Removal Action Report
Tronox AUM Section 32
Eastern Agency
Prewitt, McKinley County, New Mexico

AUM Section 32
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Region IX

Prepared by:

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

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List of Abbreviations and Acronyms

AUM	Abandoned Uranium Mine
bgs	below ground surface
cpm	counts per minute
E & E	Ecology and Environment, Inc.'s
EML	Environmental Measurements Laboratory
ERRS	Emergency and Rapid Response Services
ERT	Environmental Response Team
FOSC	Federal On-Scene Coordinator
GIS	Geographical Information System
GPS	Global Positioning System
HASL	Health and Safety Laboratory
hi-vol	high volume air sampler
HSP	Health and Safety Plan
NAAQS	National Ambient Air Quality Standards
pCi/g	picocurie per gram
PRG	Preliminary Remediation Goal
QA/QC	quality assurance/quality control
Ra-226	Radium-226
r^2	coefficient of determination
SAP	Sampling and Analysis Plan
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 (E & E) Superfund Technical Assessment and Response Team (START) to support the removal action at Tronox Abandoned Uranium Mine (AUM) Section 32 located in Prewitt, McKinley County, New Mexico, in the Casamero Lake and Haystack Chapters of the Navajo Nation. AUM 32 is part of the Five-Year Plan for cleaning up the legacy of abandoned uranium mining in the Navajo Nation (Bureau of Indian Affairs *et al.* 2008). START documented the excavated areas and conducted gamma radiation surveys and soil sampling to confirm that gamma radiation activity and Radium-226 (Ra-226) concentrations in soil remaining in place at the removal areas were below the cleanup level. This report documents the excavated areas and the results of the gamma radiation survey and soil sampling during the removal action.

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 1, Appendix A). 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, which is privately owned. The transfer area is located approximately 0.3 mile southwest of the mine area. AUM 32 is located in a range land.

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 shows an ephemeral stream or river located north and south of the mine area that converges approximately 0.25 mile west of the mine area (Figure 2, Appendix A). A 10-foot deep ditch was observed to run from east to west and bounds the mine area to the north. The ditch connects to a pond located northwest of the mine area. Approximately 309,000 sf of the AUM 32 mine area was documented to have elevated gamma radiation activity and Ra-226 concentrations in soil.

The AUM 32 transfer area is approximately 267,432 sf and contains a concrete pad and a sealed vent (E & E 2012). The transfer area is located on a slight elevation with sparse vegetation. Evidence of past water flow in a northwest direction was observed. Approximately 323,000 sf of the area around and within the AUM 32 transfer area was documented to have elevated gamma radiation activity and Ra-226 concentrations in soil.

Groundwater depth and information on nearby water wells used for drinking water were not available. Soil borings during field activities documented bedrock at 3 feet below ground surface (bgs). No residences and public structures were found within 0.25 miles of AUM 32. The nearest resident lives approximately 0.5 mile to the west. Materials obtained from the mine (tarps and lumber) were reportedly used as building materials by the residents (Weston 2009). Domestic pets such as dogs, terrestrial wildlife, and horses were observed during site activities.

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).

AUM 32 contained a historical mine which was reportedly owned by Cobb Nuclear Company and was 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.

In June 2012, USEPA and Navajo Nation Environmental Protection Agency interviewed a local resident who pointed out 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 presumed former transfer area. The resident had relatives who formerly worked for Cobb Nuclear Company and reported that rail cars transported material south and southeast of the mine. The reported structures were not evident in historical aerial photographs available after the July 2012 USEPA-led assessment activities (E & E 2012) discussed in the following section.

2.4 Previous Investigation

A site screening was conducted at AUM 32 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 area and along two diagonal intersecting transects from the mine area's four corners. Gamma radiation activity measurements ranged from 10,689 to 180,367 counts per minute (cpm) at AUM 32. 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.

In June and July 2012, a removal assessment was conducted by USEPA and START at AUM 32 (E & E 2012). The removal assessment consisted of surface gamma radiation survey, sampling of soil and waste piles for Ra-226 analysis, and home site assessment. Gamma radiation activity in surface soils at the site was detected above background levels. Gamma radiation activity ranged from 38,560 to 962,400 cpm at the AUM 32 mine area and 16,880 to above 1,000,000 cpm at the AUM 32 transfer area. Rocks and potential buried rocks had gamma radiation activity over 500,000 cpm. Ra-226 concentrations were documented above the action level of 2.11 picocuries per gram (pCi/g) in surface soil and down to 3 feet bgs. Ra-226 was detected up to 300 pCi/g. The action level was based on the highest background level recorded and the preliminary remediation goal (PRG), which is based on an estimated excess cancer risk of 1 in 10,000 (10^{-4}), for Ra-226 and its radioactive decay chain products in residential soil (USEPA 2010). Rocks and mine waste material were observed at locations with elevated gamma radiation activity and Ra-226 concentrations. The results of the removal assessment defined areas of soil to be removed at AUM 32 to protect human health. Fourteen removal areas were proposed at AUM 32 (Figures 3 through 5, Appendix A). An estimated 27,009 cubic yards of soil was identified for removal at the mine area and 18,043 cubic yards of soil was calculated for removal at the transfer area. Based on the results of the removal assessment, USEPA determined a removal action was necessary at AUM 32.

A cultural resources inventory survey was conducted on September 19, 2012 by an Emergency and Rapid Response Services (ERRS) subcontractor. According to the survey, no cultural resources or sacred places were located in the area of the site (CSWTA, Inc. 2012). Archaeological clearances were recommended before removal of the mine.

3 START Field Activities

START mobilized to AUM 32 on October 9, 2012 and demobilized on November 15, 2012. USEPA Federal On-Scene Coordinator (FOSC) Randy Nattis, USEPA Environmental Response Team (ERT), and ERRS were also on site. The START field activities for the removal action consisted of the following:

1. Documentation of excavation activities at AUM 32.
2. Surface gamma radiation surveys of soil remaining in place in the excavated areas.
3. Sampling of surface soil remaining in place at the excavated areas for Ra-226 analysis.

Prior to mobilization, the START prepared the *Sampling and Analysis Plan* (SAP)*, Tronox AUM Sections 32 and 33 Removal Action*, *Prewitt*, *McKinely County*, *New Mexico*,dated October 2012, and approved by the U.S. EPA FOSC Randy Nattis. E & E START followed all pre-determined standard operating procedures (SOPs) for sample collection, sample handling, and site documentation as outlined in the SAP during the removal activities of this project, unless otherwise specified below in Section 3.1.The data objectives of the SAP were to:

1. Determine whether gamma radiation activity in soil remaining in place within the removal area required additional excavation removal or confirmation sampling for Ra-226 analysis.
2. Determine whether concentrations of Ra-226 in soil remaining in place within the removal area required removal or no further action.

Appendix C contains photographs of the field activities.

3.1 Site-Specific SAP Deviations

The following deviations from the SAP (Appendix B) resulted from changes made at the direction of FOSC Nattis during the field assessment in response to field observations and conditions:

- AUM32-RA-15, -16, and -17 were added to the removal action due to elevated gamma radiation activity found in these areas.

- Soils were excavated to 50,000 cpm in removal areas AUM32-RA-05, -08, -15, and -16 and not the cleanup level of 40,000 cpm addressed in the SAP.

- After initial excavations, removal areas were only excavated to a maximum depth of 4-ft bgs regardless of gamma radiation activity readings.

- Removal areas AUM32-RA-14 and -17 were not addressed as planned during this removal activity; they will be addressed during a future removal action for the Section 33 AUM site.

3.2 Documentation of Excavation Activities

The proposed removal areas were marked by START on site using a global positioning system (GPS) unit and stakes color-coded according to the planned excavation depth. The boundaries of areas excavated by ERRS were documented by START using a GPS unit. Data was mapped using geographical information system (GIS) software. GPS data for site features such as roads, telephone poles, work zones, and stockpile area were also collected.

Thirteen of fourteen proposed removal areas (AUM32-RA-01 through -13) were excavated during the removal action (Figures 6-7, Appendix A). AUM32-RA-14, which was originally proposed for removal, will be addressed as part of a removal action at AUM 33. Three additional removal areas, AUM32-RA-15, 16, 17 (Figure 6, Appendix A), were identified during the pre-excavation gamma radiation survey. AUM32-RA-15 and -16 were excavated during the removal action. ERRS did not excavate AUM32-RA-17 due to it being part of a drainage ditch that flows from the Section 33 property that will be remediated at a future time. A total of 607,445 sf and 34,686 cubic yards were excavated from AUM 32. The final excavation boundaries are shown in Figures 6 and 7 (Appendix A). The final excavation volumes are presented in Table 1 (Appendix D). The excavated material was placed in a stockpile located in the AUM 32 mine area.

During excavation in the removal areas, three mine shafts were over excavated to the extent possible with the excavator and backfilled. On October 19, 2013, the open mine shaft located in AUM32-RA-04 was over excavated exposing underground structures such as rail lines and steel cables. On October 23, 2013 a second mine shaft was discovered near the first mine shaft. Excavation at the mine shafts in AUM32-RA-04 and -05 was discontinued at 12 feet because soil was caving in and backfilling the holes. On November 8, 2013, a third mine shaft was discovered in AUM32-RA-08. The hole was 5 by 5 feet in area and 10 feet deep and was covered by a 6- by 6-foot, 8-inch thick concrete slab. The hole in AUM32-RA-08 was over excavated to a 12- by 12-foot area and 4 feet bgs depth where a rock with elevated gamma activity was detected. Gray material with elevated gamma activity was found adjacent to the mine shaft and was also excavated. At all three mineshaft locations the gamma activity readings were recorded above the action level of 40,000 cpm and below 50,000 cpm. OSC Nattis directed that the soils in the vicinity of the mineshafts be excavated to a gamma radiation activity level of 50,000 cpm as they would also be backfilled with cleaner, lower gamma activity soils. The excavated area was backfilled to 1 foot bgs with soil from an adjacent area. Photographs of the mine shafts are included in Appendix C.

Final excavated areas were graded and contoured to blend with the overall topography and drainage course of the area according to the specifications in the *"Site Restoration Preliminary Design for Sections 32 & 33 Abandoned Uranium Mines, Casamero Lake Chapter, New Mexico"* prepared by the Scientific, Engineering, Response and Analytical Services contractor for ERT (Lockheed Martin 2012).

Soil removed from the excavated areas was placed in an interim stockpile located in the AUM 32 mine area (Figure 8, Appendix A). The stockpile area occupies 121,840 sf and has a height of 30 feet above the surrounding ground surface. The stockpile was constructed by ERRS according to the site restoration specifications (Lockheed Martin 2012). After excavated materials from all removal areas were placed on the stockpile, the stockpile was compacted with a smooth roller and then a soil stabilizer and dust control agent called Gorilla-Snot® was applied on the compacted stockpile by spraying with a water truck. Gorilla-Snot®, manufactured by

Soilworks®, LLC, is an eco-safe, biodegradable, liquid copolymer used to stabilize and solidify soil for erosion control and dust suppression. A surface runoff drainage system was then constructed around the base of the stockpile and away from the stockpile to the west. Finally, a fence with signage was installed around the perimeter of the stockpile to prevent access and help maintain the integrity of the stockpile area until USEPA determines a final action.

3.3 Surface Gamma Radiation Surveys

Surface gamma radiation surveys were 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 2 microcuries 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 and background check was also conducted before each survey day.

Surface gamma radiation surveys were conducted in the background area and excavation areas at AUM 32. The radiation survey equipment was mounted 6 inches from the ground surface to measure gamma radiation activity in surface soil. Real-time *in situ* surface soil surveys consisted of traversing 3- to 6-foot wide transects covering 100 percent of the survey area at a pace of 3 feet per second. The transect width was based on the field of view of the detector, which was 3 to 6 feet in diameter.

The VIPER system and GIS were used for geospatial information collection and analysis before and after excavation. VIPER is a wireless network-based communications system designed to enable real time transmission of data from field sensors to a local computer, remote computer, or enterprise server also providing data management, analysis, and visualization. The radiation 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.

FOSC Nattis directed START to confirm that the removal area boundaries were in fact the boundaries of lower gamma radiation activity below the 40,000 cpm action level by conducting a pre-excavation surface gamma radiation survey. As a result of the additional survey, AUM32-RA-15 and AUM32-RA-16 located west of AUM32-RA-01; and AUM32-RA-17 located north of AUM32-RA-03 were added for removal. The results of the pre-excavation surface gamma radiation survey at AUM 32 are shown in Figure 10 and 11 (Appendix A). Gamma radiation activity ranged from 1,620 to 298,110 cpm.

Interim surface gamma radiation surveys guided further excavation. Interim surveys during excavation were conducted by walking 5 feet from the perimeter of the excavation while holding the radiation survey equipment 6 inches from the floor of the excavation. As directed by FOSC Nattis, areas with levels greater than 50,000 cpm were further excavated at 1-foot lifts and step-outs. Elevated gamma activity was detected at the mine shafts located in the removal areas. Surface gamma radiation levels at the two mine shafts located in AUM32-RA-04 were 500,000 and greater than 999,000 cpm during excavation. Surface gamma radiation levels at the mine shaft located in AUM32-RA-08 were greater than 120,000 cpm. A rock located at a depth of 4 feet bgs in the hole had a gamma activity measurement as high as 100,000 cpm. Gray material found adjacent to the mine shaft had gamma activity levels of greater than 600,000 cpm.

After completion of all planned excavation, a final surface gamma radiation survey covering 100 percent of the excavation footprint was conducted from November 12 through 15, 2012. The results of the final surface gamma radiation survey at AUM 32 are shown in Figures 8 and 9 (Appendix A). Gamma radiation activity ranged from 470 to 134,470 cpm. No further excavation was conducted at areas with gamma radiation activity below 50,000 cpm and at depths exceeding 4 feet bgs as directed by FOSC Nattis.

Areas with elevated gamma radiation activity were left in place at AUM32-15, 16, and -17. AUM32-17 was not excavated at all as it was located along a drainage ditch that runs through elevated mine waste piles to the east in Section 33, which is private land. FOSC Nattis decided to leave the drainage in its current state as it will be addressed when remedial activities are conducted in the neighboring property to the east at Section 33. AUM-15 and -16 are part of an old roadway that was added to the removal areas and was excavated with a front end loader to 0.5-ft bgs. As directed by FOSC Nattis, these areas were only excavated to gamma activity readings of 50,000 cpm and not the action level of 40,000 cpm. An area of 8,676 sf of soil with gamma radiation activity greater than 50,000 cpm and a maximum of 134,470 cpm in was left in place at AUM32-08 in a drainage ditch area that ERRS and FOSC Nattis did not want to excavate further. In AUM32-15, an area of 1,656 sf with a maximum gamma radiation activity of 61,801 cpm was left in place as directed by FOSC Nattis.

3.4 Soil Sampling for Ra-226 Analysis

Soil samples were collected on November 15 and 16, 2012, after all removal was completed. Confirmation soil samples were collected from three locations within the excavation footprint of each removal area determined to be below the cleanup level based on gamma radiation activity measurements. Confirmation soil sample locations in each removal area were determined using Visual Sampling Plan software version 6.2 (Pacific Northwest National Laboratory 2013) and located in the field using a GPS unit pre-loaded with the GIS-assigned coordinates. The sampling locations are shown in Figures 8 and 9 (Appendix A). Discrete surface soil samples were collected from 0 to 2 inches bgs using a sterile plastic scoop 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. Surface static 1-minute gamma radiation activity was also measured at soil sampling locations to determine the relationship between surface gamma radiation activity level and Ra-226 concentration in soil left in place. Sample information was recorded in the field logbook. A total of 45 discreet surface soil samples were collected.

Duplicate samples were collected from 10 percent of the total soil samples to assess sample variability. A total of five duplicate samples 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).

3.5 Health and Safety Monitoring

Radiation contamination monitoring and air sampling were conducted during the removal action according to START's Health and Safety Plan (HSP) (Appendix B). Personnel and equipment were scanned for radiation before leaving the site. Radiation levels detected on personnel during the removal were below the HSP action level. Equipment was decontaminated until detected radiation was below the HSP action level.

Dust monitoring data was collected with a Thermo Scientific DataRAM 4™ particulate monitor. The dust data collected over 24 work days were compared to National Ambient Air Quality Standards (NAAQS) to ensure adequate dust control measures were in place during removal activities. The DataRAM 4 was situated near the command post at a location between the work zone to the east and the closest residence to the west. Dust concentrations exceeded the NAAQS on several occasions but the exceedences were all on days with high wind and dust storms at the site and therefore not attributed to removal activities on site.

Air samples were also collected for 24 days when removal activity work included excavation and backfilling. Samples were collected using F&J Specialty Products, Inc high volume (hi-vol) air samplers. One hi-vol sampler was located in the work zone around dust-generating activities, another upwind and near the command post to the west or set up at the closest residence further to the west. After a day of sampling, the 4-inch filters were removed from the sampler and a 1 minute count on the filter was run in a Ludlum 3030 alpha counter. The air samples' alpha activity was compared to indicator radioisotopes selected based on the most conservative derived air concentration published by the U.S. Nuclear Regulatory Commission. Dust concentration and radioisotope activity detected throughout the removal action were below the HSP action levels.

4 Results

Once data were generated by GEL Laboratories, a data review was completed, and the laboratory data were validated using the *Region 9 Draft Superfund Data Evaluation/Validation Guidance* (U.S. EPA, 2001). A START chemist then conducted Tier 2 data validation for all laboratory-generated data in accordance with the EPA guidance *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) April 1990 (U.S. EPA, 1990). All analytical results were found to be acceptable to meet project objectives for use as definitive-level data without qualification. Validated analytical results are included in Appendix E.

4.1 Soil Sampling for Ra-226 Analysis

Each detected Ra-226 concentration was compared to the action level of 2.11 pCi/g which was based on the sum of the highest background concentration of Ra-226 and the USEPA PRG of 1.21 pCi/g (USEPA 2010).

Ra-226 concentrations detected in surface soil left in place are shown in Figures 8 and 9 (Appendix A). The sample results and co-located 1-minute gamma radiation activity measurements from AUM 32 are presented in Table 2 (Appendix D). Ra-226 concentrations in surface soil at AUM 32 ranged from 0.8 to 31.4 pCi/g. The following locations exceeded the action level of 2.11 pCi/g:

- AUM-32-RA-03-1 located on the north boundary of AUM32-RA-03 contained 28.7 pCi/g of Ra-226 at 1 foot bgs. During interim gamma activity measurements, this location was marked by START for further excavation but was not removed by ERRS.

- AUM-32-RA-03-3 located north of the stockpile contained 5.14 pCi/g of Ra-226 at 1 foot bgs. The gamma radiation activity at this location was less than 50,000 cpm, which as previously noted, was the level that FOSC Nattis directed be left in place. AUM-32-RA-03-2 located west of this elevated location was below the action level.

- AUM-32-RA-05-2 and -3 located along the fence line between AUM32 and AUM33 contained 7.73 and 3.32 pCi/g, respectively, of Ra-226 at 4 feet bgs. The gamma radiation activity at these locations were less than 50,000 cpm.

- AUM-32-RA-08-2 located in the drainage in the transfer area contained 31 pCi/g of Ra-226 at 1 foot bgs. This location was in an area left in place with elevated gamma radiation activity as discussed in Section 3.3. During interim gamma activity measurements, this area was marked by START for further excavation but was not removed by ERRS.

- AUM-32-RA-10-1 located on the southern boundary of the removal area contained 15.5 pCi/g of Ra-226 at 1 foot bgs. During interim gamma activity measurements, this location was marked by START for further excavation but was not removed by ERRS.

- AUM-32-RA-11-3 located on the southern boundary of the removal area contained 2.52 pCi/g, which was slightly above the action level of 2.11 pCi/g for Ra-226, at 1 foot bgs. The gamma radiation activity at this location was less than 50,000 cpm. The Ra-226 concentrations detected in the other two locations (AUM-32-RA-11-1 and -2) in soil left in place in this removal area were both below the action level.

- AUM-32-RA-12-2 located in the center of the removal area contained 31.4 pCi/g of Ra-226 at 3 feet bgs. The gamma radiation activity at this location was less than 50,000 cpm.

- AUM-32-RA-13-1 and -2 located in the western portion of the removal area contained 3.24 and 2.75 pCi/g, respectively, of Ra-226 at 2 feet bgs. The gamma radiation activity at these locations were less than 50,000 cpm.

- All sampling locations at AUM-32-RA-15 and -16 exceeded the action level of 2.11 pCi/g for Ra-226 at 0.5 foot bgs. The gamma radiation activity at these locations were less than 50,000 cpm, except for AUM-32-RA-15-1 where the gamma radiation activity was 61,000 cpm as discussed in Section 3.3. As directed by FOSC Nattis, removal at AUM-32-RA-15 and -16 was complete after ERRS scraped the areas to 0.5 foot bgs using a front end loader.

4.2 Relationship between Gamma Radiation Activity and Ra-226 Concentration

Gamma radiation activity measurement was used as a field screening tool during the removal action to estimate Ra-226 concentrations in soil left in place because results from laboratory analysis would not be available in a time-frame that allowed for real-time site decision making. According to the assessment report, locations with gamma radiation activity measurements below 40,000 cpm measured using the same equipment will likely have mean surface soil concentrations of Ra-226 below the action level of 2.11 pCi/g; however, the 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 (E & E 2012). During the removal action, 22 percent of the Ra-226 concentrations in confirmation soil samples with co-located 1-minute gamma radiation activity measurements below 40,000 cpm were above the action level of 2.11 pCi/g. To determine if the confirmation data from the removal action show a similar relationship as the removal assessment data, correlation and linear regression analyses were performed.

