bhpbilliton **Rio Algom Mining LLC**

January 19, 2005

Via UPS Overnight

ATTN: Document Control Desk
Mr. Gary Janosko, Chief
Fuel Cycle Licensing Branch, NMSS
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Re: **License SUA-1473**
Docket No. 40-8905

Dear Mr. Janosko,

Please find enclosed Rio Algom Mining LLC's Soil Decommissioning Plan for the Ambrosia Lake facility. This plan outlines the approach Rio Algom proposes to demonstrate compliance with 10 CFR 40, Appendix A, Crtierion 6. Rio Algom believes that implementation of the Plan will result in achieving cleanup and protecting the public and environment.

Rio Algom is available to discuss the Plan and its details with your staff should it be deemed beneficial for both parties in achieving approval of the Plan. If you have any questions, please call me at (505) 287-8851, extension 205.

Regards,

Peter Luthiger
Manager, Radiation Safety
and Environmental Affairs

xc: T. Fletcher
R. Jones (w/o attachment)
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USNRC- MD (J. Caverly – 2 copies)
File

NMSS01

DOCKET 40-8905

SOIL DECOMMISSIONING PLAN

RIO ALGOM MINING LLC
AMBROSIA LAKE FACILITY
GRANTS, NEW MEXICO

SOURCE MATERIAL LICENSE SUA-1473
DOCKET NUMBER 40-8905

Prepared For:

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December 2004

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LIST OF ACRONYMS AND ABBREVIATIONS

ACL	Alternate Concentration Limit
ARC	Alternate Release Criteria
CFR	Code of Federal Regulations
cm	centimeter
cpm	counts per minute
d	day
ft	feet
g	gram
FSS	Final Status Survey
Kd	soil distribution coefficient
kg	kilogram
l	liters
m	meters
mg	milligram
mm	millimeters
mrem	millirem
NRC	United States Nuclear Regulatory Commission
pCi	pico curie
QAPP	Quality Assurance Project Procedure
Ra	radium

LIST OF ACRONYMS AND ABBREVIATIONS (CONT'D)

RAM Rio Algom Mining LLC

RESRAD RESidual RADiation dose modeling software

RoC Radionuclide of Concern

RSO Radiation Safety Officer

Th thorium

TEDE Total Effective Dose Equivalent

U uranium

yr year

1.0 INTRODUCTION

The Rio Algom Mining LLC (RAM) Ambrosia Lake mill facility ("the site") is located in the Ambrosia Lake mining district in the southeastern part of McKinley County, New Mexico (**Figure 1-1**). The site is located 25 road miles north of Grants, New Mexico on Route 509, in a valley within the Ambrosia Lake portion of the Grants mineral belt, a major uranium production region. The Grants Uranium Belt, and more specifically the Ambrosia Lake mining district, contained numerous mining companies who operated two uranium ore processing mills and over 20 underground uranium mines within the Ambrosia Lake valley. Extensive surface disturbance has occurred at and near the site as a result of over 40 years of mining and milling activities throughout the valley. The locations of nearby mines are shown on **Figure 1-2**.

1.1 PLAN OBJECTIVES AND REPORT STRUCTURE

This Soil Decommission Plan ("the Plan") has been prepared in accordance with NUREG-1620[1] and addresses comments received from the U.S. Nuclear Regulatory Commission (NRC)[2] concerning the original Contaminated Soils Clean up Plan submitted in October 2000[3]. The Soil Decommissioning Plan is one component of the overall site decommissioning plan. The purpose of the Plan is to remediate the windblown tailings, effluent contaminated soils, and soils contaminated by license activities that originated from the milling operation and disposal area, and to demonstrate that the clean up plan was successful in remediating the contaminated soils to comply with the proposed release criteria. For areas of deeper contamination attributed to licensed activities, RAM will apply Alternate Release Criteria (ARC) to allow these soils to be left in place with an appropriate cover. The ARC will achieve appropriate closure to allow for the transfer of these areas to the U.S. Department of Energy under institutional controls.

Radiological constituents of concern and the distribution of contaminants are described in Section 2 of this Plan. The development of background soil concentrations for constituents of concern is presented in Section 3. Development of the Benchmark Dose is described in Section

[1] U.S. Nuclear Regulatory Commission (NRC), Final Report Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act, NUREG-1620, Revision 1, June 2003.

[2] Request for Additional Information Concerning the Soil Decommissioning Plan for the Quivera Mining Company Ambrosia Lake Uranium Mill Site, U.S. Nuclear Regulatory Commission, January 3, 2001.

[3] Contaminated Soil Clean Up Plan, Source Material License SUA-1473, Docket Number 40-8905, Quivera Mining Company, October 26, 2000.

4. Applicable clean up criteria to be applied to surface soils and ARC for deeper soils are described in Section 5. Development of the gamma guideline value (field clean up criteria based on indirect measurement of radium-226 in surface soils) is presented in Section 6. The soil remediation strategy, including methods and techniques applicable for the remediation of surface soils, are described in Section 7. The application of the gamma guideline value and associated compliance demonstration are described in Section 8 – Final Status Survey. A discussion of non-radiological hazardous constituents and the soil decommissioning cost estimate and surety fund is provided in Sections 9 and 10, respectively.

1.2 HISTORY AND MILL PROCESS DESCRIPTION

Ambrosia Lake began processing uranium ore in 1958. The initial rated capacity was 3630 tons per day, but this was expanded to a maximum capacity of 7000 tons per day. Approximately 33 million tons of ore had been processed through the facility from start-up in 1958 through January 1985.

The ore was leached with sulfuric acid, and pregnant solution was separated from spent solids in a countercurrent decantation circuit utilizing cyclones, classifiers, and thickeners. Uranium was recovered from solution by solvent extraction and stripped with salt brine, and the yellowcake was precipitated from the strip solutions with ammonia. The recovery of U_3O_8 exceeded 96%.

The tailings disposal area was constructed in 1958 and consisted of eight ponding areas (Figure 1-2). Impoundments 1 and 2 were used for solids disposal, Pond 3 was a decant and seepage collection pond, and Ponds 4 through 8 were used for evaporation of liquids decanted from Impoundments 1 and 2. All starter dike and retention dikes were constructed from clayey natural soils that were present on the site. Tailings disposal operations consisted of utilizing the upstream spigoting method which is designed to allow the tailings slurry to run down from the edge of the impoundment to the center so that the sands are deposited first, then the finer fractions are deposited as the solution is decanted off. By the end of 1984, nearly 33 million tons of tailing solids had been deposited at the site since startup and no failures allowing discharge of radioactive material outside the restricted area have occurred.

Ponds 9 and 10 were constructed in 1976. Contrary to Ponds 4 through 8, these ponds included a liner. These ponds were used for same purpose as Ponds 4 through 8; i.e. evaporation of liquids decanted from Impoundments 1 and 2. Pond 10 was removed service in 1984 and allowed to dry out. The accumulated sediments and liner material were relocated to Pond 2.

The area was cleaned down to bedrock (sandstone). The area then received 3 feet of fill material.

The Section 4 ponds were used to evaporate liquid wastes generated from Rio Algom's acid leach uranium ore processing mill located approximately 2 miles northwest of the ponds. The ponds were constructed in two phases with the northern ponds (Ponds 11–15) being built in 1976 and the southern ponds (Ponds 16-21) constructed in 1979. The ponds provide an overall evaporative area of 256 acres with a total holding capacity of 1570 acre-feet. Additional wastewater streams that were evaporated at the Section 4 Ponds included wastewater from the ion exchange plant consisting of backwash solutions and resin regeneration solutions. The yellowcake precipitation process generated acidic decant solutions. Groundwater collected as part of the alluvial remediation plan, as well as other mill process solutions, were also disposed via evaporation at the Section 4 Ponds. The ponds remained in active service through April 2004 and are scheduled for reclamation in the fall of 2004 by relocating the pond sediments to the main tailings disposal area.

Utilization of the acid leach process required the sandstone ores to be ground to the natural grain size of approximately 28 mesh rather than the much finer grinding required for alkaline leach processing which typically was down to a 200 mesh. This coarser grain size along with crust formed on the deposited tailings provided greater protection from possible wind dispersion for acid leach tailings than for alkaline leach tailings.

Ambrosia Lake's mill processing facility was placed on deferred production status in early 1985 pending more favorable market conditions. The facility continued to be an active uranium production facility through December 2002 in addition to maintaining disposal capacity for an additional 16 million tons upon the approved disposal area. Reclamation of the tailings management facilities commenced in 1989 with the initiation of consolidating the top surface of Impoundment 1 along the center portion of the pile and excavation of evaporation pond residues from Pond 8.

Ongoing reclamation activities have occurred including excavation and disposal of unlined evaporation pond residues, contaminated soil clean up, completion of the majority of the required reclamation for Impoundments 1 and 2, and construction of a rock apron on Impoundment 2. Demolition of the conventional milling structures and most of the support facilities were completed in February 2004. Additional activities concentrated on the construction of erosion protection features adjacent to the tailings disposal facility.

1.3 AREAS COVERED BY THE PLAN

Geographic areas covered by the provisions of this Plan are shown in **Figure 1-3**. The rationale for the location of certain area boundaries are provided in Sections 2 and 3 of this Plan. Areas covered by the Plan include:

- Areas of surface soil contamination impacted by windblown tailings. These areas are located downwind, toward the east and northeast (down slope).
- Haulways and roads impacted by spilled material.
- Areas of deeper soil contamination affected by effluent from licensed activities that have been adequately characterized. These areas include unlined evaporation Ponds 4 through 8, and Pond 10. These areas will be closed through the application of ARC by comparison of the site-specific dose assessment with the Benchmark Dose (see Section 5.2 for ARC development).
- Areas of possible deeper soil contamination that currently lack adequate characterization data. These areas include the Mill Area and lined evaporation ponds including Pond 9 and the Section 4 Ponds (11 through 21). Other areas included are the mine water treatment pond, the saturated area immediately north of the treatment pond resulting from mine water seepage, and the former saturated zones adjacent to Pond 9 that existed prior to the installation and operation of the dewatering trench, and pipelines that contained process solutions. These areas are covered by the basic provisions and methods outlined in this Plan, but clean up levels and compliance criteria cannot be finalized until further soil characterization and dose modeling (for ARC) can be completed. It is anticipated that separate reports will be submitted to the NRC as addenda to this Plan that contain the required soil characterization data, any dose modeling, and final status survey plans for each of the aforementioned areas.

1.4 AREAS NOT COVERED BY THE PLAN

Geographic areas *not* covered by the provisions of this Plan are shown in **Figure 1-3**, and include the following:

- Pond 3, which is considered part of the main disposal cell and is covered by those relevant requirements.

- Unaffected areas not impacted by windblown tailings, process solutions, or mining activities (pristine areas). Unaffected areas are located upwind of mill facilities and tailings impoundments, or beyond the area of influence of windblown tailings.
- Areas of surface soil contamination affected by mining activities. Mining operations have impacted significant areas surrounding the site to the west, north and east of the site (**Figure 1-2**). Although remediation of these areas is not covered by the Plan, identification of these areas is addressed in Section 3.4.
- Areas of possible deeper soil contamination containing non-11e.(2) materials impacted by mining operations. These areas include the surface drainages that have received mine water discharge (e.g. Puertocito Creek and Homestake mine drainage).

1.5 ORGANIZATIONAL RESPONSIBILITIES

Radiation surveys, sampling, analysis and data management will be performed by qualified personnel currently employed by RAM or by qualified consulting firms and contract laboratories with well-recognized analytical capabilities.

