM32-09-36	**4.59**		
AUM32-09-36 (G)	0.797		
AUM32-09-48 (G)	1.18		
AUM32-10-02	**8.98**	59,729	A1
AUM32-11-02	1.36	68,578	A1
AUM32-111-02	1.25	68,578	A1
AUM32-12-02	1.19	64,143	A1
AUM32-13-02	2.07	86,820	A1
AUM32-14-02	1.37	32,594	A1
AUM32-15-02	**13.5**	77,649	A1
AUM32-16-02	**3.20**	44,563	A1
AUM32-17-02	**7.88**	55,612	A1
AUM32-18-02	**10.0**	58,320	A1
AUM32-19-02	2.02	36,800	A1
AUM32-20-02	**16.6**	66,519	A1
AUM32-21-02	1.94	43,890	A1
AUM32-22-02	**3.59**	71,148	A1
AUM32-23-02	**4.75**	45,470	A1
AUM32-123-02	**5.43**	45,470	A1
AUM32-24-02	1.53	36,444	A1
AUM32-25-02	**3.00**	46,329	A1
Transfer Area[f]			
AUM32-26-02	1.69	30,994	B2
AUM32-26-12	0.963		
AUM32-26-24	0.786		
AUM32-26-36	0.779		
AUM32-27-02	**237**	356,219	B2
AUM32-27-12	**15.7**		
AUM32-27-24	0.866		
AUM32-27-36	0.767		
AUM32-28-02	**300**	381,942	B2
AUM32-28-12	**48.3**		
AUM32-28-24	0.759		

Table 4-2
Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity
Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Sample ID[a]	Ra-226 Concentration[b] (pCi/g)	Surface Gamma Radiation Activity[c] (cpm)	Radiation Survey Equipment[d]
AUM32-28-36	0.967		
AUM32-29-02	**262**	313,237	B2
AUM32-29-12	**2.68**		
AUM32-29-24	2.06		
AUM32-29-36	**13.9**		
AUM32-30-02	**4.29**	38,309	B2
AUM32-30-12	0.982		
AUM32-130-12	1.03		
AUM32-30-24	1.14		
AUM32-30-36	1.03		
AUM32-31-02	**20.3**	60,674	B2
AUM32-31-12	1.56		
AUM32-31-24	1.14		
AUM32-31-36	1.07		
AUM32-32-02	**7.78**	35,581	B2
AUM32-32-12	0.964		
AUM32-32-24	1.19		
AUM32-32-36	0.966		
AUM32-132-36	0.909		
AUM32-33-02	**4.22**	60,721	B2
AUM32-33-12	1.02		
AUM32-33-24	1.30		
AUM32-33-36	1.16		
AUM32-34-02	**20.1**	62,878	B2
AUM32-134-02	**18.2**	62,878	B2
AUM32-34-12	0.921		
AUM32-34-24	1.29		
AUM32-34-36	0.740		
AUM32-35-02	**2.72**	47,842	B2
AUM32-35-12	0.832		
AUM32-35-24	1.10		
AUM32-135-24	1.00		
AUM32-35-36	0.991		
AUM32-36-02	**39.4**	56,926	B2
AUM32-36-12	0.986		
AUM32-136-12	1.20		
AUM32-36-24	1.60		
AUM32-36-36	0.544		

Table 4-2
Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity
Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Sample ID[a]	Ra-226 Concentration[b] (pCi/g)	Surface Gamma Radiation Activity[c] (cpm)	Radiation Survey Equipment[d]
AUM32-37-02	**2.60**	34,570	B2
AUM32-37-12	0.846		
AUM32-37-24	0.901		
AUM32-37-36	0.777		
AUM32-38-02	**13.6**	67,451	B2
AUM32-138-02	**12.1**	67,451	B2
AUM32-38-12	1.17		
AUM32-38-24	0.897		
AUM32-38-36	1.13		
AUM32-39-02	**2.84**	31,108	B2
AUM32-40-02	0.761	28,824	B2
AUM32-41-02	0.789	29,694	B2
AUM32-42-02	**3.11**	31,173	B2
AUM32-43-02	0.993	27,817	B2
AUM32-44-02	**23.4**	89,687	B2
AUM32-44-12	1.43		
AUM32-44-24	1.04		
AUM32-144-24	0.875		
AUM32-44-36	0.815		
AUM32-45-02	0.923	27,751	A1
AUM32-46-02	1.10	26,615	A1
AUM32-47-02	0.900	29,128	A1
AUM32-48-02	**2.21**	29,905	A1
AUM32-148-02	2.04	29,905	A1
AUM32-49-02	**108**	237,696	A1
AUM32-49-12	**94.8**		
AUM32-49-24	**6.13**		

Notes:

a The sample ID indicates the following:

AUM32-102-36

Sample depth in inches below ground surface

Sample number greater than 100 is a duplicate

Sampled area

Table 4-2
Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity
Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Notes (continued):

b	Concentrations shown in **bold** exceed the action level of 2.11 pCi/g
c	Static 1-minute measurement at sampling location
d	Paired radiation survey equipment which consisted of Ludlum Model 44-20 (3x3) detector and 2241 meter: Equipment A1 consisted of a Ludlum 2241-3 meter (Serial No. 256844) and an Alpha Spectra detector (Serial No. 121611BP). Equipment B2 consisted of a Ludlum 2241-3 meter (Serial No. 256852) and an Alpha Spectra detector (Serial No. 121611BQ).
e	Soil samples from the mine area were collected using a hand auger. Soil samples noted with a (G) were collected using a Geoprobe® system.
f	Soil samples from the transfer area were collected using a Geoprobe® system except for AUM32-49 which was collected using a hand auger.
AUM	Abandoned uranium mine
cpm	Counts per minute
pCi/g	Picocuries per gram
Ra-226	Radium-226

Table 4-3
Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity
Tronox AUM Section 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0005 Project No.: EE-002693-2165-01TTO

Sample ID[a]	Ra-226 Concentration[b] (pCi/g)	Surface Gamma Radiation Activity[c] (cpm)	Radiation Survey Equipment[d]
AUM33-01-02	1.30	37,862	B2
AUM33-01-12	1.37		
AUM33-101-12	1.38		
AUM33-01-24	1.04		
AUM33-01-36	1.05		
AUM33-02-02	**20.3**	116,387	B2
AUM33-02-12	**4.07**		
AUM33-02-24	**6.00**		
AUM33-102-24	**6.08**		
AUM33-02-36	**7.15**		
AUM33-03-02	0.996	43,300	B2
AUM33-03-12	**2.14**		
AUM33-03-24	1.55		
AUM33-03-36	1.14		
AUM33-103-36	1.26		
AUM33-04-02	**76.1**	158,830	B2
AUM33-04-12	**35.4**		
AUM33-04-24	**19.0**		
AUM33-04-36	**22.2**		
AUM33-05-02	**9.13**	67,668	B2
AUM33-05-12	**3.93**		
AUM33-05-24	**4.61**		
AUM33-05-36	1.32		
AUM33-06-02	1.33	37,582	B2
AUM33-06-12	1.10		
AUM33-06-24	0.816		
AUM33-06-34	1.01		
AUM33-07-02	**39.4**	116,594	B2
AUM33-07-12	**5.83**		
AUM33-07-24	**3.36**		
AUM33-07-36	**2.84**		
AUM33-07-36 (G)	0.847		
AUM33-07-48 (G)	1.07		
AUM33-08-02	**4.78**	58,287	A1
AUM33-108-02	**6.11**	58,287	A1
AUM33-09-02	**6.70**	81,632	A1

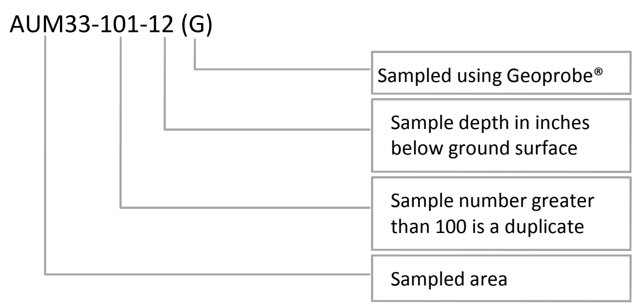
Table 4-3
Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity
Tronox AUM Section 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0005 Project No.: EE-002693-2165-01TTO

Sample ID[a]	Ra-226 Concentration[b] (pCi/g)	Surface Gamma Radiation Activity[c] (cpm)	Radiation Survey Equipment[d]
AUM33-10-02	**4.31**	47,868	A1
AUM33-11-02	1.37	41,483	A1
AUM33-12-02	1.45	39,720	A1
AUM33-13-02	**9.70**	75,707	A1
AUM33-14-02	1.65	36,513	A1
AUM33-15-02	**9.85**	57,764	A1
AUM33-16-02	**6.59**	62,778	A1
AUM33-WP-01	**52.2**		
AUM33-WP-02	**47.7**		
AUM33-WP-03	**23.3**		

Notes:

a The sample ID indicates the following:



The waste pile (WP) samples were all collected from the surface (0 to 2 inches below ground surface). The last 2 digits of the sample ID of the WP samples represent the sample number.

b Concentrations shown in **bold** exceed the action level of 2.11 pCi/g

c Static 1-minute measurement at sampling location

d Paired radiation survey equipment which consisted of Ludlum Model 44-20 (3x3) detector and 2241 meter:
Equipment A1 consisted of a Ludlum 2241-3 meter (Serial No. 256844) and an Alpha Spectra detector (Serial No. 121611BP).
Equipment B2 consisted of a Ludlum 2241-3 meter (Serial No. 256852) and an Alpha Spectra detector (Serial No. 121611BQ).

AUM Abandoned uranium mine
cpm Counts per minute
pCi/g Picocuries per gram
Ra-226 Radium-226

Table 4-4
Relationship Coefficients for Ra-226 concentrations and Static Gamma Radiation Activity in Surface Soil
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO
TO-02-09-11-10-0005 EE-002693-2165-01TTO

Data Set	Correlation Coefficient	Linear Regression Coefficient
All data	0.77	0.60
All data less than 60 kcpm	0.78	0.61
Data from Equipment A1	0.92	0.84
Data from Equipment B2	0.75	0.56
Data from Equipment B2 from Locations with No Subsurface Samples	0.86	0.73
Mine area	0.54	0.30
Mine area, less than 60 kcpm	0.89	0.79

Notes:

Equipment A1 consisted of a Ludlum 2241-3 meter (Serial No. 256844) and an Alpha Spectra detector (Serial No. 121611BP).

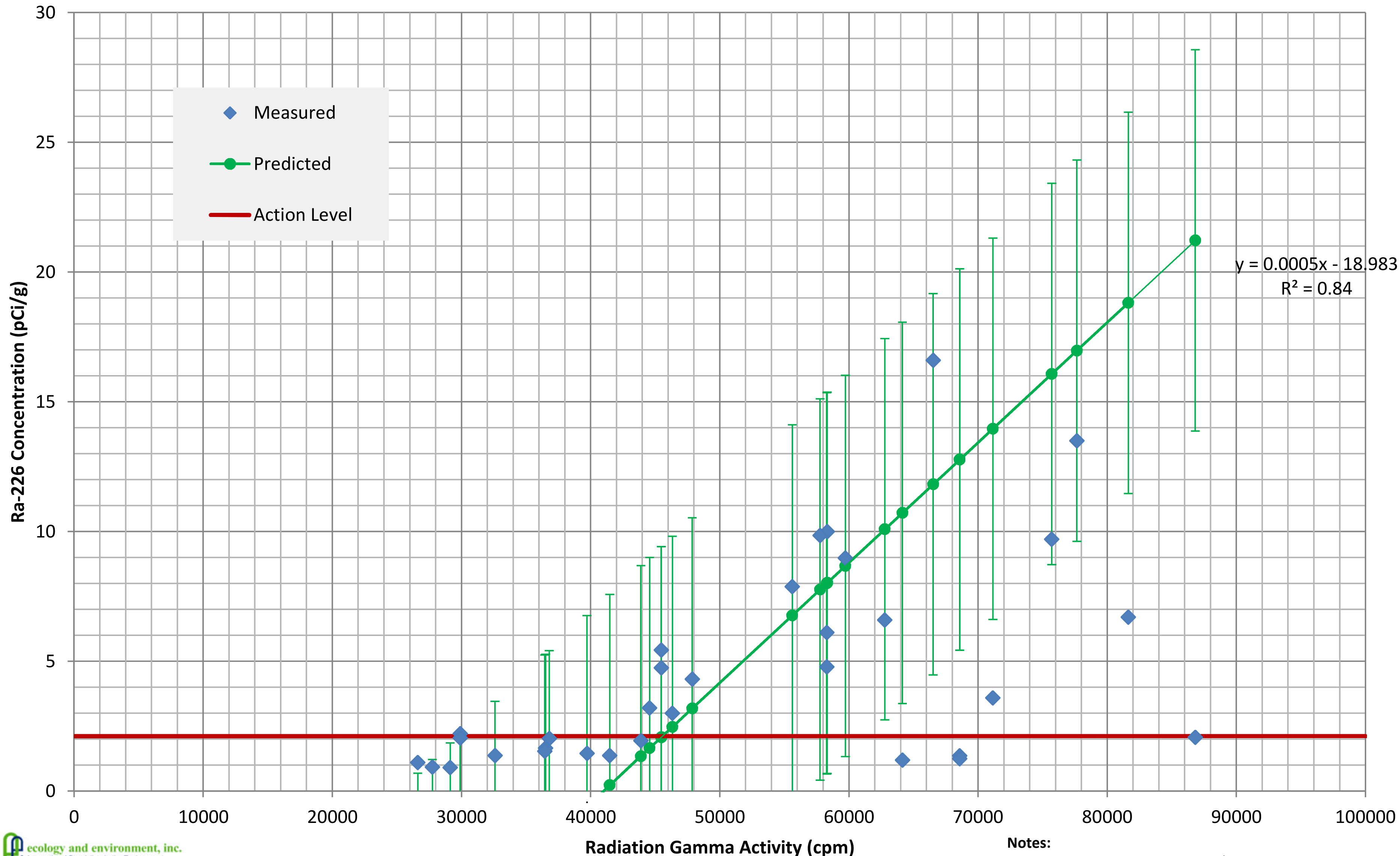
Equipment B2 consisted of a Ludlum 2241-3 meter (Serial No. 256852) and an Alpha Spectra detector (Serial No. 121611BQ).

kcpm Kilocounts per minute

Figure 4-4

Predicted Ra-226 Concentration Based on the Best-Fit Linear Equation (r^2=0.84)

Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico



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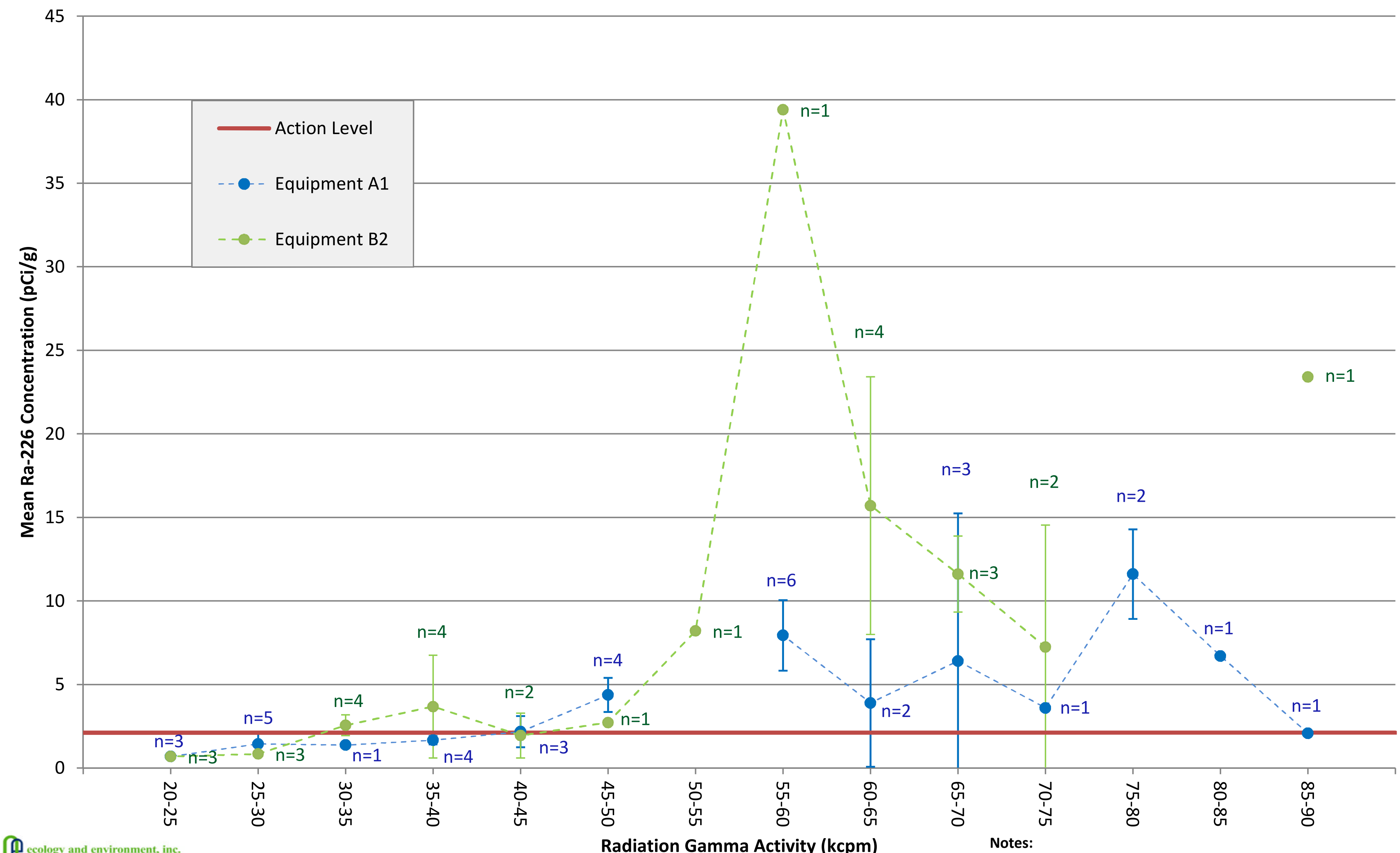
International Specialists in the Environment

Notes:
cpm counts per minute pCi/g picoCuries per gram

Figure 4-5
Mean Ra-226 Concentrations
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico



Notes:
kcpm kilo counts per minute
pCi/g picoCuries per gram

Table 4-5

Summary of Gamma Radiation Dose Rate Data for CL-001

Tronox AUM Sections 32 and 33

Casamero Lake Chapter, Navajo Nation

Prewitt, New Mexico

TDD No. TO-02-09-11-10-0004
TO-02-09-11-10-0005

Project No. EE-002693-2164-01TTO
EE-002693-2165-01TTO

PIC Instrument ID	Monitoring Location	Sub Location	Date	Monitor Measurement (µR/hr)	Background Dose Rate by Date & Instrument (µR/hr)	Total Dose mrem/yr[1]	Background dose mrem/yr[1]	Difference
828176	CL-001A	LR1	6/14/2012	13.61	14.46	119.3	126.8	-7.5
828176	CL-001A	LR2	6/14/2012	13.35	14.46	117.0	126.8	-9.7
828176	CL-001A	BR1	6/14/2012	13.55	14.46	118.8	126.8	-8.0
828176	CL-001B	SR	6/14/2012	13.33	14.46	116.9	126.8	-9.9
828176	CL-001B	KIT	6/14/2012	12.92	14.46	113.3	126.8	-13.5
828176	CL-001B	LR	6/14/2012	13.41	14.46	117.6	126.8	-9.2
828176	CL-001B	BR1	6/14/2012	13.19	14.46	115.6	126.8	-11.1
828176	CL-001B	BATH	6/14/2012	13.42	14.46	117.6	126.8	-9.1
828176	CL-001B	BR2	6/14/2012	13.23	14.46	116.0	126.8	-10.8
828176	CL-001C	SR	6/14/2012	13.68	14.46	119.9	126.8	-6.8

Notes:

Assumed daily duration of exposure to hazard	24	hours/day
Assumed lifetime duration of exposure to hazard	30	years/lifetime
Assumed fatal cancer risk per lifetime unit dose	7%	per Sievert
=	7%	per 100 rem
Assumed excess fatal cancer risk per CERCLA annual dose	3.E-04	per 15 mrem/yr

1	Assumes 1:1 conversion when converting Roentgen to rem
BATH	Bathroom
BR	Bedroom
KIT	Kitchen
LR	Living room
SR	Storage Room
µR/hr	microRoentgen Per Hour
mrem/yr	milliRoentgen Equivalent Man units per year

Table 4-6
Summary of Gamma Radiation Dose Rate Data for CL-002
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No. TO-02-09-11-10-0004
TO-02-09-11-10-0005

Project No. EE-002693-2164-01TTO
EE-002693-2165-01TTO

PIC Instrument ID	Monitoring Location	Sub Location	Date	Monitor Measurement (µR/hr)	Background Dose Rate by Date & Instrument (µR/hr)	Total Dose mrem/yr[1]	Background dose mrem/yr[1]	Difference
828176	CL-002A	LR1	6/14/2012	15.24	14.46	133.6	126.8	6.8
828176	CL-002A	LR2	6/14/2012	15.37	14.46	134.7	126.8	8.0
828176	CL-002B	LR	6/14/2012	13.40	14.46	117.5	126.8	-9.3

Notes:

Assumed daily duration of exposure to hazard	24	hours/day
Assumed lifetime duration of exposure to hazard	30	years/lifetime
Assumed fatal cancer risk per lifetime unit dose	7%	per Sievert
=	7%	per 100 rem
Assumed excess fatal cancer risk per CERCLA annual dose	3.E-04	per 15 mrem/yr

1	Assumes 1:1 conversion when converting Roentgen to rem
BATH	Bathroom
BR	Bedroom
KIT	Kitchen
LR	Living room
SR	Storage Room
µR/hr	microRoentgen Per Hour
mrem/yr	milliRoentgen Equivalent Man units per year

Project # EE-002693-2164-01TTO
TDD# TO-02-09-11-10-0004

Source: Aerial Photography - Bing Maps

LEGEND

Gamma activity levels in kilo counts per minute

- Less than or equal to Investigation Level (0 - 40)
- Greater than Investigation Level (40.1 - 50)
- Greater than 2x Background Level (50.1 - 240)
- Greater than 10x Background Level (>240)

Ra-226 Concentration in Surface Soil (0 to 2 inches bgs)

- Less than or equal to Action Level (2.11 pCi/g)
- Greater than Action Level
- Removal area
- Chapter boundary

Note:

ft bgs: Feet below ground surface
pCi/g: Picocuries per gram
AUM32-RA-11 - Removal area
1 ft bgs - Excavation depth

N

0 100 200 300 400 Feet

Figure 4-6
Proposed Removal Areas at AUM 32 Mine Area
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

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Ecology & Environment, Inc. GIS Department Project: L:\Oakland\Tronox\Maps\MXDs\Figure_4-6_Proposed_Removal_Area_AUM_32_Mine_Area.mxd Date: 9/19/2012

Project # EE-002693-2164-01TTO
TDD# TO-02-09-11-10-0004

Project: L:\Oakland\Tronox\Maps\MXDs\Figure 4-7_Proposed_Removal_Area_AUM_32_South_Transfer.mxd Date: 9/19/2012)

Ecology & Environment, Inc. GIS Department

LEGEND

Gamma activity levels in kilo counts per minute

- Less than or equal to Investigation Level (0 - 40)
- Greater than Investigation Level (40.1 - 50)
- Greater than 2x Background Level (50.1 - 240)
- Greater than 10x Background Level (>240)

Ra-226 Concentration in Surface Soil (0 to 2 inches bgs)

- Less than or equal to Action Level (2.11 pCi/g)
- Greater than Action Level
- Removal area
- Chapter boundary

Note:

ft bgs: Feet below ground surface

pCi/g: Picocuries per gram

AUM32-RA-11 - Removal area

1 ft bgs - Excavation depth

N

0 100 200 300 400 Feet

Figure 4-7
Proposed Removal Areas in the Southern Portion of AUM 32 Transfer Area
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

ecology and environment, inc.
International Specialists in the Environment

Project # EE-002693-2164-01TTO
TDD# TO-02-09-11-10-0004

Source: Aerial Photography - Bing Maps

LEGEND

Gamma activity levels in kilo counts per minute

- Less than or equal to Investigation Level (0 - 40)
- Greater than Investigation Level (40.1 - 50)
- Greater than 2x Background Level (50.1 - 240)
- Greater than 10x Background Level (>240)

Ra-226 Concentration in Surface Soil (0 to 2 inches bgs)

- Less than or equal to Action Level (2.11 pCi/g)
- Greater than Action Level
- Removal area
- Chapter boundary

Note:

ft bgs: Feet below ground surface

pCi/g: Picocuries per gram

AUM32-RA-11 - Removal area

1 ft bgs - Excavation depth

N

0 100 200 300 400 Feet

Figure 4-8
Proposed Removal Areas in the Northern Portion of AUM 32 Transfer Area
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

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International Specialists in the Environment

Ecology & Environment, Inc. GIS Department Project: L:\Oakland\Tronox\Maps\MXDs\Figure_4-8_Proposed_Removal_Area_AUM_32_North_Transfer.mxd Date: 9/19/2012)

Project # EE-002693-2165-01TTO
TDD# TO-02-09-11-10-0005

Source: Aerial Photography - Bing Maps

LEGEND

Gamma activity levels in kilo counts per minute

- Less than or equal to Investigation Level (0 - 40)
- Greater than Investigation Level (40.1 - 50)
- Greater than 2x Background Level (50.1 - 240)
- Greater than 10x Background Level (>240)

Ra-226 Concentration in Surface Soil (0 to 2 inches bgs)

- Less than or equal to Action Level (2.11 pCi/g)
- Greater than Action Level
- Removal area
- Chapter boundary

Note:

ft bgs: Feet below ground surface

pCi/g: Picocuries per gram

AUM32-RA-11 - Removal area

1 ft bgs - Excavation depth

N

0 100 200 300 400 Feet

Figure 4-9
Proposed Removal Areas
at AUM 33
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

ecology and environment, inc.
International Specialists in the Environment

Ecology & Environment, Inc. GIS Department Project: L:\Oakland\Tronox\Maps\MXDs\Figure_4-9_Proposed_Removal_Area_AUM_33_Mine_Area.mxd Date: 9/19/2012)

Table 4-7
Proposed Removal Volumes
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO
TO-02-09-11-10-0005 EE-002693-2165-01TTO

Removal Area	Excavation		
	Depth (feet bgs)	Area (ft^2)	Volume (yd^3)
AUM32-RA-01	3	23,222	2,580
AUM32-RA-02	2	105,402	7,808
AUM32-RA-03	1	60,850	2,254
AUM32-RA-04	3	88,704	9,856
AUM32-RA-05	4	30,454	4,512
AUM 32 Mine Area		***308,632***	***27,009***
AUM32-RA-06	4	23,762	3,520
AUM32-RA-07	2	15,308	1,134
AUM32-RA-08	1	156,756	5,806
AUM32-RA-09	1	69,940	2,590
AUM32-RA-10	1	2,770	103
AUM32-RA-11	1	3,915	145
AUM32-RA-12	3	27,822	3,091
AUM32-RA-13	2	21,099	1,563
AUM32-RA-14	2	1,220	90
AUM 32 Transfer Area		***322,592***	***18,043***
AUM33-RA-01	2	29,890	2,214
AUM33-RA-02	4	76,253	11,297
AUM33-RA-03	3	45,409	5,045
AUM 33		***151,552***	***18,556***
TOTAL		***782,777***	***63,608***

Notes:

bgs	Below ground surface
ft^2	Square feet
yd^3	Cubic yards

5 Conclusion

The removal assessment for AUM Sections 32 and 33 consisted of surface gamma radiation survey, sampling for Ra-226 analysis, and home site assessment. Surface gamma radiation activity at AUM Sections 32 and 33 was detected above background levels. Ra-226 concentrations were detected above the action level in surface soil and down to 3 feet bgs. Rocks and mine waste material were observed at locations with elevated gamma radiation activity and Ra-226 concentrations. The results of the gamma radiation survey and Ra-226 analysis were used to determine the relationship between gamma radiation activity and Ra-226 concentrations and proposed removal areas. The static gamma radiation activity correlates with Ra-226 concentrations in surface soil. However, gamma radiation activity measurements cannot predict Ra-226 concentrations based on a linear relationship. Fourteen removal areas were proposed at AUM 32 and three removal areas were proposed at AUM 33. The total proposed removal volume is 63,608 cubic yards. For the home sites, the difference between the background and measured dose rate in the structures was below 15 mrem/yr which was based on an excess cancer risk of 3×10^{-4}. The gamma radiation activity results inside the structures and from surface soil outside the structures within the property were below background levels. Based on the results of the removal assessment, further action is necessary at AUM Sections 32 and 33 and no further action is warranted at the home sites.

The following factors listed in the National Oil and Hazardous Substances Pollution Contingency Plan §300.415(b)(2) are present at AUM Sections 32 and 33 and may be used by USEPA in determining the appropriateness of a removal action.

(i) Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants;

Ra-226 concentrations detected in soil to depths of 3 feet bgs at AUM Sections 32 and 33 were above background levels and PRG. The PRG is based on Ra-226 and its radioactive decay chain products (Ra-226+D) in residential soil and an estimated excess cancer risk of 1 in 10,000 (10^{-4}) (USEPA 2010). The PRG considers human exposure pathways which include incidental ingestion of soil, inhalation of particulates emitted from soil, external exposure to ionizing radiation, and consumption of fruits and vegetables. This standardized PRG is based on default exposure parameters and incorporate exposure factors that present reasonable maximum exposure selected to be protective of human health for most site conditions.

Residents live 0.5 mile from AUM Sections 32 and 33. Vegetation and animals were observed at the AUMs. AUM 32 has no fence and signage. AUM 33 has an existing unsecured fence and no signage.

(iv) High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface, that may migrate;

Ra-226 concentrations were detected in surface soil (0 to 2 inches bgs) at AUM Sections 32 and 33 above the action level of 2.11 pCi/g, which was based on background level and PRG. Ra-226 concentrations were detected up to 300 pCi/g in surface soil which mostly had sparse vegetation.

(v) Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released;

Thunderstorms, events of high winds, and evidence of flooding were observed at AUM Sections 32 and 33.

(viii) Other situations or factors that may pose threats to public health or welfare of the United States or the environment

AUM 32 contains an unsecured open shaft. AUM 33 contains an unsecured vent and several waste piles.

6 References

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A Site Photographs

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 | Project No.: EE-002693-2164-01TTO

Direction: East | **Date:** 06/12/12

Description:

View of the S portion of the initial AUM32 mine area

Direction: North | **Date:** 06/12/12

Description:

Gamma radiation survey at the E portion of AUM 32 mine area where an open shaft is located

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Direction: North **Date:** 06/12/12

Description:

Transects of gamma radiation survey at AUM 32

Direction: North **Date:** 06/12/12

Description:

Boundary between AUM 32 and AUM 33 mine areas

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004   Project No.: EE-002693-2164-01TTO

Direction:	Date:
North	06/12/12

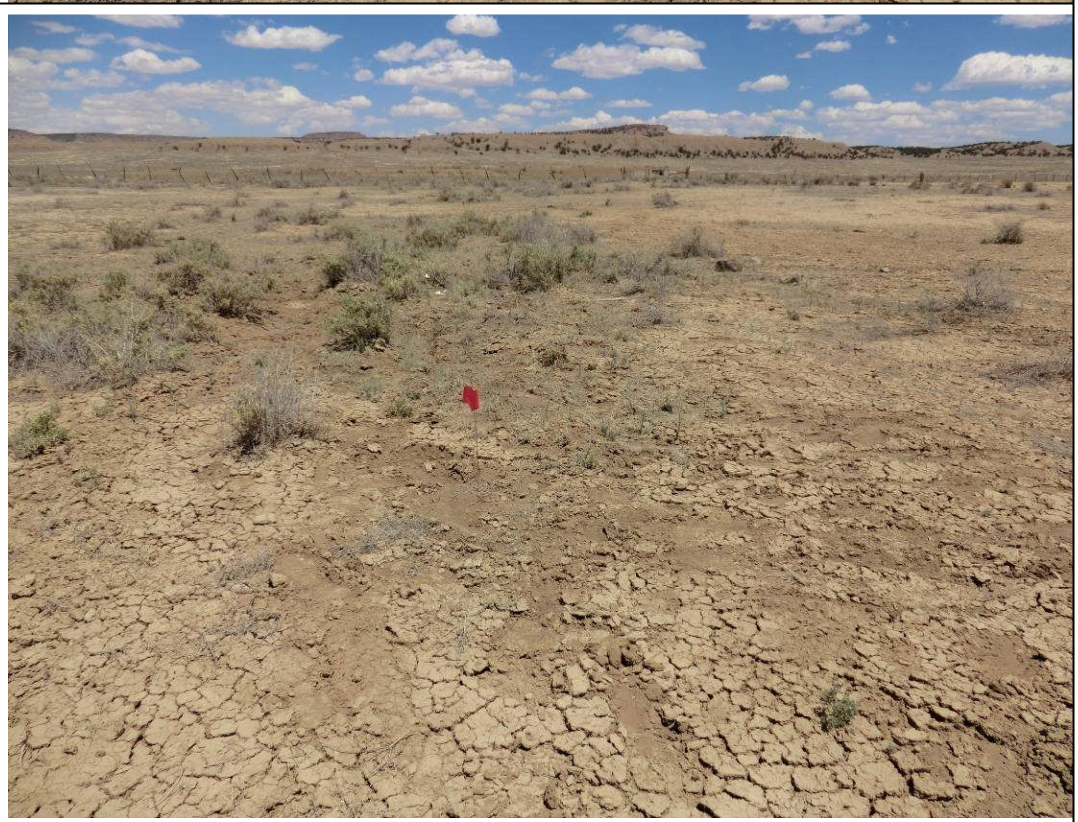
Description:

View of the initial W boundary of the AUM32 mine area

Direction:	Date:
East	06/12/12

Description:

N portion of AUM 32 mine area



PHOTOGRAPHIC LOG

Removal Assessment

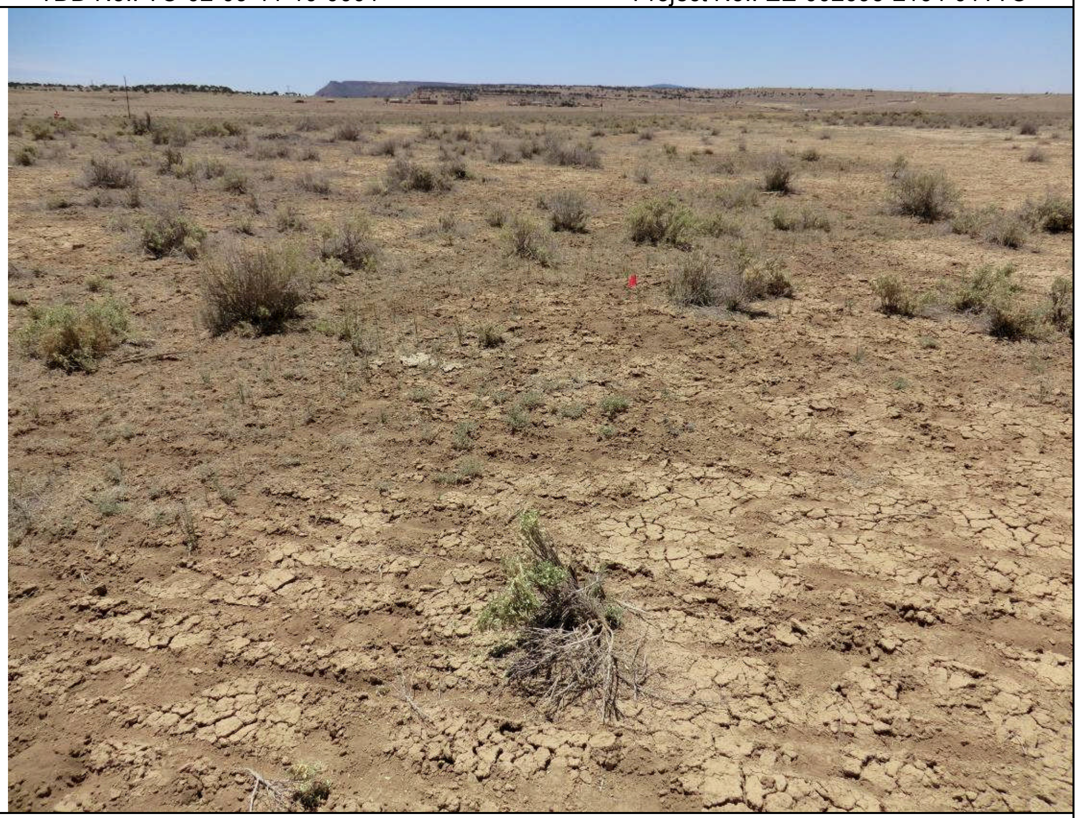
Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Direction: West	**Date:** 06/12/12

Description:

View of the step-out from the initial AUM32 mine area



Direction: East	**Date:** 06/13/12

Description:

Dry pond located NW of the AUM 32 mine area

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Direction:	Date:
West	06/13/12

Description:

Step-out gamma radiation survey at AUM32 mine area

Direction:	Date:
South	06/13/12

Description:

Gamma radiation survey at W boundary of AUM 32 mine area

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Direction:	Date:
North	06/13/12

Description:

W boundary of AUM 32 mine area

Direction:	Date:
East	06/13/12

Description:

View of the S portion of the AUM 32 mine area

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Direction:	Date:
Downward	06/13/12

Description:

Rock with gamma radiation activity reading above 500 kilo counts per minute at the AUM 32 mine area

Direction:	Date:
Downward	06/13/12

Description:

Buried rock(s) with gamma radiation activity reading above 500 kilo counts per minute at the AUM 32 mine area

Direction:	Date:
North	06/14/12

Description:

Gamma radiation survey equipment

Direction:	Date:
Downward	06/14/12

Description:

Concrete pad at AUM 32 transfer area

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Direction: North	**Date:** 06/14/12

Description:

Local resident showing USEPA and NNEPA the concrete pad where a crane was reportedly staged in the former transfer area; START hand-scanning area for gamma radiation activity.

Direction: South	**Date:** 06/14/12

Description:

Vent located in the AUM 32 transfer area

Direction: West

Date: 06/15/12

Description:

Wind-blown dust before a storm

Direction: Northwest

Date: 07/17/12

Description:

View of background area, home site in the background

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Direction: East	Date: 07/17/12

Description:

Background measurement of utility locating equipment (L) and radiation survey equipment (C)

Direction: South	Date: 07/17/12

Description:

View of background area

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Direction:	Date:
North	07/17/12

Description:

View of concrete pad in AUM 32 transfer area

Direction:	Date:
North	07/17/12

Description:

START's subcontractor measuring area for utility location

	PHOTOGRAPHIC LOG
	Removal Assessment Tronox AUM Section 32 Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Direction: South

Date: 07/17/12

Description:

E boundary of AUM 32 transfer area

Direction: West

Date: 07/17/12

Description:

View of AUM 32 transfer area

Direction:	Date:
Northwest	07/17/12

Description:

View of AUM 32 transfer area, home site in the background

Direction:	Date:
North	07/17/12

Description:

View of E portion of AUM 32 transfer area

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Direction:	Date:
East	07/17/12

Description:

Hill bordering the E side of AUM 32 transfer area

Direction:	Date:
North	07/17/12

Description:

Water path at AUM 32 transfer area

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 | Project No.: EE-002693-2164-01TTO

Direction: South	**Date:** 07/17/12

Description:

Water path at AUM 32 transfer area

Direction: Downward	**Date:** 07/19/12

Description:

A hare observed at the AUM 32 transfer area

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Direction:	**Date:**
North	07/17/12

Description:

Subsurface sampling at AUM 32 transfer area using a Geoprobe®

Direction:	**Date:**
North	07/17/12

Description:

Radiation monitoring of personnel

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Direction:	Date:
North	07/17/12

Description:

START's subcontractor performing utility location

Direction:	Date:
East	07/17/12

Description:

Gamma radiation survey of E boundary of AUM 32 transfer area

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Direction:	Date:
South	07/17/12

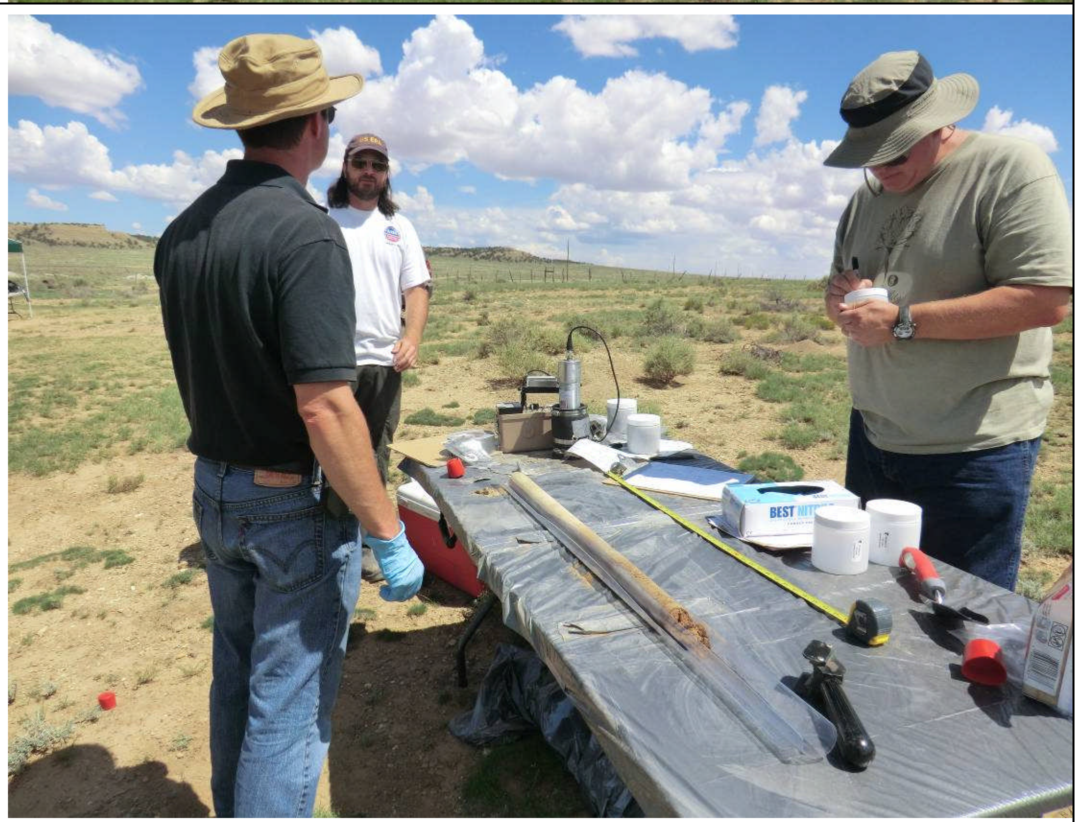
Description:

Subsurface sampling using a Geoprobe®

Direction:	Date:
East	07/17/12

Description:

Sampling and logging of soil core from AUM32-35



	PHOTOGRAPHIC LOG
	Removal Assessment Tronox AUM Section 32 Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

Direction: North	**Date:** 07/18/12
Description: Drill bit located S of AUM 33	

Direction: Downward	**Date:** 07/18/12
Description: Drill bits located S of AUM 33	

Direction:	Date:
North	07/18/12

Description:

EPA showing NNEPA the gamma radiation survey equipment

Direction:	Date:
Downward	07/19/12

Description:

Rocks with gamma radiation activity reading above 500 kilo counts per minute at the AUM 32 transfer area

Direction: North	**Date:** 07/19/12

Description:

Location of AUM 32-49

Direction: Downward	**Date:** 07/19/12

Description:

Hand-augered borehole

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0005 Project No.: EE-002693-2165-01TTO

Direction: North **Date:** 06/13/12

Description:

Setting up the gamma radiation survey equipment

Direction: South **Date:** 06/12/12

Description:

VIPER system deployment manager and gateway (R)

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0005 Project No.: EE-002693-2165-01TTO

Direction:	Date:
East	06/12/12

Description:

View of the N portion of AUM 33.

Direction:	Date:
South	06/13/12

Description:

View of the western portion of AUM 33 and fence between AUM 32 and AUM 33

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0005 Project No.: EE-002693-2165-01TTO

Direction: East

Date: 06/13/12

Description:

Gamma radiation survey of the waste piles located in the northeast corner of AUM 33

Direction: South

Date: 06/13/12

Description:

Gamma radiation survey and waste piles at AUM 33

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0005 Project No.: EE-002693-2165-01TTO

Direction:	Date:
Northeast	06/12/12

Description:

Gamma radiation survey of waste pile

Direction:	Date:
South	06/13/12

Description:

Gamma radiation survey of the southeast corner of AUM 33; waste piles (R)

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0005   Project No.: EE-002693-2165-01TTO

Direction:	**Date:**
East	06/13/12

Description:

Gamma radiation survey of the waste piles located in the northeast corner of AUM 33

Direction:	**Date:**
South	06/13/12

Description:

Gamma radiation survey and waste piles at AUM 33

PHOTOGRAPHIC LOG

Removal Assessment

Tronox AUM Section 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0005 | Project No.: EE-002693-2165-01TTO

Direction:	Date:
East	06/15/12

Description:

Measuring static gamma radiation activity at soil sampling location AUM33-07

Direction:	Date:
South	06/13/12

Description:

Collecting subsurface samples by hand auger at AUM33-07

B Home Site Packet

Homesite/Structure Assessment

Casamero Lake Chapter 2012

In June of 2012, the United States Environmental Protection Agency (USEPA) and Navajo Nation Environmental Protection Agency (NNEPA) completed a radiological assessment of your homesite and/or structures located in the Navajo community of Casamero Lake.

The assessment tested the soils and other materials on your homesite, surrounding your structures. The assessment also tested building materials inside the structures and collected radiation exposure measurements. The result of the assessment is as follows:

[ ] **An exposure risk** to radiation was found on your homesite or within your structures and additional investigations and/or mitigative action are required

[**X**] **NO exposure risk** to radiation was found on your homesite or within your structures.

Following is a brief description of how a homesite and structure are determined to present or to not present an exposure risk.

What makes a structure an exposure risk?

(A) If any single exposure reading inside a structure is greater than 15 millirem/year above background.

15 millirem per year is equivalent to a 1 in 10,000 risk of getting cancer if you spend 24 hours per day, 7 days per week in the structure for 30 years.

OR

(B) If you have contamination above the action level[1] <u>and</u> you have a radon level above 4.0 picocuries/liter (pCi/l)[2]. No radon data was collected at your property by NNEPA.

What makes a yard a candidate for further action?

(A) If a soil area was identified on your homesite that was equal to or greater than twice the daily background.

What makes your structure require no additional assessment?

(A) If all exposure readings inside a structure are less than 15 millirem/year above background.

15 millirem per year is equivalent to a 1 in 10,000 risk of getting cancer if you spend 24 hours per day, 7 days per week in the structure for 30 years.

AND

(B) If your structure has no area above the action level[1] and you have a radon level below 4.0 pCi/l[2].

What makes your yard require no additional assessment?

(A) If all soil on your homesite is less than twice the daily background level.

---

(1) The action level is based on a daily average background plus 10 times the standard deviation. The standard deviation is a number which represents the variability of all the background readings collected that day.

(2) 4.0 pCi/l is based on a USEPA recommendation that states if the indoor radon level is at or exceeds 4.0 pCi/l, you should take some kind of corrective measure to reduce your exposure. Contact Vivian Craig with NNEPA for additional information.

Assessment Result Packet

The following items are included in your assessment result packet:

1. Structure Radiation Survey Data Table – One data table summary per structure
2. Radiation Survey Figure – One schematic per structure
3. Radiation Survey Surface Soil Data Figure – One per homesite
4. Photographic Log – 4 pictures per structure and pictures of potential sources of contamination

(1) Structure Radiation Survey Data Table – One per structure

This sheet includes data collected inside the structure. On the structure data summary sheet there are several columns:

Column 1: Date	– This is the date that the assessment was done.
Column 2: Homesite ID	– This is a code that was assigned to your home site for identification purposes to preserve your privacy.
Column 3: Building ID	– This is a letter ("A", "B", etc.) attached to the Homesite ID to uniquely identify the structures on your homesite.
Column 4: Monitoring ID	– This is a code to identify each individual measurement or sample.
Column 5: Room ID	– Kit = Kitchen, Bath = Bathroom, BR =Bedroom, LR = Living Room, DR = Dining Room, SR= Storage Room

Note: If there is a number with the room abbreviation such as BR1, it is intended to distinguish between multiple bedrooms and is reflected on the Structure Schematic Sheet. The numbers that are assigned have no value associated to them.

Column 6: Instrument Type	– Several types of instruments are used to determine if contamination is present, where it is, and how much contamination there is.

*Note: The **3 X 3** measures activity or the energy that is emitted from a radiation source. Measurements are recorded in counts per minute (cpm). The Pressurized Ionization Chamber or **PIC** is used to determine how much radiation a person would receive while in a specific room. Measurements are recorded in micro-roentgen per hour (µR/hr).*

Column 7: Instrument ID	– This identifies which specific instrument was used.
Column 8: Measurement	– The numbers in this column are the values that the instrument identified and were recorded. The numbers vary greatly because they all relate to different units of measurement, similar to the difference between kilometers and miles.

Column 9: Units – There are several units used to measure radioactivity. **µR/hr** - this is a measurement of the dose of radiation that relates to health risks. **cpm –** this measures radioactivity, and can indicate the source(s) of radiation.

Column 10: Room Quadrant – This identifies where the measurements were taken in the room.

Column 11: Room Dimensions – This records the dimensions of the room, length x width x height

Column 12: Sub Location Material – This describes either the flooring material or the material that is underneath the flooring.

(2) Radiation Survey Figure – One schematic per structure

Each structure was measured and a diagram was created to delineate the physical layout of the structure, display the specific site of the radiation sampling, and record the value of the measurements. All of the rooms are identified and the various readings for each room are also recorded on this sheet.

A 'LEGEND' has been included to link the measurements to instruments that collected the information as discussed above under 'Instrument Type' and 'Units'.

(3) Radiation Survey Surface Soil Data Figure – One per homesite

The homesite radiation survey depicts the area that was monitored by the USEPA's VIPER system. A cart loaded with highly sensitive instruments, including radiation detectors and a GPS (an instrument to help determine exact locations and mapping), was pushed across the homesite recording measurements every second. The black lines represent a structure location. Each dot represents a location where measurements were taken. Green dots indicate areas at or below the investigation or action level. Yellow dots represent areas at or below twice the background level. Orange and red dots represent areas greater than at least twice the background level.

CONTACT INFORMATION

US EPA	**Navajo Nation EPA**
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USEPA	NNEPA
75 Hawthorne St, 8th Floor	PO Box 2946
San Francisco, CA 94105	Window Rock, AZ 86511
nattis.randy@epa.gov	vivcraig@juno.com
Telephone: (415) 972-3053	Telephone: (928) 871-7663
	or (800) 314-1846

CL-001 Structure Radiation Survey Data
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

Homesite ID: CL-001

Instrument ID	Mon Date	Mon Time	Building ID	Room ID	SubLocation Detail	SubLocation Material	Measurement	Units	Room Quadrant	Room Length (in)	Room Width (in)	Room Height (in)
C3	6/14/2012	10:48	CL-001A	LR1	6 in above floor	wood	23.0	kcpm	Average	186	100	96
C3	6/14/2012	10:54	CL-001A	LR2	6 in above floor	wood	23.0	kcpm	Average	186	126	96
C3	6/14/2012	11:01	CL-001A	BR1	6 in above floor	wood	23.0	kcpm	Average	149	174	96
828176	6/14/2012	10:48	CL-001A	LR1	1 m above floor	wood	13.61	µR/hr	Center	186	100	96
828176	6/14/2012	10:54	CL-001A	LR2	1 m above floor	wood	13.35	µR/hr	Center	186	126	96
828176	6/14/2012	11:01	CL-001A	BR1	1 m above floor	wood	13.55	µR/hr	Center	149	174	96
C3	6/14/2012	11:12	CL-001B	SR	6 in above floor	wood, cement blocks	22.0	kcpm	Average	99	189	96
C3	6/14/2012	11:18	CL-001B	KIT	6 in above floor	wood, cement blocks	19.0	kcpm	Average	162	125	96
C3	6/14/2012	11:23	CL-001B	LR	6 in above floor	wood, cement blocks	21.0	kcpm	Average	162	189	96
C3	6/14/2012	11:29	CL-001B	BR1	6 in above floor	wood, cement blocks	20.0	kcpm	Average	123	96	96
C3	6/14/2012	11:37	CL-001B	BATH	6 in above floor	wood, cement blocks	20.0	kcpm	Average	98	88	96
C3	6/14/2012	11:43	CL-001B	BR2	6 in above floor	wood, cement blocks	22.0	kcpm	Average	162	129	96
828176	6/14/2012	11:12	CL-001B	SR	1 m above floor	wood, cement blocks	13.33	µR/hr	Center	99	189	96
828176	6/14/2012	11:18	CL-001B	KIT	1 m above floor	wood, cement blocks	12.92	µR/hr	Center	162	125	96
828176	6/14/2012	11:23	CL-001B	LR	1 m above floor	wood, cement blocks	13.41	µR/hr	Center	162	189	96
828176	6/14/2012	11:29	CL-001B	BR1	1 m above floor	wood, cement blocks	13.19	µR/hr	Center	123	96	96
828176	6/14/2012	11:37	CL-001B	BATH	1 m above floor	wood, cement blocks	13.42	µR/hr	Center	98	88	96
828176	6/14/2012	11:43	CL-001B	BR2	1 m above floor	wood, cement blocks	13.23	µR/hr	Center	162	129	96
C3	6/14/2012	11:50	CL-001C	SR	6 in above floor	wood	20.0	kcpm	Average	84	96	84
828176	6/14/2012	11:50	CL-001C	SR	1 m above floor	wood	13.68	µR/hr	Center	84	96	84

Notes:

BATH	Bathroom
BR	Bedroom
CL	Casamero Lake
in	Inches
kcpm	Kilocounts per minute
LR	Living room
m	Meter
SR	Storage room
µR/hr	MicroRoentgen per hour

CL-002 Structure Radiation Survey Data
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

Homesite ID: CL-002

Instrument ID	Mon Date	Mon Time	Building ID	Room ID	SubLocation Detail	SubLocation	Material	Measurement	Units	Room Quadrant	Room Length (in)	Room Width (in)	Room Height (in)
B2	6/14/2012	12:24	CL-002A	LR1	6 in above floor	cement		29.0	kcpm	Average	236	226	96
B2	6/14/2012	12:30	CL-002A	LR2	6 in above floor	cement		30.0	kcpm	Average	236	148	96
828176	6/14/2012	12:24	CL-002A	LR1	1 m above floor	cement		15.24	μR/hr	Center	236	226	96
828176	6/14/2012	12:30	CL-002A	LR2	1 m above floor	cement		15.37	μR/hr	Center	236	148	96
B2	6/14/2012	12:42	CL-002B	LR	6 in above floor	cement		21.0	kcpm	Average	278	278	96
828176	6/14/2012	12:42	CL-002B	LR	1 m above floor	cement		13.40	μR/hr	Center	278	278	96

Notes:

BATH	Bathroom
BR	Bedroom
CL	Casamero Lake
in	Inches
kcpm	Kilocounts per minute
LR	Living room
m	Meter
SR	Storage room
μR/hr	MicroRoentgen per hour

LEGEND

13.35 — μR/HR Average at 1 meter above floor

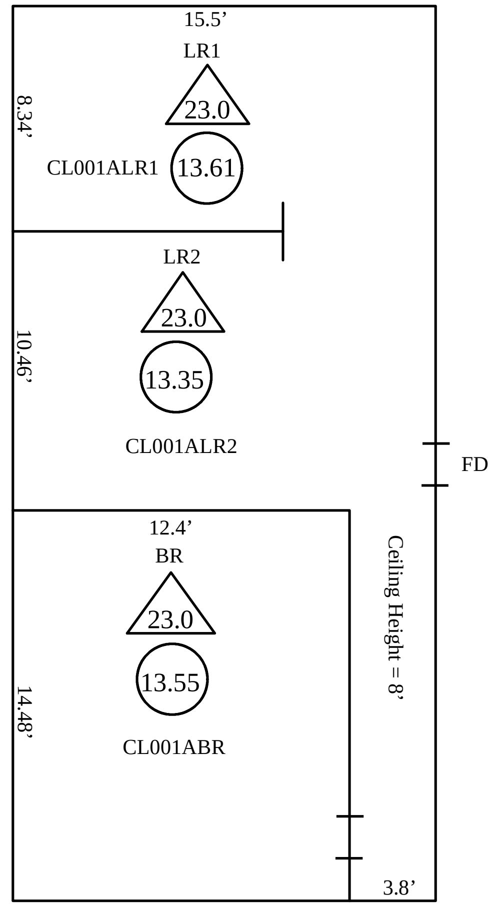
23.0 — KCPM at 6 inches above floor

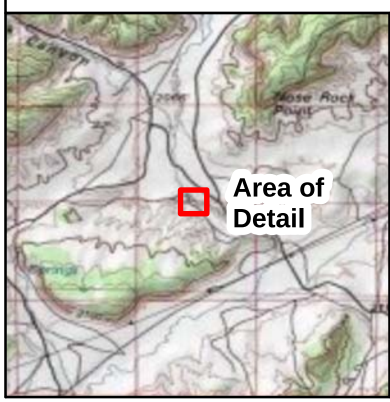
CL001ALR1 — Sample location identification number

Sample names have been abbreviated.
For example: CL001ALR1 = CL-001A-Living Room 1

ABBREVIATIONS

KCPM	KILO COUNTS PER MINUTE
10'	INSIDE WALL LENGTH
μR/HR	MICROREM PER HOUR
FD	FRONT DOOR
BR	BED ROOM
LR	LIVING ROOM





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LOCATION
LATITUDE = 35.488846
LONGITUDE = -108.024555

CL-001A Radiation Survey

Tronox AUM Sections 32 and 33
Casamero Lake Chapter,
Navajo Nation
Prewitt, New Mexico

ecology and environment, inc.
International Specialists in the Environment

Inlet: U.S. Census TIGER

LEGEND

12.92 µR/HR Average at 1 meter above floor

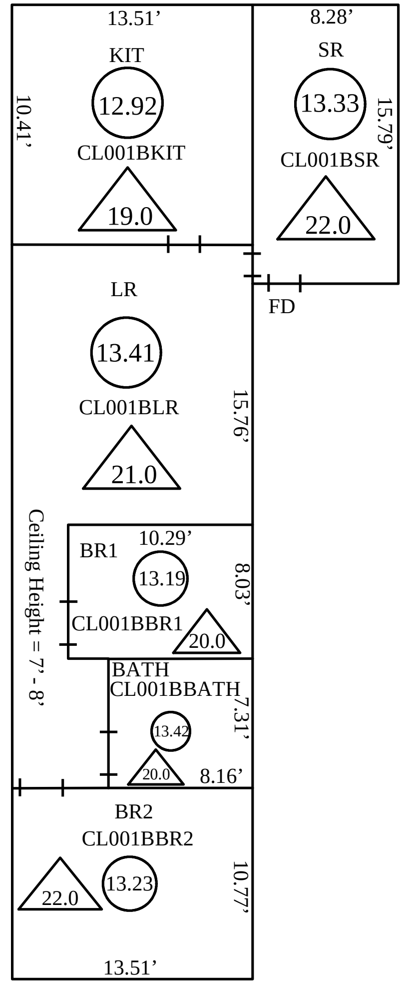
20.0 KCPM at 6 inches above floor

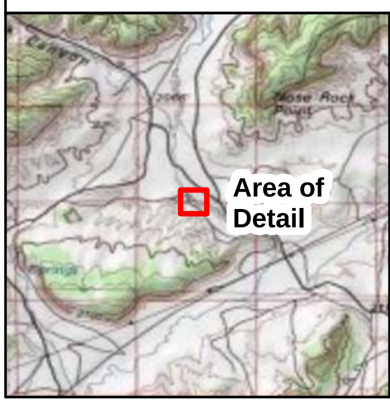
CL001BKIT Sample location identification number

Sample names have been abbreviated.
For example: CL001BKIT = CL-001B Kitchen

ABBREVIATIONS

KCPM	KILO COUNTS PER MINUTE
12’	INSIDE WALL LENGTH
µR/HR	MICROREM PER HOUR
FD	FRONT DOOR
BR	BED ROOM
BATH	BATHROOM
KIT	KITCHEN
LR	LIVING ROOM
SR	STORAGE ROOM





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LOCATION
LATITUDE = 35.488701
LONGITUDE = -108.024557

CL-001B Radiation Survey

Tronox AUM Sections 32 and 33
Casamero Lake Chapter,
Navajo Nation
Prewitt, New Mexico

ecology and environment, inc.
International Specialists in the Environment

LEGEND

13.68 — µR/HR Average at 1 meter above floor

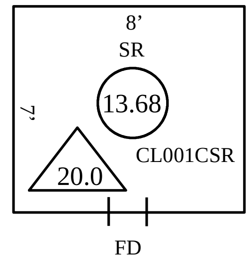
20.0 — KCPM at 6 inches above floor

CL001CSR — Sample location identification number

Sample names have been abbreviated.
For example: CL001CSR = CL-001C Storage Room

ABBREVIATIONS

KCPM	KILO COUNTS PER MINUTE
8’	INSIDE WALL LENGTH
µR/HR	MICROREM PER HOUR
FD	FRONT DOOR
SR	STORAGE ROOM



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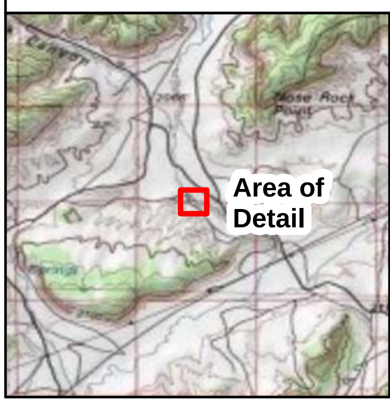

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LOCATION

LATITUDE = 35.488604
LONGITUDE = -108.024566

CL-001C Radiation Survey

Tronox AUM Sections 32 and 33
Casamero Lake Chapter,
Navajo Nation
Prewitt, New Mexico

ecology and environment, inc.
International Specialists in the Environment

TDD: TO-02-09-11-10-0004
Project No. EE-002693-2164-01TTO

Inlet: U.S. Census TIGER

LEGEND

15.24 µR/HR Average at 1 meter above floor

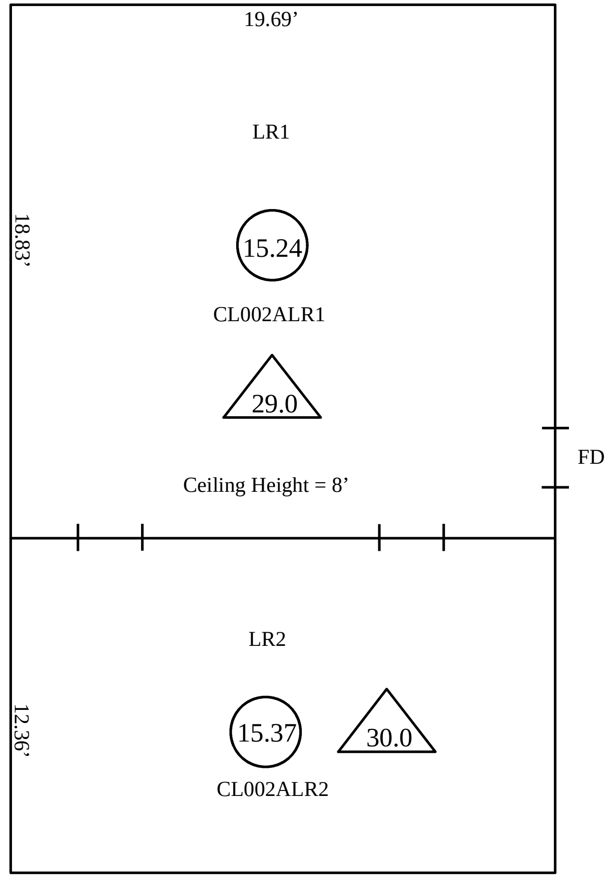
30.0 KCPM at 6 inches above floor

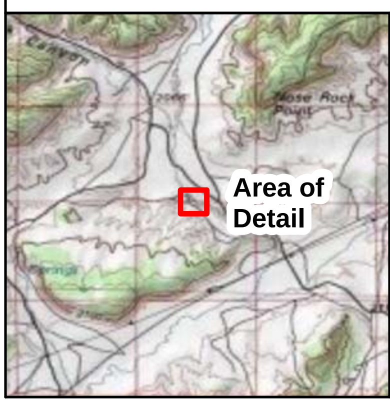
CL002ALR1 Sample location identification number

Sample names have been abbreviated.
For example: CL002ALR1 = CL-002A Living Room 1

ABBREVIATIONS

KCPM	KILO COUNTS PER MINUTE
12’	INSIDE WALL LENGTH
µR/HR	MICROREM PER HOUR
FD	FRONT DOOR
LR	LIVING ROOM





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LOCATION
LATITUDE = 35.488476
LONGITUDE = -108.024395

CL-002A Radiation Survey

Tronox AUM Section 32 and 33
Casamero Lake Chapter,
Navajo Nation
Prewitt, New Mexico

ecology and environment, inc.
International Specialists in the Environment

Inlet: U.S. Census TIGER

LEGEND

13.40 — μR/HR Average at 1 meter above floor

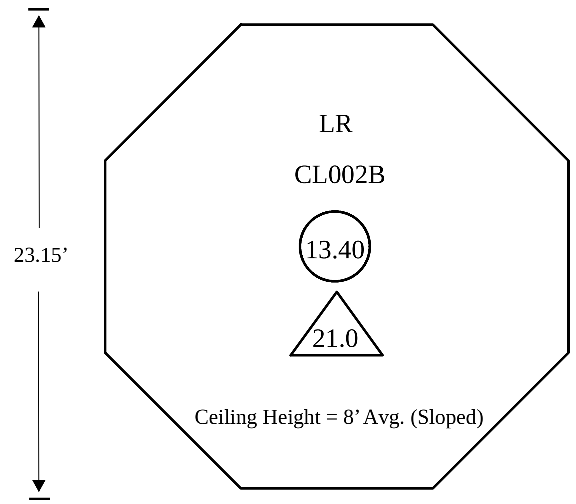
21.0 — KCPM at 6 inches above floor

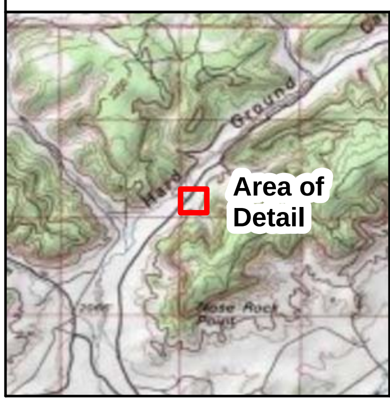
CL002BLR — Sample location identification number

Sample names have been abbreviated.
For example: CL002BLR = CL-002B Living Room

ABBREVIATIONS

KCPM	KILO COUNTS PER MINUTE
23'	INSIDE WALL LENGTH
μR/HR	MICROREM PER HOUR
LR	LIVING ROOM





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LOCATION
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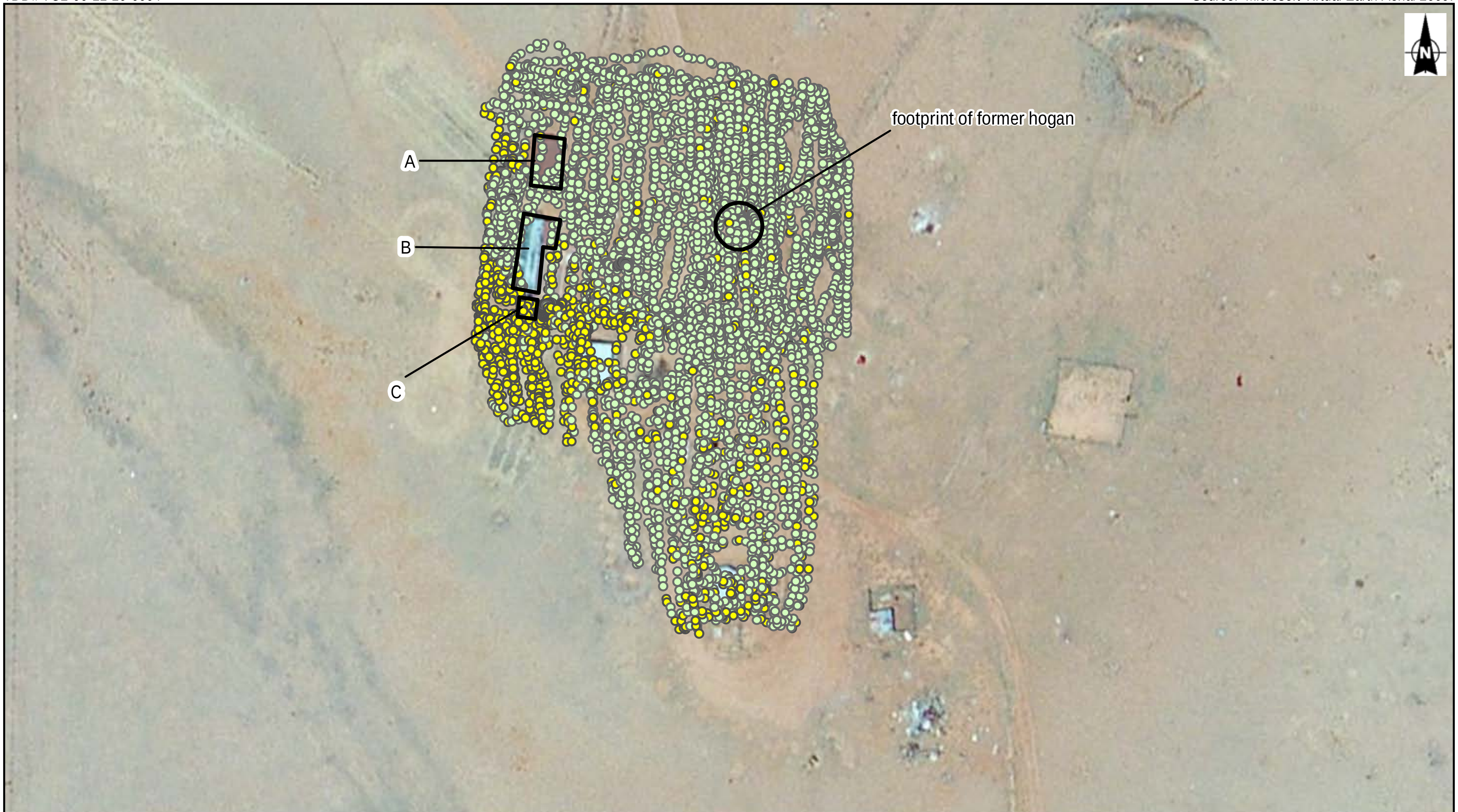
LONGITUDE = -108.024084

CL-002B Radiation Survey

Tronox AUM Sections 32 and 33
Casamero Lake Chapter,
Navajo Nation
Prewitt, New Mexico

ecology and environment, inc.
International Specialists in the Environment

Source: Microsoft Virtual Earth Aerial 2009.



0 50 100
Feet
0 20 40
Meters

Gamma radiation activity levels
- Below Investigation Level
- Investigation Level to 2x Background Level
- 2x to 5x Background Level
- Above 5x Background Level
- Home Site Structures

CL-001 Radiation Survey
Surface Soil Gamma Data
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

ecology and environment, inc.
International Specialists in the Environment

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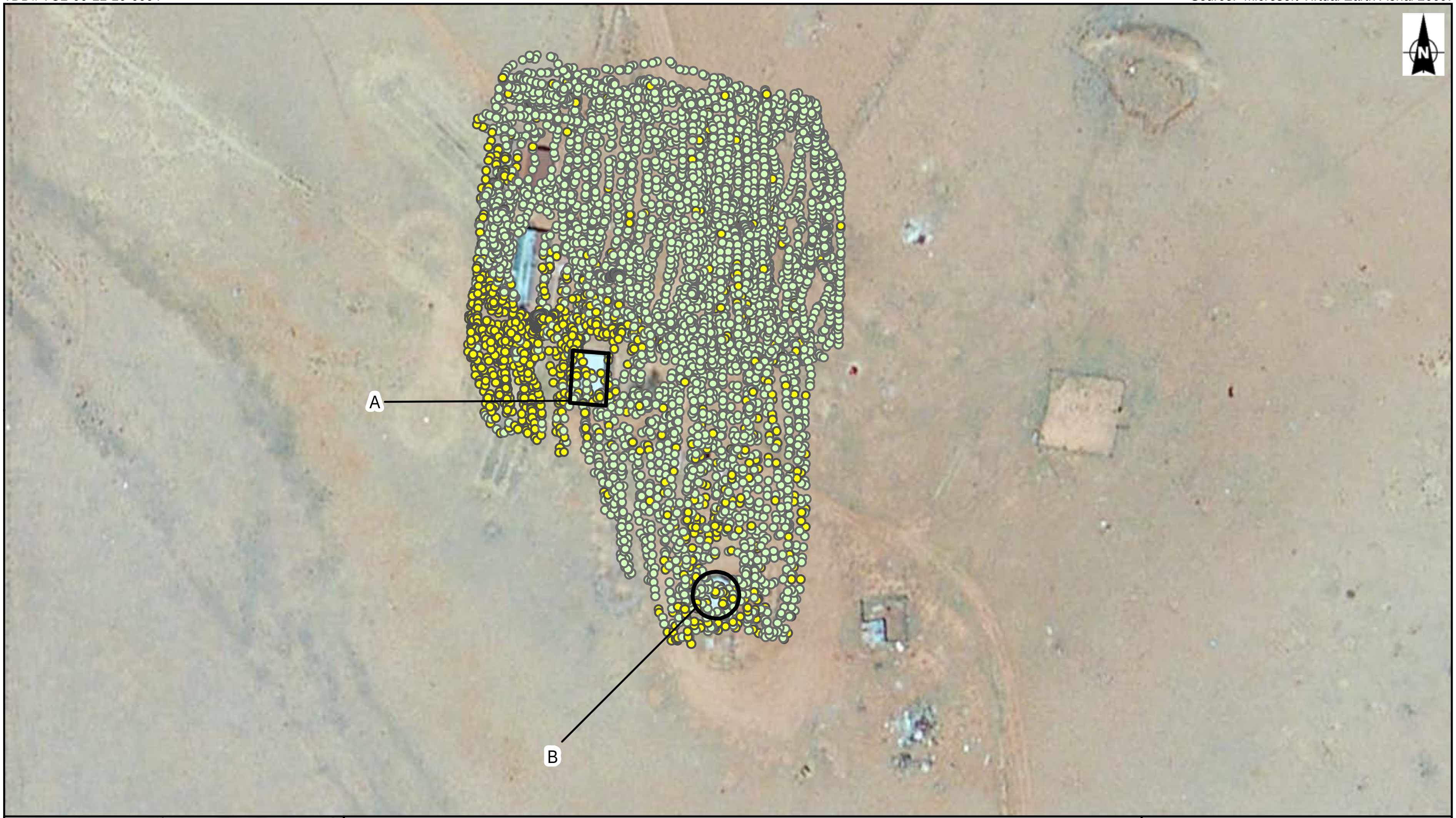
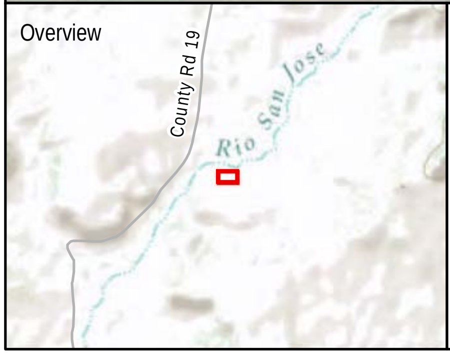
Project # 002693.2164.01RA
TDD# TO2-09-11-10-0004

Source: Microsoft Virtual Earth Aerial 2009.





0 50 100 Feet

0 20 40 Meters

Gamma radiation activity levels

- Below Investigation Level
- Investigation Level to 2x Background Level
- 2x to 5x Background Level
- Above 5x Background Level
- Home Site Structures

CL-002 Radiation Survey

Surface Soil Gamma Data

Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

ecology and environment, inc.
International Specialists in the Environment

Path: M:\Oakland\Tronox32\Maps\MXD\Radiation_Report\CL_002_radiation_survey.mxd 8/6/2012

PHOTOGRAPHIC LOG

Homesite/Structure Radiation Assessment

Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No. TO-02-09-11-10-0004 Project No. EE-002693-2164-01TTO

Date:
06/14/12

Description:

CL-001A

View of the East side of the structure.

Date:
06/14/12

Description:

CL-001A

View of the North side of the structure.

Homesite/Structure Radiation Assessment

Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No. TO-02-09-11-10-0004 | Project No. EE-002693-2164-01TTO

Date: 06/14/12

Description:

CL-001A

View of the West side of the structure.

Date: 06/14/12

Description:

CL-001A

View of the South side of the structure.

PHOTOGRAPHIC LOG

Homesite/Structure Radiation Assessment

Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No. TO-02-09-11-10-0004 Project No. EE-002693-2164-01TTO

Date: 06/14/12	
Description: CL-001B View of the East side of the structure.	
Date: 06/14/12	
Description: CL-001B View of the North side of the structure.	

PHOTOGRAPHIC LOG

Homesite/Structure Radiation Assessment

Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No. TO-02-09-11-10-0004 Project No. EE-002693-2164-01TTO

Date: 06/14/12

Description:

CL-001B

View of the West side of the structure.

Date: 06/14/12

Description:

CL-001B

View of the South side of the structure.

<table>
<tr><td rowspan="2"></td><td>PHOTOGRAPHIC LOG</td></tr>
<tr><td>Homesite/Structure Radiation Assessment
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No. TO-02-09-11-10-0004 Project No. EE-002693-2164-01TTO</td></tr>
<tr><td>Date:
06/14/12

Description:
CL-001C

View of the East side of the structure.</td><td></td></tr>
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PHOTOGRAPHIC LOG

Homesite/Structure Radiation Assessment

Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No. TO-02-09-11-10-0004 Project No. EE-002693-2164-01TTO

Date: 06/14/12

Description:

CL-001C

View of the West side of the structure.

Date: 06/14/12

Description:

CL-001C

View of the South side of the structure.

Homesite/Structure Radiation Assessment

Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No. TO-02-09-11-10-0004 Project No. EE-002693-2164-01TTO

Date:
06/14/12

Description:

CL-002A

View of the East side of the structure.

Date:
06/14/12

Description:

CL-002A

View of the North side of the structure.

PHOTOGRAPHIC LOG

Homesite/Structure Radiation Assessment

Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No. TO-02-09-11-10-0004 Project No. EE-002693-2164-01TTO

Date: 06/14/12

Description:

CL-002A

View of the West side of the structure.

Date: 06/14/12

Description:

CL-002A

View of the South side of the structure.

PHOTOGRAPHIC LOG

Homesite/Structure Radiation Assessment

Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No. TO-02-09-11-10-0004 | Project No. EE-002693-2164-01TTO

Date: 06/14/12

Description:

CL-002B

View of the East side of the structure.

Date: 06/14/12

Description:

CL-002B

View of the North side of the structure.

PHOTOGRAPHIC LOG

Homesite/Structure Radiation Assessment

Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No. TO-02-09-11-10-0004 Project No. EE-002693-2164-01TTO

Date:
06/14/12

Description:

CL-002B

View of the West side of the structure.

Date:
06/14/12

Description:

CL-002B

View of the South side of the structure.

C Historical Aerial Photographs

Tronox
AUM32/33
Thoreau, NM 87323

Inquiry Number: 3395115.1
August 23, 2012

The EDR Aerial Photo Decade Package

EDR® Environmental Data Resources Inc

440 Wheelers Farms Road
Milford, CT 06461
800.352.0050
www.edrnet.com

EDR Aerial Photo Decade Package

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Date EDR Searched Historical Sources:

Aerial Photography August 23, 2012

Target Property:

AUM32/33

Thoreau, NM 87323

Year	***Scale***	***Details***	***Source***
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1956	Aerial Photograph. Scale: 1"=750'	Panel #: 35108-D1, Thoreau NE, NM;/Flight Date: October 26, 1956	EDR
1978	Aerial Photograph. Scale: 1"=1000'	Panel #: 35108-D1, Thoreau NE, NM;/Flight Date: April 21, 1978	EDR
1981	Aerial Photograph. Scale: 1"=1000'	Panel #: 35108-D1, Thoreau NE, NM;/Flight Date: June 09, 1981	EDR
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1991	Aerial Photograph. Scale: 1"=750'	Panel #: 35108-D1, Thoreau NE, NM;/Flight Date: June 08, 1991	EDR
1997	Aerial Photograph. Scale: 1"=500'	Panel #: 35108-D1, Thoreau NE, NM;/Composite DOQQ - acquisition dates: October 09, 1997	EDR


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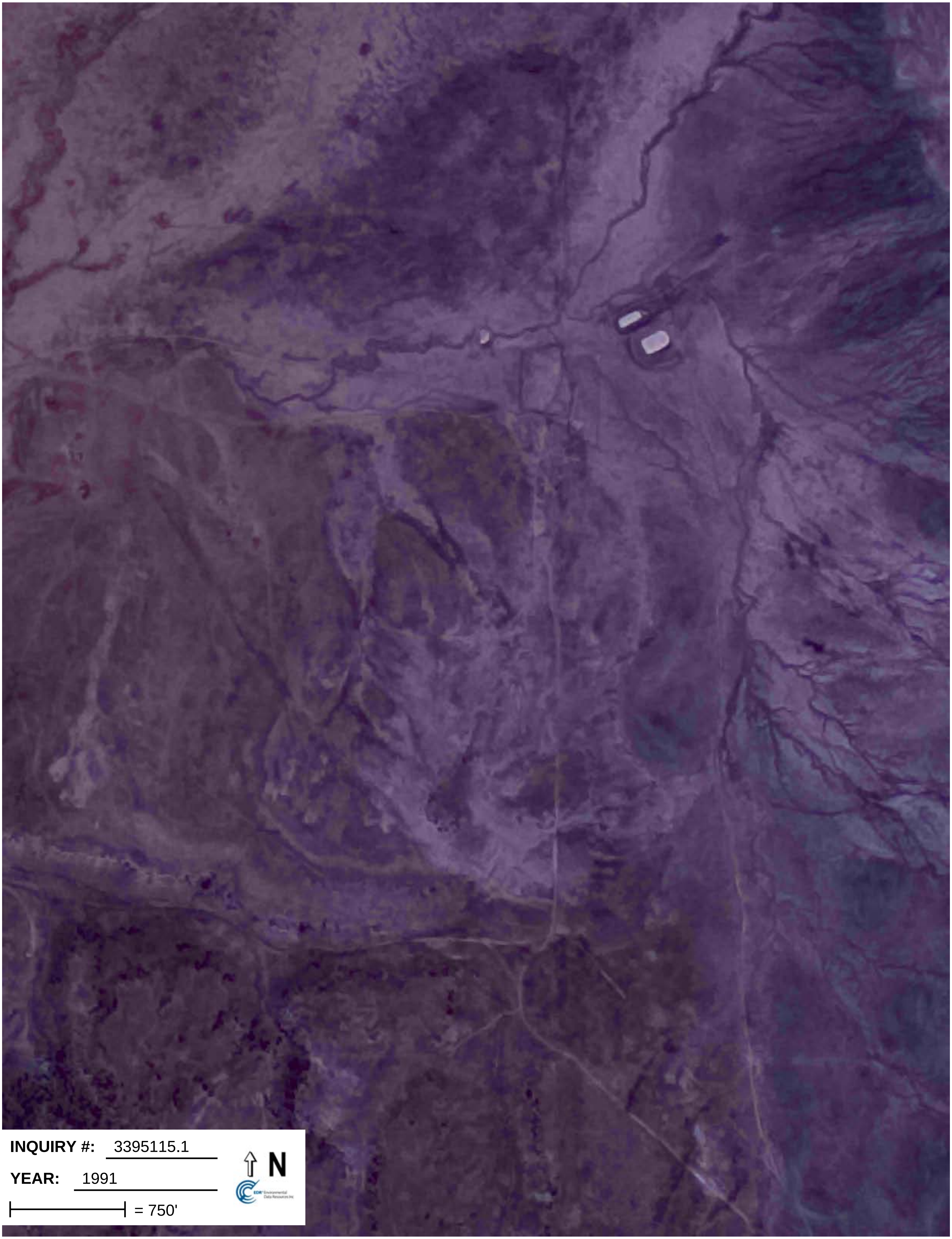
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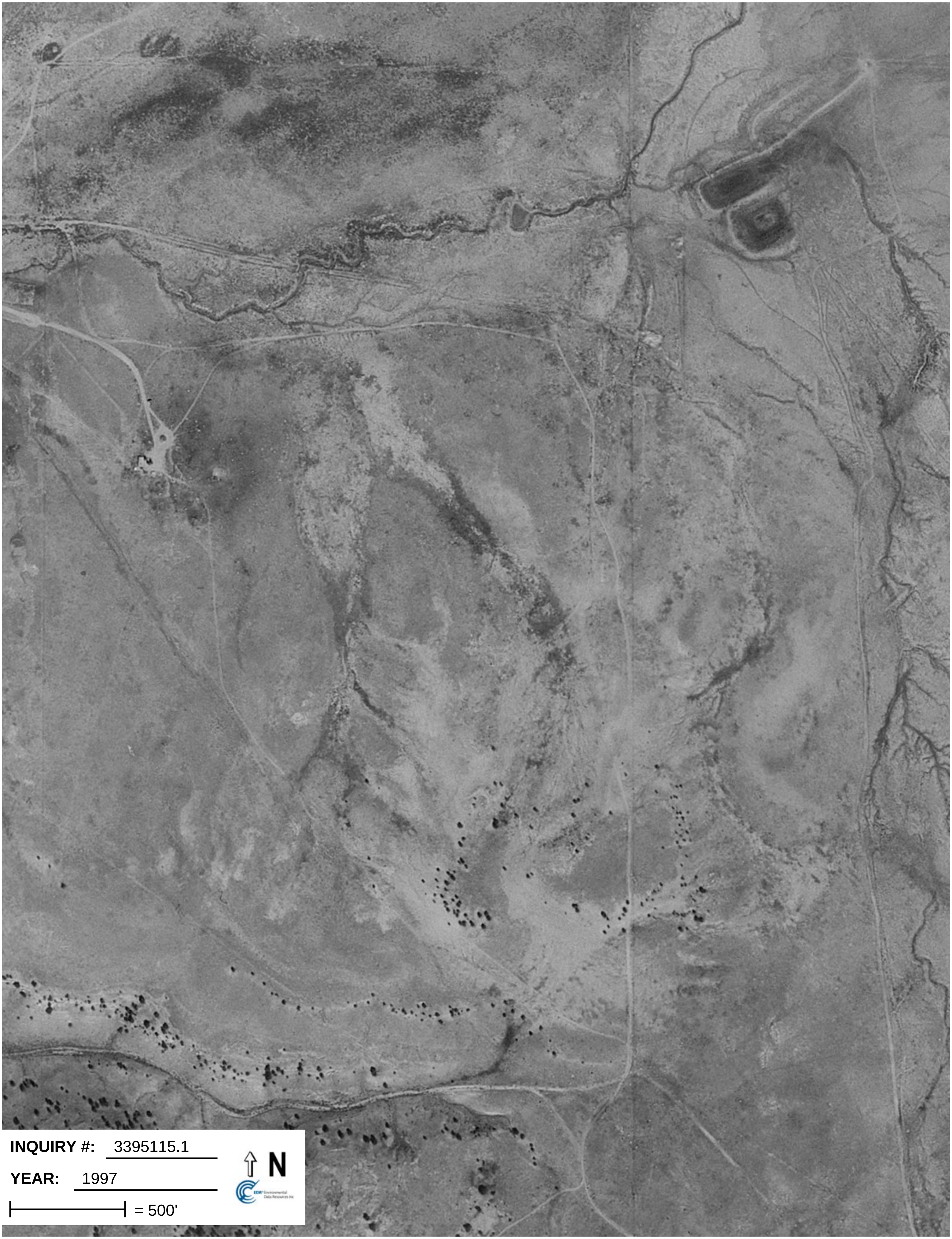
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D Sampling and Analysis Plans

D-1 Sampling and Analysis Plan, Tronox AUM Section 32, Eastern Agency, Removal Assessment, Prewitt, McKinley County, New Mexico, June 2012

D-2 Sampling and Analysis Plan, Tronox AUM Section 33, Eastern Agency, Removal Assessment, Prewitt, McKinley County, New Mexico, June 2012

D-3 Addendum to the Sampling and Analysis Plan for Tronox AUM Section 32, Eastern Agency, Removal Assessment, Prewitt, McKinley County, New Mexico Dated June 2012, July 2012

Sampling and Analysis Plan
Tronox AUM Section 32, Eastern Agency
Removal Assessment
Prewitt, McKinley County, New Mexico

TDD No.: TO-02-09-11-10-0004
Project No.: EE-002693-2164-01TTO

June 2012

Prepared for:

U.S. ENVIRONMENTAL PROTECTION AGENCY
Region IX

Prepared by:

ECOLOGY AND ENVIRONMENT, INC.
1940 Webster Street, Suite 100
Oakland, California 94612

Superfund Technical Assessment and Response Team

Sampling and Analysis Plan
Tronox AUM Section 32, Eastern Agency
Removal Assessment
Prewitt, McKinley County, New Mexico

TDD No.: TO-02-09-11-10-0004
Project No.: EE-002693-2164-01TTO

June 2012

Approved by:____
Aileen Mendoza, START Project Manager
Ecology and Environment, Inc.