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 the confirmation soil data using Excel (Microsoft 2010) was 0.78, which was similar to the removal assessment (E & E 2012).

Linear regression analysis was 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 equals 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 equals 0, the regression equation is not helpful in predicting a y value. The r^2 calculated from the confirmation soil data was 0.60, which was lower than the r^2 (0.84) calculated during the removal assessment (E & E 2012). Ra-226 concentrations and the measured co-located 1-minute gamma radiation activity did not show a linear relationship.

Gamma radiation activity measurements may be affected by various factors including soil conditions. On November 10, 2012, snow fell at the site. Snow cover and resulting soil moisture may have attenuated gamma radiation activity measured during the final survey and confirmation sampling (Offenbacher and Colbeck 1991). The relationship between gamma radiation activity and Ra-226 concentration likely varies with soil conditions. Therefore, gamma radiation activity measurements that are used to compare pre- and post-action should be performed in similar conditions.

5 Summary and Conclusions

The removal action at AUM 32 excavated soil from 15 removal areas. In addition, three mine shafts located at AUM32-RA-04, -05 and -08 were over excavated to the extent possible and backfilled. Final excavated areas were graded and contoured to blend with the overall topography and drainage course of the area. A total of 607,445 sf and 34,686 cubic yards were excavated at AUM 32.

Soil removed from the excavated areas was placed in an interim stockpile located in the AUM 32 mine area. After excavated materials from all planned removal areas were placed on the stockpile, a soil stabilizer and dust control agent was applied. The stockpile occupied 121,840 sf with a height of 30 feet. A surface runoff drainage system was constructed in the stockpile area. Finally, a fence with signage was installed around the perimeter to prevent access and help maintain the integrity of the stockpile area until USEPA determines a final action.

After completion of all planned excavation, a final surface gamma radiation survey was conducted covering 100 percent of the excavation footprint. Gamma radiation activity ranged from 470 to 134,470 cpm in soil left in place. No further excavation was conducted at areas with gamma radiation activity below 50,000 cpm and at depths exceeding 4 feet bgs as directed by FOSC Nattis. Areas with elevated gamma radiation activity were left in place at AUM32-08, -15, and -17.

Confirmation samples of the soils left in place were collected from 45 locations after the final gamma radiation survey. Ra-226 concentrations in 16 of the sampled locations exceeded the action level of 2.11 pCi/g. The highest Ra-226 concentration in soil left in place was 31.4 pCi/g.

Twenty two percent of the elevated Ra-226 concentrations had co-located 1-minute gamma radiation activity measurements below 40,000 cpm. The attenuated gamma radiation activity measured may be due to snow at the site before the gamma radiation activity measurements.

The removal action decreased the gamma radiation activity levels and Ra-226 concentrations in accessible soil areas at AUM 32. However, further action is necessary at AUM 32 as the stockpile was not a permanent remedy. Elevated gamma radiation activity levels and Ra-226 concentrations remain in place in some areas of AUM 32. In addition, two proposed removal areas (AUM32-RA-14 and -17) adjacent to AUM 33 were not excavated during this removal action and may be addressed during the removal action at AUM 33.

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Appendix A: Figures

Project No.: EE-002693-2200
TDD No.: 02-09-12-09-0002

Source: Aerial Photography - Bing Maps, County Roads - Navajo DOT

LEGEND

Site area

Chapter boundary

N

0 1 2 3 4 Miles

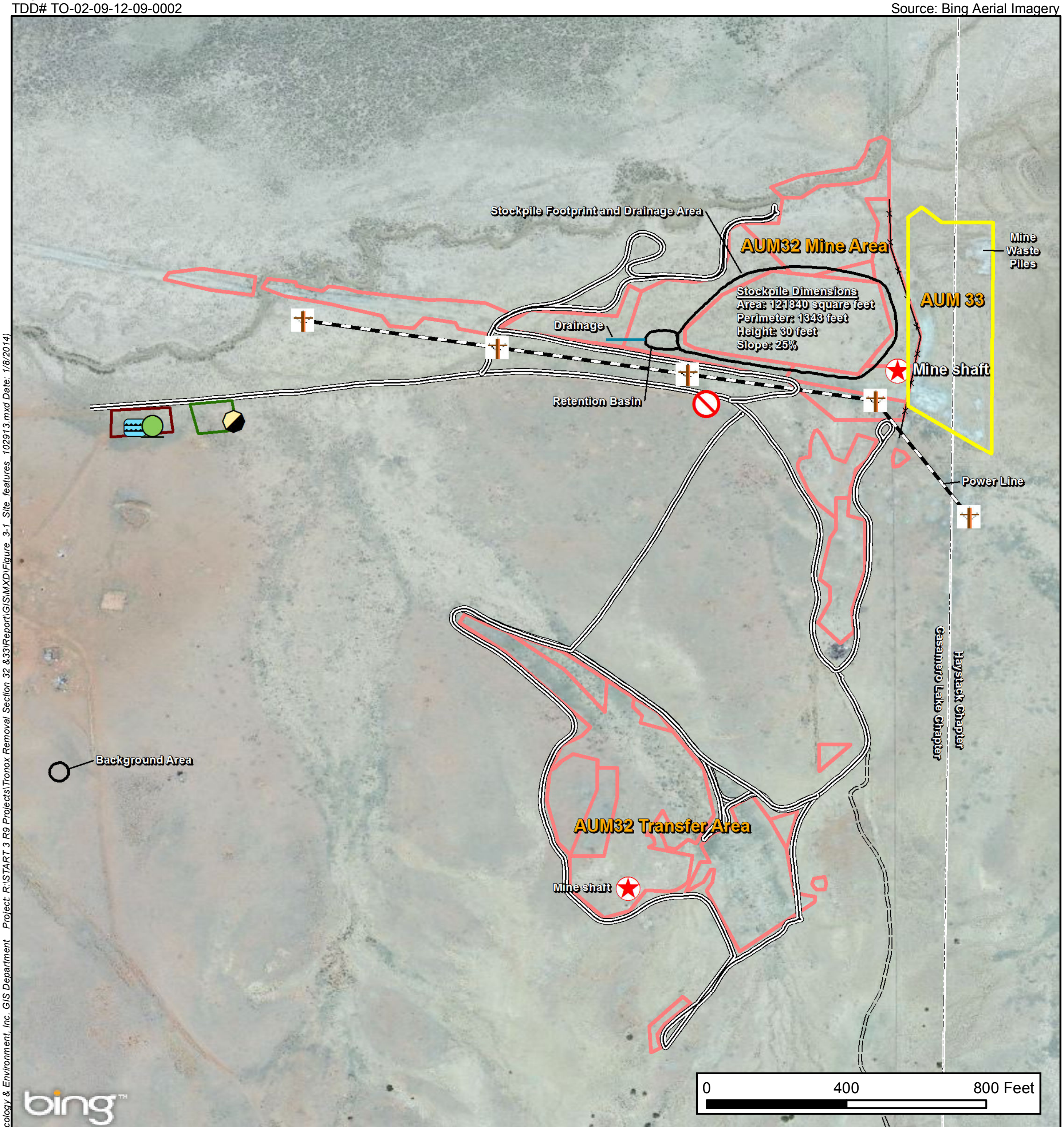
Figure 1
Site Location Map
Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

ecology and environment, inc.
International Specialists in the Environment

Ecology & Environment, Inc. GIS Department Project: R:\START 3 R9 Projects\Tronox Removal Section 32 &33\Report\GIS\MXD\Figure_2-1_Site_Location_Map_Overview10.mxd Date: 4/2/2013)

Project # EE-002693-2200
TDD# TO-02-09-12-09-0002

Source: Bing Aerial Imagery



Ecology & Environment, Inc. GIS Department Project: R:\START 3 R9 Projects\Tronox Removal Section 32 &33\Report\GIS\MXD\Figure 3-1 Site features 102913.mxd Date: 1/8/2014)

LEGEND

- Existing road
- Fence
- Road
- Chapter boundary
- Removal area
- AUM 33 boundary
- Command post
- Decon station/Exclusion zone
- Diesel tank
- Electric pole
- Mine shaft
- Water tank

N

Figure 2
Site Features Map
Tronox AUM Section 32 Removal
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

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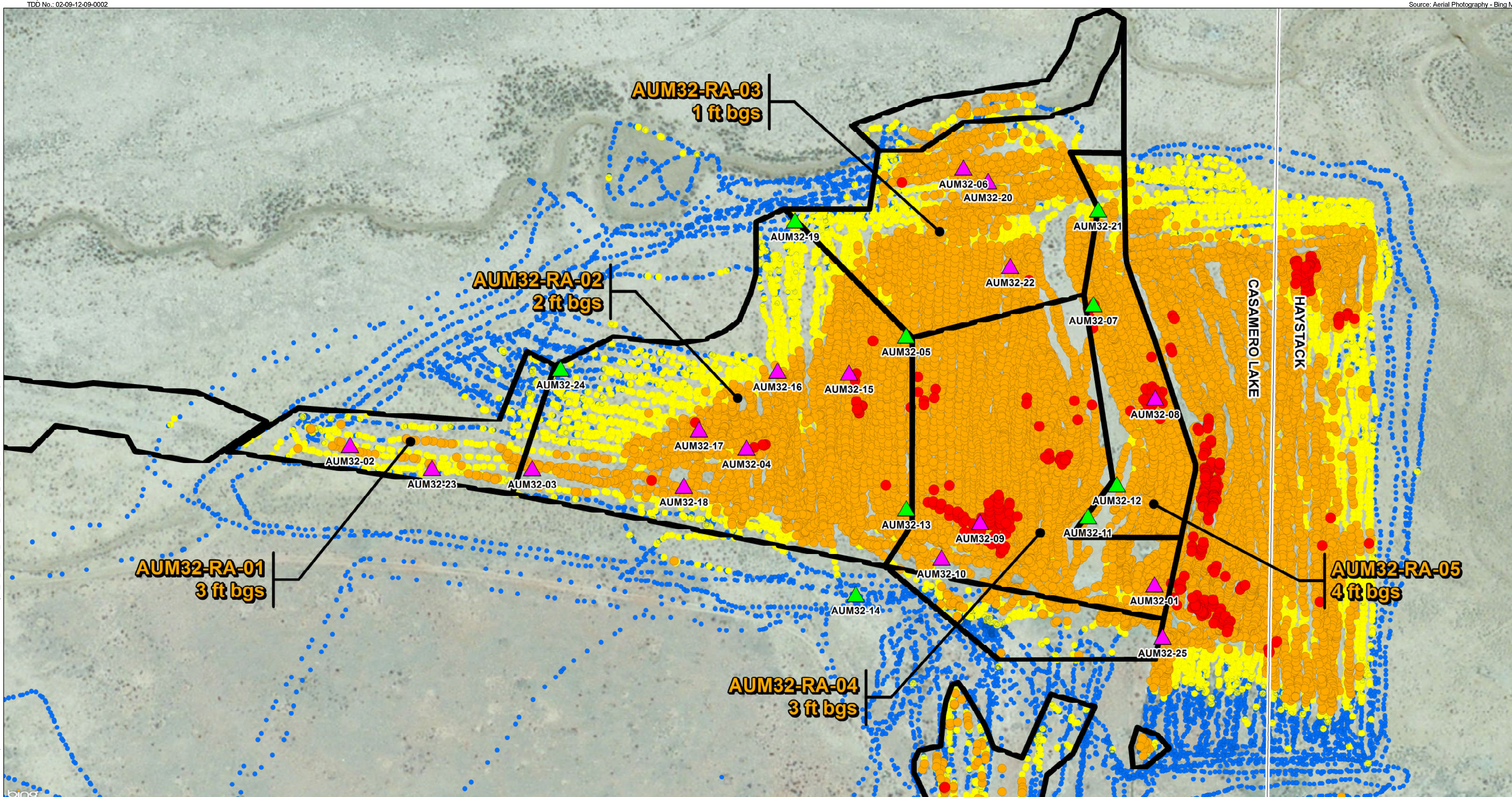
Project No.: EE-002693-2200
TDD No.: 02-09-12-09-0002

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

Notes:

Data shown are from the "Removal Assessment Report, Tronox AUM Sections 32 and 33, Eastern Agency, Prewitt, McKinley County, New Mexico, September 2012"
(Ecology and Environment, Inc. 2012).
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 3
Proposed Removal Areas at AUM 32 Mine Area
Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

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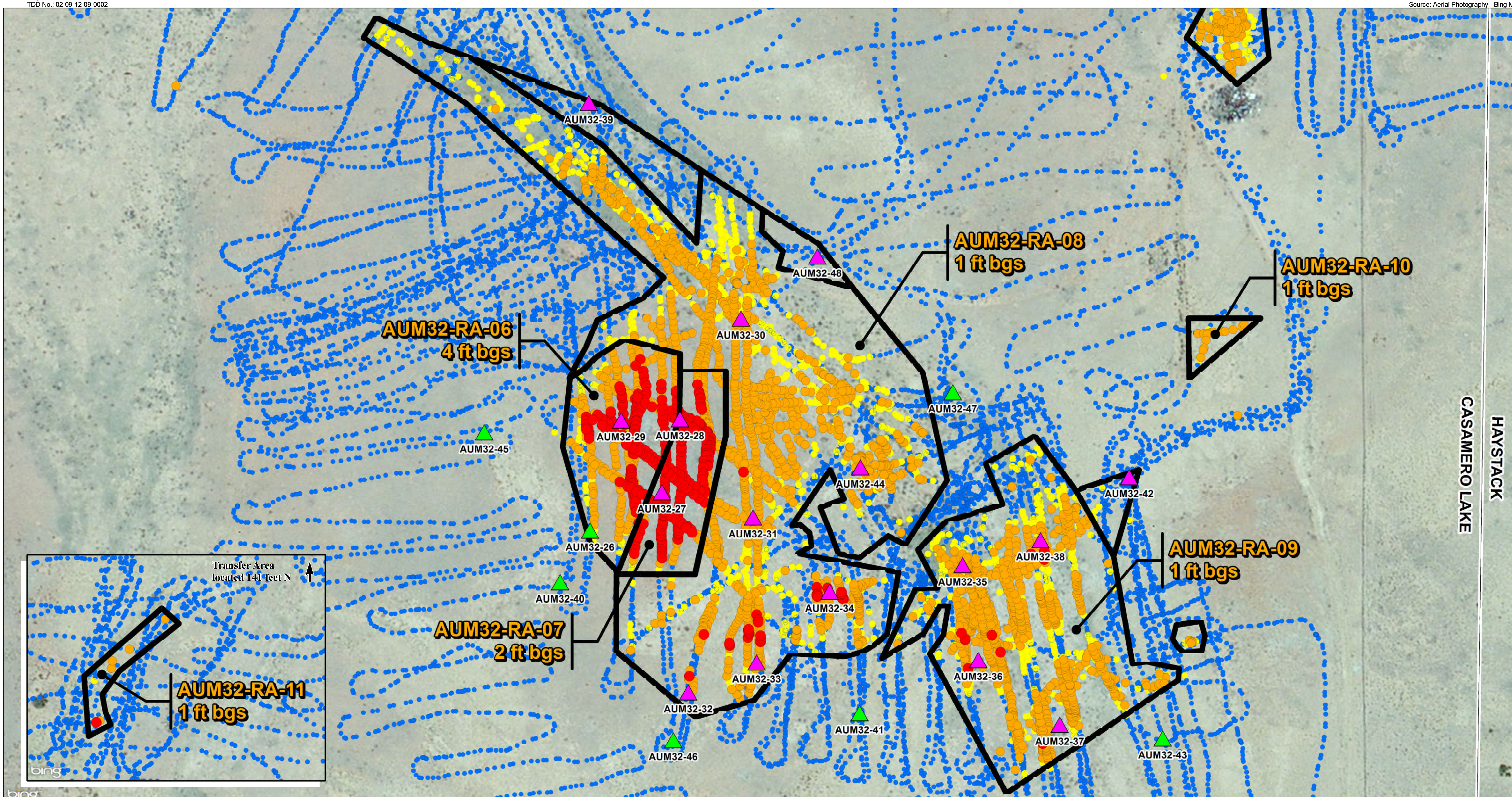
Ecology & Environment, Inc. GIS Department Project: R:\START 3 R9 Projects\Tronox Removal Section 32 &33\Report\GIS\MXD\Figure_2-2_Proposed_Removal_Area_AUM_32_Mine_Area10.mxd Date: 3/26/2013)

Project No.: EE-002693-2200
TDD No.: 02-09-12-09-0002

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:
Data shown are from the "Removal Assessment Report, Tronox AUM Sections 32 and 33, Eastern Agency, Prewitt, McKinley County, New Mexico, September 2012"
(Ecology and Environment, Inc. 2012).
ft bgs: Feet below ground surface
pCi/g: Picocuries per gram
AUM32-RA-11- Removal area
1 ft bgs - Excavation depth

N

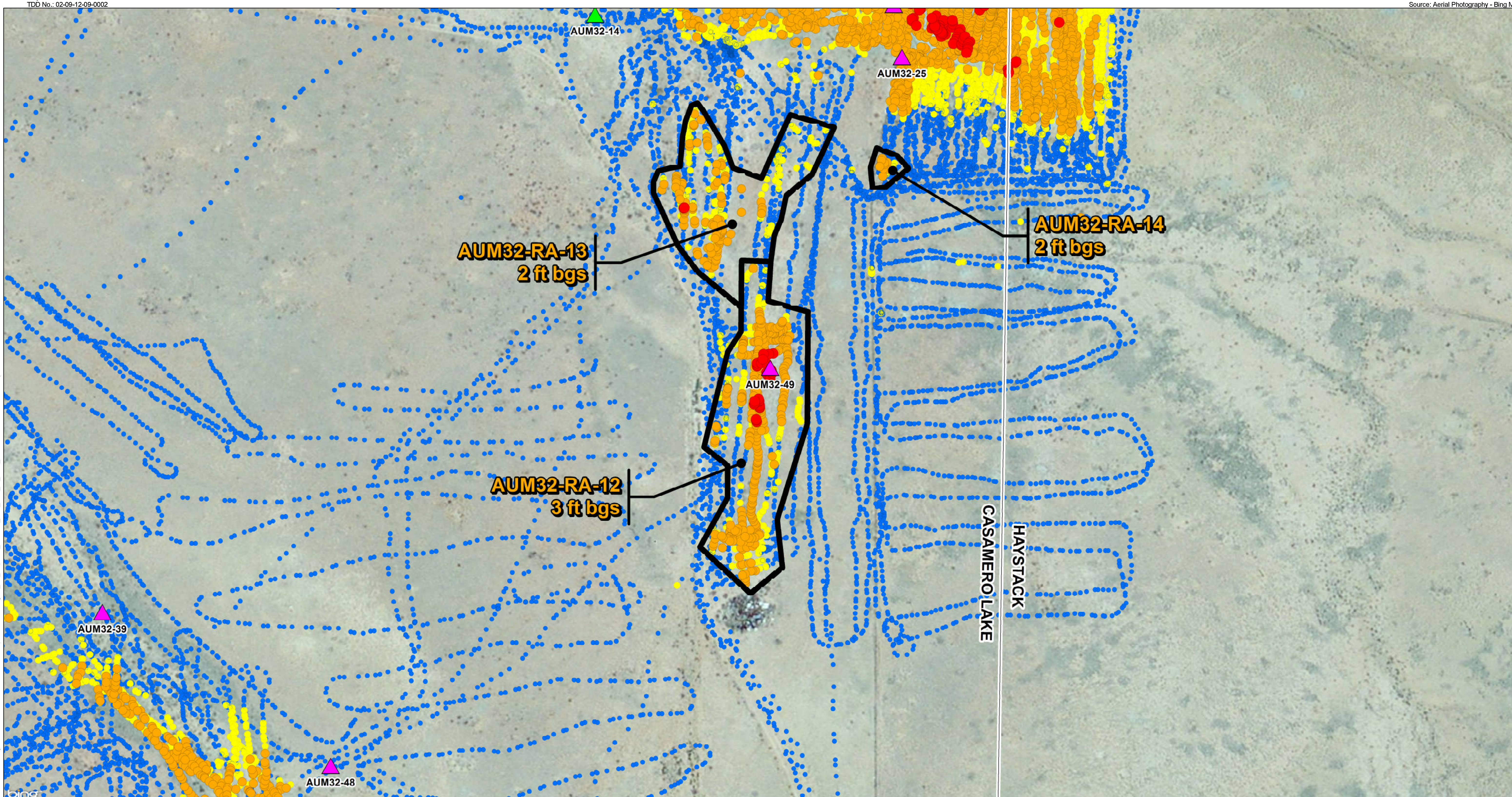
0 100 200 300 400 Feet

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

ecology and environment, inc.
International Specialists in the Environment

Project No.: EE-002693-2200
TDD No.: 02-09-12-09-0002

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:
Data shown are from the "Removal Assessment Report, Tronox AUM Sections 32 and 33, Eastern Agency, Prewitt, McKinley County, New Mexico, September 2012" (Ecology and Environment, Inc. 2012).