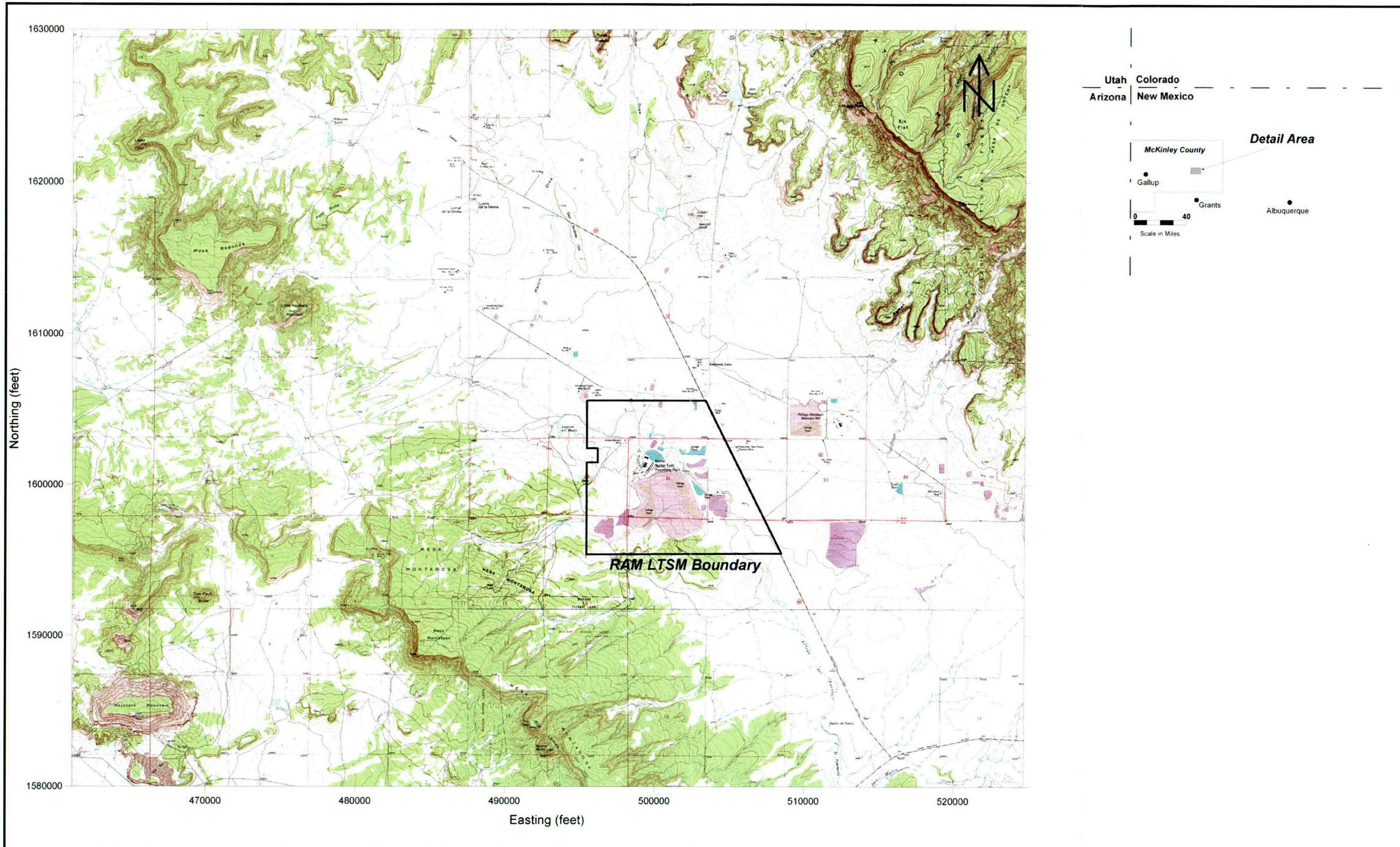
This program operates under the direction of the site Radiation Safety Officer (RSO). The RSO will have the authority to revise field survey plans as deemed necessary as work progresses. Field radiation measurements and/or sampling will be performed by trained RAM personnel or contracted to a consulting firm experienced in radiation surveys and sampling techniques.

Excavation work will be performed under the direction of the facility General Manager. The RSO will coordinate with the General Manager on any excavation work that would be required.

A Quality Assurance program description is provided in Attachment 1. Quality Assurance responsibilities will rest with Manager, Radiation Safety and Environmental Affairs.

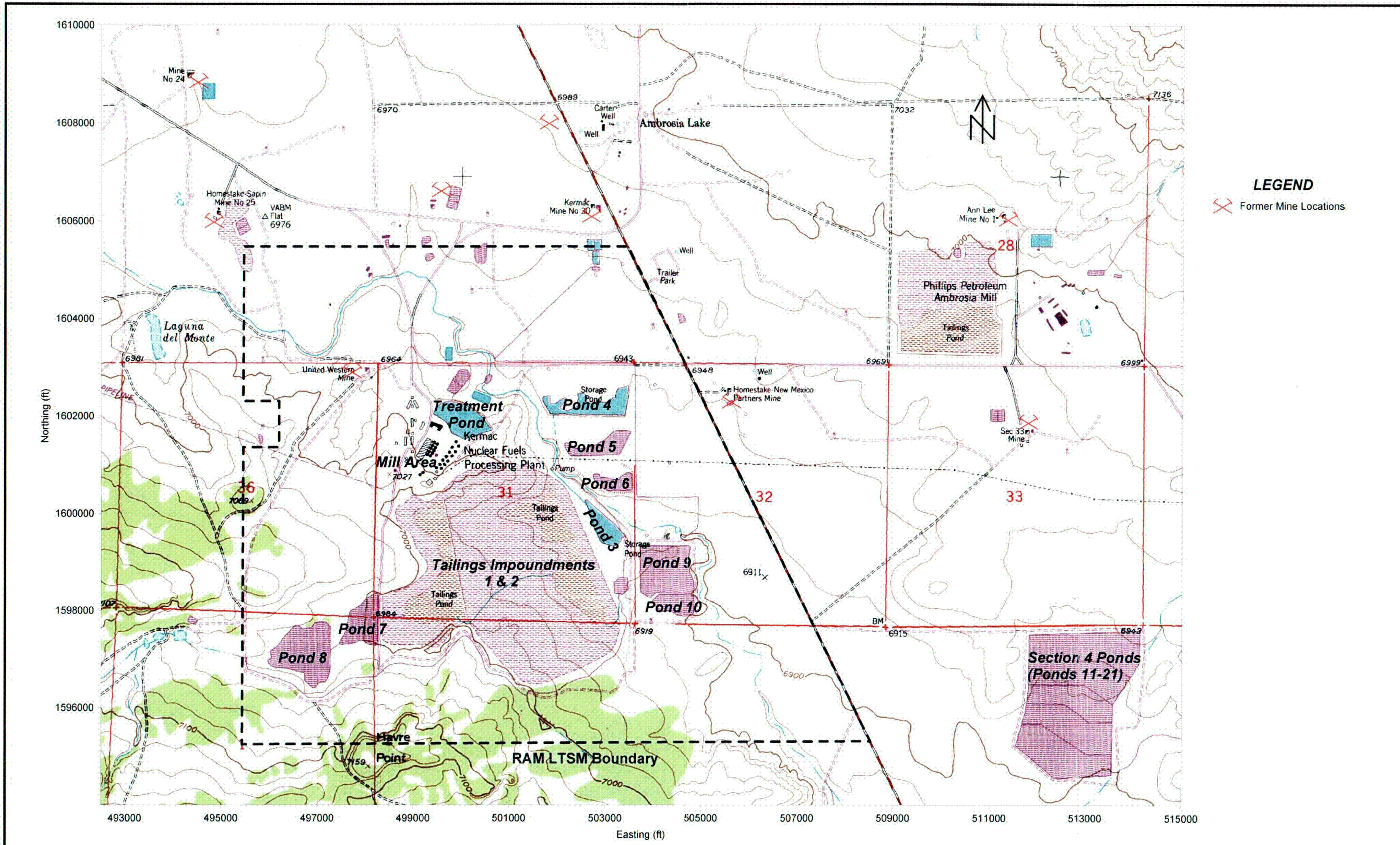
1.6 LOCATION OF RECORDS

Records associated with the Soil Decommissioning Plan are located at the Rio Algom Mining LLC Ambrosia Lake Facility (**Figure 1-1**).



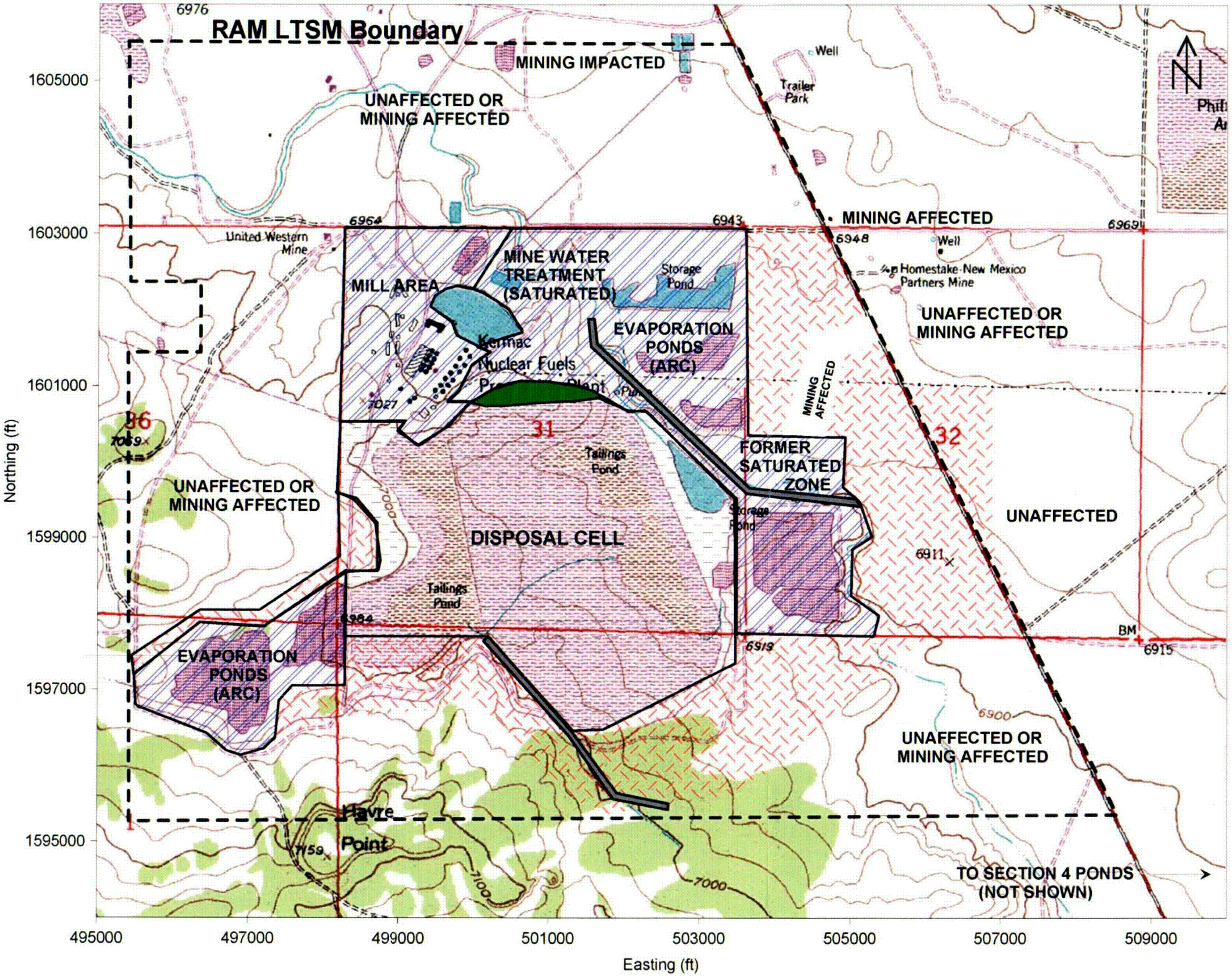
KOMEX	Figure 1-1. Regional Location Map.	Project No: D0295A Date: 11/09/2004 File Name: P:\Ambrosia Soils\NRC Report\Figures\11 x 17.ppt	**FIGURE 1-1**

C01



KOMEX	Figure 1-2. Site and Vicinity Map.	Project No: D0295A Date: 11/09/2004 File Name: P:\Ambrosia Soils\NRC Report\Figures\11 x 17.ppt	FIGURE 1-2

C02



LEGEND

- Areas of Potential Surficial Windblown Contamination
- Areas of Potential Deep Soil Contamination (ARC)
- Disposal Cell
- Rock Armoured Area
- Diversion Channels

Notes:

Areas not included in the Decommissioning Plan include unaffected areas, mining affected areas and drainages, areas that contain non 11e(2) materials, and current operational areas (see text for futher explanation).