Approved by: Howard J Edwards June 11, 2012
Howard Edwards, START Quality Assurance Coordinator
Ecology and Environment, Inc.

Approved by:____
Randy Nattis, Federal On-Scene Coordinator
U.S. Environmental Protection Agency, Region IX

Table of Contents

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Section **Page**

List of Tables

List of Figures

List of Abbreviations and Acronyms

AUM	Abandoned Uranium Mine
ARARs	Applicable or Relevant and Appropriate Requirements
bgs	below ground surface
COPC	contaminant of potential concern
cpm	counts per minute
DQI	Data Quality Indicator
DQO	Data Quality Objective
E & E	Ecology and Environment, Inc.
EML	Environmental Measurements Laboratory
EPA	United States Environmental Protection Agency
ERT	Environmental Response Team
FOP	field operating procedure
FOSC	Federal On-Scene Coordinator
GPS	Global Positioning System
HASL	Health and Safety Laboratory
ID	identification
IDW	investigation-derived waste
LCS	laboratory control sample
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MS/MSD	matrix spike/matrix spike duplicate
NA	not applicable
NNEPA	Navajo Nation Environmental Protection Agency

List of Abbreviations and Acronyms (cont.)

pCi/g	picocurie per gram
PIC	pressurized ionization chamber
PM	Project Manager
PPE	personal protective equipment
PRG	Preliminary Remediation Goal
QA	quality assurance
QC	quality control
Ra-226	Radium 226
Ra-226+D	Ra-226 and its radioactive decay chain products
RPD	relative percent difference
SAP	Sampling and Analysis Plan
SD	standard deviation
SERAS	Scientific, Engineering, Response, and Analytical Services
SOP	standard operating procedure
START	Superfund Technical Assessment and Response Team
VSP	Visual Sampling Plan
Weston	Weston Solutions, Inc.

1 Introduction

The United States Environmental Protection Agency (EPA) tasked Ecology and Environment, Inc.'s (E & E's) Superfund Technical Assessment and Response Team (START) to conduct a removal assessment at the Tronox Abandoned Uranium Mine (AUM) Section 32 (site), located in Prewitt, McKinley County, New Mexico in the Casamero Lake Chapter of the Navajo Nation. The site is part of the Five-Year Plan for cleaning up the legacy of abandoned uranium mining in the Navajo Nation (EPA *et al.* 2008). The removal assessment includes comprehensive gamma radiation scanning activity at the site and at a selected background area, collecting soil samples, and assessing a home site. START developed data quality objectives (DQO) and prepared this Sampling and Analysis Plan (SAP) under the direction of EPA Federal On-Scene Coordinator (FOSC) Randy Nattis.

This SAP describes the project and data use objectives, data collection rationale, data quality assurance goals, and requirements for sampling and analysis activities. It also defines the sampling and data collection methods that will be used for this project. This SAP is intended to accurately reflect the planned data-gathering activities for this task; however, site conditions, budget, and additional EPA direction may warrant modifications. All significant changes will be documented in site records.

The specific field sampling and chemical analysis information in this SAP was prepared according to the following EPA documents: *EPA Requirements for Quality Assurance Project Plans, EPA QA/R 5, EPA/240/B 01/003* (EPA 2001), *Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G 4, EPA/240/B-06/001* (EPA 2006), *Guidance on Choosing a Sampling Design for Environmental Data Collection, EPA QA/G 5S, EPA/240/R 02/005* (EPA 2002), and *Uniform Federal Policy for Implementing Environmental Quality System, EPA/505/F-03/001* (EPA 2005).

1.1 Project Organization

EPA FOSC – The EPA FOSC, Randy Nattis, is the primary decision-maker and will direct the project, specify tasks, and ensure that the project is proceeding on schedule and within budget. Additional duties include coordination of all preliminary and final reporting and communication with the Navajo Nation Environmental Protection Agency (NNEPA), START Project Manager (PM), EPA Environmental Response Team (ERT) and their Scientific, Engineering, Response, and Analytical Services (SERAS) contractor, EPA Quality Assurance (QA) Office, and community residents. The EPA FOSC is also responsible for access to each property to be investigated.

START PM – The START PM, Aileen Mendoza, manages the project's data collection efforts and is responsible for implementing the SAP, coordinating project tasks and field sampling, managing field data, and completing all preliminary and final reporting.

Principal Data Users – Data generated during the implementation of this SAP will be utilized by the EPA FOSC to make decisions regarding further action.

START QA Coordinator – The START QA Coordinator, Howard Edwards, is responsible for overseeing the development of this SAP. The START QA Coordinator will coordinate with the

EPA's QA Office as needed. START QA Coordinator will provide QA oversight to ensure that planning and plan implementation are according to the EPA regional quality assurance/quality control (QA/QC) protocol. START QA Coordinator will provide technical direction concerning QA/QC as needed to the EPA FOSC and the START PM.

Sample Analysis and Laboratory Support – The START-contracted laboratory, GEL Laboratories, LLC, is responsible for sample analysis by definitive analytical methodologies. START is responsible for field data analysis and data validation of laboratory-generated data.

1.2 Distribution List

Copies of the final SAP will be distributed to the following persons and organizations:

- EPA FOSC Randy Nattis, EPA Region IX
- EPA Region IX QA Office
- Joe Schaefer, EPA ERT
- E & E START Field Team
- E & E START project files

1.3 Statement of the Specific Problem

The site was identified as an AUM and gamma radiation activity in surface soil was detected at levels up to 10 times the reported background level. Gamma radiation activity in surface soil at the site may pose an imminent and substantial threat to human health. The lateral and vertical extent of gamma radiation in soil needs to be defined to support the EPA FOSC in determining whether a removal action is necessary to protect human health.

In addition, a resident lives approximately 0.5 mile west of the site and reportedly used some materials (tarps and lumber) obtained from the mine. Gamma radiation measured from the residence during the site screening was approximately 12,000 cpm (Weston 2009). A home site assessment will also be conducted to determine if radiation is present in the residential structures and whether a removal action is necessary to protect human health.

2 Site Background

2.1 Site Location and Description

The site is located approximately 1 mile east of County Road 19, Prewitt, McKinley County, New Mexico (Latitude: 35° 29' 26.7576" N, Longitude: -108° 1' 2.7798" W) (Figure 2-1). The site is located in an Indian Allotment land which is part of the Casamero Lake Chapter of the Navajo Nation. The Chapter House is approximately 1.4 miles from the site. The site is in a vacant land surrounded by open space. The eastern boundary of the site is bordered by Tronox AUM Section 33.

The site has an approximate area of 12,103 square meters, an unsecured deep shaft located in the southeastern portion, and an undetermined extent of underground workings (Weston Solutions, Inc. [Weston] 2009). The site is relatively flat with sparse vegetation. Surface water was not observed at or within the influence of the site; however, available geographical information show a stream or river located north and south of the site which converges approximately 0.25 mile west of the site, and two ponds located northeast of the site. Groundwater depth and information on nearby water wells used for drinking water were not available. No residences, public structures, water sources or sensitive environment were found within 0.25 miles of the site. The nearest resident is Lucita Sardo who lives approximately 0.5 mile west of the site and had relatives who formerly worked for Cobb Nuclear. Agricultural food production such as livestock grazing or farming common in Navajo communities was not observed at or immediately adjacent to the site.

2.2 Site History

According to EPA, portions of the Navajo Nation are located 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 AUMs. Cobb Nuclear Company operated mines in the Casamero Lake Chapter area (Weston 2009).

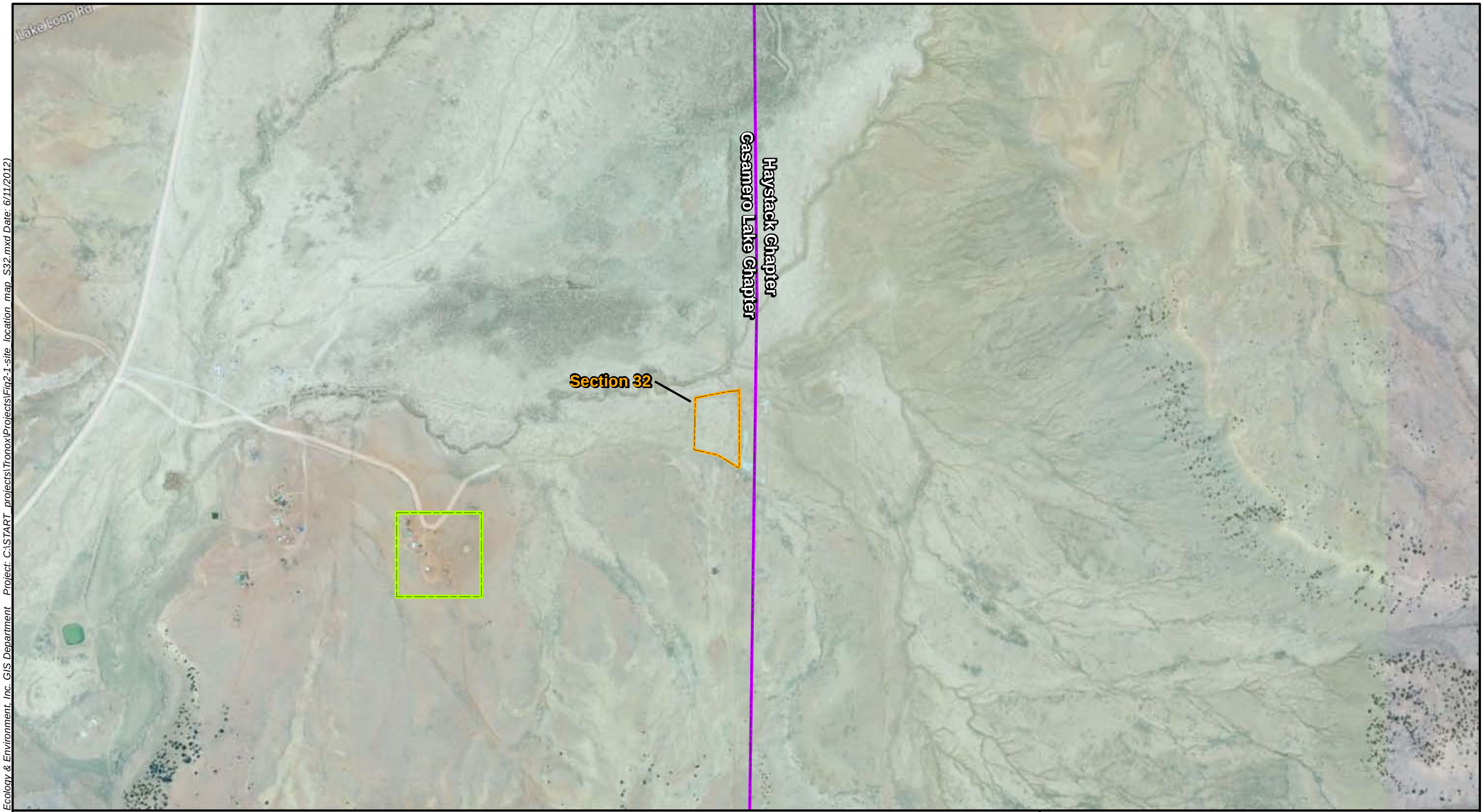
The site consists of a historical mine which was reportedly owned by Cobb Nuclear and was closed due to a fatality (Weston 2009). No other information on historical ownership of the mine and mining operations were available. No waste piles, other mine features, or visible signs of reclamation were reported.

A site screening for AUMs was conducted at the site which included collection of site information and gamma radiation survey data (Weston 2009). Gamma radiation activity was measured from surface soil along the boundary of the site and along two diagonal intersecting transects from the site’s four corners. Gamma radiation measured at the site during the site screening ranged from 10,689 cpm to 180,367 cpm. Gamma radiation measured at background locations ranged from 16,630 cpm to 17,128 cpm. The background location used in the site screening was not identified. Ms. Sardo’s residence reportedly used some materials (tarps and lumber) obtained from the mine and had gamma radiation measurements of approximately 12,000 cpm.

Materials from the mine potentially used as building materials for residential structures may expose residents to radiation. The residence near the site reportedly used some materials (tarps and lumber) obtained from the mine and had gamma radiation measurements of approximately 12,000 cpm.

Project # 002693.2164.01RA
TDD# TO2-09-11-10-0004

Source: Aerial Photography - Bing Maps



Ecology & Environment, Inc. GIS Department Project: C:\START projects\Tronox\Projects\Fig2-1-site location map S32.mxd Date: 6/11/2012)

LEGEND

Homesite boundary

Mine boundary

Chapter boundary

N

0 1,000 2,000 Feet

Figure 2-1

Site Location Map
Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation, Prewitt, New Mexico

ecology and environment, inc.
International Specialists in the Environment

3 Project Objectives

3.1 Data Use Objectives

Data generated from this investigation will be used to:

- Establish background gamma radiation activity
- Document gamma radiation activity throughout the site
- Document concentration of radium-226 (Ra-226) in soil at background and site locations
- Assist EPA with decision on further action at the site.

3.2 Project Task/Sampling Objectives

EPA tasked START to conduct a removal assessment. Under this task, START will complete this SAP, field activities, and a final report.

This SAP includes data quality objectives; the number, location, and type of proposed sampling; field sample collection and laboratory analytical methods and procedures; data quality assurance and validation procedures. Field activities include mobilization/demobilization, gamma radiation activity scans, soil sampling, and home site assessment. Data collection will be conducted according to this SAP and the following objectives.

1. Determine whether, and in what areas, site concentrations of Ra-226 in surface soil require removal, further assessment, or no further action.
   - Determine whether gamma radiation activity readings can be used to characterize the site or if further sampling to characterize the site is necessary.
   - Determine a suitable background location for collecting data to calculate a site-specific action level or identify an alternate means of setting an action level.
2. Determine whether site concentrations of Ra-226 in subsurface soil at locations where the surface levels of Ra-226 are elevated require removal, further assessment, or no further action.
3. Determine radiation levels at the home site.
   - Determine gamma exposure levels inside residential structure require removal of the structure or no further action.
   - Determine whether gamma radiation activity in floor surfaces and/or surface soil around the home site require removal or no further action.

3.3 Investigation and Action Levels

The investigation and action levels for this site were determined by the EPA FOSC. The investigation level for gamma radiation activity in surface soil will be based on background levels. The EPA FOSC determined Ra-226 is the contaminant of potential concern (COPC) at the site. The action level for Ra-226 in surface soil will be based on the sum of the background concentration of Ra-226 and the EPA Preliminary Remediation Goal (PRG) of 1.21 picocuries per gram (pCi/g). The PRG is based on Ra-226 and its radioactive decay chain products (Ra-226+D) in residential soil and an estimated excess cancer risk of 1 in 10,000 (10^{-4}) (EPA 2010). Exposure pathways considered include incidental ingestion of soil, inhalation of particulates emitted from soil, external exposure to ionizing radiation, and consumption of fruits and vegetables. This standardized PRG is based on default exposure parameters and incorporate exposure factors that present reasonable maximum exposure selected to be protective of human health for most site conditions.

For the home site, the investigation level will be an interior dose rate from gamma activity that exceeds a typical background gamma dose rate by 15 millirem per year or more. The interior dose rate and typical background dose rate will be calculated from exposure rate levels collected during the assessment in combination with a risk assessment formula. In addition, an investigation level will be used during the assessment that will trigger extent of exposure or activity surveys. The investigation level for each detector will be calculated for each home site based on the following equation:

$$IL = BG + (10\ x\ SD)$$

where:

IL = Investigation Level

BG = Average of three 1-minute static gamma radiation activity background measurements

SD = Standard deviation of the three background measurements

The investigation and action levels for this removal assessment are presented in Table 3-1.

Table 3-1 Benchmarks and Data Quality Indicator Goals
Gamma Radiation Activity Survey and Definitive Data for Ra-226 by EML HASL 300, 4.5.2.3 Method
Tronox AUM Section 32 Eastern Agency
Removal Assessment
Prewitt, McKinley County, New Mexico

E & E Project No. EE-002693-2164-01TTO TDD No. TO-02-09-11-10-0004

Analyte	Background Concentration[1]	Site-Specific Action Level for Assessment	EPA PRG (pCi/g)	Reporting Limit	Accuracy (% Recovery for MS/ MSD)	Precision (RPD from MS/MSD and Duplicates)	Percent Completeness
Gamma radiation activity[2]	To be determined (cpm)	Background (cpm)	NA	0.1 cpm with a detection range from 0.1 to 999,000 cpm	NA	20%	90
Ra-226	To be determined (pCi/g)	Sum of background and EPA PRG (pCi/g)	1.21	1.00 (pCi/g) at GEL Laboratories, LLC	NA	35%	90

Notes:

% – percent
AUM – abandoned uranium mine
cpm – count per minute
EML – Environmental Measurements Laboratory
EPA – U.S. Environmental Protection Agency
HASL – Health and Safety Laboratory
MS/MSD = Matrix Spike/Matrix Spike Duplicate
NA – Not applicable
pCi/g – picocuries per gram
PRG – EPA Preliminary Remediation Goal (August 2010)
Ra-226 – Radium isotope number 226
RPD – Relative Percent Difference

1 Background gamma radiation activity and Ra-226 concentration in soil will be determined during field activities and laboratory analysis.
2 All field instruments will be included in the quality control program to document that the instruments are operating within specified control limits. The background and gamma source control limits will be established based on plus or minus 20 percent of the respective average activity rates, determined according to the instrument FOPs.

3.4 Data Quality Objectives

The DQO process, as set forth in the EPA *Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA/240/B-06/001* (EPA 2006), was followed to establish the DQO for this project. An outline of the process and the outputs for this project are included in Appendix A.

3.5 Data Quality Indicators (DQIs)

Data quality indicators (DQIs) are defined as: precision, accuracy, representativeness, completeness, comparability, and method detection limits. The DQIs for this project were developed following the guidelines in the EPA *Requirements for Quality Assurance Project Plans* (EPA 2001). All sampling procedures are documented in Sections 6.2 and 6.3. Standard operating procedures will be followed to ensure representativeness of sample results by obtaining characteristic samples. Approved EPA methods and standard reporting limits will be used whenever possible. All data not rejected will be considered complete. Table 3-1 documents the site-specific DQI goals for the COPCs.

3.6 Schedule of Sampling Activities

Field activities will begin on June 11, 2012 and continue for up to 5 days.

3.7 Special Training Requirements/Certifications

The operation of the field analytical instruments requires specialized training that will be administered, prior to mobilization, to all START personnel scheduled to be on site. As directed by EPA FOSC Nattis, ERT’s SERAS contractor will train START on VIPER on site.

Field sampling personnel should be trained and have experience with soil sampling at hazardous waste sites while wearing appropriate protective equipment. One field sampler will be trained and familiar with Global Positioning System (GPS) data collection. All sampling personnel will have appropriate training that complies with 29 Code of Federal Regulations 1910.120. The site-specific health and safety plan for this project is included in Appendix B.

Data validation requires specialized training and experience. The START QC Coordinator will determine and verify a qualified data validation resource prior to data validation.

4 Sampling Rationale and Design

The sampling rationale and design was developed under the direction of the EPA FOSC and START Program Manager, and based on information from other EPA AUM sites.

4.1 Selection of Survey (Decision) Units

Decisions will apply to the entire site unless decision units are established based on data.

For the home site, each residential structure is a decision unit and surface soil surrounding the residential structures is considered one decision unit unless modified based on data.

4.2 Background Area

Background survey, sampling and analysis are required to determine naturally-occurring gamma activity and COPC concentrations in an area with similar geology and no known or suspected impacts from mining. The background area will be selected in the field according to the *Background Location Selection Criteria* (NNEPA and EPA 2010). The background area will be easily accessible, an appropriate distance from the site, and historically undeveloped based on visual observation.

4.2.1 Gamma Radiation Activity Investigation Level

A survey unit measuring 20 x 20 feet will be established in the selected background area. Gamma radiation activity in surface soil will be measured using a paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241 meter mounted 6 inches from the ground surface on a 3-foot wide push cart. The VIPER system and geographical information system (GIS) will be used for geospatial information collection and analysis. The surface soil survey will consist of transects spaced 3 feet apart, which will provide 100 percent characterization of the site. The transect width is based on the field of view of the detector which is 3 to 6 feet diameter. The surveyor will walk at a pace of 3 feet per second. The mean and standard deviation (SD) of the gamma radiation activity measurements in the background area surface soil will be calculated to develop the investigation level for gamma radiation activity at the site. An acceptable background area will have a low mean and SD.

4.2.2 Ra-226 Action Level

Surface soil samples will be collected at 0 to 2 inches bgs from the background survey unit and analyzed for Ra-226 by EML HASL 300 4.5.2.3 Method. Eleven samples will be collected at random locations which according to Visual Sampling Plan (VSP) software version 6.2 will provide a 95 percent confidence level that the calculated mean will be within ±1 pCi/g of the true mean. The sample data will be used to develop the action level for the RA-226. Co-located static gamma radiation activity measurements will also be collected from the surface soil location to establish the relationship between gamma radiation activity and RA-226 concentration in surface soil.

4.2.3 Exposure Rate Investigation Level

The background exposure rate will be measured using a General Electric Reuter-Stokes High PIC RSS 131 placed 1 meter above the ground surface collecting measurements every second and logging for 5 minutes at 3 individual measurement locations. The background limits will be established based on ±20 percent of the respective average activity rates, determined according to the instrument FOPs. These measurements will serve as background exposure rates to be used in comparison to structure interior exposure rates in the home site assessment.

4.3 Site Soil

Gamma radiation activity in surface soil at the site will be measured similar to the background area. A paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241 meter mounted 6 inches from the ground surface on a 3-foot wide push cart will be used to measure gamma radiation activity in surface soil. The surface soil survey will consist of 3-foot wide transects at a pace of 3 feet per second covering 100 percent of the site. If gamma radiation activity measurements along the perimeter of the site exceed the investigation level, lateral step-out will consist of additional 3-foot wide transects to a maximum of 10 feet beyond the site boundary.

Surface soil samples will be co-located with static 1-minute scans of gamma radiation activity to establish the relationship between RA-226 concentration and gamma radiation activity in surface soil. Surface soil samples will be collected from 0 to 2 inches bgs from locations of gamma radiation activity above the investigation level according to the following ranges based on previous AUM sites:

- Investigation level
- Investigation level plus 10,000 cpm (10,000 cpm was established from previous AUM sites to correlate with 1.2 pCi/g of Ra-226)
- Investigation level plus 20,000 cpm
- Investigation level plus 25,000 cpm
- Investigation level plus 30,000 cpm

Surface soil samples will also be collected from areas with gamma radiation activity at or below the investigation level to confirm the RA-226 concentrations at these locations are below the action level. Surface soil samples will be collected from locations within the ranges of interest in each soil type and vegetation cover observed at the site. Additional surface soil samples may be collected based on field observations as determined by the EPA FOSC. Based on previous AUM sites, 15 samples have provided correlation of Ra-226 concentration with gamma radiation activity. A maximum of 30 surface soil samples (site and background) will be collected from the site and shipped to the START-contracted laboratory for Ra-226 analysis by EML HASL 300 4.5.2.3 Method.

Subsurface soil samples will be collected to determine the vertical extent of contamination at locations where surface gamma radiation activity exceeds the investigation level. Elevated locations will be determined from gamma radiation activity results of the 100 percent scan of the site. Soil samples will be collected down to 3 feet bgs (or less based on refusal or groundwater) at 1-foot depth intervals bgs. Subsurface samples will be collected from each depth in clustered boreholes i.e., one sample from a 1-foot deep borehole, one sample from a 2-feet deep borehole, and one sample from a 3-feet deep borehole, to minimize soil from shallower depths from being collected with the desired subsurface sample. The number of subsurface samples collected will be initially based on 10 percent of the highest documented gamma radiation activity locations but may vary based on field data. Additional subsurface soil samples may be collected based on field observations as determined by the EPA FOSC.

4.4 Home Site

The activity of gamma radiation will be measured inside each structure with coverage of 100 percent of accessible areas. If an object is encountered during the survey it will not be moved, and the scanning survey will be performed surrounding the object. A Ludlum Model 44-20 (3x3) detector paired with a 2221 or 2241 meter will be positioned 6 inches above the floor, and moved in a serpentine motion at a scan rate of 1 to 2 feet per second. Transects will be surveyed from one wall to the opposite wall until 100 percent of the accessible areas is scanned. If the investigation level is exceeded then the extent of the elevated measurements will be determined and documented; that is, the dimensions of the elevated area and a sketch of the area on a structure diagram. The approximate average gamma radiation activity will be recorded for each room in the structure. All measurements will be documented on a survey form. Details on measurement collection are provided in Field Operating Procedure (FOP) 1, Radiation Scanning Survey; and operation of Ludlum Model 44-20 in FOP 5 and Ludlum Model 2221 in FOP 6.

Static exposure rate measurements will be collected inside each room of every accessible structure. In the center of each room, or closest location if obstructed, a General Electric Reuter-Stokes High PIC RSS 131 will be placed 1 meter above the floor, and measurements will be collected every second and logged for 5 minutes. The PIC measurements in mR/hr will be collected to represent the statistically-based average exposure rate in each room. The exposure rate will be used to determine the dose to a resident if the room were occupied, for comparison to dose risk ranges.

4.5 Analyte of Concern

Gamma radiation activity in surface soil at the site, and surface soil and floor areas in the home site will be measured in cpm. Radiation exposure rate at the home site structures will be measured in mR/hr. Soil samples will be analyzed for Ra-226 as indicator isotope to determine the extent of contamination from historical uranium mining at the site. Gamma radiation activity will be correlated with the Ra-226 concentrations detected in surface soil at the site.

5 Request for Analyses

Gamma radiation activity will be measured over the entire site surface. Surface and subsurface soil samples will be analyzed for Ra-226 concentration by the START-contracted laboratory.

Gamma radiation activity will be measured over the entire home site. Surface soil and floor surfaces in residential structures at the home site will be analyzed in the field for gamma radiation activity. Radiation exposure rate inside the residential structures will also be measured using a field instrument.

The following sections describe these analyses.

5.1 Field Analysis

Gamma radiation activity in surface soil and floor surfaces will be measured in the field using a paired Ludlum Model 2221 or 2241 meter and a 44-20 (3x3) detector. Operational checks will be conducted on the paired meter and detector before the field activities using a check source with 1 or 5 microcuries of Cesium-137 based on previous AUM sites. The optimal high voltage setting for the instrument will be set using a Fluke voltage meter . The meter used for the soil survey will be linked to a VIPER system for geospatial information collection and analysis.

Radiation exposure rate inside the residential structures will be measured using a General Electric Reuter-Stokes High Pressurized Ionization Chamber (PIC) RSS 131. The background and gamma source control limits will be established based on plus or minus 20 percent of the respective average activity rates, determined according to the instrument Field Operating Procedure (FOP).

To provide quality control for the field analytical effort, the following measures will be utilized:

- Analytical precision and sensitivity of the gamma radiation activity survey equipment will be established before beginning the field measurements and will be verified throughout the field survey through operational and background checks.
- Whenever possible, the same paired VIPER-linked meter and detector used to establish the relationship between gamma radiation activity and Ra-226 concentrations in soil will be used for all surveys conducted at the site.

5.2 Laboratory Analysis

Soil samples will be analyzed for Ra-226 by EML HASL 300, 4.5.2.3 Method (Department of Energy 1990). Soil samples will be submitted to GEL Laboratories, LLC located at 2040 Savage Road, Charleston, South Carolina 29407. Sample containers, preservatives, holding times, and estimated number of soil confirmation and quality control samples are summarized in Table 5-1.

To provide quality control for the analytical program, the following measures will be utilized:

- Duplicate samples will be collected from ten percent of the soil sampling locations or one per sample design group. Duplicate soil samples will be collected as a 50/50 split of the sample after collection and homogenization.
- If non-dedicated sampling equipment is used to collect soil samples at the site, a rinsate blank will be collected at a rate of one per day to evaluate decontamination procedures at

the site. The rinsate blank will be collected by pouring deionized water over the decontaminated sample collection device (e.g., trowel or hand auger) and capturing the water in the specified sample container.

Table 5-1 Sampling and Analysis Summary
Tronox AUM Section 32 Eastern Agency
Removal Assessment
Prewitt, McKinley County, New Mexico

E & E Project No. EE-002693-2164-01TTO — TDD No. TO-02-09-11-10-0004

Method	Ra-226 by EML HASL 300, 4.5.2.3 Method
Sample Container	4 ounce plastic soil jars
Preservation	None
Analysis Holding Time	6 Months
Estimated Number of Unique Discrete Samples	30 surface soil samples 9 subsurface soil samples
Estimated Number of Duplicate Samples	4
Minimum Total Site Sample Analyses	43
Equipment Rinse Blanks (if non-dedicated equipment is used)	
Sample Container	500 milliliter plastic bottle
Preservation	None
Analysis Holding Time	14 days
Number of Samples	1 per day (5)

Note:
AUM – abandoned uranium mine
EML – Environmental Measurements Laboratory
HASL – Health and Safety Laboratory
Ra-226 – Radium isotope number 226

6 Field Methods and Procedures

The following sections describe the procedures and equipment that will be used during the field activities.

6.1 Field Procedures

6.1.1 Standard Operating Procedures and Equipment

The equipment listed below may be utilized to obtain environmental samples from the respective media according to the following sampling standard operating procedures (SOPs) or their equivalent:

- FOP 1, Radiation Scanning Survey
- FOP 5, Ludlum Model 44-20
- FOP 6, Ludlum Model 2221
- For the VIPER system, training and procedures will be provided by ERT and its SERAS contractor.
- Environmental Response Team SOP #2012 Soil Sampling
- Ecology and Environment Inc. SOP # ENV 3.13: Soil Sampling
- Ecology and Environment Inc. SOP# ENV 3.15: Sampling Equipment Decontamination

The following is a partial list of equipment that may come in contact with samples:

- Hand auger, trowel, shovel
- Plastic sample jars
- Disposable nitrile gloves

6.1.2 Equipment Maintenance

Field instrumentation for the collection of soil samples will be operated, maintained, and have operational checks conducted by the sampling team according to the SOPs listed in Section 6.1.1 or their equivalent. Field instrumentation utilized for health and safety purposes will be operated, maintained, and have operational checks conducted by the sampling team according to the manufacturer's instruction. Operational checks and field use data will be recorded in the instrument or field logbooks.

6.1.3 Inspection/Acceptance Requirements for Supplies and Consumables

There are no project-specific inspection/acceptance criteria for supplies and consumables. It is standard operating procedure that personnel will not use broken or defective materials; items will not be used past their expiration date; supplies and consumables will be checked against order and packing slips to verify the correct items were received; and the supplier will be notified of any missing or damaged items.

6.1.4 Logbooks

Field logbooks will document where, when, how, and from whom any vital project information was obtained. Logbook entries will be complete and accurate enough to permit reconstruction of field activities. A separate logbook will be maintained for each project. Logbooks are bound with consecutively numbered pages. Each page will be dated and the time of entry noted in military time. All entries will be legible, written in ink, and signed by the individual making the entries. Language will be factual, objective, and free of personal opinions. The following information will be recorded, if applicable, during the collection of each sample:

- Sample location and description
- Site sketch showing sample location and measured distances
- Sampler's name(s)
- Date and time of sample collection
- Type of sample (matrix)
- Type of sampling equipment used
- Onsite measurement data (e.g., Background radiation measurements)
- Field observations and details important to analysis or integrity of samples (rain, odors, etc.)
- Type(s) of preservation used
- Field instrument reading (such as micro-Roentgen readings for health and safety purposes, etc.)
- Shipping arrangements (air bill numbers)
- Receiving laboratory

START team members will be on site performing different duties related to sample collection, processing, and analysis. Each logbook will document the information relevant to the site radiation activity, and at a minimum will include:

- Team members and their responsibilities
- Time of activities
- Deviations from sampling plans, site safety plans, and SAP procedures
- Levels of safety protection
- Operational check information
- Analytical data

6.1.5 Photographs

Photographs will be taken at representative sampling locations and at other areas of interest on site. They will serve to verify information entered in the field logbook. When a photograph is taken, the following information will be written in the logbook or will be recorded in a separate field photography log:

- Time, date, location, and, if appropriate, weather conditions
- Description of the subject photographed
- Name of person taking the photograph

6.1.6 Electronic Sample Logging

The sampling team may utilize field management software to prepare sample labels and chain-of-custody forms. Blank sample labels and chain-of-custody forms will also be available.

The following information should be entered for each sample after collection:

- Sample name
- Sample date and time
- Number of sample bottles
- Type of preservation
- Analyses

In addition to these items, the software may also be used to keep track of other information such as sample depth, field measurements, and split samples.

The field team will generate chain-of-custody forms for each cooler of samples packaged and sent to a laboratory. Each chain-of-custody form will refer to the shipping method and tracking number. Printed chain-of-custody forms will be submitted to the laboratory with the samples.

The use of field management software will require that the field team have access to a computer, a printer, computer paper, and labels while in the field. The field data manager will be responsible for implementing the software.

6.1.7 Mapping Equipment

Sample points and site features will be located and documented with a GPS unit. The GPS will be used to assign precise geographic coordinates to sample locations on the site. GPS mapping will be done by personnel trained in the use of the equipment and will be completed according to the manufacturer's instructions. Expected output from the use of GPS mapping will be site maps with sample locations and major site features.

6.2 Background Selection

The background area will be selected by the EPA FOSC in the field according to the *Background Location Selection Criteria* (NNEPA and EPA 2010) as follows.

- Similar elevation as the site
- Similar geology as the site. Avoid areas of naturally-occurring uranium.
- Upwind (gradient, stream) from site
- Undisturbed with natural vegetation
- Not in drainage or area impacted by flooding
- Distance to residential structures (structures should be within range of vision)
- Accessible (by vehicle and equipment)

- Should not be near a mine site or similar contaminant source
- If possible, avoid anthills and rodent holes
- Ask nearby residents about area

A survey unit measuring 20 x 20 feet will be established in the selected background area and the survey boundary will be marked with flags. Gamma radiation survey of 100 percent of the survey unit will be conducted according to Section 6.3. The mean and SD of the gamma radiation activity measurements in the background area surface soil will be calculated to determine if the background area is acceptable (low mean and SD) and to develop the investigation level for the gamma radiation activity survey.

Eleven surface soil samples will be collected at 0 to 2 inches bgs from random locations in the 20 x 20 feet area according to VSP (Appendix C) which will be estimated in the field. Soil sample results will be used to develop the action level for Ra-226. The surface soil sampling procedure is detailed in Section 6.4.1.

The background exposure rate will be measured using a General Electric Reuter-Stokes High PIC RSS 131 placed 1 meter above the ground surface collecting measurements every second and logging for 5 minutes at 3 individual measurement locations. The background limits will be established based on ±20 percent of the respective average activity rates, determined according to the instrument FOPs. These measurements will serve as background exposure rates to be used in comparison to structure interior exposure rates in the home site assessment.

The location of the background area will be documented using GPS and photographs. The calculated investigation levels will be documented electronically and in field sheets as necessary.

6.3 Gamma Radiation Survey Procedures

The survey equipment for measuring gamma radiation activity consists of a paired Ludlum Model 44-20 (3x3) detector and a 2221 or 2241 meter linked to a VIPER system which will have operational checks conducted before field activities begin according to FOPs 1, 4, and 5. Performance of the radiation survey equipment will be verified throughout the field activities through operational checks and background checks as necessary. Whenever possible, the same paired gamma activity survey system will be used for all surveys conducted at the site.

The paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241 meter linked to a VIPER system will be mounted 6 inches from the ground surface on a 3-foot wide push cart. The VIPER system and GIS will be used for geospatial information collection and analysis. ERT's SERAS will train START on site, provide technical support, and operate VIPER during the field activities. Real-time *in situ* surface soil survey will consist of 3-foot wide transects covering 100 percent of the survey area at a pace of 1 to 2 feet per second. If an immovable obstruction is encountered during the survey it will not be moved, and the scanning survey will be performed around the feature. Survey will stop at 10 feet around the open shaft.

Gamma radiation activity measurements will be used to determine soil sample locations at the site. If gamma radiation activity measurements along the perimeter of the site exceed the investigation level, lateral step-out will consist of 3-foot wide transects to a maximum of 10 feet beyond the site boundary. Static 1-minute scans of gamma radiation activity at surface soil locations will be used to establish the relationship between gamma radiation activity and Ra-226 concentration in surface soil.

For the home site, gamma radiation activity will be measured in surface soil surrounding the residential structures and the floor surfaces inside the residential structures. A minimum of a ½-acre surface soil area surrounding each residential structure or within the approximate property boundary of the home site; and inside each residential structure at the home site will be surveyed. If the residential structure layout within a home site boundary exceeds ½ acre then professional judgment will be used to ensure surface soil is appropriately screened. The activity of gamma radiation will be measured in surface soil and floor area inside each structure with coverage of 100 percent of accessible areas. If an object is encountered during the survey it will not be moved, and the scanning survey will be performed surrounding the object. For the residential structure floor surface survey, a Ludlum Model 44-20 (3x3) detector paired with a 2221 or 2241 meter will be positioned 6 inches above the floor, and moved in a serpentine motion at a scan rate of 1 to 2 feet per second. Transects will be surveyed from one wall to the opposite wall until 100 percent of the accessible areas is scanned. If the investigation level is exceeded then the extent of the elevated measurements will be determined and documented; that is, the dimensions of the elevated area and a sketch of the area on a structure diagram. The approximate average gamma radiation activity will be recorded for each room in the structure. All measurements will be documented on a survey form. Details on measurement collection are provided in FOP 1, Radiation Scanning Survey; and operation of Ludlum Model 44-20 in FOP 5 and Ludlum Model 2221 in FOP 6.

6.4 Soil Sampling Procedures

6.4.1 Surface Soil

Surface soil locations will be determined based on gamma radiation activity measurements collected in the field. Surface soil sample locations will be located in the field using a GPS unit pre-loaded with the GIS-assigned coordinates and marked with a flag. Static 1-minute scans of gamma radiation activity will be conducted at each surface soil location.

Discrete surface soil samples will be collected at 0 to 2 inches bgs. Surface soil samples will be collected using a stainless-steel trowel and placed into a 4-ounce plastic jar. If present, non-soil material including rocks larger than about ½-inch median diameter will be removed from the soil sample. Sample jars will be stored in a cooler according to the laboratory requirements in Table 5-1. Samples will be shipped to the laboratory for Ra-226 analysis using the EML HASL 300 4.5.2.3 method at the end of field activities. Sampling equipment will be decontaminated after every sample according to Section 6.5. A maximum of 30 surface soil samples (site and background) will be collected from the site.

All sample locations will be recorded in the field logbook as sampling is completed. Each field sampling team will document each individual sampling location in the logbook, which includes: the site name, where the sample was collected with a representative sketch of the area, GPS coordinates of the sample location, date, time, sample identification (ID), sampling team members, and photographs taken.

6.4.2 Subsurface Soil
Subsurface soil samples will be collected from locations of the highest gamma radiation activity results based on the 100 percent scan of the site. Soil samples will be collected down to 3 feet bgs (or less based on refusal or groundwater) at 1-foot depth intervals bgs. Subsurface samples will be collected from each depth in clustered boreholes i.e., one sample from a 1-foot deep borehole, one sample from a 2-feet deep borehole, and one sample from a 3-feet deep borehole, to minimize soil from shallower depths from being collected with the subsurface sample. The number of subsurface samples collected will be initially based on 10 percent of the highest documented gamma radiation activity locations but may vary based on field data. Additional subsurface soil samples may be collected based on field observations as determined by the EPA FOSC.

Subsurface samples will be collected using either a shovel or a hand auger according to Environmental Response Team SOP #2012 and placed into a 4-ounce plastic jar. If present, non-soil material including rocks larger than about ½-inch median diameter will be removed from the soil sample. Sample jars will be stored in a cooler according to the laboratory requirements in Table 5-1. Samples will be shipped to the laboratory for Ra-226 analysis using the EML HASL 300 4.5.2.3 method at the end of field activities. Sampling equipment will be decontaminated after every sample according to Section 6.5.

All sample locations will be recorded in the field logbook as sampling is completed. Each field sampling team will document each individual sampling location in the logbook, which includes: the site name, where the sample was collected with a representative sketch of the area, GPS coordinates of the sample location, date, time, sample ID, sampling team members, and photographs taken.

6.5 Exposure Rate Measurement
The PIC will be provided and calibrated by ERT who will be on site during the home site assessment. Daily instrument check will be conducted by START according to procedures established for the Navajo Home Site Assessments. Static exposure rate measurements will be collected inside each room of every accessible structure. In the center of each room, or closest location if obstructed, a General Electric Reuters-Stokes High PIC RSS 131 will be placed 1 meter above the floor, and measurements will be collected every second and logged for 5 minutes. The PIC measurements in mR/hr will be collected to represent the statistically-based average exposure rate in each room. The exposure rate will be used to determine the dose to a resident if the room were occupied, for comparison to dose risk ranges.

6.6 Decontamination Procedures
Decontamination activities will be conducted by START according to E & E SOP #3.15. All non-dedicated sample-handling devices will be decontaminated by non-phosphate detergent and tap water wash using a brush to scrub solids from the surface as necessary, and distilled water rinse; or non-chemical moist wipes.

7 Disposal of Investigation-Derived Waste

In the process of collecting environmental samples at this site, several different types of potentially contaminated investigation-derived wastes (IDW) will be generated, including the following:

- Used personal protective equipment (PPE)
- Disposable sampling equipment
- Decontamination fluids

The EPA's National Contingency Plan requires that management of IDW generated during site investigations comply with Applicable or Relevant and Appropriate Requirements s (ARARs) to the extent practicable. This sampling plan will follow the Office of Emergency and Remedial Response Directive 9345.3-02 (EPA 1991), which provides the guidance for management of IDW during site investigations. Listed below are the procedures that will be followed for handling IDW. The procedures are flexible enough to allow the site investigation team to use its professional judgment on the proper method for the disposal of each type of IDW generated at each sampling location.

- Used PPE and disposable sampling equipment will be scanned for elevated gamma radiation activity using a 3x3 or pancake detector. PPE and other disposable items less than 2 to 3 times background gamma radiation activity will be double-bagged in plastic trash bags and disposed of as municipal waste. These wastes are not considered hazardous and can be sent to a municipal landfill. Any PPE or dedicated equipment that is to be disposed of that can still be reused will be rendered unusable before disposal.
- Decontamination fluids which may consist of water with site materials and/or non-phosphate detergent will be placed in the highest contaminated area that will not drain from the site according to standard practice at similar sites.

8 Sample Identification, Documentation, and Shipment

8.1 Sample Nomenclature

For survey location data using the VIPER system each measurement will have a unique geospatial coordinate. Exposure rate data from the PIC will be identified by the home site name and the room where the measurement was taken. Floor locations within a home site structure where gamma radiation activity measurements exceed the investigation level will be noted in a field log book. The floor scan measurement data will identified by the home site name, the name of the room where measurement was taken, the location within the room and the area of the elevated measurement.

A unique, identifiable name will be assigned to each sample. Samples will be identified according to the following nomenclature:

[Site Name]-[Sample Description]-[Sample Number]-[Sample Depth]
Where:

> Site Name – AUM32
> Sample Description – S will designate soil and BKG will designate background
> Sample Number – Number representing the specific sampling location where the sample was collected starting with 01.
> Sample Depth – Sample depth will be identified in inches bgs e.g., 02

For example, the first background sample collected from surface soil (0 to 2 inches bgs) will be identified as follows:
AUM32-BKG-01-02

Field duplicate samples will have the same designations as their originals except the sampling location will be preceded by a "1" thus, the field duplicate for the above examples will be AUM32-BKG-101-02.

8.2 Container, Preservation, and Holding Time Requirements

All sample containers will be delivered by the laboratory to START in a pre-cleaned condition. Container, preservation, and holding time requirements are summarized in Table 5-1.

8.3 Sample Labeling, Packaging, and Shipping

All samples collected will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory. Sample labels will be affixed to the sample containers and will contain the following information:

- Sample number
- Date and time of collection
- Site name
- Analytical parameter and method of preservation

Samples will be stored in a cooler in the custody of site personnel at all times or in a secure location on site pending shipment to the laboratory after the field activities.

The procedures for shipping soil samples are:

- If ice is used then it will be packed in double zip-lock plastic bags.
- The drain plug of the cooler will be sealed with tape to prevent melting ice from leaking.
- The bottom of the cooler will be lined with bubble wrap to prevent breakage during shipment.
- Screw caps will be checked for tightness.
- Coolers will have custody seals affixed so as to prevent opening of the container without breaking the seal.
- All glass sample containers will be wrapped in bubble wrap.
- All containers will be sealed in zip-lock plastic bags as necessary.

All samples will be placed in coolers with the appropriate chain-of-custody forms. All forms will be enclosed in plastic bags and affixed to the underside of the cooler lid. If samples require refrigeration during shipment then bags of ice will be placed on top of and around samples. Empty space in the cooler will be filled with bubble wrap or other appropriate packaging material to prevent movement and breakage during shipment. Each cooler will be secured with a custody seal and will be taped shut with packing or strapping tape.

Samples will be shipped for immediate delivery to the contracted laboratory. Upon shipping, the laboratory will be notified of the following:

- Sampling contractor’s name
- The name of the site
- Shipment date and expected delivery date
- Total number of samples, by matrix and the relative level of contamination for each sample (i.e., low, medium, or high).
- Carrier; air bill number(s), method of shipment (e.g., priority)
- Irregularities or anticipated problems associated with the samples
- Number of coolers or packages shipped

8.4 Chain-of-Custody Forms and QA/QC Summary Forms

A chain-of-custody form will be maintained for all samples to be submitted for analysis, from the time the sample is collected until its final disposition. Every transfer of custody must be noted and a signature affixed. Corrections on sample paperwork will be made by drawing a single line through the mistake and initialing and dating the change. The correct information will be entered above, below, or after the mistake. When samples are not under the direct control of the individual responsible for them, they must be stored in a container sealed with a custody seal. The chain-of-custody form must include the following:

- Site name
- Sample identification numbers
- Sample date and time
- Number and volume of sample containers
- Required analyses
- Signature and name of samplers
- Signature(s) of any individual(s) with control over samples
- Note(s) indicating special holding times and/or detection limits

The chain-of-custody form will be completed and sent with the samples for each laboratory and each shipment. Each sample cooler should contain a chain-of-custody form for all samples within the sample cooler.

9 Quality Assurance and Control

9.1 Field Quality Control Samples

QA/QC samples to be collected during this sampling are listed in Table 5-1 and described in the following subsections. QA/QC described in the following sections pertains to samples collected for laboratory analysis to obtain definitive data and do not pertain to field measurements. QA/QC relevant to field measurement data is described in instrument FOPs and discussed in section 5.1.

9.1.1 Assessment of Field Contamination (Blanks)

Non-dedicated equipment such as stainless steel trowels, shovels and hand augers are used to collect samples, equipment rinsate blanks will be collected at a rate of one per day to evaluate field decontamination procedures. Equipment rinsate blank consists of a sample of analyte-free water passed through or over a decontaminated sampling device into a 500 milliliter plastic bottle. A sample of the analyte-free water (i.e., distilled water) used for decontamination will also be sent to the laboratory.

9.1.2 Assessment of Sample Variability (Field Duplicate or Co-located Samples)

Duplicate soil samples will be collected at selected sample locations. These locations will be chosen randomly in the field and will be collected at a rate of 1 for every 10 field samples. The duplicate sample will be obtained by splitting the homogenized sample collected from the soil location. The duplicate sample will be placed in a 4-ounce plastic jar and labeled accordingly.

9.1.3 Laboratory Quality Control Samples

Analyses for radioisotopes do not typically have MS/MSD requirements; therefore, none will be performed.

9.1.4 Confirmation Samples

The samples submitted to the laboratory for definitive analysis will be used to establish and/or document the comparability and correlation between field screening and laboratory data. START will determine correlation of the data sets by linear regression analysis and will determine relative percent differences for each data pair and for the data sets as a whole. Confirmation samples will determine the usefulness of the field screening technique in future activities at the site.

9.2 Analytical and Data Package Requirements

It is required that all samples be analyzed according to the methods listed in Table 5-1. The laboratory is required to supply documentation to demonstrate that their data meet the requirements specified in the method. Since the Ra-226 determination requires a 21-day ingrowth period prior to analysis, the preliminary results will be delivered to START within 4 weeks of sample delivery. A complete analytical data package will be required from the analytical laboratory 30 working days after sample delivery. The laboratory will also provide all data electronically in a Microsoft Excel-compatible format or delimited text file in the format specified for SCRIBE. The data validator will provide a full validation data package to the START PM within 15 days after receipt of complete analytical data package from the laboratory.

All field measurements and QA/QC information will be documented in log books, field forms, and spreadsheets or may be directly downloaded into a database.

Deliverables for this project must meet the guidelines in EPA Region IX's *Laboratory Documentation Requirements for Data Evaluation, R9/QA/00.4.1* (EPA 2001). The following data requirements specify and emphasize general documentation requirements and are not intended to supersede or change requirements of each method.

- A copy of the chain-of-custody, sample log-in records, and a case narrative describing the analyses and methods used.
- Analytical data (results) for up to three significant figures for all samples, method blanks, MS/MSD, Laboratory Control Samples (LCS), duplicates, Performance Evaluation samples (if applicable), and field QC samples.
- QC summary sheets/forms that summarize the following:
  - MS/MSD/LCS recovery summary
  - Method/preparation blank summary
  - Initial and continuing calibration summary (including retention time windows)
  - Sample holding time and analytical sequence (i.e., extraction and analysis)
  - Calibration curves and correlation coefficients
  - Duplicate summary
  - Detection limit information
- Analyst bench records describing dilution, sample weight, percent moisture (solids), sample size, sample extraction and cleanup, final extract volumes, and amount injected.
- Standard preparation logs, including certificates of analysis for stock standards.
- Detailed explanation of the quantitation and identification procedure used for specific analyses, giving examples of calculations from the raw data.
- The final deliverable report consisting of sequentially numbered pages.

9.3 Data Management

Data collected during the removal assessment will consist of field and laboratory data. Field activities and sample information will be documented in a logbook as discussed in Section 6.1.4. Field and laboratory data including gamma radiation measurements, Ra-226 sample results, and location coordinates, will be loaded in SCRIBE. Electronic data will be managed as described in the data management plan. All data including logbook, complete analytical and validation data packages, photographs, and electronic data will be archived by START. The laboratory data summary and validation reports will be included in the final report submitted to EPA.

9.4 Data Validation

Data validation will be performed by START or their subcontractor according to the *EPA Region IX Superfund Data Evaluation/Validation Guidance R9QA/006.1* (EPA 2001).

The standard data quality review requirements of a Tier 2 validation of 100 percent of the data (as defined in *Requirements for Quality Assurance Project Plans* [EPA 2001]) will satisfy the data quality requirements for this portion of the project. Upon completion of validation, data will be classified as one of the following: acceptable for use without qualifications, acceptable for use with qualifications, or unacceptable for use.

If during or after the evaluation of the project's analytical data it is found that the data contain excess QA/QC problems or if the data do not meet the DQI goals, then the independent reviewer may determine that additional data evaluation is necessary. Additional evaluation may include EPA Region IX Superfund Data Evaluation/Validation Guidance R9QA/006.1 for evaluation Tier 3.

To meet evaluation and project requirements, the following criteria will be evaluated during a Tier 2 evaluation:

- Data package completeness
- Laboratory QA/QC summaries
- Holding times
- Blank contamination
- Matrix related recoveries
- Field duplicates
- Random data checks
- Preservation and holding times
- Initial and continuing calibration
- Blank analyses
- Interference check samples
- Laboratory control samples
- Duplicate sample analysis
- Matrix spike sample analyses
- Sample serial dilution
- Field duplicate/replicate
- Overall assessment of data.

Upon completion of evaluation, an analytical data evaluation Tier 2 review report will be delivered to the project manager, and the data will be classified within the report as one of the following:

- acceptable for use without qualifications
- acceptable for use with qualifications
- unacceptable for use

The data with applicable qualifications will be attached to the report. Unacceptable data may be more thoroughly examined to determine whether corrective action could mitigate data usability.

9.5 Field Variances

As conditions in the field may vary, it may become necessary to implement minor modifications to this plan. When appropriate, the START QA Coordinator and the EPA FOSC will be notified of the modifications and a verbal approval obtained before implementing the modifications. Modifications to the original plan will be recorded in site records and documented in the final report.

9.6 Assessment of Project Activities

9.6.1 Assessment Activities

The following assessment activities will be performed by the START:

- All project deliverables (SAP, Data Summaries, Data Validation Reports, Removal Assessment Report) will be peer-reviewed by START prior to submission to EPA. In time-critical situations, the peer review may be concurrent with the release of a draft document to EPA.
- The START QA Coordinator will review project documentation such as logbooks and chain-of-custody forms to ensure the SAP was followed and that sampling activities were adequately documented. The START QA Coordinator will document deficiencies, and the START PM will be responsible for corrective actions.

9.6.2 Project Status Reports to Management

It is standard procedure for the START PM to report to the EPA FOSC any issues, as they occur, that arise during the course of the project that could affect data quality, data use objectives, the project objectives, or project schedules. As requested by EPA, START will provide unvalidated data as they are received from the laboratory.

9.6.3 Reconciliation of Data with DQOs

Assessment of data quality is an ongoing activity throughout all phases of a project. The following outlines the methods to be used by START for evaluating the results obtained from the project.

Review of the DQO outputs and the sampling design will be conducted by the START QA Coordinator prior to sampling activities. The reviewer will submit comments to the START PM for action, comment, or clarification. This process will be iterative.

A preliminary data review will be conducted by START. The purpose of this review is to look for problems or anomalies in the implementation of the sample collection and analysis procedures and to examine QC data for information to verify assumptions underlying the DQO and the SAP.

10 References

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U.S. Department of Energy. 1990. EML Procedures Manual, HASL-300, 27th Edition, Volume 1, Environmental Measurements Laboratory, 376 Hudson Street, New York, NY 10014-3621.

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Navajo Nation Environmental Protection Agency (NNEPA) and EPA. 2010. *Background Location Selection Criteria*. April.

Weston Solutions Inc., 2009. *Navajo Nation Abandoned Uranium Mine Site Screen Report – Section 32 AUM Site, Navajo AUM Eastern Region*, May.

A Data Quality Objective Process Document

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, REGION 9 DATA QUALITY OBJECTIVES FOR TRONOX ABANDONED URANIUM MINE SECTION 32, EASTERN AGENCY REMOVAL ASSESSMENT

STEP 1.

THE PROBLEM

Background

The United States Environmental Protection Agency (EPA) tasked Ecology and Environment, Inc.'s (E & E's) Superfund Technical Assessment and Response Team (START) to support a removal assessment of Tronox Abandoned Uranium Mine (AUM) Section 32 (site) located approximately 1 mile east of County Road 19, Prewitt, McKinley County, New Mexico (Latitude: 35° 29' 26.7576" N, Longitude: -108° 1' 2.7798" W). The site was a mine reportedly owned by Cobb Nuclear and was closed due to a fatality (Weston Solutions, Inc., *Navajo Nation Abandoned Uranium Mine Site Screen Report, Section 32 AUM Site, Navajo AUM Eastern Region,* May 2009). No other information on historical ownership of the mine and mining operations were available. The site is an allotment land with an estimated area of 12,103 square meters containing an unsecured shaft and an undetermined extent of underground workings. No waste piles, other mine features, or visible signs of reclamation were reported.

A site screening, which included collection of gamma radiation survey data, was conducted in 2009 (Weston 2009). Gamma radiation activity was measured from surface soil along the boundary of the site and along two diagonal intersecting transects from the site's four corners. Gamma radiation activity measurements ranged from 10,689 counts per minute (cpm) to 180,367 cpm. Gamma radiation activity was also measured from a background location which was not identified in the report. The gamma radiation activity at the background location ranged from 16,630 cpm to 17,128 cpm.

The site was identified as an AUM and gamma radiation activity in surface soil was detected at levels up to 10 times the reported background level. Gamma radiation activity in surface soil at the site may pose an imminent and substantial threat to human health. The lateral and vertical extent of gamma radiation in soil needs to be defined to support the EPA Task Monitor in determining whether a removal action is necessary to protect human health.

In addition, a resident lives approximately 0.5 mile west of the site and reportedly used some materials (tarps and lumber) obtained from the mine. Gamma radiation measured from the residence during the site screening was approximately 12,000 cpm (Weston 2009). A home site assessment will also be conducted to determine if radiation is present in the residential structures and whether a removal action is necessary to protect human health.

Planning Team

Primary Decision Maker:	EPA Task Monitor/Federal On-Scene Coordinator Randy Nattis
Plan Development:	START and the EPA Task Monitor

Plan Approval:	EPA Task Monitor
On-Scene Assistance:	EPA Task Monitor, START, EPA Emergency Response Team (ERT)'s Scientific, Engineering, Response, and Analytical Services (SERAS) contractor
Potential On-Scene Assistance:	Navajo Nation representative
Supplemental Off-Site Support:	The START response team managers, START quality assurance (QA) manager, START response Readiness Coordinator, START analytical service provider, START Radiological Assessment Adjunct, EPA ERT, EPA Emergency and Rapid Response Services (ERRS) contractor, and EPA Region 9 equipment warehouse

The names and affiliations of the actual planning team will be documented in the field logbook or in the sampling and analysis plan (SAP).

Conceptual Site Model

Based on previously documented elevated gamma radiation levels in surface soils, historical mining at the site may have released technologically-enhanced, naturally-occurring radioactive materials (TENORM), specifically uranium and its decay products. Based on EPA investigations at other AUM sites, the vertical extent of TENORM and elevated gamma radiation is expected to extend less than 3 feet below ground surface (bgs). The EPA Task Monitor determined that radium-226 (Ra-226) is the contaminant of potential concern in soil at the site.

Soil is the primary media of concern in this removal assessment. Surface water was not observed at or within the influence of the site; however, available geographical information show a stream or river located north and south of the site which converges approximately 0.25 mile west of the site, and two ponds are located northeast of the site. Groundwater depth and information on nearby water wells used for drinking water were not available. Agricultural food production such as livestock grazing or farming common in Navajo communities was not observed at or immediately adjacent to the site. The site is currently an open space with sparse vegetation.

Materials from the mine potentially used as building materials for residential structures may expose residents to radiation.

Exposure Scenario

Current exposure pathways considered in this assessment include direct exposure of human receptors to gamma radiation at the site. Receptors may also be exposed through ingestion, dermal contact, and inhalation of uranium and its decay products; and metals in soil, air, and water.

The open shaft, which is approximately 20 feet in diameter, poses a physical hazard at the site. Current potential human receptors include nearby residents located less than 0.5 mile from the site.

Resources

The planning and preparation are administered and implemented by the EPA Region 9 staff and their supporting START contractors. All site-specific planning activities are under the direction of the EPA Task Monitor.

This is a removal assessment under the technical direction of the EPA Task Monitor. Initial labor resources include:

- The responding EPA Task Monitor, who will oversee all data collection and operations related to the time-critical response.
- START personnel
- EPA ERT and its SERAS contractors

Analytical service resources include the following:

- Real-time field radiation monitoring will be performed by START and SERAS personnel.
- START analytical service provider will analyze collected samples.

START's initial budget for this time-critical response is $71,482.78.

Resource Constraints

The use of non-routine radiation screening instruments and equipment will require training or experienced personnel.

Availability of EPA-owned radiation screening equipment is dependent on other ongoing EPA projects requiring similar resources.

STEP 2.

THE DECISION

Principal Study Questions

1. Is Ra-226 present in surface soil at concentrations that exceed the action level and what is the lateral extent of contamination?
   a. Can the concentration of Ra-226 in surface soil be estimated from measurements of gamma radiation activity in surface soil through real-time surface scans (as it has at other AUM sites)?
   b. Can a suitable background location be identified so that a site-specific action level based on background levels can be calculated?
2. Does contamination extend to subsurface soil at locations where surface Ra-226 levels exceed the action level?
3. Do radiation levels at the home site exceed the home site investigation levels?
   a. Is the gamma exposure rate level inside the residential structure above the exposure investigation level?
   b. Is the gamma radiation activity measured in floor surface and surface soil at the home site above the home site investigation level?

Actions that Could Result from the Resolution of Study Questions

Question 1

If the concentration of Ra-226 in surface soil at the site is above the action level then the EPA may initiate or order the removal of contaminated areas.

If the concentration of Ra-226 in surface soil is at or below the action level then no further action may be required.

- If a correlation between Ra-226 concentrations in soil and gamma radiation activity measured through real-time surface scans can be verified then activity measurements will be used to characterize the site.
- If a correlation between Ra-226 concentrations in soil and gamma radiation activity measured through surface scans cannot be verified then further soil sampling may be required to characterize the site.
- If a suitable background area can be identified then measurements from the identified area will be used to calculate a site-specific action level.
- If a suitable background area cannot be identified then another method of establishing an action level will be determined.

Question 2

If the concentration of Ra-226 in the subsurface soil exceeds the action level at locations where the surface concentration also exceeds the action level, then the EPA may initiate or order the removal of contaminated areas.

If the concentration of Ra-226 in the subsurface soil exceeds the action level at locations where the surface concentration also exceeds the action level, then the EPA may require further investigation.

If the concentration of Ra-226 in subsurface soil is at or below the action level then no further action may be required.

Question 3

If the radiation levels at the home site exceed the home site investigation level then the EPA may initiate or order a removal action.

- If the radiation exposure rate level inside a residential structure is above the home site investigation level then the contaminated structure(s) may be removed.
- If the gamma radiation activity measured in floor surfaces and/or surface soil at the home site is above the home site investigation level then contaminated materials may be removed.

If the radiation levels in the home site are at or below the investigation level for the home site then no further action may be required.

Decision Statements (Directives)

Directive 1

Determine whether, and in what areas, site concentrations of Ra-226 in surface soil require removal, further assessment, or no further action.

- Determine whether gamma radiation activity readings can be used to characterize the site or if further sampling to characterize the site is necessary.
- Determine a suitable background location for collecting data to calculate a site-specific action level or identify an alternate means of setting an action level.

Directive 2

Determine whether site concentrations of Ra-226 in subsurface soil at locations where the surface levels of Ra-226 are elevated require removal, further assessment, or no further action.

Directive 3

Determine whether gamma exposure levels inside residential structure require removal of the structure or no further action.

Determine whether gamma radiation activity in floor surfaces and/or surface soil around the home site require removal or no further action.

STEP 3.
DECISION INPUTS

Specific Data Required

- Field data to establish a background level of gamma radiation from an area with similar geology and topography and no known or suspected impacts from mining.
- Field data from measuring gamma radiation activity in surface soil at the site.
- Definitive analytical data for concentrations of Ra-226 in soil.
- Risk-based investigation and action levels for the site.
- Global Positioning System (GPS) data for all gamma radiation activity measurement locations and soil sampling locations.
- Field data from measuring radiation exposure rate level in residential structures at the home site.
- Field data from measuring gamma radiation activity in floor surface and surface soil at the home site.

Sources for Study Information

- *Navajo Abandoned Uranium Mine Site Screen Report, Section 32 AUM Site, Navajo AUM Eastern Region* (Weston 2009).
- Site information collected during the removal assessment including geographical information data and photographs.
- Field data generated during the removal assessment including real-time radiation survey and soil sampling.
- Definitive analytical data generated during the removal assessment.
- EPA Radiation PRG

Information Needed to Establish Investigation and Action Levels

Dose limits and investigation levels will be established by EPA and other federal agencies. EPA Radiation PRG is available for various radioisotopes in soil, air, tap water, and fish. The following references are useful in establishing investigation and action levels for a time-critical radiation situation.

- OSC Radiological Response Guidelines, EPA OSWER and OAR, October 2006.
- Manual of Protective Action Guides (PAGs) and Protective Actions for Nuclear Incidents, EPA 400-R-92-001, May 1992.
- EPA Region 9, 2006 Emergency Response Readiness Training Guide.
- Preliminary Remediation Goals for Radionuclides, http://epa-prgs.ornl.gov/radionuclides/.

- Technology Screening Guide for Radioactively Contaminated Sites, EPA 402-R-96-017, November 1996.
- Soil Screening Guidance for Radionuclides
  - Soil Screening Guidance for Radionuclides: Technical Background Document, EPA/540-R-00-007, October 2000.
  - Soil Screening Guidance for Radionuclides: User's Guide, EPA/540/R95/128, October 2000.
- Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), EPA 402-R-97-016, August 2000.
- Decommissioning Handbook, DOE/EM-0383, January 2000.
- RESRAD Family of Codes, Argonne National Laboratory, DOE, http://web.ead.anl.gov/resrad/home2/
- EPA OSWER Guidance
  - Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination, EPA OSWER Directive 9200.4-18, August 22, 1997.
  - Use of Soil Cleanup Criteria in 40 CFR Part 192 as Remediation Goals for CERCLA Sites, EPA OSWER Directive 9200.4-25, February 12, 1998.
  - Remediation Goals for Radioactively Contaminated CERCLA Sites Using the Benchmark Dose Cleanup Criteria in 10 CFR Part 40 Appendix A, I, Criterion 6(6), EPA OSWER Directive 9200.4-35P, April 11, 2000.
  - Use of Uranium Drinking Water Standards under 40 CFR 141 and 40 CFR 192 as Remediation Goals for Groundwater at CERCLA Sites, EPA OSWER Directive 9283.1-14, November 6, 2001.
  - Interim Final Evaluation of Facilities Currently or Previously Licensed NRC Sites under CERCLA, OSWER Directive 9272.0-15P, February 17, 2000.

Confirm that Measurement Methods Exist to Provide Data

Field instrumentation and measurement methods for radiation monitoring are numerous and have varying detection limits. The same paired Ludlum 44-20 detector and 2221 or 2241 meter will be used in all radiation surveys at the site as practicable. The Ludlum Model 44-20 utilizes a Teledyne Integral Detector assembly containing a 3-inch diameter by 3-inch thick sodium iodide (NaI[T1]) crystal optically coupled to a photomultiplier tube. The detector is compatible with general purpose survey meters, rate meters, and scalers for high-energy gamma detection (approximately 60 kiloelectronvolts [eV] to 2 MeV range) such as the Ludlum Model 2221. The detector provides high sensitivity for surveying typically 2,300 cpm per microRoentgen per hour (based on Cesium-137 gamma) and pulse height discrimination. Quantity measurements are in cpm, which under certain circumstances can be converted to disintegrations per minute (dpm) or curies (Ci).

Laboratory analytical methods that more accurately determine radionuclide concentrations in units of picocuries per gram (pCi/g) in various media are published by EPA and U.S. Department of Energy (DOE). Ra-226 will be analyzed using the EML HASL 300 4.5.2.3 Method (DOE, *EML Procedures*

Manual, HASL-300, 27th Edition, Volume 1, Environmental Measurements Laboratory, 376 Hudson Street, New York, NY 10014-3621, 1990). This method is applicable to nuclides emitting gamma rays with energies greater than 20keV for germanium detectors Ge(Li)) and 50 keV for NaI(T1) detectors and has a minimum detectable activity of 0.5 pCi/g for Ra-226. This method is a modification of EPA method 901.1 and is the preferred technique for measuring Ra-226 and 228 simultaneously in solid material.

Pressurized ionization chambers (PIC) is the industry standard for measuring low-level exposure rate because of its relatively flat energy response across a wide gamma energy range. Detector response is not expected to be affected by power supply voltage bias at the exposure rate range of interest. PIC response is a linear function of the exposure rate within a range of background to 9,000 milliRoentgen per hour (mR/hr). PIC response as a function of exposure rate has less than 25 percent variation for greater than 75 keV or high energy gamma radiation.

Field instrumentation, field procedures, and laboratory analytical methods used for this project are specified in the SAP.

STEP 4.

STUDY BOUNDARIES

Specify Characteristics that Define the Population Being Studied

- Gamma radiation activity at 6 inches above the ground surface of the background area, site, and home site.
- Ra-226 concentration in surface soil (0 to 2 inches bgs) at the background area and the site.
- Ra-226 concentration in subsurface soil down to 3 feet bgs at locations at the site where gamma radiation activity exceeds the action level.
- Radiation exposure rate level at 1 meter above the ground surface and within a 10 x 10 feet area.

Geographic Boundary of Investigation

- The site is approximately 12,103 square meters. The investigation includes the site area and may be extended to a maximum of 10 feet laterally from the site perimeter based on the real-time gamma radiation activity measured at the perimeter.
- The vertical investigation boundary for the site will be approximately 3 feet bgs or less based on site conditions.
- Inside each residential structure at the home site, and a minimum of a ½-acre surface soil area surrounding each residential structure or within the approximate property boundary of the home site. If the residential structure layout within a home site boundary exceeds ½ acre then professional judgment will be used to ensure surface soil is appropriately screened.

A background area will be selected using the following criteria from *Background Location Selection Criteria* (NNEPA and EPA 2010):

- Similar elevation as the site
- Similar geology as the site. Avoid areas of naturally-occurring uranium.
- Upwind (gradient, stream) from site
- Undisturbed with natural vegetation
- Not in drainage or area impacted by flooding
- Distance to residential structures (structures should be within range of vision)
- Accessible (by vehicle and equipment)
- Should not be near a mine site or similar contaminant source
- If possible, avoid anthills and rodent holes
- Ask nearby residents about area

Temporal Boundary of Investigation

- The half-life of Ra-226 is 1,600 years. Soil data is not expected to change during the removal assessment which may take up to 90 days from sample collection to final report submittal.
- The investigation was scheduled in the dry season when the site is accessible and field work is feasible.
- Due to physical processes such as erosion and migration the extent of the contamination may expand. These physical processes could also change contamination levels once the extent has been defined.
- Widespread mining and milling of uranium ore on Navajo tribal lands since the 1940s led to a legacy of AUMs. Data is not available during mine operations at the site or since the mine closed to present. Data collected from the site during this assessment may not represent the highest concentrations historically present in soil at the site due to physical processes such as erosion and migration through the years.
- Data collected during the investigation represent current site conditions and does not consider future development such as soil mixing and changes to the residential structure.
- The exposure rate level is based on a single 5-minute measurement in each residential structure.
- The action level for Ra-226 is based on PRG which considers long-term health risk.

Scale of decision-making

Decisions will apply to the entire site unless decision units are established based on data.

For the home site, each residential structure is a decision unit and surface soil surrounding the residential structures is considered one decision unit unless modified based on data.

Practical Constraints on Data Collection

Physical Constraints:

- The sampling areas are in a relatively remote location, which will require additional planning and logistical effort to get resources to the site.
- Weather conditions such as thunderstorms, extreme heat, and high winds may require halting of field work.
- Health and safety of staff including lighting conditions and fatigue will limit sampling days to daylight hours and to a maximum of 12 hours per day.
- Topographical features may limit or prevent the collection of useful data, especially for gamma radiation activity measurements. Data collection will stop at 10 feet around the open shaft at the site.
- Site features, such as the open shaft, present fall and/or confined space hazards and assessment of these areas is beyond the scope of the current assessment.
- Residential structures in the home site may be inaccessible.
- Civil constraints, such as legal site access and unfriendly neighborhoods, and

presence of livestock or wild animals will be addressed on site and by direction of the EPA Task Monitor.

Other Constraints:

- There is no universal field monitoring instrument capable of providing qualitative, quantitative, and exposure data for all types of radiation. Knowledge of the source is necessary for the selection of the appropriate field measurement instruments.

STEP 5.

DECISION RULE

Statistical Parameter

The mean and standard deviation (SD) of the gamma radiation activity measurements in the background area will be used to determine if the background area is suitable to use for developing investigation levels for surface gamma radiation activity, action level for Ra-226 soil concentrations, and exposure rate investigation level for the home site. The r^2 is the statistical parameter of interest for predicting Ra-226 concentration based on gamma radiation activity in surface soil using linear regression.

Investigation and Action Levels

Under the direction of the EPA Task Monitor, the investigation level for gamma radiation activity in surface soil at the site will be based on gamma radiation activity measured in surface soil from the established background area. The action level for Ra-226 in soil at the site will be based on the sum of the background concentration of Ra-226 in surface soil and the EPA PRG of 1.21 pCi/g for residential soil based on an estimated excess cancer risk of 1 in 10,000 (10^{-4}) for Ra-226 and its radioactive decay chain products (Ra-226+D) (EPA 2010).

For the home site, the investigation level will be an interior dose rate from gamma activity that exceeds a typical background gamma dose rate by 15 millirem per year or more. The interior dose rate and typical background dose rate will be calculated from exposure rate levels collected during the assessment in combination with a risk assessment formula. In addition, an investigation level will be used during the assessment that will trigger extent of exposure or activity surveys. The investigation level for each detector will be calculated for each home site based on the following equation:

$$IL = BG + (10\ x\ SD)$$

where:

IL = Investigation Level

BG = Average of three 1-minute static gamma radiation activity background measurements

SD = Standard deviation of the three background measurements

Decision Rules

Question 1

If the gamma radiation activity measured in surface soil is above the investigation level, then select a surface soil location to determine areas where Ra-226 concentration exceeds the action level and removal or further action may be necessary. Otherwise, collect a surface soil sample to confirm Ra-226 concentration is below the action level and no further action may be required.

If the linear regression analysis of the co-located gamma radiation activity and the Ra-226 concentration data from surface soil yields an $r^2 \approx 1$, then gamma radiation activity readings can be used to characterize the site. Otherwise, further sampling to characterize the site is necessary.

If the mean and SD of the gamma radiation activity measurements in the background area are relatively low, then the gamma radiation activity measurements in the background area will be used to develop investigation levels for surface gamma radiation at the site and home site, surface soil samples will be collected to develop the Ra-226 action level, and background exposure rate will be measured to use in developing the exposure investigation level for the home site. Otherwise, a new background area will be selected or an alternate means of setting investigation and action levels will be identified.

Question 2

If Ra-226 concentration in a surface location exceeds the action level then a subsurface soil sample will be collected to determine if Ra-226 concentration below the elevated location is above the action level. Otherwise, no further action may be required.

Question 3

If the gamma exposure level measured inside a residential structure in the home site is above the exposure investigation level then the structure may require removal. Otherwise, no further action may be required.

If the gamma radiation activity measured in floor surfaces and/or surface soil at the home site is above the home site investigation level then contaminated materials may be removed. Otherwise, no further action may be required.

STEP 6.
LIMITS ON DECISION ERRORS

Range of the Parameters of Interest

Activity Rate

The gamma radiation activity of interest range from below background to over background, but is not expected to exceed 1,000,000 cpm. However, gamma radiation activity from the investigation level to twice the investigation level is the range most susceptible to decision error.

Concentration in Samples

Concentrations of interest of Ra-226 in soil samples are from ½ the action level to any value above the action level. Quantitatively precise and accurate determinations of contaminant concentrations that are significantly above (i.e., >10 times) the action level are not necessary. However, concentration from the action level to twice the action level is the range most susceptible to decision error.

Exposure Rate

The exposure rates of interest range from below background to over background, but they are not expected to exceed 1 mR/hr.

The Null Hypothesis or Baseline Condition

The parameter of interest (gamma radiation activity, Ra-226 concentration in soil, or exposure rate) exceeds the investigation or action level.

Alternative Hypothesis

The parameter of interest (gamma radiation activity, Ra-226 concentration in soil, or exposure rate) does not exceed the investigation or action level.

DECISION ERRORS		
Decision Error	Deciding that a decision unit is contaminated and requires further action when the decision unit is not contaminated.	Deciding that a decision unit is not contaminated and requires no further action when the decision unit is contaminated.
True Nature of Decision Error	The activity measurement, sample concentration, or exposure rate is either not representative or biased high.	The activity measurement, sample concentration, or exposure rate is either not representative or biased low.
The Consequence of Error	Either further evaluation or a removal action will be initiated. The decision will cost EPA Region 9 additional resources of time, money, and labor.	The decision could lead to exposure of the community to a substantial and imminent threat to human health.
Which Decision Error Has More Severe Consequences near the	**LESS SEVERE**	**MORE SEVERE** The error will endanger human health.

DECISION ERRORS		
Investigation or Action Level?		
Error Type **Based on Consequences**	**False Acceptance Decisions** A decision that the decision unit is contaminated when it is not.	**False Rejection Decisions** A decision that the decision unit is not contaminated when it is.
Definitions False Acceptance Decisions = A false acceptance decision error occurs when the null hypothesis is not rejected when it is false. False Rejection Decisions = A false rejection decision error occurs when the null hypothesis is rejected when it is true.		

DECISION ERROR LIMITS GOALS		
True Surface Gamma Radiation Activity or Ra-226 Soil Concentration or Exposure Rate (% of Investigation or Action Level)	**Typical Decision Error Probability Goals (Based on Professional Judgment)**	**Type of Decision Error**
Less than 50	5%	False Acceptance Decisions
50 to <100	Gray area[1]	False Acceptance Decisions
100 to <200	10%[2]	False Rejection Decisions
>200	5%	False Rejection Decisions
The goals in this table are based on professional judgment as relevant to a typical radiation response. 1 Gray Area is where relatively large decision errors are acceptable. 2 The large probability for the decision error is expected when the true contaminant concentrations are between 100% and 200% of the investigation or action level. Decreasing the probability is possible only by significantly increasing sampling number and quality assurance sampling, since sampling and analytical uncertainties and biases cannot be eliminated.		

STEP 7.

DESIGN FOR OBTAINING DATA

Design

The sampling rationale and design was developed under the direction of the EPA Task Monitor and START Program Manager, and based on information from other EPA AUM sites.

Background Area

Background survey, sampling and analysis are required to determine naturally-occurring gamma activity and Ra-226 concentrations in an area with similar geology and no known or suspected impacts from mining. The background area will be selected by the EPA Task Monitor in the field according to the *Background Location Selection Criteria* (NNEPA and EPA 2010). The background area will be easily accessible, an appropriate distance from the site, and historically undeveloped based on visual observation.

Gamma Radiation Activity Investigation Level

A survey unit measuring 20 x 20 feet will be established in the selected background area. Gamma radiation activity in surface soil will be measured using a paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241 meter mounted 6 inches from the ground surface on a 3-foot wide push cart. The VIPER system and geographical information system (GIS) will be used for geospatial information collection and analysis. The surface soil survey will consist of transects spaced 3 feet apart, which will provide 100 percent characterization of the site. The transect width is based on the field of view of the detector which is 3 to 6 feet diameter. The surveyor will walk at a pace of 3 feet per second. The mean and standard deviation (SD) of the gamma radiation activity measurements in the background area surface soil will be calculated to develop the investigation level for gamma radiation activity at the site. An acceptable background area will have a low mean and SD.

Ra-226 Action Level

Surface soil samples will be collected at 0 to 2 inches bgs from the background survey unit and analyzed for Ra-226 by EML HASL 300 4.5.2.3 Method. Eleven samples will be collected at random locations which according to Visual Sampling Plan (VSP) software version 6.2 will provide a 95 percent confidence level that the mean will be within ±1 pCi/g. The sample data will be used to develop the action level for Ra-226. Co-located static gamma radiation activity measurements will also be collected from the surface soil location to establish the relationship between gamma radiation activity and Ra-226 concentration in surface soil.

Exposure Rate Investigation Level

The background exposure rate will be measured using a General Electric Reuter-Stokes High PIC RSS 131 placed 1 meter above the ground surface collecting measurements every second and logging for 5 minutes at 3 individual measurement locations. The background limits will be established based on ±20 percent of the respective average activity rates, determined according to the instrument FOPs. These measurements will serve as background exposure rates to be used in comparison to structure interior exposure rates in the home site assessment.

Site Soil

Gamma radiation activity in surface soil at the site will be measured similar to the background area. A paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241 meter mounted 6 inches from the ground surface on a 3-foot wide push cart will be used to measure gamma radiation activity in surface soil. The surface soil survey will consist of 3-foot wide transects at a pace of 3 feet per second covering 100 percent of the site. If gamma radiation activity measurements along the perimeter of the site exceed the investigation level, lateral step-out will consist of additional 3-foot wide transects to a maximum of 10 feet beyond the site boundary.

Surface soil samples will be co-located with static 1-minute scans of gamma radiation activity to establish the relationship between Ra-226 concentration and gamma radiation activity in surface soil. Surface soil samples will be collected from 0 to 2 inches bgs from locations of gamma radiation activity at or above the investigation level according to the following ranges based on previous AUM sites:

- Investigation level
- Investigation level plus 10,000 cpm (10,000 cpm was established from previous AUM sites to correlate with 1.2 pCi/g of Ra-226)
- Investigation level plus 20,000 cpm
- Investigation level plus 25,000 cpm
- Investigation level plus 30,000 cpm

Surface soil samples will also be collected from areas with gamma radiation activity at or below the investigation level to confirm Ra-226 concentrations at these locations are below the action level. Surface soil samples will be collected from locations within the ranges of interest in each soil type and vegetation cover observed at the site. Additional surface soil samples may be collected based on field observations as determined by the EPA Task Monitor. Based on previous AUM sites, 15 samples have provided correlation of Ra-226 concentration with gamma radiation activity. A maximum of 30 surface soil samples (site and background) will be collected from the site and shipped to the START-contracted laboratory for Ra-226 analysis by EML HASL 300 4.5.2.3 Method.

Subsurface soil samples will be collected to determine the vertical extent of contamination at locations where surface gamma radiation activity exceeds the investigation level. Elevated locations will be determined from gamma radiation activity results of the 100 percent scan of the site. Soil samples will be collected down to 3 feet bgs (or less based on refusal or groundwater) at 1-foot depth intervals bgs. Subsurface samples will be collected from each depth in clustered boreholes i.e., one sample from a 1-foot deep borehole, one sample from a 2-feet deep borehole, and one sample from a 3-feet deep borehole, to minimize soil from shallower depths from being collected with the desired subsurface sample. The number of subsurface samples collected will be initially based on 10 percent of the highest documented gamma radiation activity locations but may vary based on field data. Additional subsurface soil samples may be collected based on field observations as determined by the EPA Task Monitor.

Home Site

The activity of gamma radiation will be measured inside each structure with coverage of 100 percent of accessible areas. If an object is encountered during the survey it will not be moved, and the scanning survey will be performed surrounding the object. A Ludlum Model 44-20 (3x3) detector paired with a 2221 or 2241 meter will be positioned 6 inches above the floor, and moved in a serpentine motion at a scan rate of 1 to 2 feet per second. Transects will be surveyed from one wall to the opposite wall until 100 percent of the accessible areas is scanned. If the investigation level is exceeded then the extent of the elevated measurements will be determined and documented; that is, the dimensions of the elevated area and a sketch of the area on a structure diagram. The approximate average gamma radiation activity will be recorded for each room in the structure. All measurements will be documented on a survey form. Details on measurement collection are provided in Field Operating Procedure (FOP) 1, Radiation Scanning Survey; and operation of Ludlum Model 44-20 in FOP 5 and Ludlum Model 2221 in FOP 6.

Static exposure rate measurements will be collected inside each room of every accessible structure. In the center of each room, or closest location if obstructed, a General Electric Reuter-Stokes High PIC RSS 131 will be placed 1 meter above the floor, and measurements will be collected every second and logged for 5 minutes. The PIC measurements in mR/hr will be collected to represent the statistically-based average exposure rate in each room. The exposure rate will be used to determine the dose to a resident if the room were occupied, for comparison to dose risk ranges.

Decision Error Minimization

Gamma Radiation Scanning Data

The gamma radiation activity measurement for the entire site is based on 100 percent surface gamma radiation activity scans which collect activity data on a much denser scale and allow for greater confidence in making decisions based on surface contaminant concentrations within a larger area compared to using individual soil sample data points alone. However, the relationship and confidence between gamma radiation activity data and Ra-226 concentration data must be determined in order to make decisions in the field using activity data.

The equipment, method, and background area used introduce variation in measurement results. Whenever possible, the same paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241; measurement method e.g., detector height, pace, specifications; and background area will be used throughout the project. PIC measurements will be collected in unoccupied residential structures. Regular instrument checks will be conducted.

General Requirement for Generating Usable Data

All activities and documentation related to the project will proceed under a Quality Management

Plan. All sampling, analytical, and quality assurance activities will proceed under an EPA-approved SAP. A record of sampling activities and deviation from the SAP must be documented in a bound field log book. Prior to sample collection, all project sampling personnel will review relevant sampling procedures and relevant quality assurance and control requirements for selected analytical methods.

B Site Specific Health and Safety Plan

ECOLOGY AND ENVIRONMENT, INC.

SITE-SPECIFIC HEALTH AND SAFETY PLAN

Project: Tronox AUM Section 32 Removal Assessment

Project No.: 002693.2164.01RA

TDD/PAN No.: TO2-09-11-10-0004

Project Location: Prewitt, New Mexico
Casamero Lake Chapter, Navajo Nation

Proposed Date of Field Activities:

Site Walk – April 22, 2012
Survey and Sampling – June 2012

Project Director: Cindy McLeod

Project Manager: Aileen Mendoza

Prepared by: Aileen Mendoza Date Prepared: 4/13/12

Revised by: Bill Sass Date Revised: 6/7/12

Revision Approved by: Sara Dwight Date Approved: 6/7/12

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1. INTRODUCTION

1.1 POLICY

It is E & E's policy to ensure the health and safety of its employees, the public, and the environment during the performance of work it conducts. This site-specific health and safety plan (SHASP) establishes the procedures and requirements to ensure the health and safety of E & E employees for the above-named project. E & E's overall safety and health program is described in *Corporate Health and Safety Program* (CHSP). After reading this plan, applicable E & E employees shall read and sign E & E's Site-Specific Health and Safety Plan Acceptance form.

This SHASP has been developed for the sole use of E & E employees and is not intended for use by firms not participating in E & E's training and health and safety programs. Subcontractors are responsible for developing and providing their own safety plans.

This SHASP has been prepared to meet the following applicable regulatory requirements and guidance:

Applicable Regulation/Guidance
29 CFR 1910.120, Hazardous Waste Operations and Emergency Response (HAZWOPER)
Other:

1.2 SCOPE OF WORK

Description of Work: E & E was tasked by U.S. EPA under the Superfund Technical Assistance and Response Team (START) contract to conduct a removal assessment to delineate the extent of contamination at the Tronox abandoned uranium mine (AUM): Section 32, Eastern Agency located in Prewitt, McKinley County, New Mexico. Under this task order, E & E will perform a site walk with federal on-scene coordinator (FOSC) Randy Nattis, radiation scan/survey of surface soils, soil sampling from known areas of contamination based on previous investigation (Weston Solutions, Inc. [Weston] 2009) and radiation scan/survey results, and collect survey information for a background study.

Equipment/Supplies: Attachment 1 contains a checklist of equipment and supplies that will be needed for this work.

The following is a description of each numbered task:

Task Number	**Task Description**
1	Site walk
2	Surface radiation scan/survey of known areas of contamination to delineate removal area
3	Collection of soil samples
4	Surface radiation scan/survey for background study
5	Documentation (global positioning system [GPS], photographs, logs)
6	Homesite Investigation

1.3 SITE DESCRIPTION

Site Map: See Attachment 2.

Site History/Description (see project work plan for detailed description):
Tronox AUM: Section 32 (site) is located 1 mile east of County Road 19, in Prewitt, McKinley County, New Mexico (Latitude: 35° 29' 26.7576" N, Longitude: -108° 1' 2.7798" W). The site has an area of 12,102.91 square meters and an undetermined extent of

underground workings (Weston 2009). The site is located in an Indian Allotment land which is part of the Casamero Lake Chapter of the Navajo Nation.

The site consists of a mine which was reportedly owned by Cobb Nuclear and was closed due to a fatality (Weston 2009). No other information on historical ownership of the mine and mining operations were available. Site features include an unsecured deep shaft located in the southeastern portion of the site. No residences, public structures, water sources or sensitive environment were found within 0.25 miles of the site. The nearest resident is Lucita Sardo who lives to the west of the mine and had relatives who formerly worked for Cobb Nuclear. The residential property had some materials (tarps and lumber) obtained from the mine and had gamma radiation measurements of approximately 12,000 counts per minute (cpm). Gamma radiation measured at the site ranged from 10,689 cpm to 180,367 cpm. Gamma radiation measured at background locations ranged from 16,630 cpm to 17,128 cpm. No waste piles, other mine features, or visible signs of reclamation were reported.

Is the site currently in operation? ☐ Yes ☒ No

Locations of Contaminants/Wastes: Naturally occurring uranium ore and mine waste is present at the site.

Types and Characteristics of Contaminants/Wastes:

☐ Liquid	☒ Solid	☐ Sludge	☐ Gas/Vapor
☐ Flammable/Ignitable	☐ Volatile	☐ Corrosive	☐ Acutely Toxic
☐ Explosive	☐ Reactive	☒ Carcinogenic	☒ Radioactive
☐ Medical/Pathogenic	Other: ______		

2. ORGANIZATION AND RESPONSIBILITIES

E & E team personnel shall have on-site responsibilities as described in E & E's standard operating procedure (SOP) for Site Entry Procedures (GENTECH 2.2). The project team, including qualified alternates, is identified below.

Name	Site Role/Responsibility
Aileen Mendoza	Project Manager, Field Team Leader
Craig Tiballi	Site Safety Officer, Sample Collection, Radiation Survey
E & E START Field Team	Sample Collection, Radiation Survey, Documentation

3. TRAINING

Prior to work, E & E team personnel shall have received training as indicated below. As applicable, personnel shall have read the project work plan, sampling and analysis plan, and/or quality assurance project plan prior to project work.