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 5
Proposed Removal Areas in the Northern Portion of AUM 32 Transfer Area
Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

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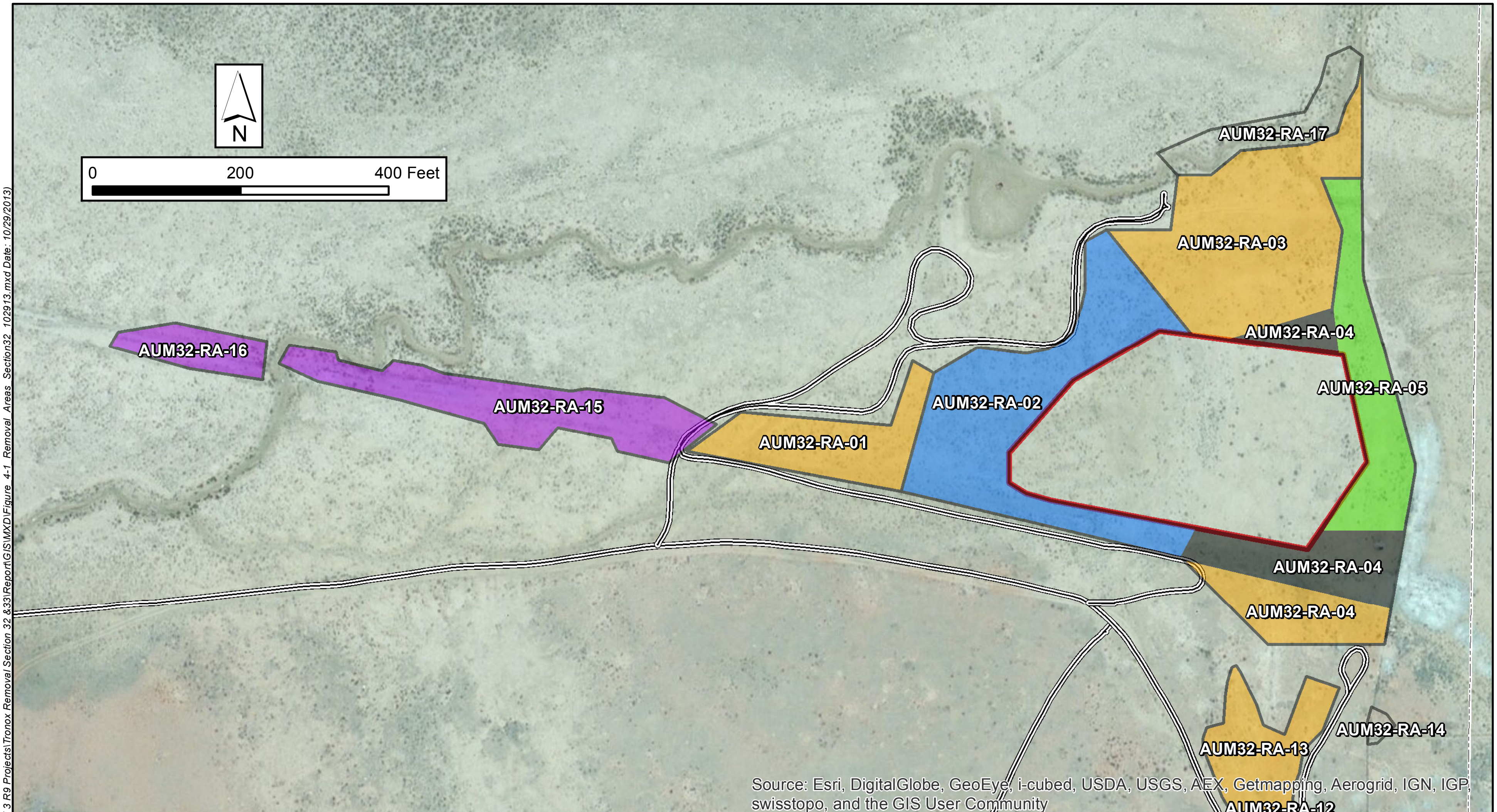
Ecology & Environment, Inc. GIS Department Project: R:\START 3 R9 Projects\Tronox Removal Section 32 &33\Report\GIS\MXD\Figure_2-4_Proposed_Removal_Area_AUM_32_North_Transfer10.mxd Date: 3/26/2013

Project # EE-002693-2200
TDD# TO-02-09-12-09-0002

Source: World Imagery (Esri and others)



LEGEND

Excavated Areas (depth)

- 0.5 ft bgs
- 1 ft bgs
- 2 ft bgs
- 3 ft bgs
- > 4 ft bgs

- Road
- Stockpile area
- Chapter boundary
- Area not excavated

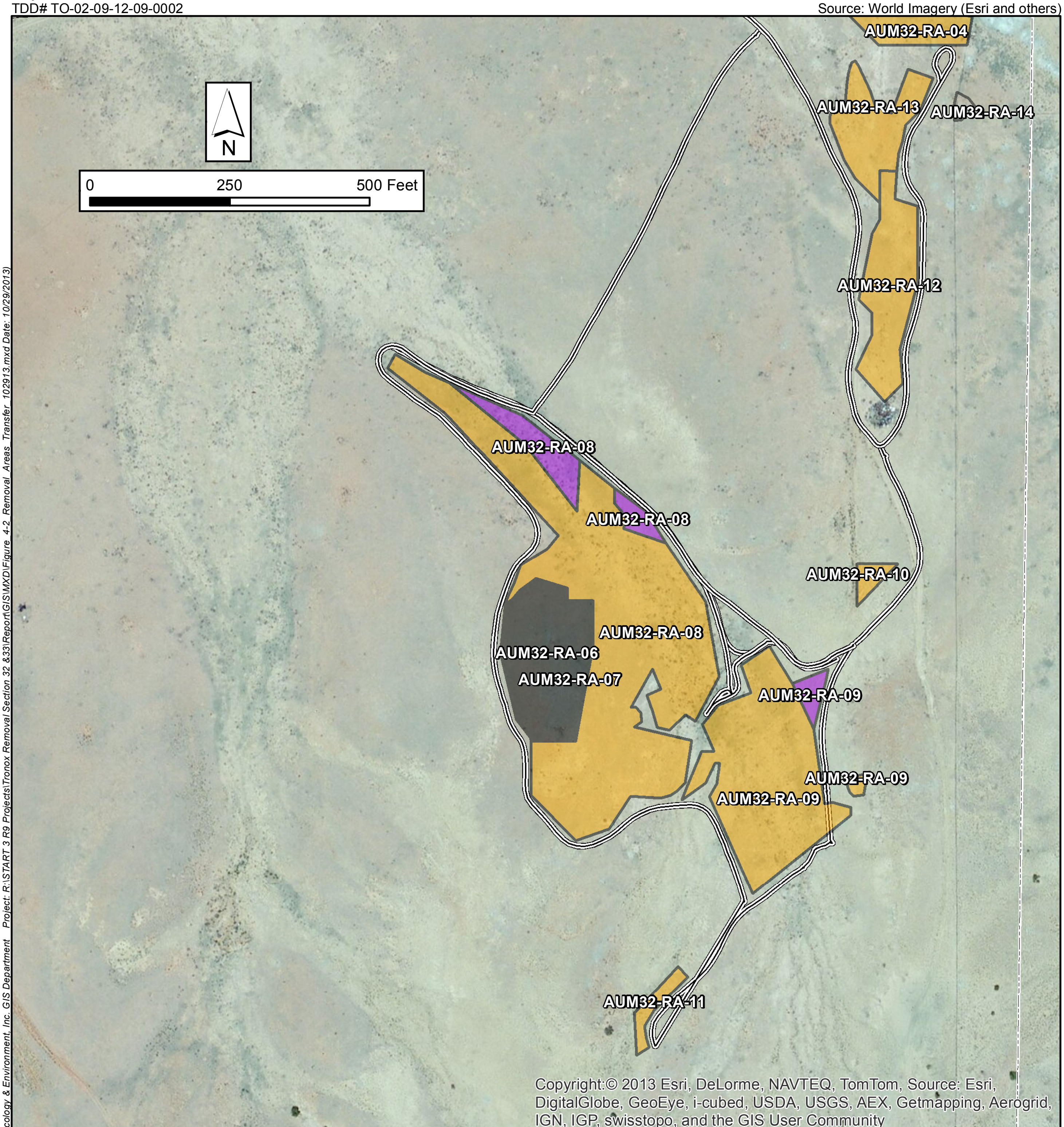
Figure 6
Excavated Areas at AUM 32 Mine Area
Tronox AUM Section 32 Removal
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

ecology and environment, inc.
International Specialists in the Environment

Ecology & Environment, Inc. GIS Department Project: R:\START 3 R9 Projects\Tronox Removal\Section 32 &33\Report\GIS\MXD\Figure 4-1 Removal Areas Section32 102913.mxd Date: 10/29/2013)

Project # EE-002693-2200
TDD# TO-02-09-12-09-0002

Source: World Imagery (Esri and others)



Ecology & Environment, Inc. GIS Department Project: R:\START 3 R9 Projects\Tronox Removal Section 32 &33\Report\GIS\MXD\Figure 4-2 Removal Areas Transfer 102913.mxd Date: 10/29/2013

LEGEND

Removal Areas (depth)

- 0.5 ft bgs
- 1 ft bgs
- 2 ft bgs
- 3 ft bgs
- Road
- Chapter boundary
- Area not excavated

Figure 7
Excavated Areas at AUM 32 Transfer Area
Tronox AUM Section 32 Removal
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

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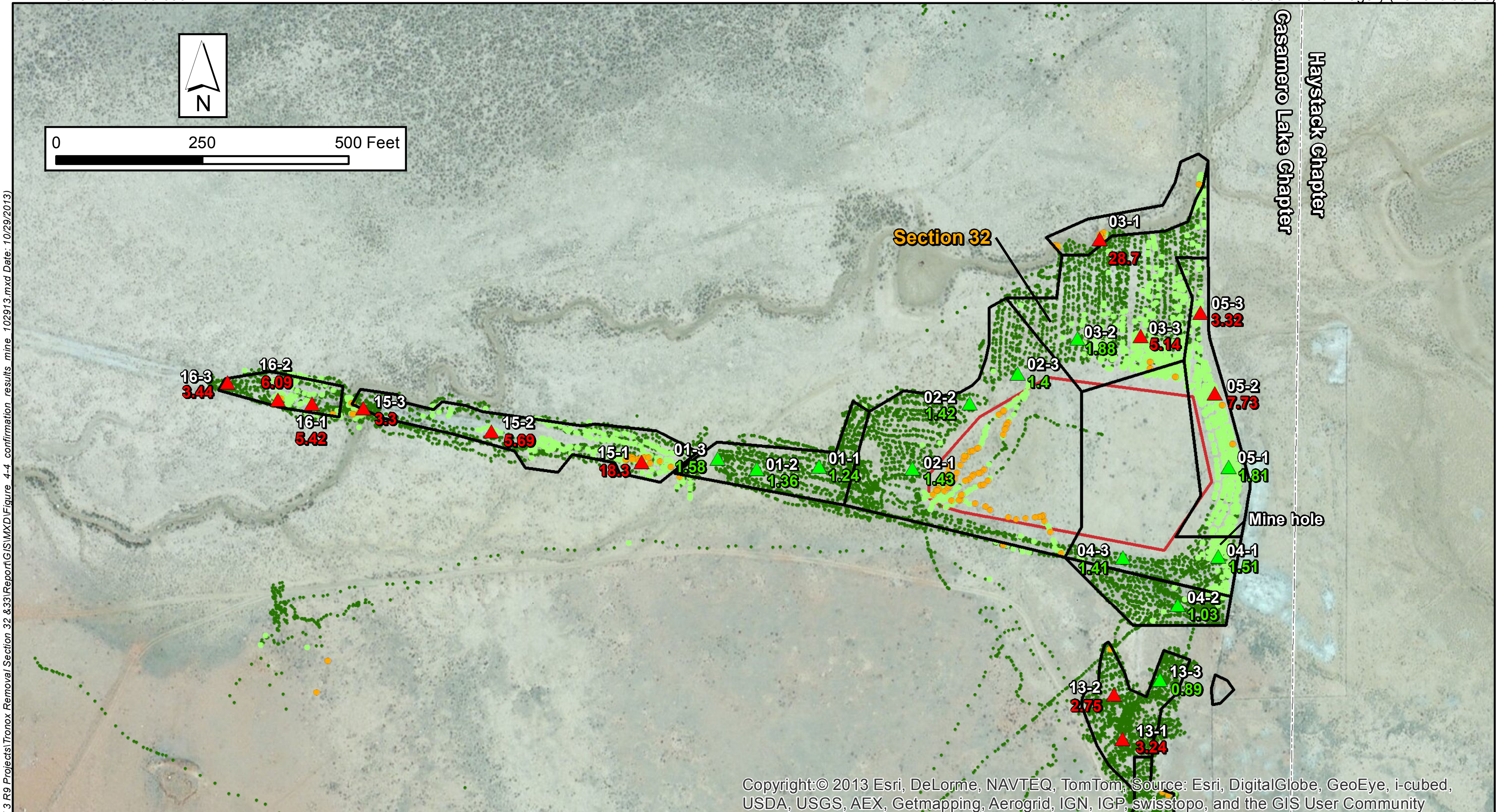
International Specialists in the Environment

Project # EE-002693-2200
TDD# TO-02-09-12-09-0002

Source: World Imagery (Esri and others)



Ecology & Environment, Inc. GIS Department Project: R:\START 3 R9 Projects\Tronox Removal Section 32 &33\Report\GIS\MXD\Figure 4-4 confirmation results mine 102913.mxd Date: 10/29/2013

LEGEND

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

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

Gamma activity 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)

Chapter boundary

Removal area

Stockpile area

Figure 8
Surface Gamma Radiation Activity and Ra-226 Concentrations in Soil Left in Place at AUM 32 Mine Area
Tronox AUM Section 32 Removal
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

ecology and environment, inc.
International Specialists in the Environment

Project # EE-002693-2200
TDD# TO-02-09-12-09-0002

Source: Aerial Photography - Bing Maps

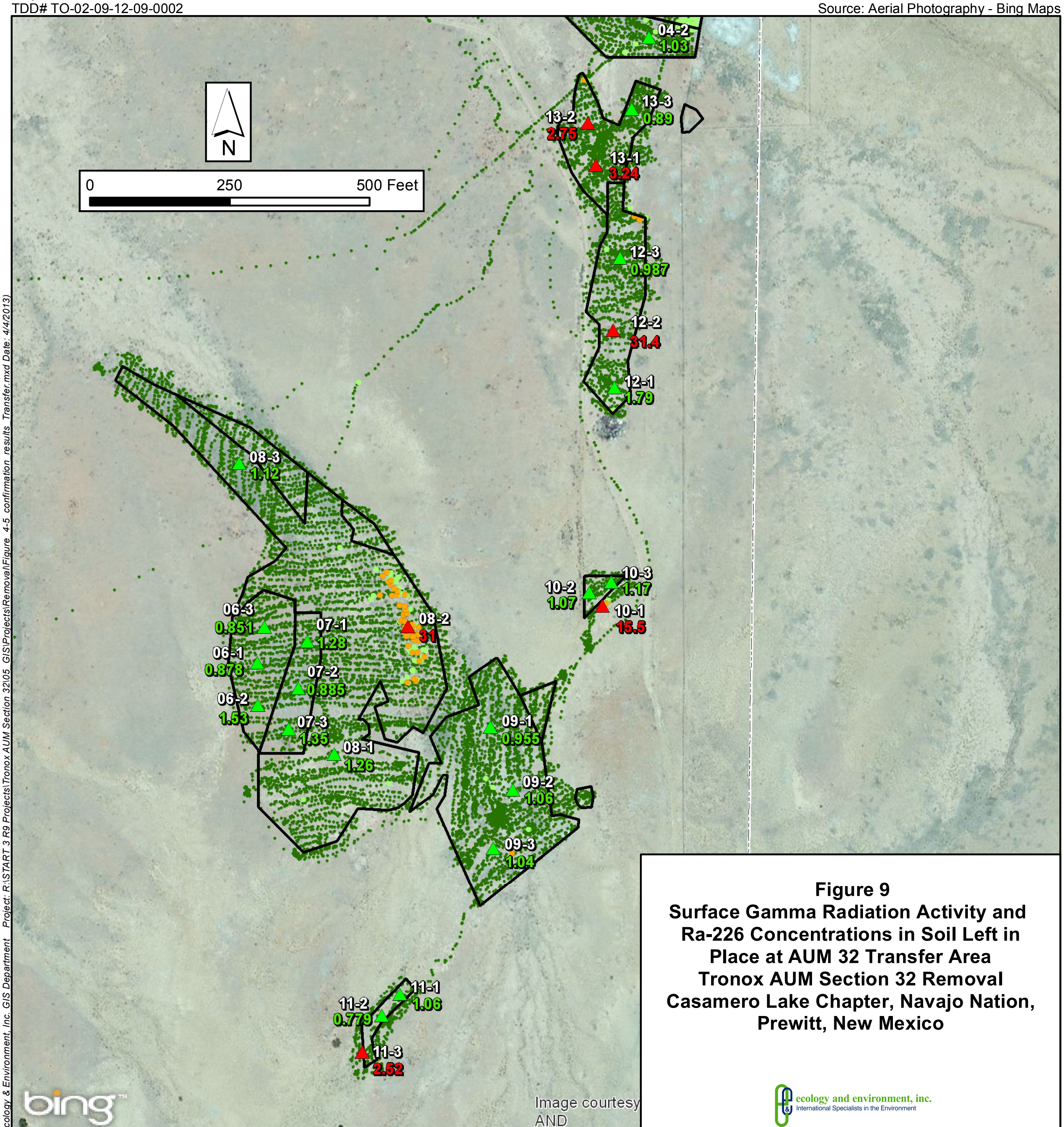


Figure 9
Surface Gamma Radiation Activity and Ra-226 Concentrations in Soil Left in Place at AUM 32 Transfer Area
Tronox AUM Section 32 Removal
Casamero Lake Chapter, Navajo Nation, Prewitt, New Mexico

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International Specialists in the Environment

Ecology & Environment, Inc. GIS Department Project: R:\START 3 R9 Projects\Tronox AUM Section 32\05 GIS\Projects\Removal\Figure 4-5 confirmation results Transfer.mxd Date: 4/4/2013

LEGEND

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

- Less than or equal to Action Level (2.11p Ci/g)
- Greater than Action Level

Gamma activity in kilo counts per minute

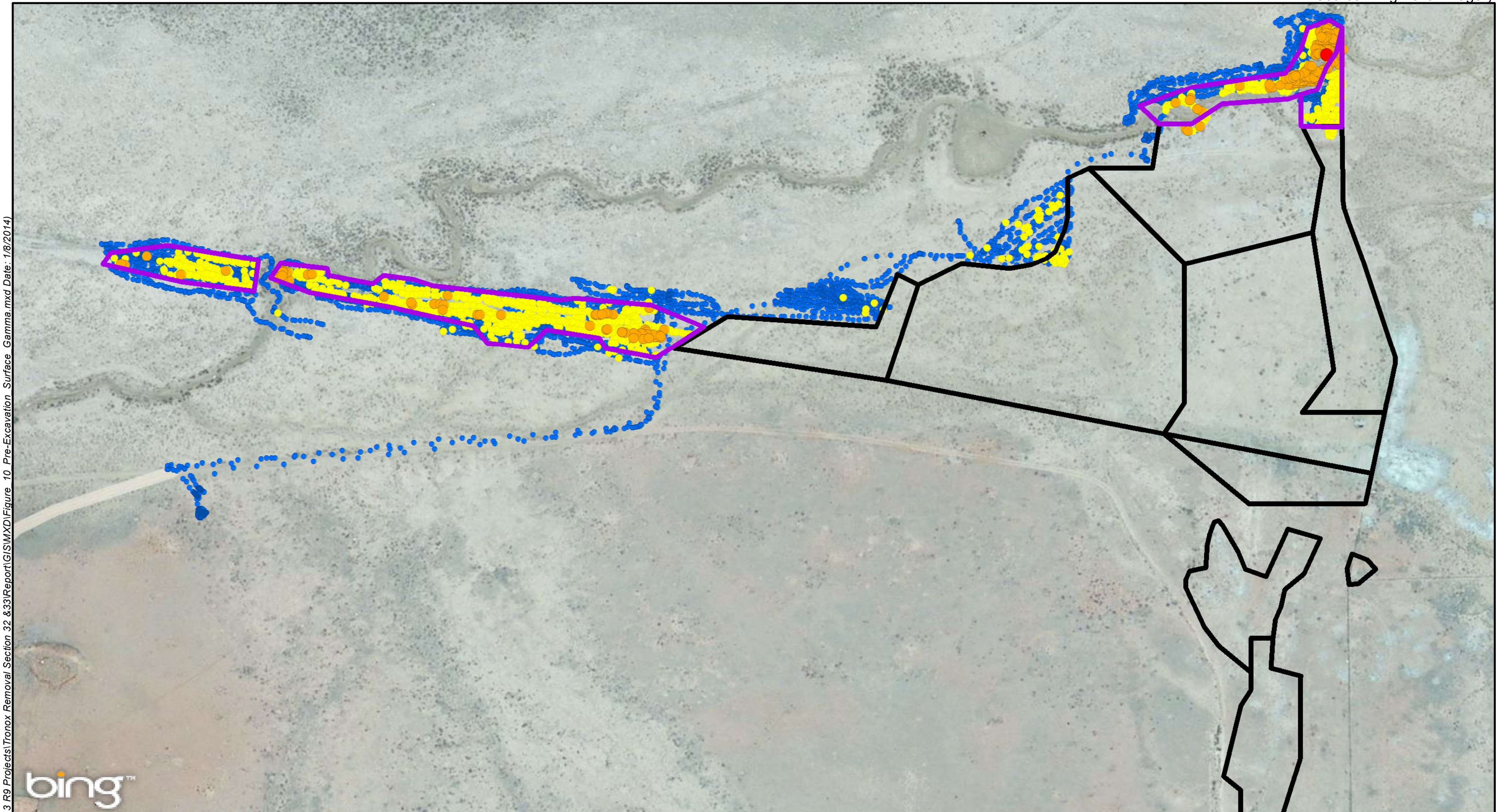
- Less than or equal to Investigation Level (0 - 40)
- Greater than Investigation Level (40.1 - 50)
- Greater than 2x Investigation Level (50.1 - 240)
- Greater than 10x Investigation Level (>240)