The Section 4 Ponds (not shown) are included in the Decommissioning Plan as an area of potential deep soil contamination (ARC).

KOMEX

Figure 1-3. Areas Covered by the Soil Decommissioning Plan.

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Date: 11/09/2004

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FIGURE 1-3

2.0 SITE CONDITIONS

Extensive surface disturbance has occurred throughout the Ambrosia Lake valley due to 40 years of mining and milling activities. Delineation of the surface area affected by licensed activities is necessary to ensure that the contaminated soil clean up effort is appropriate. Site conditions have been evaluated by examining past land uses in the vicinity of the RAM facility, analysis of surface materials to identify potential source of origin, and determination of possible cultural resources in the area of interest.

2.1 RADIONUCLIDES OF CONCERN

The radionuclides of concern (RoCs) are associated with the uranium decay series and are natural uranium, thorium-230, and radium-226. These same radionuclides may also be present in the surrounding area as a result of the extensive uranium mining activities that occurred adjacent to the RAM mill facility. The probable source of the contamination can be attributed to licensed activities or non-licensed activities through evaluation of chemical characteristics unique to the source, including element ratios (Section 3.2).

2.2 DELINATION OF AFFECTED AREA

The affected area is defined as the area affected by licensed activities, including surface contamination from windblown tailings and deeper contamination resulting from the infiltration of mill process solutions. Commencing in 1986, RAM performed extensive gamma surveys and soil sampling for radium-226 in the immediate vicinity of the milling facility in order to delineate the extent of windblown tailings contamination that originated from RAM's facility. These surveys delineated those areas affected by windblown tailings contamination from RAM's facility as being predominately east and north of the facility. This result is as expected, as the prevailing wind direction in the valley is down slope to the north and east.

Based on the results of field gamma surveys and soil sampling data, the area potentially affected by milling operations and covered by the provisions of this Plan (e.g. **Figure 1-3**) is about 740 acres (not including the Section 4 Ponds area which occupy approximately 256 acres). Of this area, about 410 acres are affected by windblown tailings (surface contamination), with approximately 330 acres subject to potential deeper soil contamination and subject to ARC.

Excavation of the affected areas delineated from the surveys was initiated in 1986 and continued through 1999. Those portions of the affected area associated with current licensed

activities will be addressed following cessation of the ground water corrective action plan and will coincide with final site decommissioning activities as authorized by NRC License Condition 40(A)(1). As windblown tailings clean up work has progressed, additional surveying and sampling has been performed to aid in determining the effectiveness of the excavation work.

In 1998, RAM incorporated an improved technique that uses a global positioning system in combination with a ratemeter instrument using a 2-inch sodium iodide detector. The system has been made more efficient by mounting the detector on an All Terrain Vehicle (ATV), and upgrading system software. The improved sensitivity of the new instrumentation and improved data management capabilities over the previous method has resulted in improved data evaluation and control over field clean up operations.

RAM submitted the original Contaminated Soil Clean up Plan in October of 2000. Historical soils characterization data presented in the original Clean up Plan were supplemented by collection and analyses of soil samples from 124 locations in August 2003 through August 2004. The primary purpose of the supplemental soil sampling was to support the development of a reliable gamma guideline value (correlation) and background soil concentrations, and to fill data gaps identified by NRC in the RAI and subsequent public meetings.

2.3 SOILS DATABASE

A Microsoft® Access soils database was developed as a data management tool designed to assist data analysis and improve overall data management. Soils data were input into the database that were received in the form of Excel spreadsheets, site reports, a partial Access database, and analytical laboratory reports received in the form of image files (*.tif) and hard copy. Data were included in the database if information was available regarding the location and date on which the sample was obtained. The original sources of the data (e.g., Excel spreadsheets, laboratory data sheets) are indicated for each analytical record included in the database. After the data were imported into the database, a series of queries were developed to allow data evaluation. The Access soils database, current as of October 2004, is included on a Compact Disk in Appendix A of this Plan.

Soils data included in the database include:

- Field gamma survey data and soil sampling data collected to support the gamma correlation presented in the original Contaminated Soil Clean up Plan,
- Samples collected in areas affected by Homestake Mining Company (HMC) operations,

- Samples collected from background areas by ORISE during a 1999 site visit,
- Samples collected by RAM for background characterization presented in the original Contaminated Soil Clean up Plan,
- Section 32 samples collected after the evaporation Ponds 4, 5, and 6 were covered and the downwind area was remediated,
- Archaeological site soil samples,
- Results for zero to 6-inch samples collected with stratified samples collected from the buffer zone, and
- Recent soil samples and gamma survey data collected from August 2003 to August 2004 to support development of the gamma guideline value (correlation) and background soil concentrations presented in this Plan.

2.4 DELINATION OF SURFACE CONTAMINATION

In April of 2003, RAM initiated a data quality review that included examination of historical soil sampling results collected to support the gamma correlation and background assessments presented the original Contaminated Soil Clean-Up Plan. This review was initiated based on the relatively poor gamma correlation that was developed using these data, and comments received in the RAI from the NRC for the original Contaminated Soils Clean-Up Plan.

Results of the data quality review indicated that, although the historical soil sampling results were of sufficient quality for purposes of site characterization, the data could not be used to develop a reliable gamma guideline value (correlation) or for purposes of background soil concentration development. Historical soil sampling results were shown to display significant and unacceptable variability for samples analyzed by multiple laboratories that were found to use differing analytical procedures and methodologies. Based on the results of the data quality review, RAM initiated a supplemental soil sampling program in August of 2003 designed to improve data quality and thus improve the gamma correlation and background soil concentration development. Approximately 124 sample locations were included in the supplemental sampling program.

Maps were prepared using the supplemental soil sampling data that illustrate the approximate distribution of RoCs including gross gamma, radium-226, thorium-230, uranium-238, and their applicable ratios. These maps are provided in **Figures 2-1 thru 2-10**. The supplemental soil sampling data used to construct the RoC distribution maps are provided in **Table 2-1**. Criteria

Criteria used to differentiate between affected, unaffected, and mining affected areas are described in detail in Section 3.2.

Substantial additional historical soil sampling data is available and is summarized in Table 2-2 and the site soils database (Appendix A). Figure 2-2 shows the site 500 x 500-foot sampling grid with coordinate references used for many of the sample locations listed in Table 2-2.

2.4.1 GAMMA SURVEY

Gamma survey data illustrating the approximate current gross gamma distribution are provided in **Figure 2-1**. In general, the gamma data identify the following distinct geographic areas with specific gamma ranges:

- Low to moderate gamma values in remediated areas and areas not impacted by windblown tailings (background),
- Elevated gamma values in areas north and northeast of the site (across main access roads) impacted by former mining operations not related to RAM,
- Elevated gamma values in unremediated areas (e.g. archaeological sites),
- Elevated gamma values adjacent to remediated areas south and east of the site,
- Elevated gamma values due east of the site and immediately east of the main access road possibly related to RAM windblown tailings, and
- Elevated gamma values in areas identified as having possible deeper soil contamination (e.g. former saturated zones adjacent to Pond 9 prior to trench operation).

2.4.2 GAMMA CORRELATION DATA

As described in Section 2.4.1, 124 grids were sampled between August 2003 and August of 2004 to support the development of the gamma guideline value (correlation) and soil background concentrations. The 10m by 10m grid locations selected for soil sample collection and gamma measurement are shown in **Figure 2-3**, and are tabulated in **Table 2-1**. Samples collected specifically for the purposes of gamma correlation development were selected to ensure a range of gamma measurements and radium-226 concentrations. A map showing the distribution of ATV gamma measurements for these samples are shown in **Figure 2-4**.

2.4.3 RADIUM-226

The distribution of radium-226 is provided in **Figure 2-5.** Areas of elevated radium-226 include mining affected areas and unremediated areas including the Homestake mine drainage.

2.4.4 THORIUM-230

The distribution of thorium-230 is provided in **Figure 2-6.** Elevated thorium-230 is observed in mining-affected areas (e.g., the Homestake mine drainage), and in unremediated windblown-tailings-affected areas.

2.4.5 URANIUM-238

The distribution of uranium-238 is provided in **Figure 2-7.** Elevated uranium-238 is apparent in former mining areas north and northeast of RAM access roads and in the unremediated Homestake mine drainage.

2.4.6 ELEMENT RATIOS

Radium-226/thorium-230 ratio in soils at the site is illustrated in **Figure 2-8.** Ratios calculated for the soils generally occur in two groups, above and below a ratio of approximately 0.4. Areas with radium-226/thorium-230 ratios less than 0.4 are localized in the Homestake mine area (northeast of the main access road) and associated drainage. Samples with ratios higher than 0.4 include windblown areas, mining affected areas, and natural background.

The distribution of radium-226/uranium-238 ratios is illustrated in **Figure 2-9.** The calculated ratios fell into two groups, which can be separated at a value of approximately 4.75. Areas with ratios below about 4.75 represent areas that are mining affected or indicative of natural background conditions. Areas with radium-226/uranium-238 above this value are generally indicative of windblown tailings, although a few mining-affected background samples had ratios above 4.75 (see Section 3.2).

The distribution of thorium-230/uranium-238 is illustrated in **Figure 2-10.** The thorium-230/uranium-238 ratios fell into three populations. Mining affected areas and natural background areas generally have ratios less than 2.5 (the two lowest populations), while windblown-tailings affected areas have ratios generally higher than 1.1 (the two higher populations).

2.5 DELINATION OF DEEPER SOIL CONTAMINATION

The extent of contamination, both horizontal and vertical, must be quantified for each distinct area in order to establish a source term for ARC development (dose assessment). The resulting source term will be a representative (or conservative) concentration of acceptable confidence for each primary radionuclide comprising the residual contamination. The most recently available analytical results for soil samples were compiled for each of the known areas of deep contamination.

Data currently exist for Ponds 4 through 8, and 10 that can be used in the development of the dose assessment and ARC development for these areas. As a conservative measure, maximum concentrations of RoCs observed in soil samples collected from evaporation ponds (Ponds 4 through 8) were used as source terms in the dose modeling.

Soil sampling data is currently lacking to support the dose assessment for the mill area, Pond 9, and the Section 4 Ponds (Ponds 11-21).

2.5.1 PONDS 4, 5, AND 6

Evaporation Ponds 4, 5 and 6 were evaluated individually but reflect a contiguous area of the site that should be considered together for purposes of the dose assessment. The analytical results for soil samples from Ponds 4, 5, and 6 are provided in **Tables 2-3 through 2-8**.

Evaporation Ponds 4, 5 and 6 are each comprised of two units: the soils around the northern edges the ponds (a.k.a. halos) and the soils marking the footprint of the ponds. The halos generally mark an extent of pond liquids or perhaps local windblown material from the ponds. The halos would be expected to exhibit surface contamination. The footprint is assumed to mark the extent of deposition of sediments in the pond. The soils in the footprint would be expected to have higher concentrations of contaminants, and contamination would be expected below the surface soil.

The statistical evaluation of Ponds 4, 5, and 6 halo data reveals quite a bit of variability in soil concentration as shown by the large standard deviation and large confidence interval about the average. However, this variability is predominately caused by samples at locations 4A, 5C, 5D, 6A and 6C. In general, the halo sample locations qualitatively show little or no presence of contamination.

Samples within the footprints of Ponds 4, 5 and 6 indicate contamination to about three feet below the surface of the remaining footprint. The statistical variability of the footprint samples improve substantially when the results indicating non-impacted soil are not included in the statistics.

2.5.2 PONDS 7 AND 8

The analytical results for soil samples from Ponds 7 and 8 are provided in **Tables 2-9 and 2-10.** The statistical evaluation of the sample data from Ponds 7 and 8 reveals a small relative error of the confidence interval about the average; i.e. good precision and accuracy of the average.

2.5.3 POND 9

Currently, no data is available for this area to describe the extent and concentration of contamination.

2.5.4 POND 10

During the previous remediation of Pond 10, a composite soil sample was developed from previously collected soil samples from the Pond 10 area. The analytical results of this composite sample were 6.41, 444, 41.8 pCi/g for Ra-226, Th-230, and U-total, respectively for the 0"-6" sample. The 6"-12" composite sample had 1.12, 66, and 19.9 pCi/g for Ra-226, Th-230, and U-total, respectively.