Training	Required
40-Hour OSHA HAZWOPER Initial Training and Annual Refresher (29 CFR 1910.120)	X
Annual First Aid/CPR	X
Hazard Communication (29 CFR 1910.1200)	X
40-Hour Radiation Protection Procedures and Investigative Methods	
8-Hour General Radiation Health and Safety	X

Training	Required
Radiation Refresher	X
DOT and Biannual Refresher	X
Other: ______________________________	

4. MEDICAL SURVEILLANCE

4.1 MEDICAL SURVEILLANCE PROGRAM

E & E field personnel shall actively participate in E & E's medical surveillance program as described in the CHSP and shall have received, within the past year, an appropriate physical examination and health rating.

E & E's health and safety record (HSR) form will be maintained on site by each E & E employee for the duration of his or her work. E & E employees should inform the site safety officer (SSO) of any allergies, medical conditions, or similar situations that are relevant to the safe conduct of the work to which this SHASP applies.

Is there a concern for radiation at the site? ☒ Yes ☐ No

If no, go to 5.1.

4.2 RADIATION EXPOSURE

4.2.1 External Dosimetry

Thermoluminescent Dosimeter (TLD) Badges: TLD badges are to be worn by all E & E field personnel at the site and when radiation exposure is anticipated.

Pocket Dosimeters: Electronic or pocket dosimeters will be worn to determine real-time personnel doses if there is a potential for an E & E worker to receive at least 1 milliroentgen (mR) in one day.

Other: ______________________________

____

4.2.2 Internal Dosimetry

☐ Whole body count ☐ Bioassay ☐ Other

Requirements: ______________________________

4.2.3 Radiation Dose

Dose Limits: E & E's radiation dose limits are stated in the CHSP and presented in Table 4-1 below.

____

Site-Specific Dose Limits: : As a general guidance, if site work will continue for more than one quarter, limit weekly doses to approximately 80 mrem to ensure that quarterly dose limits are not exceeded.

____

ALARA Policy: Radiation doses to E & E personnel shall be maintained as low as reasonably achievable (ALARA), taking into account the work objective, state of technology available, economics of improvements in dose reduction with respect to overall health and safety, and other societal and socioeconomic considerations.

Table 4-1
E & E Radiation Dose Limits

Part of Body	Quarterly Limit (rems)	Annual Limit (rems)	Dost Limit Description
Whole body[a]	1	4	Total effective dose equivalent[b]
Any individual organ or tissue other than the lens of the eye[a]	10	40	Sum of deep-dose equivalent[c] and committed dose equivalent[d]
Lens of the eye	3	12	Lens dose equivalent[e]
Skin of whole body or skin of any extremity	10	40	Shallow-dose equivalent[f]

Notes:
a Precedence given to the more limiting dose.
b The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposure).
c The dose equivalent at a tissue depth of 1 cm; applies to external whole-body exposure and must be for the part of the body receiving the highest exposure.
d The dose equivalent to organs or tissues that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.
e The external exposure of the lens of the eye, taken as the dose equivalent at a tissue depth of 0.3 cm.
f The external exposure of the skin of the whole body or the skin of an extremity; taken as the dose equivalent at a tissue depth of 0.007 cm averaged over the contiguous 10 square centimeters of skin receiving the highest exposure.

5. SITE CONTROL

5.1 SITE LAYOUT AND WORK ZONES

Site Work Zones: A site map is included as Attachment 2. The work zones will be determined and documented on site. In general, surface gamma activity counts will be used to delineate exclusion zones. Contaminant reduction (Decon) zones will be established at the entry/exits point of the exclusion zone(s). Personnel will need to pass through the Decon area to shed PPE and get checked for radiation contamination when exiting the exclusion zone(s).

Site Access Requirements and Special Considerations: Site access will be arranged by U.S. EPA.

Illumination Requirements: Work will be conducted in daylight hours unless prior approval is obtained and the illumination requirements in 29 CFR 1910.120(m) are satisfied.

Sanitary Facilities (e.g., toilet, shower, potable water): Sanitary facilities will be arranged on site. Bottled water and/or electrolyte beverages will be available.

On-Site Communications: Primary method: verbal; Secondary method: radios/cell phones

Other Site-Control Requirements:

5.2 SAFE WORK PRACTICES

Daily Safety Meeting: A daily safety meeting will be conducted for all E & E personnel and documented on the Daily Safety Meeting Record form or in the field logbook. The information and data obtained from applicable site characterization and analysis will be addressed in the safety meetings and also used to update this SHASP, as necessary.

Work Limitations: Work shall be limited to a maximum of 12 hours per day. If 12 consecutive days are worked, at least one day off shall be provided before work is resumed.

Weather Limitations: Work shall not be conducted during electrical storms. Work conducted in other inclement weather (e.g., rain, snow) will be approved by project management and the regional safety coordinator or designee.

Other Work Limitations: ______________________________

____

Buddy System: Field work will be conducted in pairs of team members according to the buddy system.

Line of Sight: Each field team member shall remain in the line of sight and within verbal communication of at least one other team member.

Eating, Drinking, and Smoking: Eating, drinking, smoking, and the use of tobacco products shall be prohibited in the exclusion and contamination reduction areas, at a minimum, and shall only be permitted in designated areas.

Contamination Avoidance: Field personnel shall avoid unnecessary contamination of personnel, equipment, and materials to the extent practicable.

Sample Handling: Protective gloves of a type designated in Section 7 will be worn when containerized samples are handled for labeling, packaging, transportation, and other purposes.

Vermiculite Handling: It is against E&E policy to use vermiculite; therefore, bubble wrap will be used to cushion sample containers for shipment.

Other Safe Work Practices: Cold drinks and a shaded area will be provided to prevent heat stress.

6. HAZARD EVALUATION AND CONTROL

6.1 PHYSICAL HAZARD EVALUATION AND CONTROL

Potential physical hazards and their applicable control measures are described in the following table for each task.

Hazard	Task Number	Hazard Control Measures
Biological (flora, fauna, etc.)	1, 2, 3, 4, 5, 6	■ Potential hazard: feral dogs, prairie dogs (plague carriers), snakes, spiders, poisonous plants ■ Establish site-specific procedures for working around identified hazards. ■ Other: See attachments
Cold Stress	1, 2, 3, 4, 5, 6	■ Provide warm break area and adequate breaks. ■ Provide warm noncaffeinated beverages. ■ Promote cold stress awareness. ■ See *Cold Stress Prevention and Treatment* (attached at the end of this plan if cold stress is a potential hazard).
Compressed Gas Cylinders	N/A	■ Use caution when moving or storing cylinders. ■ A cylinder is a projectile hazard if it is damaged or its neck is broken. ■ Store cylinders upright and secure them by chains or other means. ■ Other:
Confined Space	N/A	■ Ensure compliance with 29 CFR 1910.146. ■ See SOP for Confined Space Entry. Additional documentation is required. ■ Other:

Hazard	Task Number	Hazard Control Measures
Drilling	N/A	■ See SOP for Health and Safety on Drilling Rig Operations. Additional documentation may be required. ■ Landfill caps will not be penetrated without prior discussions with corporate health and safety staff. ■ Other:
Drums and Containers	N/A	■ Ensure compliance with 29 CFR 1910.120(j). ■ Consider unlabeled drums or containers to contain hazardous substances and handle accordingly until the contents are identified. ■ Inspect drums or containers and assure integrity prior to handling. ■ Move drums or containers only as necessary; use caution and warn nearby personnel of potential hazards. ■ Open, sample, and/or move drums or containers in accordance with established procedures; use approved drum/container-handling equipment. ■ Other:
Electrical	N/A	■ Ensure compliance with 29 CFR 1910 Subparts J and S. ■ Locate and mark energized lines. ■ De-energize lines as necessary. ■ Ground all electrical circuits. ■ Guard or isolate temporary wiring to prevent accidental contact. ■ Evaluate potential areas of high moisture or standing water and define special electrical needs. ■ Other:
Excavation and Trenching	N/A	■ Ensure that excavations comply with and personnel are informed of the requirements of 29 CFR 1926 Subpart P. ■ Ensure that any required sloping or shoring systems are approved as per 29 CFR 1926 Subpart P. ■ Identify special personal protective equipment (PPE) (see Section 7) and monitoring (see Section 8) needs if personnel are required to enter approved excavated areas or trenches. ■ Maintain line of sight between equipment operators and personnel in excavations/trenches. Such personnel are prohibited from working in close proximity to operating machinery. ■ Suspend or shut down operations at signs of cave in, excessive water, defective shoring, changing weather, or unacceptable monitoring results. ■ Other:
Fire and Explosion	1, 2, 3, 4, 5, 6	■ Other: Avoid parking vehicles on tall, dry vegetation. ■ Inform personnel of the location(s) of potential fire/explosion hazards. ■ Establish site-specific procedures for working around flammables. ■ Ensure that appropriate fire suppression equipment and systems are available and in good working order. ■ Define requirements for intrinsically safe equipment. ■ Remove ignition sources from flammable atmospheres. ■ Coordinate with local fire-fighting groups regarding potential fire/explosion situations. ■ Establish contingency plans and review daily with team members.
Heat Stress	1, 2, 3, 4, 5, 6	■ Provide cool break area and adequate breaks. ■ Provide cool noncaffeinated beverages. ■ Promote heat stress awareness.

Hazard	Task Number	Hazard Control Measures
		■ Use active cooling devices (e.g., cooling vests) where specified. ■ See *Heat Stress Prevention and Treatment* (See Attachment 3).
Heavy Equipment Operation	N/A	■ Define equipment routes, traffic patterns, and site-specific safety measures. ■ Ensure that operators are properly trained and equipment has been properly inspected and maintained. Verify back-up alarms. ■ Ensure that ground spotters are assigned and informed of proper hand signals and communication protocols. ■ Identify special PPE (Section 7) and monitoring (Section 8) needs. ■ Ensure that field personnel do not work in close proximity to operating equipment. ■ Ensure that lifting capacities, load limits, etc., are not exceeded. ■ Other: Site personnel to wear reflective safety vests
Heights (Scaffolding, Ladders, etc.)	N/A	■ Ensure compliance with applicable subparts of 29 CFR 1910. ■ Identify special PPE needs (e.g., lanyards, safety nets, etc.) ■ Other: Use of fall protection: body harness and lanyard
Noise		■ Establish noise level standards for on-site equipment/operations. ■ Inform personnel of hearing protection requirements (Section 7). ■ Define site-specific requirements for noise monitoring (Section 8). ■ Other:
Overhead Obstructions	N/A	■ Wear hard hat. ■ Other:
Power Tools	N/A	■ Ensure compliance with 29 CFR 1910 Subpart P. ■ Other:
Sunburn	1, 2, 3, 4, 5, 6	■ Apply sunscreen. ■ Wear hats/caps and long sleeves. ■ Other:
Utility Lines	N/A	■ Identify/locate existing utilities prior to work. ■ Ensure that overhead utility lines are at least 25 feet away from project activities. ■ Contact utilities to confirm locations, as necessary. ■ Other:
Weather Extremes	1, 2, 3, 4, 5, 6	■ Potential hazards: ■ Establish site-specific contingencies for severe weather situations. ■ Provide for frequent weather broadcasts. ■ Weatherize safety gear, as necessary (e.g., ensure eye wash units cannot freeze, etc.). ■ Identify special PPE (Section 7) needs. ■ Discontinue work during severe weather.
Other: Uneven Terrain: Slips, trips & falls	1, 2, 3, 4, 5, 6	■ Use three points of contact on steep or rocky slopes and use a backpack to carry tools/supplies so that at least one hand is always free. ■ Watch footing when walking among debris.
Other: Burns, Shock, Fire, Noise and heavy lifting hazards from using portable gas-powered Auger	N/A	■ Use proper PPE (Level D w/safety goggles, hardhat, work gloves, ear plugs, etc). ■ Wait 20 minutes before refueling hot equipment. Use a funnel and safety gas can to avoid spilling. ■ Always have two persons around when lifting auger

Hazard	Task Number	Hazard Control Measures
Open Mine Shaft – Open Shafts can extend hundreds of feet to the lower level of a mine. The edge shafts can be concealed by mine debris, dirt, rock, and even water. Once solid beams and frameworks may have been decaying for more many years. In many cases, there may be no support beams at all and the fractured roof or walls of the mine tunnel eventually collapse in response to vibrations and/or the force of gravity. This becomes especially hazardous to personnel conducting gamma surveys, who are often paying more attention to their instruments than what is in front of them.	1, 2, 3, 4, 5, 6	■ Bring the mine shaft to the attention of all personnel working on the site. ■ Place a visual/physical barrier at least 6 feet outside the edge of the shaft. The barrier may consist of caution tape or construction fencing. Stay away from the edge of the shaft. ■ Keep vehicles as far from the shaft as possible.
Off-road Driving	1, 2, 3, 4, 5, 6	■ Drive as slow as possible, and as fast as necessary. ■ Sometimes you cannot drive to your desired destination, so don't push it if conditions are hazardous. ■ Stay on the trail. ■ Walk it first if you cannot see the ground or if conditions are wet. **See attachment for Off-road driving safety.**

6.2 CHEMICAL HAZARD EVALUATION AND CONTROL

6.2.1 Chemical Hazard Evaluation

Potential chemical hazards are described by task number in Table 6-1. Hazard Evaluation Sheets for major known contaminants are attached at the end of this plan.

6.2.2 Chemical Hazard Control

An appropriate combination of engineering/administrative controls, work practices, and PPE shall be used to reduce and maintain employee exposures to a level at or below published exposure levels (see Section 6.2.1).

Applicable Engineering/Administrative Control Measures: Work upwind if possible. Wear PPE appropriate for each task (e.g. Level C in exclusion zone, as defined by elevated surface gamma activity. Avoid soil coming in contact with skin or clothing).

PPE: See Section 7.

6.3 RADIOLOGICAL HAZARD EVALUATION AND CONTROL

6.3.1 Radiological Hazard Evaluation

Potential radiological hazards are described below by task number. Hazard Evaluation Sheets for major known contaminants are attached at the end of this plan.

Task Number	Radionuclide	DAC (μCi/ml)	Route(s) of Exposure	Major Radiation(s)	Energy(s) (MeV)	Half-Life
1-6	Uranium, natural (primarily U-238) and daughter radionuclides	Various (most conservative is 3E-12 for Th-230)	INH, ING, external radiation exposure	Alpha, beta, gamma, depending on the radionuclide	Various	Various (from seconds to 4.5E09 yrs for U-238)
1-6	Radium-226 (a key U-238 daughter) Ra-226 daughters	3E-10 Various	INH, ING, external radiation exposure	Alpha Gamma Alpha, beta, gamma	4.8 0.186 Various	1,600 yrs Various
1-6	Radon-222 (direct daughter of Ra-226)	4E-06 (daughters removed) 3E-08 or 0.33 WL (daughters present)	INH	Alpha	5,49	3.8 days
1-6	Thorium, natural (primarily Th-232) and daughter radionuclides	Various (most conservative is 5E-13 for Th-232)	INH, ING, external radiation exposure	Alpha, beta, gamma, depending on the radionuclide	Various	Various (from seconds to 1.4E10 yrs for Th-232)

6.3.2 Radiological Hazard Control

Engineering/administrative controls and work practices shall be instituted to reduce and maintain employee exposures to a level at or below the permissible exposure/dose limits (see sections 4.2.3 and 6.3.1). Whenever engineering/administrative controls and work practices are not feasible or effective, any reasonable combination of engineering/administrative controls, work practices, and PPE shall be used to reduce and maintain employee exposures to a level at or below permissible exposure/dose limits.

Applicable Engineering/Administrative Control Measures: Ensure support zone is in an uncontaminated background radiation area. Decrease time in radiation areas; increase distance; increase shielding as needed. Avoid unprotected contact with site materials. Use dust suppression during sampling activities as required. Radiation monitoring equipment will be protected from contamination by placing it in plastic bags (leaving probe areas uncovered). If applicable, ventilate indoor areas (open windows and doors) in order to dissipate any radon buildup.

Radiation Surveying: (This section is intended to apply work-area radiation surveying for worker health and safety purposes. The surveying being conducted for work Task 1 in this safety plan will also suffice to be work-area radiation surveying for worker health and safety purposes.) The work area will be continually surveyed as appropriate to determine radiation exposure rates, areas of elevated radiation, and the location and magnitude of radioactive contamination, in order to ensure and guide worker health and safety. Surveys for gamma exposure will be conducted using a micro R meter (or ion chamber, if the micro R meter goes off-scale [5 mR/hr]) and a survey ratemeter with an attached 3-inch by 3-inch sodium iodide (NaI) (gamma) probe in accordance with established procedures. Off-site background measurements for portable survey instruments will be obtained from locations previously identified by EPA. Radiation levels exceeding approximately 2 times background will indicate radiation contamination and/or radiation areas and will be marked using surveying flags or equivalent. Previous investigations indicate that some areas exceed the action level of 2-3 times background and marking will be required. Workers performing dust generating activites in areas with elevated gamma activity will be required to use Level C PPE, including respirator, tyvek, nitrile gloves, booties, etc. Workers will also don Level C PPE if wind speeds increase to the point that visible dust is present (approx. 20 mph). Although previous data indicate they are not present, a corporate health physicist will be consulted if exposure rates $\geq$ 2 mR/hr are encountered.

Radiation Contamination Monitoring -Personnel: Personnel will be monitored for radioactive contamination at each work area if gamma activity levels exceeding the site action level (greater than approximately 2-3 times background) are measured. The monitoring will be performed using a survey ratemeter with an attached detector such as a pancake GM detector in accordance with E&E's procedure *Radiation Contamination Monitoring of Personnel*. The relative response of the different detectors to site materials will be determined during initial phases of the work in order to select the best detector for contamination monitoring. Radiation contamination monitoring will be performed of protective clothing and respirators as necessary to help with waste disposition decisions and if there is a suspicion of gross contamination that should be controlled before the protective clothing/respirator is removed (to ensure that loose contamination is not transferred to personnel). Otherwise, the protective clothing/respirator can be carefully removed without being monitored and the monitoring will focus on the person in his/her street clothes. Contamination results exceeding approximately 2 to 3 times background indicate contamination and that decontamination or disposal as a contaminated waste must be performed (see Section 9).

Radiation Contamination Monitoring - Personal and Work-Related Items, Equipment, and Materials: (This section refers to radiation contamination monitoring of personal and work-related items for health and safety purposes. Examples include monitoring instruments, personal gear, tools, and laptop computers. This does not apply to the free release of non-E & E items.) Radiation contamination monitoring will be performed for personal and work-related items, equipment, and materials as they cross the hotline into the contamination reduction area. The monitoring will be performed using a survey ratemeter with an attached detector such as a pancake GM detector in accordance with established procedures. The relative response of the different detectors to site materials will be determined during initial phases of the work in order to select the best detector for contamination monitoring. Swipe testing will be used for contamination monitoring when direct monitoring is not effective (e.g., small surface areas, nooks and crannies). Swipes will be counted by instruments suitable for the contaminant (typically, fixed-geometry, thin-window counters for uranium and its daughters). Contamination results exceeding approximately 2 to 3 times background indicate contamination and that decontamination or disposal as a contaminated waste must be performed (see Section 9).

Air Monitoring and Sampling: In leiu of performing air sampling, personnel will don Level C PPE during dust generating activities (e.g. soil sampling and auger boring) that are performed in areas with elevated gamma activity.

PPE: See Section 7.

TABLE 6-1 CHEMICAL HAZARD EVALUATION										
Task Number	**Compound**	**Exposure Limits (TWA)**			**Dermal Hazard (Y/N)**	**Route(s) of Exposure**	**Acute Symptoms**	**Odor Threshold/ Description**	**FID/PID**	
		PEL	**REL**	**TLV**					**Relative Response**	**Ioniz. Poten. (eV)**
1-6	Uranium (insoluble compounds)	0.25 mg/m3	0.2 mg/m3	0.2 mg/m3	N	inhalation, ingestion, skin and/or eye contact	Dermatitis; kidney damage; blood changes; [potential occupational carcinogen]; in animals: lung, lymph node damage [Potential for cancer is a result of alpha-emitting properties & radioactive decay products (e.g., radon).]	odorless	NA	NA
1-6	Uranium (soluble compounds)	0.05 mg/m3	0.05 mg/m3	0.2 mg/m3	N	inhalation, ingestion, skin and/or eye contact	Lacrimation (discharge of tears), conjunctivitis; shortness breath, cough, chest rales; nausea, vomiting; skin burns; red blood cell, casts in urine; proteinuria; high blood urea nitrogen; [potential occupational carcinogen] [Potential for cancer is a result of alpha-emitting properties & radioactive decay products (e.g., radon).]	odorless	NA	NA

Note: Use an asterisk (*) to indicate known or suspected carcinogens.

7. LEVEL OF PROTECTION AND PERSONAL PROTECTIVE EQUIPMENT

7.1 LEVEL OF PROTECTION

The following levels of protection (LOPs) have been selected for each work task based on an evaluation of the potential or known hazards, the routes of potential hazard, and the performance specifications of the PPE. On-site monitoring results and other information obtained from on-site activities will be used to modify these LOPs and the PPE, as necessary, to ensure sufficient personnel protection. The authorized LOP and PPE shall only be changed with the approval of the regional safety coordinator or designee. Level A is not included below because Level A activities, which are performed infrequently, will require special planning and addenda to this SHASP.

Task Number	B	C	D	Modifications Allowed
1			X	
2			X	
3		(X)	X	Based on experiences with air sampling for gross alpha/beta on other uranium mine sites in New Mexico (e.g., NECR and Skyline), air sampling results from high dust-generating activities such as vehicular traffic, soil excavation and loading, and grading were still orders of magnitude below the most conservative DAC. Dust generating activities will involve RAT work and soil sampling. If dust caused by high winds should impact work activities, it is likely that it would involve nuisance dust. Therefore, worker protection decisions can be managed visually.
4			X	
5			X	
6			X	

Note: Use "X" for initial levels of protection. Use "(X)" to indicate levels of protection that may be used as site conditions warrant.

7.2 PERSONAL PROTECTIVE EQUIPMENT

The PPE selected for each task is indicated below. E & E's PPE program complies with 29 CFR 1910.120 and 29 CFR 1910 Subpart I and is described in detail in the CHSP. Refer to 29 CFR 1910 for the minimum PPE required for each LOP.

PPE	Task Number/LOP					
	1/D	2/D	3/D	4/D	5/D	6/D
Full-face APR			(X)			
PAPR						
Cartridges:						
P100			(X)			
GMC-P100						
GME-P100			(X)			
Other:						
Positive-pressure, full-face SCBA						
Spare air tanks (Grade D air)						

PPE	Task Number/LOP					
	1/D	2/D	3/D	4/D	5/D	6/D
Positive-pressure, full-face, supplied-air system						
Cascade system (Grade D air)						
Manifold system						
5-Minute escape mask						
Safety glasses			X			
Monogoggles						
Coveralls/clothing			(X)			
Protective clothing:						
Tyvek		(X)	(X)	(X)		
Saranex						
Other:						
Splash apron						
Inner gloves:						
Cotton						
Nitrile		(X)	(X)	(X)		
Latex						
Other:						
Outer gloves:						
Viton						
Rubber						
Neoprene						
Nitrile		X	X	X		
Other:						
Work gloves		(X)	(X)	(X)		
Safety boots (as per ANSI Z41)	X	X	X	X	X	X
Neoprene safety boots (as per ANSI Z41)						
Boot covers (type: poly)		(X)	(X)	(X)	(X)	
Hearing protection (type: ________________________)						
Hard hat						
Face shield						
Other:						
Other:						

8. HEALTH AND SAFETY MONITORING

Health and safety monitoring will be conducted to ensure proper selection of engineering/administrative controls, work practices, and/or PPE so that employees are not exposed to hazardous substances at levels that exceed permissible exposure/dose limits or published exposure levels. Health and safety monitoring will be conducted using the instruments, frequency, and action levels described in Table 8-1. Health and safety monitoring instruments shall have been appropriately calibrated and/or performance-checked prior to use.

9. DECONTAMINATION PROCEDURES

All equipment, materials, and personnel will be evaluated for contamination upon leaving the exclusion area. Equipment and materials will be decontaminated and/or disposed and personnel will be decontaminated, as necessary. Decontamination will be performed at each sample area if radiation levels exceeding the site action level (greater than 2-3 times background) are recorded. Specific procedures are described below.

Equipment/Material Decontamination Procedures (specified by work plan): Every effort will be made to prevent radiation survey instruments from contacting contaminated materials. When appropriate, instruments, probe handles (not probe faces), and other personal and work-related items will be covered in plastic to prevent surficial contamination. Nondisposable items that are radioactively contaminated as determined by direct and indirect monitoring (Sections 6.3.2 and 8) will be decontaminated using controlled dry or damp methods (e.g., Radiacwash towelettes or wet wipes) and remonitored when dry to ensure the contamination was removed. Disposable items that are contaminated will be directed to the proper waste stream.

Ventilation: All decontamination procedures will be conducted in a well-ventilated area.

Personnel Decontamination Procedures: Personnel radiation contamination monitoring will be performed in accordance with Sections 6.3.2 and 8. Disposable protective clothing will be directed to the proper waste stream and respirators will be directed to a respirator washing station. Contaminated areas on the skin or body will be decontaminated using controlled dry or damp methods and re-monitored when dry to ensure the contamination was removed. Significant or stubborn contamination will be decontaminated under the guidance of a health physicist. Contaminated areas on personal apparel will be decontaminated if possible; otherwise, the apparel will be directed to the proper waste stream. “Hot spot” decon is recommended to minimize the volume of waste generated. Practices such as cutting the hot spot out of the protective clothing or using duct tape to remove the contaminant will be employed as appropriate.

PPE Requirements for Personnel Performing Decontamination: Safety glasses and nitrile gloves

Personnel Decontamination in General: Following appropriate decontamination procedures, all field personnel will wash their hands and face with soap and potable water. Personnel should shower at the end of each work shift.

Disposition of Disposable PPE: Disposable PPE must be rendered unusable and disposed as indicated in the work plan.

Disposition of Decontamination Wastes (e.g., dry wastes, decontamination fluids, etc.): Disposed of off-site by qualified disposal contractor if greater than 30 pCi/g (approximately 100 Kcpm gamma activity). Disposed of as municipal waste if less than 2-3 times background.

TABLE 8-1

HEALTH AND SAFETY MONITORING

Instrument	Task Number	Contaminant(s)	Monitoring Location	Monitoring Frequency	Action Levels[a]	
☐ PID (e.g., RAE mini RAE) ☐ FID (e.g., OVA 128-) ☐ TVA 1000				Continuous	**Unknown Vapors** Background to 1 ppm above background: Level D 1 to 5 ppm above background: Level C 5 to 500 ppm above background: Level B >500 ppm above background: Level A	**Contaminant-Specific**
Oxygen Meter/Explosimeter					**Oxygen** <19.5% or >22.0%: Evacuate area; eliminate ignition sources; reassess conditions. 19.5 to 22.0%: Continue work in accordance with action levels for other instruments.	**Explosivity** ≤10% LEL: Continue work in accordance with action levels for other instruments; monitor continuously for combustible atmospheres. >10% LEL: Evacuate area; eliminate ignition sources; reassess conditions.
Radiation Alert Monitor (Rad-mini or RAM-4)					<0.1 mR/hr: Continue work in accordance with action levels for other instruments. ≥0.1 mR/hr: Evacuate area; reassess work plan and contact radiation safety specialist.	
Mini-Ram Particulate Monitor					**General/Unknown** Evaluate health and safety measures when dust levels exceed 2.5 milligrams per cubic meter.	**Contaminant-Specific**
HCN/H_2S (Monitox)					≥4 ppm: Leave area and consult with SSO.	
Draeger Colorimetric Tubes					**Tube** **Action Level**	**Action**
Air Monitor/Sampler Type: ________________ Sampling medium: ______________________					**Action Level**	**Action**

TABLE 8-1

HEALTH AND SAFETY MONITORING

Instrument	Task Number	Contaminant(s)	Monitoring Location	Monitoring Frequency	Action Levels[a]
Personal Sampling Pump Type: ________________ Sampling medium: ______________________					**Action Level** **Action**
Micro R Meter (Ludlum 19) with Rapid Assessment Tool (RAT)		External gamma exposure	Work area	As necessary to characterize work area. Continuous when used.	<2 mR/hr: Continue work in accordance with action levels for other instruments. 2 to 5 mR/hr: In conjunction with a radiation safety specialist, continue work and perform stay-time calculations to ensure compliance with dose limits and ALARA policy.
Ion Chamber		External gamma exposure	Work area	As necessary to characterize work area. Continuous when used.	See micro R meter action levels above.

TABLE 8-1

HEALTH AND SAFETY MONITORING

Instrument	Task Number	Contaminant(s)	Monitoring Location	Monitoring Frequency	Action Levels[a]		
					Detector	**Action Level**	**Action**
Radiation Survey Ratemeter/Scaler with External Detector(s) (Ludlum 2241, pancake GM detector)	1, 2, 3, 4, 5, 6	Gamma radiation	Work area	As necessary to characterize work area. Continuous when used.	3” x 3” NaI (gamma)	> 2 to 3 x Bkg	Consider radiation levels to be elevated.
		Radionuclides	Work area (sensitive measurement of hot spots and contaminated areas) as necessary	As necessary to characterize work area	GM, ZnS, or gas-flow proportional and/or swipe testing	General: > 2 to 3x Bkg.	Consider radioactive and/or contaminated.
		Radionuclices	Personnel and personal equipment/material contamination monitoring[b]	As necessary as personnel and personal equipment/ materials cross hotline	GM detector and/or swipe testing	> 2 to 3x Bkg	Consider radioactive and/or contaminated
Noise Dosimeter (Sound Level Meter)					≤85 decibels as measured using the A-weighed network (dBa): Use hearing protection if exposure will be sustained throughout work shift. >85 dBA: Use hearing protection. >120 dBA: Leave area and consult with safety personnel.		
Other: Pocket Dosimeter	1, 2, 3, 4, 5, 6	Gamma radiation, Radionuclices	Personnel and personal equipment/material contamination monitoring[b]	As necessary as personnel and personal equipment/ materials cross hotline	Canberra	1 mRem in one day	In conjunction with a radiation safety specialist, continue work and perform stay-time calculations to ensure compliance with dose limits and ALARA policy.
Other:							

TABLE 8-1

HEALTH AND SAFETY MONITORING

Instrument	Task Number	Contaminant(s)	Monitoring Location	Monitoring Frequency	Action Levels[a]

a Unless stated otherwise, airborne contaminant concentrations are measured as a time-weighted average in the worker's breathing zone. Acceptable concentrations for known airborne contaminants will be determined based on OSHA/NIOSH/ACGIH and/or NRC exposure limits. As a guideline, 1/2 the PEL/REL/TLV, whichever is lower should be used.

10. EMERGENCY RESPONSE

This section contains additional information pertaining to on-site emergency response and does not duplicate pertinent emergency response information contained in earlier sections of this plan (e.g., site layout, monitoring equipment, etc.). Emergency response procedures will be rehearsed regularly, as applicable, during project activities.

10.1 EMERGENCY RESPONSIBILITIES

All Personnel: All personnel shall be alert to the possibility of an on-site emergency; report potential or actual emergency situations to the team leader and SSO; and notify appropriate emergency resources, as necessary.

Team Leader: The team leader will ensure that applicable incidents are reported to appropriate E & E and client project personnel and government agencies.

SSO: The SSO will determine the emergency actions to be performed by E & E personnel and will direct these actions. The SSO will recommend health/safety and protective measures appropriate to the emergency.

Other: ______

10.2 LOCAL AND SITE RESOURCES (including phone numbers)

Ambulance: 911 (Gallup Metro Dispatch)

Hospital: Cibola General Hospital, 1016 E Roosevelt Ave, Grants, NM 87020 - (505) 287-4446

Directions to Hospital (map attached at the end of this plan): Head SW on Co Rd 19. Turn left onto NM-122E/Frontage Road for 18 miles. Continue onto W Santa Fe Ave for 1.4 miles. Turn left onto 1st St for 0.9 miles. Slight right onto W Roosevelt Ave. Hospital will be on the left in 0.7 miles.

Poison Control: 800-222-1222

Police Department: 911 (Gallup Metro Dispatch)

Fire Department: 911 (Gallup Metro Dispatch)

Client Contact: Randy Nattis, EPA FOSC; Phone (415) 940-1108

Site Contact: Randy Nattis, EPA FOSC; Phone (415) 940-1108

On-Site Telephone Number: NA

Cellular Telephone Number: NA

Radios Available: Yes

Other: ______

10.3 E & E EMERGENCY CONTACTS

E & E Emergency Operations Center (24 Hours):	716/684-8060
Corporate Health and Safety Director, Dr. Paul Jonmaire:	716/684-8060 (office) 716/655-1260 (home)
Regional Office Contact: Cindy McLeod, START Program Manager	510/893-6700 (office) 415/238-3379 (cell) 510/654-6250 (home)
Other: START Oakland Office	510/893/6700 (office)

a. E & E Emergency Response Center: 716/684-8060

b. Corporate Health and Safety Director, Dr. Paul Jonmaire: 716/684-8060 (office)
716/655-1260 (home)

c. Assistant Corporate Safety Director, Tom Siener, CIH: 716/684-8060 (office)
716/662-4740 (home)
716/597-5868 (Cell)

10.4 OTHER EMERGENCY RESPONSE PROCEDURES

On-Site Evacuation Signal/Alarm (must be audible and perceptible above ambient noise and light levels): Three long blasts on car horn or air horn.

On-Site Assembly Area: An upwind location to be determined at the first Daily Safety Meeting

Emergency Egress Route to Get Off Site: To be determined at the first Daily Safety Meeting

Off-Site Assembly Area: To be determined at the first Daily Safety Meeting

Preferred Means of Reporting Emergencies: Report to FOSC Nattis and Call 911

Site Security and Control: In an emergency situation, personnel will attempt to secure the affected area and control site access.

Emergency Decontamination Procedures: Non-life-threatening: protective clothing will be removed and affected persons will be monitored for radiation, especially the hands and feet, to the extent practicable. Life-threatening: critically injured personnel will be wrapped in a blanket or plastic sheeting to prevent the spread of contamination. Plastic sheeting should be used in transport vehicle to prevent the spread of contamination. If time permits and necessary medical treatment will not be delayed, removal of protective clothing and monitoring for radiation can be performed. Emergency decontamination for other chemical hazards will include PPE removal and rinsing with water if applicable.

PPE: Personnel will don appropriate PPE when responding to an emergency situation. The SSO and Section 7 of this plan will provide guidance regarding appropriate PPE.

Emergency Equipment Appropriate emergency equipment is listed in Attachment 1. Adequate supplies of this equipment shall be maintained in the support area or other approved work location.

Incident Reporting Procedures: The SSO will notify the Regional Safety Coordinator and the EPA FOSC. Affected personnel will complete an Incident/Exposure Report within 24 hours and submit it to the Corporate Health and Safety Director.

ATTACHMENT 1

EQUIPMENT/SUPPLIES CHECKLIST

	No.
INSTRUMENTATION	
FID	
Thermal desorber	
O_2/explosimeter w/cal. Kit	
Photovac tip	
PID (probe: _________eV)	
Magnetometer	
Pipe locator	
Weather station	
Draeger tube kit (tubes: _____________________)	
Brunton compass	
Real-time cyanide monitor	
Real-time H_2S monitor	
Heat stress monitor	
Noise equipment	
Personal sampling pumps and supplies	
MiniRam dust monitor	
Mercury monitor	
Spare batteries (type: D)	
RADIATION EQUIPMENT/SUPPLIES	
Documentation forms	X
Portable ratemeter	X
Scaler/ratemeter	X
1" NaI gamma probe	
3" NaI gamma probe	X
ZnS alpha probe	
GM pancake probe	X
Tungsten-shielded GM probe	
Micro R meter	
Ion chamber	
Alert monitor	
Pocket dosimeter	X
Dosimeter charger	X
Radiation warning tape	

	No.
Radiation decon supplies	X
Spare batteries (type:D - rate meters and Micro R meter; AAA - pocket dosimeters	X
SAMPLING EQUIPMENT	
4oz. bottles	X
Half-gallon bottles	
VOA bottles	
String	
Hand bailers	
Thieving rods with bulbs	
Spoons	X
Knives	
Filter paper	
Bottle labels	X
Ziplock Bags 1 gallon	X
Ziplock Bags 2 gallon	
MISCELLANEOUS	
GPS	X
Surveyor's tape	X
100' Fiberglass tape	
300' Nylon rope	
Nylon string	X
Surveying flags	X
Camera	X
Film	
Bung wrench	
Soil auger	X
Pick	
Shovel	X
Catalytic heater	
Propane gas	
Banner tape	
Surveying meter stick	
Chaining pins and ring	

	No.
Logbooks (_____ large, __X__ small)	X
Required MSDSs	
Intrinsically safe flashlight	
Potable water	X
Gatorade or equivalent	X
Tables	
Chairs	
Weather radio	
Two-way radios	
Binoculars	
Megaphone	
Cooling vest	
EMERGENCY EQUIPMENT	
First aid kit	X
Stretcher	
Portable eye wash	
Blood pressure monitor	
Fire blanket	
Fire extinguisher	
Thermometer (medical)	
Spill kit	
DECONTAMINATION EQUIPMENT	
Wash tubs	
Buckets	
Scrub brushes	
Pressurized sprayer	
Spray bottle	X
Detergent (type: **:** _RadiacWash or equivalent_____)	X
Solvent (type: ______________________________)	
Plastic sheeting	
Tarps and poles	
Trash bags	X
Trash cans	
Masking tape	X

	No.
Duct tape	X
Paper towels	X
Face mask	
Face mask sanitizer	
Step ladders	
Distilled water	X
Deionized water	
SHIPPING EQUIPMENT	
Coolers	X
Paint cans with lids, 7 clips each	
Vermiculite	
Shipping labels	X
DOT labels:	
"Up"	
"Danger"	
"Inside Container Complies ..."	
Hazard Group	
Strapping tape	X
Baggies	X
Custody seals	X
Chain-of-custody forms	X
Express shipment forms	X
Clear packing tape	X
Permanent markers	X

D A I L Y S A F E T Y M E E T I N G R E C O R D

INITIAL PROJECT SAFETY CHECKLIST

1. Emergency information reviewed? ___ and made familiar to all team members?
2. Route to nearest hospital driven? __ and its location known to all team members?
3. Health and safety plan readily available and its location known to all team members?
4. E & E Drilling SOP on site? __ and available for team member review?

ATTENDEES

Meeting shall be attended by all personnel who will be working within the exclusion area. Daily informal update meetings will be held prior to work and when site tasks and/or conditions change.

Name (Printed)	Name (Signature)	Date	Representing (Company/Agency)
Meeting Conducted By:			

Centers for Disease Control and Prevention
CDC 24/7: Saving Lives. Protecting People. Saving Money through Prevention.

Search the Pocket Guide

SEARCH

Enter search terms separated by spaces.

Uranium (soluble compounds, as U)

Synonyms & Trade Names Synonyms vary depending upon the specific soluble uranium compound.

CAS No.	RTECS No.	DOT ID & Guide
	Conversion	IDLH Ca [10 mg/m^3 (as U)] See: uranium (/niosh/idlh/uranium.html)

Exposure Limits	Measurement Methods
NIOSH REL : Ca TWA 0.05 mg/m^3 See Appendix A (nengapdxa.html) OSHA PEL : TWA 0.05 mg/m^3	None available See: NMAM (/niosh/docs/2003-154/) or OSHA Methods (http://www.osha.gov/dts/sltc/methods/index.html)

Physical Description Appearance and odor vary depending upon the specific soluble uranium compound.

Properties vary depending upon the specific soluble uranium compound.

Incompatibilities & Reactivities Uranyl nitrate: combustibles Uranium hexafluoride: water

Exposure Routes inhalation, ingestion, skin and/or eye contact

Symptoms lacrimation (discharge of tears), conjunctivitis; short breath, cough, chest rales; nausea, vomiting; skin burns; red blood cell, casts in urine; proteinuria; high blood urea nitrogen; [potential occupational carcinogen] Potential for cancer is a result of alpha-emitting properties & radioactive decay products (e.g., radon).

Target Organs respiratory system, blood, liver, kidneys, lymphatic system, skin, bone marrow

Cancer Site [lung cancer]

Personal Protection/Sanitation (See protection codes (protect.html))
Skin: Prevent skin contact
Eyes: Prevent eye contact
Wash skin: When contaminated/Daily
Remove: When wet or contaminated
Change: Daily
Provide: Eyewash (UF_6), Quick drench

First Aid (See procedures (firstaid.html))
Eye: Irrigate immediately
Skin: Water flush immediately
Breathing: Respiratory support
Swallow: Medical attention immediately

Respirator Recommendations

NIOSH

At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Escape (Halides):
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted acid gas canister having an N100, R100, or P100 filter.
Click here (pgintrod.html#nrp) for information on selection of N, R, or P filters.
Any appropriate escape-type, self-contained breathing apparatus

Escape (Non-halides):
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.
Click here (pgintrod.html#nrp) for information on selection of N, R, or P filters.
Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection (pgintrod.html#mustread)

See also: INTRODUCTION (/niosh/npg/pgintrod.html) See MEDICAL TESTS: 0239 (/niosh/docs/2005-110/nmed0239.html)

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SEARCH

Enter search terms separated by spaces.

Uranium (insoluble compounds, as U)

Synonyms & Trade Names **Uranium metal:** Uranium I
Synonyms of other insoluble uranium compounds vary depending upon the specific compound.

CAS No. 7440-61-1 (metal)	**RTECS No.** YR3490000 (metal) (/niosh-rtecs/YR3540D0.html)	**DOT ID & Guide** 2979 162 (http://wwwapps.tc.gc.ca/saf-sec-sur/3/erg-gmu/erg/guidepage.aspx?guide=162) (metal, pyrophoric)
Formula U (metal)	**Conversion**	**IDLH** Ca [10 mg/m³ (as U)] See: 7440611 (/niosh/idlh/7440611.html)

Exposure Limits
NIOSH REL : Ca TWA 0.2 mg/m³ ST 0.6 mg/m³ See Appendix A (nengapdxa.html)
OSHA PEL † (nengapdxg.html) : TWA 0.25 mg/m³

Measurement Methods
None available
See: NMAM (/niosh/docs/2003-154/) or OSHA Methods (http://www.osha.gov/dts/sltc/methods/index.html)

Physical Description Metal: Silver-white, malleable, ductile, lustrous solid. [Note: Weakly radioactive.]

MW: 238.0	**BP:** 6895°F	MLT: 2097°F	**Sol:** Insoluble	**VP:** 0 mmHg (approx)	**IP:** NA
Sp.Gr: 19.05 (metal)	**Fl.P:** NA	**UEL:** NA	**LEL:** NA		**MEC:** 60 g/m³

Metal: Combustible Solid, especially turnings and powder.

Incompatibilities & Reactivities Carbon dioxide, carbon tetrachloride, nitric acid, fluorine [Note: Complete coverage of uranium metal scrap with oil is essential for prevention of fire.]

Exposure Routes inhalation, ingestion, skin and/or eye contact

Symptoms dermatitis; kidney damage; blood changes; [potential occupational carcinogen]; in animals: lung, lymph node damage; [potential occupational carcinogen] Potential for cancer is a result of alpha-emitting properties & radioactive decay products (e.g., radon).

Target Organs Skin, kidneys, bone marrow, lymphatic system

Cancer Site [lung cancer]

Personal Protection/Sanitation (See protection codes (protect.html))
Skin: Prevent skin contact
Eyes: Prevent eye contact
Wash skin: When contaminated/Daily

First Aid (See procedures (firstaid.html))
Eye: Irrigate immediately
Skin: Soap wash promptly
Breathing: Respiratory support
Swallow: Medical attention immediately

Remove: When wet or contaminated
Change: Daily
Provide: Eyewash

Respirator Recommendations

NIOSH

At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Escape:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.
Click here (pgintrod.html#nrp) for information on selection of N, R, or P filters.
Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection (pgintrod.html#mustread)

See also: INTRODUCTION (/niosh/npg/pgintrod.html) See ICSC CARD: 1251 (/niosh/ipcsneng/neng1251.html) See MEDICAL TESTS: 0239 (/niosh/docs/2005-110/nmed0239.html)

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<< Back to Occupational Safety and Health Guidelines

Occupational Safety and Health Guideline for Uranium and Insoluble Compounds

DISCLAIMER:

These guidelines were developed under contract using generally accepted secondary sources. The protocol used by the contractor for surveying these data sources was developed by the National Institute for Occupational Safety and Health (NIOSH), the Occupational Safety and Health Administration (OSHA), and the Department of Energy (DOE). The information contained in these guidelines is intended for reference purposes only. None of the agencies have conducted a comprehensive check of the information and data contained in these sources. It provides a summary of information about chemicals that workers may be exposed to in their workplaces. The secondary sources used for supplements III and IV were published before 1992 and 1993, respectively, and for the remainder of the guidelines the secondary sources used were published before September 1996. This information may be superseded by new developments in the field of industrial hygiene. Therefore readers are advised to determine whether new information is available.

Introduction | Applicability | Recognition | Evaluation | Controls | References | Bibliography | Reference Table

Introduction

This guideline summarizes pertinent information about uranium and insoluble uranium compounds (measured as uranium) for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and hea programs. Recommendations may be superseded by new developments in these fields; readers are therefore advised to regard these recommendations as general guidelines and to determine periodically whether new information is available.

Applicability

This guideline applies to metallic uranium and all insoluble uranium compounds; examples of such compounds include triuranium octaoxide, uranium dioxide, uranium hydride, uranium tetrafluoride, and uranium trioxide. The physical and chemical properties of uranium and of some insoluble uranium compounds are presented below fo illustrative purposes.

Recognition

Metallic uranium

SUBSTANCE IDENTIFICATION

* Formula
U
* Structure
(For Structure, see paper copy)
* Synonyms
U; Uranium metal, pyrophoric; uranium.
* Identifiers

1. CAS 7440-61-1.
2. RTECS YR3490000.
3. DOT UN: 2979 65 (for the pyrophoric forms of the metal).
4. DOT labels: Radioactive and Flammable Solid.

* Appearance and odor
Elemental uranium is a heavy, malleable, silvery white, lustrous, radioactive metal that is pyrophoric when finely divided. When uranium is obtained by reduction, it take the form of a black powder. In its natural state, uranium has three isotopes: (234)U, (235)U, and (238)U. U-238 has a half life of 4,510,000,000 years.

CHEMICAL AND PHYSICAL PROPERTIES

* Physical data

1. Atomic number: 92.
2. Atomic weight: 238.03.
3. Boiling point (760 torr): 3818 degrees C (6904 degrees F).
4. Specific gravity (water = 1): 19.05 + 0.02 at 20 degrees C (68 degrees F).
5. Vapor density: Not applicable.
6. Melting point: 1132.3 degrees C (2070 degrees F).
7. Vapor pressure at 20 degrees C (68 degrees F): Nearly zero.
8. Solubility: Insoluble in water, alcohol, and alkalies; soluble in acids.

9. Evaporation rate: Not applicable.

Triuranium Octaoxide

SUBSTANCE IDENTIFICATION

* Formula
U(3)O(8)
* Structure
(For Structure, see paper copy)
* Synonyms
Uranium oxide, pitchblende, nasturan, uraninite.
* Identifiers

1. CAS 1317-99-3.
2. RTECS YR3400000.
3. Specific DOT number: None.
4. Specific DOT label: None.

* Appearance and odor
Triuranium octaoxide is an olive green to black, odorless solid.

CHEMICAL AND PHYSICAL PROPERTIES

* Physical data

1. Molecular weight: 842.1.
2. Boiling point: Not applicable.
3. Specific gravity (water = 1): 8.30 at 20 degrees C (68 degrees F).
4. Vapor density: Not applicable.
5. Melting point: 1300 degrees C (2372 degrees F) (decomposes to uranium dioxide).
6. Vapor pressure at 20 degrees C (68 degrees F): Nearly zero.
7. Solubility: Insoluble in water; soluble in nitric and sulfuric acids.
8. Evaporation rate: Not applicable.

Uranium dioxide

SUBSTANCE IDENTIFICATION

* Formula
UO(2)
* Structure
(For Structure, see paper copy)
* Synonyms
Uranous oxide, black uranium oxide, uranium oxide, uranic oxide, urania, yellow cake.
* Identifiers

1. CAS 1344-57-6.
2. RTECS: None.
3. Specific DOT number: None.
4. Specific DOT label: None.

* Appearance and odor
Uranium dioxide is a pyrophoric, black, crystalline solid. It occurs naturally in various minerals including uraninite, pitchblende, and tyuyamunite. The latter is the most important mineral commercially.

CHEMICAL AND PHYSICAL PROPERTIES

* Physical data

1. Molecular weight: 270.03.
2. Boiling point: Data not available.
3. Specific gravity (water = 1): 10.96 at 20 degrees C (68 degrees F).
4. Vapor density: Not applicable.
5. Melting point: 2858-2898 degrees C (5176-5248 degrees F).
6. Vapor pressure: Not applicable.
7. Solubility: Insoluble in water; soluble in concentrated sulfuric acid and nitric acid.
8. Evaporation rate: Not applicable.

Uranium hydride

SUBSTANCE IDENTIFICATION

* Formula
UH(3)
* Structure
(For Structure, see paper copy)
* Synonyms
Uranium trihydride.
* Identifiers

1. CAS 13598-56-6.
2. RTECS: None.
3. Specific DOT number: None.
4. Specific DOT label: None.

* Appearance and odor

Uranium hydride is a brownish-black or brownish-gray, pyrophoric powder.

CHEMICAL AND PHYSICAL PROPERTIES

* Physical data

1. Molecular weight: 241.05.
2. Boiling point (760 torr): Not applicable.
3. Specific gravity (water = 1): 10.95 at 20 degrees C (68 degrees F).
4. Vapor density: Not applicable.
5. Melting point: Decomposes.
6. Vapor pressure at 20 degrees C (68 degrees F): Nearly zero.
7. Solubility: Insoluble in water, alcohol, acetone, or liquid ammonia; slightly soluble in dilute hydrogen chloride; decomposes in nitric acid.
8. Evaporation rate: Not applicable.

Uranium tetrafluoride

SUBSTANCE IDENTIFICATION

* Formula
UF(4)
* Structure
(For Structure, see paper copy)
* Synonyms
Green salt.
* Identifiers

1. CAS 10049-14-6.
2. RTECS: None.
3. Specific DOT number: None.
4. Specific DOT label: None.

* Appearance and odor
Uranium tetrafluoride is a nonvolatile, green, odorless, crystalline solid.

CHEMICAL AND PHYSICAL PROPERTIES

* Physical data

1. Molecular weight: 314.
2. Boiling point (760 torr): 1417 degrees C (2582 degrees F).
3. Specific gravity (water = 1): 6.7 at 20 degrees C (68 degrees F).
4. Vapor density: Not applicable.
5. Melting point: 955-965 degrees C (1751-1769 degrees F).
6. Vapor pressure at 20 degrees C (68 degrees F): Nearly zero.
7. Solubility: Insoluble in water; soluble (decomposes) in concentrated acids and alkalies.
8. Evaporation rate: Not applicable.

* Reactivity

1. Conditions contributing to instability: Heat, flame, or exposure to air. Uranium metal reacts with nearly all nonmetals. Uranium turnings and fines stored out-of-doors in closed containers under water or water-soluble oil will convert partially to the hydride and will eventually ignite during hot weather.
2. Incompatibilities: Pure uranium is very reactive and is a strong reducing agent. Clean uranium turnings or chips oxidize readily in air. Contact of uranium with carbon dioxide, carbon tetrachloride, or nitric acid causes fires or explosions. Uranium hydride is spontaneously flammable in air, and contact of the hydride with strong oxidizers may cause fires and explosions. Contact of uranium hydride with water forms flammable and explosive hydrogen gas, and contact of the hydride with halogenated hydrocarbons can cause violent reactions. In finely divided form, uranium dioxide ignites spontaneously in air.
3. Hazardous decomposition products: Toxic particulates, gases, and vapors (such as uranium metal fume, oxides of uranium, hydrogen fluoride, carbon monoxide, and dangerous radioactive materials) may be released when uranium or an insoluble uranium compound decomposes.
4. Special precautions: Uranium is radioactive and highly reactive and should be handled with extreme caution at all times. Uranium tetrafluoride is highly corrosive.

* Flammability
The National Fire Protection Association has not assigned a flammability rating to uranium or the insoluble uranium compounds. Other sources rate uranium in solid or powder form as a very dangerous fire hazard when this substance is exposed to heat or open flame.

1. Flash point: Data not available.
   Autoignition temperature: The ignition temperature depends on the extent to which the metal is subdivided. The ignition temperature of the metal is 170 degrees C (338 degrees F) (if oxygen is present); finely divided uranium metal (dust) ignites at room temperature (20 degrees C (68 degrees F)).
2. Flammable limits in air: Not applicable.
3. Minimum explosive concentration: 60 g/m(3).
4. Extinguishant: Use graphite chips, carbon dust, asbestos blankets, or flooding with water to extinguish small uranium fires. There is no effective way to extinguish large uranium fires.

   Fires involving uranium or an insoluble uranium compound should be fought upwind and from the maximum distance possible. Keep unnecessary people away; isolate hazard area and deny entry. Emergency personnel should stay out of low areas and ventilate closed spaces before entering. Finely divided uranium (chips, turnings, shavings, etc.) are much more reactive than uranium in bulk form. If these are present during a fire, do not disperse them into a dust cloud, which may be explosive. Uranium metal may ignite spontaneously if exposed to air or other substances, may burn rapidly with a flare-burning effect, and may re-ignite after the fire has been extinguished. Containers of uranium or an insoluble uranium compound may explode in the heat of the fire and should be moved from the fire area if it is possible to do so safely. If this is not possible, cool containers from the sides with water until well after the fire is out. Stay away from the ends of containers. Personnel should withdraw immediately if a rising sound from a venting safety device is heard or if there is discoloration of a container due to fire. Dikes should be used to contain fire-control water for later disposal. If a tank car or truck is involved in a fire, personnel should isolate an area of a half a mile in all directions. Delay cleanup until arrival of, or instruction from, a qualified radiation authority. Firefighters should wear a full set of protective clothing, including a self-contained breathing apparatus, when fighting fires involving uranium or an insoluble uranium compound. Firefighters' protective clothing may provide limited protection against fires involving uranium or an insoluble uranium compound.

* Warning properties
No quantitative data are available on the odor threshold for uranium or insoluble uranium compounds; several of these substances are odorless. For the purpose of selecting appropriate respiratory protection, these substances are therefore considered to have inadequate odor warning properties.

* Eye irritation properties
No quantitative data are available on the eye irritation threshold for uranium or the insoluble uranium compounds.

EXPOSURE LIMITS

The current Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs) for uranium and the insoluble uranium compounds (measured as uranium) are 0.2 milligram per cubic meter (mg/m(3)) of air as an 8-hour time-weighted average (TWA) concentration and 0.6 mg/m(3) as a 15-minute TWA short-term exposure limit (STEL). A STEL is the maximum 15-minute concentration to which workers may be exposed during any 15-minute period of the working day [29 CFR 1910.1000, Table Z-1-A]. The National Institute for Occupational Safety and Health (NIOSH) has not issued a recommended exposure limit (REL) for uranium or its insol uranium compounds; however, NIOSH concurs with the PEL established for this substance by OSHA [NIOSH 1988]. The American Conference of Governmental Industria Hygienists (ACGIH) has assigned uranium and the insoluble uranium compounds a threshold limit value (TLV) of 0.2 mg/m(3) as a TWA for a normal 8-hour workday an 40-hour workweek and a short-term exposure limit (STEL) of 0.6 mg/m(3) for periods not to exceed 15 minutes [ACGIH 1988, p. 37]. The OSHA and ACGIH limits are ba on the risk of kidney and blood disorders and on the radiological damage associated with exposure to uranium or an insoluble uranium compound.

Evaluation

HEALTH HAZARD INFORMATION

* Routes of Exposure
Exposure to uranium or an insoluble uranium compound can occur via inhalation, ingestion, and eye or skin contact. Exposure to uranium trioxide can occur by absorptic through the skin, eyes, and mucous membranes.

* Summary of toxicology

1. Effects on Animals: Metallic uranium and insoluble uranium compounds may produce both chemical poisoning and radiation injury to the kidneys and lungs of exposed animals [Clayton and Clayton 1981, p. 1996]. The insoluble uranium compounds are less toxic chemically than the soluble compounds, but uranium and uranium compounds have the potential to cause radiation damage [Clayton and Clayton 1981, p. 2000; Klaassen, Amdur, and Doull 1986, p. 695]. The inhalation toxicity of uranium and the insoluble compounds of uranium is much greater than their oral toxicity [Clayton and Clayton 1981, p. 2000]. No dietary amount of insoluble uranium compounds acceptable to rats was lethal, and no evidence of systemic poisoning developed after the application of an insoluble compound to rabbit skin [Clayton and Clayton 1981, p. 2000]. However, uranium trioxide is lethal when placed in the conjunctival sac of rabbits' eyes, and uranium tetrafluorid causes direct eye injury [Grant 1986, p. 965]. Acute inhalation exposure to 20-mg/m(3) concentrations of uranium tetrafluoride, uranium dioxide, or high-grade uranium ore was occasionally fatal to some laboratory animals; exposure to a 2.5-mg/m(3) concentration of uranium tetrafluoride, uranium dioxide, or high-grade uranium ore caused mild or no renal damage and no fatalities in these animals [Clayton and Clayton 1981, p. 2001]. Chronic inhalation exposure to an insoluble uranium compound may produce radiation injury. In dogs and monkeys exposed to 5 mg/m(3) uranium dioxide for 6 hours/day, 5 days/week for up to 5 years, fibrotic changes suggestive of radiation injury were found in the tracheobronchial lymph nodes of both species and in the lungs of monkeys. No kidney damage w observed in these animals [Clayton and Clayton 1981, p. 2002]. Dogs tolerated inhalation of a 10-mg/m(3) concentration of uranium dioxide every day for 1 year dietary exposure to 10 g/kg/day for 1 year [Clayton and Clayton 1981, pp. 2001-2002]. Rats injected with metallic uranium in the femoral bone marrow and ches wall developed site-of-contact sarcomas; in these cases, the effects of chemical injury could not be distinguished from those of radiation damage [Clayton and Clayton 1981, p. 2003].
2. Effects on Humans: Metallic uranium and insoluble uranium compounds may produce both chemical poisoning and radiation injury [Clayton and Clayton 1981, p. 1996]. The insoluble uranium compounds are less toxic chemically than the soluble compounds, but uranium and all uranium compounds have the potential to ca radiation damage [Clayton and Clayton 1981, p. 2000; Klaassen, Amdur, and Doull 1986, p. 695]. Exposure to the dusts of uranium or to an insoluble uranium compound may cause respiratory irritation, cough, and shortness of breath [Genium MSDS 1988, No. 238]. Dermatitis has also been reported, and prolonged skin contact causes radiation injury to the basal cells [Proctor, Hughes, and Fischman 1988, p. 502]. Studies have shown that uranium workers are at increased risk of death from respiratory, lymphatic, and hematopoietic cancers; these deaths are presumed to be caused by radiation injury from radon gas, a byproduct of uraniu decay [Rom 1983, p. 688]. A study of the risk of respiratory deaths among uranium miners in the United States showed the following dose-response: miners expo occupationally for 5 to 9.9 years had a 2-fold increase in risk; miners exposed for 10 to 24.9 years had a 3.6-fold increase in risk; and those exposed for greater t 24.9 years had a 3.75-fold increase in risk. Smoking was shown both to increase the risk of death from respiratory disease and to shorten the neoplastic latency period [Clayton and Clayton 1981, pp. 2010-2011].

* Signs and symptoms of exposure

1. Acute exposure: The signs and symptoms of acute exposure to uranium or an insoluble uranium compound include respiratory irritation, cough, and shortness of breath.
2. Chronic exposure: 2. Chronic exposure: The signs and symptoms of chronic exposure to uranium or an insoluble uranium compound include those of lung damag shortness of breath, dry or productive cough, rales, cyanosis, and clubbing of the fingers. Long-term exposure also may cause cancer of the blood-forming systen the lymph system, and the respiratory tract, as well as anemia and leukopenia. The signs and symptoms of uranium-induced dermatitis may include irritation, redness, blistering, thickening, or hyperpigmentation of the skin.

* Emergency procedures:
In the event of an emergency, remove the victim from further exposure, send for medical assistance, and initiate the following emergency procedures:

1. Eye exposure: If uranium or an insoluble uranium compound gets into the eyes, immediately flush the eyes with large amounts of water for a minimum of 15 minutes, lifting the lower and upper lids occasionally. If irritation persists, get medical attention as soon as possible.
2. Skin exposure: If uranium or an insoluble uranium compound contacts the skin, the contaminated skin should be washed with soap and water. Contaminated boc surfaces should immediately be decontaminated in accordance with radiation procedures. Get medical attention.
3. Inhalation: If uranium or an insoluble uranium compound is inhaled, move the victim at once to fresh air and get medical care as soon as possible. If the victim is breathing, perform cardiopulmonary resuscitation; if breathing is difficult, give oxygen. Keep the victim warm and quiet until medical help arrives.
4. Ingestion: If uranium or an insoluble uranium compound is ingested, give the victim several glasses of water to drink and then induce vomiting by having the vict touch the back of the throat with the finger or by giving syrup of ipecac as directed on the package. Do not force an unconscious or convulsing person to drink liquids or to vomit. Get medical help immediately. Keep the victim warm and quiet until medical help arrives.
5. Rescue: Remove an incapacitated worker from further exposure and implement appropriate emergency procedures (e.g., those listed on the Material Safety Data Sheet required by OSHA's Hazard Communication Standard, 29 CFR 1910.1200). All workers should be familiar with emergency procedures and the location and proper use of emergency equipment.

EXPOSURE SOURCES AND CONTROL METHODS

The following operations may involve uranium and insoluble uranium compounds and lead to worker exposures to these substances:

- Mining, grinding, and milling of uranium ores
- Use in nuclear reactors as fuel and to pack nuclear fuel rods and in the production of nuclear weapons
- Burning of uranium metal chips and smelting operations
- Use in the ceramics industry for pigments, coloring porcelain, painting on porcelain, and enamelling

- Use as catalysts for many reactions, in gas manufacture, and in production of fluorescent glass
- Use in photographic processes, for alloying steel, in radiation shielding, and in aircraft counterweights
- Use as a source of plutonium and radium salts

Uranium hydride:

* Use as a lab source for pure hydrogen, for separation of hydrogen isotopes, and as a reducing agent
Methods that are effective in controlling worker exposures to uranium and insoluble uranium compounds, depending on the feasibility of implementation, are

- Process enclosure,
- Local exhaust ventilation,
- General dilution ventilation, and
- Personal protective equipment.

The following publications are good sources of information on control methods:

1. ACGIH [1986]. Industrial ventilation--a manual of recommended practice. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.
2. Burton DJ [1986]. Industrial ventilation--a self study companion. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.
3. Alden JL, Kane JM [1982]. Design of industrial ventilation systems. New York, NY: Industrial Press, Inc.
4. Wadden RA, Scheff PA [1987]. Engineering design for control of workplace hazards. New York, NY: McGraw-Hill.
5. Plog BA [1988]. Fundamentals of industrial hygiene. Chicago, IL: National Safety Council.

MEDICAL MONITORING

Workers who may be exposed to chemical and radiation hazards should be monitored in a systematic program of medical surveillance that is intended to prevent occupational injury and disease. The program should include education of employers and workers about work-related hazards, placement of workers in jobs that do not jeopardize their safety or health, early detection of adverse health effects, and referral of workers for diagnosis and treatment. The occurrence of disease or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and persoı protective equipment). A medical monitoring program is intended to supplement, not replace, such measures. To place workers effectively and to detect and control wor related health effects, medical evaluations should be performed (1) before job placement, (2) periodically during the period of employment, and (3) at the time of job transfer or termination.

* Preplacement medical evaluation
Before a worker is placed in a job with a potential for exposure to uranium or an insoluble uranium compound, the examining physician should evaluate and document tl worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropria for the anticipated occupational risks. These should concentrate on the function and integrity of the kidneys, respiratory system, blood, liver, bone marrow, skin, and lymphatics. Medical monitoring for respiratory disease should be conducted using the principles and methods recommended by NIOSH and the American Thoracic Societ

A preplacement medical evaluation is recommended to assess an individual's suitability for employment at a specific job and to detect and assess medical conditions tha may be aggravated or may result in increased risk when a worker is exposed to uranium or an insoluble uranium compound at or below the prescribed exposure limit. Tl examining physician should consider the probable frequency, intensity, and duration of exposure as well as the nature and degree of any applicable medical condition. S conditions (which should not be regarded as absolute contraindications to job placement) include a history and other findings consistent with diseases of the kidneys, respiratory system, blood, liver, bone marrow, skin, or lymphatics.

* Periodic medical examinations and biological monitoring
Occupational health interviews and physical examinations should be performed at regular intervals during the employment period, as mandated by any applicable Feder State, or local standard. Where no standard exists and the hazard is minimal, evaluations should be conducted every 3 to 5 years or as frequently as recommended by a experienced occupational health physician. Additional examinations may be necessary if a worker develops symptoms attributable to uranium exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of uranium on the kidneys, respiratory system, blood, liver, bone marrow, skin lymphatics. Current health status should be compared with the baseline health status of the individual worker or with expected values for a suitable reference populatior

Biological monitoring involves sampling and analyzing body tissues or fluids to provide an index of exposure to a toxic substance or metabolite. Urinary uranium concentrations correlate well with airborne uranium levels. Some sources report that urinary concen-trations of 50 þg uranium per liter of urine or 100 þg uranium per lit of urine correspond to constant daily exposures of approximately 0.05 mg/m(3) or 0.25 mg/m(3), respectively. Because there is great interindividual and intraindividual variability in urinary uranium concentrations, a pattern of urinary uranium excretion should be established for every exposed worker by sampling individuals at the same time on several different shifts and by sampling frequently.

* Medical examinations recommended at the time of job transfer or termination
The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic or laboratory tests that were conducted at the time placement should be repeated at the time of job transfer or termination to determine the worker's medical status at the end of his or her employment. Any changes in tl worker's health status should be compared with those expected for a suitable reference population. Because occupational exposure to uranium or an insoluble uranium compound may cause diseases with prolonged latent periods, the need for medical monitoring may extend well beyond the termination of employment.

WORKPLACE MONITORING AND MEASUREMENT PROCEDURES

Determination of a worker's exposure to airborne uranium or an insoluble uranium compound (measured as uranium) is made using a mixed cellulose ester filter (0.8 micron). Samples are collected at a maximum flow rate of 2 liters per minute until a maximum air volume of 960 liters is collected. Analysis is conducted by neutron activation. This method is included in the OSHA In-House Methods File.

Controls

PERSONAL HYGIENE PROCEDURES

If uranium or an insoluble uranium compound contacts the skin, workers should immediately wash the affected areas with soap and water. Contaminated body surfaces should immediately be decontaminated in accordance with radiation procedures.
Clothing contaminated with uranium or an insoluble uranium compound should be removed immediately, and provisions should be made for the safe removal of the chemical from the clothing. Persons laundering the clothes should be informed of the toxic and radioactive hazards of uranium.
A worker who handles uranium or an insoluble uranium compound should thoroughly wash hands, forearms, and face with soap and water before eating, using tobacco products, or using toilet facilities.
Workers should not eat, drink, or use tobacco products in areas where uranium or an insoluble uranium compound is handled, processed, or stored.

STORAGE

Uranium and insoluble uranium compounds should be stored in a cool, dry, well-ventilated area in tightly sealed containers that are labeled in accordance with OSHA's Hazard Communication Standard [29 CFR 1910.1200]. Containers of uranium or of insoluble uranium compounds should be protected from physical damage and should stored separately from carbon dioxide, carbon tetra-chloride, nitric acid, air, nonmetals, heat, sparks, and open flame. Uranium hydride should not be allowed to contact water, strong oxidizers, or halogenated hydrocarbons. Because empty containers that formerly contained uranium or a uranium compound may still hold product residue they should be handled appropriately.

SPILLS AND LEAKS

In the event of a spill or leak involving uranium or an insoluble uranium compound, persons not wearing protective equipment and clothing should be restricted from contaminated areas until cleanup has been completed. A clean-up plan must be available to address an accidental leak or spill of uranium or an insoluble uranium compo because special radiation procedures are required and professional assistance is needed. The following steps should be undertaken following a spill or leak:

1. Do not touch the spilled material; stop the leak if it is possible to do so without risk.
2. Notify safety personnel.
3. Remove all sources of heat and ignition.
4. Ventilate the area of the spill or leak.
5. Protect cleanup personnel from contact with or inhalation of uranium dust.

EMERGENCY PLANNING, COMMUNITY RIGHT-TO-KNOW, AND HAZARDOUS WASTE MANAGEMENT REQUIREMENTS

The Environmental Protection Agency's (EPA's) regulatory requirements for emergency planning, community right-to-know, and hazardous waste management may vary over time. Users are therefore advised to determine periodically whether new information is available.

* Emergency planning requirements
Uranium and insoluble uranium compounds are not subject to EPA emergency planning requirements under the Superfund Amendments and Reauthorization Act (Title I

* Reportable quantity requirements for hazardous releases
Employers are not required by the emergency release notification provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [CFR Part 355.40] to notify the National Response Center of an accidental release of uranium or an insoluble uranium compound; there is no reportable quantity for these substances.

* Community right-to-know requirements
Employers are not required by Section 313 of the Superfund Amendments and Reauthorization Act (SARA) to submit a Toxic Chemical Release Inventory form (Form R) EPA reporting the amount of uranium or an insoluble uranium compound emitted or released from their facility annually.

* Hazardous waste management requirements
EPA considers a waste to be hazardous if it exhibits any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity, as defined in 40 CFR 261.21-261.24 Under the Resource Conservation and Recovery Act (RCRA), EPA has specifically listed many chemical wastes as hazardous. Although uranium and insoluble uranium compounds are not specifically listed as a hazardous waste under RCRA, EPA requires employers to treat any waste as hazardous if it exhibits any of the characteristics discussed above.

Providing more information about the removal and disposal of specific chemicals is beyond the scope of this guideline. EPA, U.S. Department of Transportation, and Stat and local regulations should be followed to ensure that removal, transport, and disposal of this substance are conducted in accordance with existing regulations. To be certain that chemical waste disposal meets EPA regulatory requirements, employers should address any questions to the RCRA hotline at (202) 382-3000 (in Washingtor D.C.) or toll-free at (800) 424-9346 (outside Washington, D.C.). In addition, relevant State and local authorities should be contacted for information on any requirements they may have for the waste removal and disposal of this substance.

RESPIRATORY PROTECTION

* Conditions for respirator use
Good industrial hygiene practice requires that engineering controls be used where feasible to reduce workplace concentrations of hazardous materials to the prescribed exposure limit. However, some situations may require the use of respirators to control exposure. Respirators must be worn if the ambient concentration of uranium or ar insoluble uranium compound exceeds prescribed exposure limits. Respirators may be used (1) before engineering controls have been installed, (2) during work operatior such as maintenance or repair activities that involve unknown exposures, (3) during operations that require entry into tanks or closed vessels, and (4) during emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by NIOSH and the Mine Safety and Health Administra (MSHA).

* Respiratory protection program
Employers should institute a complete respiratory protection program that, at a minimum, complies with the requirements of OSHA's Respiratory Protection Standard [2 CFR 1910.134]. Such a program must include respirator selection (see Table 1), an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic workplace monitoring, and regular respirator maintenance, inspection, and cleaning. The implementation of an adequat respiratory protection program (including selection of the correct respirator) requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly. For additional information on the selection and use of respirators and on the medical screening of respirator users, consult the **NIOSH Respirator Decision Logic** and the **NIOSH Guide to Industrial Respiratory Protection**.

Table 1 lists the respiratory protection that NIOSH recommends for workers exposed to uranium or an insoluble uranium compound. The recommended protection may over time because of changes in the exposure limit for uranium or the insoluble uranium compounds or in respirator certification requirements. Users are therefore advis to determine periodically whether new information is available.

PERSONAL PROTECTIVE EQUIPMENT

Protective clothing should be worn to prevent skin contact with uranium or an insoluble uranium compound. Impervious gloves, boots, and aprons should be worn as appropriate when handling any of these substances. Chemical protective clothing should be selected on the basis of available performance data, manufacturers' recommendations, and evaluation of the clothing under actual conditions of use. No reports have been published on the resistance of various protective clothing materia permeation by uranium or an insoluble uranium compound; however, one source recommends natural rubber, neoprene, or polyvinyl chloride as a protective clothing material. If permeability data are not readily available, protective clothing manufacturers should be requested to provide information on the best chemical protective clothing for workers to wear when they are exposed to uranium or an insoluble uranium compound.

If uranium or an insoluble uranium compound is dissolved in an organic solvent, the permeation properties of both the solvent and the mixture must be considered wher selecting personal protective equipment and clothing.

Safety glasses, goggles, or faceshields should be worn during operations in which uranium or an insoluble uranium compound might contact the eyes. Eyewash fountain and emergency showers should be available within the immediate work area whenever the potential exists for eye or skin contact with uranium or its insoluble compoun Contact lenses should not be worn if the potential exists for exposure to any of these substances.

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Reference Table

Table 1
NIOSH recommended respiratory protection for workers exposed to uranium or an insoluble uranium compound*

Condition	Minimum respiratory protection**
Airborne concentration of uranium or an insoluble uranium compound:	
0.2 to 2 mg/m(3) (10 X PEL)	Single-use or quarter mask respirator
5 to 50 mg/m(3) (10 X PEL)	Any air-purifying, half-mask respirator equipped with a fume or high-efficiency filter approved for radon daughters or radionuclides, or
	Any air-purifying, full-facepiece respirator equipped with a fume filter approved for radon daughters, or
	Any supplied-air respirator equipped with a half mask and operated in a

	demand (negative-pressure) mode
0.2 to 5 mg/m(3) (25 X PEL)	Any powered, air-purifying respirator equipped with a hood or helmet and a fume or high-efficiency filter approved for radon daughters or radio-nuclides, or Any supplied-air respirator equipped with a hood or helmet and operated in a continuous-flow mode
0.2 to 10 mg/m(3) (50 X PEL)	Any air-purifying, full-facepiece respirator equipped with a high-efficiency filter approved for radon daughters or radio-nuclides, or Any powered, air-purifying respirator equipped with a tight-fitting facepiece and a high-efficiency filter approved for radon daughters or radio-nuclides, or Any supplied-air respirator equipped with a full facepiece and operated in a demand (negative-pressure) mode, or Any supplied-air respirator equipped with a tight-fitting facepiece and operated in a continuous-flow mode, or Any self-contained respirator equipped with a full facepiece and operated in a demand (negative-pressure) mode
0.2 to 30 mg/m(3) (150 X PEL)	Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode
Entry into IDLH(+) or unknown concentrations	Any self-contained respirator equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode, or Any supplied-air respirator equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive-pressure mode
Firefighting	Any self-contained respirator equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode
Escape	Any air-purifying, full-facepiece respirator equipped with a high-efficiency filter approved for radon daughters or radionuclides, or Any escape-type, self-contained breathing apparatus with a suitable service life (number of minutes required to escape the environment)

* The OSHA PEL is 0.2 mg/m(3) as an 8-hour TWA. No NIOSH REL has been issued.

** Only NIOSH/MSHA-approved equipment should be used. Also note the following:

1. Respirators accepted for use at higher concentrations may be used at lower concentrations; respirators must not, however, be used at concentrations higher than those for which they are approved.
2. Air-purifying respirators may not be used in oxygen-deficient atmospheres or in airborne concentrations that are immediately dangerous to life or health (IDLH).

(+) The uranium or an insoluble uranium compound concentration that is immediately dangerous to life and health (IDLH) is 30 mg/m(3) [NIOSH 1987b].

HEAT STRESS PREVENTION AND TREATMENT

Elevated temperatures are potentially hazardous, especially when work is conducted without appropriate precautions. The following sections describe heat stress prevention and the recognition and treatment of heat emergencies.

Effects of Heat

A predictable amount of heat is generated as a result of normal oxidation processes within the body. If heat is liberated rapidly, the body cools to a point at which the production of heat is accelerated, and the excess heat brings the body temperature back to normal.

Interference with the elimination of heat leads to its accumulation and to the elevation of body temperature. This condition produces a vicious cycle in which certain body processes accelerate and generate additional heat. Afterward, the body must eliminate not only the heat that is normally generated but also the additional quantities of heat.

Most body heat is brought to the surface by the bloodstream and escapes to cooler surroundings by conduction and radiation. If moving air or a breeze strikes the body, additional heat is lost by convection. When the temperature of the surrounding air becomes equal to or rises above the body temperature, all the heat must be lost by vaporization of the moisture or sweat from skin surfaces. As the air becomes more humid (contains more moisture), vaporization from the skin decreases. Weather conditions including high temperatures (90 to 100 degrees F), high humidity, and little or no breeze cause the retention of body heat. Such conditions or a succession of such days (a heat wave) increase the chances of a medical emergency due to heat.

Preventing Emergencies Due to Heat

When working in situations where the ambient temperatures and humidity are high, and especially in situations where protection levels A, B, or C are required, the site safety officer should:

- Ensure that all employees drink plenty of fluids (Gatorade or its equivalent);

- Ensure that frequent breaks are scheduled so overheating does not occur; and

- Revise work schedules, when necessary, to take advantage of the cooler parts of the day (i.e., 5:00 a.m. to 11:00 a.m. and 6:00 p.m. to nightfall).

When protective clothing is required, the suggested guidelines correlating ambient temperature and maximum wearing time per excursion are:

Ambient Temperature	Maximum Wearing Time per Excursion
Above 90 degrees F	15 minutes
85 to 90 degrees F	30 minutes
80 to 85 degrees F	60 minutes
70 to 80 degrees F	90 minutes
60 to 70 degrees F	120 minutes
50 to 60 degrees F	180 minutes

One method of measuring the effectiveness of an employee's rest-recovery regime is by monitoring the heart rate. The "Brouha guideline" is one such method and is performed as follows:

- Count the pulse rate for the **last** 30 seconds of the first minute of a 3-minute period, the **last** 30 seconds of the second minute, and the **last** 30 seconds of the third minute; and

- Double each result to yield beats per minute.

If the recovery pulse rate during the last 30 seconds of the first minute is 110 beats/minute or less, and the deceleration between the first, second, and third minutes is **at least** 10 beats/minute, then the work-recovery regime is acceptable. If the employee's rate is above the rate specified, a longer rest period will be required, accompanied by an increased intake of fluids.

Heat Emergencies

Heat Cramps. Heat cramps usually affect people who work in hot environments and perspire a great deal. Loss of salt from the body causes very painful cramps in leg and abdominal muscles. Heat cramps may also result from drinking iced water or other drinks either too quickly or in too large a quantity. The symptoms of heat cramps are:

- Painful muscle cramps in legs and abdomen;

- Faintness; and

- Profuse perspiration.

To provide emergency care for heat cramps, move the patient to a cool place. Give him or her sips of liquids such as Gatorade or its equivalent. Apply manual pressure to the cramped muscle. Move the patient to a hospital if there is any indication of a more serious problem.

Heat Exhaustion. Heat exhaustion also may occur in individuals working in hot environments and may be associated with heat cramps. Heat exhaustion is caused by the pooling of blood in the vessels of the skin. The heat is transported from the interior of the body to the surface by the blood. The skin vessels become dilated and a large amount of blood is pooled in the skin. This condition, plus the blood that is pooled in the lower extremities when in an upright position, may lead to an inadequate return of blood to the heart and eventual physical collapse. The symptoms of heat exhaustion are:

- Weak pulse;

- Rapid and usually shallow breathing;
- Generalized weakness;
- Pale, clammy skin;
- Profuse perspiration;
- Dizziness/faintness; and
- Unconsciousness.

To provide emergency care for heat exhaustion, move the patient to a cool place and remove as much clothing as possible. Have the patient drink cool water, Gatorade, or its equivalent. If possible, fan the patient continually to remove heat by convection, but do not allow chilling or overcooling. Treat the patient for shock and move him or her to a medical facility if there is any indication of a more serious problem.

Heat Stroke. Heat stroke is a profound disturbance of the heat-regulating mechanism and is associated with high fever and collapse. It is a serious threat to life and carries a 20% mortality rate. Sometimes this condition results in convulsions, unconsciousness, and even death. Direct exposure to sun, poor air circulation, poor physical condition, and advanced age (over 40) increase the chance of heat stroke. Alcoholics are extremely susceptible. The symptoms of heat stroke are:

- Sudden onset;
- Dry, hot, and flushed skin;
- Dilated pupils;
- Early loss of consciousness;
- Full and fast pulse;
- Deep breathing at first, followed by shallow or faint breathing;
- Muscle twitching, growing into convulsions; and
- Body temperature reaching 105 to 106 degrees F or higher.

When providing emergency care for heat stroke, remember that it is a life-threatening emergency. Transportation to a medical facility should not be delayed. Move the patient to a cool environment, if possible, and remove as much clothing as possible. Ensure an open airway. Reduce body temperature promptly by dousing the body with water or, preferably, by wrapping the patient in a wet sheet. If cold packs are available, place them under the arms, around the neck, at the ankles, or any place where blood vessels that lie close to the skin can be cooled. Protect the patient from injury during convulsions.

OSHA QUICK CARD™

Rodents, Snakes and Insects

Insects, Spiders and Ticks

- To protect yourself from biting and stinging insects, wear long pants, socks, and long-sleeved shirts.
- Use insect repellents that contain DEET or Picaridin.
- Treat bites and stings with over-the-counter products that relieve pain and prevent infection.
- Avoid fire ants; their bites are painful and cause blisters.
- Severe reactions to fire ant bites (chest pain, nausea, sweating, loss of breath, serious swelling or slurred speech) require immediate medical treatment.

Rodents and Wild or Stray Animals

- Dead and live animals can spread diseases such as Rat Bite Fever and Rabies.
- Avoid contact with wild or stray animals.
- Avoid contact with rats or rat-contaminated buildings. If you can't avoid contact, wear protective gloves and wash your hands regularly.
- Get rid of dead animals as soon as possible.
- If bitten/scratched, get medical attention immediately.

Snakes

- Watch where you place your hands and feet when removing debris. If possible, don't place your fingers under debris you are moving. Wear heavy gloves.
- If you see a snake, step back and allow it to proceed.
- Wear boots at least 10 inches high.
- Watch for snakes sunning on fallen trees, limbs or other debris.
- A snake's striking distance is about 1/2 the total length of the snake.
- If bitten, note the color and shape of the snake's head to help with treatment.
- Keep bite victims still and calm to slow the spread of venom in case the snake is poisonous. Seek medical attention as soon as possible.
- Do not cut the wound or attempt to suck out the venom. Apply first aid: lay the person down so that the bite is below the level of the heart, and cover the bite with a clean, dry dressing.

For more complete information:

OSHA® Occupational Safety and Health Administration
U.S. Department of Labor
www.osha.gov (800) 321-OSHA

OSHA 3274-09N-05

OSHA FactSheet

Protect Yourself! Workers may be exposed to

Black Widow Spider

The black widow belongs to a group of spiders commonly known as cobweb spiders. The characteristic hourglass is located on the underside of the abdomen. Female black widows are dangerous and can bite and inject toxic venom.

Identification

- The female black widow is normally shiny black, with a red hourglass marking (see photo) on the underside of the abdomen.
- The abdominal marking may range in color from yellowish orange to red and its shape may range from an hourglass to a dot.
- The body of an adult black widow female is about 1/2 inch long.

Photo: Extension Entomology, Texas A&M University

Photo: University of Missouri Extension

Habitat

The black widow is commonly found in the following places:

- Outdoors - woodpiles, rubble piles, under stones, in hollow stumps, and in rodent burrows, privies, sheds and garages.
- Indoors - undisturbed, cluttered areas in basements and crawl spaces.

Symptons

- The bite of the black widow may be painful or it may go unnoticed.
- The skin may display one or two bite marks with local swelling. Pain usually progresses from the bite site and eventually to the abdomen and back.
- Severe cramping or rigidity may occur in the abdominal muscles.
- Symptoms may include nausea, profuse perspiration, tremors, labored breathing, restlessness, increased blood pressure and fever.
- The pain from the bite will usually persist for the first 8-12 hours.
- Symptoms may continue for several days.

Protection

- Wear a long-sleeved shirt, hat, gloves, and boots when handling boxes, firewood, lumber, and rocks, etc.
- Inspect and shake out clothing and shoes before getting dressed.
- Use insect repellants, such as DEET or Picaridin, on clothing and footwear.

Treatment

- Clean the bite area with soap and water.
- Apply ice to the bite area to slow absorption of the venom.
- Elevate and immobilize the extremity.
- Capture the spider, if at all possible, for identification purposes.
- Seek medical attention immediately.
- If you have a heart condition or other heart problem, you may need hospitalization.

This is one in a series of informational fact sheets highlighting OSHA programs, policies or standards. It does not impose any new compliance requirements. For a comprehensive list of compliance requirements of OSHA standards or regulations, refer to Title 29 of the Code of Federal Regulations. This information will be made available to sensory impaired individuals upon request. The voice phone is (202) 693-1999; teletypewriter (TTY) number: (877) 889-5627.

For more complete information:

OSHA Occupational Safety and Health Administration

U.S. Department of Labor

www.osha.gov

(800) 321-OSHA

DSG 10/2005

OSHA FactSheet

Protect Yourself! Workers may be exposed to

Brown Recluse Spider

The brown recluse belongs to a group of spiders commonly known as violin spiders or fiddlebacks. The characteristic fiddle-shaped pattern is located on the top of the leg attachment region (cephalothorax). Because they are secluded and withdrawn, as their name implies, the brown recluse avoids open spaces. Brown recluse spiders are dangerous and they can bite and inject toxic venom.

Identification

- Body size: 1/4 to 3/4 inch (6.4-19.1mm)
- Color: Golden brown
- A dark violin/fiddle shape (see top photo) is located on the top of the leg attachment region (cephalothorax) with the neck of the violin/fiddle pointing backward toward the abdomen.
- Unlike most spiders that have 8 eyes, the brown recluse has 6 eyes. The eyes, arranged in pairs – one pair in front and a pair on either side – can be readily seen under low magnification.

Habitat

The Brown Recluse Spider builds small retreat webs behind objects of any type.

Symptoms

- The severity of the bite may vary. Symptoms may vary from none to very severe.
- The bite generally becomes reddened within several hours.

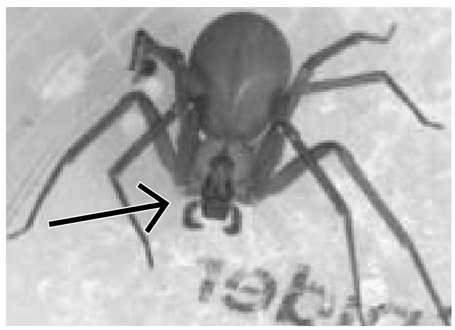


Photo: R. Bessin, University of Kentucky

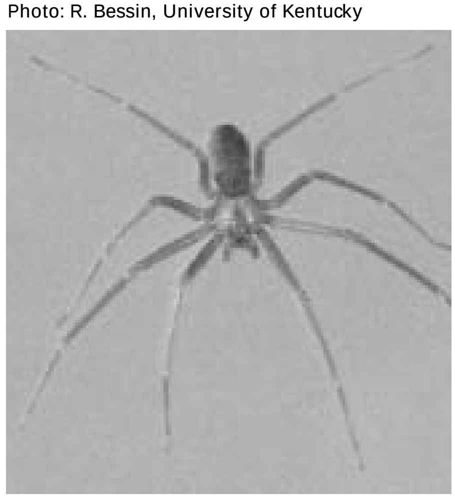


Photo: creatures.ifas.ufl.edu

- There is often a systemic reaction within 24-36 hours characterized by restlessness, fever, chills, nausea, weakness and joint pain.
- Tissue at the site of the bite and the surrounding area dies and eventually sheds.

Protection

- Wear a long-sleeved shirt, hat, gloves, and boots when handling stored boxes, firewood, lumber and rocks, etc.
- Inspect and shake out clothing and shoes before getting dressed.
- Use insect repellants, such as DEET or Picaridin, on clothing and footwear.

Treatment

- Clean the bite area with soap and water.
- Apply ice to the bite area to slow absorption of the venom.
- Elevate and immobilize the bitten extremity.
- Capture the spider, if at all possible, for identification purposes.
- Seek medical attention.

This is one in a series of informational fact sheets highlighting OSHA programs, policies or standards. It does not impose any new compliance requirements. For a comprehensive list of compliance requirements of OSHA standards or regulations, refer to Title 29 of the Code of Federal Regulations. This information will be made available to sensory impaired individuals upon request. The voice phone is (202) 693-1999; teletypewriter (TTY) number: (877) 889-5627.

For more complete information:

OSHA Occupational Safety and Health Administration

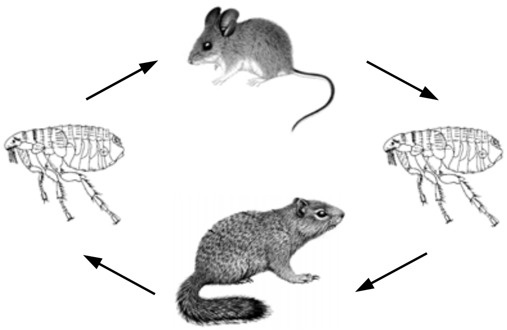
U.S. Department of Labor

www.osha.gov

(800) 321-OSHA

DSG 10/2005

What is Plague?