Chapter boundary

Removal area

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

Source: Bing Aerial Imagery



Ecology & Environment, Inc. GIS Department Project: R:\START 3 R9 Projects\Tronox Removal Section 32 &33\Report\GIS\MXD\Figure 10 Pre-Excavation Surface Gamma.mxd Date: 1/8/2014)

LEGEND

Gamma activity in kilo counts per minute

- Less than or equal to Investigation Level (0 - 40)
- Greater than Investigation Level (40.1 - 50)
- Greater than 2x Investigation Level (50.1 - 240)
- Greater than 10x Investigation Level (>240)
- Phase I assessment excavation area
- Phase II assessment excavation area

N

0 250 500 Feet

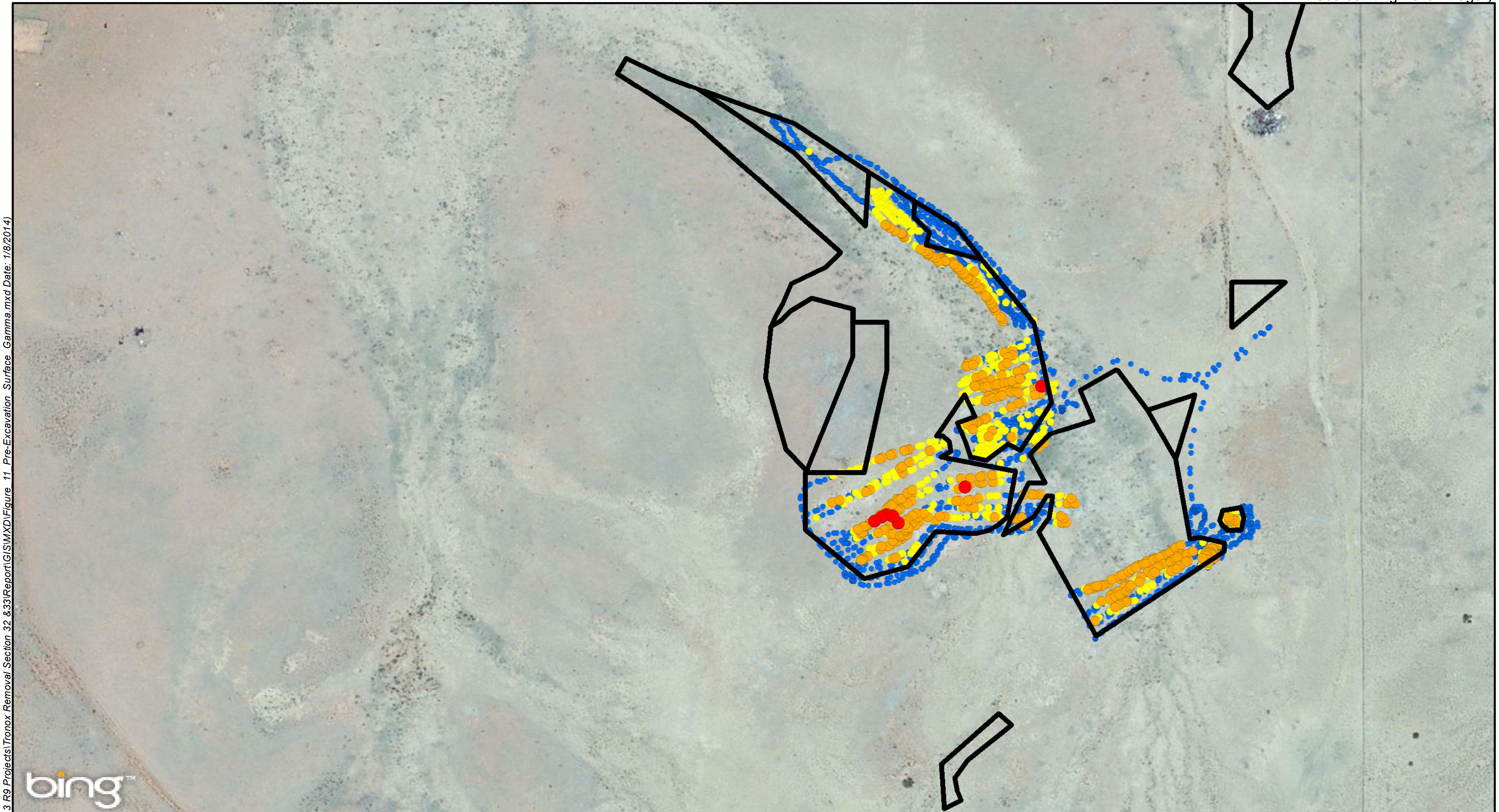
Figure 10
Pre-Excavation Surface Gamma Radiation Survey Results in AUM32 Mine Area

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

ecology and environment, inc.
International Specialists in the Environment

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

Source: Bing Aerial Imagery



Ecology & Environment, Inc. GIS Department   Project: R:\START 3 R9 Projects\Tronox Removal Section 32 &33\Report\GIS\MXD\Figure_11_Pre-Excavation_Surface_Gamma.mxd Date: 1/8/2014)

LEGEND

Gamma activity in kilo counts per minute

- Less than or equal to Investigation Level (0 - 40)
- Greater than Investigation Level (40.1 - 50)
- Greater than 2x Investigation Level (50.1 - 240)
- Greater than 10x Investigation Level (>240)
- Phase I assessment excavation area
- Phase II assessment excavation area

N

0 250 500 Feet

Figure 11
Pre-Excavation Surface Gamma Radiation Survey Results in AUM32 Transfer Area

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

ecology and environment, inc.
International Specialists in the Environment

Appendix B: Sampling and Analysis Plan

Sampling and Analysis Plan
Tronox AUM Sections 32 and 33
Removal Action
Prewitt, McKinley County, New Mexico

TDD No.: 02-09-12-09-0002
Project No.: EE-002693-2200

October 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 Sections 32 and 33
Removal Action
Prewitt, McKinley County, New Mexico

TDD No.: 02-09-12-09-0002
Project No.: EE-002693-2200

October 2012

Approved by:____
Craig Tiballi, START Project Manager
Ecology and Environment, Inc.

Approved by: ____
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
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
MS/MSD	matrix spike/matrix spike duplicate
NA	not applicable
NNEPA	Navajo Nation Environmental Protection Agency
pCi/g	picocurie per gram
PM	Project Manager

List of Abbreviations and Acronyms (cont.)

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
SOP	standard operating procedure
START	Superfund Technical Assessment and Response Team
USEPA	United States Environmental Protection Agency
VSP	Visual Sampling Plan
Weston	Weston Solutions, Inc.

1 Introduction

The United States Environmental Protection Agency (USEPA) tasked Ecology and Environment, Inc.'s (E & E's) Superfund Technical Assessment and Response Team (START) to support the removal action at the Tronox Abandoned Uranium Mine (AUM) Sections 32 and 33 located in Prewitt, McKinley County, New Mexico in the Casamero Lake Chapter of the Navajo Nation (site). The site is part of the Five-Year Plan for cleaning up the legacy of abandoned uranium mining in the Navajo Nation (USEPA *et al.* 2008). START will conduct gamma radiation survey and soil sampling to document that gamma radiation activity and Radium-226 (Ra-226) concentration in soil remaining in place at removal areas at the site are below the cleanup level. Under the direction of USEPA Federal On-Scene Coordinator (FOSC) Randy Nattis, project data quality objectives (DQO) were developed and START prepared this Sampling and Analysis Plan (SAP).

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 USEPA 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 USEPA documents: *USEPA Requirements for Quality Assurance Project Plans, USEPA QA/R 5, USEPA/240/B 01/003* (USEPA 2001), *Guidance on Systematic Planning Using the Data Quality Objectives Process, USEPA QA/G 4, USEPA/240/B-06/001* (USEPA 2006), *Guidance on Choosing a Sampling Design for Environmental Data Collection, USEPA QA/G 5S, USEPA/240/R 02/005* (USEPA 2002), and *Uniform Federal Policy for Implementing Environmental Quality System, USEPA/505/F-03/001* (USEPA 2005).

1.1 Project Organization

USEPA FOSC – The USEPA 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), USEPA Environmental Response Team (ERT), USEPA Quality Assurance (QA) Office, and community. The USEPA FOSC is also responsible for access to the site.

START PM – The START PM, Craig Tiballi, 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 USEPA FOSC to document the removal 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

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

- USEPA FOSC Randy Nattis, USEPA Region IX
- USEPA Region IX QA Office
- 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 in surface soil was detected at levels up to 10 times the reported background level. Gamma radiation activity ranged from 38,560 to 962,400 counts per minute (cpm) at the AUM 32 mine area, 16,880 to above 1,000,000 cpm at the AUM 32 transfer area, and 33,410 to above 1,000,000 cpm at AUM 33. Rocks and potential buried rocks had gamma radiation activity over 500,000 cpm. Ra-226 concentrations were detected above the action level of 2.11 picoCuries per gram (pCi/g) in surface soil and down to 3 feet below ground surface (bgs). Ra-226 was detected up to 300 pCi/g. Gamma radiation activity and Ra-226 in soil at the site may pose an imminent and substantial threat to human health.

The USEPA determined a removal action is necessary to protect human health. In October 2012 the USEPA plans to start the excavation of 63,608 cubic yards of contaminated soil from 179.6 acres. The gamma radiation activity and Ra-226 concentration in soil left in place needs to be determined.

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.

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 shows 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. Approximately 309,000 sf of the AUM 32 mine area has be documented to have elevated gamma radiation activity and Ra-226 concentration in soil.

The AUM 32 transfer area is approximately 267,432 sf, based on GIS data collected durong the assessment, and contains a concrete pad and a sealed vent. The transfer area is located on a slight elevation with sparse vegetation. Evidence of past water flows toward a northwest direction was observed. Approximately 323,000 sf of the area around and within AUM 32 transfer area has be documented to to have elevated gamma radiation activity and Ra-226 concentration in soil.

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. Approximately 152,000 sf of the AUM 32 mine area has be documented to to have elevated gamma radiation activity and Ra-226 concentration in soil.

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.

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 NNEPA interviewed a local resident who showed the location of a former transfer area southwest of the AUM 32 mine area (E & E 2012). 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.

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 Investigations

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 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.

In June and July 2012, a removal assessment was conducted by USEPA and START at the site (E & E 2012). The removal assessment consisted of surface gamma radiation survey, sampling for Radium-226 (Ra-226) analysis, and home site assessment. Surface gamma radiation activity at the site was detected above background levels. Gamma radiation activity ranged from 38,560 to 962,400 cpm at the AUM 32 mine area, 16,880 to above 1,000,000 cpm at the AUM 32 transfer area, and 33,410 to above 1,000,000 cpm at AUM 33. Rocks and potential buried rocks had gamma radiation activity over 500,000 cpm. Ra-226 concentrations were detected above the action level of 2.11 pCi/g in surface soil and down to 3 feet below ground surface (bgs). Ra-226 was detected up to 300 pCi/g. The action level was based on background level and the preliminary remediation goal (PRG) for 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). Rocks and mine waste material were observed at locations with elevated gamma radiation activity and Ra-226 concentrations. 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 millirem per year which was based on an excess cancer risk of 3 x 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, USEPA determined a removal action is necessary at the site and no further action is warranted at the home sites.

Insert
Figure 2-1 Site Location Map

TDD: TO-02-09-12-09-0002
Project No. EE-002693-2200

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

ecology and environment, inc.
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3 Project Objectives

3.1 Data Use Objectives

Data generated from this investigation will be used to:

- Document gamma radiation activity in soil remaining in place within each removal area
- Document concentration of Ra-226 in soil remaining in place within each removal area
- Assist USEPA with decision on further action at the site.

3.2 Project Task/Sampling Objectives

USEPA tasked START to support the removal action at Tronox AUM Sections 32 and 33 including confirming and documenting that soil remaining in place at removal areas at the site contains gamma radiation activity and Ra-226 concentration at or below the cleanup level. 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 gamma radiation activity in soil remaining in place within the removal area require removal or confirmation sampling for Ra-226 analysis.
2. Determine whether concentrations of Ra-226 in soil remaining in place within the removal area require removal or no further action.

3.3 Cleanup Level

The relationship between surface soil Ra-226 sample results and co-located 1-minute gamma radiation activity measurements was evaluated during the removal assessment 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. The results indicate there is a correlation between surface soil Ra-226 sample results and co-located 1-minute gamma radiation activity measurements and locations with gamma radiation activity measurements below 40,000 cpm using a specific paired radiation survey equipment (Equipment A1) will likely have mean surface soil concentrations of Ra-226 below the cleanup level of 2.11 pCi/g (E & E 2012).

The cleanup level for Ra-226 in soil at the site was based on the sum of the highest background concentration of Ra-226 established for the site and the USEPA 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) (USEPA 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 cleanup levels for the removal action 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 Sections 32 and 33 Removal Action
Prewitt, McKinley County, New Mexico

E & E Project No. EE-002693-2200 TDD No. 02-09-12-09-0002

Analyte	Background Concentration[1]	Site-Specific Cleanup Level	USEPA PRG (pCi/g)	Reporting Limit	Accuracy (% Recovery for MS/ MSD)	Precision (RPD from MS/MSD and Duplicates)	Percent Completeness
Gamma radiation activity[2]	27,000 cpm	40,000 cpm	NA	0.1 cpm with a detection range from 0.1 to 999,000 cpm	NA	20%	90
Ra-226	0.900 pCi/g	2.11 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
USEPA – 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 – USEPA 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 were determined during the removal assessment (E & E 2012).
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 USEPA *Guidance on Systematic Planning Using the Data Quality Objectives Process, USEPA/240/B-06/001* (USEPA 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 USEPA *Requirements for Quality Assurance Project Plans* (USEPA 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 USEPA 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 Gamma radiation activity and Ra-226.

3.6 Schedule of Sampling Activities

Field activities will begin on October 8, 2012 and continue for up to 42 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.

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 USEPA FOSC and START Program Manager, and based on information from other USEPA AUM sites.

4.1 Removal Areas

The removal areas are differentiated by the depth of soil recommended to be removed based on subsurface soil sampling. 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. The removal areas are shown in Figures 4-1 to 4-4.

Gamma radiation activity in soil remaining in place within each removal area will be measured using a paired Ludlum Model 44-20 (3x3) detector and 2241 meter mounted 6 inches from the ground surface. The VIPER system and geographical information system will be used for geospatial information collection and analysis. The surface soil survey will consist of transects spaced 3 to 6 feet apart which will provide 100 percent characterization of the floor of the excavation. The transect width is based on the field of view of the detector which is a diameter of 3 to 6 feet. The surveyor will walk at a pace of 3 feet per second.

Soil samples will be collected at 0 to 2 inches bgs from the floor of the excavation footprint at three locations within each removal area and analyzed for Ra-226 by the Environmental Measurements Laboratory (EML) Health and Safety Laboratory (HASL) 300 4.5.2.3 Method (Department of Energy [DOE] 1990). The concentrations of Ra-226 in soil will be compared with the 1-minute gamma radiation activity measurements to show the correlation between gamma radiation activity and Ra-226 concentrations in soil.

4.2 Analytes of Concern

Gamma radiation activity in surface soil will be measured in cpm. Gamma radiation activity was correlated with Ra-226 concentration in surface soil during the removal assessment and will be used as a field screening tool during the removal action.

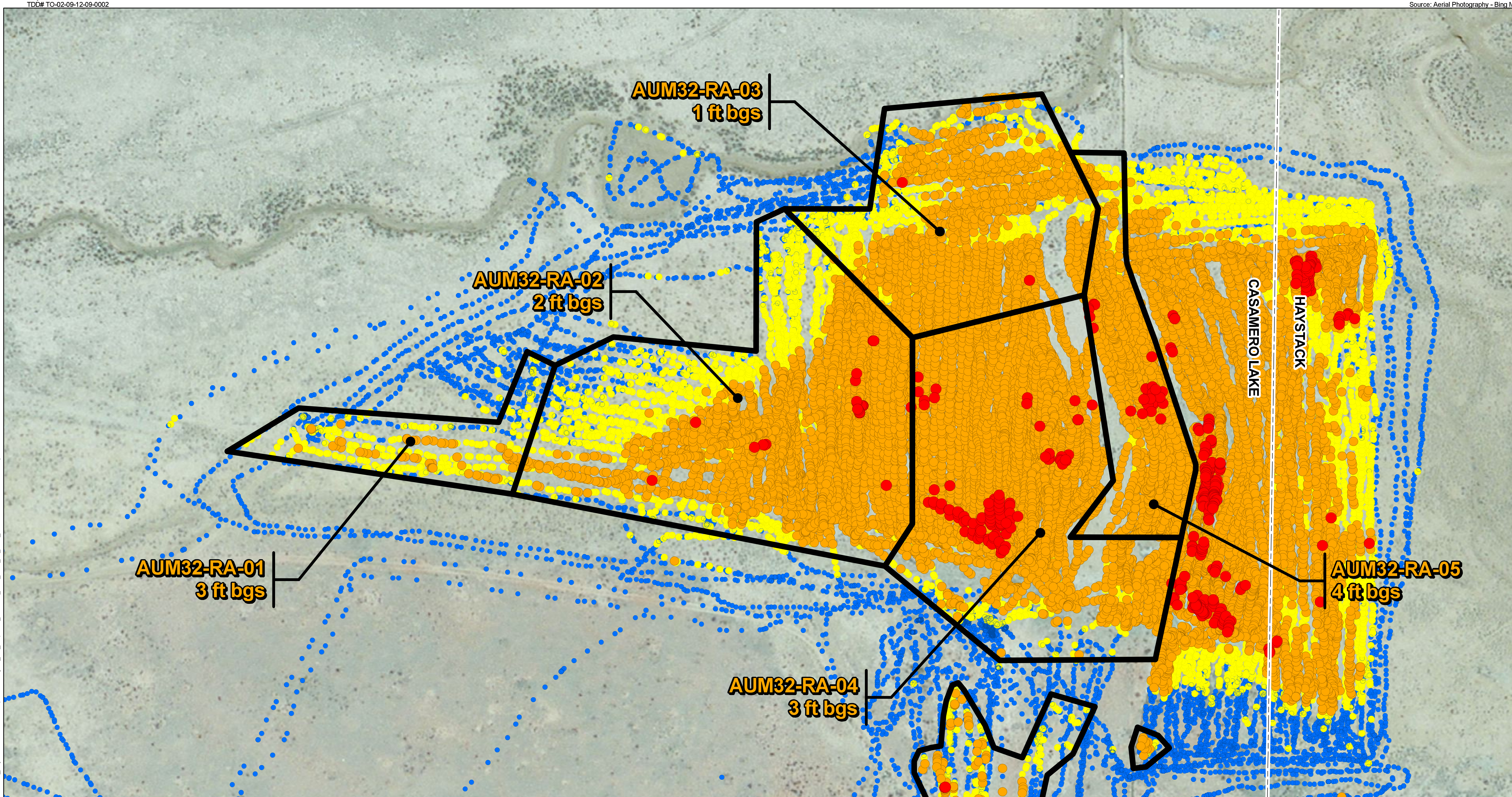
Confirmation soil samples will be analyzed for Ra-226.