2.5.5 MILL AREA

Currently, no data is available for this area to describe the extent and concentration of contamination.

2.5.6 SECTION 4 PONDS

Initial characterization data for the Section 4 Ponds area is provided in **Table 2-11** and **Figures 2-11 through 2-15.** Additional soils characterization data will be obtained as the ponds are excavated.

2.6 DELINATION OF UNAFFECTED AND MINING-AFFECTED AREAS

Areas that are not expected to contain radioactive contamination attributable to licensed activities and that have not been impacted by non-11e.(2) mining activities will be classified as unaffected areas (natural background). Unaffected areas are located generally upwind or cross-gradient of the site and possess natural background concentrations of RoCs and gamma radiation levels. Criteria used to differentiate between affected, unaffected, and mining-affected areas are discussed in detail in Section 3.1 (background assessment).

2.7 CULTURAL RESOURCES EVALUATION

Archaeological resources from the Anasazi culture have been identified near the site. Other archaeological resources undoubtedly exist in the area and are susceptible to potential impacts from site reclamation activities. Resources surveys performed in the vicinity of the site have identified sites that are potentially eligible for inclusion on the National Register of Historic Places. These areas are on land owned by the licensee and will be included in the cleanup plan. The locations of all surface artifacts will be determined by land survey and then be removed from the area. The area will be remediated, verified clean, and the artifacts returned to their original location.

Table 2-1. Soils Data for Gamma Correlation and Background Soils Assessment (August 2003 – August 2004)

Location Name	Location Type	Gamma ATV cpm	Gamma Walking cpm	Ra-226 pCi/g	Th-230 pCi/g	U-238 pCi/g
Komex-1	windblown/undisturbed	37601	36702	8.06	11.70	4.48
Komex-2	windblown/undisturbed	42755	42568	7.84	10.40	< 0.98
Komex-3	windblown/undisturbed	36465	35769	3.63	4.78	< 1.88
Komex-4	windblown/undisturbed	40477	39697	7.44	7.52	< 0.68
Komex-5	windblown/undisturbed	44703	43374	8.20	10.30	< 0.06
Komex-6	windblown/undisturbed	43157	42794	7.47	11.30	2.90
Komex-7	windblown/undisturbed	43345	38900	4.98	3.70	< 1.60
Komex-8	windblown/undisturbed	43092	37056	7.74	9.83	3.21
	replicate			8.69	10.30	2.82
	split			7.98	11.70	< 4.04
Komex-9	windblown/undisturbed	51743	44612	4.83	15.80	< 1.60
Komex-10	windblown/undisturbed	43906	39205	9.32	6.67	< 1.12
Komex-11	windblown/undisturbed	43737	39034	5.73	5.21	< 1.48
Komex-12	windblown/undisturbed	45051	40443	7.24	5.31	1.47
	replicate			8.68	6.26	< 1.77
Komex-13	windblown/undisturbed	41722	41075	8.84	14.90	< 2.89
Komex-14	windblown/undisturbed	45862	44209	11.80	16.30	2.22
Komex-15	windblown/undisturbed	44680	44169	10.70	14.60	< 2.29
Komex-16	windblown/undisturbed	52918	49795	9.52	18.70	2.53
	split			10.00	20.40	6.03
Komex-17	windblown/undisturbed	48786	40820	6.30	13.20	< 1.38
Komex-18	windblown/undisturbed	46308	39726	6.12	9.91	< 1.82
Komex-19	windblown/undisturbed	46231	40506	6.38	10.60	2.12
	split			8.57	11.60	< 1.67
Komex-20	windblown/undisturbed	48601	42775	6.33	9.45	3.57
Komex-21	background	11789	11613	0.65	0.688	< 0.61
Komex-22	background	12051	11627	0.76	0.9660	< 1.00
Komex-23	background	11447	11486	0.70	0.882	< 0.57
Komex-24	background	17813	18065	0.90	1.67	2.96
Komex-25	background	17109	17060	1.25	1.66	2.40
Komex-26	background	17915	17645	1.63	2.40	4.88
Komex-27	background	17488	17805	1.13	1.80	1.49
Komex-28	background	18856	18153	1.71	3.40	1.88
Komex-29	background	18400	18027	1.32	2.07	< 1.10
Komex-30	background	17747	17562	1.53	2.21	1.57
Komex-31	background	16605	16487	1.00	2.95	0.76
Komex-32	background	16057	15752	1.35	1.22	1.77
Komex-33	background	18728	18750	1.98	3.29	1.69
	split			1.94	3.00	1.53
Komex-34	background	18992	19386	1.42	3.43	2.10
Komex-35	background	18116	17675	2.28	2.41	2.14
Komex-36	background	18894	18728	1.63	9.75	2.59

Table 2-1. Soils Data for Gamma Correlation and Background Soils Assessment (August 2003 – August 2004)

Location Name	Location Type	Gamma ATV cpm	Gamma Walking cpm	Ra-226 pCi/g	Th-230 pCi/g		U-238 pCi/g
Komex-37	background	19411	18839	1.40	2.66		2.16
Komex-38	background	19016	18953	1.86	2.70		1.68
Komex-39	background	19865	20915	1.57	1.72		1.59
Komex-40	background	18085	19083	1.02	0.92		2.99
	replicate			1.29	1.30		0.94
Komex-41	background	21008	21999	3.57	3.74		3.79
Komex-42	background	22543	23503	4.54	5.18	<	0.90
	split			5.37	4.66	<	2.41
Komex-43	background	18968	19722	2.02	2.70	<	0.87
Komex-44	background	17910	18887	1.62	3.06	<	1.94
Komex-45	background	15811	16024	2.83	3.04	<	0.41
Komex-46	background	16646	16882	2.81	3.50	<	2.30
Komex-47	background	18327	18466	2.11	3.81	<	1.52
Komex-48	background	20079	20214	4.89	4.41	<	1.47
Komex-49	background	20030	20256	3.69	5.11		4.54
Komex-50	background	18502	18434	3.04	3.99	<	1.95
	split			3.50	3.08		1.41
Komex-51	mining	93067	100149	28.20	89.70		19.80
	split			24.70	40.70		19.10
Komex-52	mining	84344	88049	19.80	85.30		16.70
Komex-53	mining	57616	53880	4.34	23.30		7.66
Komex-54	mining	42161	42090	5.27	25.80		12.40
Komex-55	mining	59483	56136	23.80	35.80		16.20
	split			23.30	39.00		17.50
Komex-56	mining	37343	37431	5.54	53.20		3.45
Komex-57	mining	94352	88232	24.90	32.80	<	4.32
Komex-58	mining	54419	53115	6.87	18.60	<	2.80
Komex-59	mining	65307	65842	6.44	17.40		2.94
Komex-60	mining	81113	84019	23.80	60.20		12.60
	replicate			38.70	41.40		10.40
Komex-61	Mining	111381	115077	94.30	149.00		89.80
Komex-62	mining	87068	88273	27.10	62.40		11.30
Komex-63	mining	89606	89827	22.50	41.50		8.93
Komex-64	mining	66270	69484	12.60	38.60		6.61
Komex-65	mining	67600	67996	12.50	19.40		9.57
Komex-66	mining	63041	67090	10.80	24.70		10.80
Komex-67	mining	109414	105547	42.10	77.20		19.20
Komex-68	mining	87241	90062	28.70	29.60		19.30
	split			24.10	26.20		15.30
Komex-69	mining	81430	78451	19.80	29.30		15.20
Komex-70	mining	79024	77895	26.30	40.10		13.40
Komex-71	mining background	36687	35502	2.37	2.87		3.27

Table 2-1. Soils Data for Gamma Correlation and Background Soils Assessment (August 2003 – August 2004)

Location Name	Location Type	Gamma ATV cpm	Gamma Walking cpm	Ra-226 pCi/g	Th-230 pCi/g		U-238 pCi/g
Komex-72	mining background	87144	99589	32.50	23.9		16.40
Komex-73	mining background	44062	46400	11.90	11.4	<	4.72
Komex-74	mining background	24183	22382	4.50	3.95		2.34
Komex-75	mining background	28897	27607	7.72	9.25		6.88
Komex-76	mining background	16862	15812	0.86	1.66		2.67
Komex-77	mining background	14432	13541	0.49	0.889	<	0.83
	split			0.66	0.45	<	0.77
Komex-78	mining background	29577	29740	0.70	0.796		0.99
Komex-79	mining background	30595	31675	2.56	2.23	<	1.56
Komex-80	mining background	26890	25575	2.59	2.49		3.39
Komex-81	mining background	26933	25700	4.35	1.03	<	2.79
Komex-82	mining background	23390	21563	1.10	1.75	<	1.10
Komex-83	mining background	37399	36280	3.36	4.40		2.04
Komex-84	mining background	34720	39636	2.44	2.75		3.40
Komex-85	mining background	59452	59640	1.27	1.79		2.29
Komex-86	mining background	84193	80738	38.80	27.8		27.00
Komex-87	mining background	43827	42544	8.97	10.1		5.01
Komex-88	mining background	57366	55309	5.77	2.39		5.38
Komex-89	mining background	32255	31381	1.44	1.37	<	2.06
Komex-90	mining background	16251	15662	0.55	0.751	<	0.99
Komex-91	mining drainage	50228	46202	12.80	28.3	<	0.56
Komex-92	mining drainage	67661	62946	42.00	36.4		14.50
Komex-93	mining drainage	31660	28371	4.67	13.0		9.48
Komex-94	mining drainage	47608	44544	9.42	24.5	<	0.83
Komex-95	mining drainage	56982	57536	18.90	16.8		5.69
Komex-96	mining drainage	49051	46659	3.45	14.6		3.72
	split			3.25	9.18		3.26
Komex-97	mining drainage	44264	45123	9.11	15.5		6.53
Komex-98	mining drainage	56053	53541	8.84	26.7	<	1.41
Komex-99	mining drainage	41482	38025	9.63	17.5		5.88
Komex-100	mining drainage	69664	68403	99.00	76.0		12.70
Komex-101	mining	77639	73919	4.80	4.41		6.13
Komex-102	mining	56561	57668	7.93	5.53		9.32
Komex-103	mining	86706	85676	33.80	45.20		14.60
Komex-104	mining	130756	149177	96.00	146.00		119.00
Komex-105	mining	71932	739956	7.81	6.65		4.55
Komex-106	mining	66489	68118	21.80	25.50	<	3.33
Komex-107	mining	569568	554967	350.00	505.00		275.00
Komex-108	mining	84810	81812	4.23	5.06		4.21
Komex-109	mining	81792	65974	17.60	27.30		20.00
Komex-110	mining	23175	24420	2.79	3.29		5.33
Komex-111	mining drainage	28188	34835	22.00	11.70		4.86

Table 2-1. Soils Data for Gamma Correlation and Background Soils Assessment (August 2003 – August 2004)

Location Name	Location Type	Gamma ATV cpm	Gamma Walking cpm	Ra-226 pCi/g	Th-230 pCi/g	U-238 pCi/g
Komex-112	windblown/undisturbed	39248	40601	7.02	6.91	< 1.77
Komex-113	windblown/undisturbed	37800	37413	2.97	5.52	< 2.21
Komex-114	windblown/undisturbed	30782	31944	4.21	4.89	< 1.22
Komex-115	windblown/undisturbed	37487	37309	5.90	7.62	4.28
Komex-116	windblown/undisturbed	40498	41191	5.90	12.60	< 1.51
Komex-117	windblown/undisturbed	37773	37803	5.21	11.10	< 1.60
Komex-118	windblown/undisturbed	39796	43754	4.65	8.53	< 0.28
Komex-119	windblown/undisturbed	43294	43135	7.92	12.10	< 1.80
Komex-120	windblown/undisturbed	40989	43015	6.79	7.88	< 2.74
Komex-121	windblown/undisturbed	29948	29929	4.38	4.25	2.87
Komex-122	mining	35330	32260	3.15	5.50	< 0.83
Komex-123	mining	34798	33662	3.01	2.46	< 2.18
Komex-124	mining	67367	64595	10.20	8.60	2.50