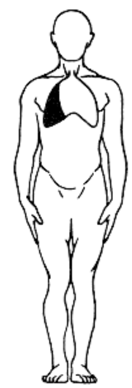
Plague is a disease of wild rodents and rabbits caused by the bacterium *Yersinia pestis*. It is spread among animals and to humans by the bites of infected fleas. Animals most often infected include rock squirrels, prairie dogs, pack rats, chipmunks, rabbits and mice.

When an animal with plague dies, the infected fleas must find a new host. This may be another rodent, a pet or a person.

Although most human plague cases result from flea bites, people have also contracted the disease by coming into direct contact with an infected animal's blood or tissues, such as when skinning a rabbit or other game.

People can also get plague by inhaling infectious droplets expelled by a person or cat with pneumonic plague.

BUBONIC



PNEUMONIC FORM

The three forms of plague are bubonic ...

Symptoms usually develop within two to six days after a flea bite or contact with an infected animal and include high fever, chills, weakness, headache and muscle aches. In bubonic plague, a lymph node in the groin, armpit or neck becomes swollen and very painful.

... septicemic ...

Sometimes the bacteria go directly into the blood and there are no swollen lymph nodes, just fever and severe flu-like symptoms. Secondary septicemic plague can result from untreated bubonic plague.

... and pneumonic.

If the bacteria invade the lungs, pneumonia may develop and the disease may be spread to other people when the patient coughs or sneezes. For plague pneumonia patients, the death rate is over 50%.

Plague is curable if treated in time.

See your doctor immediately about any illness having sudden onset of high fever. Report if you have had flea bites, have handled any wild rodents or rabbits, or have a pet that hunts. Plague is curable with antibiotics if promptly diagnosed and treated.

Pets that hunt may bring plague-infected fleas into the home and can also become infected with plague. Cats are more likely than dogs to get sick, and can spread the disease to their owners through biting, coughing, or draining abscesses. Take your pet to the vet immediately if it has had contact with rodents and develops symptoms of fever, lethargy, and loss of appetite.

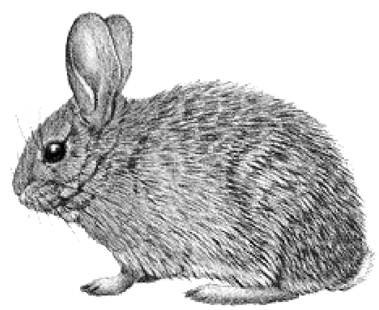
Preventing Plague

- Avoid contact with wild rodents and their fleas, nests and burrows.
- Prevent pets from hunting.
- Treat outdoor pets with flea control products regularly.
- Wear rubber gloves when handling game.
- Eliminate rodent shelter around the home:
- Stack woodpiles at least 12" above the ground and 100 feet from the house;
- Keep animal feed in rodent-proof containers;
- Get rid of junk piles and abandoned vehicles around the home.
- Report sick or dead rodents and rabbits (in the absence of poisoning or trauma) to the Zoonoses Program in the New Mexico Department of Health. (Within Bernalillo County, contact the Albuquerque Environmental Health Dept.)

For more information, contact:

Zoonoses Program
Epidemiology & Response
NM Department of Health
1190 St. Francis Dr.
Santa Fe, NM 87505

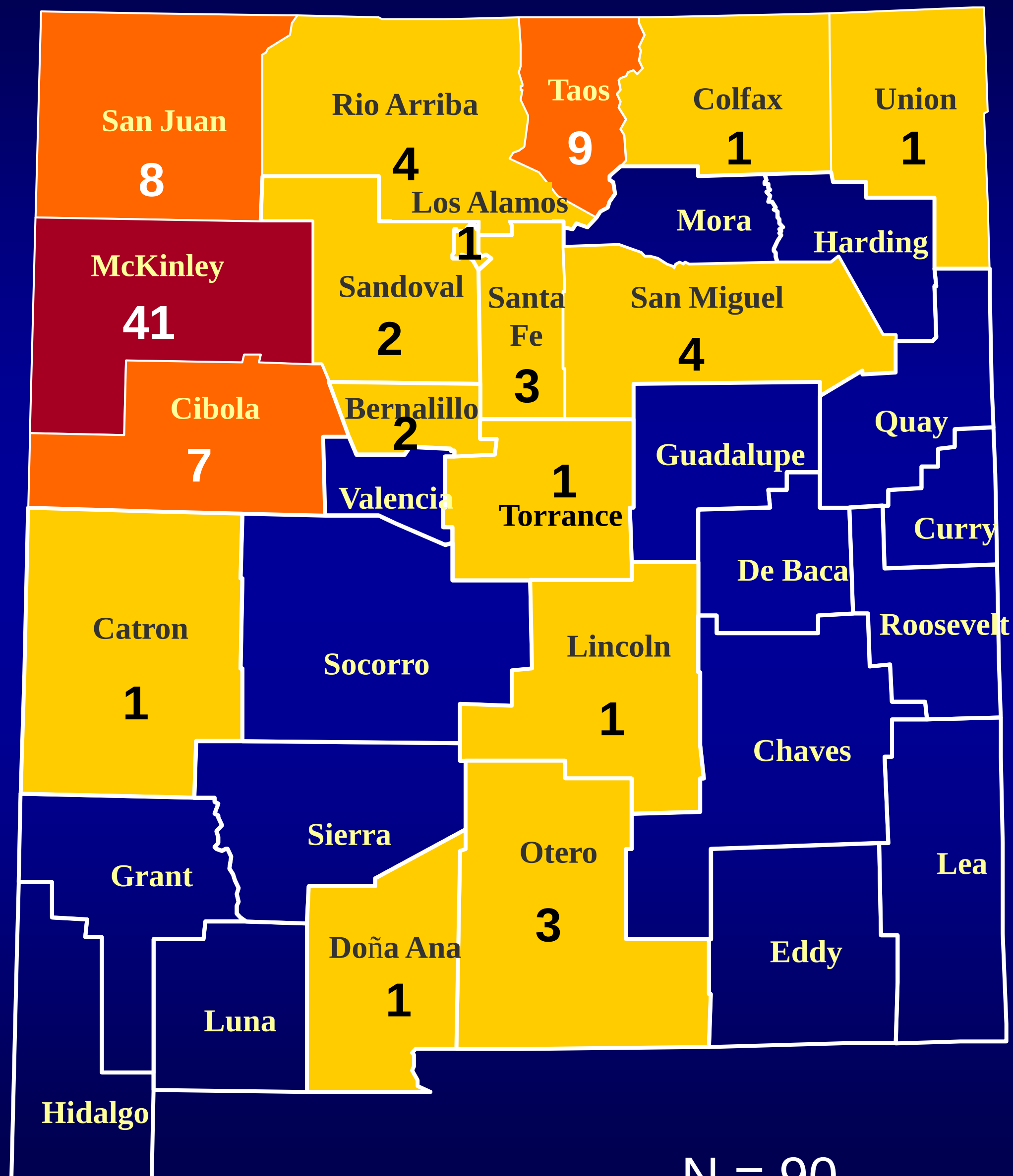
(505) 827-0006



PLAGUE IN NEW MEXICO

New Mexico Department of Health
Epidemiology and Response Division

HPS Cases in New Mexico by County, 1975 – 2011



Number of Cases

- >10
- 6-10
- 1-5
- 0

12/31/2011

N = 90

Notes From the Road

Off-Road Driving and Safety Tips

By: Mac Demere/autoMedia.com

Speed is Not Your Friend -

Going off roading? Here are your choices: Carry your stuff on your back; walk beside a mule with your stuff on its back; ride in comfort with your stuff in the back of a four-wheel-drive.

The speed will be about the same. If you drive much faster than a walking pace there's a chance you'll be forced into the first option.

As a teenager, I wanted to cross a muddy section of field in a two-wheel-drive pickup on near-bald tires. I assessed that my only hope was speed. (If you ever say, "My only hope is ... " know that the rest of the sentence is "a miracle.") When the old Ford hit the swampy strip, it sunk floorboard-deep into the mud and came to a near-instant stop. The rear tires must have come off the ground because I feared it was about to flip forward.

Here are the lessons I should have learned, but didn't because I was a teenager:

Speed is not your friend.
The off-road driver's mantra is "As Slow As Possible, As Fast As Necessary." (The original author of this quote is uncertain, but I first heard it at a Land Rover driving school.) Sometimes a little speed may be required to climb a hill or conquer a hazard. However, if you think the obstacle requires even 10 mph, you're probably not going to make it. And you're going to damage something or get stuck.

Sometimes you can't get there from here.
This is true even with a well-equipped vehicle and a skilled driver—and was certainly true of an unskilled teenager in a poorly equipped vehicle. It's far easier to discover an alternate route than to find someone willing and able to come to your rescue. Walking the rest of the way is better than walking home.

Stay on the trail.
Trying to blaze my own trail not only got me stuck, but it left ruts that remained for years. Drive on previously used paths: You'll know it's possible to make it through there and you'll do less damage to the environment. A warning: Just because somebody else made it doesn't guarantee you will. Maybe they had a better vehicle, were a more skilled driver or went through before it rained.

Walk it first.
If you can't negotiate mud, sand or other obstacles on foot, it's highly unlikely your vehicle can make it. It's critical to check out a water-covered route: Unless you've seen another vehicle go through it, you can't be certain it doesn't hide a huge hole.

Be willing to walk back.
Never tackle a questionable obstacle unless you're able to walk back to where help awaits. If you're going off road, your cell phone will be useless. Even if there is coverage, there's nobody to call unless you've made a prior arrangement. The road-service tow-truck driver won't leave the pavement, the farmer with the tractor might not be home, and the guy in the SUV you wave down on the highway may not be able or willing to help. Not all SUVs have four-wheel-drive and a tow

strap.

Re-tire to succeed.
Even the most technologically advanced four-wheel-drive system can't make up for tires that are not meant for the job or lack adequate tread depth. Some original equipment tires on SUVs and pickups can't conquer anything more rigorous than wet grass. Also, even the best mud tires become useless off road well before they run out of tread.

Help yourself.
If you're planning to regularly travel the road less paved, bring along some things that'll help you out of small jams: a hand winch (a.k.a. "come-along"), tow strap, high-lift jack, shovel, some wood blocks, and a first-aid kit. If you're going further than you can walk out, bring enough stuff (extra clothes, water, sleeping bag) to survive until somebody finds you.

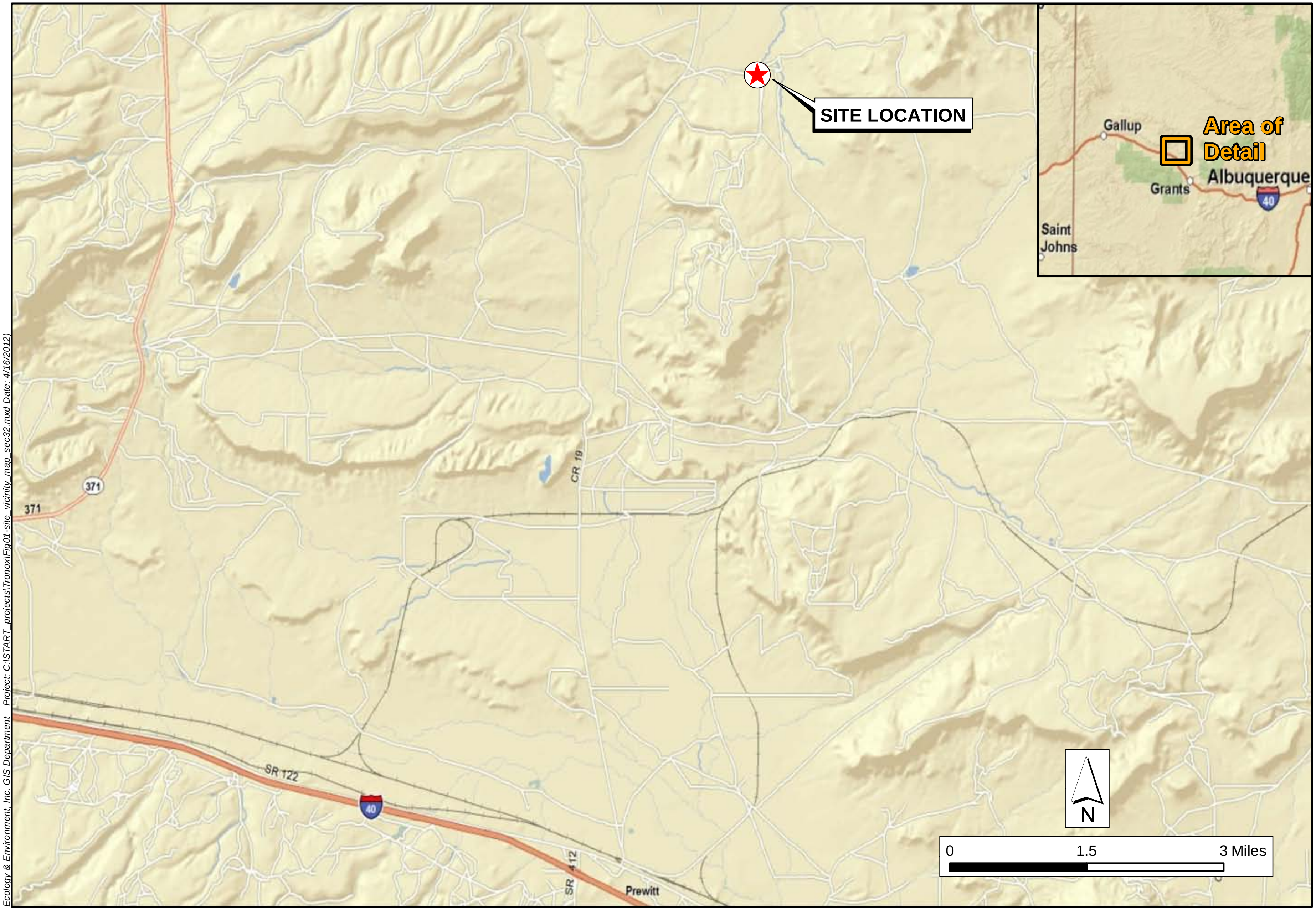
Tell somebody.
Tell somebody where you're going and when you expect to be back. At least they'll know when and where to start searching.

I got out of that ancient incident unscathed, largely because within a short hike there was a tractor with the keys in it and a long chain. Bringing along some luck never hurts.

About the Author
Mac Demere is a writer, vehicle tester and race driver who competed in the NASCAR Southwest Tour and Rolex 24 Hours at Daytona.

Project# 002693.2164.01RA
TDD# TO2 09-11-10-0004

Source: ESRI Streetmaps

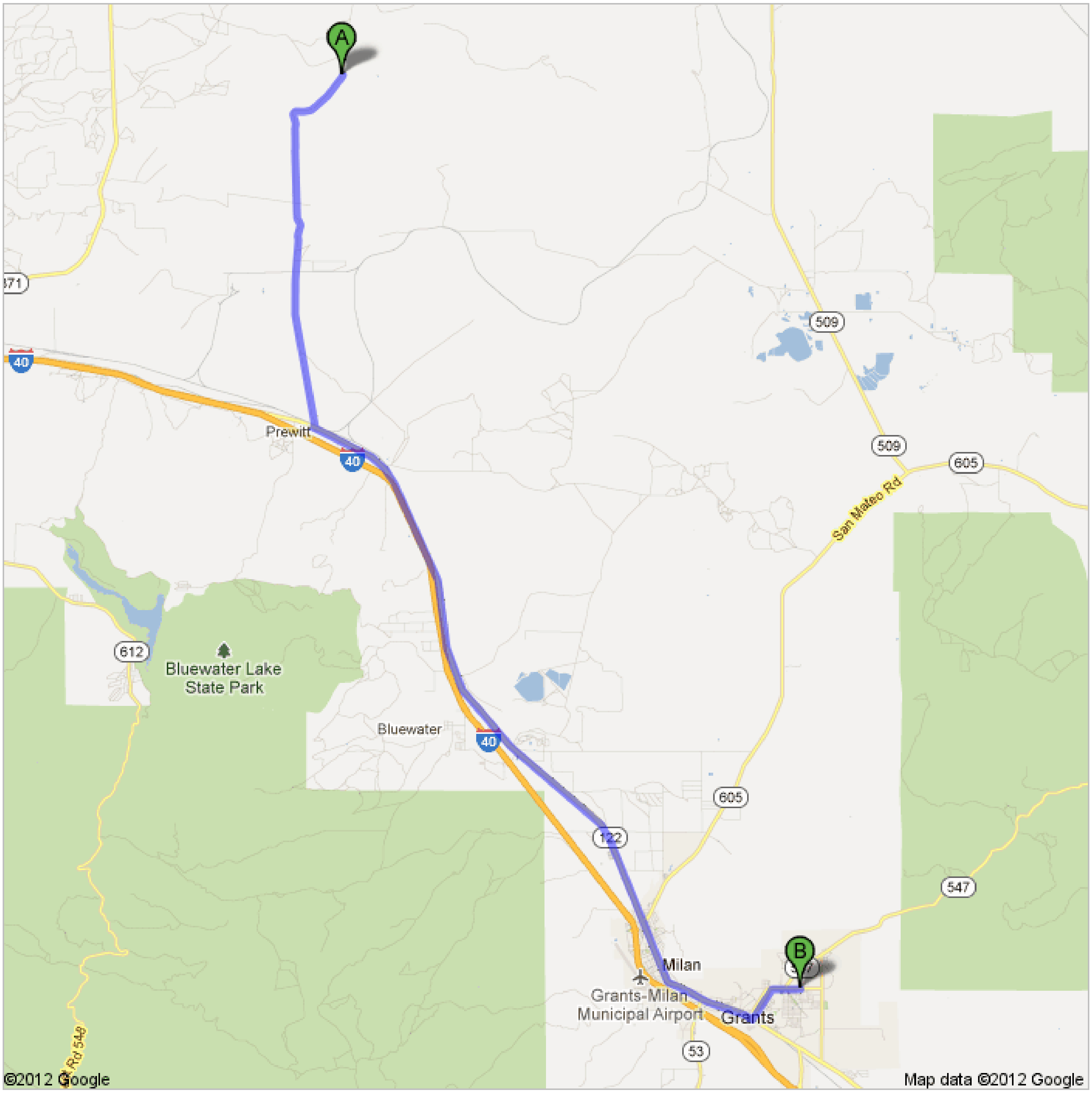


Ecology & Environment, Inc. GIS Department Project: C:\START_projects\Tronox\Fig01-site_vicinity_map_sec32.mxd Date: 4/16/2012)

ecology and environment, inc.
International Specialists in the Environment

Figure 1
Site Vicinity Map
Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation, Prewitt, New Mexico

Directions to Cibola General Hospital
1016 E Roosevelt Ave, Grants, NM 87020 - (505) 287-4446
30.8 mi – about **49 mins**



Co Rd 19

1.	Head **southwest** on **Co Rd 19** About 24 mins	go 9.7 mi total 9.7 mi
2.	Turn left onto **NM-122 E/Frontage Rd** Continue to follow NM-122 E About 20 mins	go 18.1 mi total 27.8 mi
3.	Continue onto **W Santa Fe Ave** About 2 mins	go 1.4 mi total 29.2 mi
4.	Turn left onto **1st St** About 2 mins	go 0.9 mi total 30.0 mi
5.	Slight right onto **W Roosevelt Ave** Destination will be on the left About 2 mins	go 0.7 mi total 30.8 mi

Cibola General Hospital

1016 E Roosevelt Ave, Grants, NM 87020 - (505) 287-4446

These directions are for planning purposes only. You may find that construction projects, traffic, w eather, or other events may cause conditions to differ from the map results, and you should plan your route accordingly. You must obey all signs or notices regarding your route.

Directions w eren't right? Please find your route on maps.google.com and click "Report a problem" at the bottom left.

C Visual Sampling Plan Output

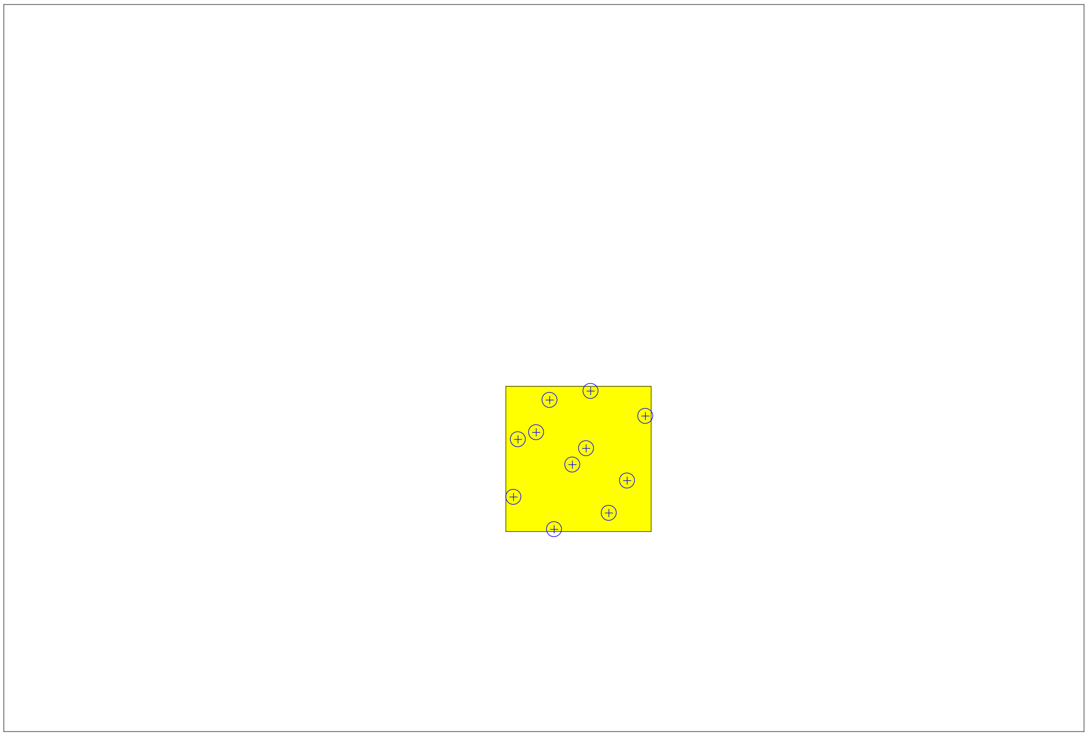
VSP Sample Design Report for Calculating a Two-Sided Confidence Interval for the Population Mean Using Simple Random Sampling

Summary
This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Construct a Confidence Interval on the True Mean
Type of Sampling Design	Parametric
Sample Placement (Location) in the Field	Simple random sampling
Formula for calculating number of sampling locations	Confidence Limits using Student's t-distribution
Calculated total number of samples	11
Number of samples on map [a]	11
Number of selected sample areas [b]	1
Specified sampling area [c]	400.00 ft^2
Total cost of sampling [d]	$20,200.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: Area 1					
X Coord	Y Coord	Label	Value	Type	Historical
1.6685	12.6771			Random	
11.6685	19.3437			Random	
6.6685	0.3314			Random	
16.6685	6.9981			Random	
4.1685	13.6647			Random	
14.1685	2.5536			Random	
9.1685	9.2203			Random	
19.1685	15.8870			Random	
1.0435	4.7758			Random	
11.0435	11.4425			Random	
6.0435	18.1092			Random	

Primary Sampling Objective
The primary purpose of sampling at this site is to construct a confidence interval on the true population mean value. After the samples are collected and analyzed, the resulting sample values can be used to construct a two-sided confidence interval. Once the confidence interval is computed (which will be an upper and a lower threshold), you can have the specified confidence that the true population mean is between the upper and lower thresholds.

Selected Sampling Approach
A parametric random sampling approach was used to determine the number of samples and to specify sampling locations. A parametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that parametric assumptions are true. These assumptions will be examined in post-sampling data analysis.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a confidence interval calculation using the Student's t-distribution. The formula used to calculate the number of samples is:

$$n = \left[\frac{t_{1-\alpha/2,df}\, S_{total}}{d} \right]^2$$

where

n is the recommended minimum sample size for the study area,

S_{total} is the estimated standard deviation due to both sampling and analytical variability,

α is the maximum acceptable probability that the true mean will not lie in the confidence interval (the confidence level is 1-α),

d is the half-width of the confidence interval,

$t_{1-\alpha/2,df}$ is the value of the Student's t-distribution with $df=n-1$ degrees of freedom such that the proportion of the distribution less than $t_{1-\alpha/2}$ is 1-α/2.

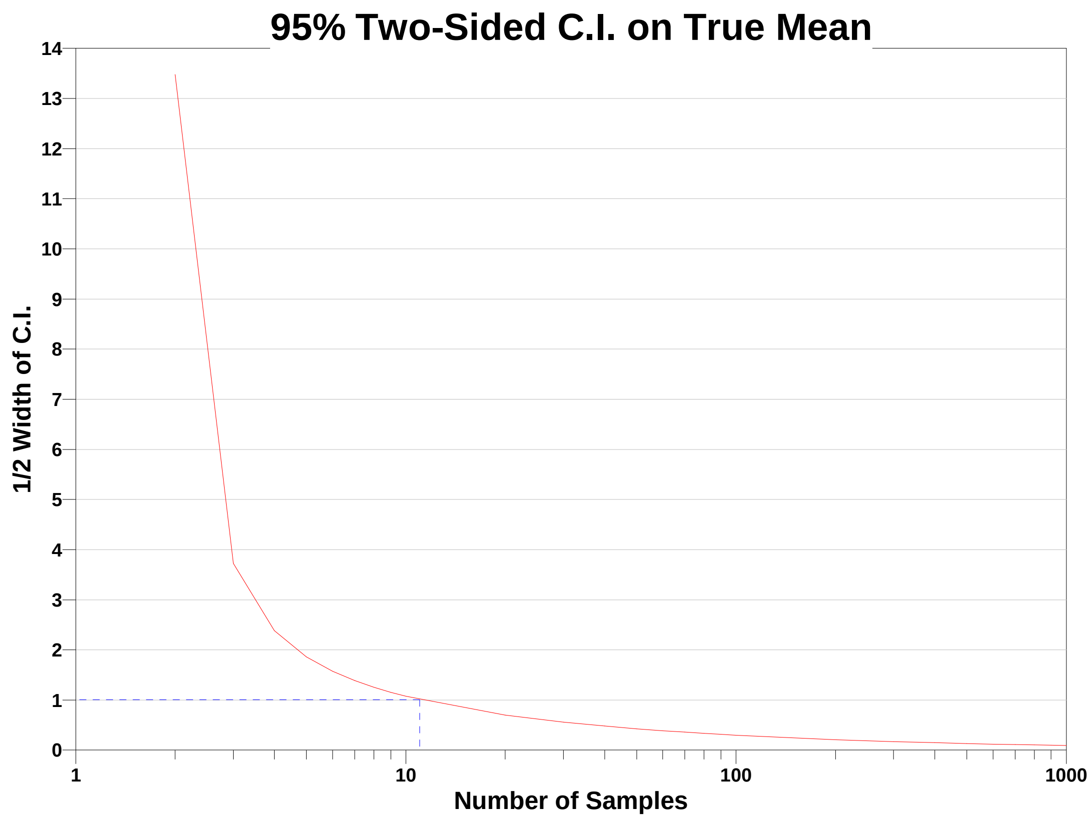
Because n appears on both sides of the equation (on the right side it appears in the degrees of freedom of the t-statistic), the equation must be solved iteratively. VSP does this automatically using the iteration scheme in Gilbert (1987, pg. 32).

The values of these inputs that result in the calculated number of sampling locations are:

Analyte	**n**	**Parameter**			
		S	**d**	α	$t_{1-\alpha/2,df}$
Ra-226	11	1.5 pCi/g	1 pCi/g	5%	2.22814 [a]

[a] This value is automatically calculated by VSP based upon the user defined value of α

The following figure is a graph representing the relationship between the half-width of the confidence interval and the number of samples. The blue dashed line illustrates the specified maximum desirable confidence interval half-width. Where this dashed line intersects the red curve is the number of samples calculated by VSP.



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:
1. the sample mean is normally distributed,
2. the population values are not spatially or temporally correlated, and
3. the sampling locations will be selected randomly.

The first two assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, confidence level (1-α) (%) and width of confidence interval. The following table shows the results of this analysis.

Number of Samples						
	d=0.5		d=1		d=1.5	
	s=3	s=1.5	s=3	s=1.5	s=3	s=1.5
CL=99	243	64	64	19	31	11
CL=97	173	46	46	14	22	9
CL=95	141	38	38	11	18	7
CL=93	121	32	32	10	16	7
CL=91	106	28	28	9	14	5

s = Standard Deviation
CL = Confidence Level (1-α) (%)
d = Width of Confidence Interval

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above,

the estimated total cost of sampling and analysis at this site is $20,200.00, which averages out to a per sample cost of $1,836.36. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**11 Samples**
Field collection costs		$100.00	$1,100.00
Analytical costs	$100.00	$100.00	$1,100.00
Sum of Field & Analytical costs		**$200.00**	**$2,200.00**
Fixed planning and validation costs			$18,000.00
Total cost			**$20,200.00**

Recommended Data Analysis Activities
Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2000). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

Because the primary objective for sampling for this site is to compute a confidence interval, the data should be assessed in this context. Assuming the data are adequate, at least one statistical test should be done to evaluate whether the data are normally distributed. Appropriate confidence intervals for the mean value should then be calculated. Results of the exploratory and quantitative assessments of the data should be reported, along with conclusions that may be supported by them.

Sampling and Analysis Plan
Tronox AUM Section 33, Eastern Agency
Removal Assessment
Prewitt, McKinley County, New Mexico

TDD No.: TO-02-09-11-10-0005
Project No.: EE-002693-2165-01TTO

June 2012

Prepared for:

U.S. ENVIRONMENTAL PROTECTION AGENCY
Region IX

Prepared by:

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Oakland, California 94612

Superfund Technical Assessment and Response Team

Sampling and Analysis Plan
Tronox AUM Section 33, Eastern Agency
Removal Assessment
Prewitt, McKinley County, New Mexico

TDD No.: TO-02-09-11-10-0005
Project No.: EE-002693-2165-01TTO

June 2012

Approved by:____
Aileen Mendoza, START Project Manager
Ecology and Environment, Inc.

Approved by: Howard F Edwards June 11, 2012
Howard Edwards, START Quality Assurance Coordinator
Ecology and Environment, Inc.

Approved by:____
Randy Nattis, Federal On-Scene Coordinator
U.S. Environmental Protection Agency, Region IX

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List of Tables

List of Figures

List of Abbreviations and Acronyms

AUM	Abandoned Uranium Mine
ARARs	Applicable or Relevant and Appropriate Requirements
bgs	below ground surface
COPC	contaminant of potential concern
cpm	counts per minute
DQI	Data Quality Indicator
DQO	Data Quality Objective
E & E	Ecology and Environment, Inc.
EML	Environmental Measurements Laboratory
EPA	United States Environmental Protection Agency
ERT	Environmental Response Team
FOP	field operating procedure
FOSC	Federal On-Scene Coordinator
GPS	Global Positioning System
HASL	Health and Safety Laboratory
HASP	Health and Safety Plan
ID	identification
IDW	investigation-derived waste
LCS	laboratory control sample
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MS/MSD	matrix spike/matrix spike duplicate
NA	not applicable

List of Abbreviations and Acronyms (cont.)

NNEPA	Navajo Nation Environmental Protection Agency
pCi/g	picocurie per gram
PM	Project Manager
PPE	personal protective equipment
PRG	Preliminary Remediation Goal
QA	quality assurance
QC	quality control
Ra-226	Radium 226
Ra-226+D	Ra-226 and its radioactive decay chain products
RPD	relative percent difference
SAP	Sampling and Analysis Plan
SD	standard deviation
SERAS	Scientific, Engineering, Response, and Analytical Services
SOP	standard operating procedure
START	Superfund Technical Assessment and Response Team
VSP	Visual Sampling Plan
Weston	Weston Solutions, Inc.

1 Introduction

The United States Environmental Protection Agency (EPA) tasked Ecology and Environment, Inc.'s (E & E's) Superfund Technical Assessment and Response Team (START) to conduct a removal assessment at the Tronox Abandoned Uranium Mine (AUM) Section 33 (site), located in Prewitt, McKinley County, New Mexico in the Casamero Lake and Haystack Chapters of the Navajo Nation. The site is part of the Five-Year Plan for cleaning up the legacy of abandoned uranium mining in the Navajo Nation (EPA *et al.* 2008). The removal assessment includes selecting a background area, scanning gamma radiation activity in soil and waste piles, and collecting soil and waste pile samples at the site. START developed data quality objectives (DQO) and prepared this Sampling and Analysis Plan (SAP) under the direction of EPA Federal On-Scene Coordinator (FOSC) Randy Nattis.

This SAP describes the project and data use objectives, data collection rationale, data quality assurance goals, and requirements for sampling and analysis activities. It also defines the sampling and data collection methods that will be used for this project. This SAP is intended to accurately reflect the planned data-gathering activities for this task; however, site conditions, budget, and additional EPA direction may warrant modifications. All significant changes will be documented in site records.

The specific field sampling and chemical analysis information in this SAP was prepared according to the following EPA documents: *EPA Requirements for Quality Assurance Project Plans, EPA QA/R 5, EPA/240/B 01/003* (EPA 2001), *Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G 4, EPA/240/B-06/001* (EPA 2006), *Guidance on Choosing a Sampling Design for Environmental Data Collection, EPA QA/G 5S, EPA/240/R 02/005* (EPA 2002), and *Uniform Federal Policy for Implementing Environmental Quality System, EPA/505/F-03/001* (EPA 2005).

1.1 Project Organization

EPA FOSC – The EPA FOSC, Randy Nattis, is the primary decision-maker and will direct the project, specify tasks, and ensure that the project is proceeding on schedule and within budget. Additional duties include coordination of all preliminary and final reporting and communication with the Navajo Nation Environmental Protection Agency (NNEPA), START Project Manager (PM), EPA Environmental Response Team (ERT) and their Scientific, Engineering, Response, and Analytical Services (SERAS) contractor, EPA Quality Assurance (QA) Office, and community residents. The EPA FOSC is also responsible for access to each property to be investigated.

START PM – The START PM, Aileen Mendoza, manages the project's data collection efforts and is responsible for implementing the SAP, coordinating project tasks and field sampling, managing field data, and completing all preliminary and final reporting.

Principal Data Users – Data generated during the implementation of this SAP will be utilized by the EPA FOSC to make decisions regarding further action.

START QA Coordinator – The START QA Coordinator, Howard Edwards, is responsible for overseeing the development of this SAP. The START QA Coordinator will coordinate with the

EPA's QA Office as needed. START QA Coordinator will provide QA oversight to ensure that planning and plan implementation are according to the EPA regional quality assurance/quality control (QA/QC) protocol. START QA Coordinator will provide technical direction concerning QA/QC as needed to the EPA FOSC and the START PM.

Sample Analysis and Laboratory Support – The START-contracted laboratory, GEL Laboratories, LLC, is responsible for sample analysis by definitive analytical methodologies. START is responsible for field data analysis and data validation of laboratory-generated data.

1.2 Distribution List

Copies of the final SAP will be distributed to the following persons and organizations:

- EPA FOSC Randy Nattis, EPA Region IX
- EPA Region IX QA Office
- Joe Schaefer, EPA ERT
- E & E START Field Team
- E & E START project files

1.3 Statement of the Specific Problem

The site was identified as an AUM. Gamma radiation activity at the site exceeds the reported background level up to 8 times in surface soil and up to 50 times in a waste pile rock. Gamma radiation activity in surface soil and waste piles at the site may pose an imminent and substantial threat to human health. The lateral and vertical extent of gamma radiation in soil and radiation levels in the waste piles need to be defined to support the EPA Task Monitor in determining whether a removal action is necessary to protect human health.

2 Site Background

2.1 Site Location and Description

The site is located approximately 1 mile east of County Road 19, Prewitt, McKinley County, New Mexico (Latitude: 35° 29' 26.1972" N, Longitude: -108° 0' 59.8583" W) (Figure 2-1). The site is located in a private land owned by Lynn “Buddy” Elkins and is part of the Casamero Lake and Haystack Chapters of the Navajo Nation. The site is in a vacant land surrounded by open space. The western boundary of the site is bordered by Tronox AUM Section 32.

The site has an approximate area of 11,005 square meters containing waste piles, a wooden hopper located in the northeastern corner, and an undetermined extent of underground workings (Weston Solutions, Inc. [Weston] 2009). The site is relatively flat with sparse vegetation. Surface water was not observed at or within the influence of the site; however, available geographical information show a stream or river located north and south of the site which converges approximately 0.25 mile west of the site, and two ponds located northeast of the site. Groundwater depth and information on nearby water wells used for drinking water were not available. No residences, public structures, water sources or sensitive environment were found within 0.25 miles of the site. The nearest resident is Lucita Sardo who lives approximately 0.5 mile west of the site and had relatives who formerly worked for Cobb Nuclear. Agricultural food production such as livestock grazing or farming common in Navajo communities was not observed at or immediately adjacent to the site.

2.2 Site History

According to EPA, portions of the Navajo Nation are located 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 AUMs. Cobb Nuclear Company operated mines in the Casamero Lake Chapter area (Weston 2009).

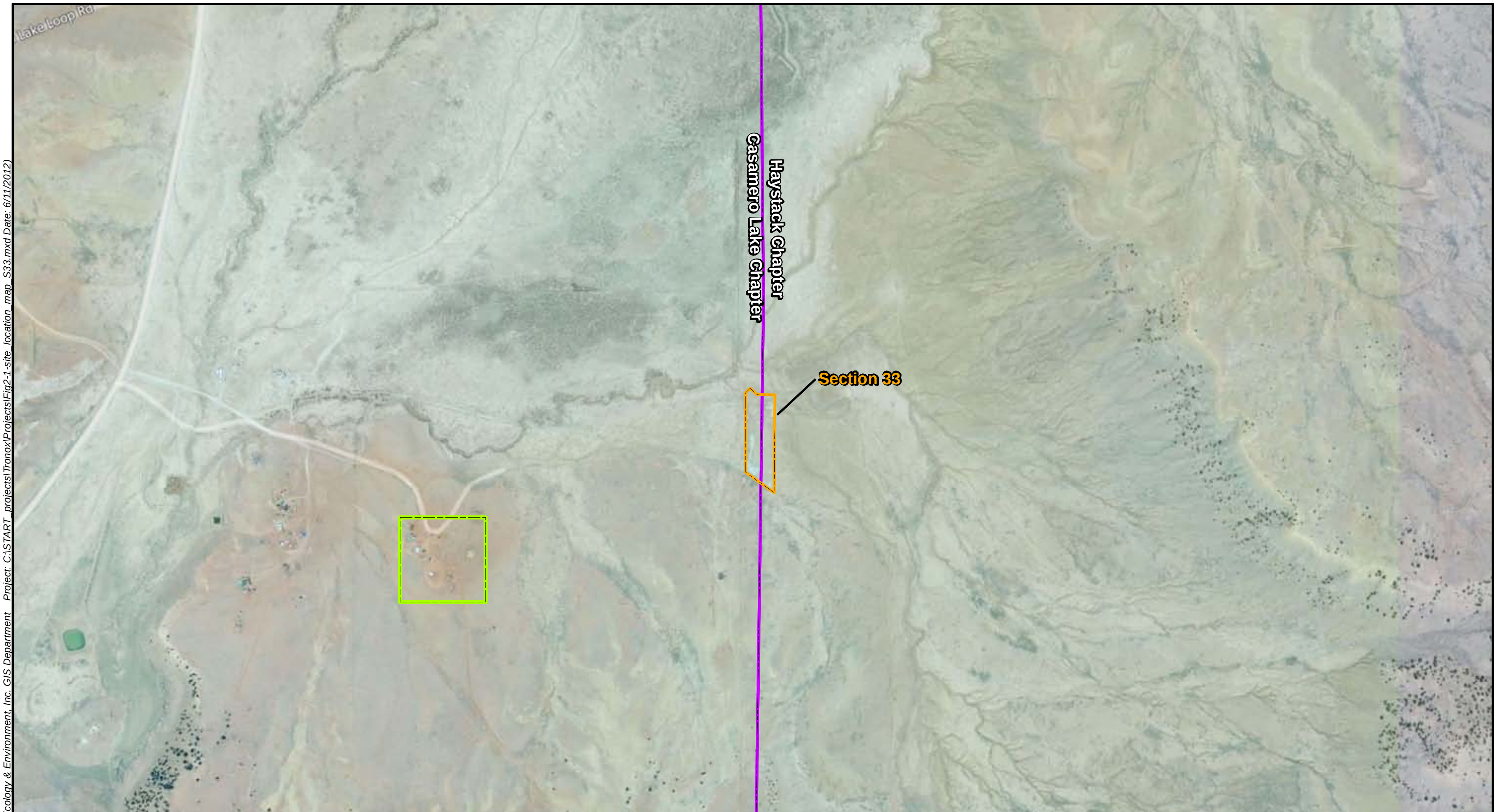
The site consists of a historical mine which was reportedly owned by Cobb Nuclear and was closed due to a fatality (Weston 2009). No other information on historical ownership of the mine and mining operations were available. No visible signs of reclamation were reported.

A site screening for AUMs was conducted at the site which included collection of site information and gamma radiation survey data (Weston 2009). Gamma radiation activity was measured from surface soil along the boundary of the site and along two diagonal intersecting transects from the site’s four corners. Gamma radiation activity measurements ranged from 14,322 counts per minute (cpm) to 140,917 cpm. A rock from a waste pile emitted over 800,000 cpm. Gamma radiation activity was also measured from a background location which was not identified in the report. The gamma radiation activity at the background location ranged from 16,630 cpm to 17,128 cpm.

Materials from the mine potentially used as building materials for residential structures may expose residents to radiation. The residence near the site reportedly used some materials (tarps and lumber) obtained from the mine and had gamma radiation measurements of approximately 12,000 cpm. The home site assessment is detailed in the AUM Section 32 removal assessment.

Project # 002693.2164.01RA
TDD# TO2-09-11-10-0004

Source: Aerial Photography - Bing Maps



Ecology & Environment, Inc. GIS Department Project: C:\START_projects\Tronox\Projects\Fig2-1-site_location_map_S33.mxd Date: 6/11/2012)

LEGEND

Homesite boundary

Mine boundary

Chapter boundary

N

0 1,000 2,000 Feet

Figure 2-1

Site Location Map
Tronox AUM Section 33

Casamero Lake Chapter, Navajo Nation, Prewitt, New Mexico

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International Specialists in the Environment

3 Project Objectives

3.1 Data Use Objectives

Data generated from this investigation will be used to:

- Establish background gamma radiation activity
- Document gamma radiation activity throughout the site
- Document concentration of radium-226 (Ra-226) in soil at background and site locations
- Assist EPA with decision on further action at the site.

3.2 Project Task/Sampling Objectives

EPA tasked START to conduct a removal assessment. Under this task, START will complete this SAP, field activities, and a final report.

This SAP includes data quality objectives; the number, location, and type of proposed sampling; field sample collection and laboratory analytical methods and procedures; data quality assurance and validation procedures. Field activities include mobilization/demobilization, gamma radiation activity scans, and soil sampling. Data collection will be conducted according to this SAP and the following objectives.

1. Determine whether, and in what areas, site concentrations of Ra-226 in surface soil and waste piles require removal, further assessment, or no further action.
    a. Determine whether gamma radiation activity readings can be used to characterize the site or if further sampling to characterize the site is necessary.
    b. Determine a suitable background location for collecting data to calculate a site-specific action level or identify an alternate means of setting an action level.
2. Determine whether site concentrations of Ra-226 in subsurface soil at locations where the surface levels of Ra-226 are elevated require removal, further assessment, or no further action.

3.3 Investigation and Action Levels

The investigation and action levels for this site were determined by the EPA FOSC. The investigation level for gamma radiation activity in surface soil and waste piles will be based on background levels. The EPA FOSC determined radium-226 (Ra-226) is the COPC at the site. The action level for Ra-226 will be based on the sum of the background concentration of Ra-226 and the EPA Preliminary Remediation Goal (PRG) of 1.21 picocuries per gram (pCi/g). The PRG is based on Ra-226 and its radioactive decay chain products (Ra-226+D) in residential soil and an estimated excess cancer risk of 1 in 10,000 (10^{-4}) (EPA 2010). Exposure pathways considered include incidental ingestion of soil, inhalation of particulates emitted from soil, external exposure to ionizing radiation, and consumption of fruits and vegetables. This standardized PRG is based on default exposure parameters and incorporate exposure factors that present reasonable maximum exposure selected to be protective of human health for most site conditions.

The investigation and action levels for this removal assessment are presented in Table 3-1.

Table 3-1 Benchmarks and Data Quality Indicator Goals
Gamma Radiation Activity Survey and Definitive Data for Ra-226 by EML HASL 300, 4.5.2.3 Method
Tronox AUM Section 33 Eastern Agency
Removal Assessment
Prewitt, McKinley County, New Mexico

E & E Project No. EE-002693-2165-01TTO TDD No. TO-02-09-11-10-0005

Analyte	Background Concentration[1]	Site-Specific Action Level for Assessment	EPA PRG (pCi/g)	Reporting Limit (pCi/g)	Accuracy (% Recovery for MS/ MSD)	Precision (RPD from MS/MSD and Duplicates)	Percent Completeness
Gamma radiation activity[2]	To be determined (cpm)	Background (cpm)	NA	0.1 cpm with a detection range from 0.1 to 999,000 cpm	NA	20%	90
Ra-226	To be determined (pCi/g)	Sum of background and EPA PRG (pCi/g)	1.21	1.00 at GEL Laboratories, LLC	NA	35%	90

Notes:
% – percent
AUM – abandoned uranium mine
cpm – count per minute
EML – Environmental Measurements Laboratory
EPA – U.S. Environmental Protection Agency
HASL – Health and Safety Laboratory
MS/MSD = Matrix Spike/Matrix Spike Duplicate
NA – Not applicable
pCi/g – picocuries per gram
PRG – EPA Preliminary Remediation Goal (August 2010)
Ra-226 – Radium isotope number 226
RPD – Relative Percent Difference

1 Background gamma radiation activity and Ra-226 concentration in soil will be determined during field activities and laboratory analysis.
2 All field instruments will be included in the quality control program to document that the instruments are operating within specified control limits.

3.4 Data Quality Objectives

The DQO process, as set forth in the EPA *Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA/240/B-06/001* (EPA 2006), was followed to establish the DQO for this project. An outline of the process and the outputs for this project are included in Appendix A.

3.5 Data Quality Indicators (DQIs)

Data quality indicators (DQIs) are defined as: precision, accuracy, representativeness, completeness, comparability, and method detection limits. The DQIs for this project were developed following the guidelines in the EPA *Requirements for Quality Assurance Project Plans* (EPA 2001). All sampling procedures are documented in Sections 6.2 and 6.3. Standard operating procedures will be followed to ensure representativeness of sample results by obtaining characteristic samples. Approved EPA methods and standard reporting limits will be used whenever possible. All data not rejected will be considered complete. Table 3-1 documents the site-specific DQI goals for the sample analytes.

3.6 Schedule of Sampling Activities

Field activities will begin on June 11, 2012 and continue for up to 5 days.

3.7 Special Training Requirements/Certifications

The operation of the field analytical instruments requires specialized training that will be administered, prior to mobilization, to all START personnel scheduled to be on site. As directed by EPA FOSC Nattis, ERT's SERAS contractor will train START on VIPER on site.

Field sampling personnel should be trained and have experience with soil sampling at hazardous waste sites while wearing appropriate protective equipment. One field sampler will be trained and familiar with Global Positioning System (GPS) data collection. All sampling personnel will have appropriate training that complies with 29 Code of Federal Regulations 1910.120. The site-specific health and safety plan for this project is included in Appendix B.

Data validation requires specialized training and experience. The START QC Coordinator will determine and verify a qualified data validation resource prior to data validation.

4 Sampling Rationale and Design

The sampling rationale and design was developed under the direction of the EPA FOSC and START Program Manager, and based on information from other EPA AUM sites.

4.1 Selection of Survey (Decision) Units

Decisions will apply to the entire site unless decision units are established based on data.

4.2 Background Area

Background survey, sampling and analysis are required to determine naturally-occurring gamma activity and COPC concentrations in an area with similar geology and no known or suspected impacts from mining. The background area will be selected in the field according to the *Background Location Selection Criteria* (NNEPA and EPA 2010). The background area will be easily accessible, an appropriate distance from the site, and historically undeveloped based on visual observation.

4.2.1 Gamma Radiation Activity Investigation Level

A survey unit measuring 20 x 20 feet will be established in the selected background area. Gamma radiation activity in surface soil will be measured using a paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241 meter mounted 6 inches from the ground surface on a 3-foot wide push cart. The VIPER system and geographical information system (GIS) will be used for geospatial information collection and analysis. The surface soil survey will consist of transects spaced 3 feet apart, which will provide 100 percent characterization of the site. The transect width is based on the field of view of the detector which is 3 to 6 feet diameter. The surveyor will walk at a pace of 3 feet per second. The mean and standard deviation (SD) of the gamma radiation activity measurements in the background area surface soil will be calculated to develop the investigation level for gamma radiation activity at the site. An acceptable background area will have a low mean and SD.

4.2.2 Ra-226 Action Level

Surface soil samples will be collected at 0 to 2 inches bgs from the background survey unit and analyzed for Ra-226 by EML HASL 300 4.5.2.3 Method. Eleven samples will be collected at random locations which according to Visual Sampling Plan (VSP) software version 6.2 will provide a 95 percent confidence level that the calculated mean will be within ±1 pCi/g of the true mean. The sample data will be used to develop the action level for the RA-226. Co-located static gamma radiation activity measurements will also be collected from the surface soil location to establish the relationship between gamma radiation activity and RA-226 concentration in surface soil.

4.3 Site Soil

Gamma radiation activity in surface soil at the site will be measured similar to the background area. A paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241 meter mounted 6 inches from the ground surface on a 3-foot wide push cart will be used to measure gamma radiation activity in surface soil. The surface soil survey will consist of 3-foot wide transects at a pace of 3 feet per second covering 100 percent of the site. If gamma radiation activity measurements along the perimeter of the site exceed the investigation level, lateral step-out will consist of additional 3-foot wide transects to a maximum of 10 feet beyond the site boundary.

Surface soil samples will be co-located with static 1-minute scans of gamma radiation activity to establish the relationship between RA-226 concentration and gamma radiation activity in surface soil. Surface soil samples will be collected from 0 to 2 inches bgs from locations of gamma radiation activity above the investigation level according to the following ranges based on previous AUM sites:

- Investigation level
- Investigation level plus 10,000 cpm (10,000 cpm was established from previous AUM sites to correlate with 1.2 pCi/g of Ra-226)
- Investigation level plus 20,000 cpm
- Investigation level plus 25,000 cpm
- Investigation level plus 30,000 cpm

Surface soil samples will also be collected from areas with gamma radiation activity at or below the investigation level to confirm the RA-226 concentrations at these locations are below the action level. Surface soil samples will be collected from locations within the ranges of interest in each soil type and vegetation cover observed at the site. Additional surface soil samples may be collected based on field observations as determined by the EPA FOSC. Based on previous AUM sites, 15 samples have provided correlation of Ra-226 concentration with gamma radiation activity. A maximum of 30 surface soil samples (site and background) will be collected from the site and shipped to the START-contracted laboratory for Ra-226 analysis by EML HASL 300 4.5.2.3 Method.

Subsurface soil samples will be collected to determine the vertical extent of contamination at locations where surface gamma radiation activity exceeds the investigation level. Elevated locations will be determined from gamma radiation activity results of the 100 percent scan of the site. Soil samples will be collected down to 3 feet bgs (or less based on refusal or groundwater) at 1-foot depth intervals bgs. Subsurface samples will be collected from each depth in clustered boreholes i.e., one sample from a 1-foot deep borehole, one sample from a 2-feet deep borehole, and one sample from a 3-feet deep borehole, to minimize soil from shallower depths from being collected with the desired subsurface sample. The number of subsurface samples collected will be initially based on 10 percent of the highest documented gamma radiation activity locations but may vary based on field data. Additional subsurface soil samples may be collected based on field observations as determined by the EPA FOSC.

4.4 Waste Piles

Gamma radiation activity in waste piles at the site will be measured using a paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241 meter held 6 inches from the surface of the waste and moved in a serpentine motion at a scan rate of 1 to 2 feet per second covering 100 percent of the waste pile or until unsafe radiation levels are encountered based on the health and safety plan (HASP, Appendix B). Unsafe areas will not be surveyed.

A surface sample (0 to 2 inches bgs) will be collected from the waste piles to represent the lowest, middle of the range, and highest gamma radiation activity detected in the waste piles. The waste pile samples will be analyzed for Ra-226 using the EML HASL 300 4.5.2.3 Method.

4.5 Analyte of Concern

Gamma radiation activity in surface soil and waste piles at the site will be measured in cpm. Soil and waste pile samples will be analyzed for Ra-226 as indicator isotope to determine the extent of contamination from historical uranium mining at the site. Gamma radiation activity will be correlated with the Ra-226 concentrations detected in surface soil at the site.

5 Request for Analyses

Surface soil and waste piles at the site will be analyzed in the field for gamma radiation activity. Soil and waste pile samples will be analyzed for Ra-226 concentration by the START-contracted laboratory.

The following sections describe these analyses.

5.1 Field Analysis

Gamma radiation activity in surface soil and waste piles will be measured in the field using a paired Ludlum Model 2221 or 2241 meter and a 44-20 (3x3) detector. Operational checks will be conducted on the paired meter and detector before the field activities using a check source with 1 or 5 microcuries of Cesium-137 based on previous AUM sites. The optimal high voltage setting for the instrument will be set using a Fluke voltage meter . The meter used for the soil survey will be linked to a VIPER system for geospatial information collection and analysis.

To provide quality control for the field analytical effort, the following measures will be utilized:

- Analytical precision and sensitivity of the gamma radiation activity survey equipment will be established before beginning the field measurements and will be verified throughout the field survey through operational and background checks.
- Whenever possible, the same paired VIPER-linked meter and detector used to establish the relationship between gamma radiation activity and Ra-226 concentrations in soil will be used for all surveys conducted at the site.

5.2 Laboratory Analysis

Soil samples will be analyzed for Ra-226 by EML HASL 300, 4.5.2.3 Method (Department of Energy 1990). Soil samples will be submitted to GEL Laboratories, LLC located at 2040 Savage Road, Charleston, South Carolina 29407. Sample containers, preservatives, holding times, and estimated number of soil confirmation and quality control samples are summarized in Table 5-1.

To provide quality control for the analytical program, the following measures will be utilized:

- Duplicate samples will be collected from ten percent of the soil sampling locations or one per sample design group. Duplicate soil samples will be collected as a 50/50 split of the sample after collection and homogenization.
- If non-dedicated sampling equipment is used to collect soil samples at the site, a rinsate blank will be collected at a rate of one per day to evaluate decontamination procedures at the site. The rinsate blank will be collected by pouring deionized water over the decontaminated sample collection device (e.g., trowel or hand auger) and capturing the water in the specified sample container.

Table 5-1 Sampling and Analysis Summary
Tronox AUM Section 33 Eastern Agency
Removal Assessment
Prewitt, McKinley County, New Mexico

E & E Project No. EE-002693-2165-01TTO TDD No. TO-02-09-11-10-0005

Method	**Ra-226 by EML HASL 300, 4.5.2.3 Method**
Sample Container	4 ounce plastic soil jars
Preservation	None
Analysis Holding Time	6 Months
Estimated Number of Unique Discrete Samples	30 surface soil samples 9 subsurface samples 5 waste pile samples
Estimated Number of Duplicate Samples	5
Minimum Total Site Sample Analyses	49
Equipment Rinse Blanks (if non-dedicated equipment is used)	
Sample Container	500 milliliter plastic bottle
Preservation	None
Analysis Holding Time	14 days
Number of Samples	1 per day (5)

Note:
AUM – abandoned uranium mine
EML – Environmental Measurements Laboratory
HASL – Health and Safety Laboratory
Ra-226 – Radium isotope number 226

6 Field Methods and Procedures

The following sections describe the procedures and equipment that will be used during the field activities.

6.1 Field Procedures

6.1.1 Standard Operating Procedures and Equipment

The equipment listed below may be utilized to obtain environmental samples from the respective media according to the following instrument field operating procedures (FOPs) and sampling standard operating procedures (SOPs) or their equivalent:

- FOP 1, Radiation Scanning Survey
- FOP 5, Ludlum Model 44-20
- FOP 6, Ludlum Model 2221
- For the VIPER system, training and procedures will be provided by ERT and its SERAS contractor.
- Environmental Response Team SOP #2012 Soil Sampling
- Ecology and Environment Inc. SOP # ENV 3.13: Soil Sampling
- Ecology and Environment Inc. SOP# ENV 3.15: Sampling Equipment Decontamination

The following is a partial list of equipment that may come in contact with samples:

- Hand auger, trowel, shovel
- Plastic sample jars
- Disposable nitrile gloves

6.1.2 Equipment Maintenance

Field instrumentation for the collection of soil samples will be operated, maintained, and have operational checks conducted by the sampling team according to the SOPs listed in Section 6.1.1 or their equivalent. Field instrumentation utilized for health and safety purposes will be operated, maintained, and have operational checks conducted by the sampling team according to the manufacturer’s instruction. Operational checks and field use data will be recorded in the instrument or field logbooks.

6.1.3 Inspection/Acceptance Requirements for Supplies and Consumables

There are no project-specific inspection/acceptance criteria for supplies and consumables. It is standard operating procedure that personnel will not use broken or defective materials; items will not be used past their expiration date; supplies and consumables will be checked against order and packing slips to verify the correct items were received; and the supplier will be notified of any missing or damaged items.

6.1.4 Logbooks

Field logbooks will document where, when, how, and from whom any vital project information was obtained. Logbook entries will be complete and accurate enough to permit reconstruction of field activities. A separate logbook will be maintained for each project. Logbooks are bound with consecutively numbered pages. Each page will be dated and the time of entry noted in military time. All entries will be legible, written in ink, and signed by the individual making the entries. Language will be factual, objective, and free of personal opinions. The following information will be recorded, if applicable, during the collection of each sample:

- Sample location and description
- Site sketch showing sample location and measured distances
- Sampler's name(s)
- Date and time of sample collection
- Type of sample (matrix)
- Type of sampling equipment used
- Onsite measurement data (e.g., Background radiation measurements)
- Field observations and details important to analysis or integrity of samples (rain, odors, etc.)
- Type(s) of preservation used
- Field instrument reading (such as micro-Roentgen readings for health and safety purposes, etc.)
- Shipping arrangements (air bill numbers)
- Receiving laboratory

START team members will be on site performing different duties related to sample collection, processing, and analysis. Each logbook will document the information relevant to the site radiation activity, and at a minimum will include:

- Team members and their responsibilities
- Time of activities
- Deviations from sampling plans, site safety plans, and SAP procedures
- Levels of safety protection
- Operational check information
- Analytical data

6.1.5 Photographs

Photographs will be taken at representative sampling locations and at other areas of interest on site. They will serve to verify information entered in the field logbook. When a photograph is taken, the following information will be written in the logbook or will be recorded in a separate field photography log:

- Time, date, location, and, if appropriate, weather conditions
- Description of the subject photographed
- Name of person taking the photograph

6.1.6 Electronic Sample Logging

The sampling team may utilize field management software to prepare sample labels and chain-of-custody forms. Blank sample labels and chain-of-custody forms will also be available.

The following information should be entered for each sample after collection:

- Sample name
- Sample date and time
- Number of sample bottles
- Type of preservation
- Analyses

In addition to these items, the software may also be used to keep track of other information such as sample depth, field measurements, and split samples.

The field team will generate chain-of-custody forms for each cooler of samples packaged and sent to a laboratory. Each chain-of-custody form will refer to the shipping method and tracking number. Printed chain-of-custody forms will be submitted to the laboratory with the samples.

The use of field management software will require that the field team have access to a computer, a printer, computer paper, and labels while in the field. The field data manager will be responsible for implementing the software.

6.1.7 Mapping Equipment

Sample points and site features will be located and documented with a GPS unit. The GPS will be used to assign precise geographic coordinates to sample locations on the site. GPS mapping will be done by personnel trained in the use of the equipment and will be completed according to the manufacturer's instructions. Expected output from the use of GPS mapping will be site maps with sample locations and major site features.

6.2 Background Selection

The background area will be selected by the EPA FOSC in the field according to the *Background Location Selection Criteria* (NNEPA and EPA 2010) as follows.

- Similar elevation as the site
- Similar geology as the site. Avoid areas of naturally-occurring uranium.
- Upwind (gradient, stream) from site
- Undisturbed with natural vegetation
- Not in drainage or area impacted by flooding
- Distance to residential structures (structures should be within range of vision)
- Accessible (by vehicle and equipment)

- Should not be near a mine site or similar contaminant source
- If possible, avoid anthills and rodent holes
- Ask nearby residents about area

A survey unit measuring 20 x 20 feet will be established in the selected background area and the survey boundary will be marked with flags. Gamma radiation survey of 100 percent of the survey unit will be conducted according to Section 6.3. The mean and SD of the gamma radiation activity measurements in the background area surface soil will be calculated to determine if the background area is acceptable (low mean and SD) and to develop the investigation level for the gamma radiation activity survey.

Eleven surface soil samples will be collected at 0 to 2 inches bgs from random locations in the 20 x 20 feet area according to VSP (Appendix C) which will be estimated in the field. Soil sample results will be used to develop the action level for Ra-226. The surface soil sampling procedure is detailed in Section 6.4.1.

The location of the background area will be documented using GPS and photographs. The calculated investigation levels will be documented electronically and in field sheets as necessary.

6.3 Gamma Radiation Survey Procedures

The survey equipment for measuring gamma radiation activity consists of a paired Ludlum Model 44-20 (3x3) detector and a 2221 or 2241 meter linked to a VIPER system which will have operational checks conducted before field activities begin according to FOPs 1, 4, and 5. Performance of the radiation survey equipment will be verified throughout the field activities through operational checks and background checks as necessary. Whenever possible, the same paired gamma activity survey system will be used for all surveys conducted at the site.

The paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241 meter linked to a VIPER system will be mounted 6 inches from the ground surface on a 3-foot wide push cart. The VIPER system and GIS will be used for geospatial information collection and analysis. ERT's SERAS will train START on site, provide technical support, and operate VIPER during the field activities. Real-time *in situ* surface soil survey will consist of 3-foot wide transects covering 100 percent of the survey area at a pace of 1 to 2 feet per second. If an immovable obstruction is encountered during the survey it will not be moved, and the scanning survey will be performed around the feature. The boundary of the waste piles will be defined.

Gamma radiation activity in waste piles at the site will be measured using a paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241 meter held 6 inches from the surface of the waste pile and moved in a serpentine motion at a scan rate of 1 to 2 feet per second covering 100 percent of the waste pile or until unsafe radiation levels are encountered based on the HASP. Unsafe areas will not be surveyed.

Gamma radiation activity measurements will be used to determine soil and waste pile sample locations at the site. If gamma radiation activity measurements along the perimeter of the site exceed the investigation level, lateral step-out will consist of 3-foot wide transects to a maximum of 10 feet beyond the site boundary. Static 1-minute scans of gamma radiation activity at surface soil locations will be used to establish the relationship between gamma radiation activity and Ra-226 concentration in surface soil.

6.4 Soil Sampling Procedures

6.4.1 Surface Soil

Surface soil locations will be determined based on gamma radiation activity measurements collected in the field. Surface soil sample locations will be located in the field using a GPS unit pre-loaded with the GIS-assigned coordinates and marked with a flag. Static 1-minute scans of gamma radiation activity will be conducted at each surface soil location.

Discrete surface soil samples will be collected at 0 to 2 inches bgs. Surface soil samples will be collected using a stainless-steel trowel and placed into a 4-ounce plastic jar. If present, non-soil material including rocks larger than about ½-inch median diameter will be removed from the soil sample. Sample jars will be stored in a cooler according to the laboratory requirements in Table 5-1. Samples will be shipped to the laboratory for Ra-226 analysis using the EML HASL 300 4.5.2.3 method at the end of field activities. Sampling equipment will be decontaminated after every sample according to Section 6.5. A maximum of 30 surface soil samples (site and background) will be collected from the site.

All sample locations will be recorded in the field logbook as sampling is completed. Each field sampling team will document each individual sampling location in the logbook, which includes: the site name, where the sample was collected with a representative sketch of the area, GPS coordinates of the sample location, date, time, sample identification (ID), sampling team members, and photographs taken.

6.4.2 Subsurface Soil

Subsurface soil samples will be collected from locations of the highest gamma radiation activity results based on the 100 percent scan of the site. Soil samples will be collected down to 3 feet bgs (or less based on refusal or groundwater) at 1-foot depth intervals bgs. Subsurface samples will be collected from each depth in clustered boreholes i.e., one sample from a 1-foot deep borehole, one sample from a 2-feet deep borehole, and one sample from a 3-feet deep borehole, to minimize soil from shallower depths from being collected with the subsurface sample. The number of subsurface samples collected will be initially based on 10 percent of the highest documented gamma radiation activity locations but may vary based on field data. Additional subsurface soil samples may be collected based on field observations as determined by the EPA FOSC.

Subsurface samples will be collected using either a shovel or a hand auger according to Environmental Response Team SOP #2012 and placed into a 4-ounce plastic jar. If present, non-soil material including rocks larger than about ½-inch median diameter will be removed from the soil sample. Sample jars will be stored in a cooler according to the laboratory requirements in Table 5-1. Samples will be shipped to the laboratory for Ra-226 analysis using the EML HASL 300 4.5.2.3 method at the end of field activities. Sampling equipment will be decontaminated after every sample according to Section 6.5.

All sample locations will be recorded in the field logbook as sampling is completed. Each field sampling team will document each individual sampling location in the logbook, which includes: the site name, where the sample was collected with a representative sketch of the area, GPS coordinates of the sample location, date, time, sample ID, sampling team members, and photographs taken.

6.5 Waste Pile

A surface sample (0 to 2 inches bgs) will be collected from the waste piles to represent the lowest, middle of the range, and highest gamma radiation activity detected in the waste piles or until unsafe radiation levels are encountered. Surface waste pile samples will be collected using a stainless-steel trowel and placed into a 4-ounce plastic jar. Sample jars will be stored in a cooler according to the laboratory requirements in Table 5-1. Samples will be shipped to the laboratory for Ra-226 analysis using the EML HASL 300 4.5.2.3 method at the end of field activities. Sampling equipment will be decontaminated after every sample according to Section 6.5. An estimated total of 5 samples will be collected from the waste piles.

All sample locations will be recorded in the field logbook as sampling is completed. Each field sampling team will document each individual sampling location in the logbook, which includes: the site name, where the sample was collected with a representative sketch of the area, GPS coordinates of the sample location, date, time, sample identification (ID), sampling team members, and photographs taken.

6.6 Decontamination Procedures

Decontamination activities will be conducted by START according to E & E SOP #3.15. All non-dedicated sample-handling devices will be decontaminated by non-phosphate detergent and tap water wash using a brush to scrub solids from the surface as necessary, and distilled water rinse; or non-chemical moist wipes.

7 Disposal of Investigation-Derived Waste

In the process of collecting environmental samples at this site, several different types of potentially contaminated investigation-derived wastes (IDW) will be generated, including the following:

- Used personal protective equipment (PPE)
- Disposable sampling equipment
- Decontamination fluids

The EPA's National Contingency Plan requires that management of IDW generated during site investigations comply with Applicable or Relevant and Appropriate Requirements s (ARARs) to the extent practicable. This sampling plan will follow the Office of Emergency and Remedial Response Directive 9345.3-02 (EPA 1991), which provides the guidance for management of IDW during site investigations. Listed below are the procedures that will be followed for handling IDW. The procedures are flexible enough to allow the site investigation team to use its professional judgment on the proper method for the disposal of each type of IDW generated at each sampling location.

- Used PPE and disposable sampling equipment will be scanned for elevated gamma radiation activity using a 3x3 or pancake detector. PPE and other disposable items less than 2 to 3 times background gamma radiation activity will be double-bagged in plastic trash bags and disposed of as municipal waste. These wastes are not considered hazardous and can be sent to a municipal landfill. Any PPE or dedicated equipment that is to be disposed of that can still be reused will be rendered unusable before disposal.
- Decontamination fluids which may consist of water with site materials and/or non-phosphate detergent will be placed in the highest contaminated area that will not drain from the site according to standard practice at similar sites.

8 Sample Identification, Documentation, and Shipment

8.1 Sample Nomenclature

For survey location data using the VIPER system each measurement will have a unique geospatial coordinate.

A unique, identifiable name will be assigned to each sample. Samples will be identified according to the following nomenclature:

[Site Name]-[Sample Description]-[Sample Number]-[Sample Depth]
Where:

> Site Name – AUM33
> Sample Description – S will designate soil, BKG will designate background, and WP will designate waste pile
> Sample Number – Number representing the specific sampling location where the sample was collected starting with 01.
> Sample Depth – Sample depth will be identified in inches bgs e.g., 02

For example, the first background sample collected from surface soil (0 to 2 inches bgs) will be identified as follows:
AUM33-BKG-01-02

Field duplicate samples will have the same designations as their originals except the sampling location will be preceded by a "1" thus, the field duplicate for the above examples will be AUM33-BKG-101-02.

8.2 Container, Preservation, and Holding Time Requirements

All sample containers will be delivered by the laboratory to START in a pre-cleaned condition. Container, preservation, and holding time requirements are summarized in Table 5-1.

8.3 Sample Labeling, Packaging, and Shipping

All samples collected will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory. Sample labels will be affixed to the sample containers and will contain the following information:

- Sample number
- Date and time of collection
- Site name
- Analytical parameter and method of preservation

Samples will be stored in a cooler in the custody of site personnel at all times or in a secure location on site pending shipment to the laboratory after the field activities.

The procedures for shipping soil samples are:

- If ice is used then it will be packed in double zip-lock plastic bags.
- The drain plug of the cooler will be sealed with tape to prevent melting ice from leaking.
- The bottom of the cooler will be lined with bubble wrap to prevent breakage during shipment.
- Screw caps will be checked for tightness.
- Coolers will have custody seals affixed so as to prevent opening of the container without breaking the seal.
- All glass sample containers will be wrapped in bubble wrap.
- All containers will be sealed in zip-lock plastic bags as necessary.

All samples will be placed in coolers with the appropriate chain-of-custody forms. All forms will be enclosed in plastic bags and affixed to the underside of the cooler lid. If samples require refrigeration during shipment then bags of ice will be placed on top of and around samples. Empty space in the cooler will be filled with bubble wrap or other appropriate packaging material to prevent movement and breakage during shipment. Each cooler will be secured with a custody seal and will be taped shut with packing or strapping tape.

Samples will be shipped for immediate delivery to the contracted laboratory. Upon shipping, the laboratory will be notified of the following:

- Sampling contractor’s name
- The name of the site
- Shipment date and expected delivery date
- Total number of samples, by matrix and the relative level of contamination for each sample (i.e., low, medium, or high).
- Carrier; air bill number(s), method of shipment (e.g., priority)
- Irregularities or anticipated problems associated with the samples
- Number of coolers or packages shipped

8.4 Chain-of-Custody Forms and QA/QC Summary Forms

A chain-of-custody form will be maintained for all samples to be submitted for analysis, from the time the sample is collected until its final disposition. Every transfer of custody must be noted and a signature affixed. Corrections on sample paperwork will be made by drawing a single line through the mistake and initialing and dating the change. The correct information will be entered above, below, or after the mistake. When samples are not under the direct control of the individual responsible for them, they must be stored in a container sealed with a custody seal. The chain-of-custody form must include the following:

- Site name
- Sample identification numbers

- Sample date and time
- Number and volume of sample containers
- Required analyses
- Signature and name of samplers
- Signature(s) of any individual(s) with control over samples
- Note(s) indicating special holding times and/or detection limits

The chain-of-custody form will be completed and sent with the samples for each laboratory and each shipment. Each sample cooler should contain a chain-of-custody form for all samples within the sample cooler.

9 Quality Assurance and Control

9.1 Field Quality Control Samples

QA/QC samples to be collected during this sampling are listed in Table 5-1 and described in the following subsections. QA/QC described in the following sections pertains to samples collected for laboratory analysis to obtain definitive data and do not pertain to field measurements. QA/QC relevant to field measurement data is described in instrument FOPs and discussed in section 5.1.

9.1.1 Assessment of Field Contamination (Blanks)

Non-dedicated equipment such as stainless steel trowels, shovels and hand augers are used to collect samples, equipment rinsate blanks will be collected at a rate of one per day to evaluate field decontamination procedures. Equipment rinsate blank consists of a sample of analyte-free water passed through or over a decontaminated sampling device into a 500 milliliter plastic bottle. A sample of the analyte-free water (i.e., distilled water) used for decontamination will also be sent to the laboratory.

9.1.2 Assessment of Sample Variability (Field Duplicate or Co-located Samples)

Duplicate soil samples will be collected at selected sample locations. These locations will be chosen randomly in the field and will be collected at a rate of 1 for every 10 field samples. The duplicate sample will be obtained by splitting the homogenized sample collected from the soil location. The duplicate sample will be placed in a 4-ounce plastic jar and labeled accordingly.

9.1.3 Laboratory Quality Control Samples

Analyses for radioisotopes do not typically have MS/MSD requirements; therefore, none will be performed.

9.1.4 Confirmation Samples

The samples submitted to the laboratory for definitive analysis will be used to establish and/or document the comparability and correlation between field screening and laboratory data. START will determine correlation of the data sets by linear regression analysis and will determine relative percent differences for each data pair and for the data sets as a whole. Confirmation samples will determine the usefulness of the field screening technique in future activities at the site.

9.2 Analytical and Data Package Requirements

It is required that all samples be analyzed according to the methods listed in Table 5-1. The laboratory is required to supply documentation to demonstrate that their data meet the requirements specified in the method. Since the Ra-226 determination requires a 21-day ingrowth period prior to analysis, the preliminary results will be delivered to START within 4 weeks of sample delivery. A complete analytical data package will be required from the analytical laboratory 30 working days after sample delivery. The laboratory will also provide all data electronically in a Microsoft Excel-compatible format or delimited text file in the format specified for SCRIBE. The data validator will provide a full validation data package to the START PM within 15 days after receipt of complete analytical data package from the laboratory.

All field measurements and QA/QC information will be documented in log books, field forms, and spreadsheets or may be directly downloaded into a database.

Deliverables for this project must meet the guidelines in EPA Region IX's *Laboratory Documentation Requirements for Data Evaluation, R9/QA/00.4.1* (EPA 2001). The following data requirements specify and emphasize general documentation requirements and are not intended to supersede or change requirements of each method.

- A copy of the chain-of-custody, sample log-in records, and a case narrative describing the analyses and methods used.
- Analytical data (results) for up to three significant figures for all samples, method blanks, MS/MSD, Laboratory Control Samples (LCS), duplicates, Performance Evaluation samples (if applicable), and field QC samples.
- QC summary sheets/forms that summarize the following:
  - MS/MSD/LCS recovery summary
  - Method/preparation blank summary
  - Initial and continuing calibration summary (including retention time windows)
  - Sample holding time and analytical sequence (i.e., extraction and analysis)
  - Calibration curves and correlation coefficients
  - Duplicate summary
  - Detection limit information
- Analyst bench records describing dilution, sample weight, percent moisture (solids), sample size, sample extraction and cleanup, final extract volumes, and amount injected.
- Standard preparation logs, including certificates of analysis for stock standards.
- Detailed explanation of the quantitation and identification procedure used for specific analyses, giving examples of calculations from the raw data.
- The final deliverable report consisting of sequentially numbered pages.

9.3 Data Management

Data collected during the removal assessment will consist of field and laboratory data. Field activities and sample information will be documented in a logbook as discussed in Section 6.1.4. Field and laboratory data including gamma radiation measurements, Ra-226 sample results, and location coordinates, will be loaded in SCRIBE. Electronic data will be managed as described in the data management plan. All data including logbook, complete analytical and validation data packages, photographs, and electronic data will be archived by START. The laboratory data summary and validation reports will be included in the final report submitted to EPA.

9.4 Data Validation

Data validation will be performed by START or their subcontractor according to the *EPA Region IX Superfund Data Evaluation/Validation Guidance R9QA/006.1* (EPA 2001).

The standard data quality review requirements of a Tier 2 validation of 100 percent of the data (as defined in *Requirements for Quality Assurance Project Plans* [EPA 2001]) will satisfy the data quality requirements for this portion of the project. Upon completion of validation, data will be classified as one of the following: acceptable for use without qualifications, acceptable for use with qualifications, or unacceptable for use.

If during or after the evaluation of the project's analytical data it is found that the data contain excess QA/QC problems or if the data do not meet the DQI goals, then the independent reviewer may determine that additional data evaluation is necessary. Additional evaluation may include EPA Region IX Superfund Data Evaluation/Validation Guidance R9QA/006.1 for evaluation Tier 3.

To meet evaluation and project requirements, the following criteria will be evaluated during a Tier 2 evaluation:

- Data package completeness
- Laboratory QA/QC summaries
- Holding times
- Blank contamination
- Matrix related recoveries
- Field duplicates
- Random data checks
- Preservation and holding times
- Initial and continuing calibration
- Blank analyses
- Interference check samples
- Laboratory control samples
- Duplicate sample analysis
- Matrix spike sample analyses
- Sample serial dilution
- Field duplicate/replicate
- Overall assessment of data.

Upon completion of evaluation, an analytical data evaluation Tier 2 review report will be delivered to the project manager, and the data will be classified within the report as one of the following:

- acceptable for use without qualifications
- acceptable for use with qualifications
- unacceptable for use

The data with applicable qualifications will be attached to the report. Unacceptable data may be more thoroughly examined to determine whether corrective action could mitigate data usability.

9.5 Field Variances

As conditions in the field may vary, it may become necessary to implement minor modifications to this plan. When appropriate, the START QA Coordinator and the EPA FOSC will be notified of the modifications and a verbal approval obtained before implementing the modifications. Modifications to the original plan will be recorded in site records and documented in the final report.

9.6 Assessment of Project Activities

9.6.1 Assessment Activities

The following assessment activities will be performed by the START:

- All project deliverables (SAP, Data Summaries, Data Validation Reports, Removal Assessment Report) will be peer-reviewed by START prior to submission to EPA. In time-critical situations, the peer review may be concurrent with the release of a draft document to EPA.
- The START QA Coordinator will review project documentation such as logbooks and chain-of-custody forms to ensure the SAP was followed and that sampling activities were adequately documented. The START QA Coordinator will document deficiencies, and the START PM will be responsible for corrective actions.

9.6.2 Project Status Reports to Management

It is standard procedure for the START PM to report to the EPA FOSC any issues, as they occur, that arise during the course of the project that could affect data quality, data use objectives, the project objectives, or project schedules. As requested by EPA, START will provide unvalidated data as they are received from the laboratory.

9.6.3 Reconciliation of Data with DQOs

Assessment of data quality is an ongoing activity throughout all phases of a project. The following outlines the methods to be used by START for evaluating the results obtained from the project.

Review of the DQO outputs and the sampling design will be conducted by the START QA Coordinator prior to sampling activities. The reviewer will submit comments to the START PM for action, comment, or clarification. This process will be iterative.

A preliminary data review will be conducted by START. The purpose of this review is to look for problems or anomalies in the implementation of the sample collection and analysis procedures and to examine QC data for information to verify assumptions underlying the DQO and the SAP.

10 References

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A Data Quality Objective Process Document

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, REGION 9 DATA QUALITY OBJECTIVES FOR TRONOX ABANDONED URANIUM MINE SECTION 33, EASTERN AGENCY REMOVAL ASSESSMENT

STEP 1.

THE PROBLEM

Background

The United States Environmental Protection Agency (EPA) tasked Ecology and Environment, Inc.'s (E & E's) Superfund Technical Assessment and Response Team (START) to support a removal assessment of Tronox Abandoned Uranium Mine (AUM) Section 33 (site) located approximately 1 mile east of County Road 19, Prewitt, McKinley County, New Mexico (Latitude: 35° 29' 26.1972" N, Longitude: -108° 0' 59.8583" W). The site was a mine reportedly owned by Cobb Nuclear and was closed due to a fatality (Weston Solutions, Inc., *Navajo Nation Abandoned Uranium Mine Site Screen Report, Section 32 AUM Site, Navajo AUM Eastern Region,* May 2009). No other information on historical ownership of the mine and mining operations were available. The site is a private land with an estimated area of 11,005 square meters containing waste piles, wooden hopper, and an undetermined extent of underground workings. No other mine features or visible signs of reclamation were reported.

A site screening, which included collection of gamma radiation survey data, was conducted in 2009 (Weston 2009). Gamma radiation activity was measured from surface soil along the boundary of the site and along two diagonal intersecting transects from the site's four corners. Gamma radiation activity measurements ranged from 14,322 counts per minute (cpm) to 140,917 cpm. A rock from a waste pile emitted over 800,000 cpm. Gamma radiation activity was also measured from a background location which was not identified in the report. The gamma radiation activity at the background location ranged from 16,630 cpm to 17,128 cpm.

The site was identified as an AUM. Gamma radiation activity at the site exceeds the reported background level up to 8 times in surface soil and up to 50 times in a waste pile rock. Gamma radiation activity in surface soil and waste piles at the site may pose an imminent and substantial threat to human health. The lateral and vertical extent of gamma radiation in soil and radiation levels in the waste piles need to be defined to support the EPA Task Monitor in determining whether a removal action is necessary to protect human health.

Planning Team

Primary Decision Maker:	EPA Task Monitor/Federal On-Scene Coordinator Randy Nattis
Plan Development:	START and the EPA Task Monitor
Plan Approval:	EPA Task Monitor
On-Scene Assistance:	EPA Task Monitor, START, EPA Emergency Response Team (ERT)'s Scientific, Engineering, Response, and Analytical Services (SERAS) contractor

Potential On-Scene Assistance:	Navajo Nation representative
Supplemental Off-Site Support:	The START response team managers, START quality assurance (QA) manager, START response Readiness Coordinator, START analytical service provider, START Radiological Assessment Adjunct, EPA ERT, EPA Emergency and Rapid Response Services (ERRS) contractor, and EPA Region 9 equipment warehouse

The names and affiliations of the actual planning team will be documented in the field logbook or in the sampling and analysis plan (SAP).

Conceptual Site Model

Based on previously documented elevated gamma radiation levels in surface soils, historical mining at the site may have released technologically-enhanced, naturally-occurring radioactive materials (TENORM), specifically uranium and its decay products. Based on EPA investigations at other AUM sites, the vertical extent of TENORM and elevated gamma radiation is expected to extend less than 3 feet below ground surface (bgs). The EPA Task Monitor determined that radium-226 (Ra-226) is the contaminant of potential concern in soil at the site.

Soil is the primary media of concern in this removal assessment. Surface water was not observed at or within the influence of the site; however, available geographical information show a stream or river located north and south of the site which converges approximately 0.25 mile west of the site, and two ponds are located northeast of the site. Groundwater depth and information on nearby water wells used for drinking water were not available. Agricultural food production such as livestock grazing or farming common in Navajo communities was not observed at or immediately adjacent to the site. The site is currently an open space with sparse vegetation.

Materials from the mine potentially used as building materials for residential structures may expose residents to radiation. The home site assessment is detailed in the AUM Section 32 removal assessment.

Exposure Scenario

Current exposure pathways considered in this assessment include direct exposure of human receptors to gamma radiation at the site. Receptors may also be exposed through ingestion, dermal contact, and inhalation of uranium and its decay products; and metals in soil, air, and water.

Current potential human receptors include nearby residents located less than 0.5 mile from the site.

Resources

The planning and preparation are administered and implemented by the EPA Region 9 staff and their supporting START contractors. All site-specific planning activities are under the direction of the EPA Task Monitor.

This is a removal assessment under the technical direction of the EPA Task Monitor. Initial labor resources include:

- The responding EPA Task Monitor, who will oversee all data collection and operations related to the time-critical response.
- START personnel
- EPA ERT and its SERAS contractors

Analytical service resources include the following:

- Real-time field radiation monitoring will be performed by START and SERAS personnel.
- START analytical service provider will analyze collected samples.

START's initial budget for this time-critical response is $71,482.78.

Resource Constraints

The use of non-routine radiation screening instruments and equipment will require training or experienced personnel.

Availability of EPA-owned radiation screening equipment is dependent on other ongoing EPA projects requiring similar resources.

STEP 2.

THE DECISION

Principal Study Questions

1. Is Ra-226 present in surface soil and waste piles at concentrations that exceed the action level and what is the lateral extent of contamination?
   a. Can the concentration of Ra-226 in surface soil be estimated from measurements of gamma radiation activity in surface soil through real-time surface scans (as it has at other AUM sites)?
   b. Can a suitable background location be identified so that a site-specific action level based on background levels can be calculated?
2. Does contamination extend to subsurface soil at locations where surface Ra-226 levels exceed the action level?

Actions that Could Result from the Resolution of Study Questions

Question 1

If the concentration of Ra-226 in surface soil and waste piles at the site is above the action level then the EPA may initiate or order the removal of contaminated areas.

If the concentration of Ra-226 in surface soil and waste piles is at or below the action level then no further action may be required.

- If a correlation between Ra-226 concentrations in soil and gamma radiation activity measured through real-time surface scans can be verified then activity measurements will be used to characterize the site.
- If a correlation between Ra-226 concentrations in soil and gamma radiation activity measured through surface scans cannot be verified then further soil sampling may be required to characterize the site.
- If a suitable background area can be identified then measurements from the identified area will be used to calculate a site-specific action level.
- If a suitable background area cannot be identified then another method of establishing an action level will be determined.

Question 2

If the concentration of Ra-226 in the subsurface soil exceeds the action level at locations where the surface concentration also exceeds the action level, then the EPA may initiate or order the removal of contaminated areas.

If the concentration of Ra-226 in the subsurface soil exceeds the action level at locations where the surface concentration also exceeds the action level, then the EPA may require further investigation.

If the concentration of Ra-226 in subsurface soil is at or below the action level then no further action may be required.

Decision Statements (Directives)

Directive 1

Determine whether, and in what areas, site concentrations of Ra-226 in surface soil and waste piles require removal, further assessment, or no further action.

- Determine whether gamma radiation activity readings can be used to characterize the site or if further sampling to characterize the site is necessary.
- Determine a suitable background location for collecting data to calculate a site-specific action level or identify an alternate means of setting an action level.

Directive 2

Determine whether site concentrations of Ra-226 in subsurface soil at locations where the surface levels of Ra-226 are elevated require removal, further assessment, or no further action.

STEP 3.
DECISION INPUTS

Specific Data Required

- Field data to establish a background level of gamma radiation from an area with similar geology and topography and no known or suspected impacts from mining.
- Field data from measuring gamma radiation activity in surface soil and waste piles at the site.
- Definitive analytical data for concentrations of Ra-226 in soil and waste piles.
- Risk-based investigation and action levels for the site.
- Global Positioning System (GPS) data for all gamma radiation activity measurement locations and soil sampling locations.

Sources for Study Information

- *Navajo Abandoned Uranium Mine Site Screen Report, Section 32 AUM Site, Navajo AUM Eastern Region* (Weston 2009).
- Site information collected during the removal assessment including geographical information data and photographs.
- Field data generated during the removal assessment including real-time radiation survey and soil sampling.
- Definitive analytical data generated during the removal assessment.
- EPA Radiation PRG

Information Needed to Establish Investigation and Action Levels

Dose limits and investigation levels will be established by EPA and other federal agencies. EPA Radiation PRG is available for various radioisotopes in soil, air, tap water, and fish. The following references are useful in establishing investigation and action levels for a time-critical radiation situation.

- OSC Radiological Response Guidelines, EPA OSWER and OAR, October 2006.
- Manual of Protective Action Guides (PAGs) and Protective Actions for Nuclear Incidents, EPA 400-R-92-001, May 1992.
- EPA Region 9, 2006 Emergency Response Readiness Training Guide.
- Preliminary Remediation Goals for Radionuclides, http://epa-prgs.ornl.gov/radionuclides/.
- Technology Screening Guide for Radioactively Contaminated Sites, EPA 402-R-96-017, November 1996.
- Soil Screening Guidance for Radionuclides

  - Soil Screening Guidance for Radionuclides: Technical Background Document, EPA/540-R-00-007, October 2000.
  - Soil Screening Guidance for Radionuclides: User's Guide, EPA/540/R95/128, October 2000.
- Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), EPA 402-R-97-016, August 2000.
- Decommissioning Handbook, DOE/EM-0383, January 2000.
- RESRAD Family of Codes, Argonne National Laboratory, DOE, http://web.ead.anl.gov/resrad/home2/
- EPA OSWER Guidance
  - Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination, EPA OSWER Directive 9200.4-18, August 22, 1997.
  - Use of Soil Cleanup Criteria in 40 CFR Part 192 as Remediation Goals for CERCLA Sites, EPA OSWER Directive 9200.4-25, February 12, 1998.
  - Remediation Goals for Radioactively Contaminated CERCLA Sites Using the Benchmark Dose Cleanup Criteria in 10 CFR Part 40 Appendix A, I, Criterion 6(6), EPA OSWER Directive 9200.4-35P, April 11, 2000.
  - Use of Uranium Drinking Water Standards under 40 CFR 141 and 40 CFR 192 as Remediation Goals for Groundwater at CERCLA Sites, EPA OSWER Directive 9283.1-14, November 6, 2001.
  - Interim Final Evaluation of Facilities Currently or Previously Licensed NRC Sites under CERCLA, OSWER Directive 9272.0-15P, February 17, 2000.