Insert

Figure 4-1 Removal Areas and Confirmation Sampling Locations at AUM 32 Mine Area

Project # EE-002693-2200
TDD# TO-02-09-12-09-0002

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

Figure 4-1
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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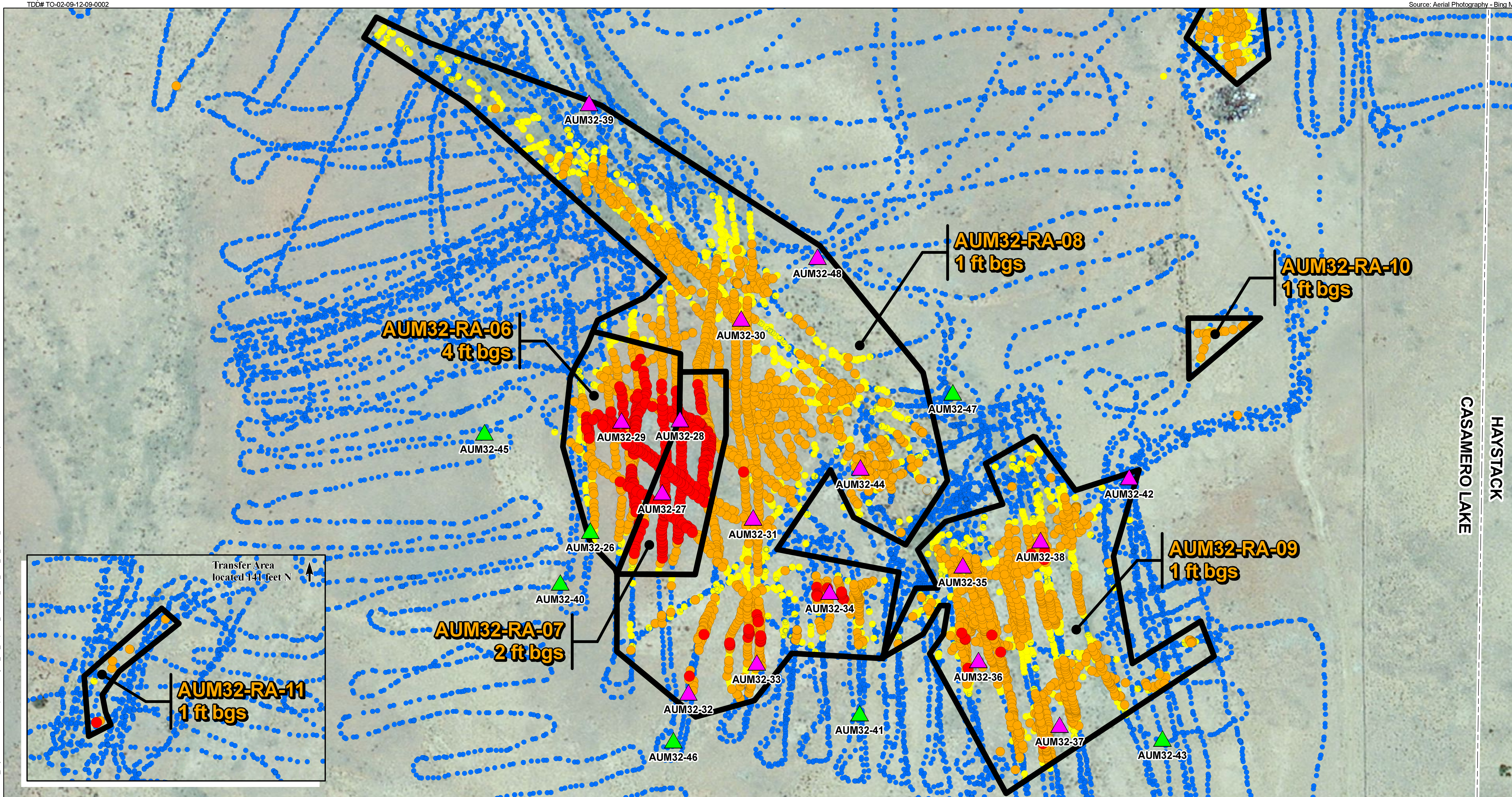
Ecology & Environment, Inc. GIS Department Project: C:\START_projects\Tronox\Murillo\Maps\MXDs\Figure_4-6_Proposed_Removal_Area_AUM_32_Mine_Area10.mxd Date: 10/5/2012)

Insert

Figure 4-2 Removal Areas and Confirmation Sampling Locations at the Southern Portion of AUM 32 Transfer Area

Project # EE-002693-2200
TDD# TO-02-09-12-09-0002

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

0 100 200 300 400 Feet

N

Figure 4-2
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

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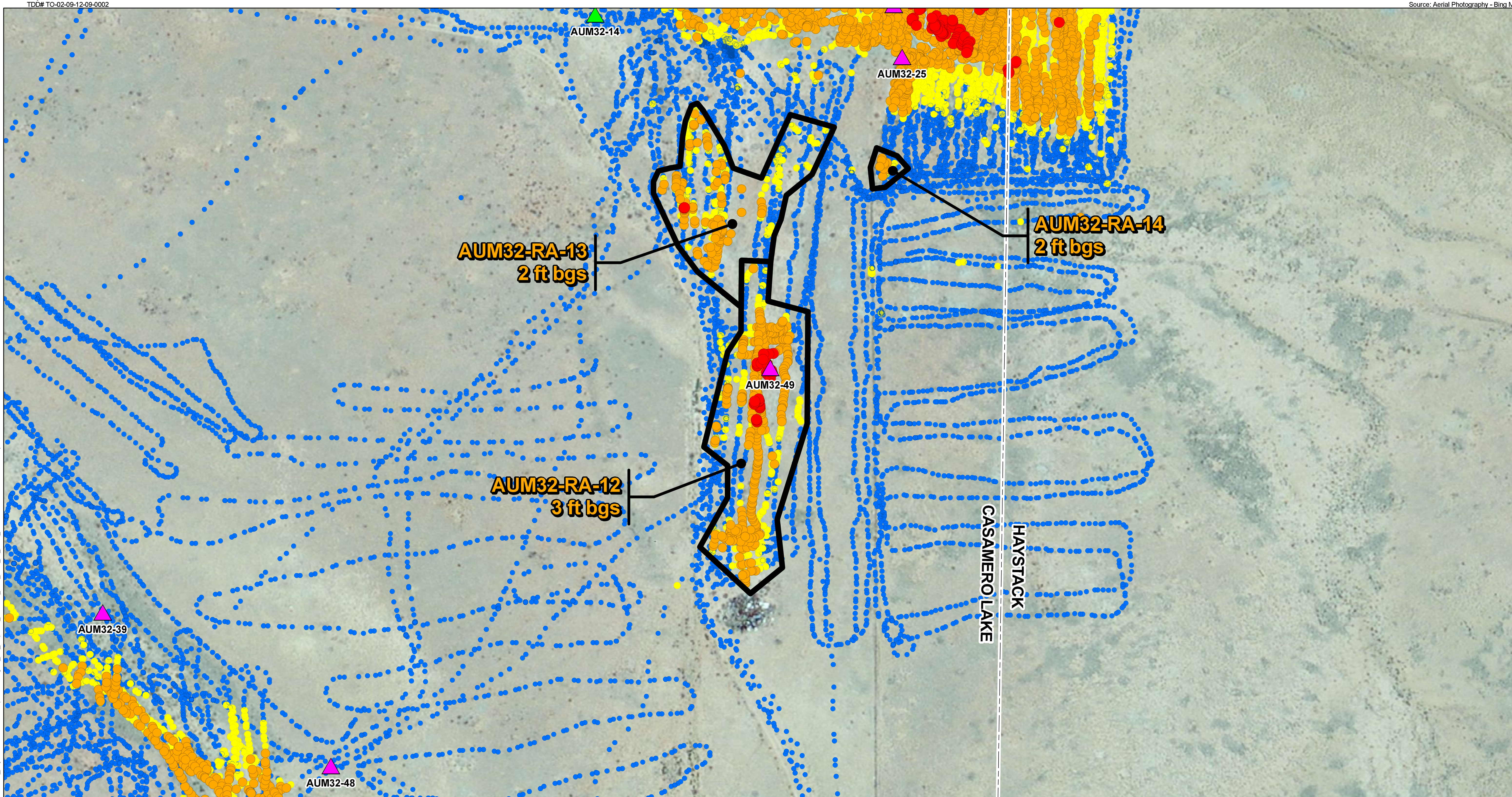
Insert

Figure 4-3 Removal Areas and Confirmation Sampling Locations at the Northern Portion of AUM 32 Transfer Area

Project # EE-002693-2200
TDD# TO-02-09-12-09-0002

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 4-3
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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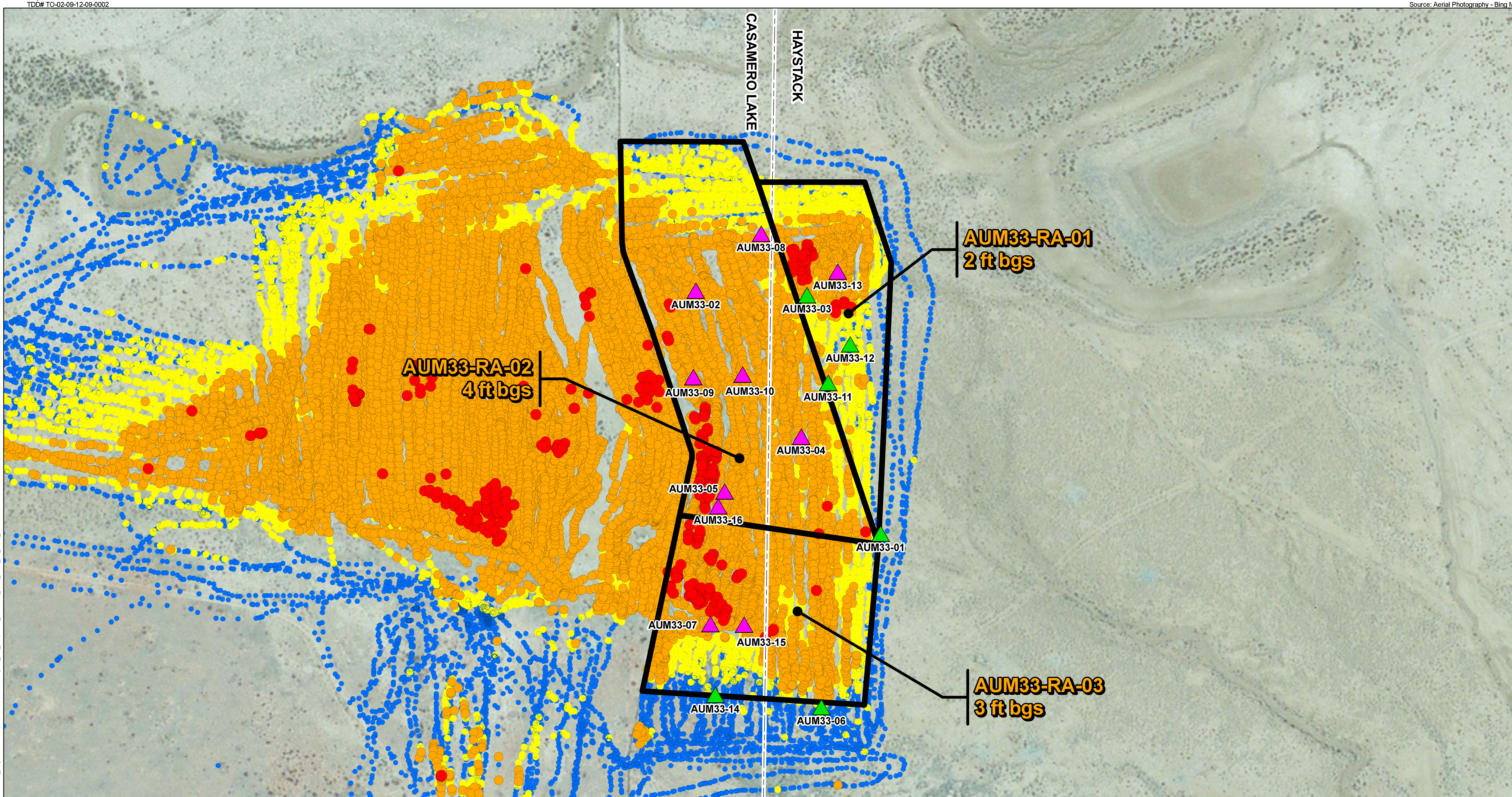
Insert

Figure 4-4 Removal Areas and Confirmation Sampling Locations at AUM 33

Project # EE-002693-2200
TDD# TO-02-09-12-09-0002

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

ecology and environment, inc.
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Ecology & Environment, Inc. GIS Department Project: C:\START_projects\Tronox\Murillo\Maps\MXDs\Figure_4-4_Proposed_Removal_Area_AUM_33_Mine_Area10.mxd Date: 10/5/2012)

5 Request for Analyses

Gamma radiation activity will be measured over the entire floor surface of each removal area. Confirmation soil samples from 0 to 2 feet bgs from the floor surface of each removal area 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 floor surfaces will be measured in the field using a paired Ludlum Model 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 microcurie 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 (DOE 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) and capturing the water in the specified sample container. The method for water analysis is Radium 226 by USEPA 903.1 modified.

Table 5-1 Sampling and Analysis Summary
Tronox AUM Sections 32 and 33 Removal Action
Prewitt, McKinley County, New Mexico

E & E Project No. EE-002693-2200 TDD No. 02-09-12-09-0002

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	45 surface soil samples
Estimated Number of Duplicate Samples	5
Minimum Total Site Sample Analyses	50
Equipment Rinse Blanks (if non-dedicated equipment is used)	
Method	**Ra-226 by USEPA 903.1 modified Radon Emanation Method**
Sample Container	500 milliliter plastic bottle
Preservation	None
Analysis Holding Time	14 days
Number of Samples	1 per day (20)

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 3, Ludlum Model 2241
- FOP 5, Ludlum Model 44-20
- For the VIPER system, procedures will be provided by ERT
- 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:

- Trowel
- 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 Gamma Radiation Survey Procedures

The survey equipment for measuring gamma radiation activity consists of a paired Ludlum Model 44-20 (3x3) detector and a 2241 meter linked to a VIPER system which will have operational checks conducted before field activities begin according to FOPs 1, 3, 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 2241 meter linked to a VIPER system will be mounted 6 inches from the ground surface of the excavation floor. The VIPER system and GIS will be used for geospatial information collection and analysis. Real-time *in situ* surface soil survey will consist of 3- to 6-foot wide transects covering 100 percent of the survey area at a pace of 3 feet per second. The transect width is based on the field of view of the detector which is a diameter of 3 to 6 feet. If an immovable obstruction is encountered during the survey it will not be moved, and the scanning survey will be performed around the feature. Gamma radiation survey will be conducted within each removal area.

Gamma radiation activity measurements will be used as a field screening tool. The relationship between 1-minute gamma radiation activity measurements and co-located surface soil Ra-226 sample results was evaluated during the removal assessment. The results indicated that locations with gamma radiation activity measurements below 40,000 cpm using a specific paired radiation survey equipment (Equipment A1) will likely have mean surface soil concentrations of Ra-226 below the cleanup level of 2.11 pCi/g (E & E 2012).

6.3 Soil Sampling Procedures

Confirmation soil samples for Ra-226 analysis will be collected from the excavation floor of each removal area determined to be below the cleanup level based on gamma radiation activity measurements. Confirmation soil sample locations in each removal area were determined using VSP. 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.

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 45 surface soil samples 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 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 USEPA'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 (USEPA 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:

[Sample Description]-[Sample Number]
Where:

> Sample Description – Removal Area ID, for example “AUM32-RA01”
> Sample Number – Number representing the specific sampling location where the sample was collected starting with 01.

For example, the first confirmation soil sample collected at AUM 32 Removal Area 01 will be identified as follows:
AUM32-RA01-01

Field duplicate samples will have the same designations as their originals except the sample number will be preceded by a “1” thus, the field duplicate for the above examples will be AUM32- RA01-101.

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)

Equipment rinsate blanks will be collected from non-dedicated equipment such as stainless steel trowels are used to collect samples, 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. Results of the confirmation samples will determine if the cleanup goal was met.

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 USEPA Region IX's *Laboratory Documentation Requirements for Data Evaluation, R9/QA/00.4.1* (USEPA 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 USEPA.

9.4 Data Validation

Data validation will be performed by START or their subcontractor according to the *USEPA Region IX Superfund Data Evaluation/Validation Guidance R9QA/006.1* (USEPA 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* [USEPA 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 USEPA 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 USEPA 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 Action Report) will be peer-reviewed by START prior to submission to USEPA. In time-critical situations, the peer review may be concurrent with the release of a draft document to USEPA.
- 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 USEPA 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 USEPA, 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

Bureau of Indian Affairs, Department of Energy, Nuclear Regulatory Commission, USEPA, and Indian Health Service. 2008. *Health and Environmental Impacts of Uranium Contamination in the Navajo Nation Five-Year Plan*. June 9.

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USEPA, 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA/240/B-06/001), February.

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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 SECTIONS 32 AND 33 REMOVAL

STEP 1.

THE PROBLEM

Background

The United States Environmental Protection Agency (USEPA) tasked Ecology and Environment, Inc.'s (E & E) Superfund Technical Assessment and Response Team (START) to support a removal action at Tronox Abandoned Uranium Mine (AUM) Sections 32 and 33 (site). The site is located approximately 1 mile east of County Road 19, Prewitt, McKinley County, New Mexico. The site consists of the 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) at AUM 32, and AUM 33 (Latitude: 35°29'26.1972"N, Longitude: -108°0'59.8583"W). AUM 32 is located in an Indian Allotment land which is part of the Casamero Lake Chapter of the Navajo Nation while AUM 33 is privately owned and is part of the Casamero Lake and Haystack Chapters of the Navajo Nation.

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

The site contained historical mines reportedly owned by Cobb Nuclear and were closed due to a fatality. No other information on historical ownership of the mine and mining operations were available. The AUM 32 transfer area was located by USEPA and Navajo Nation Environmental Protection Agency after an interview with a local resident who had relatives who formerly worked for Cobb Nuclear Company. 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. The AUM 32 transfer area is located southwest of the AUM 32 mine area, approximately 267,432 sf, and contains a concrete pad and a sealed vent. 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.

In June and July 2012, a removal assessment was conducted by USEPA and START at the site. The removal assessment consisted of surface gamma radiation survey, sampling for Radium-226 (Ra-226) analysis, and home site assessment. Surface gamma radiation activity at the site was detected above background levels. Gamma radiation activity ranged from 38,560 to 962,400 counts per minute (cpm) at the AUM 32 mine area, 16,880 to above 1,000,000 cpm at the AUM 32 transfer area, and 33,410 to above 1,000,000 cpm at AUM 33. Rocks and potential buried rocks had gamma radiation activity over 500,000 cpm. Ra-226 concentrations were detected above the action level of 2.11 picoCuries per gram (pCi/g) in surface soil and down to 3 feet below ground surface (bgs). Ra-226 was detected up to 300 pCi/g. The action level was based on background level and the preliminary remediation goal for 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, *Preliminary Remediation Goals for Radionuclides*. August 2010). Rocks and mine waste material were observed at locations with elevated gamma radiation activity and Ra-226 concentrations. 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 millirem per year 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, USEPA determined a removal action is necessary at the site and no further action is warranted at the home sites.

USEPA will conduct a removal action at the site on October 8, 2012. The removal action is an interim action which consists of excavating soil, stockpiling removed soil at the AUM 32 mine area, and stabilizing the stockpiles to protect human health. USEPA directed START to confirm and document that soil remaining in place at removal areas at the site contain gamma radiation activity and Ra-226 concentration at or below the cleanup level.

Planning Team

Primary Decision Maker:	USEPA Task Monitor/Federal On-Scene Coordinator Randy Nattis
Plan Development:	START and the USEPA Task Monitor
Plan Approval:	USEPA Task Monitor
On-Scene Assistance:	USEPA Task Monitor, START, USEPA Emergency Response Team (ERT), Emergency and Rapid Response Services (ERRS) 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, and USEPA 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

Historical mining at the site may have released technologically-enhanced, naturally-occurring radioactive materials, specifically uranium and its decay products, to surface soil. Results of the removal assessment showed elevated gamma radiation activity and Ra-226 concentrations in surface soil and down to 3 feet bgs.

Soil is the primary media of concern in this removal action. Surface water was not observed at or within the influence of the site; however, available geographical information show an ephemeral stream or river located north and south of the site which converges approximately 0.25 mile west of the site. Evidence of water flowing through the site was observed during the removal assessment. A ditch runs along northern boundary of the site and connects to a pond located northwest of the site. Two ponds filled with water are located northeast of the site. Groundwater depth and information on nearby water wells used for drinking water were not available. Soil borings during the removal assessment detected bedrock at 3 feet bgs.

No residences and public structures were found within 0.25 miles of the site. The nearest resident lives approximately 0.5 mile to the west of the site. Any dust generated during the removal action is not expected to impact the nearest resident. Agricultural food production such as livestock grazing or farming common in Navajo communities was not documented at or immediately adjacent to the site; however, domestic pets, terrestrial wildlife, and animal droppings were observed.

Exposure Scenario

Potential exposure pathways include direct exposure of human receptors to gamma radiation and Ra-226 in soil at the site. Receptors may also be exposed through ingestion, dermal contact, and inhalation of other mine-related materials in soil, air, and water affected by the site.

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 USEPA Region 9 staff and their supporting START contractors. All site-specific planning activities are under the direction of the USEPA Task Monitor.

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

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

Analytical service resources include the following:

- Real-time field radiation survey will be performed by START.
- START analytical service provider will analyze collected samples.

START's initial budget for this time-critical response is $207,839.24.

Resource Constraints

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

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

STEP 2.

THE DECISION

Principal Study Questions

1. What is gamma radiation activity in soil remaining in place within each removal area?
2. What is Ra-226 concentration in soil remaining in place within each removal area?

Actions that Could Result from the Resolution of Study Questions

Question 1

If the gamma radiation activity in soil remaining in place within the removal area exceeds 40,000 cpm then USEPA may initiate or order further excavation of soil within the removal area.

If the gamma radiation activity in soil remaining in place within the removal area is at or below 40,000 cpm then soil samples will be collected to confirm Ra-226 concentrations are at or below the cleanup level.