Table 2-2. Historical Data For Surface Soils

Location	Sample Date	Walking Gamma cpm	Ra-226 pCi/g	Th-230 pCi/g	Uranium-total pCi/g
32 STRAT#1	5/1/2001		4.64	5.39	1.64
32 STRAT#2	5/1/2001		4.06	4.19	1.16
32 STRAT#3	5/1/2001		2.28	2.08	0.84
AA-10	5/1/2001	22081	2.09	1.77	0.93
AA-11	6/22/2000	35208	2.52	2.06	1.83
AA-11-SE	5/4/2001	28329	3.42	2.82	1.74
AA-12-SE	5/14/2001		14.1	17.6	6.5
AA-13-SE	5/14/2001	32500	3.93	3.69	1.51
AA-14-SE	5/14/2001	32487	3.18	2.87	1.19
AA-15-SE	5/14/2001	32870	4.85	5.71	0.14
AA-16-SE	5/14/2001	33751	6.13	8.36	1.87
AA-9	6/22/2000	23687	1.04	0.9	0.35
AB-11	6/22/2000	28811	0.83	0.64	0.9
AB-11-SE	5/14/2001	24101	3.08	2.56	0.87
AB-12-SE	5/14/2001	29916	4.91	4.9	2.51
AB-13-SE	5/14/2001	27414	4.42	4.41	0.01
AB-9	8/1/2000	22625	2.93	3.67	1.38
Background - section 20	11/10/1999		4.2	6.2	4
Background - section 20	11/10/1999		4.9		
Background - section 20	11/10/1999		4.4		
Background - section 20	11/10/1999		5.1		
Background - section 29	11/10/1999		6.5	10	5
Background - section 29	11/10/1999		7.3		
Background - section 29	11/10/1999		7.1		
Background - section 32	11/10/1999		5	5.8	3.4
Background - section 32	11/10/1999		4.5		
Background - section 32	11/10/1999		4.8		
Buffer - south end	11/10/1999		22.3	14	3.4
Buffer - south end	11/10/1999		16.2	30	4.2
Buffer - south end	11/10/1999		15.4		
Buffer - south end	11/10/1999		13.7		
Buffer - south end	11/10/1999		18.1		
Buffer - south end	11/10/1999		10.6		
Buffer zone - southeast	11/10/1999		13.2	30	5.4
Buffer zone - southeast	11/10/1999		11.2		
Buffer zone - southeast	11/10/1999		14.5		
HMC-3	7/28/1998	41331	41.8	2.8	9.55
HMC-3	7/28/1998	42843	24.4	29.9	9.84
HMC-3	7/28/1998	54590	4.6	32.8	15.8
HMC-5	7/28/1998	57787	10.4	8.5	6.24
Mid Section 1	4/1/1997		1.1	0.82	0.707
Mid Section 1	4/1/1997		0.8		
mid Section Line 1/36	4/1/1997		1.6		
mid Section Line 1/6	4/1/1997		0.7	1.57	0.515

Table 2-2. Historical Data For Surface Soils

Location	Sample Date	Walking Gamma cpm	Ra-226 pCi/g	Th-230 pCi/g	Uranium-total pCi/g
mid Section Line 1/6	4/1/1997		1.2		
mid Section Line 24/25	4/1/1997		2.8		
mid Section Line 25/36	4/1/1997		1.5		
mid Section Line 4/5	4/1/1997		7.5		
mid Section Line 5/6	4/1/1997		5.4		
Q-18	6/22/2000		3.96	5.84	2.57
Q-21	6/22/2000	36944	1.71		
Q-7	6/22/2000	14204	1.73	2.68	0.45
Quarter Section Line 9/16	4/1/1997		2	2.03	2.25
Quarter Section Line 9/16	4/1/1997		3.5		
R-18	6/22/2000		0.8	1.54	1
R-20	6/22/2000		3.02	35.7	2.25
R-21	8/1/2000	35358	4.26	11.1	5.98
R-6	6/22/2000	22914	2.9	0.81	1.03
R-7	6/22/2000	10340	0.28	0.23	0.15
S-18	6/22/2000		1.88	5.7	1.03
S-21	5/1/2001	27956	2.92	6.15	2.51
S-22	6/22/2000	32755	3.77	7.19	5.15
S-7	6/22/2000	12083	0.45	0.4	0.19
S-8	8/1/2000	12915	2.18	3.86	0.74
Section Corner 1/2/11/12	4/1/1997		0.8		
Section Corner 1/2/35/36	4/1/1997		1.8		
Section Corner 12/13/18/7	4/1/1997		1.8		
Section Corner 13/14/23/24	4/1/1997		3.2		
Section Corner 13/18/19/24	4/1/1997		1.5		
Section Corner 14/15/22/23	4/1/1997		20.2		
Section Corner 16/17/20/21	4/1/1997		3.4		
Section Corner 17/18/19/20	4/1/1997		4.3		
Section Corner 19/20/29/30	4/1/1997		9.3		
Section Corner 20/21/28/29	4/1/1997		3.6		
Section Corner 22/23/26/27-U	4/1/1997		10.5	0.88	0.515
Section Corner 22/23/26/27-Y	4/1/1997		2.4		
Section Corner 22/23/26/27-Y	4/1/1997		0.8		
Section Corner 23/24/25/26	4/1/1997		4.4		
Section Corner 24/25/19/30	4/1/1997		3.7	2.09	1.61
Section Corner 24/25/19/30	4/1/1997		2.3		
Section Corner 25/25/35/36	4/1/1997		0.6		
Section Corner 25/25/35/36	4/1/1997		2.1	0.3	0.772
Section Corner 26/27/34/35	4/1/1997		3.7		
Section Corner 3/4/9/10	4/1/1997		1.3		
Section Corner 34/35/2/3	4/1/1997		2.1		
Section Corner 4/5/8/9	4/1/1997		2.2	0.47	0.579
Section Corner 4/5/8/9	4/1/1997		0.7		
Section Corner 5/6/7/8	4/1/1997		1.5		
Section Corner 6/7/1/12	4/1/1997		1.2		

Table 2-2. Historical Data For Surface Soils

Location	Sample Date	Walking Gamma cpm	Ra-226 pCi/g	Th-230 pCi/g	Uranium-total pCi/g
SHPO-1	4/26/2001		16.8	27.4	0.26
SHPO-2-N	4/26/2001		5.72	9.32	1.48
SHPO-2-S	4/26/2001		3.51	11	1.54
T-16-SE	7/25/2001	32140	3.6	61	2.3
T-17-SE	7/25/2001	21965	4	81	2
T-18-SE	7/25/2001	22039	3.1	78	3.2
T-19-SE	7/25/2001	17357	1.6	71	1.8
T-20-SE	7/25/2001	18932	2.3	36	1.2
T-21	6/22/2000	23005	0.76	2.29	0.55
T-21-SE	7/25/2001	16412	0.9	4.1	0.94
T-22	5/1/2001	35172	3.6	10.1	2.28
T-7	8/1/2000	16529	2.69	4.08	0.69
T-8	6/22/2000	18795	2.18	8.89	1.54
U-10	6/22/2000	25161	3.46	5.13	1
U-15	6/22/2000		17	22.7	0.96
U-16	6/22/2000	29165	0.91	3.08	0.77
U-17	7/25/2001	17533	1.3	8.5	4.2
U-18	7/25/2001	14446	0.98	2.4	0.74
U-18-SE	7/25/2001	19267	1.2	5.8	0.8
U-19	7/25/2001	14848	0.77	3.8	0.64
U-19-SE	7/25/2001	14278	0.78	2.2	0.65
U-20	7/25/2001	13811	0.62	1.3	0.64
U-20-SE	7/25/2001	13488	0.82	3.3	0.74
U-21	7/25/2001	13777	0.66	1.7	0.64
U-21-SE	7/25/2001	15834	0.88	3.4	0.87
U-22	6/22/2000	31502	3.13	15.8	1.13
U-6	5/1/2001	25948	2.21	1.27	0.39
U-7	5/1/2001	18459	1.12	0.93	0.29
V-10	6/22/2000	25113	5.03	6.68	0.74
V-15	6/22/2000		0.47	0.84	0.64
V-15	6/22/2000		0.54	1.1	0.74
V-15	6/22/2000		0.34		
V-16	6/22/2000	39364	4.33	12.4	10.6
V-17	8/1/2000	24622	0.97	3.86	0.55
V-18	6/22/2000	20156	0.55	1.01	2.32
V-19	7/25/2001	17070	1.5	9.4	0.94
V-20	7/25/2001	14691	0.95	4.5	0.64
V-21	7/25/2001	17690	1.4	24	1.2
V-7	5/1/2001	31981	2.67	2.02	0.64
V-8	5/1/2001	38081	3.82	2.84	0.71
V-9	6/22/2000	13036	0.48	1.46	0.14
W-10	6/22/2000	19721	1.4	4.49	0.48
W-10	6/22/2000		1.79	5.39	0.58
W-11	6/22/2000		2.23	55.9	0.84
W-15	6/22/2000		3.81	19.7	3.12

Table 2-2. Historical Data For Surface Soils

Location	Sample Date	Walking Gamma cpm	Ra-226 pCi/g	Th-230 pCi/g	Uranium-total pCi/g
W-17	6/22/2000		6.49	4.5	4.95
W-18	8/1/2000		7.06	22.5	6.21
W-19	6/22/2000	25169	1.47	9.03	1.09
W-21	6/22/2000	47754	5.1	13.2	5.24
W-8	5/1/2001	27559	1.82	1.62	0.39
W-9	5/1/2001	23070	2.47	2.13	0.74
X-11	6/22/2000	24662	1.02	0.65	1.03
X-12	8/1/2000	27673	3.61	3.63	1.54
X-12-SE	5/4/2001	21319	1.66	1.26	1.23
X-13	6/22/2000	25057	0.62	0.48	0.61
X-13-SE	5/4/2001	19466	1.07	0.83	0.77
X-14	6/22/2000	23121	0.78	0.51	0.64
X-14-SE	5/4/2001	18083	0.88	0.79	0.43
X-15	6/22/2000	23930	0.54	0.71	0.42
X-15-SE	5/4/2001	23214	1.72	1.48	1.22
X-16	6/22/2000	22205	0.77	1.43	1.09
X-16-SE	5/4/2001	22445	1.82	2.28	1
X-17	6/22/2000	20973	0.69	0.81	0.61
X-17-SE	5/4/2001	27271	2.01	2.27	1.48
X-18-SE	5/14/2001		7.5	17.8	2.99
X-19	6/22/2000		8.7	15.1	22.8
X-9	5/1/2001	28117	2.72	2.11	0.64
Y-10	8/1/2000	22139	2.21	2.1	1.38
Y-11	6/22/2000	25739	1.84	1.67	0.74
Y-11-SE	5/4/2001	19646	1.12	0.75	0.87
Y-12	6/22/2000	24229	3.12	2.73	1.26
Y-12	6/22/2000		1.86		
Y-12-SE	5/4/2001	30633	6.03	5.79	1.53
Y-13	8/1/2000	17782	0.63	0.43	0.35
Y-13-SE	5/4/2001	36793	3.66	3.19	0.84
Y-14	6/22/2000	24752	1.95	2.62	0.87
Y-14-SE	5/4/2001	38182	3.11	3.51	0.81
Y-15	6/22/2000	41148	3.85	5.63	1.32
Y-15-SE	5/4/2001	46061	7.14	8.85	2.6
Y-16-SE	5/14/2001		11.2	14.4	0.19
Y-17	6/22/2000	40763	2.14	4.38	1.35
Y-17-SE	5/14/2001		8.33	12.8	0.01
Y-18-SE	5/14/2001		6.21	13.5	2.22
Z-10	6/22/2000	28072	2.43	2.42	0.84
Z-11	6/22/2000	36407	1.87	1.91	0.96
Z-11-SE	5/4/2001	34437	3.55	3.19	1.38
Z-12	6/22/2000	38998	3.14	3.47	1.12
Z-12-SE	5/4/2001	34687	4.66	4.65	1.32
Z-13-SE	5/4/2001	33160	2.11	2.11	0.72
Z-14-SE	5/14/2001		12.8	12.2	4.92

Table 2-2. Historical Data For Surface Soils

Location	Sample Date	Walking Gamma cpm	Ra-226 pCi/g	Th-230 pCi/g	Uranium-total pCi/g
Z-15	6/22/2000	42899	2.31	2.4	1.48
Z-15-SE	5/14/2001	39039	5.96	7.05	2.35
Z-16-SE	5/14/2001		7.56	11.5	2.44
Z-17-SE	5/14/2001	32528	5.18	7.3	1.48
Z-9	6/22/2001	24702	2.33	1.71	0.87

Table 2-3. Analytical Results of Soil Samples from Perimeter of Evaporation Pond 4.