Confirm that Measurement Methods Exist to Provide Data

Field instrumentation and measurement methods for radiation monitoring are numerous and have varying detection limits. The same paired Ludlum 44-20 detector and 2221 or 2241 meter will be used in all radiation surveys at the site as practicable. The Ludlum Model 44-20 utilizes a Teledyne Integral Detector assembly containing a 3-inch diameter by 3-inch thick sodium iodide (NaI[T1]) crystal optically coupled to a photomultiplier tube. The detector is compatible with general purpose survey meters, rate meters, and scalers for high-energy gamma detection (approximately 60 kiloelectronvolts [eV] to 2 MeV range) such as the Ludlum Model 2221. The detector provides high sensitivity for surveying typically 2,300 cpm per microRoentgen per hour (based on Cesium-137 gamma) and pulse height discrimination. Quantity measurements are in cpm, which under certain circumstances can be converted to disintegrations per minute (dpm) or curies (Ci).

Laboratory analytical methods that more accurately determine radionuclide concentrations in units of picocuries per gram (pCi/g) in various media are published by EPA and U.S. Department of Energy (DOE). Ra-226 will be analyzed using the EML HASL 300 4.5.2.3 Method (DOE, *EML Procedures Manual, HASL-300, 27th Edition, Volume 1, Environmental Measurements Laboratory, 376 Hudson Street, New York, NY 10014-3621,* 1990). This method is applicable to nuclides emitting gamma rays with energies greater than 20keV for germanium detectors Ge(Li)) and 50 keV for NaI(T1) detectors and has a minimum detectable activity of 0.5 pCi/g for Ra-226. This method is a modification of

EPA method 901.1 and is the preferred technique for measuring Ra-226 and 228 simultaneously in solid material.

Field instrumentation, field procedures, and laboratory analytical methods used for this project are specified in the SAP.

STEP 4.

STUDY BOUNDARIES

Specify Characteristics that Define the Population Being Studied

- Gamma radiation activity at 6 inches above the ground surface of the background area and the site.
- Gamma radiation activity at 6 inches above the surface of the waste piles at the site
- Ra-226 concentration in surface soil (0 to 2 inches bgs) at the background area and the site.
- Ra-226 concentration in subsurface soil down to 3 feet bgs at locations at the site where gamma radiation activity exceeds the action level.
- Ra-226 concentration in the waste piles at the site.

Geographic Boundary of Investigation

- The site is approximately 11,005 square meters. The investigation includes the site area and may be extended to a maximum of 10 feet laterally from the site perimeter based on the real-time gamma radiation activity measured at the perimeter.
- The vertical investigation boundary for the site will be approximately 3 feet bgs or less based on site conditions.

A background area will be selected using the following criteria from *Background Location Selection Criteria* (NNEPA and EPA 2010):

- Similar elevation as the site
- Similar geology as the site. Avoid areas of naturally-occurring uranium.
- Upwind (gradient, stream) from site
- Undisturbed with natural vegetation
- Not in drainage or area impacted by flooding
- Distance to residential structures (structures should be within range of vision)
- Accessible (by vehicle and equipment)
- Should not be near a mine site or similar contaminant source
- If possible, avoid anthills and rodent holes
- Ask nearby residents about area

Temporal Boundary of Investigation

- The half-life of Ra-226 is 1,600 years. Soil data is not expected to change during the removal assessment which may take up to 90 days from sample collection to final report submittal.

- The investigation was scheduled in the dry season when the site is accessible and field work is feasible.
- Due to physical processes such as erosion and migration the extent of the contamination may expand. These physical processes could also change contamination levels once the extent has been defined.
- Widespread mining and milling of uranium ore on Navajo tribal lands since the 1940s led to a legacy of AUMs. Data is not available during mine operations at the site or since the mine closed to present. Data collected from the site during this assessment may not represent the highest concentrations historically present in soil at the site due to physical processes such as erosion and migration through the years.
- Data collected during the investigation represent current site conditions and does not consider future development such as soil mixing.
- The action level for Ra-226 is based on PRG which considers long-term health risk.

Scale of decision-making

Decisions will apply to the entire site unless decision units are established based on data.

Practical Constraints on Data Collection

Physical Constraints:

- The sampling areas are in a relatively remote location, which will require additional planning and logistical effort to get resources to the site.
- Weather conditions such as thunderstorms, extreme heat, and high winds may require halting of field work.
- Health and safety of staff including lighting conditions and fatigue will limit sampling days to daylight hours and to a maximum of 12 hours per day.
- Topographical features may limit or prevent the collection of useful data, especially for gamma radiation activity measurements.
- Site features which may present fall and/or confined space hazards is beyond the scope of the current assessment.
- Civil constraints, such as legal site access and unfriendly neighborhoods, and presence of livestock or wild animals will be addressed on site and by direction of the EPA Task Monitor.

Other Constraints:

- There is no universal field monitoring instrument capable of providing qualitative, quantitative, and exposure data for all types of radiation. Knowledge of the source is necessary for the selection of the appropriate field measurement instruments.

STEP 5.

DECISION RULE

Statistical Parameter

The mean and standard deviation (SD) of the gamma radiation activity measurements in the background area will be used to determine if the background area is suitable to use for developing the investigation level for surface gamma radiation activity and action level for Ra-226 in soil and waste piles. The r^2 is the statistical parameter of interest for predicting Ra-226 concentration based on gamma radiation activity in surface soil using linear regression.

Investigation and Action Levels

Under the direction of the EPA Task Monitor, the investigation level for gamma radiation activity in surface soil and waste piles at the site will be based on gamma radiation activity measured in surface soil from the established background area. The action level for Ra-226 in soil and waste piles at the site will be based on the sum of the background concentration of Ra-226 in surface soil and the EPA PRG of 1.21 pCi/g for residential soil based on an estimated excess cancer risk of 1 in 10,000 (10^{-4}) for Ra-226 and its radioactive decay chain products (Ra-226+D) (EPA 2010).

Decision Rules

Question 1

If the gamma radiation activity measured in surface soil and waste piles is above the investigation level, then select a surface sample location to determine soil areas and waste pile where Ra-226 concentration exceeds the action level and removal or further action may be necessary. Otherwise, collect a surface soil or waste pile sample to confirm Ra-226 concentration is below the action level and no further action may be required.

If the linear regression analysis of the co-located gamma radiation activity and the Ra-226 concentration data from surface soil yields an $r^2 \approx 1$, then gamma radiation activity readings can be used to characterize the site. Otherwise, further sampling to characterize the site is necessary.

If the mean and SD of the gamma radiation activity measurements in the background area are relatively low, then the gamma radiation activity measurements in the background area will be used to develop the investigation level for surface gamma radiation at the site and surface soil samples will be collected to develop the Ra-226 action level. Otherwise, a new background area will be selected or an alternate means of setting investigation and action levels will be identified.

Question 2

If Ra-226 concentration in a surface location exceeds the action level then a subsurface soil sample will be collected to determine if Ra-226 concentration below the elevated location is above the action level. Otherwise, no further action may be required.

STEP 6.
LIMITS ON DECISION ERRORS

Range of the Parameters of Interest

Activity Rate

The gamma radiation activity of interest range from below background to over background, but is not expected to exceed 1,000,000 cpm. However, gamma radiation activity from the investigation level to twice the investigation level is the range most susceptible to decision error.

Concentration in Samples

Concentrations of interest of Ra-226 in soil and waste pile samples are from ½ the action level to any value above the action level. Quantitatively precise and accurate determinations of contaminant concentrations that are significantly above (i.e., >10 times) the action level are not necessary. However, concentration from the action level to twice the action level is the range most susceptible to decision error.

The Null Hypothesis or Baseline Condition

The parameter of interest (gamma radiation activity or Ra-226 concentration in soil and waste piles) exceeds the investigation or action level.

Alternative Hypothesis

The parameter of interest (gamma radiation activity or Ra-226 concentration in soil and waste piles) does not exceed the investigation or action level.

DECISION ERRORS		
Decision Error	Deciding that a decision unit is contaminated and requires further action when the decision unit is not contaminated.	Deciding that a decision unit is not contaminated and requires no further action when the decision unit is contaminated.
True Nature of Decision Error	The activity measurement and sample concentration is either not representative or biased high.	The activity measurement and sample concentration is either not representative or biased low.
The Consequence of Error	Either further evaluation or a removal action will be initiated. The decision will cost EPA Region 9 additional resources of time, money, and labor.	The decision could lead to exposure of the community to a substantial and imminent threat to human health.
Which Decision Error Has More Severe Consequences near the Investigation or Action Level?	**LESS SEVERE**	**MORE SEVERE** The error will endanger human health.
Error Type **Based on Consequences**	**False Acceptance Decisions** A decision that the decision unit is contaminated when it is not.	**False Rejection Decisions** A decision that the decision unit is not contaminated when it is.

DECISION ERRORS
Definitions
False Acceptance Decisions = A false acceptance decision error occurs when the null hypothesis is not rejected when it is false.
False Rejection Decisions = A false rejection decision error occurs when the null hypothesis is rejected when it is true.

DECISION ERROR LIMITS GOALS

True Surface Gamma Radiation Activity or Ra-226 Soil Concentration (% of Investigation or Action Level)	Typical Decision Error Probability Goals (Based on Professional Judgment)	Type of Decision Error
Less than 50	5%	False Acceptance Decisions
50 to <100	Gray area[1]	False Acceptance Decisions
100 to <200	10%[2]	False Rejection Decisions
>200	5%	False Rejection Decisions

The goals in this table are based on professional judgment as relevant to a typical radiation response.

1 Gray Area is where relatively large decision errors are acceptable.

2 The large probability for the decision error is expected when the true contaminant concentrations are between 100% and 200% of the investigation or action level. Decreasing the probability is possible only by significantly increasing sampling number and quality assurance sampling, since sampling and analytical uncertainties and biases cannot be eliminated.

STEP 7.

DESIGN FOR OBTAINING DATA

<u>Design</u>

The sampling rationale and design was developed under the direction of the EPA Task Monitor and START Program Manager, and based on information from other EPA AUM sites.

Background Area

Background survey, sampling and analysis are required to determine naturally-occurring gamma activity and Ra-226 concentrations in an area with similar geology and no known or suspected impacts from mining. The background area will be selected by the EPA Task Monitor in the field according to the *Background Location Selection Criteria* (NNEPA and EPA 2010). The background area will be easily accessible, an appropriate distance from the site, and historically undeveloped based on visual observation.

Gamma Radiation Activity Investigation Level

A survey unit measuring 20 x 20 feet will be established in the selected background area. Gamma radiation activity in surface soil will be measured using a paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241 meter mounted 6 inches from the ground surface on a 3-foot wide push cart. The VIPER system and geographical information system (GIS) will be used for geospatial information collection and analysis. The surface soil survey will consist of transects spaced 3 feet apart, which will provide 100 percent characterization of the site. The transect width is based on the field of view of the detector which is 3 to 6 feet diameter. The surveyor will walk at a pace of 3 feet per second. The mean and standard deviation (SD) of the gamma radiation activity measurements in the background area surface soil will be calculated to develop the investigation level for gamma radiation activity at the site. An acceptable background area will have a low mean and SD.

Ra-226 Action Level

Surface soil samples will be collected at 0 to 2 inches bgs from the background survey unit and analyzed for Ra-226 by EML HASL 300 4.5.2.3 Method. Eleven samples will be collected at random locations which according to Visual Sampling Plan (VSP) software version 6.2 will provide a 95 percent confidence level that the mean will be within ±1 pCi/g. The sample data will be used to develop the action level for Ra-226. Co-located static gamma radiation activity measurements will also be collected from the surface soil location to establish the relationship between gamma radiation activity and Ra-226 concentration in surface soil.

Site Soil

Gamma radiation activity in surface soil at the site will be measured similar to the background area. A paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241 meter mounted 6 inches from the ground surface on a 3-foot wide push cart will be used to measure gamma radiation activity in surface soil. The surface soil survey will consist of 3-foot wide transects at a pace of 3 feet per second covering 100 percent of the site. If gamma radiation activity measurements along the perimeter of the site exceed the investigation level, lateral step-out will consist of additional 3-foot wide transects to a maximum of 10 feet beyond the site boundary.

Surface soil samples will be co-located with static 1-minute scans of gamma radiation activity to establish the relationship between Ra-226 concentration and gamma radiation activity in surface soil. Surface soil samples will be collected from 0 to 2 inches bgs from locations of gamma radiation activity at or above the investigation level according to the following ranges based on previous AUM sites:

- Investigation level
- Investigation level plus 10,000 cpm (10,000 cpm was established from previous AUM sites to correlate with 1.2 pCi/g of Ra-226)
- Investigation level plus 20,000 cpm
- Investigation level plus 25,000 cpm
- Investigation level plus 30,000 cpm

Surface soil samples will also be collected from areas with gamma radiation activity at or below the investigation level to confirm Ra-226 concentrations at these locations are below the action level. Surface soil samples will be collected from locations within the ranges of interest in each soil type and vegetation cover observed at the site. Additional surface soil samples may be collected based on field observations as determined by the EPA Task Monitor. Based on previous AUM sites, 15 samples have provided correlation of Ra-226 concentration with gamma radiation activity. A maximum of 30 surface soil samples (site and background) will be collected from the site and shipped to the START-contracted laboratory for Ra-226 analysis by EML HASL 300 4.5.2.3 Method.

Subsurface soil samples will be collected to determine the vertical extent of contamination at locations where surface gamma radiation activity exceeds the investigation level. Elevated locations will be determined from gamma radiation activity results of the 100 percent scan of the site. Soil samples will be collected down to 3 feet bgs (or less based on refusal or groundwater) at 1-foot depth intervals bgs. Subsurface samples will be collected from each depth in clustered boreholes i.e., one sample from a 1-foot deep borehole, one sample from a 2-feet deep borehole, and one sample from a 3-feet deep borehole, to minimize soil from shallower depths from being collected with the desired subsurface sample. The number of subsurface samples collected will be initially based on 10 percent of the highest documented gamma radiation activity locations but may vary based on field data. Additional subsurface soil samples may be collected based on field observations as determined by the EPA Task Monitor.

Waste Pile

Gamma radiation activity in waste piles at the site will be measured using a paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241 meter held 6 inches from the surface of the waste pile and moved in a serpentine motion at a scan rate of 1 to 2 feet per second covering 100 percent of the waste pile or until unsafe radiation levels are encountered based on the health and safety plan. Unsafe areas will not be surveyed.

A surface sample (0 to 2 inches bgs) will be collected from the waste piles to represent the lowest, middle of the range, and highest gamma radiation activity detected in the waste piles or until unsafe radiation levels are encountered. The waste pile samples will be analyzed for Ra-226.

Decision Error Minimization

Gamma Radiation Scanning Data

The gamma radiation activity measurement for the entire site is based on 100 percent surface gamma radiation activity scans which collect activity data on a much denser scale and allow for greater confidence in making decisions based on surface contaminant concentrations within a larger area compared to using individual soil sample data points alone. However, the relationship and confidence between gamma radiation activity data and Ra-226 concentration data must be determined in order to make decisions in the field using activity data.

The equipment, method, and background area used introduce variation in measurement results. Whenever possible, the same paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241; measurement method e.g., detector height, pace, specifications; and background area will be used throughout the project.

General Requirement for Generating Usable Data

All activities and documentation related to the project will proceed under a Quality Management Plan. All sampling, analytical, and quality assurance activities will proceed under an EPA-approved SAP. A record of sampling activities and deviation from the SAP must be documented in a bound field log book. Prior to sample collection, all project sampling personnel will review relevant sampling procedures and relevant quality assurance and control requirements for selected analytical methods.

B Site Specific Health and Safety Plan

ECOLOGY AND ENVIRONMENT, INC.

SITE-SPECIFIC
HEALTH AND SAFETY PLAN

Project: Tronox AUM: Section 33, Eastern Agency, Removal Assessment

Project No.: 002693.2165.01RA

TDD/PAN No.: TO2-09-11-10-0005

Project Location: Prewitt, New Mexico
Casamero Lake Chapter, Navajo Nation

Proposed Date of Field Activities:

Site Walk – April 22, 2012
Survey and Sampling – June 2012

Project Director: Cindy McLeod

Project Manager: Aileen Mendoza

Prepared by: Aileen Mendoza ______ Date Prepared: 4/16/12 ______

Approved by: _Cindy McLeod ______ Date Approved: ______

Revised by: Bill Sass ______ Date Revised: 6/7/12 ______

Revision Approved by: Sara Dwight ______ Date Approved: 6/7/12 ______

Table of Contents

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1. INTRODUCTION

1.1 POLICY

It is E & E's policy to ensure the health and safety of its employees, the public, and the environment during the performance of work it conducts. This site-specific health and safety plan (SHASP) establishes the procedures and requirements to ensure the health and safety of E & E employees for the above-named project. E & E's overall safety and health program is described in *Corporate Health and Safety Program* (CHSP). After reading this plan, applicable E & E employees shall read and sign E & E's Site-Specific Health and Safety Plan Acceptance form.

This SHASP has been developed for the sole use of E & E employees and is not intended for use by firms not participating in E & E's training and health and safety programs. Subcontractors are responsible for developing and providing their own safety plans.

This SHASP has been prepared to meet the following applicable regulatory requirements and guidance:

Applicable Regulation/Guidance
29 CFR 1910.120, Hazardous Waste Operations and Emergency Response (HAZWOPER)
Other:

1.2 SCOPE OF WORK

Description of Work: E & E was tasked by U.S. EPA under the Superfund Technical Assistance and Response Team (START) contract to conduct a removal assessment to delineate the extent of contamination at the Tronox abandoned uranium mine (AUM): Section 33, Eastern Agency located in Prewitt, McKinley County, New Mexico. Under this task order, E & E will perform a site walk with federal on-scene coordinator (FOSC) Randy Nattis, radiation scan/survey of surface soils, soil sampling from known areas of contamination based on previous investigation (Weston Solutions, Inc. [Weston] 2009) and radiation scan/survey results, and collect survey information for a background study.

Equipment/Supplies: Attachment 1 contains a checklist of equipment and supplies that will be needed for this work.

The following is a description of each numbered task:

Task Number	**Task Description**
1	Site walk
2	Surface radiation scan/survey of known areas of contamination to delineate removal area
3	Collection of soil samples
4	Surface radiation scan/survey for background study
5	Documentation (global positioning system [GPS], photographs, logs)
6	Homesite Investigation

1.3 SITE DESCRIPTION

Site Map: See Attachment 2.

Site History/Description (see project work plan for detailed description):

Tronox AUM: Section 33 (site) is located 1 mile east of County Road 19, in Prewitt, McKinley County, New Mexico (Latitude: 35° 29' 26.1972" N, Longitude: -108° 0' 59.8583" W). The site consists of an area of 11,005 square meters and an undetermined extent of underground workings (Weston 2009). The site is classified as private land owned by Lynn "Buddy" Elkins.

The site consists of a mine which was reportedly owned by Cobb Nuclear and was closed due to a fatality (Weston 2009). No other information on historical ownership of the mine and mining operations were available. No residences, public structures, water sources or sensitive environment were found within 0.25 miles of the site. The nearest resident is Lucita Sardo who lives to the west of the mine and had relatives who formerly worked for Cobb Nuclear. The residential property had some materials (tarps and lumber) obtained from the mine and had gamma radiation measurements of approximately 12,000 counts per minute (cpm). Gamma radiation measured at the site ranged from 14,322 cpm to 140,917 cpm. Gamma radiation measured at background locations ranged from 16,630 cpm to 17,128 cpm. Numerous waste piles were observed at AUM 33 and some former unidentified workings. No visible signs of reclamation were reported.

Is the site currently in operation? ☐ Yes ☒ No

Locations of Contaminants/Wastes: Naturally occurring uranium ore and mine waste is present at the site.

Types and Characteristics of Contaminants/Wastes:

☐ Liquid	☒ Solid	☐ Sludge	☐ Gas/Vapor
☐ Flammable/Ignitable	☐ Volatile	☐ Corrosive	☐ Acutely Toxic
☐ Explosive	☐ Reactive	☒ Carcinogenic	☒ Radioactive
☐ Medical/Pathogenic	Other: ______		

2. ORGANIZATION AND RESPONSIBILITIES

E & E team personnel shall have on-site responsibilities as described in E & E's standard operating procedure (SOP) for Site Entry Procedures (GENTECH 2.2). The project team, including qualified alternates, is identified below.

Name	Site Role/Responsibility
Aileen Mendoza	Project Manager, Field Team Leader
Craig Tiballi	Site Safety Officer, Sample Collection, Radiation Survey
E & E START Field Team	Sample Collection, Radiation Survey, Documentation

3. TRAINING

Prior to work, E & E team personnel shall have received training as indicated below. As applicable, personnel shall have read the project work plan, sampling and analysis plan, and/or quality assurance project plan prior to project work.

Training	Required
40-Hour OSHA HAZWOPER Initial Training and Annual Refresher (29 CFR 1910.120)	X
Annual First Aid/CPR	X
Hazard Communication (29 CFR 1910.1200)	X
40-Hour Radiation Protection Procedures and Investigative Methods	
8-Hour General Radiation Health and Safety	X

Training	Required
Radiation Refresher	X
DOT and Biannual Refresher	X
Other: ____________________	

4. MEDICAL SURVEILLANCE

4.1 MEDICAL SURVEILLANCE PROGRAM

E & E field personnel shall actively participate in E & E's medical surveillance program as described in the CHSP and shall have received, within the past year, an appropriate physical examination and health rating.

E & E's health and safety record (HSR) form will be maintained on site by each E & E employee for the duration of his or her work. E & E employees should inform the site safety officer (SSO) of any allergies, medical conditions, or similar situations that are relevant to the safe conduct of the work to which this SHASP applies.

Is there a concern for radiation at the site? ☒ Yes ☐ No

If no, go to 5.1.

4.2 RADIATION EXPOSURE

4.2.1 External Dosimetry

Thermoluminescent Dosimeter (TLD) Badges: TLD badges are to be worn by all E & E field personnel at the site and when radiation exposure is anticipated.

Pocket Dosimeters: Electronic or pocket dosimeters will be worn to determine real-time personnel doses if there is a potential for an E & E worker to receive at least 1 milliroentgen (mR) in one day.

Other: ____________________

4.2.2 Internal Dosimetry

☐ Whole body count ☐ Bioassay ☐ Other

Requirements: ____________________

4.2.3 Radiation Dose

Dose Limits: E & E's radiation dose limits are stated in the CHSP and presented in Table 4-1 below.

Site-Specific Dose Limits: : As a general guidance, if site work will continue for more than one quarter, limit weekly doses to approximately 80 mrem to ensure that quarterly dose limits are not exceeded.

ALARA Policy: Radiation doses to E & E personnel shall be maintained as low as reasonably achievable (ALARA), taking into account the work objective, state of technology available, economics of improvements in dose reduction with respect to overall health and safety, and other societal and socioeconomic considerations.

Table 4-1
E & E Radiation Dose Limits

Part of Body	Quarterly Limit (rems)	Annual Limit (rems)	Dost Limit Description
Whole body[a]	1	4	Total effective dose equivalent[b]
Any individual organ or tissue other than the lens of the eye[a]	10	40	Sum of deep-dose equivalent[c] and committed dose equivalent[d]
Lens of the eye	3	12	Lens dose equivalent[e]
Skin of whole body or skin of any extremity	10	40	Shallow-dose equivalent[f]

Notes:

a Precedence given to the more limiting dose.

b The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposure).

c The dose equivalent at a tissue depth of 1 cm; applies to external whole-body exposure and must be for the part of the body receiving the highest exposure.

d The dose equivalent to organs or tissues that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

e The external exposure of the lens of the eye, taken as the dose equivalent at a tissue depth of 0.3 cm.

f The external exposure of the skin of the whole body or the skin of an extremity; taken as the dose equivalent at a tissue depth of 0.007 cm averaged over the contiguous 10 square centimeters of skin receiving the highest exposure.

5. SITE CONTROL

5.1 SITE LAYOUT AND WORK ZONES

Site Work Zones: A site map is included as Attachment 2. The work zones will be determined and documented on site. In general, surface gamma activity counts will be used to delineate exclusion zones. Contaminant reduction (Decon) zones will be established at the entry/exits point of the exclusion zone(s). Personnel will need to pass through the Decon area to shed PPE and get checked for radiation contamination when exiting the exclusion zone(s).

Site Access Requirements and Special Considerations: Site access will be arranged by U.S. EPA.

Illumination Requirements: Work will be conducted in daylight hours unless prior approval is obtained and the illumination requirements in 29 CFR 1910.120(m) are satisfied.

Sanitary Facilities (e.g., toilet, shower, potable water): Sanitary facilities will be arranged on site. Bottled water and/or electrolyte beverages will be available.

On-Site Communications: Primary method: verbal; Secondary method: radios/cell phones

Other Site-Control Requirements: __________

5.2 SAFE WORK PRACTICES

Daily Safety Meeting: A daily safety meeting will be conducted for all E & E personnel and documented on the Daily Safety Meeting Record form or in the field logbook. The information and data obtained from applicable site characterization and analysis will be addressed in the safety meetings and also used to update this SHASP, as necessary.

Work Limitations: Work shall be limited to a maximum of 12 hours per day. If 12 consecutive days are worked, at least one day off shall be provided before work is resumed.

Weather Limitations: Work shall not be conducted during electrical storms. Work conducted in other inclement weather (e.g., rain, snow) will be approved by project management and the regional safety coordinator or designee.

Other Work Limitations:

Buddy System: Field work will be conducted in pairs of team members according to the buddy system.

Line of Sight: Each field team member shall remain in the line of sight and within verbal communication of at least one other team member.

Eating, Drinking, and Smoking: Eating, drinking, smoking, and the use of tobacco products shall be prohibited in the exclusion and contamination reduction areas, at a minimum, and shall only be permitted in designated areas.

Contamination Avoidance: Field personnel shall avoid unnecessary contamination of personnel, equipment, and materials to the extent practicable.

Sample Handling: Protective gloves of a type designated in Section 7 will be worn when containerized samples are handled for labeling, packaging, transportation, and other purposes.

Vermiculite Handling: It is against E&E policy to use vermiculite; therefore, bubble wrap will be used to cushion sample containers for shipment.

Other Safe Work Practices: Cold drinks and a shaded area will be provided to prevent heat stress.

6. HAZARD EVALUATION AND CONTROL

6.1 PHYSICAL HAZARD EVALUATION AND CONTROL

Potential physical hazards and their applicable control measures are described in the following table for each task.

Hazard	Task Number	Hazard Control Measures
Biological (flora, fauna, etc.)	1, 2, 3, 4, 5, 6	■ Potential hazard: feral dogs, prairie dogs (plague carriers), snakes, spiders, poisonous plants ■ Establish site-specific procedures for working around identified hazards. ■ Other: See attachments
Cold Stress (Promarily in early morning hours)	1, 2, 3, 4, 5, 6	■ Provide warm break area and adequate breaks. ■ Provide warm noncaffeinated beverages. ■ Promote cold stress awareness. ■ See *Cold Stress Prevention and Treatment* (attached at the end of this plan if cold stress is a potential hazard).
Compressed Gas Cylinders	N/A	■ Use caution when moving or storing cylinders. ■ A cylinder is a projectile hazard if it is damaged or its neck is broken. ■ Store cylinders upright and secure them by chains or other means. ■ Other:

Hazard	Task Number	Hazard Control Measures
Confined Space	N/A	■ Ensure compliance with 29 CFR 1910.146. ■ See SOP for Confined Space Entry. Additional documentation is required. ■ Other:
Drilling	N/A	■ See SOP for Health and Safety on Drilling Rig Operations. Additional documentation may be required. ■ Landfill caps will not be penetrated without prior discussions with corporate health and safety staff. ■ Other:
Drums and Containers	N/A	■ Ensure compliance with 29 CFR 1910.120(j). ■ Consider unlabeled drums or containers to contain hazardous substances and handle accordingly until the contents are identified. ■ Inspect drums or containers and assure integrity prior to handling. ■ Move drums or containers only as necessary; use caution and warn nearby personnel of potential hazards. ■ Open, sample, and/or move drums or containers in accordance with established procedures; use approved drum/container-handling equipment. ■ Other:
Electrical	N/A	■ Ensure compliance with 29 CFR 1910 Subparts J and S. ■ Locate and mark energized lines. ■ De-energize lines as necessary. ■ Ground all electrical circuits. ■ Guard or isolate temporary wiring to prevent accidental contact. ■ Evaluate potential areas of high moisture or standing water and define special electrical needs. ■ Other:
Excavation and Trenching	N/A	■ Ensure that excavations comply with and personnel are informed of the requirements of 29 CFR 1926 Subpart P. ■ Ensure that any required sloping or shoring systems are approved as per 29 CFR 1926 Subpart P. ■ Identify special personal protective equipment (PPE) (see Section 7) and monitoring (see Section 8) needs if personnel are required to enter approved excavated areas or trenches. ■ Maintain line of sight between equipment operators and personnel in excavations/trenches. Such personnel are prohibited from working in close proximity to operating machinery. ■ Suspend or shut down operations at signs of cave in, excessive water, defective shoring, changing weather, or unacceptable monitoring results. ■ Other:
Fire and Explosion	1, 2, 3, 4, 5, 6	■ Other: Avoid parking vehicles on tall, dry vegetation. ■ Inform personnel of the location(s) of potential fire/explosion hazards. ■ Establish site-specific procedures for working around flammables. ■ Ensure that appropriate fire suppression equipment and systems are available and in good working order. ■ Define requirements for intrinsically safe equipment. ■ Remove ignition sources from flammable atmospheres. ■ Coordinate with local fire-fighting groups regarding potential fire/explosion situations. ■ Establish contingency plans and review daily with team members.
Heat Stress	1, 2, 3, 4, 5, 6	■ Provide cool break area and adequate breaks.

Hazard	Task Number	Hazard Control Measures
		■ Provide cool noncaffeinated beverages. ■ Promote heat stress awareness. ■ Use active cooling devices (e.g., cooling vests) where specified. ■ See *Heat Stress Prevention and Treatment* (See Attachment 3).
Heavy Equipment Operation	N/A	■ Define equipment routes, traffic patterns, and site-specific safety measures. ■ Ensure that operators are properly trained and equipment has been properly inspected and maintained. Verify back-up alarms. ■ Ensure that ground spotters are assigned and informed of proper hand signals and communication protocols. ■ Identify special PPE (Section 7) and monitoring (Section 8) needs. ■ Ensure that field personnel do not work in close proximity to operating equipment. ■ Ensure that lifting capacities, load limits, etc., are not exceeded. ■ Other: Site personnel to wear reflective safety vests
Heights (Scaffolding, Ladders, etc.)	N/A	■ Ensure compliance with applicable subparts of 29 CFR 1910. ■ Identify special PPE needs (e.g., lanyards, safety nets, etc.) ■ Other: Use of fall protection: body harness and lanyard
Noise	N/A	■ Establish noise level standards for on-site equipment/operations. ■ Inform personnel of hearing protection requirements (Section 7). ■ Define site-specific requirements for noise monitoring (Section 8). ■ Other:
Overhead Obstructions	N/A	■ Wear hard hat. ■ Other:
Power Tools	N/A	■ Ensure compliance with 29 CFR 1910 Subpart P. ■ Other:
Sunburn	1, 2, 3, 4, 5, 6	■ Apply sunscreen. ■ Wear hats/caps and long sleeves. ■ Other:
Utility Lines	N/A	■ Identify/locate existing utilities prior to work. ■ Ensure that overhead utility lines are at least 25 feet away from project activities. ■ Contact utilities to confirm locations, as necessary. ■ Other:
Weather Extremes	1, 2, 3, 4, 5, 6	■ Potential hazards: ■ Establish site-specific contingencies for severe weather situations. ■ Provide for frequent weather broadcasts. ■ Weatherize safety gear, as necessary (e.g., ensure eye wash units cannot freeze, etc.). ■ Identify special PPE (Section 7) needs. ■ Discontinue work during severe weather. ■ Other:
Other: Uneven Terrain: Slips, trips & falls	1, 2, 3, 4, 5, 6	■ Use three points of contact on steep or rocky slopes and use a backpack to carry tools/supplies so that at least one hand is always free.
Other: Burns, Shock, Fire, Noise and heavy lifting hazards from using portable gas-powered	N/A	■ Use proper PPE (Level D w/safety goggles, hardhat, work gloves, ear plugs, etc). ■ Wait 20 minutes before refueling hot equipment. Use a funnel and safety gas can to avoid spilling.

Hazard	Task Number	Hazard Control Measures
Auger		■ Always have two persons around when lifting auger
Off-road driving	1, 2,3,4,5,6	■ Drive as slow as possible, and as fast as necessary. ■ Sometimes you cannot drive to your desired destination, so don't push it if conditions are hazardous. ■ Stay on the trail. ■ Walk it first if you cannot see the ground or if conditions are wet. **See attachment for Off-road driving safety.**

6.2 CHEMICAL HAZARD EVALUATION AND CONTROL

6.2.1 Chemical Hazard Evaluation

Potential chemical hazards are described by task number in Table 6-1. Hazard Evaluation Sheets for major known contaminants are attached at the end of this plan.

6.2.2 Chemical Hazard Control

An appropriate combination of engineering/administrative controls, work practices, and PPE shall be used to reduce and maintain employee exposures to a level at or below published exposure levels (see Section 6.2.1).

Applicable Engineering/Administrative Control Measures: Work upwind if possible. Wear PPE appropriate for each task (e.g. Level C in exclusion zone, as defined by elevated surface gamma activity. Avoid soil coming in contact with skin or clothing).

PPE: See Section 7.

6.3 RADIOLOGICAL HAZARD EVALUATION AND CONTROL

6.3.1 Radiological Hazard Evaluation

Potential radiological hazards are described below by task number. Hazard Evaluation Sheets for major known contaminants are attached at the end of this plan.

Task Number	Radionuclide	DAC (μCi/ml)	Route(s) of Exposure	Major Radiation(s)	Energy(s) (MeV)	Half-Life
1-6	Uranium, natural (primarily U-238) and daughter radionuclides	Various (most conservative is 3E-12 for Th-230)	INH, ING, external radiation exposure	Alpha, beta, gamma, depending on the radionuclide	Various	Various (from seconds to 4.5E09 yrs for U-238)
1-6	Radium-226 (a key U-238 daughter) Ra-226 daughters	3E-10 Various	INH, ING, external radiation exposure	Alpha Gamma Alpha, beta, gamma	4.8 0.186 Various	1,600 yrs Various
1-6	Radon-222 (direct daughter of Ra-226)	4E-06 (daughters removed) 3E-08 or 0.33 WL (daughters present)	INH	Alpha	5,49	3.8 days
1-6	Thorium, natural (primarily Th-232) and daughter radionuclides	Various (most conservative is 5E-13 for Th-232)	INH, ING, external radiation exposure	Alpha, beta, gamma, depending on the radionuclide	Various	Various (from seconds to 1.4E10 yrs for Th-232)

6.3.2 Radiological Hazard Control

Engineering/administrative controls and work practices shall be instituted to reduce and maintain employee exposures to a level at or below the permissible exposure/dose limits (see sections 4.2.3 and 6.3.1). Whenever engineering/administrative controls and work practices are not feasible or effective, any reasonable combination of engineering/administrative controls, work practices, and PPE shall be used to reduce and maintain employee exposures to a level at or below permissible exposure/dose limits.

Applicable Engineering/Administrative Control Measures: Ensure support zone is in an uncontaminated background radiation area. Decrease time in radiation areas; increase distance; increase shielding as needed. Avoid unprotected contact with site materials. Use dust suppression during sampling activities as required. Radiation monitoring equipment will be protected from contamination by placing it in plastic bags (leaving probe areas uncovered). If applicable, ventilate indoor areas (open windows and doors) in order to dissipate any radon buildup.

Radiation Surveying: (This section is intended to apply work-area radiation surveying for worker health and safety purposes. The surveying being conducted for work Task 1 in this safety plan will also suffice to be work-area radiation surveying for worker health and safety purposes.) The work area will be continually surveyed as appropriate to determine radiation exposure rates, areas of elevated radiation, and the location and magnitude of radioactive contamination, in order to ensure and guide worker health and safety. Surveys for gamma exposure will be conducted using a micro R meter (or ion chamber, if the micro R meter goes off-scale [5 mR/hr]) and a survey ratemeter with an attached 3-inch by 3-inch sodium iodide (NaI) (gamma) probe in accordance with established procedures. Off-site background measurements for portable survey instruments will be obtained from locations previously identified by EPA. Radiation levels exceeding approximately 2 times background will indicate radiation contamination and/or radiation areas and will be marked using surveying flags or equivalent. Previous investigations indicate that some areas exceed the action level of 2-3 times background and marking will be required. Workers performing dust generating activites in areas with elevated gamma activity will be required to use Level C PPE, including respirator, tyvek, nitrile gloves, booties, etc. Workers will also don Level C PPE if wind speeds increase to the point that visible dust is present (approx. 20 mph). Although previous data indicate they are not present, a corporate health physicist will be consulted if exposure rates $\geq$ 2 mR/hr are encountered.

Radiation Contamination Monitoring -Personnel: Personnel will be monitored for radioactive contamination at each work area if gamma activity levels exceeding the site action level (greater than approximately 2-3 times background) are measured. The monitoring will be performed using a survey ratemeter with an attached detector such as a pancake GM detector in accordance with E&E's procedure *Radiation Contamination Monitoring of Personnel*. The relative response of the different detectors to site materials will be determined during initial phases of the work in order to select the best detector for contamination monitoring. Radiation contamination monitoring will be performed of protective clothing and respirators as necessary to help with waste disposition decisions and if there is a suspicion of gross contamination that should be controlled before the protective clothing/respirator is removed (to ensure that loose contamination is not transferred to personnel). Otherwise, the protective clothing/respirator can be carefully removed without being monitored and the monitoring will focus on the person in his/her street clothes. Contamination results exceeding approximately 2 to 3 times background indicate contamination and that decontamination or disposal as a contaminated waste must be performed (see Section 9).

Radiation Contamination Monitoring - Personal and Work-Related Items, Equipment, and Materials: (This section refers to radiation contamination monitoring of personal and work-related items for health and safety purposes. Examples include monitoring instruments, personal gear, tools, and laptop computers. This does not apply to the free release of non-E & E items.) Radiation contamination monitoring will be performed for personal and work-related items, equipment, and materials as they cross the hotline into the contamination reduction area. The monitoring will be performed using a survey ratemeter with an attached detector such as a pancake GM detector in accordance with established procedures. The relative response of the different detectors to site materials will be determined during initial phases of the work in order to select the best detector for contamination monitoring. Swipe testing will be used for contamination monitoring when direct monitoring is not effective (e.g., small surface areas, nooks and crannies). Swipes will be counted by instruments suitable for the contaminant (typically, fixed-geometry, thin-window counters for uranium and its daughters). Contamination results exceeding approximately 2 to 3 times background indicate contamination and that decontamination or disposal as a contaminated waste must be performed (see Section 9).

Air Monitoring and Sampling: In leiu of performing air sampling, personnel will don Level C PPE during dust generating activities (e.g. soil sampling and auger boring) that are performed in areas with elevated gamma activity.

PPE: See Section 7.

TABLE 6-1

CHEMICAL HAZARD EVALUATION

Task Number	Compound	Exposure Limits (TWA)			Dermal Hazard (Y/N)	Route(s) of Exposure	Acute Symptoms	Odor Threshold/ Description	FID/PID	
		PEL	REL	TLV					Relative Response	Ioniz. Poten. (eV)
1-6	Uranium (insoluble compounds)	0.25 mg/m3	0.2 mg/m3	0.2 mg/m3	N	inhalation, ingestion, skin and/or eye contact	Dermatitis; kidney damage; blood changes; [potential occupational carcinogen]; in animals: lung, lymph node damage [Potential for cancer is a result of alpha-emitting properties & radioactive decay products (e.g., radon).]	odorless	NA	NA
1-6	Uranium (soluble compounds)	0.05 mg/m3	0.05 mg/m3	0.2 mg/m3	N	inhalation, ingestion, skin and/or eye contact	Lacrimation (discharge of tears), conjunctivitis; shortness breath, cough, chest rales; nausea, vomiting; skin burns; red blood cell, casts in urine; proteinuria; high blood urea nitrogen; [potential occupational carcinogen] [Potential for cancer is a result of alpha-emitting properties & radioactive decay products (e.g., radon).]	odorless	NA	NA

Note: Use an asterisk (*) to indicate known or suspected carcinogens.

7. LEVEL OF PROTECTION AND PERSONAL PROTECTIVE EQUIPMENT

7.1 LEVEL OF PROTECTION

The following levels of protection (LOPs) have been selected for each work task based on an evaluation of the potential or known hazards, the routes of potential hazard, and the performance specifications of the PPE. On-site monitoring results and other information obtained from on-site activities will be used to modify these LOPs and the PPE, as necessary, to ensure sufficient personnel protection. The authorized LOP and PPE shall only be changed with the approval of the regional safety coordinator or designee. Level A is not included below because Level A activities, which are performed infrequently, will require special planning and addenda to this SHASP.

Task Number	B	C	D	Modifications Allowed
1			X	
2			X	
3		(X)	X	Based on experiences with air sampling for gross alpha/beta on other uranium mine sites in New Mexico (e.g., NECR and Skyline), air sampling results from high dust-generating activities such as vehicular traffic, soil excavation and loading, and grading were still orders of magnitude below the most conservative DAC. Dust generating activities will involve RAT work and soil sampling. If dust caused by high winds should impact work activities, it is likely that it would involve nuisance dust. Therefore, worker protection decisions can be managed visually.
4			X	
5			X	
6			X	

Note: Use "X" for initial levels of protection. Use "(X)" to indicate levels of protection that may be used as site conditions warrant.

7.2 PERSONAL PROTECTIVE EQUIPMENT

The PPE selected for each task is indicated below. E & E's PPE program complies with 29 CFR 1910.120 and 29 CFR 1910 Subpart I and is described in detail in the CHSP. Refer to 29 CFR 1910 for the minimum PPE required for each LOP.

PPE	Task Number/LOP					
	1/D	2/D	3/D	4/D	5/D	6/D
Full-face APR			(X)			
PAPR						
Cartridges:						
P100			(X)			
GMC-P100						
GME-P100			(X)			
Other:						
Positive-pressure, full-face SCBA						

PPE	Task Number/LOP					
	1/D	2/D	3/D	4/D	5/D	6/D
Spare air tanks (Grade D air)						
Positive-pressure, full-face, supplied-air system						
Cascade system (Grade D air)						
Manifold system						
5-Minute escape mask						
Safety glasses			X			
Monogoggles						
Coveralls/clothing			(X)			
Protective clothing:						
Tyvek		(X)	(X)	(X)		
Saranex						
Other:						
Splash apron						
Inner gloves:						
Cotton						
Nitrile		(X)	(X)	(X)		
Latex						
Other:						
Outer gloves:						
Viton						
Rubber						
Neoprene						
Nitrile		X	X	X		
Other:						
Work gloves		(X)	(X)	(X)		
Safety boots (as per ANSI Z41)	X	X	X	X	X	X
Neoprene safety boots (as per ANSI Z41)						
Boot covers (type: poly)		(X)	(X)	(X)	(X)	
Hearing protection (type: ________________________________)						
Hard hat						
Face shield						
Other:						

PPE	Task Number/LOP					
	1/D	2/D	3/D	4/D	5/D	6/D
Other:						

8. HEALTH AND SAFETY MONITORING

Health and safety monitoring will be conducted to ensure proper selection of engineering/administrative controls, work practices, and/or PPE so that employees are not exposed to hazardous substances at levels that exceed permissible exposure/dose limits or published exposure levels. Health and safety monitoring will be conducted using the instruments, frequency, and action levels described in Table 8-1. Health and safety monitoring instruments shall have been appropriately calibrated and/or performance-checked prior to use.

9. DECONTAMINATION PROCEDURES

All equipment, materials, and personnel will be evaluated for contamination upon leaving the exclusion area. Equipment and materials will be decontaminated and/or disposed and personnel will be decontaminated, as necessary. Decontamination will be performed at each sample area if radiation levels exceeding the site action level (greater than 2-3 times background) are recorded. Specific procedures are described below.

Equipment/Material Decontamination Procedures (specified by work plan): Every effort will be made to prevent radiation survey instruments from contacting contaminated materials. When appropriate, instruments, probe handles (not probe faces), and other personal and work-related items will be covered in plastic to prevent surficial contamination. Nondisposable items that are radioactively contaminated as determined by direct and indirect monitoring (Sections 6.3.2 and 8) will be decontaminated using controlled dry or damp methods (e.g., Radiacwash towelettes or wet wipes) and remonitored when dry to ensure the contamination was removed. Disposable items that are contaminated will be directed to the proper waste stream.

Ventilation: All decontamination procedures will be conducted in a well-ventilated area.

Personnel Decontamination Procedures: Personnel radiation contamination monitoring will be performed in accordance with Sections 6.3.2 and 8. Disposable protective clothing will be directed to the proper waste stream and respirators will be directed to a respirator washing station. Contaminated areas on the skin or body will be decontaminated using controlled dry or damp methods and re-monitored when dry to ensure the contamination was removed. Significant or stubborn contamination will be decontaminated under the guidance of a health physicist. Contaminated areas on personal apparel will be decontaminated if possible; otherwise, the apparel will be directed to the proper waste stream. "Hot spot" decon is recommended to minimize the volume of waste generated. Practices such as cutting the hot spot out of the protective clothing or using duct tape to remove the contaminant will be employed as appropriate.

PPE Requirements for Personnel Performing Decontamination: Safety glasses and nitrile gloves

Personnel Decontamination in General: Following appropriate decontamination procedures, all field personnel will wash their hands and face with soap and potable water. Personnel should shower at the end of each work shift.

Disposition of Disposable PPE: Disposable PPE must be rendered unusable and disposed as indicated in the work plan.

Disposition of Decontamination Wastes (e.g., dry wastes, decontamination fluids, etc.): Disposed of off-site by qualified disposal contractor if greater than 30 pCi/g (approximately 100 Kcpm gamma activity). Disposed of as municipal waste if less than 2-3 times background.

TABLE 8-1

HEALTH AND SAFETY MONITORING

Instrument	Task Number	Contaminant(s)	Monitoring Location	Monitoring Frequency	Action Levels[a]	
☐ PID (e.g., RAE mini RAE) ☐ FID (e.g., OVA 128-) ☐ TVA 1000				Continuous	**Unknown Vapors** Background to 1 ppm above background: Level D 1 to 5 ppm above background: Level C 5 to 500 ppm above background: Level B >500 ppm above background: Level A	**Contaminant-Specific**
Oxygen Meter/Explosimeter					**Oxygen** <19.5% or >22.0%: Evacuate area; eliminate ignition sources; reassess conditions. 19.5 to 22.0%: Continue work in accordance with action levels for other instruments.	**Explosivity** $\leq$10% LEL: Continue work in accordance with action levels for other instruments; monitor continuously for combustible atmospheres. >10% LEL: Evacuate area; eliminate ignition sources; reassess conditions.
Radiation Alert Monitor (Rad-mini or RAM-4)					<0.1 mR/hr: Continue work in accordance with action levels for other instruments. $\geq$0.1 mR/hr: Evacuate area; reassess work plan and contact radiation safety specialist.	
Mini-Ram Particulate Monitor					**General/Unknown** Evaluate health and safety measures when dust levels exceed 2.5 milligrams per cubic meter.	**Contaminant-Specific**
HCN/H_2S (Monitox)					$\geq$4 ppm: Leave area and consult with SSO.	
Draeger Colorimetric Tubes					**Tube** **Action Level**	**Action**
Air Monitor/Sampler Type: ________________ Sampling medium: ____________________					**Action Level**	**Action**

TABLE 8-1

HEALTH AND SAFETY MONITORING

Instrument	Task Number	Contaminant(s)	Monitoring Location	Monitoring Frequency	Action Levels[a]
Personal Sampling Pump Type: ________________ Sampling medium: ______________________					**Action Level** **Action**
Micro R Meter (Ludlum 19) with Rapid Assessment Tool (RAT)		External gamma exposure	Work area	As necessary to characterize work area. Continuous when used.	<2 mR/hr: Continue work in accordance with action levels for other instruments. 2 to 5 mR/hr: In conjunction with a radiation safety specialist, continue work and perform stay-time calculations to ensure compliance with dose limits and ALARA policy.
Ion Chamber		External gamma exposure	Work area	As necessary to characterize work area. Continuous when used.	See micro R meter action levels above.

TABLE 8-1

HEALTH AND SAFETY MONITORING

Instrument	Task Number	Contaminant(s)	Monitoring Location	Monitoring Frequency	Action Levels[a]
Radiation Survey Ratemeter/Scaler with External Detector(s) (Ludlum 2241, pancake GM detector)	1, 2, 3, 4, 5, 6	Gamma radiation	Work area	As necessary to characterize work area. Continuous when used.	**Detector** / **Action Level** / **Action** 3” x 3” NaI (gamma) / > 2 to 3 x Bkg / Consider radiation levels to be elevated.
		Radionuclides	Work area (sensitive measurement of hot spots and contaminated areas) as necessary	As necessary to characterize work area	GM, ZnS, or gas-flow proportional and/or swipe testing / General: > 2 to 3x Bkg. / Consider radioactive and/or contaminated.
		Radionuclices	Personnel and personal equipment/material contamination monitoring[b]	As necessary as personnel and personal equipment/ materials cross hotline	GM detector and/or swipe testing / > 2 to 3x Bkg / Consider radioactive and/or contaminated
Noise Dosimeter (Sound Level Meter)					$\leq$85 decibels as measured using the A-weighed network (dBa): Use hearing protection if exposure will be sustained throughout work shift. >85 dBA: Use hearing protection. >120 dBA: Leave area and consult with safety personnel.
Other: Pocket Dosimeter	1, 2, 3, 4, 5, 6	Gamma radiation, Radionuclices	Personnel and personal equipment/ material contamination monitoring[b]	As necessary as personnel and personal equipment/ materials cross hotline	Canberra / 1 mRem in one day / In conjunction with a radiation safety specialist, continue work and perform stay-time calculations to ensure compliance with dose limits and ALARA policy.
Other:					

TABLE 8-1

HEALTH AND SAFETY MONITORING

Instrument	Task Number	Contaminant(s)	Monitoring Location	Monitoring Frequency	Action Levels[a]

a Unless stated otherwise, airborne contaminant concentrations are measured as a time-weighted average in the worker's breathing zone. Acceptable concentrations for known airborne contaminants will be determined based on OSHA/NIOSH/ACGIH and/or NRC exposure limits. As a guideline, 1/2 the PEL/REL/TLV, whichever is lower should be used.

10. EMERGENCY RESPONSE

This section contains additional information pertaining to on-site emergency response and does not duplicate pertinent emergency response information contained in earlier sections of this plan (e.g., site layout, monitoring equipment, etc.). Emergency response procedures will be rehearsed regularly, as applicable, during project activities.

10.1 EMERGENCY RESPONSIBILITIES

All Personnel: All personnel shall be alert to the possibility of an on-site emergency; report potential or actual emergency situations to the team leader and SSO; and notify appropriate emergency resources, as necessary.

Team Leader: The team leader will ensure that applicable incidents are reported to appropriate E & E and client project personnel and government agencies.

SSO: The SSO will determine the emergency actions to be performed by E & E personnel and will direct these actions. The SSO will recommend health/safety and protective measures appropriate to the emergency.

Other: __________

10.2 LOCAL AND SITE RESOURCES (including phone numbers)

Ambulance: 911 (Gallup Metro Dispatch)

Hospital: Cibola General Hospital, 1016 E Roosevelt Ave, Grants, NM 87020 - (505) 287-4446

Directions to Hospital (map attached at the end of this plan): Head SW on Co Rd 19. Turn left onto NM-122E/Frontage Road for 18 miles. Continue onto W Santa Fe Ave for 1.4 miles. Turn left onto 1st St for 0.9 miles. Slight right onto W Roosevelt Ave. Hospital will be on the left in 0.7 miles.

Poison Control: 800-222-1222

Police Department: 911 (Gallup Metro Dispatch)

Fire Department: 911 (Gallup Metro Dispatch)

Client Contact: Randy Nattis, EPA FOSC; Phone (415) 940-1108

Site Contact: Randy Nattis, EPA FOSC; Phone (415) 940-1108

On-Site Telephone Number: NA

Cellular Telephone Number: NA

Radios Available: Yes

Other: __________

10.3 E & E EMERGENCY CONTACTS

E & E Emergency Operations Center (24 Hours):	716/684-8060
Corporate Health and Safety Director, Dr. Paul Jonmaire:	716/684-8060 (office) 716/655-1260 (home)
Regional Office Contact: Cindy McLeod, START Program Manager	510/893-6700 (office) 415/238-3379 (cell) 510/654-6250 (home)
Other: START Oakland Office	510/893/6700 (office)

a. E & E Emergency Response Center: 716/684-8060

b. Corporate Health and Safety Director, Dr. Paul Jonmaire: 716/684-8060 (office)
716/655-1260 (home)

c. Assistant Corporate Safety Director, Tom Siener, CIH: 716/684-8060 (office)
716/662-4740 (home)
716/597-5868 (Cell)

10.4 OTHER EMERGENCY RESPONSE PROCEDURES

On-Site Evacuation Signal/Alarm (must be audible and perceptible above ambient noise and light levels): Three long blasts on car horn or air horn.

On-Site Assembly Area: An upwind location to be determined at the first Daily Safety Meeting

Emergency Egress Route to Get Off Site: To be determined at the first Daily Safety Meeting

Off-Site Assembly Area: To be determined at the first Daily Safety Meeting

Preferred Means of Reporting Emergencies: Report to FOSC Nattis and Call 911

Site Security and Control: In an emergency situation, personnel will attempt to secure the affected area and control site access.

Emergency Decontamination Procedures: Non-life-threatening: protective clothing will be removed and affected persons will be monitored for radiation, especially the hands and feet, to the extent practicable. Life-threatening: critically injured personnel will be wrapped in a blanket or plastic sheeting to prevent the spread of contamination. Plastic sheeting should be used in transport vehicle to prevent the spread of contamination. If time permits and necessary medical treatment will not be delayed, removal of protective clothing and monitoring for radiation can be performed. Emergency decontamination for other chemical hazards will include PPE removal and rinsing with water if applicable.

PPE: Personnel will don appropriate PPE when responding to an emergency situation. The SSO and Section 7 of this plan will provide guidance regarding appropriate PPE.

Emergency Equipment Appropriate emergency equipment is listed in Attachment 1. Adequate supplies of this equipment shall be maintained in the support area or other approved work location.

Incident Reporting Procedures: The SSO will notify the Regional Safety Coordinator and the EPA FOSC. Affected personnel will complete an Incident/Exposure Report within 24 hours and submit it to the Corporate Health and Safety Director.

ATTACHMENT 1

EQUIPMENT/SUPPLIES CHECKLIST

	No.
INSTRUMENTATION	
FID	
Thermal desorber	
O_2/explosimeter w/cal. Kit	
Photovac tip	
PID (probe: _________eV)	
Magnetometer	
Pipe locator	
Weather station	
Draeger tube kit (tubes: _____________________)	
Brunton compass	
Real-time cyanide monitor	
Real-time H_2S monitor	
Heat stress monitor	
Noise equipment	
Personal sampling pumps and supplies	
MiniRam dust monitor	
Mercury monitor	
Spare batteries (type: D)	
RADIATION EQUIPMENT/SUPPLIES	
Documentation forms	X
Portable ratemeter	X
Scaler/ratemeter	X
1" NaI gamma probe	
3" NaI gamma probe	X
ZnS alpha probe	
GM pancake probe	X
Tungsten-shielded GM probe	
Micro R meter	
Ion chamber	
Alert monitor	
Pocket dosimeter	X
Dosimeter charger	X
Radiation warning tape	

	No.
Radiation decon supplies	X
Spare batteries (type:D - rate meters and Micro R meter; AAA - pocket dosimeters	X
SAMPLING EQUIPMENT	
4oz. bottles	X
Half-gallon bottles	
VOA bottles	
String	
Hand bailers	
Thieving rods with bulbs	
Spoons	X
Knives	
Filter paper	
Bottle labels	X
Ziplock Bags 1 gallon	X
Ziplock Bags 2 gallon	
MISCELLANEOUS	
GPS	X
Surveyor's tape	X
100' Fiberglass tape	
300' Nylon rope	
Nylon string	X
Surveying flags	X
Camera	X
Film	
Bung wrench	
Soil auger	X
Pick	
Shovel	X
Catalytic heater	
Propane gas	
Banner tape	
Surveying meter stick	
Chaining pins and ring	

	No.
Logbooks (_____ large, __X___ small)	X
Required MSDSs	
Intrinsically safe flashlight	
Potable water	X
Gatorade or equivalent	X
Tables	
Chairs	
Weather radio	
Two-way radios	
Binoculars	
Megaphone	
Cooling vest	
EMERGENCY EQUIPMENT	
First aid kit	X
Stretcher	
Portable eye wash	
Blood pressure monitor	
Fire blanket	
Fire extinguisher	
Thermometer (medical)	
Spill kit	
DECONTAMINATION EQUIPMENT	
Wash tubs	
Buckets	
Scrub brushes	
Pressurized sprayer	
Spray bottle	X
Detergent (type: : _RadiacWash or equivalent_____)	X
Solvent (type: ______________________________)	
Plastic sheeting	
Tarps and poles	
Trash bags	X
Trash cans	
Masking tape	X

	No.
Duct tape	X
Paper towels	X
Face mask	
Face mask sanitizer	
Step ladders	
Distilled water	X
Deionized water	
SHIPPING EQUIPMENT	
Coolers	X
Paint cans with lids, 7 clips each	
Vermiculite	
Shipping labels	X
DOT labels:	
"Up"	
"Danger"	
"Inside Container Complies ..."	
Hazard Group	
Strapping tape	X
Baggies	X
Custody seals	X
Chain-of-custody forms	X
Express shipment forms	X
Clear packing tape	X
Permanent markers	X

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DAILY SAFETY MEETING RECORD

GENERAL INFORMATION		
Project:		
Project No:	TDD/PAN No.:	
Project Location:		
Date:	Time:	Weather:
Specific Location:		
Planned Activities:		

SAFETY TOPICS PRESENTED
Chemical Hazards Update:
Physical Hazards Update:
Radiation Hazards Update:
Review of Previous Monitoring Results:
Protective Clothing/Equipment Modifications:
Special Equipment/Procedures:
Drilling Safety Issues (including testing the operation of drill rig emergency stop switches):
Emergency Procedures:
Additional Topics/Observations:
Team Members' Comments/Suggestions:

D A I L Y S A F E T Y M E E T I N G R E C O R D

INITIAL PROJECT SAFETY CHECKLIST

1. Emergency information reviewed? ___ and made familiar to all team members?
2. Route to nearest hospital driven? __ and its location known to all team members?
3. Health and safety plan readily available and its location known to all team members?
4. E & E Drilling SOP on site? __ and available for team member review?

ATTENDEES

Meeting shall be attended by all personnel who will be working within the exclusion area. Daily informal update meetings will be held prior to work and when site tasks and/or conditions change.

Name (Printed)	Name (Signature)	Date	Representing (Company/Agency)
Meeting Conducted By:			

Uranium (soluble compounds, as U)

Synonyms & Trade Names Synonyms vary depending upon the specific soluble uranium compound.

CAS No.	RTECS No.	DOT ID & Guide
	Conversion	**IDLH** Ca [10 mg/m³ (as U)] See: uranium (/niosh/idlh/uranium.html)

Exposure Limits

NIOSH REL : Ca TWA 0.05 mg/m³ See Appendix A (nengapdxa.html)

OSHA PEL : TWA 0.05 mg/m³

Measurement Methods

None available

See: NMAM (/niosh/docs/2003-154/) or OSHA Methods (http://www.osha.gov/dts/sltc/methods/index.html)

Physical Description Appearance and odor vary depending upon the specific soluble uranium compound.

Properties vary depending upon the specific soluble uranium compound.

Incompatibilities & Reactivities Uranyl nitrate: combustibles Uranium hexafluoride: water

Exposure Routes inhalation, ingestion, skin and/or eye contact

Symptoms lacrimation (discharge of tears), conjunctivitis; short breath, cough, chest rales; nausea, vomiting; skin burns; red blood cell, casts in urine; proteinuria; high blood urea nitrogen; [potential occupational carcinogen] Potential for cancer is a result of alpha-emitting properties & radioactive decay products (e.g., radon).

Target Organs respiratory system, blood, liver, kidneys, lymphatic system, skin, bone marrow

Cancer Site [lung cancer]

Personal Protection/Sanitation (See protection codes (protect.html))

Skin: Prevent skin contact
Eyes: Prevent eye contact
Wash skin: When contaminated/Daily
Remove: When wet or contaminated
Change: Daily
Provide: Eyewash (UF_6), Quick drench

First Aid (See procedures (firstaid.html))

Eye: Irrigate immediately
Skin: Water flush immediately
Breathing: Respiratory support
Swallow: Medical attention immediately

Respirator Recommendations

NIOSH

At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Escape (Halides):
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted acid gas canister having an N100, R100, or P100 filter.
Click here (pgintrod.html#nrp) for information on selection of N, R, or P filters.
Any appropriate escape-type, self-contained breathing apparatus

Escape (Non-halides):
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.
Click here (pgintrod.html#nrp) for information on selection of N, R, or P filters.
Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection (pgintrod.html#mustread)

See also: INTRODUCTION (/niosh/npg/pgintrod.html) See MEDICAL TESTS: 0239 (/niosh/docs/2005-110/nmed0239.html)

Page last reviewed: April 4, 2011
Page last updated: November 18, 2010
Content source: National Institute for Occupational Safety and Health (NIOSH) Education and Information Division

Centers for Disease Control and Prevention 1600 Clifton Rd. Atlanta, GA 30333, USA
800-CDC-INFO (800-232-4636) TTY: (888) 232-6348, New Hours of Operation 8am-8pm ET/Monday-Friday
Closed Holidays - cdcinfo@cdc.gov

Uranium (insoluble compounds, as U)

Synonyms & Trade Names **Uranium metal:** Uranium I
Synonyms of other insoluble uranium compounds vary depending upon the specific compound.

CAS No. 7440-61-1 (metal)	**RTECS No.** YR3490000 (metal) (/niosh-rtecs/YR3540D0.html)	**DOT ID & Guide** 2979 162 (http://wwwapps.tc.gc.ca/saf-sec-sur/3/erg-gmu/erg/guidepage.aspx?guide=162) (metal, pyrophoric)
Formula U (metal)	**Conversion**	**IDLH** Ca [10 mg/m³ (as U)] See: 7440611 (/niosh/idlh/7440611.html)

Exposure Limits
NIOSH REL : Ca TWA 0.2 mg/m³ ST 0.6 mg/m³ See Appendix A (nengapdxa.html)
OSHA PEL † (nengapdxg.html) : TWA 0.25 mg/m³

Measurement Methods
None available
See: NMAM (/niosh/docs/2003-154/) or OSHA Methods (http://www.osha.gov/dts/sltc/methods/index.html)

Physical Description Metal: Silver-white, malleable, ductile, lustrous solid. [Note: Weakly radioactive.]

MW: 238.0	**BP:** 6895°F	MLT: 2097°F	**Sol:** Insoluble	**VP:** 0 mmHg (approx)	**IP:** NA
Sp.Gr: 19.05 (metal)	**Fl.P:** NA	**UEL:** NA	**LEL:** NA		**MEC:** 60 g/m³

Metal: Combustible Solid, especially turnings and powder.

Incompatibilities & Reactivities Carbon dioxide, carbon tetrachloride, nitric acid, fluorine [Note: Complete coverage of uranium metal scrap with oil is essential for prevention of fire.]

Exposure Routes inhalation, ingestion, skin and/or eye contact

Symptoms dermatitis; kidney damage; blood changes; [potential occupational carcinogen]; in animals: lung, lymph node damage; [potential occupational carcinogen] Potential for cancer is a result of alpha-emitting properties & radioactive decay products (e.g., radon).

Target Organs Skin, kidneys, bone marrow, lymphatic system

Cancer Site [lung cancer]

Personal Protection/Sanitation (See protection codes (protect.html))
Skin: Prevent skin contact
Eyes: Prevent eye contact
Wash skin: When contaminated/Daily

First Aid (See procedures (firstaid.html))
Eye: Irrigate immediately
Skin: Soap wash promptly
Breathing: Respiratory support
Swallow: Medical attention immediately

Remove: When wet or contaminated
Change: Daily
Provide: Eyewash

Respirator Recommendations

NIOSH

At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Escape:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.
Click here (pgintrod.html#nrp) for information on selection of N, R, or P filters.
Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection (pgintrod.html#mustread)

See also: INTRODUCTION (/niosh/npg/pgintrod.html) See ICSC CARD: 1251 (/niosh/ipcsneng/neng1251.html) See MEDICAL TESTS: 0239 (/niosh/docs/2005-110/nmed0239.html)

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<< Back to Occupational Safety and Health Guidelines

Occupational Safety and Health Guideline for Uranium and Insoluble Compounds

DISCLAIMER:

These guidelines were developed under contract using generally accepted secondary sources. The protocol used by the contractor for surveying these data sources was developed by the National Institute for Occupational Safety and Health (NIOSH), the Occupational Safety and Health Administration (OSHA), and the Department of Energy (DOE). The information contained in these guidelines is intended for reference purposes only. None of the agencies have conducted a comprehensive check of the information and data contained in these sources. It provides a summary of information about chemicals that workers may be exposed to in their workplaces. The secondary sources used for supplements III and IV were published before 1992 and 1993, respectively, and for the remainder of the guidelines the secondary sources used were published before September 1996. This information may be superseded by new developments in the field of industrial hygiene. Therefore readers are advised to determine whether new information is available.

Introduction | Applicability | Recognition | Evaluation | Controls | References | Bibliography | Reference Table

Introduction

This guideline summarizes pertinent information about uranium and insoluble uranium compounds (measured as uranium) for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and hea programs. Recommendations may be superseded by new developments in these fields; readers are therefore advised to regard these recommendations as general guidelines and to determine periodically whether new information is available.

Applicability

This guideline applies to metallic uranium and all insoluble uranium compounds; examples of such compounds include triuranium octaoxide, uranium dioxide, uranium hydride, uranium tetrafluoride, and uranium trioxide. The physical and chemical properties of uranium and of some insoluble uranium compounds are presented below f illustrative purposes.

Recognition

Metallic uranium

SUBSTANCE IDENTIFICATION

* Formula
U
* Structure
(For Structure, see paper copy)
* Synonyms
U; Uranium metal, pyrophoric; uranium.
* Identifiers

1. CAS 7440-61-1.
2. RTECS YR3490000.
3. DOT UN: 2979 65 (for the pyrophoric forms of the metal).
4. DOT labels: Radioactive and Flammable Solid.

* Appearance and odor
Elemental uranium is a heavy, malleable, silvery white, lustrous, radioactive metal that is pyrophoric when finely divided. When uranium is obtained by reduction, it take the form of a black powder. In its natural state, uranium has three isotopes: (234)U, (235)U, and (238)U. U-238 has a half life of 4,510,000,000 years.

CHEMICAL AND PHYSICAL PROPERTIES

* Physical data

1. Atomic number: 92.
2. Atomic weight: 238.03.
3. Boiling point (760 torr): 3818 degrees C (6904 degrees F).
4. Specific gravity (water = 1): 19.05 + 0.02 at 20 degrees C (68 degrees F).
5. Vapor density: Not applicable.
6. Melting point: 1132.3 degrees C (2070 degrees F).
7. Vapor pressure at 20 degrees C (68 degrees F): Nearly zero.
8. Solubility: Insoluble in water, alcohol, and alkalies; soluble in acids.

9. Evaporation rate: Not applicable.

Triuranium Octaoxide

SUBSTANCE IDENTIFICATION

* Formula
U(3)O(8)
* Structure
(For Structure, see paper copy)
* Synonyms
Uranium oxide, pitchblende, nasturan, uraninite.
* Identifiers

1. CAS 1317-99-3.
2. RTECS YR3400000.
3. Specific DOT number: None.
4. Specific DOT label: None.

* Appearance and odor
Triuranium octaoxide is an olive green to black, odorless solid.

CHEMICAL AND PHYSICAL PROPERTIES

* Physical data

1. Molecular weight: 842.1.
2. Boiling point: Not applicable.
3. Specific gravity (water = 1): 8.30 at 20 degrees C (68 degrees F).
4. Vapor density: Not applicable.
5. Melting point: 1300 degrees C (2372 degrees F) (decomposes to uranium dioxide).
6. Vapor pressure at 20 degrees C (68 degrees F): Nearly zero.
7. Solubility: Insoluble in water; soluble in nitric and sulfuric acids.
8. Evaporation rate: Not applicable.

Uranium dioxide

SUBSTANCE IDENTIFICATION

* Formula
UO(2)
* Structure
(For Structure, see paper copy)
* Synonyms
Uranous oxide, black uranium oxide, uranium oxide, uranic oxide, urania, yellow cake.
* Identifiers

1. CAS 1344-57-6.
2. RTECS: None.
3. Specific DOT number: None.
4. Specific DOT label: None.

* Appearance and odor
Uranium dioxide is a pyrophoric, black, crystalline solid. It occurs naturally in various minerals including uraninite, pitchblende, and tyuyamunite. The latter is the most important mineral commercially.

CHEMICAL AND PHYSICAL PROPERTIES

* Physical data

1. Molecular weight: 270.03.
2. Boiling point: Data not available.
3. Specific gravity (water = 1): 10.96 at 20 degrees C (68 degrees F).
4. Vapor density: Not applicable.
5. Melting point: 2858-2898 degrees C (5176-5248 degrees F).
6. Vapor pressure: Not applicable.
7. Solubility: Insoluble in water; soluble in concentrated sulfuric acid and nitric acid.
8. Evaporation rate: Not applicable.

Uranium hydride

SUBSTANCE IDENTIFICATION

* Formula
UH(3)
* Structure
(For Structure, see paper copy)
* Synonyms
Uranium trihydride.
* Identifiers

1. CAS 13598-56-6.
2. RTECS: None.
3. Specific DOT number: None.
4. Specific DOT label: None.

* Appearance and odor

Uranium hydride is a brownish-black or brownish-gray, pyrophoric powder.

CHEMICAL AND PHYSICAL PROPERTIES

* Physical data

1. Molecular weight: 241.05.
2. Boiling point (760 torr): Not applicable.
3. Specific gravity (water = 1): 10.95 at 20 degrees C (68 degrees F).
4. Vapor density: Not applicable.
5. Melting point: Decomposes.
6. Vapor pressure at 20 degrees C (68 degrees F): Nearly zero.
7. Solubility: Insoluble in water, alcohol, acetone, or liquid ammonia; slightly soluble in dilute hydrogen chloride; decomposes in nitric acid.
8. Evaporation rate: Not applicable.

Uranium tetrafluoride

SUBSTANCE IDENTIFICATION

* Formula
UF(4)
* Structure
(For Structure, see paper copy)
* Synonyms
Green salt.
* Identifiers

1. CAS 10049-14-6.
2. RTECS: None.
3. Specific DOT number: None.
4. Specific DOT label: None.

* Appearance and odor
Uranium tetrafluoride is a nonvolatile, green, odorless, crystalline solid.

CHEMICAL AND PHYSICAL PROPERTIES

* Physical data

1. Molecular weight: 314.
2. Boiling point (760 torr): 1417 degrees C (2582 degrees F).
3. Specific gravity (water = 1): 6.7 at 20 degrees C (68 degrees F).
4. Vapor density: Not applicable.
5. Melting point: 955-965 degrees C (1751-1769 degrees F).
6. Vapor pressure at 20 degrees C (68 degrees F): Nearly zero.
7. Solubility: Insoluble in water; soluble (decomposes) in concentrated acids and alkalies.
8. Evaporation rate: Not applicable.

* Reactivity

1. Conditions contributing to instability: Heat, flame, or exposure to air. Uranium metal reacts with nearly all nonmetals. Uranium turnings and fines stored out-of-doors in closed containers under water or water-soluble oil will convert partially to the hydride and will eventually ignite during hot weather.
2. Incompatibilities: Pure uranium is very reactive and is a strong reducing agent. Clean uranium turnings or chips oxidize readily in air. Contact of uranium with carbon dioxide, carbon tetrachloride, or nitric acid causes fires or explosions. Uranium hydride is spontaneously flammable in air, and contact of the hydride with strong oxidizers may cause fires and explosions. Contact of uranium hydride with water forms flammable and explosive hydrogen gas, and contact of the hydride with halogenated hydrocarbons can cause violent reactions. In finely divided form, uranium dioxide ignites spontaneously in air.
3. Hazardous decomposition products: Toxic particulates, gases, and vapors (such as uranium metal fume, oxides of uranium, hydrogen fluoride, carbon monoxide, and dangerous radioactive materials) may be released when uranium or an insoluble uranium compound decomposes.
4. Special precautions: Uranium is radioactive and highly reactive and should be handled with extreme caution at all times. Uranium tetrafluoride is highly corrosive.

* Flammability
The National Fire Protection Association has not assigned a flammability rating to uranium or the insoluble uranium compounds. Other sources rate uranium in solid or powder form as a very dangerous fire hazard when this substance is exposed to heat or open flame.

1. Flash point: Data not available.
   Autoignition temperature: The ignition temperature depends on the extent to which the metal is subdivided. The ignition temperature of the metal is 170 degrees C (338 degrees F) (if oxygen is present); finely divided uranium metal (dust) ignites at room temperature (20 degrees C (68 degrees F)).
2. Flammable limits in air: Not applicable.
3. Minimum explosive concentration: 60 g/m(3).
4. Extinguishant: Use graphite chips, carbon dust, asbestos blankets, or flooding with water to extinguish small uranium fires. There is no effective way to extinguish large uranium fires.

   Fires involving uranium or an insoluble uranium compound should be fought upwind and from the maximum distance possible. Keep unnecessary people away; isolate hazard area and deny entry. Emergency personnel should stay out of low areas and ventilate closed spaces before entering. Finely divided uranium (chips, turnings, shavings, etc.) are much more reactive than uranium in bulk form. If these are present during a fire, do not disperse them into a dust cloud, which may be explosive. Uranium metal may ignite spontaneously if exposed to air or other substances, may burn rapidly with a flare-burning effect, and may re-ignite after the fire has been extinguished. Containers of uranium or an insoluble uranium compound may explode in the heat of the fire and should be moved from the fire area if it is possible to do so safely. If this is not possible, cool containers from the sides with water until well after the fire is out. Stay away from the ends of containers. Personnel should withdraw immediately if a rising sound from a venting safety device is heard or if there is discoloration of a container due to fire. Dikes should be used to contain fire-control water for later disposal. If a tank car or truck is involved in a fire, personnel should isolate an area of a half a mile in all directions. Delay cleanup until arrival of, or instruction from, a qualified radiation authority. Firefighters should wear a full set of protective clothing, including a self-contained breathing apparatus, when fighting fires involving uranium or an insoluble uranium compound. Firefighters' protective clothing may provide limited protection against fires involving uranium or an insoluble uranium compound.

* Warning properties
No quantitative data are available on the odor threshold for uranium or insoluble uranium compounds; several of these substances are odorless. For the purpose of selecting appropriate respiratory protection, these substances are therefore considered to have inadequate odor warning properties.

* Eye irritation properties
No quantitative data are available on the eye irritation threshold for uranium or the insoluble uranium compounds.

EXPOSURE LIMITS

The current Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs) for uranium and the insoluble uranium compounds (measured as uranium) are 0.2 milligram per cubic meter (mg/m(3)) of air as an 8-hour time-weighted average (TWA) concentration and 0.6 mg/m(3) as a 15-minute TWA short-term exposure limit (STEL). A STEL is the maximum 15-minute concentration to which workers may be exposed during any 15-minute period of the working day [29 CFR 1910.1000, Table Z-1-A]. The National Institute for Occupational Safety and Health (NIOSH) has not issued a recommended exposure limit (REL) for uranium or its insol uranium compounds; however, NIOSH concurs with the PEL established for this substance by OSHA [NIOSH 1988]. The American Conference of Governmental Industria Hygienists (ACGIH) has assigned uranium and the insoluble uranium compounds a threshold limit value (TLV) of 0.2 mg/m(3) as a TWA for a normal 8-hour workday an 40-hour workweek and a short-term exposure limit (STEL) of 0.6 mg/m(3) for periods not to exceed 15 minutes [ACGIH 1988, p. 37]. The OSHA and ACGIH limits are ba on the risk of kidney and blood disorders and on the radiological damage associated with exposure to uranium or an insoluble uranium compound.

Evaluation

HEALTH HAZARD INFORMATION

* Routes of Exposure
Exposure to uranium or an insoluble uranium compound can occur via inhalation, ingestion, and eye or skin contact. Exposure to uranium trioxide can occur by absorptio through the skin, eyes, and mucous membranes.

* Summary of toxicology

1. Effects on Animals: Metallic uranium and insoluble uranium compounds may produce both chemical poisoning and radiation injury to the kidneys and lungs of exposed animals [Clayton and Clayton 1981, p. 1996]. The insoluble uranium compounds are less toxic chemically than the soluble compounds, but uranium and uranium compounds have the potential to cause radiation damage [Clayton and Clayton 1981, p. 2000; Klaassen, Amdur, and Doull 1986, p. 695]. The inhalation toxicity of uranium and the insoluble compounds of uranium is much greater than their oral toxicity [Clayton and Clayton 1981, p. 2000]. No dietary amount of insoluble uranium compounds acceptable to rats was lethal, and no evidence of systemic poisoning developed after the application of an insoluble compound to rabbit skin [Clayton and Clayton 1981, p. 2000]. However, uranium trioxide is lethal when placed in the conjunctival sac of rabbits' eyes, and uranium tetrafluorid causes direct eye injury [Grant 1986, p. 965]. Acute inhalation exposure to 20-mg/m(3) concentrations of uranium tetrafluoride, uranium dioxide, or high-grade uranium ore was occasionally fatal to some laboratory animals; exposure to a 2.5-mg/m(3) concentration of uranium tetrafluoride, uranium dioxide, or high-grade uranium ore caused mild or no renal damage and no fatalities in these animals [Clayton and Clayton 1981, p. 2001]. Chronic inhalation exposure to an insoluble uranium compound may produce radiation injury. In dogs and monkeys exposed to 5 mg/m(3) uranium dioxide for 6 hours/day, 5 days/week for up to 5 years, fibrotic changes suggestive of radiation injury were found in the tracheobronchial lymph nodes of both species and in the lungs of monkeys. No kidney damage w observed in these animals [Clayton and Clayton 1981, p. 2002]. Dogs tolerated inhalation of a 10-mg/m(3) concentration of uranium dioxide every day for 1 year dietary exposure to 10 g/kg/day for 1 year [Clayton and Clayton 1981, pp. 2001-2002]. Rats injected with metallic uranium in the femoral bone marrow and ches wall developed site-of-contact sarcomas; in these cases, the effects of chemical injury could not be distinguished from those of radiation damage [Clayton and Clayton 1981, p. 2003].
2. Effects on Humans: Metallic uranium and insoluble uranium compounds may produce both chemical poisoning and radiation injury [Clayton and Clayton 1981, p. 1996]. The insoluble uranium compounds are less toxic chemically than the soluble compounds, but uranium and all uranium compounds have the potential to ca radiation damage [Clayton and Clayton 1981, p. 2000; Klaassen, Amdur, and Doull 1986, p. 695]. Exposure to the dusts of uranium or to an insoluble uranium compound may cause respiratory irritation, cough, and shortness of breath [Genium MSDS 1988, No. 238]. Dermatitis has also been reported, and prolonged skin contact causes radiation injury to the basal cells [Proctor, Hughes, and Fischman 1988, p. 502]. Studies have shown that uranium workers are at increased risk of death from respiratory, lymphatic, and hematopoietic cancers; these deaths are presumed to be caused by radiation injury from radon gas, a byproduct of uraniu decay [Rom 1983, p. 688]. A study of the risk of respiratory deaths among uranium miners in the United States showed the following dose-response: miners expo occupationally for 5 to 9.9 years had a 2-fold increase in risk; miners exposed for 10 to 24.9 years had a 3.6-fold increase in risk; and those exposed for greater t 24.9 years had a 3.75-fold increase in risk. Smoking was shown both to increase the risk of death from respiratory disease and to shorten the neoplastic latency period [Clayton and Clayton 1981, pp. 2010-2011].

* Signs and symptoms of exposure

1. Acute exposure: The signs and symptoms of acute exposure to uranium or an insoluble uranium compound include respiratory irritation, cough, and shortness of breath.
2. Chronic exposure: 2. Chronic exposure: The signs and symptoms of chronic exposure to uranium or an insoluble uranium compound include those of lung damag shortness of breath, dry or productive cough, rales, cyanosis, and clubbing of the fingers. Long-term exposure also may cause cancer of the blood-forming syster the lymph system, and the respiratory tract, as well as anemia and leukopenia. The signs and symptoms of uranium-induced dermatitis may include irritation, redness, blistering, thickening, or hyperpigmentation of the skin.

* Emergency procedures:
In the event of an emergency, remove the victim from further exposure, send for medical assistance, and initiate the following emergency procedures:

1. Eye exposure: If uranium or an insoluble uranium compound gets into the eyes, immediately flush the eyes with large amounts of water for a minimum of 15 minutes, lifting the lower and upper lids occasionally. If irritation persists, get medical attention as soon as possible.
2. Skin exposure: If uranium or an insoluble uranium compound contacts the skin, the contaminated skin should be washed with soap and water. Contaminated boc surfaces should immediately be decontaminated in accordance with radiation procedures. Get medical attention.
3. Inhalation: If uranium or an insoluble uranium compound is inhaled, move the victim at once to fresh air and get medical care as soon as possible. If the victim is breathing, perform cardiopulmonary resuscitation; if breathing is difficult, give oxygen. Keep the victim warm and quiet until medical help arrives.
4. Ingestion: If uranium or an insoluble uranium compound is ingested, give the victim several glasses of water to drink and then induce vomiting by having the vict touch the back of the throat with the finger or by giving syrup of ipecac as directed on the package. Do not force an unconscious or convulsing person to drink liquids or to vomit. Get medical help immediately. Keep the victim warm and quiet until medical help arrives.
5. Rescue: Remove an incapacitated worker from further exposure and implement appropriate emergency procedures (e.g., those listed on the Material Safety Data Sheet required by OSHA's Hazard Communication Standard, 29 CFR 1910.1200). All workers should be familiar with emergency procedures and the location and proper use of emergency equipment.

EXPOSURE SOURCES AND CONTROL METHODS

The following operations may involve uranium and insoluble uranium compounds and lead to worker exposures to these substances:

- Mining, grinding, and milling of uranium ores
- Use in nuclear reactors as fuel and to pack nuclear fuel rods and in the production of nuclear weapons
- Burning of uranium metal chips and smelting operations
- Use in the ceramics industry for pigments, coloring porcelain, painting on porcelain, and enamelling

- Use as catalysts for many reactions, in gas manufacture, and in production of fluorescent glass
- Use in photographic processes, for alloying steel, in radiation shielding, and in aircraft counterweights
- Use as a source of plutonium and radium salts

Uranium hydride:

* Use as a lab source for pure hydrogen, for separation of hydrogen isotopes, and as a reducing agent
Methods that are effective in controlling worker exposures to uranium and insoluble uranium compounds, depending on the feasibility of implementation, are

- Process enclosure,
- Local exhaust ventilation,
- General dilution ventilation, and
- Personal protective equipment.

The following publications are good sources of information on control methods:

1. ACGIH [1986]. Industrial ventilation--a manual of recommended practice. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.
2. Burton DJ [1986]. Industrial ventilation--a self study companion. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.
3. Alden JL, Kane JM [1982]. Design of industrial ventilation systems. New York, NY: Industrial Press, Inc.
4. Wadden RA, Scheff PA [1987]. Engineering design for control of workplace hazards. New York, NY: McGraw-Hill.
5. Plog BA [1988]. Fundamentals of industrial hygiene. Chicago, IL: National Safety Council.

MEDICAL MONITORING

Workers who may be exposed to chemical and radiation hazards should be monitored in a systematic program of medical surveillance that is intended to prevent occupational injury and disease. The program should include education of employers and workers about work-related hazards, placement of workers in jobs that do not jeopardize their safety or health, early detection of adverse health effects, and referral of workers for diagnosis and treatment. The occurrence of disease or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and persor protective equipment). A medical monitoring program is intended to supplement, not replace, such measures. To place workers effectively and to detect and control wor related health effects, medical evaluations should be performed (1) before job placement, (2) periodically during the period of employment, and (3) at the time of job transfer or termination.

* Preplacement medical evaluation
Before a worker is placed in a job with a potential for exposure to uranium or an insoluble uranium compound, the examining physician should evaluate and document tl worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropria for the anticipated occupational risks. These should concentrate on the function and integrity of the kidneys, respiratory system, blood, liver, bone marrow, skin, and lymphatics. Medical monitoring for respiratory disease should be conducted using the principles and methods recommended by NIOSH and the American Thoracic Societ

A preplacement medical evaluation is recommended to assess an individual's suitability for employment at a specific job and to detect and assess medical conditions tha may be aggravated or may result in increased risk when a worker is exposed to uranium or an insoluble uranium compound at or below the prescribed exposure limit. Tl examining physician should consider the probable frequency, intensity, and duration of exposure as well as the nature and degree of any applicable medical condition. S conditions (which should not be regarded as absolute contraindications to job placement) include a history and other findings consistent with diseases of the kidneys, respiratory system, blood, liver, bone marrow, skin, or lymphatics.

* Periodic medical examinations and biological monitoring
Occupational health interviews and physical examinations should be performed at regular intervals during the employment period, as mandated by any applicable Federa State, or local standard. Where no standard exists and the hazard is minimal, evaluations should be conducted every 3 to 5 years or as frequently as recommended by a experienced occupational health physician. Additional examinations may be necessary if a worker develops symptoms attributable to uranium exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of uranium on the kidneys, respiratory system, blood, liver, bone marrow, skin lymphatics. Current health status should be compared with the baseline health status of the individual worker or with expected values for a suitable reference populatior

Biological monitoring involves sampling and analyzing body tissues or fluids to provide an index of exposure to a toxic substance or metabolite. Urinary uranium concentrations correlate well with airborne uranium levels. Some sources report that urinary concen-trations of 50 þg uranium per liter of urine or 100 þg uranium per lit of urine correspond to constant daily exposures of approximately 0.05 mg/m(3) or 0.25 mg/m(3), respectively. Because there is great interindividual and intraindividual variability in urinary uranium concentrations, a pattern of urinary uranium excretion should be established for every exposed worker by sampling individuals at the same time on several different shifts and by sampling frequently.

* Medical examinations recommended at the time of job transfer or termination
The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic or laboratory tests that were conducted at the time placement should be repeated at the time of job transfer or termination to determine the worker's medical status at the end of his or her employment. Any changes in tl worker's health status should be compared with those expected for a suitable reference population. Because occupational exposure to uranium or an insoluble uranium compound may cause diseases with prolonged latent periods, the need for medical monitoring may extend well beyond the termination of employment.

WORKPLACE MONITORING AND MEASUREMENT PROCEDURES

Determination of a worker's exposure to airborne uranium or an insoluble uranium compound (measured as uranium) is made using a mixed cellulose ester filter (0.8 micron). Samples are collected at a maximum flow rate of 2 liters per minute until a maximum air volume of 960 liters is collected. Analysis is conducted by neutron activation. This method is included in the OSHA In-House Methods File.

Controls

PERSONAL HYGIENE PROCEDURES

If uranium or an insoluble uranium compound contacts the skin, workers should immediately wash the affected areas with soap and water. Contaminated body surfaces should immediately be decontaminated in accordance with radiation procedures.
Clothing contaminated with uranium or an insoluble uranium compound should be removed immediately, and provisions should be made for the safe removal of the chemical from the clothing. Persons laundering the clothes should be informed of the toxic and radioactive hazards of uranium.
A worker who handles uranium or an insoluble uranium compound should thoroughly wash hands, forearms, and face with soap and water before eating, using tobacco products, or using toilet facilities.
Workers should not eat, drink, or use tobacco products in areas where uranium or an insoluble uranium compound is handled, processed, or stored.

STORAGE

Uranium and insoluble uranium compounds should be stored in a cool, dry, well-ventilated area in tightly sealed containers that are labeled in accordance with OSHA's Hazard Communication Standard [29 CFR 1910.1200]. Containers of uranium or of insoluble uranium compounds should be protected from physical damage and should stored separately from carbon dioxide, carbon tetra-chloride, nitric acid, air, nonmetals, heat, sparks, and open flame. Uranium hydride should not be allowed to contact water, strong oxidizers, or halogenated hydrocarbons. Because empty containers that formerly contained uranium or a uranium compound may still hold product residue they should be handled appropriately.

SPILLS AND LEAKS

In the event of a spill or leak involving uranium or an insoluble uranium compound, persons not wearing protective equipment and clothing should be restricted from contaminated areas until cleanup has been completed. A clean-up plan must be available to address an accidental leak or spill of uranium or an insoluble uranium compo because special radiation procedures are required and professional assistance is needed. The following steps should be undertaken following a spill or leak:

1. Do not touch the spilled material; stop the leak if it is possible to do so without risk.
2. Notify safety personnel.
3. Remove all sources of heat and ignition.
4. Ventilate the area of the spill or leak.
5. Protect cleanup personnel from contact with or inhalation of uranium dust.