Question 2

If the concentration of Ra-226 in soil remaining in place within the removal area is above the cleanup level then USEPA may initiate or order additional excavation of soil within the removal area.

If the concentration of Ra-226 in soil remaining in place within the removal area is at or below the cleanup level then no further action may be required.

Decision Statements (Directives)

Directive 1

Determine whether gamma radiation activity in soil remaining in place within the removal area require removal or confirmation sampling for Ra-226 analysis.

Directive 2

Determine whether concentrations of Ra-226 in soil remaining in place within the removal area require removal or no further action.

STEP 3.
DECISION INPUTS

Specific Data Required

- Field data from the established background area to establish a background level of gamma radiation for the radiation survey equipment.
- Field data from measuring gamma radiation activity in soil at the site.
- Definitive analytical data for concentration of Ra-226 in soil at the site.
- Correlated gamma radiation activity to soil cleanup level for Ra-226 determined for the site.
- Soil cleanup level for Ra-226 for the site.
- Global Positioning System data for removal area boundaries, 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)
- *Removal Assessment Report, Tronox AUM Sections 32 and 33, Eastern Agency, Prewitt, McKinley County, New Mexico* (E & E, *Removal Assessment Report, Tronox AUM Sections 32 and 33, Eastern Agency, Prewitt, McKinley County, New Mexico*, September 2012)
- Site information collected during the removal action including geographical information data and photographs.
- Field data generated during the removal action including real-time radiation survey and soil sampling.
- Definitive analytical data generated during the removal action.
- USEPA Radiation Preliminary Remediation Goals (PRG)

Information Needed to Establish Cleanup Level

The relationship between surface soil Ra-226 sample results and co-located 1-minute gamma radiation activity measurements was evaluated during the removal assessment 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. The results indicate there is a correlation between surface soil Ra-226 sample results and co-located 1-minute gamma radiation activity measurements and 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 cleanup level of 2.11 pCi/g (E & E 2012).

The cleanup level for Ra-226 was based on the sum of the highest background concentration of Ra-226 established for the site during the removal assessment and the USEPA PRG of 1.21 pCi/g (USEPA 2010). The cleanup level for Ra-226 in soil at the site is 2.11 pCi/g.

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 or curies.

Laboratory analytical methods that more accurately determine radionuclide concentrations in units of pCi/g in various media are published by USEPA and U.S. Department of Energy (DOE). Ra-226 will be analyzed using the Environmental Measurements Laboratory (EML) Health and Safety Laboratory (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 USEPA 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 surface of the excavation area.
- Ra-226 concentration in soil (0 to 2 inches bgs) remaining in place within the removal area.

Geographic Boundary of Investigation

- The site consists two contiguous areas; AUM 32 (365,005 sf) and AUM 33 (153,963 sf) and a non-contiguous transfer Area (267,432 sf). These mine areas are further subdivided for the removal activities into 17 removal areas.
- The vertical investigation boundary for the site will be approximately 4 feet bgs or less based on site conditions.

Temporal Boundary of Investigation

- The half-life of Ra-226 is 1,600 years. Soil data is not expected to change during the removal action which may take up to 90 days from the last sample collection to final report submittal.
- The removal action was scheduled when the site is accessible and field work is feasible.
- 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 cleanup level for Ra-226 is based on PRG which considers long-term health risk.

Scale of decision-making

Decisions will apply to each removal area (decision unit) at the site.

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. The wet season may start during the field work schedule; weather conditions such as rain and snow may require field work to be postponed

until the next dry season.

- 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.
- Presence of heavy equipment during the removal action and site features such as the open shaft at AUM 32 pose unsafe conditions to staff.
- 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.
- 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 USEPA 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 overall gamma radiation activity measurements at each removal area will be compared to the 40,000 cpm field screening level.

The concentration of Ra-226 at each removal area will be compared to the cleanup level.

Cleanup Level

Gamma radiation activity below 40,000 cpm will likely have mean surface soil concentrations of Ra-226 below the cleanup level of 2.11 pCi/g (E & E 2012). Thus the field screening level is 40,000 cpm.

The cleanup level for Ra-226 in soil at the site was based on the sum of the highest background concentration of Ra-226 established for the site and the USEPA 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) (USEPA 2010).

Decision Rules

Question 1

If the gamma radiation activity measured above larger area of soil remaining in place within a removal area is above 40,000 cpm, then further excavation may be necessary. Otherwise, collect soil samples (0 to 2 inches bgs) within removal area to determine the Ra-226 concentration in soil remaining in place.

Question 2

If the mean Ra-226 concentration in soil remaining in place within the removal area exceeds the cleanup level then removal or further action may be necessary. 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 ranges from background to 10 times background. However, the gamma radiation activity from 40,000 cpm to 80,000 cpm is the range most susceptible to decision error.

Concentration in Samples

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

The Null Hypothesis or Baseline Condition

The parameter of interest (gamma radiation activity and Ra-226 concentration in soil) exceeds the cleanup level.

Alternative Hypothesis

The parameter of interest (gamma radiation activity and Ra-226 concentration in soil) does not exceed the cleanup 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 USEPA 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 Cleanup 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 Cleanup 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 cleanup 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 USEPA Task Monitor and START Program Manager, and based on information from other USEPA AUM sites.

Gamma Radiation Activity

Gamma radiation activity in soil remaining in place within each removal area will be measured using a paired Ludlum Model 44-20 (3x3) detector and 2241 meter mounted 6 inches from the ground surface. The VIPER system and geographical information system will be used for geospatial information collection and analysis. The surface soil survey will consist of transects spaced 3 to 6 feet apart which will provide 100 percent characterization of the floor of the excavation. The transect width is based on the field of view of the detector which is a diameter of 3 to 6 feet. The surveyor will walk at a pace of 3 feet per second.

Ra-226

Soil samples will be collected at 0 to 2 inches bgs from the floor of the excavation footprint and analyzed for Ra-226 by EML HASL 300 4.5.2.3 Method. Three surface soil samples will be collected in each removal area and the concentration compared to the cleanup level of RA-226 of 2.11 pCi/g..

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, decisions in the field using activity data hinge on the relationship and confidence between gamma radiation activity data and Ra-226 concentration 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 2241; measurement method e.g., detector height, pace, specifications; and background area will be used throughout the project. 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 USEPA-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 32/33 Removal Action

Project No.: EE-002693-2200-01RA

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

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

Proposed Date of Field Activities:

Removal Activity – October 8, 2012 to November 16, 2012

Project Director: Cindy McLeod

Project Manager: Craig Tiballi

Prepared by: Craig Tiballi Date Prepared: 10/5/12

Approved by: Sara Dwight Date Approved: 10/8/12

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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: The United States Environmental Protection Agency (USEPA) tasked Ecology and Environment, Inc.'s (E & E's) Superfund Technical Assessment and Response Team (START) to support the removal action at the Tronox Abandoned Uranium Mine (AUM) Sections 32 and 33 located in Prewitt, McKinley County, New Mexico in the Casamero Lake Chapter of the Navajo Nation (site). The site is part of the Five-Year Plan for cleaning up the legacy of abandoned uranium mining in the Navajo Nation (USEPA *et al.* 2008). START will conduct gamma radiation survey and soil sampling to document that gamma radiation activity and Radium-226 (Ra-226) concentration in soil remaining in place at removal areas at the site are below the cleanup level. START developed data quality objectives (DQO) and prepared this Sampling and Analysis Plan (SAP) under the direction of USEPA Federal On-Scene Coordinator (FOSC) Randy Nattis.

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	Radiation scan/survey of selected soils to determine areas of elevated radiation
2	Collection of soil samples
3	Photo documentation and GPS location.
4	Collection of air samples
5	
6	

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
Craig Tiballi	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	

Training	Required
8-Hour General Radiation Health and Safety	X
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	■ 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	1, 2, 3, 4	■ 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	■ 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.

Hazard	Task Number	Hazard Control Measures
Heat Stress	1, 2, 3, 4	■ Provide cool break area and adequate breaks. ■ 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	1, 2, 3, 4	■ 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	■ 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	■ 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	■ 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.

Hazard	Task Number	Hazard Control Measures
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
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	■ 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,	■ 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)	3E-10	INH, ING, external radiation exposure	Alpha Gamma	4.8 0.186	1,600 yrs
	Ra-226 daughters	Various		Alpha, beta, gamma	Various	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: E&E personnel will collect air samples upwind, downwind and in the work zone while dust generating activities are occurring in contaminated areas. This sampling is primarily to assess and document whether contaminated fugitive dust is being generated by site activities but sample results will also be used for health and safety. When sample data for a work zone are not available or if data documents airborne contamination that requires use of respiratory protection, personnel will don Level C PPE during dust generating activities that are performed in areas with elevated gamma activity. The U.S. Nuclear Regulatory Commission derived air concentrations (DACs, 10 Code of Federal Regulations Part 20 Appendix B Table 1) for the radioisotopes thorium-232 (5E-13 microCuries per milliliter [μCi/mL]) and Ra-226 (3E-10 μCi/mL) will be used as the permissible exposure levels. The DAC for thorium-232 (Th-232) was selected over the DACs for other thorium species because it is the most conservative. The Ra-226 DAC was selected over the DACs for its shorter-lived daughter products (such as radon-222 [Rn-222]) because it is more conservative.

The activity concentration value will be measured on the collected air filters each day, several hours after collection. The alpha activity concentration will initially be compared to the Th-232 DAC to identify whether additional engineering controls are required (e.g. respirators). The alpha activity concentration for each air filter will then be measured again approximately 24 hours and 72 hours after collection to identify whether the alpha activity counts are declining, which is expected due to decay. If significant decay is demonstrated, then the source of radioisotopes are not a thorium species, which have extremely long half-lives (billions of years). Instead, the likely source radioisotopes are the shorter-lived uranium-decay series daughter products such as Rn-222. Previous air sampling results for the USEPA Skyline Mine AUM Removal Project located approximately 50 miles northwest in a similar topographic and geologic setting indicate that worker exposure at concentrations exceeding the DAC does not occur when gamma activity is less than approximately 3-4 times background. During the Skyline project in March to October 2011, daily air samples were collected from locations upwind, downwind and in the work zone while relatively heavy dust generating activities were occurring. The START analyzed the samples using an alpha detector. Calculations based on the known volume of air and the measured alpha activity indicated detected concentrations of airborne radioactive particulates were consistently below the DAC for Thorium 232 of 5×10^{-13}. This is the most conservative DAC of expected radioactive site contaminants. Additionally, the DAC is based on the dose a worker would receive in a 2000 hour work year. Work on this and all other radiation sites for project team members is not expected to exceed 240 hours per year. The limited exposure period, in conjunction with the documented air sampling results will be used to documents that workers are not being exposed above the permissible levels. Radon levels are not considered a health risk as all activities will occur outdoors in open areas.

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)**
1-4	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
1-4	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	

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		
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)						
Positive-pressure, full-face, supplied-air system						

PPE	Task Number/LOP					
	1/D	2/D	3/D	4/D		
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** $\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]		
					Detector	**Action Level**	**Action**
Radiation Survey Ratemeter/Scaler with External Detector(s) (Ludlum 2241, pancake GM detector)	1, 2, 3, 4	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	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	
Logbooks (_____ large, __X__ small)	X

	No.
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
Duct tape	X

	No.
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:			

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	Measurement Methods
NIOSH REL : Ca TWA 0.05 mg/m3 See Appendix A (nengapdxa.html) OSHA PEL : TWA 0.05 mg/m3	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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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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Closed Holidays - cdcinfo@cdc.gov

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 skir 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 bod 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 that 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 Washington 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 a 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].

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

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.

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.

Photo: Extension Entomology, Texas A&M University

Photo: University of Missouri Extension

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.

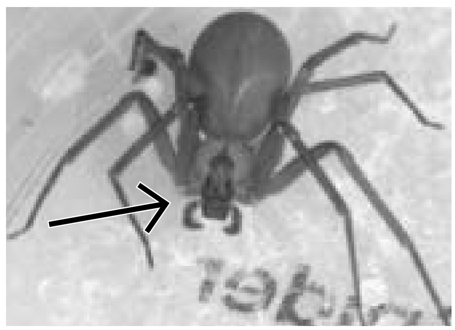


Photo: R. Bessin, University of Kentucky

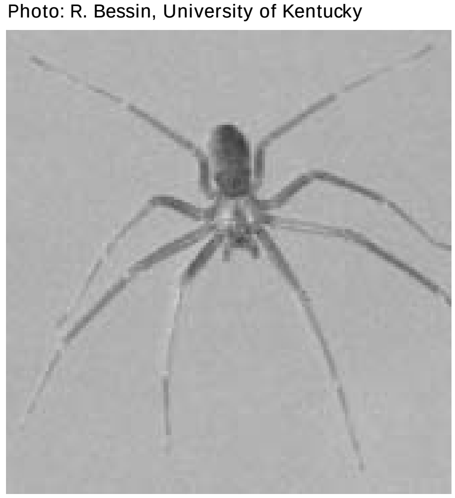


Photo: creatures.ifas.ufl.edu

- 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

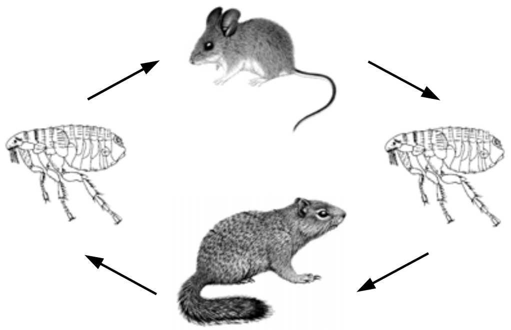
U.S. Department of Labor

www.osha.gov

(800) 321-OSHA

DSG 10/2005

What is Plague?



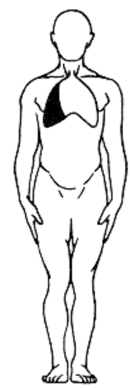
Plague is a disease of wild rodents and rabbits caused by the bacterium *Yersinia pestis*. It is spread among animals and to humans by the bites of infected fleas. Animals most often infected include rock squirrels, prairie dogs, pack rats, chipmunks, rabbits and mice.

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.

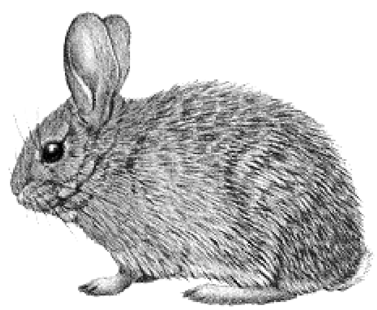
Preventing Plague

- 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

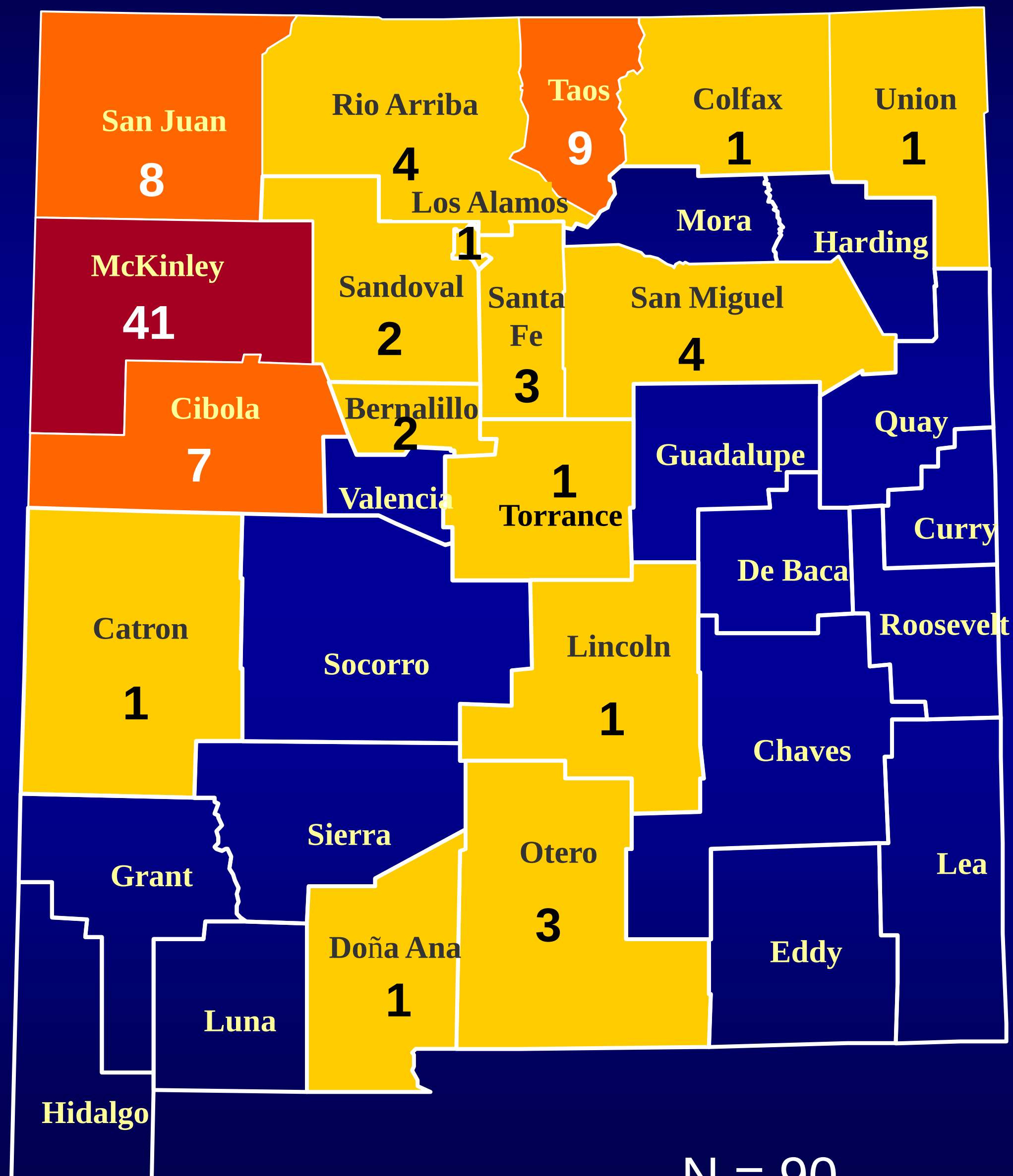
(505) 827-0006



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

STATE OF NEW MEXICO DEPARTMENT OF HEALTH

CARING FOR NEW MEXICO

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.

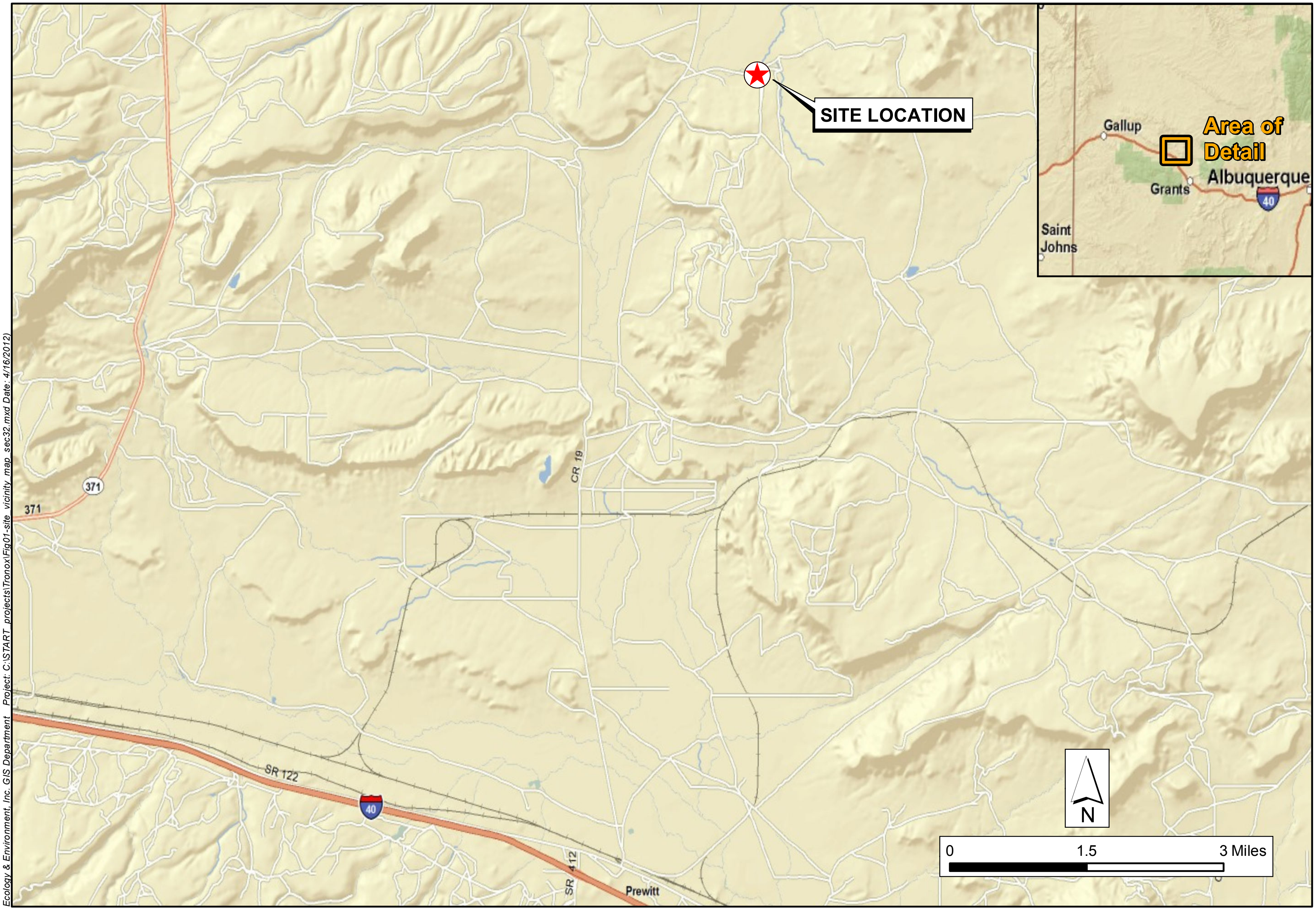
Tell somebody.
Tell somebody where you're going and when you expect to be back. At least they'll know when and where to start searching.