Sample location	Sample date	Sample depth top (ft)	Sample depth bottom (ft)	Ra-226 (pCi/g)	Th-230 (pCi/g)	U-total (pCi/g)
POND 4 HALO PIT 4A	6/5/2001	0	1	13.3	1590	13
POND 4 HALO PIT 4A	6/5/2001	1	2	3.63	516	51.1
POND 4 HALO PIT 4A	6/5/2001	2	3	0.74	2.95	54
POND 4 HALO PIT 4A	6/5/2001	3	4	0.52	1.97	33.1
POND 4 HALO PIT 4A	6/5/2001	4	5	0.58	2.57	28.5
POND 4 HALO PIT 4B	6/5/2001	0	1	0.43	1.86	2.02
POND 4 HALO PIT 4B	6/5/2001	1	2	0.77	1.22	1.84
POND 4 HALO PIT 4B	6/5/2001	2	3	0.81	1.66	2.42
POND 4 HALO PIT 4B	6/5/2001	3	4	0.59	1.03	0.83
POND 4 HALO PIT 4B	6/5/2001	4	5	0.75	2.24	0.91
POND 4 HALO PIT 4C	6/5/2001	0	1	1.14	2.57	1.06
POND 4 HALO PIT 4C	6/5/2001	1	2	1.23	1.46	1.11
POND 4 HALO PIT 4C	6/5/2001	2	3	0.64	0.71	0.75
POND 4 HALO PIT 4C	6/5/2001	3	4	0.83	0.69	0.67
POND 4 HALO PIT 4C	6/5/2001	4	5	0.74	0.77	0.72
POND 4 HALO PIT 4D	6/5/2001	0	1	0.59	2.45	0.45
POND 4 HALO PIT 4D	6/5/2001	1	2	0.48	0.49	0.29
POND 4 HALO PIT 4D	6/5/2001	2	3	0.41	0.29	0.35
POND 4 HALO PIT 4D	6/5/2001	3	4	0.4	0.32	0.38
POND 4 HALO PIT 4D	6/5/2001	4	5	0.39	0.34	0.37
POND 4 HALO PIT 4E	6/5/2001	0	1	1.97	22.7	3.57
POND 4 HALO PIT 4E	6/5/2001	1	2	0.77	2.71	2.16
POND 4 HALO PIT 4E	6/5/2001	2	3	0.4	0.54	1.68
POND 4 HALO PIT 4E	6/5/2001	3	4	0.52	0.88	1.91
Average				1	90	8
Standard Deviation				3	336	16
Count				24	24	24
Upper 80% Confidence Level (two-tailed)[a]				2	80	13
% error of average at Upper 80% Confidence Level				52	101	51

[a] - Based on September 1986, Revision 0, SW-846 "EPA Test Methods for Evaluating Solid Wastes", Table 9-1, Equation 8

Table 2-4. Analytical Results of Soil Samples from Footprint of Evaporation Pond 4.

Sample location	Sample date	Sample depth top (ft)	Sample depth bottom (ft)	Ra-226 (pCi/g)	Th-230 (pCi/g)	U-total (pCi/g)
POND 4-A	4/18/1997	0	0.5	11	1010	2
POND 4-A	7/1/1997	0.5	1	31	825	35
POND 4-A	11/1/1998	2	2	21	1730	1
POND 4-A	11/1/1998	3	3	12	1040	2
POND 4-A	11/1/1998	4	4	19	1660	6
POND 4-A	11/1/1998	5	5	4	479	2
POND 4-A	11/1/1998	6	6	3	391	3
POND 4-A	11/1/1998	7	7	2	1	68
POND 4-A	11/1/1998	8	8	2	32	5
POND 4-B	4/18/1997	0	0.5	17	1810	2
POND 4-B	7/1/1997	0.5	1	12	1310	2
POND 4-B	7/1/1997	1	1.5	14	1250	1
POND 4-B	7/1/1997	1.5	2	12	1260	2
POND 4-C	4/18/1997	0	0.5	22	2410	3
POND 4-C	7/1/1997	0.5	1	29	2380	7
POND 4-D	4/18/1997	0	0.5	15	1360	30
POND 4-D	7/1/1997	0.5	1	60	3600	12
POND 4-E	4/18/1997	0	0.5	60	3770	27
POND 4-E	7/1/1997	0.5	1	62	3290	9
POND 4-E	7/1/1997	1	1.5	62	4470	13
POND 4-E	7/1/1997	1.5	2	40	2620	49
Average				24	1748	13
Standard Deviation				21	1247	18
Count				21	21	21
Upper 80% Confidence Level (two-tailed)[a]				30	2108	19
% error of average at Upper 80% Confidence Level				25	21	39

[a] - Based on September 1986, Revision 0, SW-846 "EPA Test Methods for Evaluating Solid Wastes", Table 9-1, Equation 8

Table 2-5. Analytical Results of Soil Samples from Perimeter of Evaporation Pond 5.

Sample location	Sample date	Sample depth top (ft)	Sample depth bottom (ft)	Ra-226 (pCi/g)	Th-230 (pCi/g)	U-total (pCi/g)
POND 5 HALO PIT 5A	6/5/200	0	1	0.58	2.38	0.43
POND 5 HALO PIT 5A	6/5/200	1	2	0.35	0.64	0.44
POND 5 HALO PIT 5A	6/5/200	2	3	0.61	0.76	0.52
POND 5 HALO PIT 5A	6/5/200	3	4	0.92	1.25	0.97
POND 5 HALO PIT 5A	6/5/200	4	5	1.13	3.55	1.49
POND 5 HALO PIT 5B	6/5/200	0	3	1.04	7.58	0.91
POND 5 HALO PIT 5B	6/5/200	1	2	0.48	1.38	0.83
POND 5 HALO PIT 5B	6/5/200	2	3	0.38	0.4	1.78
POND 5 HALO PIT 5B	6/5/200	3	4	0.47	4.81	2.26
POND 5 HALO PIT 5B	6/5/200	4	5	0.46	1.11	1.14
POND 5 HALO PIT 5C	6/5/200	0	1	7.45	365	5.98
POND 5 HALO PIT 5C	6/5/200	1	2	0.79	3.56	1.41
POND 5 HALO PIT 5C	6/5/200	2	3	0.79	2.08	2.78
POND 5 HALO PIT 5C	6/5/200	3	4	0.48	0.58	5.18
POND 5 HALO PIT 5C	6/5/200	4	5	0.3	0.35	3.11
POND 5 HALO PIT 5D	6/5/200	0	1	6.19	65.9	2.58
POND 5 HALO PIT 5D	6/5/200	1	2	8.12	371	7.85
POND 5 HALO PIT 5D	6/5/200	2	3	1.3	17.7	1.22
POND 5 HALO PIT 5D	6/5/200	3	4	1.17	1.62	1.16
POND 5 HALO PIT 5D	6/5/200	4	5	1.03	1.13	1.29
Average				2	43	2
Standard Deviation				2	112	2
Count				20	20	20
Upper 80% Confidence Level (two-tailed)[a]				2	76	3
% error of average at Upper 80% Confidence Level				42	78	27

[a] - Based on September 1986, Revision 0, SW-846 "EPA Test Methods for Evaluating Solid Wastes", Table 9-1, Equation 8

Table 2-6. Analytical Results of Soil Samples from Footprint of Evaporation Pond 5

Sample location	Sample date	Sample depth top (ft)	Sample depth bottom (ft)	Ra-226 (pCi/g)	Th-230 (pCi/g)	U-total (pCi/g)
POND 5-A	4/18/1997	0	0.5	22	1660	7
POND 5-A	7/1/1997	0.5	1	14	612	2
POND 5-A	7/1/1997	1	1.5	29	1490	3
POND 5-A	7/1/1997	1.5	2	20	1050	3
POND 5-A	11/1/1998	3	3	52	1730	1
POND 5-A	11/1/1998	4	4	20	709	1
POND 5-A	11/1/1998	5	5	27	2330	24
POND 5-B	4/18/1997	0	0.5	28	1750	3
POND 5-B	7/1/1997	0.5	1	14	720	2
POND 5-C	4/18/1997	0	0.5	5	340	43
POND 5-C	7/1/1997	0.5	1	7	618	43
POND 5-D	4/18/1997	0	0.5	20	899	1
POND 5-D	7/1/1997	0.5	1	6	386	7
POND 5-D	7/1/1997	1	1.5	4	324	6
POND 5-D	7/1/1997	1.5	2	7	768	6
POND 5-D	11/1/1998	3	3	17	918	2
POND 5-D	11/1/1998	4	4	8	677	19
POND 5-D	11/1/1998	5	5	8	680	5
POND 5-D	11/1/1998	6	6	5	632	2
POND 5-D	11/1/1998	7	7	8	976	4
POND 5-D	11/1/1998	8	8	8	784	6
POND 5-E	4/18/1997	0	0.5	14	1200	6
POND 5-E	7/1/1997	0.5	1	20	2780	12
Average				16	1045	9
Standard Deviation				11	636	12
Count				23	23	23
Upper 80% Confidence Level (two-tailed)[a]				19	1220	12
% error of average at Upper 80% Confidence Level				19	17	37

[a] - Based on September 1986, Revision 0, SW-846 "EPA Test Methods for Evaluating Solid Wastes", Table 9-1, Equation 8

Table 2-7. Analytical Results of Soil Samples from Perimeter of Evaporation Pond 6.

Sample location	Sample date	Sample depth top (ft)	Sample depth bottom (ft)	Ra-226 (pCi/g)	Th-230 (pCi/g)	U-total (pCi/g)
POND 6 HALO PIT 6A	6/5/2001	0	1	1.66	3.35	1.34
POND 6 HALO PIT 6A	6/5/2001	1	2	0.77	1.23	3.1
POND 6 HALO PIT 6A	6/5/2001	2	3	9.4	966	14.6
POND 6 HALO PIT 6A	6/5/2001	3	4	9.81	631	4.86
POND 6 HALO PIT 6A	6/5/2001	4	5	4.31	705	44.1
POND 6 HALO PIT 6B	6/5/2001	0	1	2.39	12.6	5.15
POND 6 HALO PIT 6B	6/5/2001	1	2	1.36	2.43	1.2
POND 6 HALO PIT 6B	6/5/2001	2	3	1.06	2.39	1.05
POND 6 HALO PIT 6B	6/5/2001	3	4	1.07	1.4	1.01
POND 6 HALO PIT 6B	6/5/2001	4	5	0.91	0.86	1.08
POND 6 HALO PIT 6C	6/5/2001	0	1	10.7	131	2.46
POND 6 HALO PIT 6C	6/5/2001	1	2	0.95	3.94	1.05
POND 6 HALO PIT 6C	6/5/2001	2	3	0.8	1.89	0.71
POND 6 HALO PIT 6C	6/5/2001	3	4	0.61	1.27	0.68
POND 6 HALO PIT 6C	6/5/2001	4	5	0.46	3.23	0.64
Average				3	165	6
Standard Deviation				4	321	11
Count				15	15	15
Upper 80% Confidence Level (two-tailed)[a]				4	276	9
% error of average at Upper 80% Confidence Level				42	68	71

[a] - Based on September 1986, Revision 0, SW-846 "EPA Test Methods for Evaluating Solid Wastes", Table 9-1, Equation 8

Table 2-8. Analytical Results of Soil Samples from Footprint of Evaporation Pond 6