EMERGENCY PLANNING, COMMUNITY RIGHT-TO-KNOW, AND HAZARDOUS WASTE MANAGEMENT REQUIREMENTS

The Environmental Protection Agency's (EPA's) regulatory requirements for emergency planning, community right-to-know, and hazardous waste management may vary over time. Users are therefore advised to determine periodically whether new information is available.

* Emergency planning requirements
Uranium and insoluble uranium compounds are not subject to EPA emergency planning requirements under the Superfund Amendments and Reauthorization Act (Title I

* Reportable quantity requirements for hazardous releases
Employers are not required by the emergency release notification provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [CFR Part 355.40] to notify the National Response Center of an accidental release of uranium or an insoluble uranium compound; there is no reportable quantity for these substances.

* Community right-to-know requirements
Employers are not required by Section 313 of the Superfund Amendments and Reauthorization Act (SARA) to submit a Toxic Chemical Release Inventory form (Form R) EPA reporting the amount of uranium or an insoluble uranium compound emitted or released from their facility annually.

* Hazardous waste management requirements
EPA considers a waste to be hazardous if it exhibits any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity, as defined in 40 CFR 261.21-261.24 Under the Resource Conservation and Recovery Act (RCRA), EPA has specifically listed many chemical wastes as hazardous. Although uranium and insoluble uranium compounds are not specifically listed as a hazardous waste under RCRA, EPA requires employers to treat any waste as hazardous if it exhibits any of the characteristics discussed above.

Providing more information about the removal and disposal of specific chemicals is beyond the scope of this guideline. EPA, U.S. Department of Transportation, and Stat and local regulations should be followed to ensure that removal, transport, and disposal of this substance are conducted in accordance with existing regulations. To be certain that chemical waste disposal meets EPA regulatory requirements, employers should address any questions to the RCRA hotline at (202) 382-3000 (in Washingtor D.C.) or toll-free at (800) 424-9346 (outside Washington, D.C.). In addition, relevant State and local authorities should be contacted for information on any requirements they may have for the waste removal and disposal of this substance.

RESPIRATORY PROTECTION

* Conditions for respirator use
Good industrial hygiene practice requires that engineering controls be used where feasible to reduce workplace concentrations of hazardous materials to the prescribed exposure limit. However, some situations may require the use of respirators to control exposure. Respirators must be worn if the ambient concentration of uranium or ar insoluble uranium compound exceeds prescribed exposure limits. Respirators may be used (1) before engineering controls have been installed, (2) during work operatior such as maintenance or repair activities that involve unknown exposures, (3) during operations that require entry into tanks or closed vessels, and (4) during emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by NIOSH and the Mine Safety and Health Administra (MSHA).

* Respiratory protection program
Employers should institute a complete respiratory protection program that, at a minimum, complies with the requirements of OSHA's Respiratory Protection Standard [29 CFR 1910.134]. Such a program must include respirator selection (see Table 1), an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic workplace monitoring, and regular respirator maintenance, inspection, and cleaning. The implementation of an adequat respiratory protection program (including selection of the correct respirator) requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly. For additional information on the selection and use of respirators and on the medical screening of respirator users, consult the **NIOSH Respirator Decision Logic** and the **NIOSH Guide to Industrial Respiratory Protection**.

Table 1 lists the respiratory protection that NIOSH recommends for workers exposed to uranium or an insoluble uranium compound. The recommended protection may over time because of changes in the exposure limit for uranium or the insoluble uranium compounds or in respirator certification requirements. Users are therefore advis to determine periodically whether new information is available.

PERSONAL PROTECTIVE EQUIPMENT

Protective clothing should be worn to prevent skin contact with uranium or an insoluble uranium compound. Impervious gloves, boots, and aprons should be worn as appropriate when handling any of these substances. Chemical protective clothing should be selected on the basis of available performance data, manufacturers' recommendations, and evaluation of the clothing under actual conditions of use. No reports have been published on the resistance of various protective clothing materia permeation by uranium or an insoluble uranium compound; however, one source recommends natural rubber, neoprene, or polyvinyl chloride as a protective clothing material. If permeability data are not readily available, protective clothing manufacturers should be requested to provide information on the best chemical protective clothing for workers to wear when they are exposed to uranium or an insoluble uranium compound.

If uranium or an insoluble uranium compound is dissolved in an organic solvent, the permeation properties of both the solvent and the mixture must be considered wher selecting personal protective equipment and clothing.

Safety glasses, goggles, or faceshields should be worn during operations in which uranium or an insoluble uranium compound might contact the eyes. Eyewash fountain and emergency showers should be available within the immediate work area whenever the potential exists for eye or skin contact with uranium or its insoluble compoun Contact lenses should not be worn if the potential exists for exposure to any of these substances.

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Reference Table

Table 1
NIOSH recommended respiratory protection for workers exposed to uranium or an insoluble uranium compound*

Condition	Minimum respiratory protection**
Airborne concentration of uranium or an insoluble uranium compound:	
0.2 to 2 mg/m(3) (10 X PEL)	Single-use or quarter mask respirator
5 to 50 mg/m(3) (10 X PEL)	Any air-purifying, half-mask respirator equipped with a fume or high-efficiency filter approved for radon daughters or radionuclides, or
	Any air-purifying, full-facepiece respirator equipped with a fume filter approved for radon daughters, or
	Any supplied-air respirator equipped with a half mask and operated in a

	demand (negative-pressure) mode
0.2 to 5 mg/m(3) (25 X PEL)	Any powered, air-purifying respirator equipped with a hood or helmet and a fume or high-efficiency filter approved for radon daughters or radio-nuclides, or Any supplied-air respirator equipped with a hood or helmet and operated in a continuous-flow mode
0.2 to 10 mg/m(3) (50 X PEL)	Any air-purifying, full-facepiece respirator equipped with a high-efficiency filter approved for radon daughters or radio-nuclides, or Any powered, air-purifying respirator equipped with a tight-fitting facepiece and a high-efficiency filter approved for radon daughters or radio-nuclides, or Any supplied-air respirator equipped with a full facepiece and operated in a demand (negative-pressure) mode, or Any supplied-air respirator equipped with a tight-fitting facepiece and operated in a continuous-flow mode, or Any self-contained respirator equipped with a full facepiece and operated in a demand (negative-pressure) mode
0.2 to 30 mg/m(3) (150 X PEL)	Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode
Entry into IDLH(+) or unknown concentrations	Any self-contained respirator equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode, or Any supplied-air respirator equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive-pressure mode
Firefighting	Any self-contained respirator equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode
Escape	Any air-purifying, full-facepiece respirator equipped with a high-efficiency filter approved for radon daughters or radionuclides, or Any escape-type, self-contained breathing apparatus with a suitable service life (number of minutes required to escape the environment)

* The OSHA PEL is 0.2 mg/m(3) as an 8-hour TWA. No NIOSH REL has been issued.

** Only NIOSH/MSHA-approved equipment should be used. Also note the following:

1. Respirators accepted for use at higher concentrations may be used at lower concentrations; respirators must not, however, be used at concentrations higher than those for which they are approved.
2. Air-purifying respirators may not be used in oxygen-deficient atmospheres or in airborne concentrations that are immediately dangerous to life or health (IDLH).

(+) The uranium or an insoluble uranium compound concentration that is immediately dangerous to life and health (IDLH) is 30 mg/m(3) [NIOSH 1987b].

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HEAT STRESS PREVENTION AND TREATMENT

Elevated temperatures are potentially hazardous, especially when work is conducted without appropriate precautions. The following sections describe heat stress prevention and the recognition and treatment of heat emergencies.

Effects of Heat

A predictable amount of heat is generated as a result of normal oxidation processes within the body. If heat is liberated rapidly, the body cools to a point at which the production of heat is accelerated, and the excess heat brings the body temperature back to normal.

Interference with the elimination of heat leads to its accumulation and to the elevation of body temperature. This condition produces a vicious cycle in which certain body processes accelerate and generate additional heat. Afterward, the body must eliminate not only the heat that is normally generated but also the additional quantities of heat.

Most body heat is brought to the surface by the bloodstream and escapes to cooler surroundings by conduction and radiation. If moving air or a breeze strikes the body, additional heat is lost by convection. When the temperature of the surrounding air becomes equal to or rises above the body temperature, all the heat must be lost by vaporization of the moisture or sweat from skin surfaces. As the air becomes more humid (contains more moisture), vaporization from the skin decreases. Weather conditions including high temperatures (90 to 100 degrees F), high humidity, and little or no breeze cause the retention of body heat. Such conditions or a succession of such days (a heat wave) increase the chances of a medical emergency due to heat.

Preventing Emergencies Due to Heat

When working in situations where the ambient temperatures and humidity are high, and especially in situations where protection levels A, B, or C are required, the site safety officer should:

- Ensure that all employees drink plenty of fluids (Gatorade or its equivalent);
- Ensure that frequent breaks are scheduled so overheating does not occur; and
- Revise work schedules, when necessary, to take advantage of the cooler parts of the day (i.e., 5:00 a.m. to 11:00 a.m. and 6:00 p.m. to nightfall).

When protective clothing is required, the suggested guidelines correlating ambient temperature and maximum wearing time per excursion are:

Ambient Temperature	Maximum Wearing Time per Excursion
Above 90 degrees F	15 minutes
85 to 90 degrees F	30 minutes
80 to 85 degrees F	60 minutes
70 to 80 degrees F	90 minutes
60 to 70 degrees F	120 minutes
50 to 60 degrees F	180 minutes

One method of measuring the effectiveness of an employee's rest-recovery regime is by monitoring the heart rate. The "Brouha guideline" is one such method and is performed as follows:

- Count the pulse rate for the **last** 30 seconds of the first minute of a 3-minute period, the **last** 30 seconds of the second minute, and the **last** 30 seconds of the third minute; and

- Double each result to yield beats per minute.

If the recovery pulse rate during the last 30 seconds of the first minute is 110 beats/minute or less, and the deceleration between the first, second, and third minutes is **at least** 10 beats/minute, then the work-recovery regime is acceptable. If the employee's rate is above the rate specified, a longer rest period will be required, accompanied by an increased intake of fluids.

Heat Emergencies

Heat Cramps. Heat cramps usually affect people who work in hot environments and perspire a great deal. Loss of salt from the body causes very painful cramps in leg and abdominal muscles. Heat cramps may also result from drinking iced water or other drinks either too quickly or in too large a quantity. The symptoms of heat cramps are:

- Painful muscle cramps in legs and abdomen;

- Faintness; and

- Profuse perspiration.

To provide emergency care for heat cramps, move the patient to a cool place. Give him or her sips of liquids such as Gatorade or its equivalent. Apply manual pressure to the cramped muscle. Move the patient to a hospital if there is any indication of a more serious problem.

Heat Exhaustion. Heat exhaustion also may occur in individuals working in hot environments and may be associated with heat cramps. Heat exhaustion is caused by the pooling of blood in the vessels of the skin. The heat is transported from the interior of the body to the surface by the blood. The skin vessels become dilated and a large amount of blood is pooled in the skin. This condition, plus the blood that is pooled in the lower extremities when in an upright position, may lead to an inadequate return of blood to the heart and eventual physical collapse. The symptoms of heat exhaustion are:

- Weak pulse;

- Rapid and usually shallow breathing;
- Generalized weakness;
- Pale, clammy skin;
- Profuse perspiration;
- Dizziness/faintness; and
- Unconsciousness.

To provide emergency care for heat exhaustion, move the patient to a cool place and remove as much clothing as possible. Have the patient drink cool water, Gatorade, or its equivalent. If possible, fan the patient continually to remove heat by convection, but do not allow chilling or overcooling. Treat the patient for shock and move him or her to a medical facility if there is any indication of a more serious problem.

Heat Stroke. Heat stroke is a profound disturbance of the heat-regulating mechanism and is associated with high fever and collapse. It is a serious threat to life and carries a 20% mortality rate. Sometimes this condition results in convulsions, unconsciousness, and even death. Direct exposure to sun, poor air circulation, poor physical condition, and advanced age (over 40) increase the chance of heat stroke. Alcoholics are extremely susceptible. The symptoms of heat stroke are:

- Sudden onset;
- Dry, hot, and flushed skin;
- Dilated pupils;
- Early loss of consciousness;
- Full and fast pulse;
- Deep breathing at first, followed by shallow or faint breathing;
- Muscle twitching, growing into convulsions; and
- Body temperature reaching 105 to 106 degrees F or higher.

When providing emergency care for heat stroke, remember that it is a life-threatening emergency. Transportation to a medical facility should not be delayed. Move the patient to a cool environment, if possible, and remove as much clothing as possible. Ensure an open airway. Reduce body temperature promptly by dousing the body with water or, preferably, by wrapping the patient in a wet sheet. If cold packs are available, place them under the arms, around the neck, at the ankles, or any place where blood vessels that lie close to the skin can be cooled. Protect the patient from injury during convulsions.

OSHA QUICK CARD™

Rodents, Snakes and Insects

Insects, Spiders and Ticks

- To protect yourself from biting and stinging insects, wear long pants, socks, and long-sleeved shirts.
- Use insect repellents that contain DEET or Picaridin.
- Treat bites and stings with over-the-counter products that relieve pain and prevent infection.
- Avoid fire ants; their bites are painful and cause blisters.
- Severe reactions to fire ant bites (chest pain, nausea, sweating, loss of breath, serious swelling or slurred speech) require immediate medical treatment.

Rodents and Wild or Stray Animals

- Dead and live animals can spread diseases such as Rat Bite Fever and Rabies.
- Avoid contact with wild or stray animals.
- Avoid contact with rats or rat-contaminated buildings. If you can't avoid contact, wear protective gloves and wash your hands regularly.
- Get rid of dead animals as soon as possible.
- If bitten/scratched, get medical attention immediately.

Snakes

- Watch where you place your hands and feet when removing debris. If possible, don't place your fingers under debris you are moving. Wear heavy gloves.
- If you see a snake, step back and allow it to proceed.
- Wear boots at least 10 inches high.
- Watch for snakes sunning on fallen trees, limbs or other debris.
- A snake's striking distance is about 1/2 the total length of the snake.
- If bitten, note the color and shape of the snake's head to help with treatment.
- Keep bite victims still and calm to slow the spread of venom in case the snake is poisonous. Seek medical attention as soon as possible.
- Do not cut the wound or attempt to suck out the venom. Apply first aid: lay the person down so that the bite is below the level of the heart, and cover the bite with a clean, dry dressing.

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Protect Yourself! Workers may be exposed to

Black Widow Spider

The black widow belongs to a group of spiders commonly known as cobweb spiders. The characteristic hourglass is located on the underside of the abdomen. Female black widows are dangerous and can bite and inject toxic venom.

Identification

- The female black widow is normally shiny black, with a red hourglass marking (see photo) on the underside of the abdomen.
- The abdominal marking may range in color from yellowish orange to red and its shape may range from an hourglass to a dot.
- The body of an adult black widow female is about 1/2 inch long.

Photo: Extension Entomology, Texas A&M University

Photo: University of Missouri Extension

Habitat

The black widow is commonly found in the following places:

- Outdoors - woodpiles, rubble piles, under stones, in hollow stumps, and in rodent burrows, privies, sheds and garages.
- Indoors - undisturbed, cluttered areas in basements and crawl spaces.

Symptons

- The bite of the black widow may be painful or it may go unnoticed.
- The skin may display one or two bite marks with local swelling. Pain usually progresses from the bite site and eventually to the abdomen and back.
- Severe cramping or rigidity may occur in the abdominal muscles.
- Symptoms may include nausea, profuse perspiration, tremors, labored breathing, restlessness, increased blood pressure and fever.
- The pain from the bite will usually persist for the first 8-12 hours.
- Symptoms may continue for several days.

Protection

- Wear a long-sleeved shirt, hat, gloves, and boots when handling boxes, firewood, lumber, and rocks, etc.
- Inspect and shake out clothing and shoes before getting dressed.
- Use insect repellants, such as DEET or Picaridin, on clothing and footwear.

Treatment

- Clean the bite area with soap and water.
- Apply ice to the bite area to slow absorption of the venom.
- Elevate and immobilize the extremity.
- Capture the spider, if at all possible, for identification purposes.
- Seek medical attention immediately.
- If you have a heart condition or other heart problem, you may need hospitalization.

This is one in a series of informational fact sheets highlighting OSHA programs, policies or standards. It does not impose any new compliance requirements. For a comprehensive list of compliance requirements of OSHA standards or regulations, refer to Title 29 of the Code of Federal Regulations. This information will be made available to sensory impaired individuals upon request. The voice phone is (202) 693-1999; teletypewriter (TTY) number: (877) 889-5627.

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Protect Yourself! Workers may be exposed to

Brown Recluse Spider

The brown recluse belongs to a group of spiders commonly known as violin spiders or fiddlebacks. The characteristic fiddle-shaped pattern is located on the top of the leg attachment region (cephalothorax). Because they are secluded and withdrawn, as their name implies, the brown recluse avoids open spaces. Brown recluse spiders are dangerous and they can bite and inject toxic venom.

Identification

- Body size: 1/4 to 3/4 inch (6.4-19.1mm)
- Color: Golden brown
- A dark violin/fiddle shape (see top photo) is located on the top of the leg attachment region (cephalothorax) with the neck of the violin/fiddle pointing backward toward the abdomen.
- Unlike most spiders that have 8 eyes, the brown recluse has 6 eyes. The eyes, arranged in pairs – one pair in front and a pair on either side – can be readily seen under low magnification.

Habitat

The Brown Recluse Spider builds small retreat webs behind objects of any type.

Symptoms

- The severity of the bite may vary. Symptoms may vary from none to very severe.
- The bite generally becomes reddened within several hours.

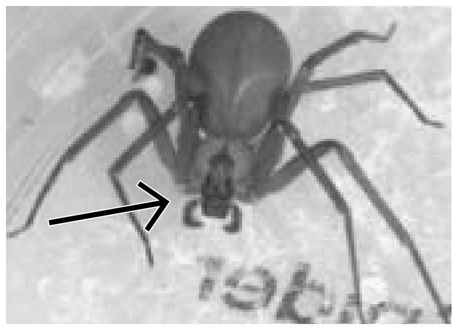

Photo: R. Bessin, University of Kentucky

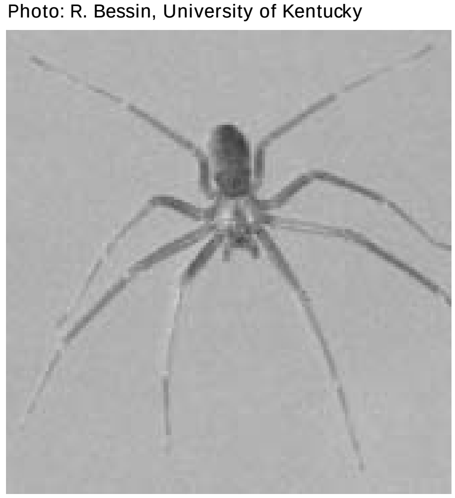

Photo: creatures.ifas.ufl.edu

- There is often a systemic reaction within 24-36 hours characterized by restlessness, fever, chills, nausea, weakness and joint pain.
- Tissue at the site of the bite and the surrounding area dies and eventually sheds.

Protection

- Wear a long-sleeved shirt, hat, gloves, and boots when handling stored boxes, firewood, lumber and rocks, etc.
- Inspect and shake out clothing and shoes before getting dressed.
- Use insect repellants, such as DEET or Picaridin, on clothing and footwear.

Treatment

- Clean the bite area with soap and water.
- Apply ice to the bite area to slow absorption of the venom.
- Elevate and immobilize the bitten extremity.
- Capture the spider, if at all possible, for identification purposes.
- Seek medical attention.

This is one in a series of informational fact sheets highlighting OSHA programs, policies or standards. It does not impose any new compliance requirements. For a comprehensive list of compliance requirements of OSHA standards or regulations, refer to Title 29 of the Code of Federal Regulations. This information will be made available to sensory impaired individuals upon request. The voice phone is (202) 693-1999; teletypewriter (TTY) number: (877) 889-5627.

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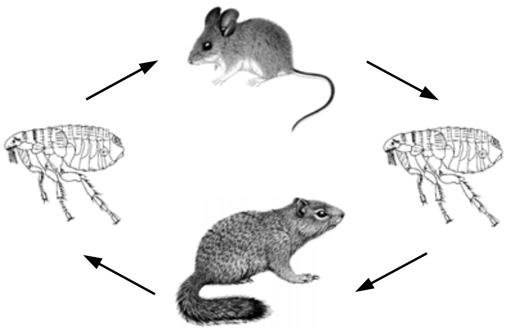
DSG 10/2005

What is Plague?

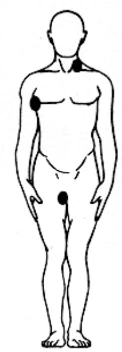


Plague is a disease of wild rodents and rabbits caused by the bacterium *Yersinia pestis*. It is spread among animals and to humans by the bites of infected fleas. Animals most often infected include rock squirrels, prairie dogs, pack rats, chipmunks, rabbits and mice.

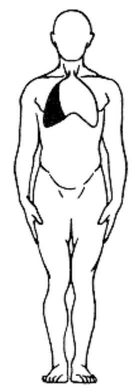
When an animal with plague dies, the infected fleas must find a new host. This may be another rodent, a pet or a person.

Although most human plague cases result from flea bites, people have also contracted the disease by coming into direct contact with an infected animal's blood or tissues, such as when skinning a rabbit or other game.

People can also get plague by inhaling infectious droplets expelled by a person or cat with pneumonic plague.



BUBONIC



PNEUMONIC FORM

The three forms of plague are bubonic ...

Symptoms usually develop within two to six days after a flea bite or contact with an infected animal and include high fever, chills, weakness, headache and muscle aches. In bubonic plague, a lymph node in the groin, armpit or neck becomes swollen and very painful.

... septicemic ...

Sometimes the bacteria go directly into the blood and there are no swollen lymph nodes, just fever and severe flu-like symptoms. Secondary septicemic plague can result from untreated bubonic plague.

... and pneumonic.

If the bacteria invade the lungs, pneumonia may develop and the disease may be spread to other people when the patient coughs or sneezes. For plague pneumonia patients, the death rate is over 50%.

Plague is curable if treated in time.

See your doctor immediately about any illness having sudden onset of high fever. Report if you have had flea bites, have handled any wild rodents or rabbits, or have a pet that hunts. Plague is curable with antibiotics if promptly diagnosed and treated.

Pets that hunt may bring plague-infected fleas into the home and can also become infected with plague. Cats are more likely than dogs to get sick, and can spread the disease to their owners through biting, coughing, or draining abscesses. Take your pet to the vet immediately if it has had contact with rodents and develops symptoms of fever, lethargy, and loss of appetite.

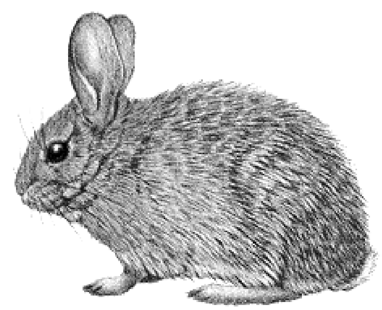
Preventing Plague

- Avoid contact with wild rodents and their fleas, nests and burrows.
- Prevent pets from hunting.
- Treat outdoor pets with flea control products regularly.
- Wear rubber gloves when handling game.
- Eliminate rodent shelter around the home:
- Stack woodpiles at least 12" above the ground and 100 feet from the house;
- Keep animal feed in rodent-proof containers;
- Get rid of junk piles and abandoned vehicles around the home.
- Report sick or dead rodents and rabbits (in the absence of poisoning or trauma) to the Zoonoses Program in the New Mexico Department of Health. (Within Bernalillo County, contact the Albuquerque Environmental Health Dept.)

For more information, contact:

Zoonoses Program
Epidemiology & Response
NM Department of Health
1190 St. Francis Dr.
Santa Fe, NM 87505

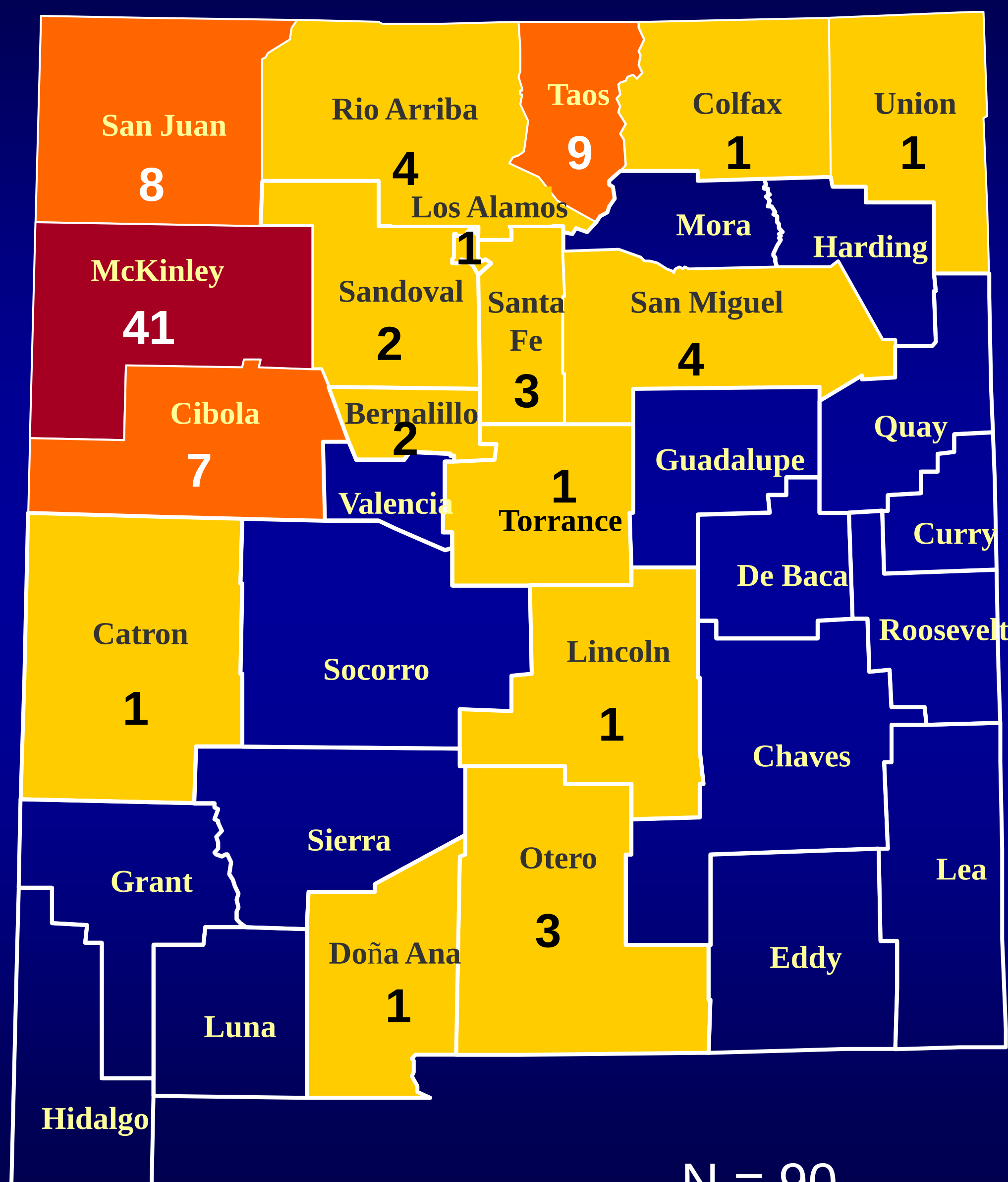
(505) 827-0006



PLAGUE IN NEW MEXICO

New Mexico Department of Health
Epidemiology and Response Division

HPS Cases in New Mexico by County, 1975 – 2011



Number of Cases

- >10
- 6-10
- 1-5
- 0

12/31/2011

N = 90

Mobil

Notes From the Road

Off-Road Driving and Safety Tips

By: Mac Demere/autoMedia.com

Speed is Not Your Friend -

Going off roading? Here are your choices: Carry your stuff on your back; walk beside a mule with your stuff on its back; ride in comfort with your stuff in the back of a four-wheel-drive.

The speed will be about the same. If you drive much faster than a walking pace there's a chance you'll be forced into the first option.

As a teenager, I wanted to cross a muddy section of field in a two-wheel-drive pickup on near-bald tires. I assessed that my only hope was speed. (If you ever say, "My only hope is ... " know that the rest of the sentence is "a miracle.") When the old Ford hit the swampy strip, it sunk floorboard-deep into the mud and came to a near-instant stop. The rear tires must have come off the ground because I feared it was about to flip forward.

Here are the lessons I should have learned, but didn't because I was a teenager:

Speed is not your friend.
The off-road driver's mantra is "As Slow As Possible, As Fast As Necessary." (The original author of this quote is uncertain, but I first heard it at a Land Rover driving school.) Sometimes a little speed may be required to climb a hill or conquer a hazard. However, if you think the obstacle requires even 10 mph, you're probably not going to make it. And you're going to damage something or get stuck.

Sometimes you can't get there from here.
This is true even with a well-equipped vehicle and a skilled driver—and was certainly true of an unskilled teenager in a poorly equipped vehicle. It's far easier to discover an alternate route than to find someone willing and able to come to your rescue. Walking the rest of the way is better than walking home.

Stay on the trail.
Trying to blaze my own trail not only got me stuck, but it left ruts that remained for years. Drive on previously used paths: You'll know it's possible to make it through there and you'll do less damage to the environment. A warning: Just because somebody else made it doesn't guarantee you will. Maybe they had a better vehicle, were a more skilled driver or went through before it rained.

Walk it first.
If you can't negotiate mud, sand or other obstacles on foot, it's highly unlikely your vehicle can make it. It's critical to check out a water-covered route: Unless you've seen another vehicle go through it, you can't be certain it doesn't hide a huge hole.

Be willing to walk back.
Never tackle a questionable obstacle unless you're able to walk back to where help awaits. If you're going off road, your cell phone will be useless. Even if there is coverage, there's nobody to call unless you've made a prior arrangement. The road-service tow-truck driver won't leave the pavement, the farmer with the tractor might not be home, and the guy in the SUV you wave down on the highway may not be able or willing to help. Not all SUVs have four-wheel-drive and a tow

strap.

Re-tire to succeed.
Even the most technologically advanced four-wheel-drive system can't make up for tires that are not meant for the job or lack adequate tread depth. Some original equipment tires on SUVs and pickups can't conquer anything more rigorous than wet grass. Also, even the best mud tires become useless off road well before they run out of tread.

Help yourself.
If you're planning to regularly travel the road less paved, bring along some things that'll help you out of small jams: a hand winch (a.k.a. "come-along"), tow strap, high-lift jack, shovel, some wood blocks, and a first-aid kit. If you're going further than you can walk out, bring enough stuff (extra clothes, water, sleeping bag) to survive until somebody finds you.

Tell somebody.
Tell somebody where you're going and when you expect to be back. At least they'll know when and where to start searching.

I got out of that ancient incident unscathed, largely because within a short hike there was a tractor with the keys in it and a long chain. Bringing along some luck never hurts.

About the Author
Mac Demere is a writer, vehicle tester and race driver who competed in the NASCAR Southwest Tour and Rolex 24 Hours at Daytona.

Project# 002693.2165.01RA
TDD# TO2 09-11-10-0005

Source: ESRI Streetmaps

Ecology & Environment, Inc. GIS Department   Project: C:\START_projects\Tronox\Fig01-site_vicinity_map_sec33.mxd Date: 4/16/2012)

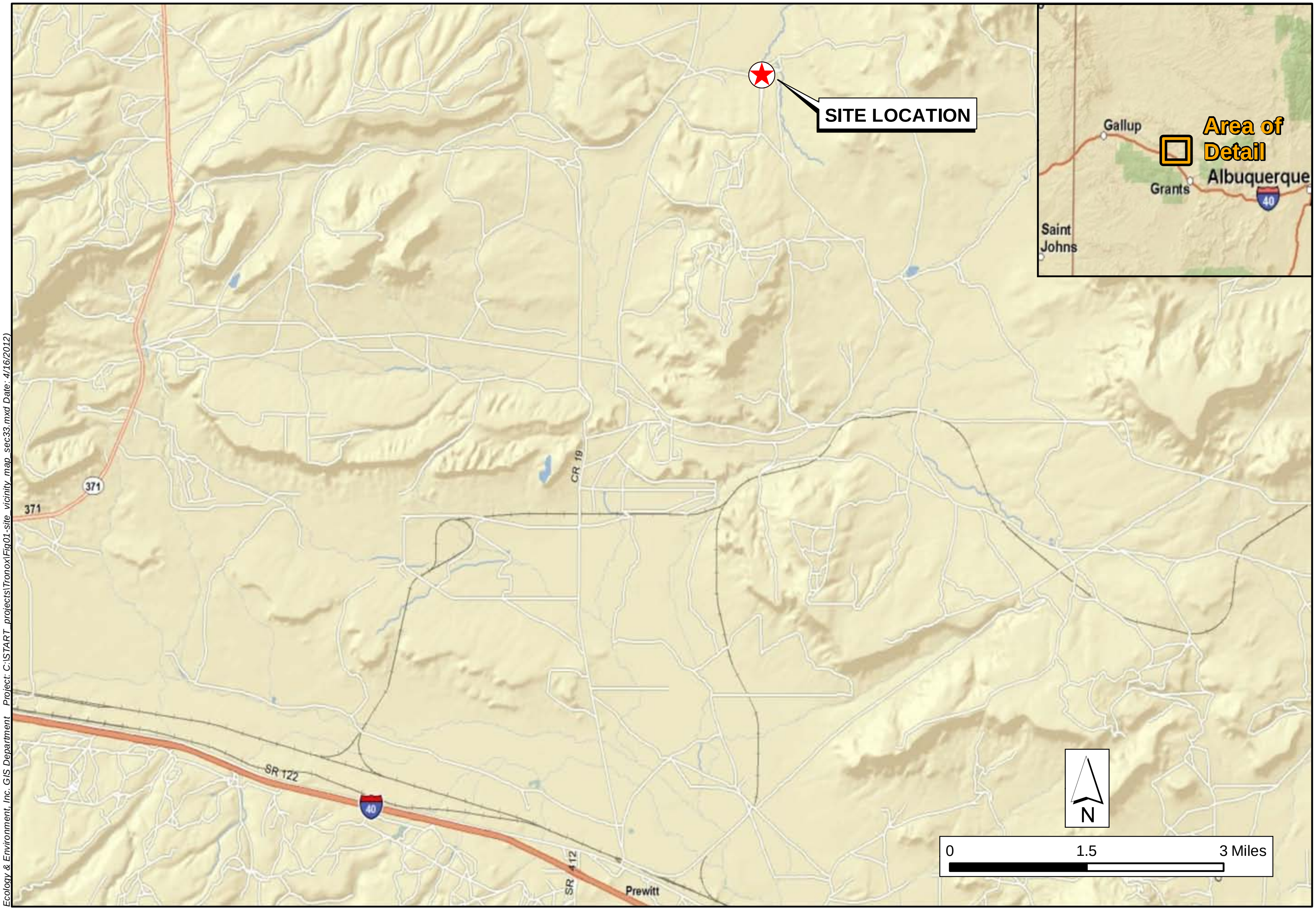


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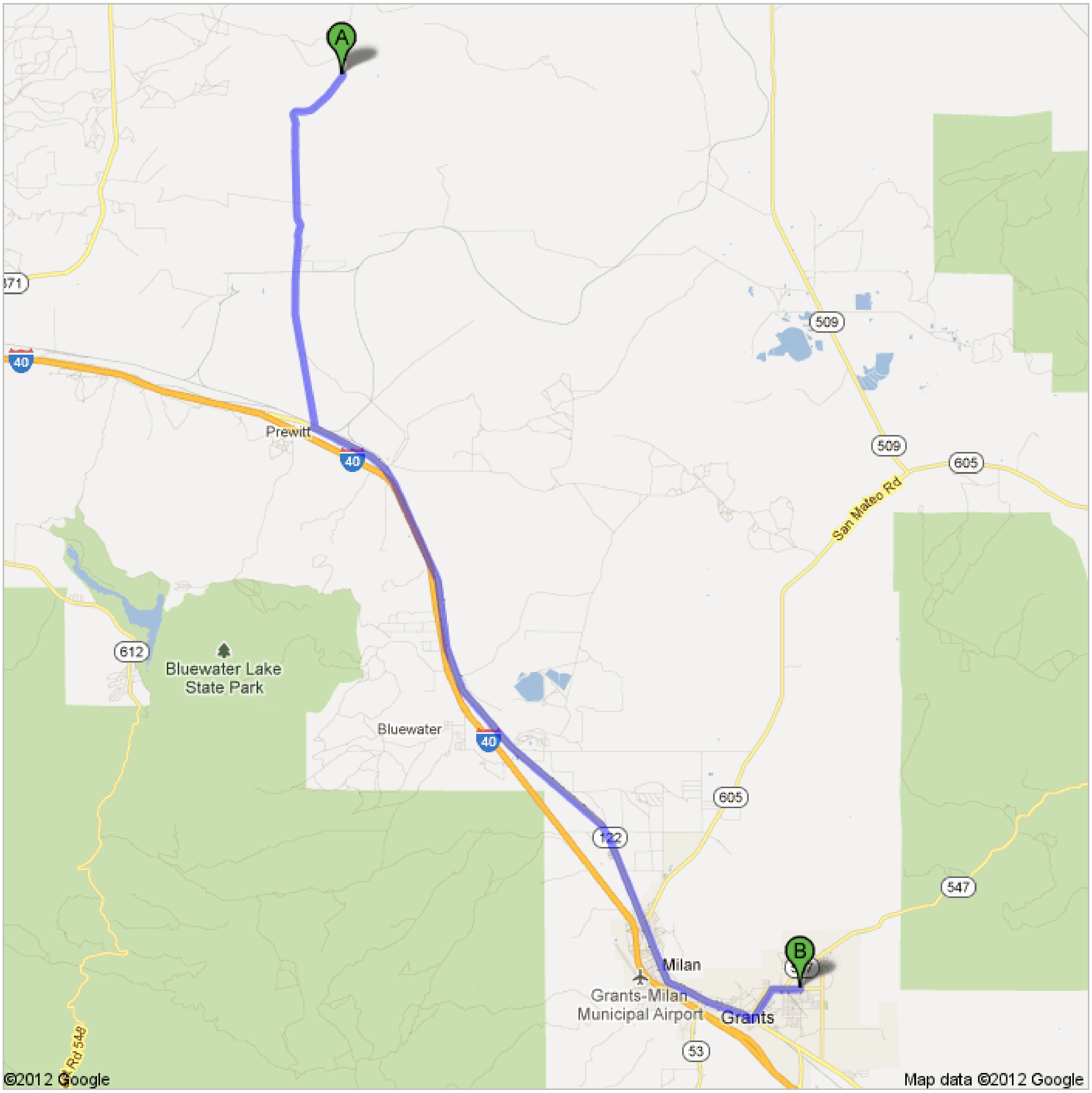
Figure 1
Site Vicinity Map
Tronox AUM Section 33
Casamero Lake Chapter, Navajo Nation, Prewitt, New Mexico

Directions to Cibola General Hospital
1016 E Roosevelt Ave, Grants, NM 87020 - (505) 287-4446
30.8 mi – about **49 mins**



Co Rd 19

1.	Head **southwest** on **Co Rd 19** About 24 mins	go 9.7 mi total 9.7 mi
2.	Turn left onto **NM-122 E/Frontage Rd** Continue to follow NM-122 E About 20 mins	go 18.1 mi total 27.8 mi
3.	Continue onto **W Santa Fe Ave** About 2 mins	go 1.4 mi total 29.2 mi
4.	Turn left onto **1st St** About 2 mins	go 0.9 mi total 30.0 mi
5.	Slight right onto **W Roosevelt Ave** Destination will be on the left About 2 mins	go 0.7 mi total 30.8 mi

Cibola General Hospital

1016 E Roosevelt Ave, Grants, NM 87020 - (505) 287-4446

C Visual Sampling Plan Output

VSP Sample Design Report for Calculating a Two-Sided Confidence Interval for the Population Mean Using Simple Random Sampling

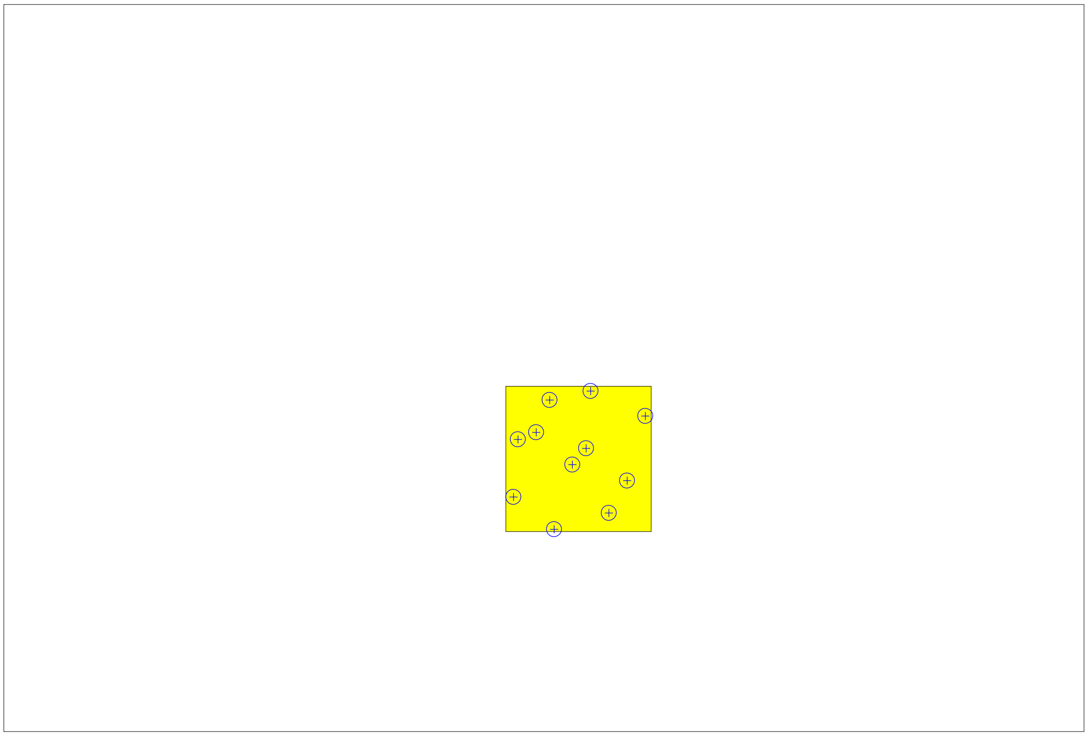
Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Construct a Confidence Interval on the True Mean
Type of Sampling Design	Parametric
Sample Placement (Location) in the Field	Simple random sampling
Formula for calculating number of sampling locations	Confidence Limits using Student's t-distribution
Calculated total number of samples	11
Number of samples on map [a]	11
Number of selected sample areas [b]	1
Specified sampling area [c]	400.00 ft^2
Total cost of sampling [d]	$20,200.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: Area 1					
X Coord	Y Coord	Label	Value	Type	Historical
1.6685	12.6771			Random	
11.6685	19.3437			Random	
6.6685	0.3314			Random	
16.6685	6.9981			Random	
4.1685	13.6647			Random	
14.1685	2.5536			Random	
9.1685	9.2203			Random	
19.1685	15.8870			Random	
1.0435	4.7758			Random	
11.0435	11.4425			Random	
6.0435	18.1092			Random	

Primary Sampling Objective
The primary purpose of sampling at this site is to construct a confidence interval on the true population mean value. After the samples are collected and analyzed, the resulting sample values can be used to construct a two-sided confidence interval. Once the confidence interval is computed (which will be an upper and a lower threshold), you can have the specified confidence that the true population mean is between the upper and lower thresholds.

Selected Sampling Approach
A parametric random sampling approach was used to determine the number of samples and to specify sampling locations. A parametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that parametric assumptions are true. These assumptions will be examined in post-sampling data analysis.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a confidence interval calculation using the Student's t-distribution. The formula used to calculate the number of samples is:

$$n = \left[\frac{t_{1-\alpha/2,df}\, S_{total}}{d} \right]^2$$

where
n is the recommended minimum sample size for the study area,
S_{total} is the estimated standard deviation due to both sampling and analytical variability,
α is the maximum acceptable probability that the true mean will not lie in the confidence interval (the confidence level is 1-α),
d is the half-width of the confidence interval,
$t_{1-\alpha/2,df}$ is the value of the Student's t-distribution with *df=n-1* degrees of freedom such that the proportion of the distribution less than $t_{1-\alpha/2}$ is 1-α/2.

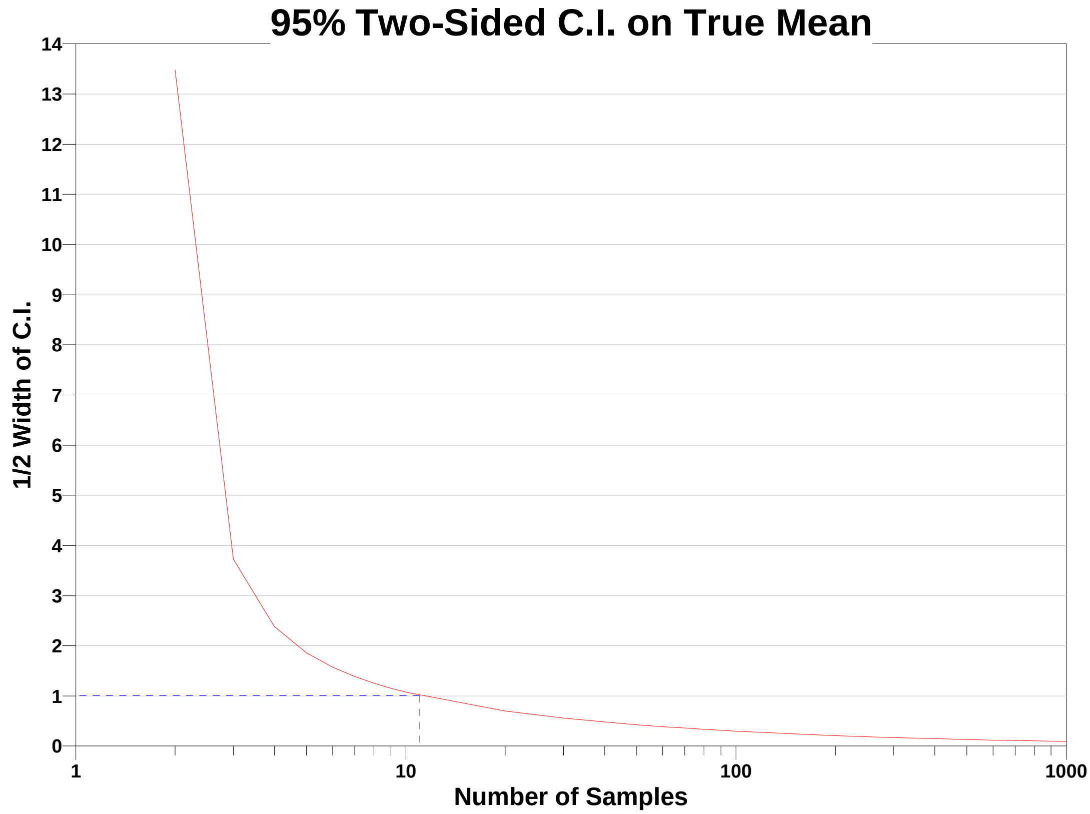
Because *n* appears on both sides of the equation (on the right side it appears in the degrees of freedom of the t-statistic), the equation must be solved iteratively. VSP does this automatically using the iteration scheme in Gilbert (1987, pg. 32).

The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n	Parameter			
		S	d	α	$t_{1-\alpha/2,df}$
Ra-226	11	1.5 pCi/g	1 pCi/g	5%	2.22814 [a]

[a] This value is automatically calculated by VSP based upon the user defined value of α

The following figure is a graph representing the relationship between the half-width of the confidence interval and the number of samples. The blue dashed line illustrates the specified maximum desirable confidence interval half-width. Where this dashed line intersects the red curve is the number of samples calculated by VSP.



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:
1. the sample mean is normally distributed,
2. the population values are not spatially or temporally correlated, and
3. the sampling locations will be selected randomly.

The first two assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, confidence level (1-α) (%) and width of confidence interval. The following table shows the results of this analysis.

Number of Samples						
	d=0.5		d=1		d=1.5	
	s=3	s=1.5	s=3	s=1.5	s=3	s=1.5
CL=99	243	64	64	19	31	11
CL=97	173	46	46	14	22	9
CL=95	141	38	38	11	18	7
CL=93	121	32	32	10	16	7
CL=91	106	28	28	9	14	5

s = Standard Deviation
CL = Confidence Level (1-α) (%)
d = Width of Confidence Interval

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above,

the estimated total cost of sampling and analysis at this site is $20,200.00, which averages out to a per sample cost of $1,836.36. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**11 Samples**
Field collection costs		$100.00	$1,100.00
Analytical costs	$100.00	$100.00	$1,100.00
Sum of Field & Analytical costs		**$200.00**	**$2,200.00**
Fixed planning and validation costs			$18,000.00
Total cost			**$20,200.00**

Recommended Data Analysis Activities
Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2000). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

Because the primary objective for sampling for this site is to compute a confidence interval, the data should be assessed in this context. Assuming the data are adequate, at least one statistical test should be done to evaluate whether the data are normally distributed. Appropriate confidence intervals for the mean value should then be calculated. Results of the exploratory and quantitative assessments of the data should be reported, along with conclusions that may be supported by them.

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Oakland, California 94612
Tel: (510) 893-6700

July 12, 2012

MEMORANDUM

SUBJECT: Addendum to the Sampling and Analysis Plan
for Tronox AUM Section 32, Eastern Agency, Removal Assessment
Prewitt, McKinley County, New Mexico
Dated June 2012

FROM: Aileen Mendoza, START Project Manager
Ecology and Environment, Inc.

TO: Randy Nattis, Federal On-Scene Coordinator
United States Environmental Protection Agency Region 9
Emergency Response Section

Ecology and Environment, Inc. (E & E)'s Superfund Technical Assessment and Response Team (START) was directed by the United States Environmental Protection Agency (U.S. EPA) to conduct additional radiation survey and collect soil samples from an additional area associated with Abandoned Uranium Mine (AUM) Section 32 identified during the Tronox AUM Section 32 removal assessment conducted in June 2012 (TDD No. TO-02-09-11-10-0004; START Project No. EE-002693-2164-01TTO). To meet this directive, E & E START is requesting an addendum to the Sampling and Analysis Plan (SAP) for the Tronox AUM Section 32, Eastern Agency, Removal Assessment dated June 2012.

The SAP was implemented in June 2012 which included removal assessment of the AUM Section 32 mine area. During the field activities, U.S. EPA interviewed a local resident who showed the location of a former transfer area approximately 0.3 mile southwest of the AUM Section 32 mine area (Figure 2-1). A concrete pad where a crane was reportedly mounted was observed in the potential former transfer area. A preliminary radiation survey conducted in the new area measured gamma radiation activity above 1 million counts per minute (cpm). Based on the radiation activity in the potential former transfer area, Federal On-Scene Coordinator (FOSC) Nattis determined additional assessment is necessary.

The additional assessment will consist of additional radiation survey for surface gamma activity and soil sampling in the new area identified in the June 2012 assessment as a former transfer area.
The additional assessment will be similar to the June 2012 assessment except for the following which are further described in the requested addendum.

1. New area (Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W)
2. Subsurface soil samples will be collected using a Geoprobe® sampling system
3. No background and home site assessments
Field activities will begin on July 16, 2012 and continue for up to 5 days.

The requested addendums are as follows:

Addendum
Section 1.3 Statement of the Specific Problem
An additional area of concern (AOC)associated with AUM Section 32 was identified during the June 2012 assessment with gamma radiation activity in surface soil detected at levels greater than 1 million cpm which is over 40 times the highest measured background level of 24,087 cpm. Gamma radiation activity in surface soil at the AOC may pose an imminent and substantial threat to human health. The lateral and vertical extent of gamma radiation in soil needs to be defined to support the EPA FOSC in determining whether a removal action is necessary to protect human health.

Addendum
Section 2.1 Site Location and Description
The AOC is located approximately 0.3 mile southwest of the AUM Section 32 mine area (Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W) and is within the Casamero Lake Chapter of the Navajo Nation (Figure 2-1). The AOC is in a vacant land surrounded by open space. Some portions of the AOC are slightly hilly with scrub vegetation but generally similar to the AUM Section 32 mine area.

Addendum
Section 2.2 Site History
According to a local resident, the AOC was a former transfer area. A concrete pad where a crane was reportedly mounted may indicate former mining-related activities at the AOC. Initial radiation survey conducted in June 2012 showed elevated surface gamma radiation activity in approximately 10 acres. Gamma radiation measured at the AOC during the initial survey ranged from 28,980 cpm to greater than 1 million cpm. Gamma radiation activity was measured from surface soil in transects spaced 5 feet apart using a paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241 meter. The highest gamma radiation activity measured at the background area was 24,087 cpm.

Addendum
Figure 2-1 Site Location Map (Attachment A)

Addendum
Section 3.1 Data Use Objectives
Data generated from this investigation will be used to:

- Document gamma radiation activity in soil at the AOC,
- Document concentration of radium-226 (Ra-226) in soil at the AOC,
- Assist EPA with decision on further action at the AOC.

Addendum
Section 3.2 Project Task/Sampling Objectives
Data collection will be conducted according to the June 2012 SAP, this addendum, and the following objectives.

1. Determine whether, and in what areas, site concentrations of Ra-226 in surface soil require removal, further assessment, or no further action.
    - Determine whether gamma radiation activity readings can be used to characterize the site or if further sampling to characterize the site is necessary.
    - Determine a suitable background location for collecting data to calculate a site-specific action level or identify an alternate means of setting an action level.
2. Determine whether site concentrations of Ra-226 in subsurface soil at locations where the surface levels of Ra-226 are elevated require removal, further assessment, or no further action.

Addendum
Section 3.4 Data Quality Objectives
The updated Data Quality Objectives (DQOs) for this project are attached as Attachment B to this SAP Addendum. Any additional objectives and DQO outputs generated by the DQO process and not included in the SAP or this SAP addendum will be archived with the field log book and other project documents.

Addendum
Section 3.6 Schedule of Sampling Activities
Additional field activities will occur on July 16, 2012 and continue for up to 5 days.

Addendum
Section 4.2.1 Gamma Radiation Activity Investigation Level
Gamma radiation activity in surface soil will be measured using the same paired Ludlum Model 44-20 (3x3) detector and 2241 meter from the June 2012 assessment mounted 6 inches from the ground surface on a vehicle moving at a pace of 3 feet per second.

Addendum
Section 4.3 Site Soil
Gamma radiation activity in surface soil will be measured using the same paired Ludlum Model 44-20 (3x3) detector and 2241 meter from the June 2012 assessment mounted 6 inches from the ground surface on a vehicle moving at a pace of 3 feet per second. Radiation survey will be conducted at lateral step-outs from the perimeter of the areas with radiation levels above the investigation level. Lateral step-outs will consist of additional 3- to 5-foot wide transects until readings are below the investigation level; physical barriers are encountered; or terminated based on professional judgment.

The new AOC is observed to be similar to the previous areas assessed in June. No additional correlation sampling will be conducted at the new AOC. However, surface sample data from the new AOC may be included in the data set for establishing the relationship between Ra-226 concentration and gamma radiation activity in surface soil.

A maximum of 10 surface confirmation samples will be collected.

Subsurface samples will be collected using a direct push drilling equipment or Geoprobe®. A continuous core will be extracted down to 3 feet below surface locations with elevated gamma radiation activity. Soil boring logs will be documented. A soil sample will be collected from each 1-foot depth interval of the soil core.

Addendum
Table 5-1 Sampling and Analysis Summary

Table 5-1 Sampling and Analysis Summary
Tronox AUM Section 32 Eastern Agency
Additional Removal Assessment
Prewitt, McKinley County, New Mexico

E & E Project No. EE-002693-2164-01TTO — TDD No. TO-02-09-11-10-0004

Method	Ra-226 by EML HASL 300, 4.5.2.3 Method
Sample Container	4 ounce plastic soil jars
Preservation	None
Analysis Holding Time	6 Months
Estimated Number of Unique Discrete Samples	10 surface soil confirmation samples 45 subsurface soil samples
Estimated Number of Duplicate Samples	6
Minimum Total Site Sample Analyses	61
Equipment Rinse Blanks (if non-dedicated equipment is used)	
Sample Container	500 milliliter plastic bottle
Preservation	None
Analysis Holding Time	14 days
Number of Samples	1 per day (5)

Note:

AUM – abandoned uranium mine

EML – Environmental Measurements Laboratory

HASL – Health and Safety Laboratory

Ra-226 – Radium isotope number 226

Addendum
Section 6.1.1 Standard Operating Procedures and Equipment

The sampling sleeve used in the Geoprobe® sampling system will also come in contact with samples.

Addendum
Section 6.3 Gamma Radiation Survey Procedures

Gamma radiation activity in surface soil will be measured using the same paired Ludlum Model 44-20 (3x3) detector and 2241 meter from the June 2012 assessment mounted 6 inches from the ground surface on a vehicle moving at a pace of 3 feet per second. START will operate VIPER during the field activities.

Addendum
Section 6.4.2 Subsurface Soil

Subsurface samples will be collected using a direct push drilling equipment or Geoprobe®. Prior to drilling, location of underground utilities will be marked by the Navajo Tribal Utility Authority and a

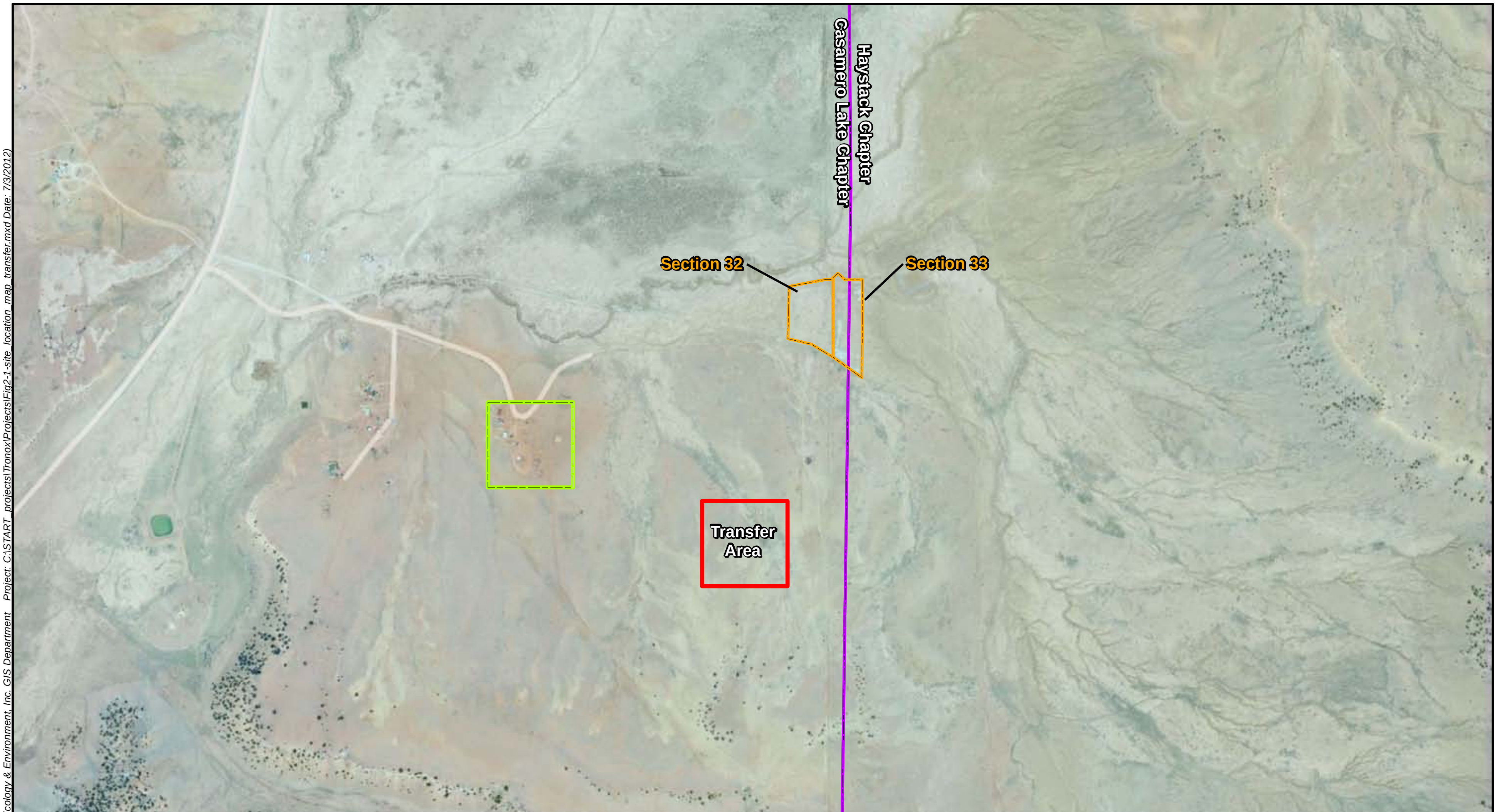
START-contracted utility locator. A continuous core will be extracted down to 3 feet below surface locations with elevated gamma radiation activity. Soil boring logs will be documented. A soil sample will be collected from each 1-foot depth interval of the soil core using a clean trowel and placed into a 4-ounce plastic jar.

Addendum
Section 8.1 Sample Nomenclature
Samples will be identified according to the nomenclature in the June 2012 SAP. The sample number will start at 26 i.e., AUM32-26-.

Addendum
Section 8.3 Sample Labeling, Packaging, and Shipping
Coolers containing the samples will be scanned to ensure radiation levels are below 0.5 microRoentgen per hour prior to shipping. Sample coolers with radiation levels above this threshold will not be shipped to the laboratory and will be discussed with E&E's Health and Safety Director, Dr. Paul Jonmaire, at 716-684-8060 (office) and the QA coordinator.

Project # 002693.2164.01RA
TDD# TO2-09-11-10-0004

Source: Aerial Photography - Bing Maps



LEGEND

- Homesite boundary
- Mine boundary
- Chapter boundary

N

0 1,000 2,000 Feet

Figure 2-1

Site Location Map
Tronox AUM Section 32 and 33 Transfer Area

Casamero Lake Chapter, Navajo Nation, Prewitt, New Mexico

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Ecology & Environment, Inc. GIS Department Project: C:\START projects\Tronox\Projects\Fig2-1-site location map transfer.mxd Date: 7/3/2012)

The DQO developed in June 2012 for the project was updated in July 2012 to include an additional area for assessment. Revisions are printed in bold, italic and underline.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, REGION 9
DATA QUALITY OBJECTIVES FOR
TRONOX ABANDONED URANIUM MINE SECTION 32, EASTERN AGENCY REMOVAL ASSESSMENT

STEP 1.

THE PROBLEM

Background

The United States Environmental Protection Agency (EPA) tasked Ecology and Environment, Inc.'s (E & E's) Superfund Technical Assessment and Response Team (START) to support a removal assessment of Tronox Abandoned Uranium Mine (AUM) Section 32 (site) located approximately 1 mile east of County Road 19, Prewitt, McKinley County, New Mexico (Latitude: 35° 29' 26.7576" N, Longitude: -108° 1' 2.7798" W). The site was a mine reportedly owned by Cobb Nuclear and was closed due to a fatality (Weston Solutions, Inc., *Navajo Nation Abandoned Uranium Mine Site Screen Report, Section 32 AUM Site, Navajo AUM Eastern Region,* May 2009). No other information on historical ownership of the mine and mining operations were available. The ***mine area*** is an allotment land with an estimated area of 12,103 square meters containing an unsecured shaft and an undetermined extent of underground workings. No waste piles, other mine features, or visible signs of reclamation were reported.

A site screening, which included collection of gamma radiation survey data, was conducted in 2009 (Weston 2009). Gamma radiation activity was measured from surface soil along the boundary of the ***mine area*** and along two diagonal intersecting transects from the ***mine area***'s four corners. Gamma radiation activity measurements ranged from 10,689 counts per minute (cpm) to 180,367 cpm. Gamma radiation activity was also measured from a background location which was not identified in the report. The gamma radiation activity at the background location ranged from 16,630 cpm to 17,128 cpm.

An additional area associated with AUM Section 32 was identified during the June 2012 assessment. The area of concern (AOC) is located approximately 0.3 mile southwest of the AUM Section 32 mine area (Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W). According to a local resident, the AOC was a former transfer area. A concrete pad where a crane was reportedly mounted near the center of the AOC and rock bolts indicating former mining-related activities were observed in the former transfer area. Initial radiation survey conducted during the June 2012 assessment showed elevated surface gamma radiation activity in approximately 10 acres. Gamma radiation measured ranged from 28,980 cpm to greater than 1 million cpm. The highest gamma radiation activity measured at the background area was 24,087 cpm.

The site was identified as an AUM and gamma radiation activity in surface soil ***at the mine area*** was detected at levels up to 10 times the reported background level. ***Gamma radiation activity in surface soil at the former transfer area was detected at levels over 40 times the highest measured background level.*** Gamma radiation activity in surface soil at the site may pose an imminent and substantial threat to human health. The lateral and vertical extent of gamma radiation in soil needs to be defined to support the EPA Task Monitor in determining whether a removal action is necessary to protect human health.

In addition, a resident lives approximately 0.5 mile west of the site and reportedly used some materials (tarps and lumber) obtained from the mine. Gamma radiation measured from the residence during the site screening was approximately 12,000 cpm (Weston 2009). A home site assessment ***was conducted by START at the above residence during the June 2012 assessment***.

Planning Team

Primary Decision Maker:	EPA Task Monitor/Federal On-Scene Coordinator Randy Nattis
Plan Development:	START and the EPA Task Monitor
Plan Approval:	EPA Task Monitor
On-Scene Assistance:	EPA Task Monitor, START, EPA Emergency Response Team (ERT)'s Scientific, Engineering, Response, and Analytical Services (SERAS) contractor
Potential On-Scene Assistance:	Navajo Nation representative
Supplemental Off-Site Support:	The START response team managers, START quality assurance (QA) manager, START response Readiness Coordinator, START analytical service provider, START Radiological Assessment Adjunct, EPA ERT, EPA Emergency and Rapid Response Services (ERRS) contractor, and EPA Region 9 equipment warehouse

The names and affiliations of the actual planning team will be documented in the field logbook or in the sampling and analysis plan (SAP).

Conceptual Site Model

Based on previously documented elevated gamma radiation levels in surface soils, historical mining at the site may have released technologically-enhanced, naturally-occurring radioactive materials (TENORM), specifically uranium and its decay products. Based on EPA investigations at ***AUM Section 32 and*** other AUM sites, the vertical extent of TENORM and elevated gamma radiation is expected to extend less than 3 feet below ground surface (bgs). The EPA Task Monitor determined that radium-226 (Ra-226) is the contaminant of potential concern in soil at the site.

Soil is the primary media of concern in this removal assessment. Surface water was not observed at or within the influence of the site; however, available geographical information show a stream or river located north and south of the site which converges approximately 0.25 mile west of the site, and two ponds are located northeast of the site. Groundwater depth and information on nearby water wells used for drinking water were not available. Agricultural food production such as livestock grazing or farming common in Navajo communities was not observed at or immediately adjacent to the site. The site is currently an open space with sparse vegetation.

Materials from the mine potentially used as building materials for residential structures may expose residents to radiation.

Exposure Scenario

Current exposure pathways considered in this assessment include direct exposure of human receptors to gamma radiation at the site. Receptors may also be exposed through ingestion, dermal contact, and inhalation of uranium and its decay products; and metals in soil, air, and water.

The open shaft, which is approximately 20 feet in diameter, poses a physical hazard at the site. Current potential human receptors include nearby residents located less than 0.5 mile from the site.

Resources

The planning and preparation are administered and implemented by the EPA Region 9 staff and their supporting START contractors. All site-specific planning activities are under the direction of the EPA Task Monitor.

This is a removal assessment under the technical direction of the EPA Task Monitor. Initial labor resources include:

- The responding EPA Task Monitor, who will oversee all data collection and operations related to the time-critical response.
- START personnel
- EPA ERT and its SERAS contractors

Analytical service resources include the following:

- Real-time field radiation monitoring will be performed by START and SERAS personnel.
- START analytical service provider will analyze collected samples.

START's initial budget for this time-critical response is ***$180,376.10***.

Resource Constraints

The use of non-routine radiation screening instruments and equipment will require training or experienced personnel.

Availability of EPA-owned radiation screening equipment is dependent on other ongoing EPA projects requiring similar resources.

STEP 2.

THE DECISION

Principal Study Questions

1. Is Ra-226 present in surface soil at concentrations that exceed the action level and what is the lateral extent of contamination?
   a. Can the concentration of Ra-226 in surface soil be estimated from measurements of gamma radiation activity in surface soil through real-time surface scans (as it has at other AUM sites)?
   b. Can a suitable background location be identified so that a site-specific action level based on background levels can be calculated?
2. Does contamination extend to subsurface soil at locations where surface Ra-226 levels exceed the action level?
3. Do radiation levels at the home site exceed the home site investigation levels?
   a. Is the gamma exposure rate level inside the residential structure above the exposure investigation level?
   b. Is the gamma radiation activity measured in floor surface and surface soil at the home site above the home site investigation level?

Actions that Could Result from the Resolution of Study Questions

Question 1

If the concentration of Ra-226 in surface soil at the site is above the action level then the EPA may initiate or order the removal of contaminated areas.

If the concentration of Ra-226 in surface soil is at or below the action level then no further action may be required.

- If a correlation between Ra-226 concentrations in soil and gamma radiation activity measured through real-time surface scans can be verified then activity measurements will be used to characterize the site.
- If a correlation between Ra-226 concentrations in soil and gamma radiation activity measured through surface scans cannot be verified then further soil sampling may be required to characterize the site.
- If a suitable background area can be identified then measurements from the identified area will be used to calculate a site-specific action level.
- If a suitable background area cannot be identified then another method of establishing an action level will be determined.

Question 2

If the concentration of Ra-226 in the subsurface soil exceeds the action level at locations where the surface concentration also exceeds the action level, then the EPA may initiate or order the removal of contaminated areas.

If the concentration of Ra-226 in the subsurface soil exceeds the action level at locations where the surface concentration also exceeds the action level, then the EPA may require further investigation.

If the concentration of Ra-226 in subsurface soil is at or below the action level then no further action may be required.

Question 3

If the radiation levels at the home site exceed the home site investigation level then the EPA may initiate or order a removal action.

- If the radiation exposure rate level inside a residential structure is above the home site investigation level then the contaminated structure(s) may be removed.
- If the gamma radiation activity measured in floor surfaces and/or surface soil at the home site is above the home site investigation level then contaminated materials may be removed.

If the radiation levels in the home site are at or below the investigation level for the home site then no further action may be required.

Decision Statements (Directives)

Directive 1

Determine whether, and in what areas, site concentrations of Ra-226 in surface soil require removal, further assessment, or no further action.

- Determine whether gamma radiation activity readings can be used to characterize the site or if further sampling to characterize the site is necessary.
- Determine a suitable background location for collecting data to calculate a site-specific action level or identify an alternate means of setting an action level.

Directive 2

Determine whether site concentrations of Ra-226 in subsurface soil at locations where the surface levels of Ra-226 are elevated require removal, further assessment, or no further action.

Directive 3

Determine whether gamma exposure levels inside residential structure require removal of the structure or no further action.

Determine whether gamma radiation activity in floor surfaces and/or surface soil around the home site require removal or no further action.

STEP 3.

DECISION INPUTS

Specific Data Required

- Field data to establish a background level of gamma radiation from an area with similar geology and topography and no known or suspected impacts from mining.
- Field data from measuring gamma radiation activity in surface soil at the site.
- Definitive analytical data for concentrations of Ra-226 in soil.
- Risk-based investigation and action levels for the site.
- Global Positioning System (GPS) data for all gamma radiation activity measurement locations and soil sampling locations.
- Field data from measuring radiation exposure rate level in residential structures at the home site.
- Field data from measuring gamma radiation activity in floor surface and surface soil at the home site.

Sources for Study Information

- *Navajo Abandoned Uranium Mine Site Screen Report, Section 32 AUM Site, Navajo AUM Eastern Region* (Weston 2009).
- Site information collected during the removal assessment including geographical information data and photographs.
- Field data generated during the removal assessment including real-time radiation survey***, soil boring logs,*** and soil sampling.
- Definitive analytical data generated during the removal assessment.
- EPA Radiation PRG

Information Needed to Establish Investigation and Action Levels

Dose limits and investigation levels will be established by EPA and other federal agencies. EPA Radiation PRG is available for various radioisotopes in soil, air, tap water, and fish. The following references are useful in establishing investigation and action levels for a time-critical radiation situation.

- OSC Radiological Response Guidelines, EPA OSWER and OAR, October 2006.
- Manual of Protective Action Guides (PAGs) and Protective Actions for Nuclear Incidents, EPA 400-R-92-001, May 1992.
- EPA Region 9, 2006 Emergency Response Readiness Training Guide.
- Preliminary Remediation Goals for Radionuclides, http://epa-prgs.ornl.gov/radionuclides/.

- Technology Screening Guide for Radioactively Contaminated Sites, EPA 402-R-96-017, November 1996.
- Soil Screening Guidance for Radionuclides
  - Soil Screening Guidance for Radionuclides: Technical Background Document, EPA/540-R-00-007, October 2000.
  - Soil Screening Guidance for Radionuclides: User's Guide, EPA/540/R95/128, October 2000.
- Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), EPA 402-R-97-016, August 2000.
- Decommissioning Handbook, DOE/EM-0383, January 2000.
- RESRAD Family of Codes, Argonne National Laboratory, DOE, http://web.ead.anl.gov/resrad/home2/
- EPA OSWER Guidance
  - Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination, EPA OSWER Directive 9200.4-18, August 22, 1997.
  - Use of Soil Cleanup Criteria in 40 CFR Part 192 as Remediation Goals for CERCLA Sites, EPA OSWER Directive 9200.4-25, February 12, 1998.
  - Remediation Goals for Radioactively Contaminated CERCLA Sites Using the Benchmark Dose Cleanup Criteria in 10 CFR Part 40 Appendix A, I, Criterion 6(6), EPA OSWER Directive 9200.4-35P, April 11, 2000.
  - Use of Uranium Drinking Water Standards under 40 CFR 141 and 40 CFR 192 as Remediation Goals for Groundwater at CERCLA Sites, EPA OSWER Directive 9283.1-14, November 6, 2001.
  - Interim Final Evaluation of Facilities Currently or Previously Licensed NRC Sites under CERCLA, OSWER Directive 9272.0-15P, February 17, 2000.

Confirm that Measurement Methods Exist to Provide Data

Field instrumentation and measurement methods for radiation monitoring are numerous and have varying detection limits. The same paired Ludlum 44-20 detector and 2221 or 2241 meter will be used in all radiation surveys at the site as practicable. The Ludlum Model 44-20 utilizes a Teledyne Integral Detector assembly containing a 3-inch diameter by 3-inch thick sodium iodide (NaI[T1]) crystal optically coupled to a photomultiplier tube. The detector is compatible with general purpose survey meters, rate meters, and scalers for high-energy gamma detection (approximately 60 kiloelectronvolts [eV] to 2 MeV range) such as the Ludlum Model 2221. The detector provides high sensitivity for surveying typically 2,300 cpm per microRoentgen per hour (based on Cesium-137 gamma) and pulse height discrimination. Quantity measurements are in cpm, which under certain circumstances can be converted to disintegrations per minute (dpm) or curies (Ci).

Laboratory analytical methods that more accurately determine radionuclide concentrations in units of picocuries per gram (pCi/g) in various media are published by EPA and U.S. Department of Energy (DOE). Ra-226 will be analyzed using the EML HASL 300 4.5.2.3 Method (DOE, *EML Procedures*

Manual, HASL-300, 27th Edition, Volume 1, Environmental Measurements Laboratory, 376 Hudson Street, New York, NY 10014-3621, 1990). This method is applicable to nuclides emitting gamma rays with energies greater than 20keV for germanium detectors Ge(Li)) and 50 keV for NaI(T1) detectors and has a minimum detectable activity of 0.5 pCi/g for Ra-226. This method is a modification of EPA method 901.1 and is the preferred technique for measuring Ra-226 and 228 simultaneously in solid material.

Pressurized ionization chambers (PIC) is the industry standard for measuring low-level exposure rate because of its relatively flat energy response across a wide gamma energy range. Detector response is not expected to be affected by power supply voltage bias at the exposure rate range of interest. PIC response is a linear function of the exposure rate within a range of background to 9,000 milliRoentgen per hour (mR/hr). PIC response as a function of exposure rate has less than 25 percent variation for greater than 75 keV or high energy gamma radiation.

Field instrumentation, field procedures, and laboratory analytical methods used for this project are specified in the SAP.

STEP 4.

STUDY BOUNDARIES

Specify Characteristics that Define the Population Being Studied

- Gamma radiation activity at 6 inches above the ground surface of the background area, site, and home site.
- Ra-226 concentration in surface soil (0 to 2 inches bgs) at the background area and the site.
- Ra-226 concentration in subsurface soil down to 3 feet bgs at locations at the site where gamma radiation activity exceeds the action level.
- Radiation exposure rate level at 1 meter above the ground surface and within a 10 x 10 feet area.

Geographic Boundary of Investigation

- ***Each AOC*** is approximately ***10 acres***. The investigation includes the site area and may be extended laterally from the site perimeter based on the real-time gamma radiation activity measured at the perimeter. ***The maximum lateral extension from the site perimeter will be based on gamma radiation activity readings i.e., radiation scans will continue laterally as long as readings exceed the investigation level; physical barriers; and professional judgment.***
- The vertical investigation boundary for the site will be approximately 3 feet bgs or less based on site conditions.
- Inside each residential structure at the home site, and a minimum of a ½-acre surface soil area surrounding each residential structure or within the approximate property boundary of the home site. If the residential structure layout within a home site boundary exceeds ½ acre then professional judgment will be used to ensure surface soil is appropriately screened.

A background area will be selected using the following criteria from *Background Location Selection Criteria* (NNEPA and EPA 2010):

- Similar elevation as the site
- Similar geology as the site. Avoid areas of naturally-occurring uranium.
- Upwind (gradient, stream) from site
- Undisturbed with natural vegetation
- Not in drainage or area impacted by flooding
- Distance to residential structures (structures should be within range of vision)
- Accessible (by vehicle and equipment)
- Should not be near a mine site or similar contaminant source

- If possible, avoid anthills and rodent holes
- Ask nearby residents about area

Temporal Boundary of Investigation

- The half-life of Ra-226 is 1,600 years. Soil data is not expected to change during the removal assessment which may take up to 90 days from sample collection to final report submittal.
- The investigation was scheduled in the dry season when the site is accessible and field work is feasible.
- Due to physical processes such as erosion and migration the extent of the contamination may expand. These physical processes could also change contamination levels once the extent has been defined.
- Widespread mining and milling of uranium ore on Navajo tribal lands since the 1940s led to a legacy of AUMs. Data is not available during mine operations at the site or since the mine closed to present. Data collected from the site during this assessment may not represent the highest concentrations historically present in soil at the site due to physical processes such as erosion and migration through the years.
- Data collected during the investigation represent current site conditions and does not consider future development such as soil mixing and changes to the residential structure.
- The exposure rate level is based on a single 5-minute measurement in each residential structure.
- The action level for Ra-226 is based on PRG which considers long-term health risk.

Scale of decision-making

Decisions will apply to the entire site unless decision units are established based on data.

For the home site, each residential structure is a decision unit and surface soil surrounding the residential structures is considered one decision unit unless modified based on data.

Practical Constraints on Data Collection

Physical Constraints:

- The sampling areas are in a relatively remote location, which will require additional planning and logistical effort to get resources to the site.
- Weather conditions such as thunderstorms, extreme heat, and high winds may require halting of field work.
- Health and safety of staff including lighting conditions and fatigue will limit sampling days to daylight hours and to a maximum of 12 hours per day.
- Topographical features may limit or prevent the collection of useful data, especially for gamma radiation activity measurements. Data collection will stop at 10 feet around the open shaft at the site.
- Site features, such as the open shaft, present fall and/or confined space hazards and

assessment of these areas is beyond the scope of the current assessment.

- Residential structures in the home site may be inaccessible.
- Civil constraints, such as legal site access and unfriendly neighborhoods, and presence of livestock or wild animals will be addressed on site and by direction of the EPA Task Monitor.

Other Constraints:

- There is no universal field monitoring instrument capable of providing qualitative, quantitative, and exposure data for all types of radiation. Knowledge of the source is necessary for the selection of the appropriate field measurement instruments.

STEP 5.

DECISION RULE

Statistical Parameter

The mean and standard deviation (SD) of the gamma radiation activity measurements in the background area will be used to determine if the background area is suitable to use for developing investigation levels for surface gamma radiation activity, action level for Ra-226 soil concentrations, and exposure rate investigation level for the home site. The r^2 is the statistical parameter of interest for predicting Ra-226 concentration based on gamma radiation activity in surface soil using linear regression.

Investigation and Action Levels

Under the direction of the EPA Task Monitor, the investigation level for gamma radiation activity in surface soil at the site will be based on gamma radiation activity measured in surface soil from the established background area. The action level for Ra-226 in soil at the site will be based on the sum of the background concentration of Ra-226 in surface soil and the EPA PRG of 1.21 pCi/g for residential soil based on an estimated excess cancer risk of 1 in 10,000 (10^{-4}) for Ra-226 and its radioactive decay chain products (Ra-226+D) (EPA 2010).

For the home site, the investigation level will be an interior dose rate from gamma activity that exceeds a typical background gamma dose rate by 15 millirem per year or more. The interior dose rate and typical background dose rate will be calculated from exposure rate levels collected during the assessment in combination with a risk assessment formula. In addition, an investigation level will be used during the assessment that will trigger extent of exposure or activity surveys. The investigation level for each detector will be calculated for each home site based on the following equation:

$$IL = BG + (10\ x\ SD)$$

where:

IL = Investigation Level

BG = Average of three 1-minute static gamma radiation activity background measurements

SD = Standard deviation of the three background measurements

Decision Rules

Question 1

If the gamma radiation activity measured in surface soil is above the investigation level, then select a surface soil location to determine areas where Ra-226 concentration exceeds the action level and removal or further action may be necessary. Otherwise, collect a surface soil sample to confirm Ra-226 concentration is below the action level and no further action may be required.

If the linear regression analysis of the co-located gamma radiation activity and the Ra-226 concentration data from surface soil yields an $r^2 \approx 1$, then gamma radiation activity readings can be used to characterize the site. Otherwise, further sampling to characterize the site is necessary.

If the mean and SD of the gamma radiation activity measurements in the background area are relatively low, then the gamma radiation activity measurements in the background area will be used to develop investigation levels for surface gamma radiation at the site and home site, surface soil samples will be collected to develop the Ra-226 action level, and background exposure rate will be measured to use in developing the exposure investigation level for the home site. Otherwise, a new background area will be selected or an alternate means of setting investigation and action levels will be identified.

Question 2

If Ra-226 concentration in a surface location exceeds the action level then a subsurface soil sample will be collected to determine if Ra-226 concentration below the elevated location is above the action level. Otherwise, no further action may be required.

Question 3

If the gamma exposure level measured inside a residential structure in the home site is above the exposure investigation level then the structure may require removal. Otherwise, no further action may be required.

If the gamma radiation activity measured in floor surfaces and/or surface soil at the home site is above the home site investigation level then contaminated materials may be removed. Otherwise, no further action may be required.

STEP 6.
LIMITS ON DECISION ERRORS

Range of the Parameters of Interest

Activity Rate

The gamma radiation activity of interest range from below background to over background, but is not expected to exceed 1,000,000 cpm. However, gamma radiation activity from the investigation level to twice the investigation level is the range most susceptible to decision error.

Concentration in Samples

Concentrations of interest of Ra-226 in soil samples are from ½ the action level to any value above the action level. Quantitatively precise and accurate determinations of contaminant concentrations that are significantly above (i.e., >10 times) the action level are not necessary. However, concentration from the action level to twice the action level is the range most susceptible to decision error.

Exposure Rate

The exposure rates of interest range from below background to over background, but they are not expected to exceed 1 mR/hr.

The Null Hypothesis or Baseline Condition

The parameter of interest (gamma radiation activity, Ra-226 concentration in soil, or exposure rate) exceeds the investigation or action level.

Alternative Hypothesis

The parameter of interest (gamma radiation activity, Ra-226 concentration in soil, or exposure rate) does not exceed the investigation or action level.

DECISION ERRORS		
Decision Error	Deciding that a decision unit is contaminated and requires further action when the decision unit is not contaminated.	Deciding that a decision unit is not contaminated and requires no further action when the decision unit is contaminated.
True Nature of Decision Error	The activity measurement, sample concentration, or exposure rate is either not representative or biased high.	The activity measurement, sample concentration, or exposure rate is either not representative or biased low.
The Consequence of Error	Either further evaluation or a removal action will be initiated. The decision will cost EPA Region 9 additional resources of time, money, and labor.	The decision could lead to exposure of the community to a substantial and imminent threat to human health.
Which Decision Error Has More Severe Consequences near the	**LESS SEVERE**	**MORE SEVERE** The error will endanger human health.

DECISION ERRORS		
Investigation or Action Level?		
Error Type **Based on Consequences**	**False Acceptance Decisions** A decision that the decision unit is contaminated when it is not.	**False Rejection Decisions** A decision that the decision unit is not contaminated when it is.
Definitions False Acceptance Decisions = A false acceptance decision error occurs when the null hypothesis is not rejected when it is false. False Rejection Decisions = A false rejection decision error occurs when the null hypothesis is rejected when it is true.		

DECISION ERROR LIMITS GOALS		
True Surface Gamma Radiation Activity or Ra-226 Soil Concentration or Exposure Rate (% of Investigation or Action Level)	**Typical Decision Error Probability Goals (Based on Professional Judgment)**	**Type of Decision Error**
Less than 50	5%	False Acceptance Decisions
50 to <100	Gray area[1]	False Acceptance Decisions
100 to <200	10%[2]	False Rejection Decisions
>200	5%	False Rejection Decisions
The goals in this table are based on professional judgment as relevant to a typical radiation response. 1 Gray Area is where relatively large decision errors are acceptable. 2 The large probability for the decision error is expected when the true contaminant concentrations are between 100% and 200% of the investigation or action level. Decreasing the probability is possible only by significantly increasing sampling number and quality assurance sampling, since sampling and analytical uncertainties and biases cannot be eliminated.		

STEP 7.

DESIGN FOR OBTAINING DATA

Design

The sampling rationale and design was developed under the direction of the EPA Task Monitor and START Program Manager, and based on information from other EPA AUM sites.

Background Area

Background survey, sampling and analysis are required to determine naturally-occurring gamma activity and Ra-226 concentrations in an area with similar geology and no known or suspected impacts from mining. The background area will be selected by the EPA Task Monitor in the field according to the *Background Location Selection Criteria* (NNEPA and EPA 2010). The background area will be easily accessible, an appropriate distance from the site, and historically undeveloped based on visual observation.

Gamma Radiation Activity Investigation Level

A survey unit measuring 20 x 20 feet will be established in the selected background area. Gamma radiation activity in surface soil will be measured using a paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241 meter mounted 6 inches from the ground surface on a 3-foot wide push cart ***or similar vehicle***. The VIPER system and geographical information system (GIS) will be used for geospatial information collection and analysis. The surface soil survey will consist of transects spaced 3 feet apart, which will provide 100 percent characterization of the site. The transect width is based on the field of view of the detector which is 3 to 6 feet diameter. The surveyor will walk at a pace of 3 feet per second. The mean and standard deviation (SD) of the gamma radiation activity measurements in the background area surface soil will be calculated to develop the investigation level for gamma radiation activity at the site. An acceptable background area will have a low mean and SD.

Ra-226 Action Level

Surface soil samples will be collected at 0 to 2 inches bgs from the background survey unit and analyzed for Ra-226 by EML HASL 300 4.5.2.3 Method. Eleven samples will be collected at random locations which according to Visual Sampling Plan (VSP) software version 6.2 will provide a 95 percent confidence level that the mean will be within ±1 pCi/g. The sample data will be used to develop the action level for Ra-226. Co-located static gamma radiation activity measurements will also be collected from the surface soil location to establish the relationship between gamma radiation activity and Ra-226 concentration in surface soil.

Exposure Rate Investigation Level

The background exposure rate will be measured using a General Electric Reuter-Stokes High PIC RSS 131 placed 1 meter above the ground surface collecting measurements every second and logging for 5 minutes at 3 individual measurement locations. The background limits will be established based on ±20 percent of the respective average activity rates, determined according to the instrument FOPs. These measurements will serve as background exposure rates to be used in comparison to structure interior exposure rates in the home site assessment.

Site Soil

Gamma radiation activity in surface soil at the site will be measured similar to the background area. A paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241 meter mounted 6 inches from the ground surface on a 3-foot wide push cart ***or similar vehicle*** will be used to measure gamma radiation activity in surface soil. The surface soil survey will consist of 3-foot wide transects at a pace of 3 feet per second covering 100 percent of the site. If gamma radiation activity measurements along the perimeter of the site exceed the investigation level, lateral step-out will consist of additional 3-foot wide transects to a maximum ***lateral extension from the site perimeter based on gamma radiation activity readings i.e., radiation scans will continue laterally as long as readings exceed the investigation level; physical barriers; and professional judgment.***.