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

Source: ESRI Streetmaps

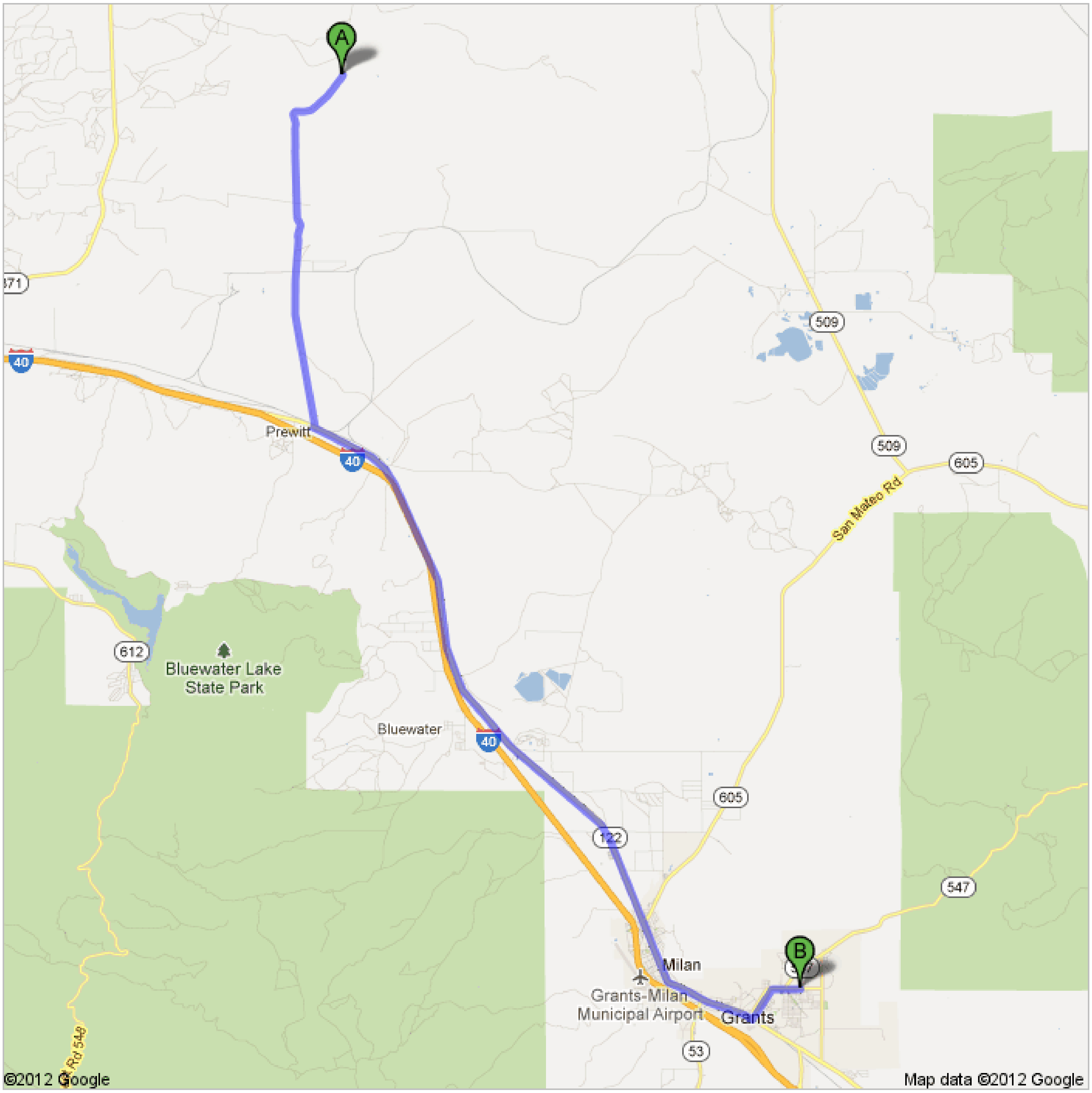


Ecology & Environment, Inc. GIS Department   Project: C:\START_projects\Tronox\Fig01-site_vicinity_map_sec32.mxd Date: 4/16/2012)

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

Appendix C: Site Photographs

PHOTOGRAPHIC LOG

Removal Action

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

TDD No.: 02-09-12-09-0002 Project No.: EE-002693-2200

Direction:	**Date:**
Southwest	10/13/12

Description:

Incident Command Post and support zone during the removal action

Direction:	**Date:**
North	10/17/12

Description:

Air sampling during dust-generating activities

PHOTOGRAPHIC LOG

Removal Action

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

TDD No.: 02-09-12-09-0002 Project No.: EE-002693-2200

Direction:	Date:
North	10/18/12

Description:

Documenting excavated area with a GPS

Direction:	Date:
South	10/19/12

Description:

Dust control during excavation

Removal Action

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

TDD No.: 02-09-12-09-0002 Project No.: EE-002693-2200

Direction: North	Date: 10/20/12

Description:

Over excavation of the mine shaft located in AUM32-RA-04

Direction: West	Date: 10/23/12

Description:

Underground structures uncovered around the mine shaft during excavation

PHOTOGRAPHIC LOG

Removal Action

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

TDD No.: 02-09-12-09-0002 Project No.: EE-002693-2200

Direction:	Date:
North	10/29/12

Description:

Surface gamma radiation survey of the excavation floor

Direction:	Date:
North	10/30/12

Description:

Excavation of AUM32-RA-06 in the transfer area

	PHOTOGRAPHIC LOG
	Removal Action Tronox AUM Section 32 Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico TDD No.: 02-09-12-09-0002 Project No.: EE-002693-2200

Direction: West	**Date:** 11/02/12

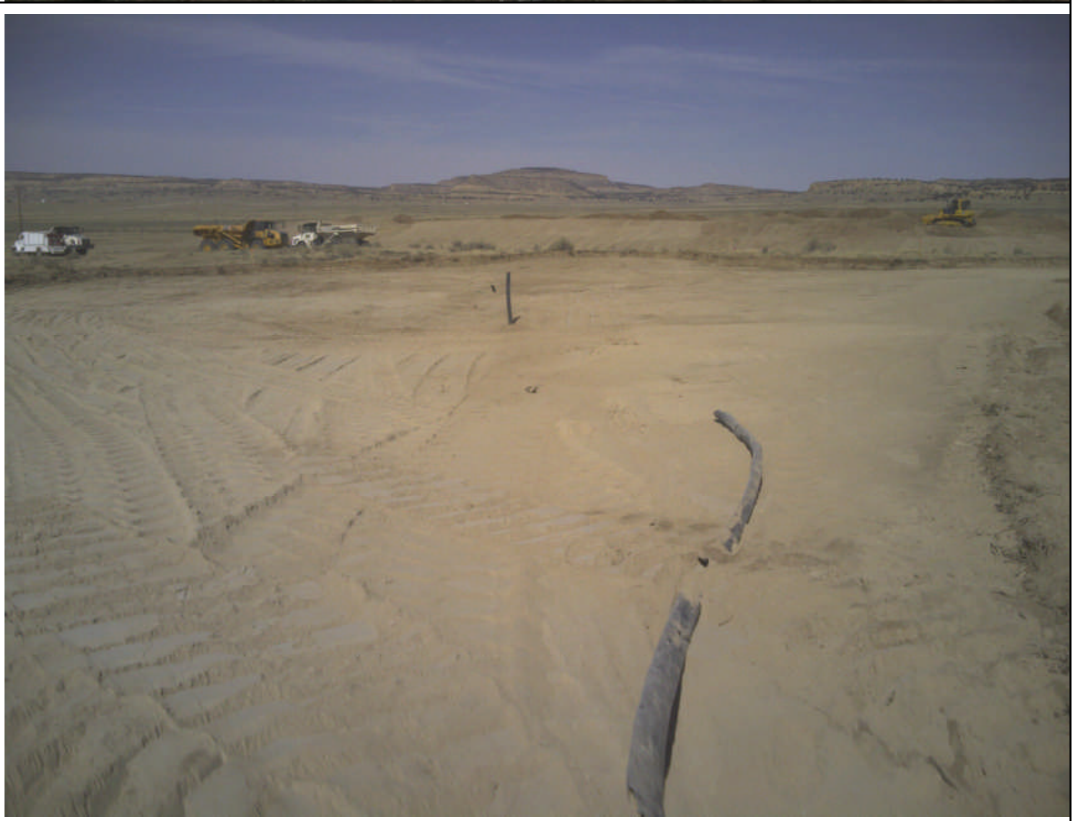
Description:

Air sampling between the removal area and the nearest residence

Direction: North	**Date:** 11/03/12

Description:

Pipes uncovered during excavation of AUM32-RA-12



PHOTOGRAPHIC LOG

Removal Action

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

TDD No.: 02-09-12-09-0002 Project No.: EE-002693-2200

Direction:	Date:
Northwest	11/08/12

Description:

Mine shaft at AUM32-RA-08

Direction:	Date:
Downward	11/08/12

Description:

Mine shaft uncovered during excavation at AUM32-RA-08

Direction: North

Date: 11/09/12

Description:

Removal activities at AUM 32

Direction: North

Date: 11/14/12

Description:

Spraying a soil stabilizer and dust control agent (Gorilla-Snot®) on the stockpile

PHOTOGRAPHIC LOG

Removal Action

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

TDD No.: 02-09-12-09-0002 | Project No.: EE-002693-2200

Direction:	Date:
East	11/14/12

Description:

Surface gamma radiation survey of excavated areas

Direction:	Date:
West	11/15/12

Description:

Surface runoff drainage system for the stockpile

Appendix D: Tables

Table 1
Removal Volumes
Tronox AUM Section 32 Removal
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: 02-09-12-09-0002 Project No.: EE-002693-2200

Removal Area	Proposed Excavation[a]			Final Excavation		
	Depth (ft bgs)	Area (ft^2)	Volume (yd^3)	Depth (ft bgs)	Area (ft^2)	Volume (yd^3)
AUM32-RA-01	3	23,222	2,580	1	25,040	927
AUM32-RA-02	2	105,402	7,808	2	55,567	4,116
AUM32-RA-03	1	60,850	2,254	1	64,133	2,375
AUM32-RA-04[b]	3	88,704	9,856	1,3	31,413	2,809
AUM32-RA-05[b]	4	30,454	4,512	4,6	21,181	3,834
AUM32-RA-15[c]	0.5	30,961	573	0.5	30,961	573
AUM32-RA-16[c]	0.5	9,902	183	0.5	9,902	183
AUM32-RA-17[d]	1	14,164	525	--	--	--
AUM 32 Mine Area		***363,659***	***28,291***		***238,197***	***14,819***
AUM32-RA-06	4	23,762	3,520	3	23,762	2,640
AUM32-RA-07	2	15,308	1,134	3	15,308	1,701
AUM32-RA-08[b]	1	156,756	5,806	0.5,1	160,270	5,936
AUM32-RA-09	1	69,940	2,590	0.5,1	67,017	2,482
AUM32-RA-10	1	2,770	103	1	2,770	103
AUM32-RA-11	1	3,915	145	1	3,920	145
AUM32-RA-12	3	27,822	3,091	1	27,822	1,030
AUM32-RA-13	2	21,099	1,563	1	21,099	781
AUM32-RA-14[d]	2	1,220	90	--	--	--
AUM 32 Transfer Area		***322,592***	***18,043***		***321,968***	***14,819***
TOTAL		***686,251***	***46,333***		***560,165***	***29,638***

Notes:

a	Proposed excavation information shown were from the Removal Assessment Report (E&E 2012).
b	The excavation volumes for AUM32-RA-04, -05, and -08 include overexcavated material from mine shafts located in these removal areas.
c	AUM32-RA-15 and -16 were delineated during the removal action and removed as shown in the final excavation.
d	AUM32-RA-14 and -17 were not excavated during this removal action. AUM32-RA-14 will be addressed as part of AUM 33. AUM32-RA-17 was identified during the pre-excavation gamma radiation survey but was not excavated by the Emergency and Rapid Response Services contractor.
AUM	Abandoned Uranium Mine
ft bgs	Feet below ground surface
ft^2	Square feet
yd^3	Cubic yards
--	Not available

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

TDD No.: 02-09-12-09-0002 Project No.: EE-002693-2200

Sample ID[a]	Ra-226 Concentration[b] (pCi/g)	Surface Gamma Radiation Activity[c] (cpm)
AUM-32-RA-01-1	1.24	32,740
AUM-32-RA-01-2	1.36	32,887
AUM-32-RA-01-3	1.58	35,042
AUM-32-RA-02-1	1.43	34,008
AUM-32-RA-02-2	1.42	35,079
AUM-32-RA-02-3	1.4	34,622
AUM-32-RA-03-1	**28.7**	75,389
AUM-32-RA-03-2	1.88	35,779
AUM-32-RA-03-3	**5.14**	40,957
AUM-32-RA-03-30	**5.83**	40,957
AUM-32-RA-04-1	1.51	37,041
AUM-32-RA-04-2	1.03	29,344
AUM-32-RA-04-3	1.41	27,578
AUM-32-RA-05-1	1.81	38,837
AUM-32-RA-05-2	**7.73**	45,133
AUM-32-RA-05-3	**3.32**	40,183
AUM-32-RA-06-1	0.878	24,061
AUM-32-RA-06-2	1.53	27,216
AUM-32-RA-06-3	0.851	24,901
AUM-32-RA-07-1	1.28	25,021
AUM-32-RA-07-2	0.885	24,494
AUM-32-RA-07-3	1.35	25,548
AUM-32-RA-08-1	1.26	30,547
AUM-32-RA-08-2	**31**	79,831
AUM-32-RA-08-3	1.12	26,573
AUM-32-RA-08-30	1.08	26,573
AUM-32-RA-09-1	0.955	27,884
AUM-32-RA-09-2	1.06	27,720
AUM-32-RA-09-3	1.04	27,548
AUM-32-RA-10-1	**15.5**	96,449
AUM-32-RA-10-2	1.07	29,967
AUM-32-RA-10-3	1.17	30,558
AUM-32-RA-10-30	1.4	30,558
AUM-32-RA-11-1	1.06	28,945
AUM-32-RA-11-2	0.779	27,135
AUM-32-RA-11-3	**2.52**	29,944

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

TDD No.: 02-09-12-09-0002 Project No.: EE-002693-2200

Sample ID[a]	Ra-226 Concentration[b] (pCi/g)	Surface Gamma Radiation Activity[c] (cpm)
AUM-32-RA-12-1	1.79	28,525
AUM-32-RA-12-2	**31.4**	40,567
AUM-32-RA-12-3	0.987	24,292
AUM-32-RA-13-1	**3.24**	28,502
AUM-32-RA-13-2	**2.75**	24,587
AUM-32-RA-13-3	0.89	26,807
AUM-32-RA-13-30	0.896	26,807
AUM-32-RA-15-1	**18.3**	61,801
AUM-32-RA-15-2	**5.69**	38,161
AUM-32-RA-15-3	**3.3**	35,913
AUM-32-RA-16-1	**5.42**	39,530
AUM-32-RA-16-2	**6.09**	37,415
AUM-32-RA-16-3	**3.44**	38,267
AUM-32-RA-16-30	**3.16**	38,267

Notes:

a The sample ID indicates the following:

AUM-32-RA-03-30

Sample number. A number ending in 0 indicates a duplicate.

Sampled removal area

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

c Static 1-minute measurement at sampling location

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

Appendix E: Validated Analytical Data

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Sections 32 and 33	**Location:** Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	**PAN:** EE-002693-2200

Laboratory: GEL Laboratories	**Lab Project Number:** SDG 315573
Sampling Dates: November 15-16, 2012	**Sample Matrix:** Soil
Analytical Method: *DOE HASL 300, 4.5.2.3/Ga-01-R, Gamma Spectroscopy*	**Data Reviewer:** Joanna Z. Christopher

REVIEW AND APPROVAL:

Data Reviewer: JZChristopher **Date:** 4/5/13
Technical QA Reviewer: [signature] **Date:** 4/5/13
Project Manager: ____________ **Date:** ____________

SAMPLE IDENTIFICATION:

Sample No.	Sample I.D.	Laboratory I.D.
1	AUM-32-RA-01-1	315573001
2	AUM-32-RA-01-2	315573002
3	AUM-32-RA-01-3	315573003
4	AUM-32-RA-02-1	315573004
5	AUM-32-RA-02-2	315573005
6	AUM-32-RA-02-3	315573006
7	AUM-32-RA-03-1	315573007
8	AUM-32-RA-03-2	315573008
9	AUM-32-RA-03-3	315573009
10	AUM-32-RA-03-30	315573010
11	AUM-32-RA-05-1	315573011
12	AUM-32-RA-05-2	315573012
13	AUM-32-RA-05-3	315573013
14	AUM-32-RA-04-1	315573014
15	AUM-32-RA-04-2	315573015
16	AUM-32-RA-04-3	315573016
17	AUM-32-RA-06-1	315573017
18	AUM-32-RA-06-2	315573018
19	AUM-32-RA-06-3	315573019
20	AUM-32-RA-07-1	315573020
21	AUM-32-RA-07-2	315573021
22	AUM-32-RA-07-3	315573022
23	AUM-32-RA-08-1	315573023
24	AUM-32-RA-08-2	315573024
25	AUM-32-RA-08-3	315573025
26	AUM-32-RA-08-30	315573026
27	AUM-32-RA-09-1	315573027
28	AUM-32-RA-09-2	315573028
29	AUM-32-RA-09-3	315573029
30	AUM-32-RA-11-1	315573030
31	AUM-32-RA-11-2	315573031
32	AUM-32-RA-11-3	315573032
33	AUM-32-RA-10-1	315573033

ANALYTICAL DATA REVIEW SUMMARY
Tier 2 Validation

Site Name: Tronox AUM Sections 32 and 33	**Location:** Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	**PAN:** EE-002693-2200

Sample No.	Sample I.D.	Laboratory I.D.
34	AUM-32-RA-10-2	315573034
35	AUM-32-RA-10-3	315573035
36	AUM-32-RA-10-30	315573036
37	AUM-32-RA-12-1	315573037
38	AUM-32-RA-12-2	315573038
39	AUM-32-RA-12-3	315573039
40	AUM-32-RA-13-1	315573040
41	AUM-32-RA-13-2	315573041
42	AUM-32-RA-13-3	315573042
43	AUM-32-RA-13-30	315573043
44	AUM-32-RA-15-1	315573044
45	AUM-32-RA-15-2	315573045
46	AUM-32-RA-15-3	315573046
47	AUM-32-RA-16-1	315573047
48	AUM-32-RA-16-2	315573048
49	AUM-32-RA-16-3	315573049
50	AUM-32-RA-16-30	315573050

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Sections 32 and 33	**Location:** Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	**PAN:** EE-002693-2200

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 period was 21 to 22 days, which was acceptable. The samples were analyzed 26 to 27 days after collection, which was acceptable.

Five field duplicate samples were collected, as required by the project Sampling and Analysis Plan (SAP). The field duplicate sample nomenclature was slightly different from that specified in the SAP.

No rinsate samples were required because dedicated sampling equipment was used.

Background samples were collected and analyzed during a previous sampling event.

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Sections 32 and 33	**Location:** Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	**PAN:** EE-002693-2200

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: None.

ANALYTICAL DATA REVIEW SUMMARY
Tier 2 Validation

Site Name: Tronox AUM Sections 32 and 33	**Location:** Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	**PAN:** EE-002693-2200

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 Sections 32 and 33	**Location:** Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	**PAN:** EE-002693-2200

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

______ **Acceptable**
______ **Acceptable with qualification**
______ **Unacceptable**
__X__ **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 Ra-226 analysis and was not performed.

Site Name: Tronox AUM Sections 32 and 33	**Location:** Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	**PAN:** EE-002693-2200

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
______ 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:

No sample results were qualified on the basis of blank samples.

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Sections 32 and 33	**Location:** Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	**PAN:** EE-002693-2200

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. Five field duplicate sample pairs were collected for this sampling effort, which was acceptable. Precision was acceptable (≤35% RPD) for the field duplicate sample pairs, as shown below.

Field Duplicate Sample Pair	RPD
AUM-32-RA-03-3/AUM-32-RA-03-30	12.6
AUM-32-RA-08-3/AUM-32-RA-08-30	3.64
AUM-32-RA-10-3/AUM-32-RA-10-30	17.9
AUM-32-RA-13-3/AUM-32-RA-13-30	0.67
AUM-32-RA-16-3/AUM-32-RA-16-30	8.48

The laboratory performed one laboratory duplicate analysis for gamma spec analysis for every analytical batch of 20 samples or fewer, with acceptable precision.