Sample location	Sample date	Sample depth top (ft)	Sample depth bottom (ft)	Ra-226 (pCi/g)	Th-230 (pCi/g)	U-total (pCi/g)
POND 6 TEST HOLE #1	7/14/1999	0	0	17.1	1130	16.4
POND 6 TEST HOLE #1	7/14/1999	0	6	4.55	279	13.5
POND 6 TEST HOLE #1	7/14/1999	1	1	1.57	22.5	48.7
POND 6 TEST HOLE #1	7/14/1999	2	2	1.61	2.44	1.67
POND 6 TEST HOLE #1	7/14/1999	3	3	1.69	2.22	1.45
POND 6 TEST HOLE #1	7/14/1999	4	4	1.67	0.93	1.25
POND 6 TEST HOLE #1	7/14/1999	6	6	1.25	32.2	5.4
POND 6 TEST HOLE #2	7/14/1999	0	0	27.1	1920	27.6
POND 6 TEST HOLE #2	7/14/1999	0	6	10.3	959	21.1
POND 6 TEST HOLE #2	7/14/1999	1	1	12.3	990	45.8
POND 6 TEST HOLE #2	7/14/1999	2	2	13.3	457	27.8
POND 6 TEST HOLE #2	7/14/1999	3	3	1.22	12.9	2.25
POND 6 TEST HOLE #2	7/14/1999	4	4	0.98	0.92	1.38
POND 6 TEST HOLE #3	7/14/1999	0	0	26.1	1640	10.7
POND 6 TEST HOLE #3	7/14/1999	0	6	7.05	579	20.7
POND 6 TEST HOLE #3	7/14/1999	1	1	11.7	853	8.2
POND 6 TEST HOLE #3	7/14/1999	2	2	14.1	1040	25.3
POND 6 TEST HOLE #3	7/14/1999	3	3	1.22	64	24.8
POND 6 TEST HOLE #3	7/14/1999	4	4	0.81	1.7	50.9
POND 6 TEST HOLE #3	7/14/1999	6	6	0.64	1.4	26.4
Average				8	499	19
Standard Deviation				8	607	16
Count				20	20	20
Upper 80% Confidence Level (two-tailed)[a]				10	680	24
% error of average at Upper 80% Confidence Level				32	36	25

[a] - Based on September 1986, Revision 0, SW-846 "EPA Test Methods for Evaluating Solid Wastes", Table 9-1, Equation 8

Table 2-9. Analytical Results of Soil Samples from Evaporation Pond 7.

Sample location	Sample date	Sample depth top (ft)	Sample depth bottom (ft)	Ra-226 (pCi/g)	Th-230 (pCi/g)	U-total (pCi/g)
POND 7 TEST HOLE #1	6/1/1999	1	1	4.74	297	10.2
POND 7 TEST HOLE #1	6/1/1999	2	2	5.03	366	8.84
POND 7 TEST HOLE #1	6/1/1999	3	3	2.01	151	5.11
POND 7 TEST HOLE #1	6/1/1999	4	4	4.63	366	4.76
POND 7 TEST HOLE #1	6/1/1999	5	5	2.81	226	10.3
POND 7 TEST HOLE #1	6/1/1999	6	6	0.83	7.32	3.67
POND 7 TEST HOLE #1	6/1/1999	7	7	3.27	199	7.4
POND 7 TEST HOLE #1	6/1/1999	8	8	0.86	9.88	10.2
POND 7 TEST HOLE #2	6/1/1999	1	1	9.65	312	2.03
POND 7 TEST HOLE #2	6/1/1999	3	3	1.14	22.8	8.73
POND 7 TEST HOLE #2	6/1/1999	4	4	6.83	562	7.72
POND 7 TEST HOLE #2	6/1/1999	5	5	1.16	54.9	10.4
POND 7 TEST HOLE #2	6/1/1999	6	6	10.1	565	8.1
POND 7 TEST HOLE #2	6/1/1999	7	7	1.27	158	4.34
POND 7 TEST HOLE #3	6/1/1999	1	1	5.52	924	2.15
POND 7 TEST HOLE #3	6/1/1999	2	2	11.6	1000	7.85
POND 7 TEST HOLE #3	6/1/1999	3	3	9.13	685	3.28
POND 7 TEST HOLE #3	6/1/1999	4	4	7.09	560	3.12
POND 7 TEST HOLE #3	6/1/1999	5	5	2.63	34.8	0.87
POND 7 TEST HOLE #3	6/1/1999	6	6	0.76	13	14.7
POND 7 TEST HOLE #3	6/1/1999	7	7	2.8	141	2.64
POND 7 TEST HOLE #3	6/1/1999	8	8	0.63	0.07	4.44
POND 7 TEST HOLE #3	6/1/1999	10	10	2.15	95.1	4.66
POND 7 TEST HOLE #4	6/1/1999	1	1	4.28	255	3.92
POND 7 TEST HOLE #4	6/1/1999	2	2	0.65	72.8	1.87
POND 7 TEST HOLE #4	6/1/1999	3	3	0.91	7.49	8.17
POND 7 TEST HOLE #4	6/1/1999	4	4	0.5	10	4.08
POND 7 TEST HOLE #4	6/1/1999	5	5	2.69	334	22.5
POND 7 TEST HOLE #4	6/1/1999	6	6	1.25	21.2	17.2
POND 7 TEST HOLE #5	6/1/1999	1	1	7.94	639	7.33
POND 7 TEST HOLE #5	6/1/1999	2	2	2.34	37.1	1.03
POND 7 TEST HOLE #5	6/1/1999	3	3	1.03	28.6	4.34
POND 7 TEST HOLE #5	6/1/1999	4	4	14	292	3.44
POND 7 TEST HOLE #5	6/1/1999	5	5	18.6	850	6.66
POND 7 TEST HOLE #6	6/1/1999	1	1	1.75	24.9	0.87
POND 7 TEST HOLE #6	6/1/1999	2	2	0.89	59.3	3.47
POND 7 TEST HOLE #6	6/1/1999	3	3	0.53	10.1	3.7
POND 7 TEST HOLE #6	6/1/1999	4	4	0.47	17.8	4.31
POND 7 TEST HOLE #6	6/1/1999	5	5	11.5	1030	6.3
POND 7 TEST HOLE #6	6/1/1999	6	6	9.24	925	10.2
POND 7 TEST HOLE #6	6/1/1999	7	7	0.56	9.54	14.6
POND 7 TEST HOLE #6	6/1/1999	8	8	2.19	238	5.6
POND 7 TEST HOLE #6	6/1/1999	10	10	5.1	448	14.8
Average				4	280	7
Standard Deviation				4	312	5
Count				43	43	43
Upper 80% Confidence Level (two-tailed)				5	343	8
% error of average at Upper 80% Confidence Level				20	22	14

[a] - Based on September 1986, Revision 0, SW-846 "EPA Test Methods for Evaluating Solid Wastes", Table 9-1, Equation 8

Table 2-10. Analytical Results of Soil Samples from Evaporation Pond 8.

Sample location	Sample date	Sample depth top (ft)	Sample depth bottom (ft)	Ra-226 (pCi/g)	Th-230 (pCi/g)	U-total (pCi/g)
POND 8 PIT A	6/1/2001	0	1	60.3	1160	2.16
POND 8 PIT A	6/1/2001	1	2	78.2	2070	2.58
POND 8 PIT A	6/1/2001	2	3	32.6	918	1.29
POND 8 PIT A	6/1/2001	3	4	28.3	1020	1.56
POND 8 PIT A	6/1/2001	4	5	20.8	580	1.56
POND 8 PIT B	6/1/2001	0	1	39.3	1450	1.06
POND 8 PIT B	6/1/2001	1	2	26.6	1040	1.76
POND 8 PIT B	6/1/2001	2	3	39	1720	3.6
POND 8 PIT B	6/1/2001	3	4	21.7	1010	3.11
POND 8 PIT B	6/1/2001	4	5	16.1	717	2.86
POND 8 PIT C	6/1/2001	0	1	12.2	613	7.04
POND 8 PIT C	6/1/2001	1	2	32.6	677	3.19
POND 8 PIT C	6/1/2001	2	3	25.4	441	2.29
POND 8 PIT C	6/1/2001	3	4	18	362	2.05
POND 8 PIT C	6/1/2001	4	5	34.7	628	2.84
POND 8 PIT D	6/1/2001	0	1	22.9	149	2.16
POND 8 PIT D	6/1/2001	1	2	27.1	822	3.04
POND 8 PIT D	6/1/2001	2	3	9.16	456	2.17
POND 8 PIT D	6/1/2001	3	4	10.8	832	5.08
POND 8 PIT D	6/1/2001	4	5	6.79	622	3.7
POND 8 PIT E	6/1/2001	0	1	25.6	353	2.59
POND 8 PIT E	6/1/2001	1	2	27	719	1.65
POND 8 PIT E	6/1/2001	2	3	29.4	1030	2.07
POND 8 PIT E	6/1/2001	3	4	14.2	603	2.68
POND 8 PIT E	6/1/2001	4	5	9.85	632	2.05
Average				27	825	3
Standard Deviation				16	434	1
Count				25	25	25
Upper 80% Confidence Level (two-tailed)[a]				31	939	3
% error of average at Upper 80% Confidence Level				16	14	13

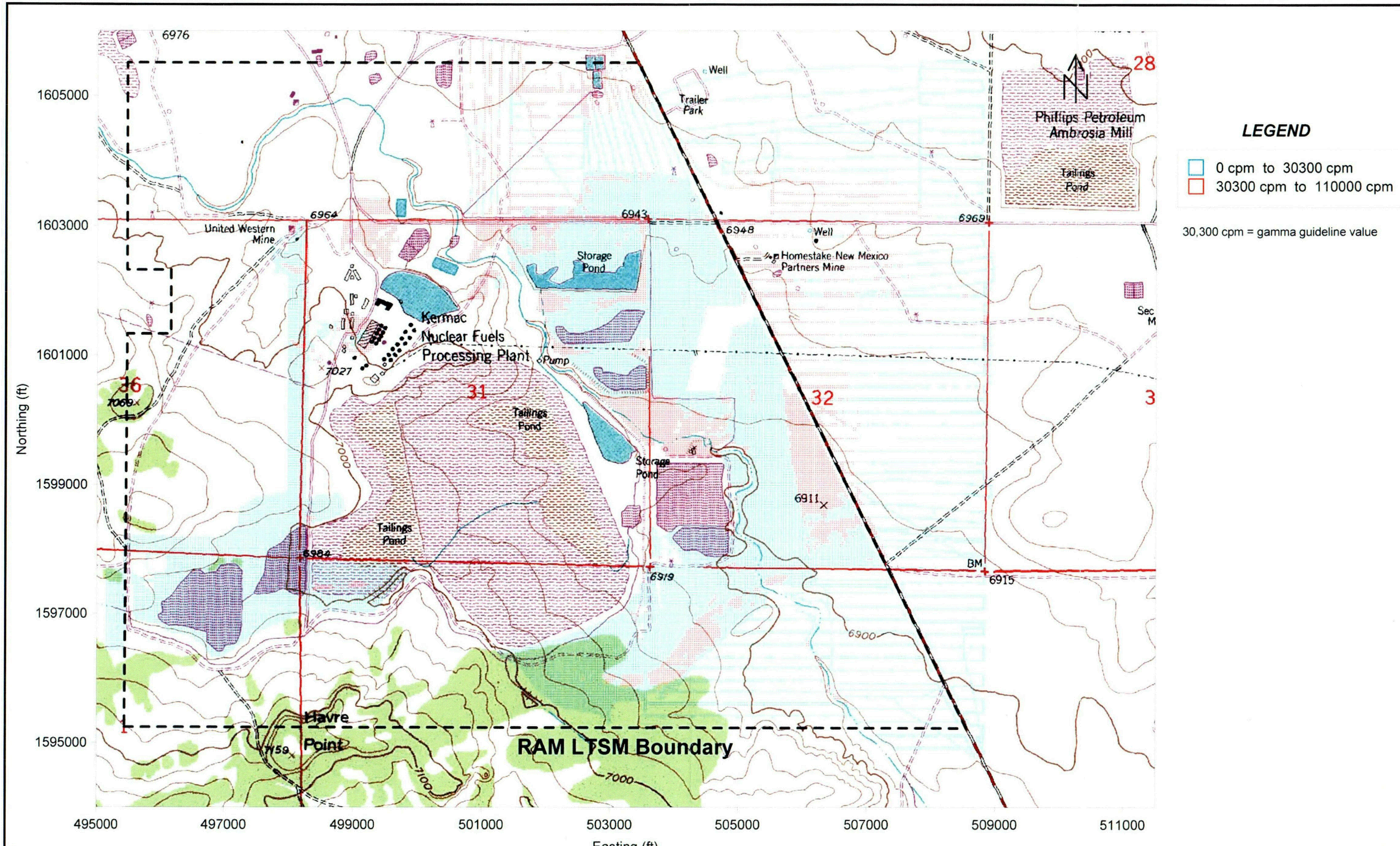
[a] - Based on September 1986, Revision 0, SW-846 "EPA Test Methods for Evaluating Solid Wastes", Table 9-1, Equation 8