Surface soil samples will be co-located with static 1-minute scans of gamma radiation activity to establish the relationship between Ra-226 concentration and gamma radiation activity in surface soil. Surface soil samples will be collected from 0 to 2 inches bgs from locations of gamma radiation activity at or above the investigation level according to the following ranges based on previous AUM sites:

- Investigation level
- Investigation level plus 10,000 cpm (10,000 cpm was established from previous AUM sites to correlate with 1.2 pCi/g of Ra-226)
- Investigation level plus 20,000 cpm
- Investigation level plus 25,000 cpm
- Investigation level plus 30,000 cpm

Surface soil samples will also be collected from areas with gamma radiation activity at or below the investigation level to confirm Ra-226 concentrations at these locations are below the action level. Surface soil samples will be collected from locations within the ranges of interest in each soil type and vegetation cover observed at the site. Additional surface soil samples may be collected based on field observations as determined by the EPA Task Monitor. Based on previous AUM sites, 15 samples have provided correlation of Ra-226 concentration with gamma radiation activity. A maximum of 30 surface soil samples (site and background) will be collected from the site and shipped to the START-contracted laboratory for Ra-226 analysis by EML HASL 300 4.5.2.3 Method.

Subsurface soil samples will be collected to determine the vertical extent of contamination at locations where surface gamma radiation activity exceeds the investigation level. Elevated locations will be determined from gamma radiation activity results of the 100 percent scan of the site. Soil samples will be collected down to 3 feet bgs (or less based on refusal or groundwater) at 1-foot depth intervals bgs. Subsurface samples will be collected from each depth in clustered boreholes i.e., one sample from a 1-foot deep borehole, one sample from a 2-feet deep borehole, and one sample from a 3-feet deep borehole***; or continuous core*** to minimize soil from shallower depths from being collected with the desired subsurface sample. ***Soil boring logs will document soil description.*** The number of subsurface samples collected will be initially based on 10 percent of the highest documented gamma radiation activity locations but may vary based on field data. Additional subsurface soil samples may be collected based on field observations as determined by the EPA Task Monitor.

Home Site

The activity of gamma radiation will be measured inside each structure with coverage of 100 percent of accessible areas. If an object is encountered during the survey it will not be moved, and the scanning survey will be performed surrounding the object. A Ludlum Model 44-20 (3x3) detector paired with a 2221 or 2241 meter will be positioned 6 inches above the floor, and moved in a serpentine motion at a scan rate of 1 to 2 feet per second. Transects will be surveyed from one wall to the opposite wall until 100 percent of the accessible areas is scanned. If the investigation level is exceeded then the extent of the elevated measurements will be determined and documented; that is, the dimensions of the elevated area and a sketch of the area on a structure diagram. The approximate average gamma radiation activity will be recorded for each room in the structure. All measurements will be documented on a survey form. Details on measurement collection are provided in Field Operating Procedure (FOP) 1, Radiation Scanning Survey; and operation of Ludlum Model 44-20 in FOP 5 and Ludlum Model 2221 in FOP 6.

Static exposure rate measurements will be collected inside each room of every accessible structure. In the center of each room, or closest location if obstructed, a General Electric Reuter-Stokes High PIC RSS 131 will be placed 1 meter above the floor, and measurements will be collected every second and logged for 5 minutes. The PIC measurements in mR/hr will be collected to represent the statistically-based average exposure rate in each room. The exposure rate will be used to determine the dose to a resident if the room were occupied, for comparison to dose risk ranges.

Decision Error Minimization

Gamma Radiation Scanning Data

The gamma radiation activity measurement for the entire site is based on 100 percent surface gamma radiation activity scans which collect activity data on a much denser scale and allow for greater confidence in making decisions based on surface contaminant concentrations within a larger area compared to using individual soil sample data points alone. However, the relationship and confidence between gamma radiation activity data and Ra-226 concentration data must be determined in order to make decisions in the field using activity data.

The equipment, method, and background area used introduce variation in measurement results. Whenever possible, the same paired Ludlum Model 44-20 (3x3) detector and 2221 or 2241; measurement method e.g., detector height, pace, specifications; and background area will be used throughout the project. PIC measurements will be collected in unoccupied residential structures.

Regular instrument checks will be conducted.

General Requirement for Generating Usable Data

All activities and documentation related to the project will proceed under a Quality Management Plan. All sampling, analytical, and quality assurance activities will proceed under an EPA-approved SAP. A record of sampling activities and deviation from the SAP must be documented in a bound field log book. Prior to sample collection, all project sampling personnel will review relevant sampling procedures and relevant quality assurance and control requirements for selected analytical methods.

E Validated Analytical Results

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

Laboratory: GEL Laboratories	**Lab Project Number:** SDG 306310
Sampling Dates: June 14-15, 2012	**Sample Matrix:** Soil; Water
Analytical Method: *DOE HASL 300, 4.5.2.3/Ga-01-R, Gamma Spectroscopy; EPA 903.1 Modified, Ra-226, Lucas Cell.*	**Data Reviewer:** Joanna Z. Christopher

REVIEW AND APPROVAL:

Data Reviewer: Joanna Z. Christopher **Date:** 7/27/12
Technical QA Reviewer: ____________ **Date:** ____________
Project Manager: ____________ **Date:** ____________

SAMPLE IDENTIFICATION:

Sample No.	Sample I.D.	Laboratory I.D.
1	AUM-32-01-02	306310013
2	AUM-32-01-12	306310014
3	AUM-32-01-24	306310015
4	AUM-32-01-36	306310016
5	Tronox-QC-01	306310017
6	Tronox-QC-02	306310018
7	Tronox-QC-03	306310019
8	Tronox-QC-07	306310020
9	AUM32-10-02	306310021
10	AUM32-111-02	306310022
11	AUM32-11-02	306310023
12	AUM32-12-02	306310024
13	AUM32-13-02	306310025
14	AUM32-14-02	306310026
15	AUM32-15-02	306310027
16	AUM32-16-02	306310028
17	AUM32-17-02	306310029
18	AUM32-18-02	306310030
19	AUM32-19-02	306310031
20	AUM32-20-02	306310032
21	AUM32-21-02	306310033
22	AUM32-22-02	306310034
23	AUM32-23-02	306310035
24	AUM32-123-02	306310036
25	AUM32-24-02	306310037
26	AUM32-25-02	306310038
27	AUM33-08-02	306310039
28	AUM33-108-02	306310040
29	AUM33-09-02	306310041
30	AUM33-10-02	306310042

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

Sample No.	Sample I.D.	Laboratory I.D.
31	AUM33-11-02	306310043
32	AUM33-12-02	306310044
33	AUM33-13-02	306310045
34	AUM33-14-02	306310046
35	AUM33-15-02	306310047
36	AUM33-16-02	306310048
37	AUM33-WP-01	306310049
38	AUM33-WP-02	306310050
39	AUM33-01-02	306310051
40	AUM33-01-12	306310052
41	AUM33-01-24	306310053
42	AUM33-01-36	306310054
43	AUM33-101-12	306310055
44	AUM33-02-02	306310056
45	AUM33-02-12	306310057
46	AUM33-02-24	306310058
47	AUM33-02-36	306310059
48	AUM33-102-24	306310060
49	AUM33-03-02	306310061
50	AUM33-03-12	306310062
51	AUM33-03-24	306310063
52	AUM33-03-36	306310064
53	AUM33-103-36	306310065
54	AUM33-04-02	306310066
55	AUM33-04-12	306310067
56	AUM33-04-24	306310068
57	AUM33-04-36	306310069
58	AUM33-05-02	306310070
59	AUM33-05-12	306310071
60	AUM33-05-24	306310072
61	AUM33-05-36	306310073
62	AUM33-06-02	306310074
63	AUM33-06-12	306310075
64	AUM33-06-24	306310076
65	AUM33-06-34	306310077
66	AUM33-07-02	306310078
67	AUM33-07-12	306310079
68	AUM33-07-24	306310080
69	AUM33-07-36	306310081
70	AUM32-02-02	306310082
71	AUM32-02-12	306310083
72	AUM32-02-24	306310084
73	AUM32-02-36	306310085

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

Sample No.	Sample I.D.	Laboratory I.D.
74	AUM32-102-36	306310086
75	AUM32-03-02	306310087
76	AUM32-03-12	306310088
77	AUM32-03-24	306310089
78	AUM32-03-36	306310090
79	AUM32-103-12	306310091
80	AUM32-04-02	306310092
81	AUM32-04-12	306310093
82	AUM32-04-24	306310094
83	AUM32-04-36	306310095
84	AUM32-05-02	306310096
85	AUM32-05-12	306310097
86	AUM32-05-24	306310098
87	AUM32-05-36	306310099
88	AUM32-06-02	306310100
89	AUM32-06-12	306310101
90	AUM32-06-24	306310102
91	AUM32-06-36	306310103
92	AUM32-07-02	306310104
93	AUM32-07-12	306310105
94	AUM32-07-24	306310106
95	AUM32-07-36	306310107
96	AUM32-106-24	306310108
97	AUM32-08-02	306310109
98	AUM32-08-12	306310110
99	AUM32-08-24	306310111
100	AUM32-08-36	306310112
101	AUM32-09-02	306310113
102	AUM32-09-12	306310114
103	AUM32-09-24	306310115
104	AUM32-09-36	306310116
105	AUM33-WP-03	306310117
106	Tronox-QC-04	306310118
107	Tronox-QC-05	306310119
108	Tronox-QC-06	306310120

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

DATA PACKAGE COMPLETENESS CHECKLIST:

Checklist Code:

__X__ **Included: no problems**
__*__ **Included: problems noted in review**
__O__ **Not Included and/or Not Available**
__NR__ **Not Required**
__RS__ **Provided As Re-submission**

Case Narrative:

__X__ **Case Narrative present**

Quality Control Summary Package:

__X__ **Data Summary sheets**
__X__ **Initial and Continuing Calibration results**
__X__ **Detector Background Control Charts**
__X__ **Matrix Spike recoveries**
__X__ **Matrix Duplicate results**
__X__ **Laboratory Control Sample recoveries**
__X__ **Analysis Detection Limits**
__X__ **Preparation Log**
__X__ **Analysis Run Log**

Raw QC Data Package Section

__X__ **Chain-of-Custody Records**
__X__ **Instrument Printouts**
__X__ **Sample Preparation Notebook Pages**
__X__ **Logbook and Worksheet Pages**
__NR__ **Percent Solids Determination**

Comments: Soil samples were prepared using a dry soil preparation method and results were reported on a dry weight basis, therefore percent solids determination was not required.

For this analysis there was a minimum 21-day ingrowth period for radon gas to decay to bismuth for analysis. The laboratory ingrowth was 21 to 22 days. The samples were analyzed 27 to 28 days after collection.

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

DATA VALIDATION SUMMARY

The data were reviewed following procedures and limits specified in the EPA OSWER directive, *Quality Assurance/Quality Control Guidance for Removal Activities, Sampling QA/QC Plan and Data Validation Procedures* (EPA/540/G-90/004, OSWER Directive 9360.4-01, dated April 1990).

Indicate with a YES or NO whether each item is acceptable without qualification:

1	**Holding Times**	**Yes**
2	**Initial and Continuing Calibrations**	**Yes**
3	**Laboratory Control Sample**	**Yes**
4	**Matrix Spike**	**Yes**
5	**Blanks and Background Samples**	**Yes**
6	**Duplicate Analyses**	**Yes**
7	**Analyte Quantitation**	**Yes**
8	**Overall Assessment of Data**	**Yes**
9	**Usability of Data**	**Yes**

Comments: A sample was called AM33-06-34 on the COC and the laboratory commented that this did not match the container ID ("AUM33-06-36 is AUM33-06-34 on containers"); the laboratory used AM33-06-34 as the sample ID for reporting purposes.

Samples Tronox-QC-04, -05, and -06 were designated soil on the COC but were actually water samples.

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

1. HOLDING TIMES

__X__ Acceptable
______ Acceptable with qualification
______ Unacceptable

Samples were extracted and analyzed within required holding times except as noted under Comments. In addition, no problems were identified with regard to sample preservation or custody unless specified. For those samples analyzed outside holding time requirements, the detected results have been qualified as estimated (J), and the nondetected results have been qualified either as estimated (UJ) or rejected (R) based on the reviewer's judgment.

<u>All Sample Matrices:</u>
Radiochemistry analyses: 6 months from collection to analysis.

Comments: None.

2. INITIAL AND CONTINUING CALIBRATION VERIFICATION

__X__ Acceptable
______ Acceptable with qualification
______ Unacceptable

Unless flagged below, an initial calibration verification (ICV), background, and efficiency check were performed for each detector at the beginning of the run, and were within the laboratory acceptance limits.

Comments: None

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
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3. LABORATORY CONTROL SAMPLE

__X__ **Acceptable**
______ **Acceptable with qualification**
______ **Unacceptable**
______ **No Laboratory Control Samples Analyzed**

Laboratory control sample recoveries are used for a qualitative indication of accuracy (bias) independent of matrix effects. LCS recovery limits should either be specified in the Sampling and Analysis Plan or can be established by the laboratory. For analytes which exceeded these control limits, associated detected results are qualified as estimated (J). In cases where the recovery was below 30%, all associated nondetected results are rejected (R) and detected results are qualified as estimated (J).

Comments: None.

4. MATRIX SPIKE

__X__ **Acceptable**
______ **Acceptable with qualification**
______ **Unacceptable**
______ **No Matrix Spikes Analyzed**

Matrix spike recoveries are used for a qualitative indication of accuracy (bias) due to matrix effects. Unless flagged below, one matrix spike sample was analyzed at a rate of one per batch or one per 20 samples. Recoveries were within a range of 75-125%. For analytes which exceeded these control limits, associated detected results are qualified as estimated (J). In cases where the recovery was below 30%, all associated nondetected results are rejected (R) and detected results are qualified as estimated (J).

Comments: The SAP does not require laboratory QC samples (MS/MSD) for gamma spec or Lucas Cell Ra-226 analyses. The laboratory performed an MS analysis for Ra-226 for every 10 samples with acceptable accuracy.

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

5. BLANKS AND BACKGROUND SAMPLES

__X__ Acceptable
______ Detection Limits Adjusted

The following blanks were analyzed:
__X__ Method (preparation) Blanks
______ Field Blanks
__X__ Calibration Blanks (instrument background check)
__X__ Rinsate Blanks
__X__ Background Samples

Preparation (method) blanks were prepared for each batch of samples extracted. A preparation blank was analyzed after every continuing calibration standard, prior to sample analysis unless noted below. Any radionuclide detected in the sample and also detected in any associated blank, must be qualified as non-detect (U) when the sample concentration is less than 5x the blank concentration.

Comments: Eleven background samples were collected as required by the SAP for Ra-226 analysis and analyzed under a separate SDG (SDG 306761). See the DVM for that SDG for more information.

Seven equipment rinsate blank samples were collected over the two-day sampling period. The SAP required one per day for nondedicated equipment.

A sample of the clean deionized water used to rinse the nondedicated equipment for the rinsate blank samples was required by the SAP but was not provided to the laboratory for analysis. However, because the rinsate blank sample results were all below the reporting limit of 1.00 pCi/L, no results were qualified on the basis of blank samples.

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

6. DUPLICATE ANALYSES

__X__ **Acceptable**
______ **Acceptable with qualification**
______ **Unacceptable**
______ **No Duplicates Analyzed**

Type of duplicates analyzed:
__X__ **Field Duplicates**
__X__ **Laboratory Duplicates**

Calculate the relative Percent Difference (RPD) between the members of duplicate pairs using the equation indicated below. Qualify the detected results as estimated (J) for any analyte whose RPD in a laboratory duplicate exceeds 20% for water samples or 35% for soil samples.

$$\text{RPD} = \frac{2(\text{Value 1} - \text{Value 2})}{\text{Value 1} + \text{Value 2}} \times 100\%$$

Comments:
The SAP requires collection of field duplicate samples at the rate of one for every ten samples. Nine field duplicate sample pairs were collected for this sampling effort. Precision was acceptable for the nine field duplicate sample pairs.

The laboratory performed one laboratory duplicate analysis for gamma spec analysis for every 16 samples and for Ra-226 for every 10 samples with acceptable precision.

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

7. ANALYTE QUANTITATION

Confirm that analyte quantitation was performed correctly using the following formula:

$$\text{Ra-226 (pci/g)} = \frac{\text{gross sample cts} - \text{gross background counts}}{2.22 \times \text{counting efficiency} \times \text{sample mass} \times \text{isotopic abundance} \times \text{count time} \times \text{ingrowth factor}}$$

Comments: 10% of the results were calculated and found to be correct, as shown below.

Ra-226 by gamma spec:

GEL sample id	net cts	ingrowth factor	% eff	Mass, g	% abn	ct time, min	calc result	rpt res	% calc v rpt
306310060	3914	1	0.03682	141.65	0.463	120	6.0842	6.08	100.0695
306310065	510	1	0.02358	139.27	0.463	120	1.2591	1.26	99.9270
306310026	600	1	0.02741	129.65	0.463	120	1.3688	1.37	99.9157
306310034	1095	1	0.02027	122.13	0.463	120	3.5861	3.59	99.8915
306310105	7889	1	0.03682	135.526	0.463	120	12.8174	12.8	100.1360
306310112	3042	1	0.02357	142.743	0.463	82	10.7275	10.8	99.3284
306310044	218	1	0.01989	122.67	0.463	60	1.4488	1.45	99.9149
306310056	3997	1	0.02621	121.69	0.463	60	20.3202	20.3	100.0993
306310083	315	1	0.02027	120.38	0.463	60	2.0932	2.09	100.1546
306310094	268	1	0.02373	126.38	0.463	60	1.4490	1.45	99.9322
306310117	11047	1	0.02445	157.56	0.463	120	23.2490	23.3	99.7811

Ra-226 by Lucas cell:

GEL sample ID	net cts	ingrowth factor	% eff	sample vol, L	% abn	ct time min	calc result	rpt res	% calc v rpt
306310020	18	0.37238328	2.177	0.5	1	30	0.6668	0.667	99.97

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

8. OVERALL ASSESSMENT OF DATA

On the basis of this review, the following determination has been made with regard to the overall data usability for the specified level.

__X__ Acceptable
______ Acceptable with Qualification
______ Rejected

Accepted data meet the minimum requirements for the following EPA data category:
______ ERS Screening
______ Non-definitive with 10 % Conformation by Definitive Methodology
______ Definitive, Comprehensive Statistical Error Determination was performed.
__X__ Definitive, Comprehensive Statistical Error Determination was not performed.

Any qualifications to individual sample analysis results are detailed in the appropriate section above or appear under the comments section below. In cases where several QC criteria are out of specification, it may be appropriate to further qualify the data usability. The data reviewer must use professional judgment and express concerns and comments on the data validity for each specific data package.

Comments: Ra-228 was detected in most of the samples in this SDG at low levels ranging from 0.56 to 2.1 pCi/g, likely due to radioactive decay of naturally occurring Th-232. Cs-137 was detected in 18 samples in this SDG at low levels ranging from 0.079 to 0.48 pCi/g, likely due to atmospheric radioactive fallout.

9. DOCUMENTATION OF LABORATORY CORRECTIVE ACTION

Problem: None.

Resolution:

Attached are copies of all data summary sheets, with data qualifiers indicated, and a copy of the chain of custody for the samples.

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM-32-01-02	Project:	ECOL00722
Sample ID:	306310013	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	14-JUN-12 16:55		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		10.2	+/-1.10	0.214	1.00	pCi/g		MXR1	07/11/12	1053	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Z Christopher 7/27/12

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Certificate of Analysis

Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM-32-01-12	Project:	ECOL00722
Sample ID:	306310014	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	14-JUN-12 16:50		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		8.86	+/-0.965	0.221	1.00	pCi/g		MXR1	07/11/12	1124	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Z Christopher 7/27/12

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Certificate of Analysis

Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM-32-01-24	Project:	ECOL00722
Sample ID:	306310015	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	14-JUN-12 16:52		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		4.50	+/-0.514	0.117	1.00	pCi/g		MXR1	07/11/12	1125	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Christopher 7/27/12

GEL LABORATORIES LLC

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Certificate of Analysis

Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM-32-01-36	Project:	ECOL00722
Sample ID:	306310016	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	14-JUN-12 16:54		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		6.18	+/-0.686	0.147	1.00	pCi/g		MXR1	07/11/12	1203	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Christophe 7/27/12

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Certificate of Analysis

Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox-QC-01	Project:	ECOL00722
Sample ID:	306310017	Client ID:	ECOL007
Matrix:	Water		
Collect Date:	14-JUN-12 18:30		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Radium-226												
Lucas Cell, Ra226, liquid "As Received"												
Radium-226	U	0.539	+/-0.466	0.726	1.00	pCi/L		KSD1	07/13/12	0910	1226249	1

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 903.1 Modified	

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Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox-QC-02	Project:	ECOL00722
Sample ID:	306310018	Client ID:	ECOL007
Matrix:	Water		
Collect Date:	14-JUN-12 18:35		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Radium-226												
Lucas Cell, Ra226, liquid "As Received"												
Radium-226	U	0.688	+/-0.528	0.795	1.00	pCi/L		KSD1	07/13/12	0940	1226249	1

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 903.1 Modified	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox-QC-03	Project:	ECOL00722
Sample ID:	306310019	Client ID:	ECOL007
Matrix:	Water		
Collect Date:	14-JUN-12 18:40		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Radium-226												
Lucas Cell, Ra226, liquid "As Received"												
Radium-226	U	0.397	+/-0.477	0.802	1.00	pCi/L		KSD1	07/13/12	0940	1226249	1

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 903.1 Modified	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox-QC-07	Project:	ECOL00722
Sample ID:	306310020	Client ID:	ECOL007
Matrix:	Water		
Collect Date:	15-JUN-12 17:10		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Radium-226												
Lucas Cell, Ra226, liquid "As Received"												
Radium-226		0.667	+/-0.423	0.599	1.00	pCi/L		KSD1	07/13/12	0940	1226249	1

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 903.1 Modified	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-10-02	Project:	ECOL00722
Sample ID:	306310021	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 09:45		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		8.98	+/-0.973	0.186	1.00	pCi/g		MXR1	07/11/12	1203	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-111-02	Project:	ECOL00722
Sample ID:	306310022	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 10:15		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.25	+/-0.149	0.106	1.00	pCi/g		MXR1	07/11/12	1206	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-11-02	Project:	ECOL00722
Sample ID:	306310023	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 10:10		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.36	+/-0.201	0.105	1.00	pCi/g		MXR1	07/11/12	1313	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-12-02	Project:	ECOL00722
Sample ID:	306310024	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 10:20		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.19	+/-0.181	0.104	1.00	pCi/g		MXR1	07/11/12	1313	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-13-02	Project:	ECOL00722
Sample ID:	306310025	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 10:35		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.07	+/-0.288	0.145	1.00	pCi/g		MXR1	07/11/12	1314	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-14-02	Project:	ECOL00722
Sample ID:	306310026	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 10:40		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.37	+/-0.190	0.100	1.00	pCi/g		MXR1	07/11/12	1314	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-15-02	Project:	ECOL00722
Sample ID:	306310027	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 11:05		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		13.5	+/-1.37	0.174	1.00	pCi/g		MXR1	07/11/12	1314	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-16-02	Project:	ECOL00722
Sample ID:	306310028	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 11:10		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		3.20	+/-0.443	0.203	1.00	pCi/g		MXR1	07/11/12	1315	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-17-02	Project:	ECOL00722
Sample ID:	306310029	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 11:20		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		7.88	+/-0.877	0.186	1.00	pCi/g		MXR1	07/11/12	1315	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-18-02	Project:	ECOL00722
Sample ID:	306310030	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 11:25		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		10.0	+/-1.08	0.165	1.00	pCi/g		MXR1	07/11/12	1316	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-19-02	Project:	ECOL00722
Sample ID:	306310031	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 11:45		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.02	+/-0.309	0.164	1.00	pCi/g		MXR1	07/11/12	1316	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-20-02	Project:	ECOL00722
Sample ID:	306310032	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 12:00		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		16.6	+/-1.87	0.199	1.00	pCi/g		MXR1	07/11/12	1317	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-21-02	Project:	ECOL00722
Sample ID:	306310033	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 12:05		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.94	+/-0.271	0.144	1.00	pCi/g		MXR1	07/11/12	1323	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-22-02	Project:	ECOL00722
Sample ID:	306310034	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 12:10		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		3.59	+/-0.445	0.178	1.00	pCi/g		MXR1	07/11/12	1331	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-23-02	Project:	ECOL00722
Sample ID:	306310035	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 14:25		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		4.75	+/-0.534	0.128	1.00	pCi/g		MXR1	07/11/12	1332	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-123-02	Project:	ECOL00722
Sample ID:	306310036	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 14:30		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		5.43	+/-0.612	0.153	1.00	pCi/g		MXR1	07/12/12	0707	1223190	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1522	1223042

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-24-02	Project:	ECOL00722
Sample ID:	306310037	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 14:40		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.53	+/-0.356	0.233	1.00	pCi/g		MXR1	07/12/12	0953	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-25-02	Project:	ECOL00722
Sample ID:	306310038	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 15:10		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		3.00	+/-0.408	0.194	1.00	pCi/g		MXR1	07/12/12	1003	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-08-02	Project:	ECOL00722
Sample ID:	306310039	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 12:55		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		4.78	+/-0.560	0.177	1.00	pCi/g		MXR1	07/12/12	1003	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-108-02	Project:	ECOL00722
Sample ID:	306310040	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 13:00		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		6.11	+/-0.816	0.330	1.00	pCi/g		MXR1	07/12/12	1003	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-09-02	Project:	ECOL00722
Sample ID:	306310041	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 13:05		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		6.70	+/-0.754	0.212	1.00	pCi/g		MXR1	07/12/12	1008	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-10-02	Project:	ECOL00722
Sample ID:	306310042	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 13:10		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		4.31	+/-0.555	0.199	1.00	pCi/g		MXR1	07/12/12	1009	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-11-02	Project:	ECOL00722
Sample ID:	306310043	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 13:15		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.37	+/-0.276	0.157	1.00	pCi/g		MXR1	07/12/12	1010	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-12-02	Project:	ECOL00722
Sample ID:	306310044	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 13:25		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.45	+/-0.277	0.196	1.00	pCi/g		MXR1	07/12/12	1046	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-13-02	Project:	ECOL00722
Sample ID:	306310045	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 13:30		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		9.70	+/-1.07	0.209	1.00	pCi/g		MXR1	07/12/12	1046	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-14-02	Project:	ECOL00722
Sample ID:	306310046	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 15:15		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.65	+/-0.333	0.193	1.00	pCi/g		MXR1	07/12/12	1046	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-15-02	Project:	ECOL00722
Sample ID:	306310047	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 15:25		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		9.85	+/-1.10	0.241	1.00	pCi/g		MXR1	07/12/12	1047	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Report Date: July 13, 2012

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-16-02	Project:	ECOL00722
Sample ID:	306310048	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 15:35		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		6.59	+/-0.833	0.315	1.00	pCi/g		MXR1	07/12/12	1047	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-WP-01	Project:	ECOL00722
Sample ID:	306310049	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 15:40		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		52.2	+/-5.27	0.432	1.00	pCi/g		MXR1	07/12/12	1048	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-WP-02	Project:	ECOL00722
Sample ID:	306310050	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 15:45		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		47.7	+/-4.82	0.397	1.00	pCi/g		MXR1	07/12/12	1048	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-01-02	Project:	ECOL00722
Sample ID:	306310051	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 13:20		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.30	+/-0.284	0.172	1.00	pCi/g		MXR1	07/12/12	1052	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-01-12	Project:	ECOL00722
Sample ID:	306310052	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 13:25		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.37	+/-0.261	0.155	1.00	pCi/g		MXR1	07/12/12	1053	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-01-24	Project:	ECOL00722
Sample ID:	306310053	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 13:35		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.04	+/-0.231	0.150	1.00	pCi/g		MXR1	07/12/12	1053	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-01-36	Project:	ECOL00722
Sample ID:	306310054	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 13:45		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.05	+/-0.229	0.158	1.00	pCi/g		MXR1	07/12/12	1053	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-101-12	Project:	ECOL00722
Sample ID:	306310055	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 13:30		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.38	+/-0.291	0.224	1.00	pCi/g		MXR1	07/12/12	1058	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-02-02	Project:	ECOL00722
Sample ID:	306310056	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 14:18		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		20.3	+/-2.10	0.282	1.00	pCi/g		MXR1	07/12/12	1143	1223191	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1527	1223043

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-02-12	Project:	ECOL00722
Sample ID:	306310057	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 14:20		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		4.07	+/-0.462	0.125	1.00	pCi/g		MXR1	07/11/12	0759	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-02-24	Project:	ECOL00722
Sample ID:	306310058	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 14:23		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		6.00	+/-0.674	0.180	1.00	pCi/g		MXR1	07/11/12	0759	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Report Date: July 13, 2012

Company : Ecology & Environment, Inc.
Address : 3700 Industry Ave.
#102
Lakewood, California 90712
Contact: Ms. Mindy Song
Project: Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID: AUM33-02-36 — Project: ECOL00722
Sample ID: 306310059 — Client ID: ECOL007
Matrix: Soil
Collect Date: 15-JUN-12 14:26
Receive Date: 18-JUN-12
Collector: Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		7.15	+/-0.794	0.141	1.00	pCi/g		MXR1	07/11/12	0800	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-102-24	Project:	ECOL00722
Sample ID:	306310060	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 14:29		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		6.08	+/-0.633	0.110	1.00	pCi/g		MXR1	07/11/12	0800	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-03-02	Project:	ECOL00722
Sample ID:	306310061	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 14:45		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.996	+/-0.188	0.134	1.00	pCi/g		MXR1	07/11/12	0817	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-03-12	Project:	ECOL00722
Sample ID:	306310062	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 14:48		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.14	+/-0.270	0.124	1.00	pCi/g		MXR1	07/11/12	0836	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-03-24	Project:	ECOL00722
Sample ID:	306310063	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 14:50		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.55	+/-0.260	0.163	1.00	pCi/g		MXR1	07/11/12	0836	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Report Date: July 13, 2012

Company : Ecology & Environment, Inc.
Address : 3700 Industry Ave.
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Lakewood, California 90712
Contact: Ms. Mindy Song
Project: Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID: AUM33-03-36 | Project: ECOL00722
Sample ID: 306310064 | Client ID: ECOL007
Matrix: Soil
Collect Date: 15-JUN-12 15:00
Receive Date: 18-JUN-12
Collector: Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.14	+/-0.177	0.0986	1.00	pCi/g		MXR1	07/11/12	0910	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-103-36	Project:	ECOL00722
Sample ID:	306310065	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 14:55		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.26	+/-0.142	0.109	1.00	pCi/g		MXR1	07/11/12	1044	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-04-02	Project:	ECOL00722
Sample ID:	306310066	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 15:03		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		76.1	+/-7.45	0.312	1.00	pCi/g		MXR1	07/11/12	1044	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-04-12	Project:	ECOL00722
Sample ID:	306310067	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 15:12		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		35.4	+/-3.69	0.264	1.00	pCi/g		MXR1	07/11/12	1045	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-04-24	Project:	ECOL00722
Sample ID:	306310068	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 15:19		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		19.0	+/-1.88	0.187	1.00	pCi/g		MXR1	07/11/12	1045	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-04-36	Project:	ECOL00722
Sample ID:	306310069	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 15:30		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		22.2	+/-2.23	0.254	1.00	pCi/g		MXR1	07/11/12	1046	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-05-02	Project:	ECOL00722
Sample ID:	306310070	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 15:35		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		9.13	+/-0.935	0.136	1.00	pCi/g		MXR1	07/11/12	1046	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-05-12	Project:	ECOL00722
Sample ID:	306310071	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 15:38		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		3.93	+/-0.455	0.137	1.00	pCi/g		MXR1	07/11/12	1047	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Company : Ecology & Environment, Inc.
Address : 3700 Industry Ave.
#102
Lakewood, California 90712
Contact: Ms. Mindy Song
Project: Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-05-24	Project:	ECOL00722
Sample ID:	306310072	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 15:45		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		4.61	+/-0.505	0.117	1.00	pCi/g		MXR1	07/11/12	1047	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-05-36	Project:	ECOL00722
Sample ID:	306310073	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 15:55		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.32	+/-0.215	0.120	1.00	pCi/g		MXR1	07/11/12	1047	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-06-02	Project:	ECOL00722
Sample ID:	306310074	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 16:05		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.33	+/-0.203	0.106	1.00	pCi/g		MXR1	07/11/12	1048	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-06-12	Project:	ECOL00722
Sample ID:	306310075	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 16:10		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.10	+/-0.182	0.139	1.00	pCi/g		MXR1	07/11/12	1048	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-06-24	Project:	ECOL00722
Sample ID:	306310076	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 16:15		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.816	+/-0.171	0.114	1.00	pCi/g		MXR1	07/11/12	1049	1223411	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/19/12	1604	1223044

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-06-34	Project:	ECOL00722
Sample ID:	306310077	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 16:20		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.01	+/-0.281	0.239	1.00	pCi/g		MXR1	07/12/12	1145	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-07-02	Project:	ECOL00722
Sample ID:	306310078	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 16:30		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		39.4	+/-4.10	0.373	1.00	pCi/g		MXR1	07/12/12	1146	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-07-12	Project:	ECOL00722
Sample ID:	306310079	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 16:32		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		5.83	+/-0.733	0.226	1.00	pCi/g		MXR1	07/12/12	1153	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-07-24	Project:	ECOL00722
Sample ID:	306310080	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 16:35		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		3.36	+/-0.451	0.202	1.00	pCi/g		MXR1	07/12/12	1153	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-07-36	Project:	ECOL00722
Sample ID:	306310081	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 16:40		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.84	+/-0.421	0.202	1.00	pCi/g		MXR1	07/12/12	1154	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-02-02	Project:	ECOL00722
Sample ID:	306310082	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 09:45		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.89	+/-0.426	0.196	1.00	pCi/g		MXR1	07/12/12	1155	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address : 3700 Industry Ave.
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Lakewood, California 90712
Contact: Ms. Mindy Song
Project: Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-02-12	Project:	ECOL00722
Sample ID:	306310083	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 09:50		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.09	+/-0.423	0.280	1.00	pCi/g		MXR1	07/12/12	1155	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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	Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-02-24	Project:	ECOL00722
Sample ID:	306310084	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 10:00		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.47	+/-0.411	0.198	1.00	pCi/g		MXR1	07/12/12	1157	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-02-36	Project:	ECOL00722
Sample ID:	306310085	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 10:10		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.98	+/-0.250	0.184	1.00	pCi/g		MXR1	07/12/12	1158	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-102-36	Project:	ECOL00722
Sample ID:	306310086	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 10:12		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.51	+/-0.374	0.183	1.00	pCi/g		MXR1	07/12/12	1205	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-03-02	Project:	ECOL00722
Sample ID:	306310087	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 10:17		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		8.21	+/-0.970	0.235	1.00	pCi/g		MXR1	07/12/12	1205	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-03-12	Project:	ECOL00722
Sample ID:	306310088	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 10:25		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.94	+/-0.422	0.217	1.00	pCi/g		MXR1	07/12/12	1205	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-03-24	Project:	ECOL00722
Sample ID:	306310089	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 10:32		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.98	+/-0.360	0.198	1.00	pCi/g		MXR1	07/12/12	1206	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-03-36	Project:	ECOL00722
Sample ID:	306310090	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 10:36		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.40	+/-0.243	0.167	1.00	pCi/g		MXR1	07/12/12	1206	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-103-12	Project:	ECOL00722
Sample ID:	306310091	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 10:28		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.67	+/-0.374	0.177	1.00	pCi/g		MXR1	07/12/12	1206	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address : 3700 Industry Ave.
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Contact: Ms. Mindy Song
Project: Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-04-02	Project:	ECOL00722
Sample ID:	306310092	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 10:42		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		12.4	+/-1.33	0.234	1.00	pCi/g		MXR1	07/12/12	1207	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-04-12	Project:	ECOL00722
Sample ID:	306310093	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 10:51		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.58	+/-0.362	0.161	1.00	pCi/g		MXR1	07/12/12	1207	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-04-24	Project:	ECOL00722
Sample ID:	306310094	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 10:55		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.45	+/-0.263	0.181	1.00	pCi/g		MXR1	07/12/12	1207	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-04-36	Project:	ECOL00722
Sample ID:	306310095	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 11:00		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.15	+/-0.375	0.203	1.00	pCi/g		MXR1	07/12/12	1208	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-05-02	Project:	ECOL00722
Sample ID:	306310096	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 11:25		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.07	+/-0.350	0.203	1.00	pCi/g		MXR1	07/12/12	1236	1223413	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1603	1223045

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Report Date: July 13, 2012

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-05-12	Project:	ECOL00722
Sample ID:	306310097	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 11:30		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.12	+/-0.275	0.120	1.00	pCi/g		MXR1	07/12/12	0713	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-05-24	Project:	ECOL00722
Sample ID:	306310098	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 11:34		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.39	+/-0.211	0.127	1.00	pCi/g		MXR1	07/12/12	0731	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-05-36	Project:	ECOL00722
Sample ID:	306310099	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 11:40		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.42	+/-0.226	0.115	1.00	pCi/g		MXR1	07/12/12	0731	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-06-02	Project:	ECOL00722
Sample ID:	306310100	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 11:50		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		22.2	+/-2.30	0.258	1.00	pCi/g		MXR1	07/12/12	0732	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-06-12	Project:	ECOL00722
Sample ID:	306310101	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 11:52		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.14	+/-0.179	0.0894	1.00	pCi/g		MXR1	07/12/12	0732	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-06-24	Project:	ECOL00722
Sample ID:	306310102	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 11:54		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.62	+/-0.223	0.110	1.00	pCi/g		MXR1	07/12/12	0733	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-06-36	Project:	ECOL00722
Sample ID:	306310103	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 11:56		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.49	+/-0.257	0.149	1.00	pCi/g		MXR1	07/12/12	0733	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-07-02	Project:	ECOL00722
Sample ID:	306310104	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 12:10		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.65	+/-0.233	0.106	1.00	pCi/g		MXR1	07/12/12	0746	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-07-12	Project:	ECOL00722
Sample ID:	306310105	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 12:12		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		12.8	+/-1.29	0.134	1.00	pCi/g		MXR1	07/12/12	0747	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave.
	#102
	Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-07-24	Project:	ECOL00722
Sample ID:	306310106	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 12:15		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		31.0	+/-3.16	0.298	1.00	pCi/g		MXR1	07/12/12	0747	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-07-36	Project:	ECOL00722
Sample ID:	306310107	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 12:20		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		40.7	+/-3.95	0.230	1.00	pCi/g		MXR1	07/12/12	0800	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-106-24	Project:	ECOL00722
Sample ID:	306310108	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 11:54		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.01	+/-0.270	0.0992	1.00	pCi/g		MXR1	07/12/12	0801	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-08-02	Project:	ECOL00722
Sample ID:	306310109	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 12:30		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		37.3	+/-3.81	0.394	1.00	pCi/g		MXR1	07/12/12	0923	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-08-12	Project:	ECOL00722
Sample ID:	306310110	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 12:35		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		112	+/-11.3	0.569	1.00	pCi/g		MXR1	07/12/12	0917	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-08-24	Project:	ECOL00722
Sample ID:	306310111	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 12:40		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		9.78	+/-1.09	0.225	1.00	pCi/g		MXR1	07/12/12	0932	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Company : Ecology & Environment, Inc.
Address : 3700 Industry Ave.
#102
Lakewood, California 90712
Contact: Ms. Mindy Song
Project: Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID: AUM32-08-36
Project: ECOL00722
Sample ID: 306310112
Client ID: ECOL007
Matrix: Soil
Collect Date: 15-JUN-12 12:42
Receive Date: 18-JUN-12
Collector: Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		10.8	+/-1.17	0.190	1.00	pCi/g		MXR1	07/12/12	0918	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-09-02	Project:	ECOL00722
Sample ID:	306310113	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 12:47		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.41	+/-0.373	0.222	1.00	pCi/g		MXR1	07/12/12	0919	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-09-12	Project:	ECOL00722
Sample ID:	306310114	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 12:55		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		50.7	+/-5.10	0.370	1.00	pCi/g		MXR1	07/12/12	0919	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-09-24	Project:	ECOL00722
Sample ID:	306310115	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 13:00		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		57.1	+/-6.33	0.450	1.00	pCi/g		MXR1	07/12/12	0947	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Z Christopher 7/27/12

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-09-36	Project:	ECOL00722
Sample ID:	306310116	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 13:10		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		4.59	+/-0.553	0.192	1.00	pCi/g		MXR1	07/12/12	0948	1223414	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1558	1223046

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Z Christopher 7/27/12

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave.
	#102
	Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-WP-03	Project:	ECOL00722
Sample ID:	306310117	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-JUN-12 15:00		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		23.3	+/-2.35	0.205	1.00	pCi/g		MXR1	07/12/12	0709	1223415	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	LYT1	06/20/12	1557	1223049

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Z Christopher 7/27/12

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox-QC-04	Project:	ECOL00722
Sample ID:	306310118	Client ID:	ECOL007
Matrix:	Water		
Collect Date:	15-JUN-12 17:00		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Radium-226												
Lucas Cell, Ra226, liquid "As Received"												
Radium-226	U	0.424	+/-0.392	0.623	1.00	pCi/L		KSD1	07/13/12	0940	1226249	1

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 903.1 Modified	

Jessina Christopher 7/27/12

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave.
	#102
	Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox-QC-05	Project:	ECOL00722
Sample ID:	306310119	Client ID:	ECOL007
Matrix:	Water		
Collect Date:	15-JUN-12 17:05		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Radium-226												
Lucas Cell, Ra226, liquid "As Received"												
Radium-226	U	0.0981	+/-0.333	0.657	1.00	pCi/L		KSD1	07/13/12	0940	1226249	1

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 903.1 Modified	

Joanna Z Christopher 7/27/12

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: July 13, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox-QC-06	Project:	ECOL00722
Sample ID:	306310120	Client ID:	ECOL007
Matrix:	Water		
Collect Date:	15-JUN-12 17:08		
Receive Date:	18-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Radium-226												
Lucas Cell, Ra226, liquid "As Received"												
Radium-226		0.502	+/-0.341	0.384	1.00	pCi/L		KSD1	07/13/12	0940	1226249	1

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 903.1 Modified	

Joanna Z Christopher 7/27/12

<a copy> Joanna Z Christopher 7/27/12

Page: 1 of 12
Project #: EE-002693-2164-06TT
GEL Quote #: EE-002693-2165-06TT
COC Number (1):
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number: 306310

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: ECOLOGY & ENVIRONMENT Phone #: 415-971-9633
Project/Site Name: TRONOX Fax #: 510-550-2760
Address: 1940 WEBSTER ST SUITE 100, OAKLAND, CA 94612
Collected by: BILL SASS Send Results To: AILEEN MENDOZA

Sample Analysis Requested (5) (Fill in the number of containers for each test)

<-- Preservative Type (6)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Radioactive	TSCA Regulated	Total number of containers	Ra-226	EML HASL 300, 4.5.2.3									Comments Note: extra sample is required for sample specific QC
TRONOX-BKG-01-02	06/14/12	0935			SOIL	X		1	X										
-02		0938																	
-03		0941																	
-04		0945																	
-05		0947																	
-06		0949																	
-07		0950																	
-08		0952																	
-09		0954																	
-10		0956																	

Should this sample be considered: Radioactive / TSCA Regulated

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No — OR EMAIL AMENDOZA@ENE.COM

Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards*

Sample Collection Time Zone: Eastern Pacific Central Other ______ Mountain

Chain of Custody Signatures						Sample Shipping and Delivery Details
Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time	GEL PM:
1 William Sass	6/16/12		1 JLJ	6-18-12	0815	Method of Shipment: / Date Shipped:
2			2			Airbill #:
3			3			Airbill #:

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. 8260B - 3, 6010B/7470A - 1).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only
Custody Seal Intact? YES NO
Cooler Temp: C

WHITE = LABORATORY YELLOW = FILE PINK = CLIENT

<a copy> Joanna Christopher 7/27/12

Page: 2 of 12
Project #: EE-002693-2164-06TT
GEL Quote #: EE-002693-2165-06TT
COC Number (1):
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: Ecology and Environment — Phone #: 415-971-9633
Project/Site Name: Tronox — Fax #: 510-550-2760
Address: 1940 Webster St, Ste 100, Oakland, CA 94612
Collected by: Bill Sed — Send Results To: Aileen Mendoza

Sample Analysis Requested (5) (Fill in the number of containers for each test)

<-- Preservative Type (6)

Sample ID • For composites - indicate start and stop date/time	•Date Collected (mm-dd-yy)	•Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive	TSCA Regulated	Total number of containers	Ra-226 EML HASL 300, [illegible]	Comments: Note: extra sample is required for sample specific QC
TRONOX-BKG-11-02	06/14/12	0958			SOIL	X		1	X	
-111-02		1000								
AMM32-01-02		1655								
-12		1650								
-24		1652								
-36		1654								
TRONOX-QC-01		1830			WATER					
-02		1835			WATER					
-03		1840			WATER					
TRONOX-QC-07	06/15/12	1710								

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No

Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list ~~the hazards~~* See P. 1

Sample Collection Time Zone
Eastern Pacific
Central Other ______
~~Mountain~~

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 William Sed	6/16/12		1 JRJ	6-18-12	0815
2			2		
3			3		

Sample Shipping and Delivery Details

GEL PM:
Method of Shipment: — Date Shipped:
Airbill #:
Airbill #:

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B - 3, 6010B/7470A - 1*).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only
Custody Seal Intact?
YES NO
Cooler Temp:
C

WHITE = LABORATORY YELLOW = FILE PINK = CLIENT

<a copy> Joanna Christopher 7/27/12

Page: 3 of 12
Project #: EE-002693-2164-06TT
GEL Quote #: EE-002693-2165-06TT
COC Number (1):
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: Ecology and Environment Phone #: 415-771-9633
Project/Site Name: Tronox Fax #: 510-550-2760
Address: 1940 Webster St, Ste 100, Oakland, CA 94612
Collected by: Bill Sass Send Results To: Aileen Mendoza

Sample Analysis Requested (5) (Fill in the number of containers for each test)

<-- Preservative Type (6)

Sample ID (* For composites - indicate start and stop date/time)	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive	TSCA Regulated	Total number of containers	Ra-226 EML HASL 300 4.5.2.3										Comments: Note: extra sample is required for sample specific QC
AUM32-10-02	06/15/12	0945			SOIL	X		1	X										
-111-02		1015																	
-11-02		1010																	
-12-02		1020																	
-13-02		1035																	
-14-02		1040																	
-15-02		1105																	
-16-02		1110																	
-17-02		1120																	
-18-02		1125																	

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* see p. 1

Sample Collection Time Zone
Eastern Pacific
Central Other ______
Mountain

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 William Sass	6/15/12		1 JRJ	6-18-12	0815
2			2		
3			3		

Sample Shipping and Delivery Details

GEL PM:
Method of Shipment: Date Shipped:
Airbill #:
Airbill #:

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B - 3, 6010B/7470A - 1*).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only
Custody Seal Intact?
YES NO
Cooler Temp:
C

WHITE = LABORATORY **YELLOW = FILE** **PINK = CLIENT**

<a copy> Joanna Christopher 7/27/12

Page: 4 of 12	
Project #: EE-002693-2164-06TT	
GEL Quote #: EE-002693-2165-06TT	
COC Number (1):	
PO Number:	GEL Work Order Number:

GEL Chain of Custody and Analytical Request

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: Ecology and Environment   Phone #: 415-971-9633

Project/Site Name: Tronox   Fax #: 510-550-2760

Address: 1910 Webster St, Ste 100, Oakland, CA 94612

Collected by: Bill Sass   Send Results To: Aileen Mendoza

Sample Analysis Requested (5) (Fill in the number of containers for each test)

Sample ID (* For composites - indicate start and stop date/time)	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive	TSCA Regulated	Total number of containers	Ra-226 Full Hold 30d 4.5" 2:3									<-- Preservative Type (6) / Comments: Note: extra sample is required for sample specific QC
Amm32-19-02	06/15/12	1145			SOIL	X		1	X									
-20-02		1200																
-21-02		1205																
-22-02		1210																
-23-02		1425																
-123-02		1430																
-24-02		1440																
-25-02		1510																
Amm33-08-02		1255																
-108-02		1300																

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No   Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* See p. 1

Sample Collection Time Zone: Eastern Pacific Central Other ______ Mountain

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 William Sass	6/16/12		1 [signature]	6-18-12	0815
2			2		
3			3		

Sample Shipping and Delivery Details

GEL PM:

Method of Shipment: Date Shipped:

Airbill #:

Airbill #:

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B - 3, 6010B/7470A - 1*).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only
Custody Seal Intact? *YES* *NO*
Cooler Temp: C

WHITE = LABORATORY YELLOW = FILE PINK = CLIENT

<a copy> Jeanne Z Christopher 7/27/12

Page: 5 of 12
Project #: EE-002693-2164-06TT
GEL Quote #: EE-002693-2165-06TT
COC Number (1):
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: Ecology and Environment Phone #: 415-971-9633
Project/Site Name: Tronox Fax #:
Address: 1940 Webster St, Ste 100, Oakland, CA 94612
Collected by: Bill Sass Send Results To: Aileen Mendoza

Sample Analysis Requested (5) (Fill in the number of containers for each test)

<-- Preservative Type (6)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive	TSCA Regulated	Total number of containers	Ra-226 EML HASL 300, 4.5.2.3	Comments Note: extra sample is required for sample specific QC
AMM33-09-02	06/15/12	1305			Soil	X		1	X	
-10-02		1310								
-11-02		1315								
-12-02		1325								
-13-02		1330								
-14-02		1515								
-15-02		1525								
-16-02		1535								
-WP-01		1540								
-WP-02		1545								

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* Sep. i

Sample Collection Time Zone
Eastern Pacific
Central Other ________
Mountain

Chain of Custody Signatures						Sample Shipping and Delivery Details	
Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time	GEL PM:	
1 William Sass	6/16/12		1 JRJ	6-18-12	0815	Method of Shipment:	Date Shipped:
2			2			Airbill #:	
3			3			Airbill #:	

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. 8260B - 3, 6010B/7470A - 1).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only
Custody Seal Intact?
YES NO
Cooler Temp:
C

WHITE = LABORATORY YELLOW = FILE PINK = CLIENT

<a copy> Joanna Christopher 7/27/12

Page: 6 of 12
Project #: EE-002693-2164-06TT
GEL Quote #: EE-002693-2165-06TT
COC Number (1):
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: Geology and Environment Phone #: 415-971-9633
Project/Site Name: Tronox Fax #: 510-550-2760
Address: 1940 Webster St, Ste 100, Oakland, CA 94612
Collected by: Bill Sass Send Results To: Aileen Mendoza

Sample Analysis Requested (5) (Fill in the number of containers for each test)

<-- Preservative Type (6)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive	TSCA Regulated	Total number of containers	Ra-226 EML HASL 300, Th-232										Comments Note: extra sample is required for sample specific QC
AUM33-01-02	06/15/12	1320			SOIL	X		1	X										
-01-12		1325																	
-01-24		1335																	
-01-36		1345																	
-101-12		1330																	
-02-02		1418																	
-02-12		1420																	
-02-24		1423																	
-02-36		1426																	
-102-24		1429																	

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* See p. 1

Sample Collection Time Zone
Eastern Pacific
Central Other ______
Mountain

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 William Sass	6/16/12		1 [illegible]	6-18-12	0815
2			2		
3			3		

Sample Shipping and Delivery Details

GEL PM:
Method of Shipment: Date Shipped:
Airbill #:
Airbill #:

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B - 3, 6010B/7470A - 1*).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only
Custody Seal Intact?
YES NO
Cooler Temp:
C

WHITE = LABORATORY YELLOW = FILE PINK = CLIENT

<Lacgjt? Joanna Z Christopher 7/27/12

Page: 7 of 12
Project #: EE-2693-2164-06TT
GEL Quote #: EE-2693-2165-06TT
COC Number (1):
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: Ecology and Environment Phone #: 415-971-9633
Project/Site Name: Tronox Fax #: 510-550-2760
Address: 1940 Webster ST, STE 100, Oakland, CA 94612
Collected by: Bill Sass Send Results To: Aileen Mendoza

Sample Analysis Requested (5) (Fill in the number of containers for each test)

<-- Preservative Type (6)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive	TSCA Regulated	Total number of containers	RA-226 EML HASL 300 4.5.2.3										Comments Note: extra sample is required for sample specific QC
AUM33-03-02	06/15/12	1445			SOIL	X		1	X										
-03-12	↓	1448			↓	↓		↓	↓										
-03-24	↓	1450			↓	↓		↓	↓										
-03-36	↓	1500			↓	↓		↓	↓										
-103-36	↓	1455			↓	↓		↓	↓										
-04-02	↓	1503			↓	↓		↓	↓										
-04-12	↓	1512			↓	↓		↓	↓										
-04-24	↓	1519			↓	↓		↓	↓										
-04-36	↓	1530			↓	↓		↓	↓										
-05-02	↓	1535			↓	↓		↓	↓										

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* See p.1

Sample Collection Time Zone
Eastern Pacific
Central Other ______
Mountain

Chain of Custody Signatures						Sample Shipping and Delivery Details	
Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time	GEL PM:	
1 William Sass	6/16/12		1 JJ	6-18-12	0815	Method of Shipment:	Date Shipped:
2			2			Airbill #:	
3			3			Airbill #:	

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B* - 3, *6010B/7470A* - 1).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only	
Custody Seal Intact?	
YES	*NO*
Cooler Temp:	
C	

WHITE = LABORATORY YELLOW = FILE PINK = CLIENT

<a copy> Joanna Christopher 7/27/12

Page: 8 of 12
Project #: EE-002693-2164-06TT
GEL Quote #: EE-002693-2165 06TT
COC Number (1):
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: Bill Sass Phone #: 415-971-9633
Project/Site Name: Tronox Fax #: 510-550-2760
Address: 1940 Webster St, Ste 100, Oakland, CA 94612
Collected by: Bill Sass Send Results To: Aileen Mendoza

Sample Analysis Requested (5) (Fill in the number of containers for each test)

<-- Preservative Type (6)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive	TSCA Regulated	Total number of containers	Am-241 EML HASL 300, 4.5.2.3	Comments Note: extra sample is required for sample specific QC
AUM33-05-12	06/15/12	1538			SOIL	X		1	X	
-05-24		1545								
-05-36		1555								
-06-02		1605								
-06-12		1610								
-06-24		1615								
-06-34		1620								
-07-02		1630								
-07-12		1632								
-07-24		1635								

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No   Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* See p. 3

Sample Collection Time Zone
Eastern Pacific
Central Other ______
Mountain

Chain of Custody Signatures					
Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 William Sass	6/16/12		1 JDJ	6-18-12	0815
2			2		
3			3		

Sample Shipping and Delivery Details

GEL PM:
Method of Shipment: Date Shipped:
Airbill #:
Airbill #:

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. 8260B - 3, 6010B/7470A - 1).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only
Custody Seal Intact?
YES *NO*
Cooler Temp:
C

WHITE = LABORATORY YELLOW = FILE PINK = CLIENT

<a copy> Joanna Z Christy [illegible] 7/21/12

Page: 9 of 12
Project #: EE-002693-2164-CGTT
GEL Quote #: EE-002693-2165-CGTT
COC Number (1):
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: Ecology and Environment Phone #: 415-971-9633
Project/Site Name: Tronox Fax #: 510-550-2760
Address: 1940 Webster St, Ste 100, Oakland, CA 94612
Collected by: Bill Sass Send Results To: Aileen Mendoza

Sample Analysis Requested (5) (Fill in the number of containers for each test)

<-- Preservative Type (6)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive	TSCA Regulated	Total number of containers	Au-226 RML HASL 300, 4.5.2.3										Comments Note: extra sample is required for sample specific QC
AUM33-07-36	06/15/12	1640			SOL	X		1	X										
AUM32-02-02	↓	0945			↓	↓		↓	↓										
-02-12		0950																	
-02-24		1000																	
-02-36		1010																	
-102-36		1012																	
-03-02		1017																	
-03-12		1025																	
-03-24		1032																	
-03-36		1036																	

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* See p. 1

Sample Collection Time Zone
Eastern Pacific
Central Other ______
Mountain

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 William Sass	6/16/12		1 JRJ	6-18-12	0815
2			2		
3			3		

Sample Shipping and Delivery Details

GEL PM:
Method of Shipment: Date Shipped:
Airbill #:
Airbill #:

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B - 3, 6010B/7470A - 1*).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only
Custody Seal Intact? YES NO
Cooler Temp: C

WHITE = LABORATORY YELLOW = FILE PINK = CLIENT

<a copy> Joanna Christopher 7/27/12

Page: 10 of 12 Project #: EE-2693-2164-06TT GEL Quote #: EE-002693-2165-06TT COC Number (1): PO Number:	**GEL Chain of Custody and Analytical Request** GEL Work Order Number:	GEL Laboratories, LLC 2040 Savage Road Charleston, SC 29407 Phone: (843) 556-8171 Fax: (843) 766-1178

Client Name: Ecology and Environment Phone #: 415-971-9633

Project/Site Name: Tronox Fax #: 510-550-2760

Address: 1940 Webster ST., Ste 100, Oakland, CA 94612

Collected by: Bill Jass Send Results To: Aileen Mendoza

Sample Analysis Requested (5) (Fill in the number of containers for each test)

<-- Preservative Type (6)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive	TSCA Regulated	Total number of containers	Ra-226 EML HASL-300 4.5.2.3									Comments Note: extra sample is required for sample specific QC
AUM32-103-12	06/15/12	1028			SOIL	X		1	X									
-04-02		1042																
-04-12		1051																
-04-24		1055																
-04-36		1100																
-05-02		1125																
-05-12		1130																
-05-24		1134																
-05-36		1140																
-06-02		1150																

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* See p. 1

Sample Collection Time Zone: Eastern Pacific Central Other ______ Mountain

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 William Jass	6/16/12		1 [signature]	6-18-12	0815
2			2		
3			3		

Sample Shipping and Delivery Details

GEL PM:

Method of Shipment: Date Shipped:

Airbill #:

Airbill #:

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B - 3, 6010B/7470A - 1*).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only
Custody Seal Intact? *YES* *NO*
Cooler Temp: *C*

WHITE = LABORATORY **YELLOW = FILE** **PINK = CLIENT**

<a copy> Joanna Z Christopher 7/27/12

Page: 11 of 13
Project #: EE-002693-2164-06TT
GEL Quote #: EE-002693-2165-06TT
COC Number (1):
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: Ecology and Environment Phone #: 415-971-9633
Project/Site Name: Tronox Fax #: 510-550-2760
Address: 1940 Webster St, Ste 100, Oakland CA 94612
Collected by: Bill Sass Send Results To: Aileen Mendoza

Sample Analysis Requested (5) (Fill in the number of containers for each test)

<-- Preservative Type (6)

Should this sample be considered:

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Radioactive	TSCA Regulated	Total number of containers	Ra-226 EML HASL 300 4.5.2.3	Comments Note: extra sample is required for sample specific QC
Aum 32-06-12	06/15/12	1152			SOIL	X		1	X	
-06-24		1154								
-06-36		1156								
-07-02		1210								
-07-12		1212								
-07-24		1215								
-07-36		1220								
-106-24		1154								
-08-02		1230								
-08-12		1235								

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: ~~Yes~~ / No

Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* See p. 1

Sample Collection Time Zone
Eastern Pacific
Central Other ________
Mountain

Chain of Custody Signatures					
Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 William Sass	6/14/12		1 [signature]	6-18-12	0815
2			2		
3			3		

Sample Shipping and Delivery Details

GEL PM:
Method of Shipment: Date Shipped:
Airbill #:
Airbill #:

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B - 3, 6010B/7470A - 1*).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only
Custody Seal Intact?
YES NO
Cooler Temp:
C

WHITE = LABORATORY **YELLOW = FILE** **PINK = CLIENT**

<a copy> Joanna Z Christopher 7/27/12

Page: 12 of 12
Project #: EE-002693-2164-06TT
GEL Quote #: EE-002693-2165-06TT
COC Number (1):
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: Ecology and Environment Phone #: 415-971-9633
Project/Site Name: Tronox Fax #: 510-556-2760
Address: 1940 Webster St, Ste 100, Oakland, CA 94612
Collected by: Bill Sass Send Results To: Aileen Mendoza

Sample Analysis Requested (5) (Fill in the number of containers for each test)

<-- Preservative Type (6)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive	TSCA Regulated	Total number of containers	Ra-226 EML HASL 300 4.5.2.3	Comments Note: extra sample is required for sample specific QC
AUM32-08-24	06/15/12	1240			Soil	X		1	X	
-08-36		1242								
-09-02		1247								
-09-12		1255								
-09-24		1300								
-09-36		1310								
AUM33-WP-03		1500								
TRONOX-QC-04		1700								
QC-05		1705								
QC-06		1708								

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* See p. 1

Sample Collection Time Zone
Eastern Pacific
Central Other ________
Mountain

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time		Received by (signed)	Date	Time
1	William Sass	6/16/12		1	[signature]	6-18-12	0815
2				2			
3				3			

Sample Shipping and Delivery Details

GEL PM:
Method of Shipment: Date Shipped:
Airbill #:
Airbill #:

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B* - 3, *6010B/7470A* - 1).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only
Custody Seal Intact?
YES NO
Cooler Temp:
C

WHITE = LABORATORY YELLOW = FILE PINK = CLIENT

GEL Laboratories LLC

SAMPLE RECEIPT & REVIEW FORM

Client: ECOL	SDG/AR/COC/Work Order: 306310
Received By: JP	Date Received: 6-18-12

Suspected Hazard Information	Yes	No	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
COC/Samples marked as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 cpm
Classified Radioactive II or III by RSO?		✓	If yes, Were swipes taken of sample containers < action levels?
COC/Samples marked containing PCBs?		✓	
Package, COC, and/or Samples marked as beryllium or asbestos containing?		✓	If yes, samples are to be segregated as Safety Controlled Samples, and opened by the GEL Safety Group.
Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#:
Samples identified as Foreign Soil?		✓	

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*		✓		Preservation Method: Ice bags Blue ice Dry ice None Other (describe) 22 *all temperatures are recorded in Celsius
2a	Daily check performed and passed on IR temperature gun?	✓			Temperature Device Serial #: 41552209 Secondary Temperature Device Serial # (If Applicable):
3	Chain of custody documents included with shipment?	✓			
4	Sample containers intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
5	Samples requiring chemical preservation at proper pH?		✓		Sample ID's, containers affected and observed pH: If Preservation added, Lot#:
6	VOA vials free of headspace (defined as < 6mm bubble)?		✓		Sample ID's and containers affected:
7	Are Encore containers present?			✓	(If yes, immediately deliver to Volatiles laboratory)
8	Samples received within holding time?	✓			ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?			✓	Sample ID's and containers affected: AUM33-06-36 is AUM33-06-34 on container
10	Date & time on COC match date & time on bottles?	✓			Sample ID's affected:
11	Number of containers received match number indicated on COC?			✓	Sample ID's affected: See below
12	Are sample containers identifiable as GEL provided?	✓			
13	COC form is properly signed in relinquished/received sections?	✓			
14	Carrier and tracking number.				Circle Applicable: FedEx Air FedEx Ground UPS Field Services Courier Other 7936 8910 2654 7936 8910 2076 7936 8910 2584

Comments (Use Continuation Form if needed):

Did not receive any of the Tronox -QC samples
all QC samples are water

PM (or PMA) review: Initials JP Date 6-18-12 Page 1 of 1

<a copy> Joanna Christopher 7/27/12

GEL Laboratories LLC

SAMPLE RECEIPT & REVIEW FORM

Client: ECOL			**SDG/AR/COC/Work Order:** 306310
Received By: JP			**Date Received:** 6-19-12
Suspected Hazard Information	**Yes**	**No**	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
COC/Samples marked as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0cpm
Classified Radioactive II or III by RSO?		✓	If yes, Were swipes taken of sample contatiners < action levels?
COC/Samples marked containing PCBs?		✓	
Package, COC, and/or Samples marked as beryllium or asbestos containing?		✓	If yes, samples are to be segregeated as Safety Controlled Samples, and opened by the GEL Safety Group.
Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#:
Samples identified as Foreign Soil?		✓	

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*		✓		Preservation Method: Ice bags Blue ice Dry ice None Other (describe) *all temperatures are recorded in Celsius 24
2a	Daily check performed and passed on IR temperature gun?	✓			Temperature Device Serial #: 41802209 Secondary Temperature Device Serial # (If Applicable):
3	Chain of custody documents included with shipment?			✓	COC received w/ first 3 coolers on 6-18-12
4	Sample containers intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
5	Samples requiring chemical preservation at proper pH?	✓			Sample ID's, containers affected and observed pH: If Preservation added, Lot#:
6	VOA vials free of headspace (defined as < 6mm bubble)?		✓		Sample ID's and containers affected:
7	Are Encore containers present?			✓	(If yes, immediately deliver to Volatiles laboratory)
8	Samples received within holding time?				ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓			Sample ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓			Sample ID's affected:
11	Number of containers received match number indicated on COC?	✓			Sample ID's affected:
12	Are sample containers identifiable as GEL provided?	✓			
13	COC form is properly signed in relinquished/received sections?	✓			
14	Carrier and tracking number.				Circle Applicable: FedEx Air FedEx Ground UPS Field Services Courier Other

Comments (Use Continuation Form if needed):

Received all Tronox-QC samples

PM (or PMA) review: Initials JP Date 6-19-12 Page 1 of 1

<a copy> Joanna Christopher 7/27/12

Subject: RE: Tronox Sampling
From: "Mendoza, Aileen" <AMendoza@ene.com>
Date: 6/18/2012 12:29 PM
To: <jen01574@gel.com>

From: Mendoza, Aileen
Sent: Monday, June 18, 2012 9:27 AM
To: jennifer.pellegrini@gel.com
Cc: Song, Mindy; Edwards, Howard F.
Subject: RE: Tronox Sampling

Hi Jennifer,
The first shipment has 4 coolers. FedEx said the 4th cooler will arrive tomorrow morning; please start processing these samples as soon as it arrive. Please start processing the samples in the 3 coolers you received except the sample IDs with BKG.

Please place the BKG samples on hold (do not analyze); a new set of samples with ID BKG2 will be shipped to you to replace these. Let me know if you have any questions.

Thanks,

Aileen Mendoza
Superfund Technical Assessment & Response Team (START)
Ecology and Environment, Inc.
1940 Webster Street Suite 100, Oakland CA 94612
Office: (510) 893-6700 Ext: 4810 | Mobile: (415) 971-9633
amendoza@ene.com | www.ene.com
40
Celebrating 40 Years of Green Solutions

-----Original Message-----
From: Jennifer Pellegrini [mailto:jennifer.pellegrini@gel.com]
Sent: Monday, June 18, 2012 7:53 AM
To: Song, Mindy
Cc: team.crook
Subject: Tronox Sampling

Mindy,

We received the first set of Tronox samples today, however it looks like one of the coolers didn't make it. The inbound report says there were 4 coolers, but we only got 3. It says they were all delivered, so you may want to check in with Fed-Ex on that part. The cooler we did not receive container all the samples where the ID started with Tronox-QC. Please let us know if you'd like us to go ahead and start the other samples, or wait for the other cooler to come before we log them in.

Thanks,
Jennifer
--
Jennifer Pellegrini Project Manager Assistant GEL Laboratories, LLC 2040 Savage Road PO Box 30712 Charleston, SC 29417 (843) 769-7376 ext 4708

<a copy> Joanna Christopher 7/27/12

(843) 766-1178 fax jen01574@gel.com

<a copy> Joanna Christopher 7/25/12

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location:** **Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

Laboratory: GEL Laboratories	**Lab Project Number:** SDG 306761
Sampling Dates: June 16, 2012	**Sample Matrix:** Soil; Water
Analytical Method: *DOE HASL 300, 4.5.2.3/Ga-01-R, Gamma Spectroscopy.*	**Data Reviewer:** Joanna Z. Christopher

REVIEW AND APPROVAL:

Data Reviewer: Joanna Z Christopher **Date:** 7/27/12
Technical QA Reviewer: ____________ **Date:** ________
Project Manager: ____________ **Date:** ________

SAMPLE IDENTIFICATION:

Sample No.	Sample I.D.	Laboratory I.D.
1	Tronox - BKG2 - 01	306761001
2	Tronox - BKG2 - 02	306761002
3	Tronox - BKG2 - 03	306761003
4	Tronox - BKG2 - 04	306761004
5	Tronox - BKG2 - 05	306761005
6	Tronox - BKG2 - 06	306761006
7	Tronox - BKG2 - 07	306761007
8	Tronox - BKG2 - 08	306761008
9	Tronox - BKG2 - 09	306761009
10	Tronox - BKG2 - 10	306761010
11	Tronox - BKG2 - 11	306761011

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

DATA PACKAGE COMPLETENESS CHECKLIST:

Checklist Code:

X **Included: no problems**
* **Included: problems noted in review**
O **Not Included and/or Not Available**
NR **Not Required**
RS **Provided As Re-submission**

Case Narrative:

X **Case Narrative present**

Quality Control Summary Package:

X **Data Summary sheets**
X **Initial and Continuing Calibration results**
X **Detector Background Control Charts**
X **Matrix Spike recoveries**
X **Matrix Duplicate results**
X **Laboratory Control Sample recoveries**
X **Analysis Detection Limits**
X **Preparation Log**
X **Analysis Run Log**

Raw QC Data Package Section

X **Chain-of-Custody Records**
X **Instrument Printouts**
X **Sample Preparation Notebook Pages**
X **Logbook and Worksheet Pages**
NR **Percent Solids Determination**

Comments: Soil samples were prepared using a dry soil preparation method and results were reported on a dry weight basis, therefore percent solids determination was not required.

For this analysis there was a minimum 21-day ingrowth period for radon gas to decay to bismuth for analysis. The laboratory ingrowth was 22 days. The samples were analyzed 34 days after collection.

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

DATA VALIDATION SUMMARY

The data were reviewed following procedures and limits specified in the EPA OSWER directive, *Quality Assurance/Quality Control Guidance for Removal Activities, Sampling QA/QC Plan and Data Validation Procedures* (EPA/540/G-90/004, OSWER Directive 9360.4-01, dated April 1990).

Indicate with a YES or NO whether each item is acceptable without qualification:

1	**Holding Times**	**Yes**
2	**Initial and Continuing Calibrations**	**Yes**
3	**Laboratory Control Sample**	**Yes**
4	**Matrix Spike**	**Yes**
5	**Blanks and Background Samples**	**Yes**
6	**Duplicate Analyses**	**Yes**
7	**Analyte Quantitation**	**Yes**
8	**Overall Assessment of Data**	**Yes**
9	**Usability of Data**	**Yes**

Comments: This SDG consists of background samples for the samples under SDG 306310 for this project.

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

1. HOLDING TIMES

__X__ Acceptable
______ Acceptable with qualification
______ Unacceptable

Samples were extracted and analyzed within required holding times except as noted under Comments. In addition, no problems were identified with regard to sample preservation or custody unless specified. For those samples analyzed outside holding time requirements, the detected results have been qualified as estimated (J), and the nondetected results have been qualified either as estimated (UJ) or rejected (R) based on the reviewer's judgment.

<u>All Sample Matrices:</u>
Radiochemistry analyses: 6 months from collection to analysis.

Comments: None.

2. INITIAL AND CONTINUING CALIBRATION VERIFICATION

__X__ Acceptable
______ Acceptable with qualification
______ Unacceptable

Unless flagged below, an initial calibration verification (ICV), background, and efficiency check were performed for each detector at the beginning of the run, and were within the laboratory acceptance limits.

Comments: None

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location:** **Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

3. LABORATORY CONTROL SAMPLE

__X__ Acceptable
______ Acceptable with qualification
______ Unacceptable
______ No Laboratory Control Samples Analyzed

Laboratory control sample recoveries are used for a qualitative indication of accuracy (bias) independent of matrix effects. LCS recovery limits should either be specified in the Sampling and Analysis Plan or can be established by the laboratory. For analytes which exceeded these control limits, associated detected results are qualified as estimated (J). In cases where the recovery was below 30%, all associated nondetected results are rejected (R) and detected results are qualified as estimated (J).

Comments: None.

4. MATRIX SPIKE

__X__ Acceptable
______ Acceptable with qualification
______ Unacceptable
______ No Matrix Spikes Analyzed

Matrix spike recoveries are used for a qualitative indication of accuracy (bias) due to matrix effects. Unless flagged below, one matrix spike sample was analyzed at a rate of one per batch or one per 20 samples. Recoveries were within a range of 75-125%. For analytes which exceeded these control limits, associated detected results are qualified as estimated (J). In cases where the recovery was below 30%, all associated nondetected results are rejected (R) and detected results are qualified as estimated (J).

Comments: The SAP does not require laboratory QC samples (MS/MSD) for gamma spec or Lucas Cell Ra-226 analyses. No MS/MSD analyses were performed for this SDG.

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

5. BLANKS AND BACKGROUND SAMPLES

___X___ **Acceptable**
_______ **Detection Limits Adjusted**

The following blanks were analyzed:
___X___ **Method (preparation) Blanks**
_______ **Field Blanks**
___X___ **Calibration Blanks (instrument background check)**
_______ **Rinsate Blanks**
___X___ **Background Samples**

Preparation (method) blanks were prepared for each batch of samples extracted. A preparation blank was analyzed after every continuing calibration standard, prior to sample analysis unless noted below. Any radionuclide detected in the sample and also detected in any associated blank, must be qualified as non-detect (U) when the sample concentration is less than 5x the blank concentration.

Comments: This SDG consists of eleven background samples that were collected as required by the SAP for Ra-226 analysis for the samples that were analyzed under a separate SDG (SDG 306310). See the DVM for that SDG for more information.

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

6. DUPLICATE ANALYSES

__X__ **Acceptable**
_______ **Acceptable with qualification**
_______ **Unacceptable**
_______ **No Duplicates Analyzed**

Type of duplicates analyzed:
_______ **Field Duplicates**
__X__ **Laboratory Duplicates**

Calculate the relative Percent Difference (RPD) between the members of duplicate pairs using the equation indicated below. Qualify the detected results as estimated (J) for any analyte whose RPD in a laboratory duplicate exceeds 20% for water samples or 35% for soil samples.

$$\text{RPD} = \frac{2(\text{Value 1} - \text{Value 2})}{\text{Value 1} + \text{Value 2}} \times 100\%$$

Comments:
The SAP does not require collection of field duplicate samples for the background sampling effort.

The laboratory performed one laboratory duplicate analysis for gamma spec analysis for this SDG with acceptable precision.

7. ANALYTE QUANTITATION

Confirm that analyte quantitation was performed correctly using the following formula:

$$\text{Ra-226 (pci/g)} = \frac{\text{gross sample cts} - \text{gross background counts}}{2.22 \times \text{counting efficiency} \times \text{sample mass} \times \text{isotopic abundance} \times \text{count time} \times \text{ingrowth factor}}$$

Comments: 10% of the results were calculated and found to be correct, as shown below.

Ra-226 by gamma spec:

GEL sample id	net cts	ingrowth factor	% eff	Mass, g	% abn	ct time, min	calc result	rpt res	% calc v rpt
3067610005	331	1	0.02712	152.46	0.463	120	0.6490	0.648	100.1595
3067610008	390	1	0.02841	154.25	0.463	120	0.7215	0.722	99.9346

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: TO-02-09-11-10-0004 and TO-02-09-11-10-0005	**PAN:** EE-002693-2164-01TTO and EE-002693-2165-01TTO

8. OVERALL ASSESSMENT OF DATA

On the basis of this review, the following determination has been made with regard to the overall data usability for the specified level.

__X__ **Acceptable**
______ **Acceptable with Qualification**
______ **Rejected**

Accepted data meet the minimum requirements for the following EPA data category:
______ **ERS Screening**
______ **Non-definitive with 10 % Conformation by Definitive Methodology**
______ **Definitive, Comprehensive Statistical Error Determination was performed.**
__X__ **Definitive, Comprehensive Statistical Error Determination was not performed.**

Any qualifications to individual sample analysis results are detailed in the appropriate section above or appear under the comments section below. In cases where several QC criteria are out of specification, it may be appropriate to further qualify the data usability. The data reviewer must use professional judgment and express concerns and comments on the data validity for each specific data package.

Comments: Ra-228 was detected in all of the samples in this SDG at low levels ranging from 0.52 to 0.92 pCi/g, likely due to radioactive decay of naturally occurring Th-232. Cs-137 was also detected in all of the samples in this SDG at low levels ranging from 0.12 to 0.38 pCi/g, likely due to atmospheric radioactive fallout.

9. DOCUMENTATION OF LABORATORY CORRECTIVE ACTION

Problem: None.

Resolution:

Attached are copies of all data summary sheets, with data qualifiers indicated, and a copy of the chain of custody for the samples.

GEL LABORATORIES LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: July 24, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox - BKG2 - 01	Project:	ECOL00722
Sample ID:	306761001	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-JUN-12 12:20		
Receive Date:	28-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.666	+/-0.142	0.0913	1.00	pCi/g		MXR1	07/20/12	0708	1225618	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/28/12	1411	1225586

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Christopher 7/27/12

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: July 24, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox - BKG2 - 02	Project:	ECOL00722
Sample ID:	306761002	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-JUN-12 12:22		
Receive Date:	28-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.592	+/-0.132	0.0809	1.00	pCi/g		MXR1	07/20/12	0709	1225618	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/28/12	1411	1225586

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Z Christopher 7/27/12

GEL LABORATORIES LLC
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Certificate of Analysis

Report Date: July 24, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox - BKG2 - 03	Project:	ECOL00722
Sample ID:	306761003	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-JUN-12 12:24		
Receive Date:	28-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.801	+/-0.152	0.107	1.00	pCi/g		MXR1	07/20/12	0709	1225618	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/28/12	1411	1225586

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Christopher 7/27/12

GEL LABORATORIES LLC

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Certificate of Analysis

Report Date: July 24, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox - BKG2 - 04	Project:	ECOL00722
Sample ID:	306761004	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-JUN-12 12:26		
Receive Date:	28-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.900	+/-0.150	0.0979	1.00	pCi/g		MXR1	07/20/12	0709	1225618	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/28/12	1411	1225586

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Christopher 7/27/12

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Certificate of Analysis

Report Date: July 24, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox - BKG2 - 05	Project:	ECOL00722
Sample ID:	306761005	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-JUN-12 12:29		
Receive Date:	28-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.648	+/-0.133	0.0725	1.00	pCi/g		MXR1	07/20/12	0710	1225618	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/28/12	1411	1225586

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Z Christopher 7/27/12

GEL LABORATORIES LLC

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Certificate of Analysis

Report Date: July 24, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox - BKG2 - 06	Project:	ECOL00722
Sample ID:	306761006	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-JUN-12 12:30		
Receive Date:	28-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.740	+/-0.126	0.0856	1.00	pCi/g		MXR1	07/20/12	0710	1225618	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/28/12	1411	1225586

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Christopher 7/27/12

GEL LABORATORIES LLC

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Certificate of Analysis

Report Date: July 24, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox - BKG2 - 07	Project:	ECOL00722
Sample ID:	306761007	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-JUN-12 12:32		
Receive Date:	28-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.701	+/-0.148	0.0931	1.00	pCi/g		MXR1	07/20/12	0710	1225618	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/28/12	1411	1225586

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Z Christopher 7/27/12

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Certificate of Analysis

Report Date: July 24, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox - BKG2 - 08	Project:	ECOL00722
Sample ID:	306761008	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-JUN-12 12:54		
Receive Date:	28-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.722	+/-0.128	0.0787	1.00	pCi/g		MXR1	07/20/12	0711	1225618	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/28/12	1411	1225586

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Z Christopher 7/27/12

GEL LABORATORIES LLC

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Certificate of Analysis

Report Date: July 24, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox - BKG2 - 09	Project:	ECOL00722
Sample ID:	306761009	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-JUN-12 12:36		
Receive Date:	28-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.728	+/-0.134	0.0797	1.00	pCi/g		MXR1	07/20/12	0711	1225618	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/28/12	1411	1225586

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Z Christopher 7/27/12

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: July 24, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox - BKG2 - 10	Project:	ECOL00722
Sample ID:	306761010	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-JUN-12 12:38		
Receive Date:	28-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.698	+/-0.136	0.0708	1.00	pCi/g		MXR1	07/20/12	0712	1225618	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/28/12	1411	1225586

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Christopher 7/27/12

GEL LABORATORIES LLC

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Certificate of Analysis

Report Date: July 24, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	Tronox - BKG2 - 11	Project:	ECOL00722
Sample ID:	306761011	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-JUN-12 12:40		
Receive Date:	28-JUN-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.626	+/-0.173	0.147	1.00	pCi/g		MXR1	07/20/12	0712	1225618	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	06/28/12	1411	1225586

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Page: 1 of 2	
Project #: EE-2693-2244-06TTO	
GEL Quote #:	
COC Number (1):	
PO Number:	

GEL Chain of Custody and Analytical Request

20120692708

GEL Work Order Number: 306TC1%

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: Ecology and Environment   Phone #: 510-893-6700

Project/Site Name: Tronox   Fax #:

Address: 1940 Webster ST, Suite 100, Oakland, CA 94612

Collected by: Adam Ellis   Send Results To: Aileen Mendoza

Sample Analysis Requested (5) (Fill in the number of containers for each test)

Sample ID (* For composites - indicate start and stop date/time)	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive	TSCA Regulated	Total number of containers	Ra-226 EML HASL 300, 4.5.2.3										Comments (<-- Preservative Type (6)) Note: extra sample is required for sample specific QC
Tronox-BKG2-01	6-16-12	1220			50	X		1	X										
Tronox-BKG2-02		1222							X										
Tronox-BKG2-03		1224							X										
Tronox-BKG2-04		1226							X										
Tronox-BKG2-05		1229							X										
Tronox-BKG2-06		1230							X										
Tronox-BKG2-07		1232							X										
Tronox-BKG2-08		1254							X										
Tronox-BKG2-09		1236							X										
Tronox-BKG2-10		1238				✓			X										

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards*

Aileen Mendoza
amendoza@ene.com

Sample Collection Time Zone: Eastern, Pacific, Central, Other ______, Mountain

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1	[signature]	6/25/12		[signature]	6-28-12	0855
2						
3						

Sample Shipping and Delivery Details

GEL PM:

Method of Shipment: FedEx   Date Shipped: 6/25/12

Airbill #:

Airbill #:

For Lab Receiving Use Only

Custody Seal Intact? *YES* *NO*

Cooler Temp: *C*

1.) Chain of Custody Number = Client Determined
2.) QC Codes: **N** = Normal Sample, **TB** = Trip Blank, **FD** = Field Duplicate, **EB** = Equipment Blank, **MS** = Matrix Spike Sample, **MSD** = Matrix Spike Duplicate Sample, **G** = Grab, **C** = Composite
3.) Field Filtered: For liquid matrices, indicate with a - **Y** - for yes the sample was field filtered or - **N** - for sample was not field filtered.
4.) Matrix Codes: **DW**=Drinking Water, **GW**=Groundwater, **SW**=Surface Water, **WW**=Waste Water, **W**=Water, **SO**=Soil, **SD**=Sediment, **SL**=Sludge, **SS**=Solid Waste, **O**=Oil, **F**=Filter, **P**=Wipe, **U**=Urine, **F**=Fecal, **N**=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. **8260B, 6010B/7470A**) and number of containers provided for each (i.e. *8260B - 3, 6010B/7470A - 1*).
6.) Preservative Type: **HA** = Hydrochloric Acid, **NI** = Nitric Acid, **SH** = Sodium Hydroxide, **SA** = Sulfuric Acid, **AA** = Ascorbic Acid, **HX** = Hexane, **ST** = Sodium Thiosulfate, If no preservative is added = leave field blank

WHITE = LABORATORY   **YELLOW = FILE**   **PINK = CLIENT**

<a copy> Joanna Z Christopher 7/27/12

Page: 2 of 2
Project #: EE-2693-2244-06TTO
GEL Quote #:
COC Number [1]:
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: Ecology and Environment Phone #: 510-893-6700
Project/Site Name: Tronox Fax #:
Address: 1940 Webster St, Suite 100, Oakland, CA 94612
Collected by: Adam Ellis Send Results To: Aileen Mendoza

Sample Analysis Requested [5] (Fill in the number of containers for each test)

<-- Preservative Type (6)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code [2]	Field Filtered [3]	Sample Matrix [4]	Should this sample be considered: Radioactive	TSCA Regulated	Total number of containers	Ra-226 EML HASL 300.4.5.2.3	Comments Note: extra sample is required for sample specific QC
Tronox-BKG2-11	6-16-12	1240			SO	X		1	Y	

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards*

~~amme~~ amendoza@ene.com

Sample Collection Time Zone
Eastern Pacific
Central Other ______
Mountain

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 [signature]	6/25/12		1 [signature]	6-28-12	0855
2			2		
3			3		

Sample Shipping and Delivery Details

GEL PM:
Method of Shipment: FedEx Date Shipped: 6/25/12
Airbill #:
Airbill #:

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B - 3, 6010B/7470A - 1*).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only
Custody Seal Intact? YES NO
Cooler Temp: C

WHITE = LABORATORY **YELLOW = FILE** **PINK = CLIENT**

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GEL Laboratories LLC

SAMPLE RECEIPT & REVIEW FORM

Client: ECOL			**SDG/AR/COC/Work Order:** 306761
Received By: JP			**Date Received:** 6-28-12
Suspected Hazard Information	**Yes**	**No**	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
COC/Samples marked as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0cpm
Classified Radioactive II or III by RSO?		✓	If yes, Were swipes taken of sample containers < action levels?
COC/Samples marked containing PCBs?		✓	
Package, COC, and/or Samples marked as beryllium or asbestos containing?		✓	If yes, samples are to be segregated as Safety Controlled Samples, and opened by the GEL Safety Group.
Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#:
Samples identified as Foreign Soil?		✓	

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*		✓		Preservation Method: Ice bags Blue ice Dry ice None Other (describe) 22 *all temperatures are recorded in Celsius
2a	Daily check performed and passed on IR temperature gun?	✓			Temperature Device Serial #41502209 Secondary Temperature Device Serial # (If Applicable):
3	Chain of custody documents included with shipment?	✓			
4	Sample containers intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
5	Samples requiring chemical preservation at proper pH?		✓		Sample ID's, containers affected and observed pH: If Preservation added, Lot#:
6	VOA vials free of headspace (defined as < 6mm bubble)?		✓		Sample ID's and containers affected:
7	Are Encore containers present?			✓	(If yes, immediately deliver to Volatiles laboratory)
8	Samples received within holding time?	✓			ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓			Sample ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓	✓		Sample ID's affected:
11	Number of containers received match number indicated on COC?	✓			Sample ID's affected:
12	Are sample containers identifiable as GEL provided?	✓			
13	COC form is properly signed in relinquished/received sections?	✓			
14	Carrier and tracking number.				Circle Applicable: FedEx Air FedEx Ground UPS Field Services Courier Other 899634870824

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials MK Date 07/2?/12 Page 1 of 1

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: 4500000368	**PAN:** EE-002693-2164-06TTO

Laboratory: GEL Laboratories	**Lab Project Number:** SDG 308334
Sampling Dates: July 17-19, 2012	**Sample Matrix:** Soil; Water
Analytical Method: *DOE HASL 300, 4.5.2.3/Ga-01-R, Gamma Spectroscopy; EPA 903.1 Modified, Ra-226, Lucas Cell.*	**Data Reviewer:** Joanna Z. Christopher

REVIEW AND APPROVAL:

Data Reviewer: Joanna Z Christopher **Date:** 8/31/12
Technical QA Reviewer: ______ **Date:** ______
Project Manager: ______ **Date:** ______

SAMPLE IDENTIFICATION:

Sample No.	Sample I.D.	Laboratory I.D.
1	AUM32-27-2	308334001
2	AUM32-27-12	308334002
3	AUM32-27-24	308334003
4	AUM32-27-36	308334004
5	AUM32-26-2	308334005
6	AUM32-26-12	308334006
7	AUM32-26-24	308334007
8	AUM32-26-36	308334008
9	AUM32-28-2	308334009
10	AUM32-28-12	308334010
11	AUM32-28-24	308334011
12	AUM32-28-36	308334012
13	AUM32-31-2	308334013
14	AUM32-31-12	308334014
15	AUM32-31-24	308334015
16	AUM32-31-36	308334016
17	AUM32-29-2	308334017
18	AUM32-29-12	308334018
19	AUM32-29-24	308334019
20	AUM32-29-36	308334020
21	AUM32-30-2	308334021
22	AUM32-30-12	308334022
23	AUM32-130-12	308334023
24	AUM32-30-24	308334024
25	AUM32-30-36	308334025
26	AUM32-44-2	308334026
27	AUM32-44-12	308334027
28	AUM32-44-24	308334028

ANALYTICAL DATA REVIEW SUMMARY
Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: 4500000368	**PAN:** EE-002693-2164-06TTO

Sample No.	Sample I.D.	Laboratory I.D.
29	AUM32-144-24	308334029
30	AUM32-44-36	308334030
31	AUM32-34-2	308334031
32	AUM32-134-2	308334032
33	AUM32-34-12	308334033
34	AUM32-34-24	308334034
35	AUM32-34-36	308334035
36	AUM32-33-2	308334036
37	AUM32-33-12	308334037
38	AUM32-33-24	308334038
39	AUM32-33-36	308334039
40	AUM32-41-2	308334040
41	AUM32-32-2	308334041
42	AUM32-32-12	308334042
43	AUM32-32-24	308334043
44	AUM32-32-36	308334044
45	AUM32-132-36	308334045
46	AUM32-36-2	308334046
47	AUM32-36-12	308334047
48	AUM32-136-12	308334048
49	AUM32-36-24	308334049
50	AUM32-36-36	308334050
51	AUM32-35-2	308334051
52	AUM32-35-12	308334052
53	AUM32-35-24	308334053
54	AUM32-135-24	308334054
55	AUM32-35-36	308334055
56	AUM32-38-2	308334056
57	AUM32-138-2	308334057
58	AUM32-38-12	308334058
59	AUM32-38-24	308334059
60	AUM32-38-36	308334060
61	AUM32-37-2	308334061
62	AUM32-37-12	308334062
63	AUM32-37-24	308334063
64	AUM32-37-36	308334064
65	AUM32-43-2	308334065
66	AUM32-39-2	308334066
67	AUM32-42-2	308334067
68	TRONOX-QC-11	308334068
69	TRONOX-QC-12	308334069

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location:** **Prewitt,** McKinley County, New Mexico
Project TDD Number: 4500000368	**PAN:** EE-002693-2164-06TTO

Sample No.	Sample I.D.	Laboratory I.D.
70	TRONOX-QC-13	308334070
71	AUM33-07-36	308334071
72	AUM33-07-48	308334072
73	AUM32-01-36	308334073
74	AUM32-01-48	308334074
75	AUM32-09-36	308334075
76	AUM32-09-48	308334076
77	AUM32-08-36	308334077
78	AUM32-08-48	308334078
79	TRONOX-QC-10	308334079
80	AUM32-40-2	308334080
81	AUM32-45-2	308334081
82	AUM32-46-2	308334082
83	AUM32-47-2	308334083
84	AUM32-48-2	308334084
85	AUM32-148-2	308334085
86	AUM32-49-2	308334086
87	AUM32-49-12	308334087
88	AUM32-49-24	308334088
89	TRONOX-QC-08	308334090
90	TRONOX-QC-09	308334091

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: 4500000368	**PAN:** EE-002693-2164-06TTO

DATA PACKAGE COMPLETENESS CHECKLIST:

Checklist Code:

- X — **Included: no problems**
- * — **Included: problems noted in review**
- O — **Not Included and/or Not Available**
- NR — **Not Required**
- RS — **Provided As Re-submission**

Case Narrative:

- X — **Case Narrative present**

Quality Control Summary Package:

- X — **Data Summary sheets**
- X — **Initial and Continuing Calibration results**
- X — **Detector Background Control Charts**
- X — **Matrix Spike recoveries**
- X — **Matrix Duplicate results**
- X — **Laboratory Control Sample recoveries**
- X — **Analysis Detection Limits**
- X — **Preparation Log**
- X — **Analysis Run Log**

Raw QC Data Package Section

- X — **Chain-of-Custody Records**
- X — **Instrument Printouts**
- X — **Sample Preparation Notebook Pages**
- X — **Logbook and Worksheet Pages**
- NR — **Percent Solids Determination**

Comments: Soil samples were prepared using a dry soil preparation method and results were reported on a dry weight basis, therefore percent solids determination was not required.