ANALYTICAL DATA REVIEW SUMMARY

Tier 2 Validation

Site Name: Tronox AUM Sections 32 and 33	**Location:** Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	**PAN:** EE-002693-2200

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
315573012	4054	1	0.02748	157.57	0.455	120	7.7258	7.73	99.9456
315573026	281	1	0.02748	156.82	0.455	60	1.0761	1.08	99.6424
315573030	260	1	0.02579	157.00	0.455	60	1.0597	1.06	99.9761
315573039	234	1	0.02386	163.97	0.455	60	0.9871	0.987	100.0101
315573046	1191	1	0.0388	153.57	0.455	60	3.2988	3.3	99.9631

Site Name: Tronox AUM Sections 32 and 33	**Location:** Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	**PAN:** EE-002693-2200

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 43 of the samples in this SDG at low levels ranging from 0.83 to 2.09 pCi/g, likely due to radioactive decay of naturally occurring Th-232. Cs-137 was detected in two samples in this SDG at low levels ranging from 0.175 to 0.180 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: December 14, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-01-1	Project:	ECOL00724
Sample ID:	315573001	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-NOV-12 15:46		
Receive Date:	20-NOV-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	+/-0.181	0.124	1.00	pCi/g		MXR1	12/12/12	0849	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

BChristopher 4/5/13

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Contact:	Ms. Mindy Song
Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-01-2	Project:	ECOL00724
Sample ID:	315573002	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-NOV-12 15:50		
Receive Date:	20-NOV-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	+/-0.153	0.0984	1.00	pCi/g		MXR1	12/12/12	0849	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

JChristopher 4/5/13

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Contact:	Ms. Mindy Song
Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-01-3	Project:	ECOL00724
Sample ID:	315573003	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-NOV-12 15:54		
Receive Date:	20-NOV-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		1.58	+/-0.204	0.157	1.00	pCi/g		MXR1	12/12/12	0905	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

JChristopher 4/5/13

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Report Date: December 14, 2012

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Contact:	Ms. Mindy Song
Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-02-1	Project:	ECOL00724
Sample ID:	315573004	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-NOV-12 16:01		
Receive Date:	20-NOV-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	+/-0.158	0.110	1.00	pCi/g		MXR1	12/12/12	0905	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

JChristopher 4/5/13

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Certificate of Analysis

Report Date: December 14, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-02-2	Project:	ECOL00724
Sample ID:	315573005	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-NOV-12 16:04		
Receive Date:	20-NOV-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	+/-0.149	0.108	1.00	pCi/g		MXR1	12/12/12	0906	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

JJChristopher 4/5/13

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Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-02-3	Project:	ECOL00724
Sample ID:	315573006	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-NOV-12 16:08		
Receive Date:	20-NOV-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	+/-0.144	0.104	1.00	pCi/g		MXR1	12/12/12	0906	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-03-1	Project:	ECOL00724
Sample ID:	315573007	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-NOV-12 16:16		
Receive Date:	20-NOV-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		28.7	+/-0.541	0.194	1.00	pCi/g		MXR1	12/12/12	0907	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

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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Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-03-2	Project:	ECOL00724
Sample ID:	315573008	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-NOV-12 16:23		
Receive Date:	20-NOV-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		1.88	+/-0.162	0.0938	1.00	pCi/g		MXR1	12/12/12	0907	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

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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Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-03-3	Project:	ECOL00724
Sample ID:	315573009	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-NOV-12 16:27		
Receive Date:	20-NOV-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		5.14	+/-0.342	0.203	1.00	pCi/g		MXR1	12/12/12	0908	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-03-30	Project:	ECOL00724
Sample ID:	315573010	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	15-NOV-12 16:28		
Receive Date:	20-NOV-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	+/-0.356	0.208	1.00	pCi/g		MXR1	12/12/12	0940	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-05-1	Project:	ECOL00724
Sample ID:	315573011	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 10:49		
Receive Date:	20-NOV-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		1.81	+/-0.193	0.126	1.00	pCi/g		MXR1	12/12/12	0940	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-05-2	Project:	ECOL00724
Sample ID:	315573012	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 10:54		
Receive Date:	20-NOV-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		7.73	+/-0.280	0.139	1.00	pCi/g		MXR1	12/12/12	0941	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-05-3	Project:	ECOL00724
Sample ID:	315573013	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 10:57		
Receive Date:	20-NOV-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		3.32	+/-0.184	0.104	1.00	pCi/g		MXR1	12/12/12	0948	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-04-1	Project:	ECOL00724
Sample ID:	315573014	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 11:12		
Receive Date:	20-NOV-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		1.51	+/-0.189	0.130	1.00	pCi/g		MXR1	12/12/12	0952	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-04-2	Project:	ECOL00724
Sample ID:	315573015	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 11:17		
Receive Date:	20-NOV-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	+/-0.157	0.0924	1.00	pCi/g		MXR1	12/12/12	0959	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-04-3	Project:	ECOL00724
Sample ID:	315573016	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 11:20		
Receive Date:	20-NOV-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		1.41	+/-0.132	0.0949	1.00	pCi/g		MXR1	12/12/12	1004	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-06-1	Project:	ECOL00724
Sample ID:	315573017	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 11:31		
Receive Date:	20-NOV-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		0.878	+/-0.119	0.0892	1.00	pCi/g		MXR1	12/12/12	1004	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

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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Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-06-2	Project:	ECOL00724
Sample ID:	315573018	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 11:34		
Receive Date:	20-NOV-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	+/-0.142	0.0927	1.00	pCi/g		MXR1	12/12/12	1117	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

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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Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-06-3	Project:	ECOL00724
Sample ID:	315573019	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 11:37		
Receive Date:	20-NOV-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		0.851	+/-0.197	0.141	1.00	pCi/g		MXR1	12/12/12	1118	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-07-1	Project:	ECOL00724
Sample ID:	315573020	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 11:43		
Receive Date:	20-NOV-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		1.28	+/-0.172	0.123	1.00	pCi/g		MXR1	12/12/12	1149	1265266	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1400	1265149

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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Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-07-2	Project:	ECOL00724
Sample ID:	315573021	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 11:48		
Receive Date:	20-NOV-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		0.885	+/-0.179	0.119	1.00	pCi/g		MXR1	12/13/12	0808	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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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Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-07-3	Project:	ECOL00724
Sample ID:	315573022	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 11:51		
Receive Date:	20-NOV-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	+/-0.176	0.127	1.00	pCi/g		MXR1	12/13/12	0809	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-08-1	Project:	ECOL00724
Sample ID:	315573023	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 11:59		
Receive Date:	20-NOV-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	+/-0.223	0.141	1.00	pCi/g		MXR1	12/13/12	0821	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-08-2	Project:	ECOL00724
Sample ID:	315573024	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 12:04		
Receive Date:	20-NOV-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	+/-0.661	0.256	1.00	pCi/g		MXR1	12/13/12	0822	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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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Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-08-3	Project:	ECOL00724
Sample ID:	315573025	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 12:09		
Receive Date:	20-NOV-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		1.12	+/-0.164	0.124	1.00	pCi/g		MXR1	12/13/12	0822	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

JB Christopher 4/5/13

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Certificate of Analysis

Report Date: December 14, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-08-30	Project:	ECOL00724
Sample ID:	315573026	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 12:10		
Receive Date:	20-NOV-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		1.08	+/-0.180	0.131	1.00	pCi/g		MXR1	12/13/12	0823	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-09-1	Project:	ECOL00724
Sample ID:	315573027	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 13:05		
Receive Date:	20-NOV-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		0.955	+/-0.179	0.134	1.00	pCi/g		MXR1	12/13/12	0823	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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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Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-09-2	Project:	ECOL00724
Sample ID:	315573028	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 13:10		
Receive Date:	20-NOV-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		1.06	+/-0.189	0.127	1.00	pCi/g		MXR1	12/13/12	0902	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-09-3	Project:	ECOL00724
Sample ID:	315573029	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 13:12		
Receive Date:	20-NOV-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	+/-0.220	0.180	1.00	pCi/g		MXR1	12/13/12	0902	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-11-1	Project:	ECOL00724
Sample ID:	315573030	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 13:22		
Receive Date:	20-NOV-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		1.06	+/-0.198	0.135	1.00	pCi/g		MXR1	12/13/12	0903	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-11-2	Project:	ECOL00724
Sample ID:	315573031	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 13:24		
Receive Date:	20-NOV-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	+/-0.205	0.203	1.00	pCi/g		MXR1	12/13/12	0903	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-11-3	Project:	ECOL00724
Sample ID:	315573032	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 13:27		
Receive Date:	20-NOV-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		2.52	+/-0.377	0.224	1.00	pCi/g		MXR1	12/13/12	0903	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-10-1	Project:	ECOL00724
Sample ID:	315573033	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 13:41		
Receive Date:	20-NOV-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		15.5	+/-0.609	0.241	1.00	pCi/g		MXR1	12/13/12	0904	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-10-2	Project:	ECOL00724
Sample ID:	315573034	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 13:44		
Receive Date:	20-NOV-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	+/-0.252	0.191	1.00	pCi/g		MXR1	12/13/12	0933	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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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Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-10-3	Project:	ECOL00724
Sample ID:	315573035	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 13:45		
Receive Date:	20-NOV-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	+/-0.188	0.119	1.00	pCi/g		MXR1	12/13/12	0933	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-10-30	Project:	ECOL00724
Sample ID:	315573036	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 13:46		
Receive Date:	20-NOV-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	+/-0.228	0.175	1.00	pCi/g		MXR1	12/13/12	0933	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-12-1	Project:	ECOL00724
Sample ID:	315573037	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 13:52		
Receive Date:	20-NOV-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		1.79	+/-0.252	0.148	1.00	pCi/g		MXR1	12/13/12	0934	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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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Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-12-2	Project:	ECOL00724
Sample ID:	315573038	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 13:55		
Receive Date:	20-NOV-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		31.4	+/-0.922	0.357	1.00	pCi/g		MXR1	12/13/12	0934	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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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Client Sample ID:	AUM-32-RA-12-3	Project:	ECOL00724
Sample ID:	315573039	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 13:57		
Receive Date:	20-NOV-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		0.987	+/-0.169	0.114	1.00	pCi/g		MXR1	12/13/12	0937	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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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Client Sample ID:	AUM-32-RA-13-1	Project:	ECOL00724
Sample ID:	315573040	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 14:01		
Receive Date:	20-NOV-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		3.24	+/-0.285	0.175	1.00	pCi/g		MXR1	12/13/12	0935	1265268	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1407	1265151

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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Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-13-2	Project:	ECOL00724
Sample ID:	315573041	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 14:04		
Receive Date:	20-NOV-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		2.75	+/-0.178	0.105	1.00	pCi/g		MXR1	12/12/12	1303	1265273	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1415	1265153

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-13-3	Project:	ECOL00724
Sample ID:	315573042	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 14:07		
Receive Date:	20-NOV-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		0.890	+/-0.189	0.136	1.00	pCi/g		MXR1	12/12/12	1311	1265273	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1415	1265153

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-13-30	Project:	ECOL00724
Sample ID:	315573043	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 14:10		
Receive Date:	20-NOV-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		0.896	+/-0.197	0.169	1.00	pCi/g		MXR1	12/12/12	1320	1265273	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1415	1265153

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:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-15-1	Project:	ECOL00724
Sample ID:	315573044	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 14:20		
Receive Date:	20-NOV-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		18.3	+/-0.624	0.267	1.00	pCi/g		MXR1	12/12/12	1320	1265273	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1415	1265153

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

JJChristopher 4/5/13

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: December 14, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-15-2	Project:	ECOL00724
Sample ID:	315573045	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 14:23		
Receive Date:	20-NOV-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		5.69	+/-0.343	0.168	1.00	pCi/g		MXR1	12/12/12	1320	1265273	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1415	1265153

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

JChristopher 4/5/13

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: December 14, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-15-3	Project:	ECOL00724
Sample ID:	315573046	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 14:25		
Receive Date:	20-NOV-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		3.30	+/-0.228	0.152	1.00	pCi/g		MXR1	12/12/12	1321	1265273	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1415	1265153

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

JJChristopher 4/5/13

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: December 14, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-16-1	Project:	ECOL00724
Sample ID:	315573047	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 14:45		
Receive Date:	20-NOV-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		5.42	+/-0.332	0.157	1.00	pCi/g		MXR1	12/12/12	1321	1265273	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1415	1265153

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

JJChristopher 4/5/13

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: December 14, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-16-2	Project:	ECOL00724
Sample ID:	315573048	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 14:48		
Receive Date:	20-NOV-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		6.09	+/-0.357	0.189	1.00	pCi/g		MXR1	12/12/12	1321	1265273	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1415	1265153

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

JJChristopher 4/5/13

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: December 14, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave. #102 Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-16-3	Project:	ECOL00724
Sample ID:	315573049	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 14:50		
Receive Date:	20-NOV-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		3.44	+/-0.329	0.189	1.00	pCi/g		MXR1	12/13/12	0805	1265273	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1415	1265153

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

JB Christopher 4/5/13

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: December 14, 2012

Company :	Ecology & Environment, Inc.
Address :	3700 Industry Ave.
	#102
	Lakewood, California 90712
Contact:	Ms. Mindy Song
Project:	2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:	AUM-32-RA-16-30	Project:	ECOL00724
Sample ID:	315573050	Client ID:	ECOL007
Matrix:	Soil		
Collect Date:	16-NOV-12 14:51		
Receive Date:	20-NOV-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		3.16	+/-0.307	0.197	1.00	pCi/g		MXR1	12/13/12	0805	1265273	1

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
Dry Soil Prep	Dry Soil Prep GL-RAD-A-021	DRS1	11/20/12	1415	1265153

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	DOE HASL 300, 4.5.2.3/Ga-01-R	

JJChristopher 4/5/13

GEL Chain of Custody and Analytical Request

Page: 1 of 5
Project #: EE-002693-2200
GEL Quote #:
COC Number (1):
PO Number:

GEL Work Order Number: 315573

GEL Laboratories, LLC
2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171
Fax: (843) 766-1178

Client Name: Craig Tiballi / Ecology + Environment Phone #: 415.306.1490
Project/Site Name: Tronox Section 32/33 Removal Fax #:
Address: Casamero Lake, Navajo Nation, New Mexico
Collected by: Send Results To:

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										<-- Preservative Type (6) / Comments Note: extra sample is required for sample specific QC
AUM-32-RA-01-1	11/15/12	1546	N		SO	✓		1	✓										
AUM-32-RA-01-2	↓	1550	N		SO	✓		1	✓										<a copy>
AUM-32-RA-01-3	↓	1554	N		SO	✓		1	✓										J Christopher 4/5/13
AUM-32-RA-02-1	↓	1601	N		SO	✓		1	✓										
AUM-32-RA-02-2	↓	1604	N		SO	✓		1	✓										
AUM-32-RA-02-3	↓	1608	N		SO	✓		1	✓										
AUM-32-RA-03-1	↓	1616	N		SO	✓		1	✓										
AUM-32-RA-03-2	↓	1623	N		SO	✓		1	✓										
AUM-32-RA-03-3	↓	1627	N		SO	✓		1	✓										
AUM-32-RA-03-30	11/15/12	1628	N		SO	✓		1	✓										

TAT Requested: Normal: ✓ 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*

Sample Collection Time Zone
Eastern Pacific
Central Other ______
Mountain

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time		Received by (signed)	Date	Time
1	Craig Tiballi	11/17/12	1000	1	OPJ	11-20-12	0910
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: 19 C

WHITE = LABORATORY YELLOW = FILE PINK = CLIENT

GEL Chain of Custody and Analytical Request

Page: 2 of 5
Project #:
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: Phone #:

Project/Site Name: Tronox Sect. 32/33 Removal Fax #:

Address:

Collected by: Send Results To:

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	Comments Note: extra sample is required for sample specific QC
AUM-32-RA-05-1	11/16/12	1049	N		SO	✓		1	✓	
AUM-32-RA-05-2		1054	N			✓		1	✓	<a copy>
AUM-32-RA-05-3		1057	N			✓		1	✓	J Christopher
AUM-32-RA-04-1		1112	N			✓		1	✓	4/5/13
AUM-32-RA-04-2		1117	N			✓		1	✓	
AUM-32-RA-04-3		1120	N			✓		1	✓	
AUM-32-RA-06-1		1131	N			✓		1	✓	
AUM-32-RA-06-2		1134	N			✓		1	✓	
AUM-32-RA-06-3		1137	N			✓		1	✓	
AUM-32-RA-07-1	11/16/12	1143	N		SO	✓		1	✓	

TAT Requested: Normal: ✓ 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*

Sample Collection Time Zone
Eastern Pacific
Central Other ______
Mountain

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time		Received by (signed)	Date	Time
1	Craig Zelulli	11/17/12	1000	1	JJ	11-20-12	0910
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: 19 C

WHITE = LABORATORY YELLOW = FILE PINK = CLIENT

Page: 3 of 5
Project #:
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: Phone #:
Project/Site Name: Tronox Sect. 32/33 Removal Fax #:
Address:
Collected by: Send Results To:

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	<-- Preservative Type (6)	Comments Note: extra sample is required for sample specific QC
AUM-32-RA-07-2	11/16/12	1148	N		SO	✓		1		
AUM-32-RA-07-3		1151				✓		1		
AUM-32-RA-08-1		1159				✓		1		
AUM-32-RA-08-2		1204				✓		1		
AUM-32-RA-08-3		1209				✓		1		
AUM-32-RA-08-30		1210				✓		1		
AUM-32-RA-09-1		1305				✓		1		
AUM-32-RA-09-2		1310				✓		1		
AUM-32-RA-09-3		1312				✓		1		
AUM-32-RA-11-1	11/16/12	1322	N		SO	✓		1		

{a copy} JChristopher 4/5/13

TAT Requested: Normal: ✓ 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*

Sample Collection Time Zone
Eastern Pacific
Central Other ______
Mountain

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1	Craig Zlalli	11/17/12	1000	[signature]	11-20-12	0910
2						
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: 19 C

WHITE = LABORATORY YELLOW = FILE PINK = CLIENT

Page: 4 of 5
Project #:
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: Phone #:
Project/Site Name: Tronox Sect. 32/33 Removal Fax #:
Address:
Collected by: Send Results To:

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	Comments Note: extra sample is required for sample specific QC
									<-- Preservative Type (6)	
AUM-32-RA-11-2	11/16/12	1324	N		SO	✓		1	✓	<a copy> JJChristopher 4/5/13
AUM-32-RA-11-3		1327				✓		1	✓	
AUM-32-RA-10-1		1341				✓		1	✓	
AUM-32-RA-10-2		1344				✓		1	✓	
AUM-32-RA-10-3		1345				✓		1	✓	
AUM-32-RA-10-30		1346				✓		1	✓	
AUM-32-RA-12-1		1352				✓		1	✓	
AUM-32-RA-12-2		1355				✓		1	✓	
AUM-32-RA-12-3		1357				✓		1	✓	
AUM-32-RA-13-1	11/16/12	1401	N		SO	✓		1	✓	

TAT Requested: Normal: ✓ 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*

Sample Collection Time Zone
Eastern Pacific
Central Other ______
Mountain

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time		Received by (signed)	Date	Time
1	Craig Zelaski	11/17/12	1000	1	JRJ	11-20-12	0910
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: 19 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**

Page: 5 of 5
Project #:
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: | Phone #:

Project/Site Name: Tronox Sect. 32/33 Removal | Fax #:

Address:

Collected by: | Send Results To:

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	Comments Note: extra sample is required for sample specific QC
AUM-32-RA-13-2	11/16/12	1404	N		SO	✓		1	✓	
AUM-32-RA-13-3		1407				✓		1	✓	<a copy>
AUM-32-RA-13-30		1410				✓		1	✓	JJ Christopher 4/5/13
AUM-32-RA-15-1		1420				✓		1	✓	
AUM-32-RA-15-2		1423				✓		1	✓	
AUM-32-RA-15-3		1425				✓		1	✓	
AUM-32-RA-16-1		1445				✓		1	✓	
AUM-32-RA-16-2		1448				✓		1	✓	
AUM-32-RA-16-3		1450				✓		1	✓	
AUM-32-RA-16-30	11/16/12	1451	N		SO	✓		1	✓	

TAT Requested: Normal: ✓ 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*

Sample Collection Time Zone
Eastern Pacific
Central Other ______
Mountain

Chain of Custody Signatures

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1 Craig Zeballo	11/17/12	1000	1 JRJ	11-20-12	0910
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: 19 C

WHITE = LABORATORY YELLOW = FILE PINK = CLIENT

GEL Laboratories LLC

SAMPLE RECEIPT & REVIEW FORM

Client: ECOL			**SDG/AR/COC/Work Order:** 315573
Received By: JP			**Date Received:** 11-20-12
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) *all temperatures are recorded in Celsius 19
2a	Daily check performed and passed on IR temperature gun?	✓			Temperature Device Serial #: 41SCR2209 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 7941 0037 8939 " " 9199

Comments (Use Continuation Form if needed):

<a copy> SChristopher 4/5/13

PM (or PMA) review: Initials JP Date 11-20-12 Page 1 of 1