For the soil gamma spec analysis there was a minimum 21-day ingrowth period for radon gas to decay to bismuth for analysis. The laboratory ingrowth was 21 days. The samples were analyzed 28 to 29 days after collection.

For the water Lucas cell analysis there was no ingrowth period required and the samples were analyzed 14 to 16 days after collection.

Sample AUM32-44-24 was listed twice on the COC; however, the laboratory logged in the second sample as AUM32-144-24, likely due to the sample label.

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: 4500000368	**PAN:** EE-002693-2164-06TTO

Sample AUM32-49-27 was listed on the COC but was not logged in by the laboratory (and no results were reported); its laboratory ID would have been 308334089 and this number was skipped. There was not enough of this sample to perform the gamma analysis, therefore the analysis was canceled by the laboratory at E & E's direction.

DATA VALIDATION SUMMARY

The data were reviewed following procedures and limits specified in the EPA OSWER directive, *Quality Assurance/Quality Control Guidance for Removal Activities, Sampling QA/QC Plan and Data Validation Procedures* (EPA/540/G-90/004, OSWER Directive 9360.4-01, dated April 1990).

Indicate with a YES or NO whether each item is acceptable without qualification:

1	**Holding Times**	**Yes**
2	**Initial and Continuing Calibrations**	**Yes**
3	**Laboratory Control Sample**	**Yes**
4	**Matrix Spike**	**Yes**
5	**Blanks and Background Samples**	**Yes**
6	**Duplicate Analyses**	**Yes**
7	**Analyte Quantitation**	**Yes**
8	**Overall Assessment of Data**	**Yes**
9	**Usability of Data**	**Yes**

Comments: The radium-226 concentration in the field blank deionized water sample TRONOX-QC-09 was above the detection limit and above most of the rinsate sample concentrations. No results were qualified on this basis because all were below the reporting limit of 1 pCi/L. No indication of possible cross-contamination or interference during analysis was found in the data package during the validation process.

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location:** **Prewitt,** McKinley County, New Mexico
Project TDD Number: 4500000368	**PAN:** EE-002693-2164-06TTO

1. HOLDING TIMES

__X__ **Acceptable**
______ **Acceptable with qualification**
______ **Unacceptable**

Samples were extracted and analyzed within required holding times except as noted under Comments. In addition, no problems were identified with regard to sample preservation or custody unless specified. For those samples analyzed outside holding time requirements, the detected results have been qualified as estimated (J), and the nondetected results have been qualified either as estimated (UJ) or rejected (R) based on the reviewer's judgment.

All Sample Matrices:
Radiochemistry analyses: 6 months from collection to analysis.

Comments: None.

2. INITIAL AND CONTINUING CALIBRATION VERIFICATION

__X__ **Acceptable**
______ **Acceptable with qualification**
______ **Unacceptable**

Unless flagged below, an initial calibration verification (ICV), background, and efficiency check were performed for each detector at the beginning of the run, and were within the laboratory acceptance limits.

Comments: None

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: 4500000368	**PAN:** EE-002693-2164-06TTO

3. LABORATORY CONTROL SAMPLE

__X__ **Acceptable**
______ **Acceptable with qualification**
______ **Unacceptable**
______ **No Laboratory Control Samples Analyzed**

Laboratory control sample recoveries are used for a qualitative indication of accuracy (bias) independent of matrix effects. LCS recovery limits should either be specified in the Sampling and Analysis Plan or can be established by the laboratory. For analytes which exceeded these control limits, associated detected results are qualified as estimated (J). In cases where the recovery was below 30%, all associated nondetected results are rejected (R) and detected results are qualified as estimated (J).

Comments: None.

4. MATRIX SPIKE

__X__ **Acceptable**
______ **Acceptable with qualification**
______ **Unacceptable**
______ **No Matrix Spikes Analyzed**

Matrix spike recoveries are used for a qualitative indication of accuracy (bias) due to matrix effects. Unless flagged below, one matrix spike sample was analyzed at a rate of one per batch or one per 20 samples. Recoveries were within a range of 75-125%. For analytes which exceeded these control limits, associated detected results are qualified as estimated (J). In cases where the recovery was below 30%, all associated nondetected results are rejected (R) and detected results are qualified as estimated (J).

Comments: Matrix spike analysis (MS/MSD) was not required for gamma spec or Lucas Cell Ra-226 analysis and was not performed.

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: 4500000368	**PAN:** EE-002693-2164-06TTO

5. BLANKS AND BACKGROUND SAMPLES

__X__ Acceptable
_____ Detection Limits Adjusted

The following blanks were analyzed:
__X__ Method (preparation) Blanks
__X__ Field Blanks
__X__ Calibration Blanks (instrument background check)
__X__ Rinsate Blanks
__X__ Background Samples

Preparation (method) blanks were prepared for each batch of samples extracted. A preparation blank was analyzed after every continuing calibration standard, prior to sample analysis unless noted below. Any radionuclide detected in the sample and also detected in any associated blank, must be qualified as non-detect (U) when the sample concentration is less than 5x the blank concentration.

Comments: Five equipment rinsate blank samples were collected over the two-day sampling period. The SAP required one per day for nondedicated equipment. The rinsate blank sample results were all below the reporting limit of 1.00 pCi/L.

A sample of the clean deionized water used to rinse the nondedicated equipment for the rinsate blank samples was required by the SAP and was provided to the laboratory for analysis. The radium-226 concentration in the deionized water sample TRONOX-QC-09 was above the detection limit and above most of the rinsate sample concentrations. No results were qualified on this basis because all were below the reporting limit of 1 pCi/L. No indication of cross-contamination or interference during analysis was found in the data package during the validation process.

No results were qualified on the basis of blank samples.

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: 4500000368	**PAN:** EE-002693-2164-06TTO

6. DUPLICATE ANALYSES

__X__ Acceptable
_____ Acceptable with qualification
_____ Unacceptable
_____ No Duplicates Analyzed

Type of duplicates analyzed:
__X__ Field Duplicates
__X__ Laboratory Duplicates

Calculate the relative Percent Difference (RPD) between the members of duplicate pairs using the equation indicated below. Qualify the detected results as estimated (J) for any analyte whose RPD in a laboratory duplicate exceeds 20% for water samples or 35% for soil samples.

$$RPD = \frac{2(\text{Value 1} - \text{Value 2})}{\text{Value 1} + \text{Value 2}} \times 100\%$$

Comments:
The SAP requires collection of field duplicate samples at the rate of one for every ten samples. Eight field duplicate sample pairs were collected for this sampling effort. Precision was acceptable for the field duplicate sample pairs.

The laboratory performed one laboratory duplicate analysis for gamma spec analysis for every analytical batch of 20 samples or fewer (one analytical batch consisted of only four samples) and for Lucas cell analysis for every 10 samples or fewer with acceptable precision.

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: 4500000368	**PAN:** EE-002693-2164-06TTO

7. ANALYTE QUANTITATION

Confirm that analyte quantitation was performed correctly using the following formula:

$$\text{Ra-226 (pci/g)} = \frac{\text{gross sample cts} - \text{gross background counts}}{2.22 \times \text{counting efficiency} \times \text{sample mass} \times \text{isotopic abundance} \times \text{count time} \times \text{ingrowth factor}}$$

Comments: 10% of the results were calculated and found to be correct, as shown below.

Ra-226 by gamma spec:

GEL sample id	net cts	ingrowth factor	% eff	Mass, g	% abn	ct time, min	calc result	rpt res	% calc v rpt
308334002	6619	1	0.0228	150.19	0.463	120	15.6712	15.7	99.8163
308334013	7630	1	0.01988	153.16	0.463	120	20.3164	20.3	100.0810
308334021	1144	1	0.02741	157.67	0.463	60	4.2922	4.29	100.0519
308334033	201	1	0.02579	137.19	0.463	60	0.9212	0.921	100.0178
308334045	188	1	0.0228	147.53	0.463	60	0.9063	0.909	99.6996
308334062	268	1	0.03682	139.73	0.463	60	0.8446	0.846	99.8403
308334073	299	1	0.02663	134.3	0.463	60	1.3556	1.35	100.4165
308334082	301	1	0.02711	164.6	0.463	60	1.0938	1.095	99.8867
308334084	596	1	0.02748	159.27	0.463	60	2.2081	2.21	99.9121

Ra-226 by Lucas cell:

GEL sample ID	net cts	ingrowth factor	% eff	sample vol, L	% abn	ct time min	calc result	rpt res	% calc v rpt
308334091	19	0.385313088	1.953	0.5	1	30	0.7582	0.758	100.03

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Section 32 and Tronox AUM Section 33	**Location: Prewitt,** McKinley County, New Mexico
Project TDD Number: 4500000368	**PAN:** EE-002693-2164-06TTO

8. OVERALL ASSESSMENT OF DATA

On the basis of this review, the following determination has been made with regard to the overall data usability for the specified level.

__X__ **Acceptable**
______ **Acceptable with Qualification**
______ **Rejected**

Accepted data meet the minimum requirements for the following EPA data category:

______ **ERS Screening**
______ **Non-definitive with 10 % Conformation by Definitive Methodology**
______ **Definitive, Comprehensive Statistical Error Determination was performed.**
__X__ **Definitive, Comprehensive Statistical Error Determination was not performed.**

Any qualifications to individual sample analysis results are detailed in the appropriate section above or appear under the comments section below. In cases where several QC criteria are out of specification, it may be appropriate to further qualify the data usability. The data reviewer must use professional judgment and express concerns and comments on the data validity for each specific data package.

Comments: Ra-228 was detected in most of the samples in this SDG at low levels ranging from 0.78 to 2.0 pCi/g, likely due to radioactive decay of naturally occurring Th-232. Cs-137 was detected in 19 samples in this SDG at low levels ranging from 0.12 to 0.72 pCi/g, likely due to atmospheric radioactive fallout.

9. DOCUMENTATION OF LABORATORY CORRECTIVE ACTION

Problem: None.

Resolution:

Attached are copies of all data summary sheets, with data qualifiers indicated, and a copy of the chain of custody for the samples.

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Certificate of Analysis

Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-27-2	Project:	ECOL00722
Sample ID:	308334001	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 12:08		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		237	+/-23.7	0.635	1.00	pCi/g		MXR1	08/14/12	0847	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-27-12	Project:	ECOL00722
Sample ID:	308334002	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 14:40		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		15.7	+/-1.58	0.196	1.00	pCi/g		MXR1	08/14/12	0848	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-27-24	Project:	ECOL00722
Sample ID:	308334003	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 14:41		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.866	+/-0.175	0.118	1.00	pCi/g		MXR1	08/14/12	0848	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-27-36	Project:	ECOL00722
Sample ID:	308334004	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 14:42		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.767	+/-0.181	0.124	1.00	pCi/g		MXR1	08/14/12	0850	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-26-2	Project:	ECOL00722
Sample ID:	308334005	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 11:32		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.69	+/-0.211	0.0835	1.00	pCi/g		MXR1	08/14/12	0858	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-26-12	Project:	ECOL00722
Sample ID:	308334006	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 14:54		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.963	+/-0.152	0.0819	1.00	pCi/g		MXR1	08/14/12	0914	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-26-24	Project:	ECOL00722
Sample ID:	308334007	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 14:55		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.786	+/-0.157	0.0939	1.00	pCi/g		MXR1	08/14/12	0915	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-26-36	Project:	ECOL00722
Sample ID:	308334008	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 14:56		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.779	+/-0.147	0.106	1.00	pCi/g		MXR1	08/14/12	1007	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-28-2	Project:	ECOL00722
Sample ID:	308334009	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 12:55		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		300	+/-29.2	0.502	1.00	pCi/g		MXR1	08/14/12	1004	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-28-12	Project:	ECOL00722
Sample ID:	308334010	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 15:09		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		48.3	+/-4.89	0.336	1.00	pCi/g		MXR1	08/14/12	1038	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-28-24	Project:	ECOL00722
Sample ID:	308334011	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 15:10		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.759	+/-0.156	0.0962	1.00	pCi/g		MXR1	08/14/12	1039	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-28-36	Project:	ECOL00722
Sample ID:	308334012	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 15:11		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.967	+/-0.194	0.113	1.00	pCi/g		MXR1	08/14/12	1055	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-31-2	Project:	ECOL00722
Sample ID:	308334013	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 12:35		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		20.3	+/-2.07	0.207	1.00	pCi/g		MXR1	08/14/12	1217	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-31-12	Project:	ECOL00722
Sample ID:	308334014	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 15:20		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.56	+/-0.202	0.083	1.00	pCi/g		MXR1	08/14/12	1218	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-31-24	Project:	ECOL00722
Sample ID:	308334015	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 15:21		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.14	+/-0.182	0.0921	1.00	pCi/g		MXR1	08/14/12	1218	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-31-36	Project:	ECOL00722
Sample ID:	308334016	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 15:22		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.07	+/-0.172	0.0904	1.00	pCi/g		MXR1	08/14/12	1256	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-29-2	Project:	ECOL00722
Sample ID:	308334017	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 13:16		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		262	+/-26.6	0.583	1.00	pCi/g		MXR1	08/14/12	1257	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Certificate of Analysis

Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-29-12	Project:	ECOL00722
Sample ID:	308334018	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 15:30		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.68	+/-0.355	0.170	1.00	pCi/g		MXR1	08/15/12	0601	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave.
	#102
	Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-29-24	Project:	ECOL00722
Sample ID:	308334019	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 15:31		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.06	+/-0.274	0.112	1.00	pCi/g		MXR1	08/15/12	0602	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-29-36	Project:	ECOL00722
Sample ID:	308334020	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 15:32		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		13.9	+/-1.39	0.157	1.00	pCi/g		MXR1	08/15/12	0602	1232283	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/23/12	1544	1231792

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-30-2	Project:	ECOL00722
Sample ID:	308334021	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 16:00		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		4.29	+/-0.522	0.170	1.00	pCi/g		MXR1	08/15/12	0758	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-30-12	Project:	ECOL00722
Sample ID:	308334022	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 16:21		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.982	+/-0.209	0.127	1.00	pCi/g		MXR1	08/15/12	0758	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-130-12	Project:	ECOL00722
Sample ID:	308334023	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 16:21		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.03	+/-0.257	0.198	1.00	pCi/g		MXR1	08/15/12	0810	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave.
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	Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-30-24	Project:	ECOL00722
Sample ID:	308334024	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 16:22		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.14	+/-0.308	0.232	1.00	pCi/g		MXR1	08/15/12	0811	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-30-36	Project:	ECOL00722
Sample ID:	308334025	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 16:23		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.03	+/-0.200	0.136	1.00	pCi/g		MXR1	08/15/12	0811	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-44-2	Project:	ECOL00722
Sample ID:	308334026	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 16:40		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		23.4	+/-2.40	0.265	1.00	pCi/g		MXR1	08/15/12	0811	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-44-12	Project:	ECOL00722
Sample ID:	308334027	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 16:54		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.43	+/-0.241	0.116	1.00	pCi/g		MXR1	08/15/12	0836	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-44-24	Project:	ECOL00722
Sample ID:	308334028	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 16:55		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.04	+/-0.224	0.133	1.00	pCi/g		MXR1	08/15/12	0837	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-144-24	Project:	ECOL00722
Sample ID:	308334029	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 16:55		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.875	+/-0.195	0.136	1.00	pCi/g		MXR1	08/15/12	0837	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave.
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	Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-44-36	Project:	ECOL00722
Sample ID:	308334030	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 16:56		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.815	+/-0.184	0.196	1.00	pCi/g		MXR1	08/15/12	0907	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-34-2	Project:	ECOL00722
Sample ID:	308334031	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 09:42		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		20.1	+/-2.09	0.287	1.00	pCi/g		MXR1	08/15/12	0908	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-134-2	Project:	ECOL00722
Sample ID:	308334032	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 09:42		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		18.2	+/-1.94	0.294	1.00	pCi/g		MXR1	08/15/12	0919	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-34-12	Project:	ECOL00722
Sample ID:	308334033	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 09:58		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.921	+/-0.198	0.143	1.00	pCi/g		MXR1	08/15/12	0908	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-34-24	Project:	ECOL00722
Sample ID:	308334034	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 09:59		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.29	+/-0.258	0.159	1.00	pCi/g		MXR1	08/15/12	0928	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-34-36	Project:	ECOL00722
Sample ID:	308334035	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 10:00		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.740	+/-0.187	0.139	1.00	pCi/g		MXR1	08/15/12	0913	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-33-2	Project:	ECOL00722
Sample ID:	308334036	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 10:10		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		4.22	+/-0.524	0.167	1.00	pCi/g		MXR1	08/15/12	0921	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-33-12	Project:	ECOL00722
Sample ID:	308334037	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 10:25		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.02	+/-0.206	0.165	1.00	pCi/g		MXR1	08/15/12	0921	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Certificate of Analysis

Report Date: August 15, 2012

Company : Ecology & Environment, Inc.
Address : 3700 Industry Ave.
#102
Lakewood, California 90712
Contact: Ms. Mindy Song
Project: Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID: AUM32-33-24
Sample ID: 308334038
Matrix: Soil
Collect Date: 18-JUL-12 10:26
Receive Date: 21-JUL-12
Collector: Client

Project: ECOL00722
Client ID: ECOL007

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.30	+/-0.334	0.231	1.00	pCi/g		MXR1	08/15/12	0922	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-33-36	Project:	ECOL00722
Sample ID:	308334039	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 10:27		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.16	+/-0.232	0.336	1.00	pCi/g		MXR1	08/15/12	0922	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-41-2	Project:	ECOL00722
Sample ID:	308334040	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 10:18		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.789	+/-0.183	0.141	1.00	pCi/g		MXR1	08/15/12	0922	1232285	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1350	1231793

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-32-2	Project:	ECOL00722
Sample ID:	308334041	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 10:41		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		7.78	+/-0.858	0.187	1.00	pCi/g		MXR1	08/15/12	0951	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-32-12	Project:	ECOL00722
Sample ID:	308334042	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 10:54		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.964	+/-0.208	0.158	1.00	pCi/g		MXR1	08/15/12	1024	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-32-24	Project:	ECOL00722
Sample ID:	308334043	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 10:55		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.19	+/-0.236	0.143	1.00	pCi/g		MXR1	08/15/12	1024	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Company : Ecology & Environment, Inc.
Address : 3700 Industry Ave.
#102
Lakewood, California 90712
Contact: Ms. Mindy Song
Project: Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID: AUM32-32-36
Sample ID: 308334044
Matrix: Soil
Collect Date: 18-JUL-12 10:57
Receive Date: 21-JUL-12
Collector: Client

Project: ECOL00722
Client ID: ECOL007

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.966	+/-0.223	0.150	1.00	pCi/g		MXR1	08/15/12	1025	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-132-36	Project:	ECOL00722
Sample ID:	308334045	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 10:57		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.909	+/-0.231	0.177	1.00	pCi/g		MXR1	08/15/12	1025	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-36-2	Project:	ECOL00722
Sample ID:	308334046	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 11:18		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		39.4	+/-3.88	0.317	1.00	pCi/g		MXR1	08/15/12	1026	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-36-12	Project:	ECOL00722
Sample ID:	308334047	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 11:28		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.986	+/-0.235	0.158	1.00	pCi/g		MXR1	08/15/12	1026	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-136-12	Project:	ECOL00722
Sample ID:	308334048	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 11:28		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.20	+/-0.200	0.147	1.00	pCi/g		MXR1	08/15/12	1027	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-36-24	Project:	ECOL00722
Sample ID:	308334049	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 11:31		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.60	+/-0.236	0.108	1.00	pCi/g		MXR1	08/15/12	1027	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-36-36	Project:	ECOL00722
Sample ID:	308334050	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 11:32		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.544	+/-0.190	0.132	1.00	pCi/g		MXR1	08/15/12	1028	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-35-2	Project:	ECOL00722
Sample ID:	308334051	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 11:51		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.72	+/-0.383	0.172	1.00	pCi/g		MXR1	08/15/12	1028	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-35-12	Project:	ECOL00722
Sample ID:	308334052	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 12:11		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.832	+/-0.244	0.172	1.00	pCi/g		MXR1	08/15/12	1029	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact: Ms. Mindy Song
Project: Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-35-24	Project:	ECOL00722
Sample ID:	308334053	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 12:13		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.10	+/-0.238	0.159	1.00	pCi/g		MXR1	08/15/12	1035	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-135-24	Project:	ECOL00722
Sample ID:	308334054	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 12:13		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.00	+/-0.211	0.158	1.00	pCi/g		MXR1	08/15/12	1035	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-35-36	Project:	ECOL00722
Sample ID:	308334055	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 12:15		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.991	+/-0.201	0.138	1.00	pCi/g		MXR1	08/15/12	1035	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-38-2	Project:	ECOL00722
Sample ID:	308334056	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 12:30		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		13.6	+/-1.50	0.309	1.00	pCi/g		MXR1	08/15/12	1036	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Certificate of Analysis

Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-138-2	Project:	ECOL00722
Sample ID:	308334057	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 12:30		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		12.1	+/-1.29	0.223	1.00	pCi/g		MXR1	08/15/12	1036	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-38-12	Project:	ECOL00722
Sample ID:	308334058	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 12:40		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.17	+/-0.263	0.159	1.00	pCi/g		MXR1	08/15/12	1036	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-38-24	Project:	ECOL00722
Sample ID:	308334059	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 12:41		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.897	+/-0.161	0.147	1.00	pCi/g		MXR1	08/15/12	1037	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-38-36	Project:	ECOL00722
Sample ID:	308334060	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 12:42		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.13	+/-0.243	0.190	1.00	pCi/g		MXR1	08/15/12	1037	1232286	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1356	1231794

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-37-2	Project:	ECOL00722
Sample ID:	308334061	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 12:53		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.60	+/-0.408	0.212	1.00	pCi/g		MXR1	08/15/12	0621	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-37-12	Project:	ECOL00722
Sample ID:	308334062	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 13:06		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.846	+/-0.170	0.129	1.00	pCi/g		MXR1	08/15/12	0622	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-37-24	Project:	ECOL00722
Sample ID:	308334063	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 13:07		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.901	+/-0.184	0.126	1.00	pCi/g		MXR1	08/15/12	0622	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-37-36	Project:	ECOL00722
Sample ID:	308334064	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 13:08		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.777	+/-0.184	0.118	1.00	pCi/g		MXR1	08/15/12	0623	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-43-2	Project:	ECOL00722
Sample ID:	308334065	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 13:20		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.993	+/-0.188	0.151	1.00	pCi/g		MXR1	08/15/12	0624	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave.
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	Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-39-2	Project:	ECOL00722
Sample ID:	308334066	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 13:33		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.84	+/-0.408	0.188	1.00	pCi/g		MXR1	08/15/12	0651	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-42-2	Project:	ECOL00722
Sample ID:	308334067	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 13:43		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		3.11	+/-0.408	0.173	1.00	pCi/g		MXR1	08/15/12	0652	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	TRONOX-QC-11	Project:	ECOL00722
Sample ID:	308334068	Client ID:	ECOL007
Matrix:	Water		
Collect Date:	19-JUL-12 19:30		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Radium-226												
Lucas Cell, Ra226, liquid "As Received"												
Radium-226	U	0.222	+/-0.341	0.599	1.00	pCi/L		KSD1	08/02/12	1350	1232917	1

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 903.1 Modified	

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Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	TRONOX-QC-12	Project:	ECOL00722
Sample ID:	308334069	Client ID:	ECOL007
Matrix:	Water		
Collect Date:	19-JUL-12 19:35		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Radium-226												
Lucas Cell, Ra226, liquid "As Received"												
Radium-226	U	0.217	+/-0.300	0.520	1.00	pCi/L		KSD1	08/02/12	1350	1232917	1

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 903.1 Modified	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	TRONOX-QC-13	Project:	ECOL00722
Sample ID:	308334070	Client ID:	ECOL007
Matrix:	Water		
Collect Date:	19-JUL-12 19:40		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Radium-226												
Lucas Cell, Ra226, liquid "As Received"												
Radium-226		0.784	+/-0.394	0.353	1.00	pCi/L		KSD1	08/02/12	1350	1232917	1

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 903.1 Modified	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-07-36	Project:	ECOL00722
Sample ID:	308334071	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 14:22		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.847	+/-0.206	0.152	1.00	pCi/g		MXR1	08/15/12	0652	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM33-07-48	Project:	ECOL00722
Sample ID:	308334072	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 14:23		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.07	+/-0.204	0.122	1.00	pCi/g		MXR1	08/15/12	0652	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Company :	Ecology & Environment, Inc..
Address :	3700 Industry Ave.
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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-01-36	Project:	ECOL00722
Sample ID:	308334073	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 14:35		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.35	+/-0.249	0.144	1.00	pCi/g		MXR1	08/15/12	0653	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-01-48	Project:	ECOL00722
Sample ID:	308334074	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 14:36		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.24	+/-0.253	0.204	1.00	pCi/g		MXR1	08/15/12	0654	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-09-36	Project:	ECOL00722
Sample ID:	308334075	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 14:57		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.797	+/-0.234	0.180	1.00	pCi/g		MXR1	08/15/12	0654	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-09-48	Project:	ECOL00722
Sample ID:	308334076	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 14:58		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.18	+/-0.250	0.179	1.00	pCi/g		MXR1	08/15/12	0654	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Christopher 8/31/12

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-08-36	Project:	ECOL00722
Sample ID:	308334077	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 16:25		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.45	+/-0.403	0.249	1.00	pCi/g		MXR1	08/15/12	0657	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Z Christopher 8/31/12

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-08-48	Project:	ECOL00722
Sample ID:	308334078	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	18-JUL-12 16:26		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.07	+/-0.315	0.223	1.00	pCi/g		MXR1	08/15/12	0703	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Z Christopher 8/31/12

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	TRONOX-QC-10	Project:	ECOL00722
Sample ID:	308334079	Client ID:	ECOL007
Matrix:	Water		
Collect Date:	18-JUL-12 17:45		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Radium-226												
Lucas Cell, Ra226, liquid "As Received"												
Radium-226	U	0.185	+/-0.332	0.598	1.00	pCi/L		KSD1	08/02/12	1350	1232917	1

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 903.1 Modified	

Joanna Z Christopher 8/31/12

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-40-2	Project:	ECOL00722
Sample ID:	308334080	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	17-JUL-12 11:54		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.761	+/-0.218	0.155	1.00	pCi/g		MXR1	08/15/12	0727	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Z Christopher 8/31/12

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-45-2	Project:	ECOL00722
Sample ID:	308334081	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	19-JUL-12 11:28		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.923	+/-0.188	0.105	1.00	pCi/g		MXR1	08/15/12	0727	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Jeanna Z Christopher 8/31/12

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-46-2	Project:	ECOL00722
Sample ID:	308334082	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	19-JUL-12 11:43		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		1.10	+/-0.199	0.116	1.00	pCi/g		MXR1	08/15/12	0728	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanna Christopher 8/31/12

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-47-2	Project:	ECOL00722
Sample ID:	308334083	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	19-JUL-12 11:46		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		0.900	+/-0.204	0.133	1.00	pCi/g		MXR1	08/15/12	0728	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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GEL LABORATORIES LLC

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Certificate of Analysis

Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-48-2	Project:	ECOL00722
Sample ID:	308334084	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	19-JUL-12 11:58		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.21	+/-0.322	0.154	1.00	pCi/g		MXR1	08/15/12	0729	1232287	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1403	1231795

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Certificate of Analysis

Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-148-2	Project:	ECOL00722
Sample ID:	308334085	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	19-JUL-12 11:58		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		2.04	+/-0.310	0.147	1.00	pCi/g		MXR1	08/15/12	1055	1232288	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1348	1231796

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Certificate of Analysis

Report Date: August 15, 2012

Company : Ecology & Environment, Inc.
Address : 3700 Industry Ave.
#102
Lakewood, California 90712
Contact: Ms. Mindy Song
Project: Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID: AUM32-49-2
Sample ID: 308334086
Matrix: Soil
Collect Date: 19-JUL-12 13:40
Receive Date: 21-JUL-12
Collector: Client

Project: ECOL00722
Client ID: ECOL007

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		108	+/-10.8	0.615	1.00	pCi/g		MXR1	08/15/12	1139	1232288	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1348	1231796

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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Certificate of Analysis

Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-49-12	Project:	ECOL00722
Sample ID:	308334087	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	19-JUL-12 13:43		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		94.8	+/-9.48	0.530	1.00	pCi/g		MXR1	08/15/12	1140	1232288	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1348	1231796

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

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2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	AUM32-49-24	Project:	ECOL00722
Sample ID:	308334088	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	19-JUL-12 13:46		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Gamma Spec Analysis												
Gamma, Ra226, Solid "Dry Weight Corrected"												
Radium-226		6.13	+/-0.723	0.180	1.00	pCi/g		MXR1	08/15/12	1140	1232288	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	CXC1	07/24/12	1348	1231796

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

Joanne Christopher 8/31/12

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	TRONOX-QC-08	Project:	ECOL00722
Sample ID:	308334090	Client ID:	ECOL007
Matrix:	Water		
Collect Date:	17-JUL-12 17:20		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Radium-226												
Lucas Cell, Ra226, liquid "As Received"												
Radium-226	U	0.301	+/-0.256	0.361	1.00	pCi/L		KSD1	08/02/12	1350	1232917	1

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 903.1 Modified	

Joanna Christopher 8/31/12

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: August 15, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	Tronox 4500000368/EE-002693-2164-06TTO

Client Sample ID:	TRONOX-QC-09	Project:	ECOL00722
Sample ID:	308334091	Client ID:	ECOL007
Matrix:	Water		
Collect Date:	17-JUL-12 17:25		
Receive Date:	21-JUL-12		
Collector:	Client		

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Rad Radium-226												
Lucas Cell, Ra226, liquid "As Received"												
Radium-226		0.758	+/-0.462	0.645	1.00	pCi/L		KSD1	08/02/12	1430	1232917	1

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 903.1 Modified	

Joanna Z Christopher 8/31/12

<a copy> Joanna Christopher 8/31/12

Page: 1 of 9	
Project #: EE-002693-2164-01 TTO	
GEL Quote #:	
COC Number [1]:	
PO Number:	

GEL Chain of Custody and Analytical Request

GEL Work Order Number: 308334

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: ECOLOGY & ENVIRONMENT, INC. Phone #: 510-893-6700

Project/Site Name: TRONOX Fax #: 510-550-2760

Address: 1940 WEBSTER ST. SUITE 100, OAKLAND, CA 94612

Collected by: B. SASI / P. JONES Send Results To: A. MENDOZA

Sample Analysis Requested [5] (Fill in the number of containers for each test)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code [2]	Field Filtered [3]	Sample Matrix [4]	Should this sample be considered: Radioactive	Should this sample be considered: TSCA Regulated	Total number of containers	Ra-226 HASL 300, 4.5.2.3	Comments Note: extra sample is required for sample specific QC
										<-- Preservative Type (6)
AUM32-27-2	07-17-12	1208			SO	Y		1	X	
AUM32-27-12		1440			SO	Y		1		
AUM32-27-24		1441			SO	Y		1		
AUM32-27-36		1442			SO	Y		1		
AUM32-26-2		1132			SO	Y		1		
AUM32-26-12		1454			SO	Y		1		
AUM32-26-24		1455			SO	Y		1		
AUM32-26-36		1456			SO	Y		1		
AUM32-28-2		1255			SO	Y		1		
AUM32-28-12		1509			SO	Y		1		

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* EMAIL AMENDOZA@ENE.COM

Sample Collection Time Zone: Eastern Pacific Central Other ______ Mountain

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time		Received by (signed)	Date	Time
1	William Sasi	7/19/12		1	[signature]	7-21-12	0900
2				2			
3				3			

Sample Shipping and Delivery Details

GEL PM:

Method of Shipment: Date Shipped:

Airbill #:

Airbill #:

1.) Chain of Custody Number = Client Determined
2.) QC Codes: **N** = Normal Sample, **TB** = Trip Blank, **FD** = Field Duplicate, **EB** = Equipment Blank, **MS** = Matrix Spike Sample, **MSD** = Matrix Spike Duplicate Sample, **G** = Grab, **C** = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: **DW**=Drinking Water, **GW**=Groundwater, **SW**=Surface Water, **WW**=Waste Water, **W**=Water, **SO**=Soil, **SD**=Sediment, **SL**=Sludge, **SS**=Solid Waste, **O**=Oil, **F**=Filter, **P**=Wipe, **U**=Urine, **F**=Fecal, **N**=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. **8260B, 6010B/7470A**) and number of containers provided for each (i.e. *8260B - 3, 6010B/7470A - 1*).
6.) Preservative Type: **HA** = Hydrochloric Acid, **NI** = Nitric Acid, **SH** = Sodium Hydroxide, **SA** = Sulfuric Acid, **AA** = Ascorbic Acid, **HX** = Hexane, **ST** = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only
Custody Seal Intact? YES NO
Cooler Temp: 23 C

WHITE = LABORATORY **YELLOW = FILE** **PINK = CLIENT**

<a copy> Joanna Christopher 8/31/12

GEL Chain of Custody and Analytical Request

Page: 2 of 9
Project #: EE-002693-2164-9110
GEL Quote #:
COC Number [1]:
PO Number:

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: E&E Phone #: 510-893-6700
Project/Site Name: TRONOX A Fax #: 510-550-2760
Address: 1940 WEBSTER ST. SUITE 100, OAKLAND, CA 94612
Collected by: B. SASS / P. JONES Send Results To: A. MENDOZA

Sample Analysis Requested [5] (Fill in the number of containers for each test)

Sample ID (• For composites - indicate start and stop date/time)	•Date Collected (mm-dd-yy)	•Time Collected (Military) (hhmm)	QC Code [2]	Field Filtered [3]	Sample Matrix [4]	Should this sample be considered: Radioactive	Should this sample be considered: TSCA Regulated	Total number of containers	Ra-226 EML HASL 300, 4.5.2.3	Comments (Note: extra sample is required for sample specific QC)
<-- Preservative Type (6)										
AUM32-28-24	7-17-12	1510			SOIL	X		1	X	
AUM32-28-36		1511								
AUM32-31-2		1235								
AUM32-31-12		1520								
AUM32-31-24		1521								
AUM32-31-36		1522								
AUM32-29-2		1316								
AUM32-29-12		1530								
AUM32-29-24		1531								
AUM32-29-36		1532								

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* EMAIL AMENDOZA@ENE.COM

Sample Collection Time Zone
Eastern Pacific
Central Other ______
Mountain

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time		Received by (signed)	Date	Time
1	William Sass	7/19/12		1	[signature]	7-21-12	0900
2				2			
3				3			

Sample Shipping and Delivery Details

GEL PM:
Method of Shipment: Date Shipped:
Airbill #:
Airbill #:

1.) Chain of Custody Number = Client Determined
2.) QC Codes: **N** = Normal Sample, **TB** = Trip Blank, **FD** = Field Duplicate, **EB** = Equipment Blank, **MS** = Matrix Spike Sample, **MSD** = Matrix Spike Duplicate Sample, **G** = Grab, **C** = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: **DW**=Drinking Water, **GW**=Groundwater, **SW**=Surface Water, **WW**=Waste Water, **W**=Water, **SO**=Soil, **SD**=Sediment, **SL**=Sludge, **SS**=Solid Waste, **O**=Oil, **F**=Filter, **P**=Wipe, **U**=Urine, **F**=Fecal, **N**=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. **8260B, 6010B/7470A**) and number of containers provided for each (i.e. *8260B - 3, 6010B/7470A - 1*).
6.) Preservative Type: **HA** = Hydrochloric Acid, **NI** = Nitric Acid, **SH** = Sodium Hydroxide, **SA** = Sulfuric Acid, **AA** = Ascorbic Acid, **HX** = Hexane, **ST** = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only
Custody Seal Intact? YES NO
Cooler Temp: 23 C

WHITE = LABORATORY **YELLOW = FILE** **PINK = CLIENT**

<a copy> Joanna Z Christopher 8/31/12

Page: 2 of 9
Project #: EE-0026932144-01 TTD
GEL Quote #:
COC Number [1]:
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: E&E Phone #: 510-893-6700
Project/Site Name: TRONOX Fax #: 510-550-2760
Address: 1940 WEBSTER ST. SUITE 100, OAKLAND, CA 94612
Collected by: B SASS / P. JONES Send Results To: A. MENDOZA

Sample Analysis Requested [5] (Fill in the number of containers for each test)

<-- Preservative Type (6)

Sample ID (* For composites - indicate start and stop date/time)	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code [2]	Field Filtered [3]	Sample Matrix [4]	Radioactive	TSCA Regulated	Total number of containers	Ra-226 EML HASL 300 4.5.2.3	Comments: Note: extra sample is required for sample specific QC
AUM32-30-2	7-17-12	1600			SOIL	X		1	X	
AUM32-30-12	↓	1621			↓	↓		↓	↓	
AUM32-130-12	↓	1621			↓	↓		↓	↓	
AUM32-30-24	↓	1622			↓	↓		↓	↓	
AUM32-30-36	↓	1623			↓	↓		↓	↓	
AUM32-44-2	↓	1640			↓	↓		↓	↓	
AUM32-44-12	↓	1654			↓	↓		↓	↓	
AUM32-44-24	↓	1655			↓	↓		↓	↓	
AUM32-44-24	↓	1655			↓	↓		↓	↓	
AUM32-44-36	↓	1656			↓	↓		↓	↓	

Should this sample be considered: Radioactive / TSCA Regulated

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No

Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* EMAIL AMENDOZA@ENE.COM

Sample Collection Time Zone: Eastern, Pacific, Central, Other ____, Mountain

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time		Received by (signed)	Date	Time
1	[signature]	7/19/12		1	[signature]	7-21-12	0900
2				2			
3				3			

Sample Shipping and Delivery Details

GEL PM:
Method of Shipment: Date Shipped:
Airbill #:
Airbill #:

For Lab Receiving Use Only
Custody Seal Intact? YES NO
Cooler Temp: 23 C

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B - 3, 6010B/7470A - 1*).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

WHITE = LABORATORY YELLOW = FILE PINK = CLIENT

<a copy> Joanna Christopher 8/31/12

Page: 4 of 9
Project #: EE-002643-2164-0140
GEL Quote #:
COC Number [1]:
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: E&E Phone #: 510-893-6700
Project/Site Name: TRONOX Fax #: 510-550-2760
Address: 1940 WEBSTER ST. SUITE 100, OAKLAND, CA 94612
Collected by: B. CASS / D. JONES Send Results To: A. MENDOZA

Sample Analysis Requested [5] (Fill in the number of containers for each test)

<-- Preservative Type (6)

Sample ID (* For composites - indicate start and stop date/time)	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code [2]	Field Filtered [3]	Sample Matrix [4]	Should this sample be considered: Radioactive	TSCA Regulated	Total number of containers	Ra-226 HAL HASL 300 4.5.23	Comments: Note: extra sample is required for sample specific QC
AUM32-34-2	7-18-12	0942			SOIL	X		1	X	
AUM32-134-2	↓	0942			↓	↓		↓	↓	
AUM32-34-12	↓	958			↓	↓		↓	↓	
AUM32-34-24	↓	959			↓	↓		↓	↓	
AUM32-34-36	↓	1000			↓	↓		↓	↓	
AUM32-33-2	↓	1010			↓	↓		↓	↓	
AUM32-33-12	↓	1025			↓	↓		↓	↓	
AUM32-33-24	↓	1026			↓	↓		↓	↓	
AUM32-33-36	↓	1027			↓	↓		↓	↓	
AUM32-41-2	↓	1018			↓	↓		↓	↓	

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* EMAIL AMENDOZA@ENE.com

Sample Collection Time Zone
Eastern Pacific
Central Other ______
Mountain

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1	[signature]	7/19/12		[signature]	7-21-12	0900
2						
3						

Sample Shipping and Delivery Details

GEL PM:
Method of Shipment: Date Shipped:
Airbill #:
Airbill #:

For Lab Receiving Use Only
Custody Seal Intact? YES NO
Cooler Temp: 23 C

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. 8260B - 3, 6010B/7470A - 1).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

WHITE = LABORATORY YELLOW = FILE PINK = CLIENT

<a copy> Joanna Z Christopher 8/31/12

Page: 5 of 9
Project #: EE- DO2693-2164-01tto
GEL Quote #:
COC Number (1):
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: E&E Phone #: 510-893-6700
Project/Site Name: TRONOX Fax #: 510-530-2760
Address: 1940 WEBSTER ST. SUITE 100 OAKLAND, CA 94612
Collected by: B. SASS / P. JONES Send Results To: A. MENDOZA

Sample Analysis Requested (5) (Fill in the number of containers for each test)

<-- Preservative Type (6)

Sample ID (* For composites - indicate start and stop date/time)	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive	TSCA Regulated	Total number of containers	RA-226 EML HASL 300, 4.5.2.3										Comments Note: extra sample is required for sample specific QC
AUM32-32-2	7-18-12	1041			SOIL	X		1	X										
AUM32-32-12		1054																	
AUM32-32-24		1055																	
AUM32-32-36		1057																	
AUM32-132-36		1057																	
AUM32-36-2		1118																	
AUM32-36-12		1128																	
AUM32-136-12		1128																	
AUM32-36-24		1131																	
AUM32-36-36		1132																	

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* EMAIL AMENDOZA@ENE.COM

Sample Collection Time Zone
Eastern Pacific
Central Other ______
Mountain

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 William Sue	7/19/12		1 [signature]	7-21-12	0900
2			2		
3			3		

Sample Shipping and Delivery Details

GEL PM:
Method of Shipment: Date Shipped:
Airbill #:
Airbill #:

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B - 3, 6010B/7470A - 1*).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only
Custody Seal Intact? YES NO
Cooler Temp: 23 C

WHITE = LABORATORY **YELLOW = FILE** **PINK = CLIENT**

<a copy> Joanna Z Christopher 8/31/12

Page: 6 of 9
Project #: ~~EE~~ - GD2693-2164-01 UD
GEL Quote #:
COC Number [1]:
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: E&E Phone #: 510-893-6700
Project/Site Name: TRONOX Fax #: 510-550-2760
Address: 1940 WEBSTER ST. SUITE 100, OAKLAND, CA 94612
Collected by: B. SASS / P. JONES Send Results To: A. MENDOZA

Sample Analysis Requested [5] (Fill in the number of containers for each test)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code [2]	Field Filtered [3]	Sample Matrix [4]	Should this sample be considered: Radioactive	TSCA Regulated	Total number of containers	Ra-226 EML HASL 300 4.5.23										<-- Preservative Type (6) Comments Note: extra sample is required for sample specific QC
AUM32-35-2	7-18-12	1151			SOIL	X		1	X										
AUM32-35-12	↓	1211			↓	↓		↓	↓										
AUM32-35-24	↓	1213			↓	↓		↓	↓										
AUM32-135-24	↓	1213			↓	↓		↓	↓										
AUM32-35-36	↓	1215			↓	↓		↓	↓										
AUM32-38-2	↓	1230			↓	↓		↓	↓										
AUM32-138-2	↓	1230			↓	↓		↓	↓										
AUM32-38-12	↓	1240			↓	↓		↓	↓										
AUM32-38-24	↓	1241			↓	↓		↓	↓										
AUM32-38-36	↓	1242			↓	↓		↓	↓										

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No

Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* EMAIL AMENDOZA@ENE.COM

Sample Collection Time Zone
Eastern Pacific
Central Other ______
Mountain

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 William Sass	7/19/12		1 [signature]	7-21-12	0900
2			2		
3			3		

Sample Shipping and Delivery Details

GEL PM:
Method of Shipment: Date Shipped:
Airbill #:
Airbill #:

For Lab Receiving Use Only
Custody Seal Intact? *YES* *NO*
Cooler Temp: 23 C

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. *8260B - 3, 6010B/7470A - 1*).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

WHITE = LABORATORY **YELLOW = FILE** **PINK = CLIENT**

<a copy> Joanna Christopher 8/31/12

Page: 7 of 9
Project #: EE-002693-2164-01ITD
GEL Quote #:
COC Number (1):
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: E&E   Phone #: 510-893-6700
Project/Site Name: TRONOX   Fax #: 510-550-2765
Address: 1940 WEBSTER ST. SUITE 100, OAKLAND, CA 94612
Collected by: B. SASS / P. JONES   Send Results To: A. MENDOZA

Sample Analysis Requested (5) (Fill in the number of containers for each test)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Should this sample be considered: Radioactive	TSCA Regulated	Total number of containers	RA-226 EML HASL 300, 4.5.2.3									<-- Preservative Type (6) / Comments Note: extra sample is required for sample specific QC
AUM32-37-2	7-18-12	1253			SOIL	X		1	X									
AUM32-37-12	↓	1306			↓	↓		↓	↓									
AUM32-37-24	↓	1307			↓	↓		↓	↓									
AUM32-37-36	↓	1318			↓	↓		↓	↓									
AUM32-43-2	↓	1320			↓	↓		↓	↓									
AUM32-39-2	↓	1333			↓	↓		↓	↓									
AUM32-42-2	↓	1343			↓	↓		↓	↓									
TRONOX-QC-11	7/19/12	1930			WATER	↓		↓	↓									
TRONOX-QC-12	↓	1935			↓	↓		↓	↓									
TRONOX-QC-13	↓	1940			↓	↓		↓	↓									

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge)   Fax Results: Yes / No   Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards*
EMAIL AMENDOZA@ENE.COM

Sample Collection Time Zone: Eastern / Central / Mountain / Pacific / Other ______

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 William Sass	7/19/12		1 [signature]	7-21-12	0900
2			2		
3			3		

Sample Shipping and Delivery Details

GEL PM:
Method of Shipment: Date Shipped:
Airbill #:
Airbill #:

For Lab Receiving Use Only
Custody Seal Intact? YES NO
Cooler Temp: 23 C

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. 8260B - 3, 6010B/7470A - 1).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

WHITE = LABORATORY   YELLOW = FILE   PINK = CLIENT

To copy 7 Joanna Christopher 8/31/12

Page: 8 of 9
Project #: EE-002693-264-01 TTD
GEL Quote #:
COC Number (1):
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: E&E   Phone #: 510-893-6700
Project/Site Name: TRONOX   Fax #: 510-~~55~~-2760
Address: 1940 WEBSTER ST. SUITE 100, OAKLAND, CA 94612
Collected by: B. SASS / P. JONES   Send Results To: A. MENDOZA

Sample Analysis Requested (5) (Fill in the number of containers for each test)

Sample ID * For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code (2)	Field Filtered (3)	Sample Matrix (4)	Radioactive	TSCA Regulated	Total number of containers	Ra-226 EML HASL 300, 4.5.2.3										Comments Note: extra sample is required for sample specific QC
																			<-- Preservative Type (6)
AUM33-07-36	7-18-12	1422			SOIL	X		1	X										
AUM33-07-48		1423																	
AUM32-01-36		1435																	
AUM32-01-48		1436																	
AUM32-09-36		1457																	
AUM32-09-48		1458																	
AUM32-08-36		1625																	
AUM32-08-48		1626																	
TRONOX-QC-10		1745			WATER	X		1	X										
AUM32-40-2	7-17-12	1154			SO	X		1	X										

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge)   Fax Results: Yes / No   Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards* EMAIL AMENDOZA@ENE.COM

Sample Collection Time Zone
Eastern   Pacific
Central   Other ______
~~Mountain~~

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time		Received by (signed)	Date	Time
1	[signature]	7/19/12		1	[signature]	7-21-12	0900
2				2			
3				3			

Sample Shipping and Delivery Details

GEL PM:
Method of Shipment: Date Shipped:
Airbill #:
Airbill #:

For Lab Receiving Use Only
Custody Seal Intact? *YES* *NO*
Cooler Temp: 23 C

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. 8260B - 3, 6010B/7470A - 1).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

WHITE = LABORATORY   YELLOW = FILE   PINK = CLIENT

<a copy> Joanna Christopher 8/31/12

Page: 9 of 9
Project #: EE-002693-2164-01TTO
GEL Quote #:
COC Number [1]:
PO Number:

GEL Chain of Custody and Analytical Request

GEL Work Order Number:

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: Ecology and Environment, Inc. Phone #: 510-893-6700
Project/Site Name: Tronox Fax #: 510-550-2760
Address: 1940 Webster St. Suite 100, Oakland, CA 94612
Collected by: B. Sass / P. Jones Send Results To: A. Mendoza

Sample Analysis Requested [5] (Fill in the number of containers for each test)

Sample ID (* For composites - indicate start and stop date/time)	*Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	QC Code [2]	Field Filtered [3]	Sample Matrix [4]	Radioactive	TSCA Regulated	Total number of containers	Ra-226 HASL 300, 4.5.2.3									Comments: Note: extra sample is required for sample specific QC
						Should this sample be considered:												<-- Preservative Type (6)
AUM32-45-2	7-19-12	1128			SO	X		1	X									
AUM32-46-2		1143			SO	X		1	X									
AUM32-47-2		1146			SO	X		1	X									
AUM32-48-2		1158			SO	X		1	X									
AUM32-148-2		1158			SO	X		1	X									
AUM32-49-2	7-19-12	1340			SO	X		1	X									
AUM32-49-12		1343			SO	X		1	X									
AUM32-49-24		1346			SO	X		1	X									
AUM32-49-27		1350			SO	X		1	X									
TRONOX-QC-08	7/17/12	1720			WATER	X		1	X									

TAT Requested: Normal: X Rush: Specify: (Subject to Surcharge) Fax Results: Yes / No Circle Deliverable: C of A / QC Summary / Level 1 / Level 2 / Level 3 / Level 4

Remarks: *Are there any known hazards applicable to these samples? If so, please list the hazards*
email amendoza@ene.com
TRONOX-QC-09 7/17/12 1725 WATER / RADIOACTIVE / 1 CONTAINER / HASL

Sample Collection Time Zone
Eastern Pacific
Central Other ________
Mountain

Chain of Custody Signatures						Sample Shipping and Delivery Details	
Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time	GEL PM:	
1 William Sass	7/19/12		1 [signature]	7-21-12	0900	Method of Shipment:	Date Shipped:
2			2			Airbill #:	
3			3			Airbill #:	

1.) Chain of Custody Number = Client Determined
2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered.
4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surface Water, WW=Waste Water, W=Water, SO=Soil, SD=Sediment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nasal
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A) and number of containers provided for each (i.e. 8260B - 3, 6010B/7470A - 1).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank

For Lab Receiving Use Only
Custody Seal Intact? YES NO
Cooler Temp: C

WHITE = LABORATORY YELLOW = FILE PINK = CLIENT

<a copy> Joanna Christopher 8/31/12

GEL Laboratories LLC

SAMPLE RECEIPT & REVIEW FORM

Client: ECOL	SDG/AR/COC/Work Order: 308334
Received By: MK	Date Received: 7-21-12

Suspected Hazard Information	Yes	No	
			*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
COC/Samples marked as radioactive?	✓		Maximum Net Counts Observed* (Observed Counts - Area Background Counts): cpm 450
Classified Radioactive II or III by RSO?		✓	If yes, Were swipes taken of sample containers < action levels?
COC/Samples marked containing PCBs?		✓	
Package, COC, and/or Samples marked as beryllium or asbestos containing?		✓	If yes, samples are to be segregated as Safety Controlled Samples, and opened by the GEL Safety Group.
Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#:
Samples identified as Foreign Soil?		✓	

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*		✓		Preservation Method: Ice bags Blue ice Dry ice None Other (describe) 23 C *all temperatures are recorded in Celsius
2a	Daily check performed and passed on IR temperature gun?	✓			Temperature Device Serial #: 57049919 Secondary Temperature Device Serial # (If Applicable):
3	Chain of custody documents included with shipment?	✓			
4	Sample containers intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
5	Samples requiring chemical preservation at proper pH?	✓			Sample ID's, containers affected and observed pH: If Preservation added, Lot#:
6	VOA vials free of headspace (defined as < 6mm bubble)?		✓		Sample ID's and containers affected:
7	Are Encore containers present?			✓	(If yes, immediately deliver to Volatiles laboratory)
8	Samples received within holding time?	✓			ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓			Sample ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓			Sample ID's affected:
11	Number of containers received match number indicated on COC?	✓			Sample ID's affected:
12	Are sample containers identifiable as GEL provided?	✓			
13	COC form is properly signed in relinquished/received sections?	✓			
14	Carrier and tracking number.	✓			Circle Applicable: FedEx Air FedEx Ground UPS Field Services Courier Other 7938 1252 0821 23 C 0957 23 C 1004 23 C

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials JMC Date 07/27/12 Page 1 of 1

F Soil Boring Logs

E&E Overburden Borehole Logging Form

Location ID: 32-01

Client: U.S. EPA | Date: 7/18/2012 | Page: 1 of 1
Project: Tronox AUM Section 32 Removal Assessment | Drilling Company:
Site/Area: Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W | Operator(s): P. Jones
Project No. EE-002693-2164-01TTO | Rig/Type: Geoprobe
Geologist: Paul Jones | Drill Bit - Type/Size: Macrocore
Signature: | Sample Method:

Start Time: 1430
Top Depth: 0.0 Ft.
Bottom Depth: 4.0 Ft.
Finish Time: 1440

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL			0-0.2 (2 in bgs)	
300, 4.5.2.3 Method			0.2-1	
			1-2	
		AUM32-01-36	2-3	
		AUM32-01-48	3-4	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain | Intrument #1: Type: Reading
Color: MUN GSA | Intrument #2: Type: Reading
Coloration: UNI MTD VAR STN | Sorting: WEL MOD POR NA
Texture: GVL: % ANG SUB RND NA | Plasticity: NON LOW MED HGH NA
SND: % ANG SUB RND NA | Moisture: DRY MST WET SAT NA
SLT: % | Cementation: NON SLT MOD WEL NA
CLY: % USCS SYM: | Strength: NOC / COH
ORG: % | Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Silty sand fill

1.0 FT BGS

Material: Natural Fill Uncertain | Intrument #1: Type: Reading
Color: MUN GSA Brown | Intrument #2: Type: Reading
Coloration: UNI MTD VAR STN | Sorting: WEL MOD POR NA
Texture: GVL: % ANG SUB RND NA | Plasticity: NON LOW MED HGH NA
SND: % ANG SUB RND NA | Moisture: DRY MST WET SAT NA
SLT: 90 % | Cementation: NON SLT MOD WEL NA
CLY: 10 % USCS SYM: ML | Strength: NOC / COH
ORG: % | Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Clayey silt

4.0 FT BGS

Bottom of boring 4.0 feet

Material: Natural Fill Uncertain | Intrument #1: Type: Reading
Color: MUN GSA | Intrument #2: Type: Reading
Coloration: UNI MTD VAR STN | Sorting: WEL MOD POR NA
Texture: GVL: % ANG SUB RND NA | Plasticity: NON LOW MED HGH NA
SND: % ANG SUB RND NA | Moisture: DRY MST WET SAT NA
SLT: % | Cementation: NON SLT MOD WEL NA
CLY: % USCS SYM: | Strength: NOC / COH
ORG: % | Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

Material: Natural Fill Uncertain | Intrument #1: Type: Reading
Color: MUN GSA | Intrument #2: Type: Reading
Coloration: UNI MTD VAR STN | Sorting: WEL MOD POR NA
Texture: GVL: % ANG SUB RND NA | Plasticity: NON LOW MED HGH NA
SND: % ANG SUB RND NA | Moisture: DRY MST WET SAT NA
SLT: % | Cementation: NON SLT MOD WEL NA
CLY: % USCS SYM: | Strength: NOC / COH
ORG: % | Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 32-08

Page: 1 of 1

Client:	U.S. EPA	Date:	7/18/2012
Project:	Tronox AUM Section 32 Removal Assessment	Drilling Company:	
Site/Area:	Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W	Operator(s):	P. Jones
Project No.	EE-002693-2164-01TTO	Rig/Type:	Geoprobe
Geologist:	Paul Jones	Drill Bit - Type/Size:	Macrocore
Signature:		Sample Method:	

Start Time: 1615
Top Depth: 0.0 Ft.
Bottom Depth: 4.0 Ft.
Finish Time: 1625

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL			0-0.2 (2 in bgs)	
300, 4.5.2.3 Method			0.2-1	
			1-2	
		AUM32-08-36	2-3	
		AUM32-08-48	3-4	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA Light brown and gray
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type:___ Reading ___
Intrument #2: Type:___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA
Mixed sandy silt fill. Gray only 0-1 foot.

3.0 FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA Brown
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: 95 %
CLY: 5 %
ORG: ___ %
USCS SYM: ML
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type:___ Reading ___
Intrument #2: Type:___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA
Silt with some clay

4.0 FT BGS

Bottom of boring 4.0 feet

Material: Natural Fill Uncertain
Color: MUN GSA ___
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type:___ Reading ___
Intrument #2: Type:___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA

FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA ___
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type:___ Reading ___
Intrument #2: Type:___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 32-09

Client:	U.S. EPA	Date:	7/18/2012
Project:	Tronox AUM Section 32 Removal Assessment	Drilling Company:	
Site/Area:	Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W	Operator(s):	P. Jones
Project No.	EE-002693-2164-01TTO	Rig/Type:	Geoprobe
Geologist:	Paul Jones	Drill Bit - Type/Size:	Macrocore
Signature:		Sample Method:	

Start Time: 1445
Top Depth: 0.0 Ft.
Bottom Depth: 4.0 Ft.
Finish Time: 1455

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL			0-0.2 (2 in bgs)	
300, 4.5.2.3 Method			0.2-1	
			1-2	
		AUM32-09-36	2-3	
		AUM32-09-48	3-4	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type:____ Reading ____
Color: MUN GSA Brown — Intrument #2: Type:____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: 90 % — Cementation: NON SLT MOD WEL NA
CLY: 10 % — USCS SYM: ML — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Clayey silt 0-0.5 feet with more moisture and slight plasticity

4.0 FT BGS

Bottom of boring 4.0 feet

Material: Natural Fill Uncertain — Intrument #1: Type:____ Reading ____
Color: MUN GSA ____ — Intrument #2: Type:____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: ___ % — Cementation: NON SLT MOD WEL NA
CLY: ___ % — USCS SYM: — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type:____ Reading ____
Color: MUN GSA ____ — Intrument #2: Type:____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: ___ % — Cementation: NON SLT MOD WEL NA
CLY: ___ % — USCS SYM: — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type:____ Reading ____
Color: MUN GSA ____ — Intrument #2: Type:____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: ___ % — Cementation: NON SLT MOD WEL NA
CLY: ___ % — USCS SYM: — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 32-26

Client:	U.S. EPA	Date:	7/17/2012
Project:	Tronox AUM Section 32 Removal Assessment	Drilling Company:	
Site/Area:	Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W	Operator(s):	P. Jones
Project No.	EE-002693-2164-01TTO	Rig/Type:	Geoprobe
Geologist:	Paul Jones	Drill Bit - Type/Size:	Macrocore
Signature:		Sample Method:	

Start Time: 1130
Top Depth: 0.0 Ft.
Bottom Depth: 4.0 Ft.
Finish Time: 1140

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL		AUM32-26-2	0-0.2 (2 in bgs)	
300, 4.5.2.3 Method		AUM32-26-12	0.2-1	
		AUM32-26-24	1-2	
		AUM32-26-36	2-3	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type: ______ Reading ______
Color: MUN GSA Reddish brown — Intrument #2: Type: ______ Reading ______
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: 100 % — Cementation: NON SLT MOD WEL NA
CLY: ___ % USCS SYM: ML — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Silt

1.0 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type: ______ Reading ______
Color: MUN GSA Light reddish brown — Intrument #2: Type: ______ Reading ______
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: 20 % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: 80 % — Cementation: NON SLT MOD WEL NA
CLY: ___ % USCS SYM: ML — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Sandy silt

3.0 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type: ______ Reading ______
Color: MUN GSA Light gray — Intrument #2: Type: ______ Reading ______
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: ___ % — Cementation: NON SLT MOD WEL NA
CLY: ___ % USCS SYM: — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Sandy siltstone weathered bedrock

4.0 FT BGS

Bottom of boring 4.0 feet

Material: Natural Fill Uncertain — Intrument #1: Type: ______ Reading ______
Color: MUN GSA ______ — Intrument #2: Type: ______ Reading ______
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: ___ % — Cementation: NON SLT MOD WEL NA
CLY: ___ % USCS SYM: — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 32-27

Client:	U.S. EPA	Date:	7/17/2012
Project:	Tronox AUM Section 32 Removal Assessment	Drilling Company:	
Site/Area:	Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W	Operator(s):	P. Jones
Project No.	EE-002693-2164-01TTO	Rig/Type:	Geoprobe
Geologist:	Paul Jones	Drill Bit - Type/Size:	Macrocore
Signature:		Sample Method:	

Start Time: 1210
Top Depth: 0.0 Ft.
Bottom Depth: 4.0 Ft.
Finish Time: 1220

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL		AUM32-27-2	0-0.2 (2 in bgs)	
300, 4.5.2.3 Method		AUM32-27-12	0.2-1	
		AUM32-27-24	1-2	
		AUM32-27-36	2-3	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA Medium reddish brown
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: 5 % ___ ANG SUB RND NA
SLT: 85 %
CLY: 10 %
ORG: ___ %
USCS SYM: ML
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA
Clayey silt with some sand

1.5 FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA Very light yellowish brown
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: 20 % ___ ANG SUB RND NA
SLT: 80 %
CLY: ___ %
ORG: ___ %
USCS SYM: ML
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA
Sandy silt

3.0 FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA Grayish brown
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA
Weathered siltstone bedrock with white fracture coatings

4.0 FT BGS

Bottom of boring 4.0 feet

Material: Natural Fill Uncertain
Color: MUN GSA ___
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 32-28

Client:	U.S. EPA	Date:	7/17/2012
Project:	Tronox AUM Section 32 Removal Assessment	Drilling Company:	
Site/Area:	Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W	Operator(s):	P. Jones
Project No.	EE-002693-2164-01TTO	Rig/Type:	Geoprobe
Geologist:	Paul Jones	Drill Bit - Type/Size:	Macrocore
Signature:		Sample Method:	

Start Time: 1140
Top Depth: 0.0 Ft.
Bottom Depth: 4.0 Ft.
Finish Time: 1150

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL		AUM32-28-2	0-0.2 (2 in bgs)	
300, 4.5.2.3 Method		AUM32-28-12	0.2-1	
		AUM32-28-24	1-2	
		AUM32-28-36	2-3	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type:____ Reading ____
Color: MUN GSA Light reddish brown — Intrument #2: Type:____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: __ % __ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: 40 % __ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: 60 % — Cementation: NON SLT MOD WEL NA
CLY: __ % USCS SYM: SM — Strength: NOC / COH
ORG: __ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Sandy silt: Sand is fine to very fine grained

3.5 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type:____ Reading ____
Color: MUN GSA ____ — Intrument #2: Type:____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: __ % __ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: 40 % __ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: 60 % — Cementation: NON SLT MOD WEL NA
CLY: __ % USCS SYM: — Strength: NOC / COH
ORG: __ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Light gray weathered sandy siltstone bedrock

4.0 FT BGS

Bottom of boring 4.0 feet

Material: Natural Fill Uncertain — Intrument #1: Type:____ Reading ____
Color: MUN GSA ____ — Intrument #2: Type:____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: __ % __ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: __ % __ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: __ % — Cementation: NON SLT MOD WEL NA
CLY: __ % USCS SYM: — Strength: NOC / COH
ORG: __ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type:____ Reading ____
Color: MUN GSA ____ — Intrument #2: Type:____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: __ % __ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: __ % __ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: __ % — Cementation: NON SLT MOD WEL NA
CLY: __ % USCS SYM: — Strength: NOC / COH
ORG: __ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 32-29

Client:	U.S. EPA	Date:	7/17/2012
Project:	Tronox AUM Section 32 Removal Assessment	Drilling Company:	
Site/Area:	Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W	Operator(s):	P. Jones
Project No.	EE-002693-2164-01TTO	Rig/Type:	Geoprobe
Geologist:	Paul Jones	Drill Bit - Type/Size:	Macrocore
Signature:		Sample Method:	

Page: 1 of 1

Start Time: 1305
Top Depth: 0.0 Ft.
Bottom Depth: 4.0 Ft.
Finish Time: 1315

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL		AUM32-29-2	0-0.2 (2 in bgs)	
300, 4.5.2.3 Method		AUM32-29-12	0.2-1	
		AUM32-29-24	1-2	
		AUM32-29-36	2-3	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type:____ Reading ____
Color: MUN GSA Reddish brown — Intrument #2: Type:____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: __ % __ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: __ % __ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: 95 % — Cementation: NON SLT MOD WEL NA
CLY: <5 % USCS SYM: ML — Strength: NOC / COH
ORG: __ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Silt with some clay

1.0 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type:____ Reading ____
Color: MUN GSA Light reddish brown — Intrument #2: Type:____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: __ % __ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: 20 % __ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: 80 % — Cementation: NON SLT MOD WEL NA
CLY: __ % USCS SYM: ML — Strength: NOC / COH
ORG: __ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Sandy silt

2.5 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type:____ Reading ____
Color: MUN GSA Light gray — Intrument #2: Type:____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: __ % __ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: __ % __ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: __ % — Cementation: NON SLT MOD WEL NA
CLY: __ % USCS SYM: — Strength: NOC / COH
ORG: __ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Heavily weathered siltstone bedrock with abundant white fracture coatings

4.0 FT BGS

Bottom of boring 4.0 feet

Material: Natural Fill Uncertain — Intrument #1: Type:____ Reading ____
Color: MUN GSA ____ — Intrument #2: Type:____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: __ % __ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: __ % __ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: __ % — Cementation: NON SLT MOD WEL NA
CLY: __ % USCS SYM: — Strength: NOC / COH
ORG: __ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 32-30

Client:	U.S. EPA	Date:	7/17/2012
Project:	Tronox AUM Section 32 Removal Assessment	Drilling Company:	
Site/Area:	Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W	Operator(s):	P. Jones
Project No.	EE-002693-2164-01TTO	Rig/Type:	Geoprobe
Geologist:	Paul Jones	Drill Bit - Type/Size:	Macrocore
Signature:		Sample Method:	

Start Time: 1610
Top Depth: 0.0 Ft.
Bottom Depth: 4.0 Ft.
Finish Time: 1620

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL		AUM32-30-2	0-0.2 (2 in bgs)	
300, 4.5.2.3 Method		AUM32-30-12/-130-12	0.2-1	
		AUM32-30-24	1-2	
		AUM32-30-36	2-3	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA Medium brown
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: 90 %
CLY: 10 %
ORG: ___ %
USCS SYM: ML
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type:__________ Reading __________
Intrument #2: Type:__________ Reading __________
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA
Clayey silt

1.0 FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA Light reddish brown
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: 20 % ___ ANG SUB RND NA
SLT: 80 %
CLY: <5 %
ORG: ___ %
USCS SYM: ML
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type:__________ Reading __________
Intrument #2: Type:__________ Reading __________
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA
Sandy silt with some clay

4.0 FT BGS

Bottom of boring 4.0 feet

Material: Natural Fill Uncertain
Color: MUN GSA ____________
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type:__________ Reading __________
Intrument #2: Type:__________ Reading __________
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA

FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA ____________
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type:__________ Reading __________
Intrument #2: Type:__________ Reading __________
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 32-31

Client: U.S. EPA
Date: 7/17/2012
Page: 1 of 1
Project: Tronox AUM Section 32 Removal Assessment
Drilling Company:
Site/Area: Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W
Operator(s): P. Jones
Project No. EE-002693-2164-01TTO
Rig/Type: Geoprobe
Geologist: Paul Jones
Drill Bit - Type/Size: Macrocore
Signature:
Sample Method:

Start Time: 1230
Top Depth: 0.0 Ft.
Bottom Depth: 4.0 Ft.
Finish Time: 1240

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL		AUM32-31-2	0-0.2 (2 in bgs)	
300, 4.5.2.3 Method		AUM32-31-12	0.2-1	
		AUM32-31-24	1-2	
		AUM32-31-36	2-3	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain
Intrument #1: Type: Reading
Color: MUN GSA
Intrument #2: Type: Reading
Coloration: UNI MTD VAR STN
Sorting: WEL MOD POR NA
Texture: GVL: % ANG SUB RND NA
Plasticity: NON LOW MED HGH NA
SND: % ANG SUB RND NA
Moisture: DRY MST WET SAT NA
SLT: 95 %
Cementation: NON SLT MOD WEL NA
CLY: 5 %
USCS SYM: ML
Strength: NOC / COH
ORG: %
Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Clayey silt

1.0 FT BGS

Material: Natural Fill Uncertain
Intrument #1: Type: Reading
Color: MUN GSA Light gray
Intrument #2: Type: Reading
Coloration: UNI MTD VAR STN
Sorting: WEL MOD POR NA
Texture: GVL: % ANG SUB RND NA
Plasticity: NON LOW MED HGH NA
SND: % ANG SUB RND NA
Moisture: DRY MST WET SAT NA
SLT: %
Cementation: NON SLT MOD WEL NA
CLY: %
USCS SYM:
Strength: NOC / COH
ORG: %
Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Heavily weathered sandy siltstone bedrock

3.5 FT BGS

Material: Natural Fill Uncertain
Intrument #1: Type: Reading
Color: MUN GSA Light reddish brown
Intrument #2: Type: Reading
Coloration: UNI MTD VAR STN
Sorting: WEL MOD POR NA
Texture: GVL: % ANG SUB RND NA
Plasticity: NON LOW MED HGH NA
SND: % ANG SUB RND NA
Moisture: DRY MST WET SAT NA
SLT: %
Cementation: NON SLT MOD WEL NA
CLY: %
USCS SYM:
Strength: NOC / COH
ORG: %
Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Weathered sandy siltstone bedrock

4.0 FT BGS

Bottom of boring 4.0 feet

Material: Natural Fill Uncertain
Intrument #1: Type: Reading
Color: MUN GSA
Intrument #2: Type: Reading
Coloration: UNI MTD VAR STN
Sorting: WEL MOD POR NA
Texture: GVL: % ANG SUB RND NA
Plasticity: NON LOW MED HGH NA
SND: % ANG SUB RND NA
Moisture: DRY MST WET SAT NA
SLT: %
Cementation: NON SLT MOD WEL NA
CLY: %
USCS SYM:
Strength: NOC / COH
ORG: %
Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 32-32

Client: U.S. EPA | Date: 7/18/2012 | Page: 1 of 1

Project: Tronox AUM Section 32 Removal Assessment | Drilling Company:

Site/Area: Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W | Operator(s): P. Jones

Project No. EE-002693-2164-01TTO | Rig/Type: Geoprobe

Geologist: Paul Jones | Drill Bit - Type/Size: Macrocore

Signature: | Sample Method:

Start Time: 1045
Top Depth: 0.0 Ft.
Bottom Depth: 4.0 Ft.
Finish Time: 1055

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL		AUM32-32-2	0-0.2 (2 in bgs)	
300, 4.5.2.3 Method		AUM32-32-12	0.2-1	
		AUM32-32-24	1-2	
		AUM32-32-36/-132-36	2-3	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA Reddish brown
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: 100 %
CLY: ___ %
ORG: ___ %
USCS SYM: ML
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA
Silt

1.0 FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA Light yellowish brown
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: 20 % ___ ANG SUB RND NA
SLT: 80 %
CLY: ___ %
ORG: ___ %
USCS SYM: ML
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA
Sandy silt

2.0 FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA Light gray to gray
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA
Heavily weathered to weathered siltstone bedrock

4.0 FT BGS

Bottom of boring 4.0 feet

Material: Natural Fill Uncertain
Color: MUN GSA ___
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 32-33

Client:	U.S. EPA	Date:	7/18/2012
Project:	Tronox AUM Section 32 Removal Assessment	Drilling Company:	
Site/Area:	Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W	Operator(s):	P. Jones
Project No.	EE-002693-2164-01TTO	Rig/Type:	Geoprobe
Geologist:	Paul Jones	Drill Bit - Type/Size:	Macrocore
Signature:		Sample Method:	

Start Time: 1010
Top Depth: 0.0 Ft.
Bottom Depth: 4.0 Ft.
Finish Time: 1020

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL		AUM32-33-2	0-0.2 (2 in bgs)	
300, 4.5.2.3 Method		AUM32-33-12	0.2-1	
		AUM32-33-24	1-2	
		AUM32-33-36	2-3	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA Light reddish brown
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: 15 % ___ ANG SUB RND NA
SLT: 85 %
CLY: ___ %
ORG: ___ %
USCS SYM: ML
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA
Sandy silt

1.0 FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA Light yellowish brown to gray
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA
Weathered siltstone bedrock

4.0 FT BGS

Bottom of boring 4.0 feet

Material: Natural Fill Uncertain
Color: MUN GSA ___
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA

FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA ___
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 32-34

Client:	U.S. EPA	Date:	7/18/2012
Project:	Tronox AUM Section 32 Removal Assessment	Drilling Company:	
Site/Area:	Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W	Operator(s):	P. Jones
Project No.	EE-002693-2164-01TTO	Rig/Type:	Geoprobe
Geologist:	Paul Jones	Drill Bit - Type/Size:	Macrocore
Signature:		Sample Method:	

Start Time: 0945
Top Depth: 0.0 Ft.
Bottom Depth: 4.0 Ft.
Finish Time: 1000

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL		AUM32-34-2/-134-2	0-0.2 (2 in bgs)	
300, 4.5.2.3 Method		AUM32-34-12	0.2-1	
		AUM32-34-24	1-2	
		AUM32-34-36	2-3	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA Light reddish brown
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: 10 % ___ ANG SUB RND NA
SLT: 90 %
CLY: ___ %
ORG: ___ %
USCS SYM: ML
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA
Sandy silt

1.0 FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA Light yellowish brown to gray
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: 20 % ___ ANG SUB RND NA
SLT: 80 %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA
Weathered siltstone bedrock

4.0 FT BGS

Bottom of boring at 4.0 feet

Material: Natural Fill Uncertain
Color: MUN GSA Light yellowish brown to gray
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA

FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA ___
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 32-35

Client:	U.S. EPA	Date:	7/18/2012
Project:	Tronox AUM Section 32 Removal Assessment	Drilling Company:	
Site/Area:	Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W	Operator(s):	P. Jones
Project No.	EE-002693-2164-01TTO	Rig/Type:	Geoprobe
Geologist:	Paul Jones	Drill Bit - Type/Size:	Macrocore
Signature:		Sample Method:	

Page: 1 of 1

Start Time: 1150
Top Depth: 0.0 Ft.
Bottom Depth: 8.0 Ft.
Finish Time: 1205

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL		AUM32-35-2	0-0.2 (2 in bgs)	
300, 4.5.2.3 Method		AUM32-35-12	0.2-1	
		AUM32-35-24/-135-24	1-2	
		AUM32-35-36	2-3	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type:______ Reading ______
Color: MUN GSA Reddish brown — Intrument #2: Type:______ Reading ______
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: 95 % — Cementation: NON SLT MOD WEL NA
CLY: 5 % — USCS SYM: ML — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Silt with some clay

1.5 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type:______ Reading ______
Color: MUN GSA Light brown — Intrument #2: Type:______ Reading ______
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: 15 % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: 85 % — Cementation: NON SLT MOD WEL NA
CLY: ___ % — USCS SYM: ML — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Sandy silt, sand grades <5% from 3.5 to 7.5 feet

7.5 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type:______ Reading ______
Color: MUN GSA Light gray — Intrument #2: Type:______ Reading ______
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: ___ % — Cementation: NON SLT MOD WEL NA
CLY: ___ % — USCS SYM: — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Weathered siltstone bedrock

8.0 FT BGS

Bottom of boring at 8.0 feet

Material: Natural Fill Uncertain — Intrument #1: Type:______ Reading ______
Color: MUN GSA ______ — Intrument #2: Type:______ Reading ______
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: ___ % — Cementation: NON SLT MOD WEL NA
CLY: ___ % — USCS SYM: — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 32-36

Client:	U.S. EPA	Date:	7/18/2012
Project:	Tronox AUM Section 32 Removal Assessment	Drilling Company:	
Site/Area:	Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W	Operator(s):	P. Jones
Project No.	EE-002693-2164-01TTO	Rig/Type:	Geoprobe
Geologist:	Paul Jones	Drill Bit - Type/Size:	Macrocore
Signature:		Sample Method:	

Start Time: 1105
Top Depth: 0.0 Ft.
Bottom Depth: 4.0 Ft.
Finish Time: 1125

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL		AUM32-36-2	0-0.2 (2 in bgs)	
300, 4.5.2.3 Method		AUM32-36-12/-136-12	0.2-1	
		AUM32-36-24	1-2	
		AUM32-36-36	2-3	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type:____ Reading ____
Color: MUN GSA Reddish brown — Intrument #2: Type:____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: __ % __ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: __ % __ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: 100 % — Cementation: NON SLT MOD WEL NA
CLY: __ % USCS SYM: ML — Strength: NOC / COH
ORG: __ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Grades with 20% sand from 3.25 to 3.5 feet

3.5 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type:____ Reading ____
Color: MUN GSA Light gray — Intrument #2: Type:____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: __ % __ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: __ % __ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: __ % — Cementation: NON SLT MOD WEL NA
CLY: __ % USCS SYM: — Strength: NOC / COH
ORG: __ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Weathered siltstone bedrock

4.0 FT BGS

Bottom of boring at 4.0 feet

Material: Natural Fill Uncertain — Intrument #1: Type:____ Reading ____
Color: MUN GSA Light yellowish brown to gray — Intrument #2: Type:____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: __ % __ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: __ % __ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: __ % — Cementation: NON SLT MOD WEL NA
CLY: __ % USCS SYM: — Strength: NOC / COH
ORG: __ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type:____ Reading ____
Color: MUN GSA ____ — Intrument #2: Type:____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: __ % __ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: __ % __ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: __ % — Cementation: NON SLT MOD WEL NA
CLY: __ % USCS SYM: — Strength: NOC / COH
ORG: __ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 32-37

Client: U.S. EPA
Date: 7/18/2012
Page: 1 of 1
Project: Tronox AUM Section 32 Removal Assessment
Drilling Company:
Site/Area: Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W
Operator(s): P. Jones
Project No. EE-002693-2164-01TTO
Rig/Type: Geoprobe
Geologist: Paul Jones
Drill Bit - Type/Size: Macrocore
Signature:
Sample Method:

Start Time: 1300
Top Depth: 0.0 Ft.
Bottom Depth: 4.0 Ft.
Finish Time: 1310

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL		AUM32-37-2	0-0.2 (2 in bgs)	
300, 4.5.2.3 Method		AUM32-37-12	0.2-1	
		AUM32-37-24	1-2	
		AUM32-37-36	2-3	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain
Intrument #1: Type: Reading
Color: MUN GSA Light reddish brown
Intrument #2: Type: Reading
Coloration: UNI MTD VAR STN
Sorting: WEL MOD POR NA
Texture: GVL: % ANG SUB RND NA
Plasticity: NON LOW MED HGH NA
SND: % ANG SUB RND NA
Moisture: DRY MST WET SAT NA
SLT: 95 %
Cementation: NON SLT MOD WEL NA
CLY: 5 %
USCS SYM: ML
Strength: NOC / COH
ORG: %
Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Silt with some clay

1.0 FT BGS

Material: Natural Fill Uncertain
Intrument #1: Type: Reading
Color: MUN GSA Light brown
Intrument #2: Type: Reading
Coloration: UNI MTD VAR STN
Sorting: WEL MOD POR NA
Texture: GVL: 5 % ANG SUB RND NA
Plasticity: NON LOW MED HGH NA
SND: 10 % ANG SUB RND NA
Moisture: DRY MST WET SAT NA
SLT: 85 %
Cementation: NON SLT MOD WEL NA
CLY: %
USCS SYM: ML
Strength: NOC / COH
ORG: %
Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Sandy silt with some gravel. <5% sand and gravel 3.5 to 4.0 feet

4.0 FT BGS

Bottom of boring at 4.0 feet

Material: Natural Fill Uncertain
Intrument #1: Type: Reading
Color: MUN GSA Light yellowish brown to gray
Intrument #2: Type: Reading
Coloration: UNI MTD VAR STN
Sorting: WEL MOD POR NA
Texture: GVL: % ANG SUB RND NA
Plasticity: NON LOW MED HGH NA
SND: % ANG SUB RND NA
Moisture: DRY MST WET SAT NA
SLT: %
Cementation: NON SLT MOD WEL NA
CLY: %
USCS SYM:
Strength: NOC / COH
ORG: %
Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

Material: Natural Fill Uncertain
Intrument #1: Type: Reading
Color: MUN GSA
Intrument #2: Type: Reading
Coloration: UNI MTD VAR STN
Sorting: WEL MOD POR NA
Texture: GVL: % ANG SUB RND NA
Plasticity: NON LOW MED HGH NA
SND: % ANG SUB RND NA
Moisture: DRY MST WET SAT NA
SLT: %
Cementation: NON SLT MOD WEL NA
CLY: %
USCS SYM:
Strength: NOC / COH
ORG: %
Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 32-38

Client:	U.S. EPA	Date:	7/18/2012
Project:	Tronox AUM Section 32 Removal Assessment	Drilling Company:	
Site/Area:	Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W	Operator(s):	P. Jones
Project No.	EE-002693-2164-01TTO	Rig/Type:	Geoprobe
Geologist:	Paul Jones	Drill Bit - Type/Size:	Macrocore
Signature:		Sample Method:	

Page: 1 of 1

Start Time: 1225
Top Depth: 0.0 Ft.
Bottom Depth: 4.0 Ft.
Finish Time: 1235

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL		AUM32-38-2/-138-2	0-0.2 (2 in bgs)	
300, 4.5.2.3 Method		AUM32-38-12	0.2-1	
		AUM32-38-24	1-2	
		AUM32-38-36	2-3	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type: ______ Reading ______
Color: MUN GSA Light reddish brown — Intrument #2: Type: ______ Reading ______
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: 95 % — Cementation: NON SLT MOD WEL NA
CLY: 5 % USCS SYM: ML — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Silt with some clay

2.0 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type: ______ Reading ______
Color: MUN GSA Light brown — Intrument #2: Type: ______ Reading ______
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: 30 % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: 70 % — Cementation: NON SLT MOD WEL NA
CLY: ___ % USCS SYM: ML — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Sandy silt

3.0 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type: ______ Reading ______
Color: MUN GSA Light reddish brown to gray — Intrument #2: Type: ______ Reading ______
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: ___ % — Cementation: NON SLT MOD WEL NA
CLY: ___ % USCS SYM: — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Weathered siltstone bedrock

4.0 FT BGS

Bottom of boring at 4.0 feet

Material: Natural Fill Uncertain — Intrument #1: Type: ______ Reading ______
Color: MUN GSA ______ — Intrument #2: Type: ______ Reading ______
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: ___ % — Cementation: NON SLT MOD WEL NA
CLY: ___ % USCS SYM: — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 32-44

Client:	U.S. EPA	Date:	7/17/2012
Project:	Tronox AUM Section 32 Removal Assessment	Drilling Company:	
Site/Area:	Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W	Operator(s):	P. Jones
Project No.	EE-002693-2164-01TTO	Rig/Type:	Geoprobe
Geologist:	Paul Jones	Drill Bit - Type/Size:	Macrocore
Signature:		Sample Method:	

Start Time: 1645
Top Depth: 0.0 Ft.
Bottom Depth: 4.0 Ft.
Finish Time: 1655

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL		AUM32-44-2	0-0.2 (2 in bgs)	
300, 4.5.2.3 Method		AUM32-44-12	0.2-1	
		AUM32-44-24/-144-24	1-2	
		AUM32-44-36	2-3	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type: ____ Reading ____
Color: MUN GSA Light reddish brown — Intrument #2: Type: ____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: 100 % — Cementation: NON SLT MOD WEL NA
CLY: <5 % — USCS SYM: ML — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Silt with some clay

3.0 FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type: ____ Reading ____
Color: MUN GSA Grayish brown — Intrument #2: Type: ____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: ___ % — Cementation: NON SLT MOD WEL NA
CLY: ___ % — USCS SYM: — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other: Weathered siltstone bedrock

4.0 FT BGS

Bottom of boring 4.0 feet

Material: Natural Fill Uncertain — Intrument #1: Type: ____ Reading ____
Color: MUN GSA ____ — Intrument #2: Type: ____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: ___ % — Cementation: NON SLT MOD WEL NA
CLY: ___ % — USCS SYM: — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

Material: Natural Fill Uncertain — Intrument #1: Type: ____ Reading ____
Color: MUN GSA ____ — Intrument #2: Type: ____ Reading ____
Coloration: UNI MTD VAR STN — Sorting: WEL MOD POR NA
Texture: GVL: ___ % ___ ANG SUB RND NA — Plasticity: NON LOW MED HGH NA
SND: ___ % ___ ANG SUB RND NA — Moisture: DRY MST WET SAT NA
SLT: ___ % — Cementation: NON SLT MOD WEL NA
CLY: ___ % — USCS SYM: — Strength: NOC / COH
ORG: ___ % — Upper Contact: SHP GRD DIF SME NA
Observed: STN SHN ODR PRD NA Other:

FT BGS

E&E Overburden Borehole Logging Form

Location ID: 33-07

Client:	U.S. EPA	Date:	7/18/2012
Project:	Tronox AUM Section 32 Removal Assessment	Drilling Company:	
Site/Area:	Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W	Operator(s):	P. Jones
Project No.	EE-002693-2164-01TTO	Rig/Type:	Geoprobe
Geologist:	Paul Jones	Drill Bit - Type/Size:	Macrocore
Signature:		Sample Method:	

Start Time: 1355
Top Depth: 0.0 Ft.
Bottom Depth: 8.0 Ft.
Finish Time: 1405

Analyses	Recovery (ft)	Sample ID	Interval	Type
Ra-226 by EML HASL			0-0.2 (2 in bgs)	
300, 4.5.2.3 Method			0.2-1	
			1-2	
		AUM33-07-36	2-3	
		AUM33-07-48	3-4	

GEO-GRAPHIC LOG IN FEET

0.0 FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA Brown
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: 70 %
CLY: 30 %
ORG: ___ %
USCS SYM: ML
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA
Clayey silt

4.0 FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA Light brown to gray
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA
Weathered siltstone bedrock

8.0 FT BGS

Bottom of boring at 8.0 feet

Material: Natural Fill Uncertain
Color: MUN GSA ___
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA

FT BGS

Material: Natural Fill Uncertain
Color: MUN GSA ___
Coloration: UNI MTD VAR STN
Texture: GVL: ___ % ___ ANG SUB RND NA
SND: ___ % ___ ANG SUB RND NA
SLT: ___ %
CLY: ___ %
ORG: ___ %
USCS SYM:
Observed: STN SHN ODR PRD NA Other:

Intrument #1: Type: ___ Reading ___
Intrument #2: Type: ___ Reading ___
Sorting: WEL MOD POR NA
Plasticity: NON LOW MED HGH NA
Moisture: DRY MST WET SAT NA
Cementation: NON SLT MOD WEL NA
Strength: NOC / COH
Upper Contact: SHP GRD DIF SME NA

FT BGS