Table 2-11. Historical Data for Section 4 Pond Area Mine Drainages

Location	Sample Depth inches	Ra-226 pCi/g	Th-230 pCi/g	Uranium-total pCi/g
Sec 4-1	0" - 6"	2.2	2.2	43.1
Sec 4-1-2	6" - 12"	3.2	6.1	28.0
Sec 4-1-3	12" - 18"	1.8	2.0	46.5
Sec 4-2	0" - 6"	14.0	16.0	350.7
Sec 4-3	0" - 6"	4.9	2.6	42.0
Sec 4-3-1	6" - 12"	7.3	4.8	64.2
Sec 4-4	0" - 6"	8.4	4.0	26.4
Sec 4-5	0" - 6"	10.0	4.2	31.7
Sec 4-5-1	6" - 12"	29.0	24.0	49.6
Sec 4-6	0" - 6"	25.0	9.5	38.3
Sec 4-7	0" - 6"	19.0	11.0	37.2
Sec 4-7-1	6" - 12"	93.0	44.0	54.9
Sec 4-8	0" - 6"	6.2	41.0	2.5
Sec 4-9	0" - 6"	57.0	28.0	20.4
Sec 4-9-1	6" - 12"	41.0	27.0	15.0
Sec 4-10	0" - 6"	4.6	2.8	11.7
Sec 4-11	0" - 6"	24.0	5.1	17.3
Sec 4-11-1	6" - 12"	31.0	7.0	12.9
Sec 4-12	0" - 6"	54.0	8.6	19.4
Sec 4-13	0" - 6"	99.0	9.8	9.8
Sec 4-13-1	6" - 12"	95.0	11.0	6.0
Sec 4-13-2	12" - 18"	94.0	5.9	14.4
Sec 4-13-3	18" - 24"	9.3	1.2	13.9
Sec 4-14	0" - 6"	4.4	3.8	2.7
Sec 4-15	0" - 6"	3.9	3.2	1.2
Sec 4-16	0" - 6"	1.1	0.9	0.7
Sec 4-17	0" - 6"	1.6	1.3	1.2
Sec 4-18	0" - 6"	1.3	1.2	0.9
Sec 4-19	0" - 6"	7.2	6.7	3.2
Sec 4-20	0" - 6"	2.8	2.3	4.6
Sec 4-21	0" - 6"	3.1	1.6	10.4
Sec 4-22	0" - 6"	27.0	15.0	25.6
Sec 4-23	0" - 6"	0.9	0.7	1.7
Sec 4-24	0" - 6"	5.7	4.5	4.4
Sec 4-25	0" - 6"	1.2	0.9	1.8
Sec 4-26	0" - 6"	2.5	2.2	1.3
Sec 4-27	0" - 6"	4.0	2.3	1.1
Sec 4-28	0" - 6"	59.0	12.0	29.4
Sec 4-29	0" - 6"	84.0	16.0	47.3
Sec 4-30	0" - 6"	14.0	4.6	7.7
Sec 4-31	0" - 6"	4.6	2.3	75.1
Sec 4-32	0" - 6"	9.2	37.0	55.4

Table 2-11. Historical Data for Section 4 Pond Area Mine Drainages

Location	Sample Depth inches	Ra-226 pCi/g	Th-230 pCi/g	Uranium-total pCi/g
Sec 4-33	0" - 6"	2.8	1.1	24.7
Sec 4-34	0" - 6"	6.1	1.7	71.8
Sec 4-35	0" - 6"	2.2	1.9	3.8



KOMEX

Figure 2-1. Gross Gamma Distribution (Walkover and ATV Driveover).

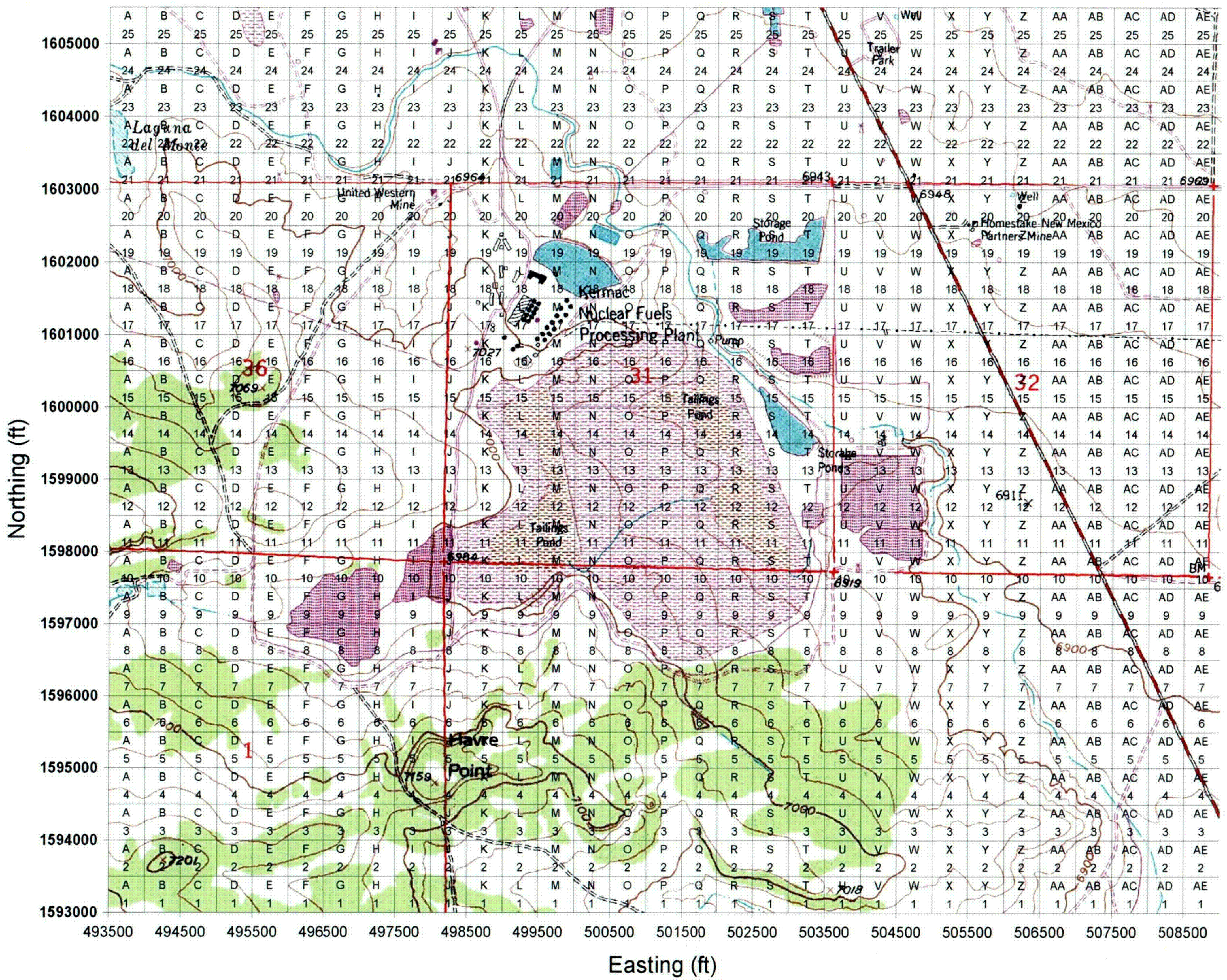
Project No: D0295A

Date: 11/09/2004

File Name: P:\Ambrosia Soils\NRC Report\Figures\11 x 17.ppt

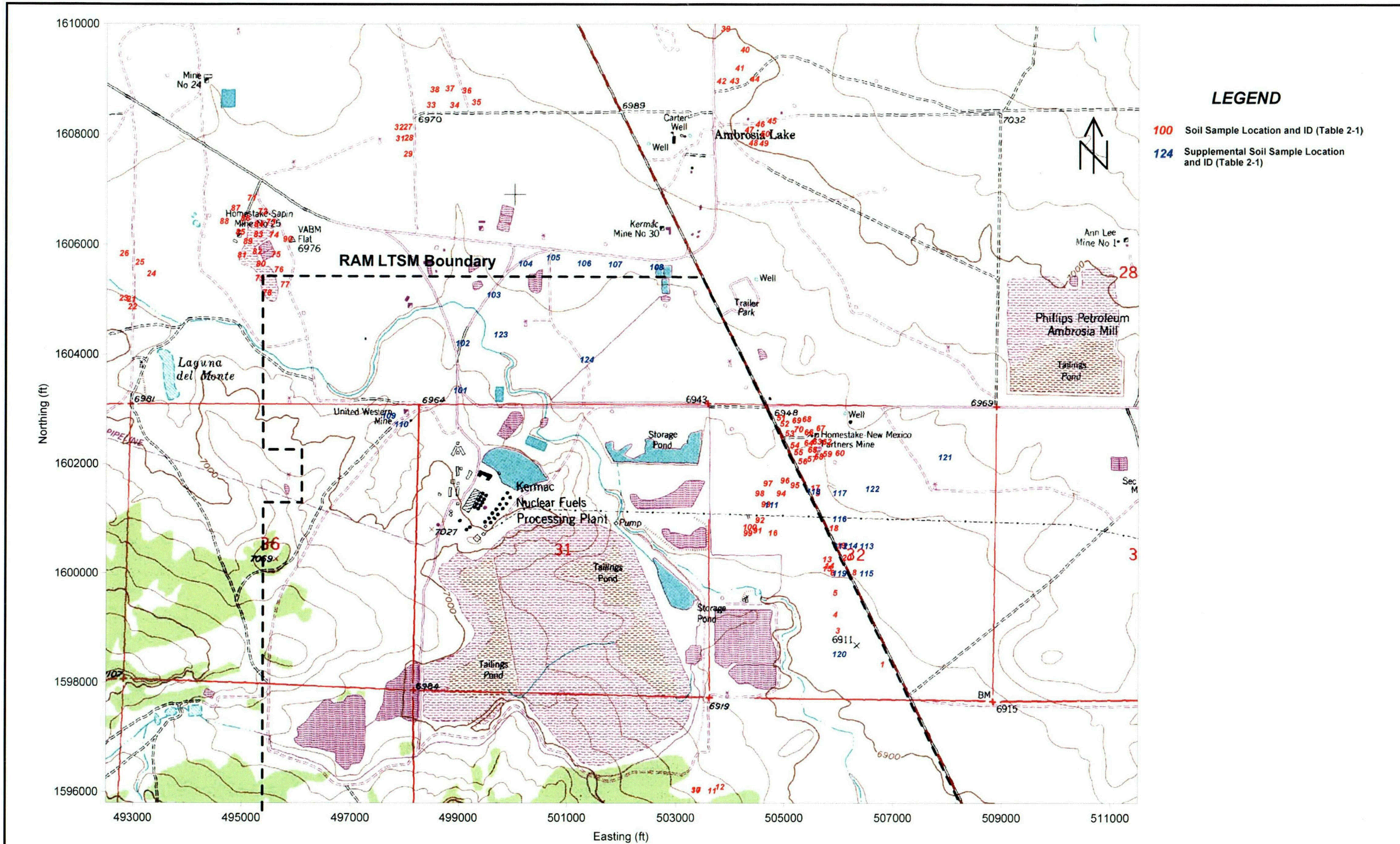
FIGURE 2-1

C04



KOMEX	Figure 2-2. Site 500 x 500-foot sampling grid.	Project No: D0295A Date: 11/09/2004 File Name: P:\Ambrosia Soils\NRC Report\Figures\11 x 17.ppt	FIGURE 2-2

C05



KOMEX

Figure 2-3. Location of Samples Used to Support Gamma Correlation and Background Development.

Project No: D0295A

Date: 11/09/2004

File Name: P:\Ambrosia Soils\NRC Report\Figures\11 x 17.ppt

FIGURE 2-3

C06

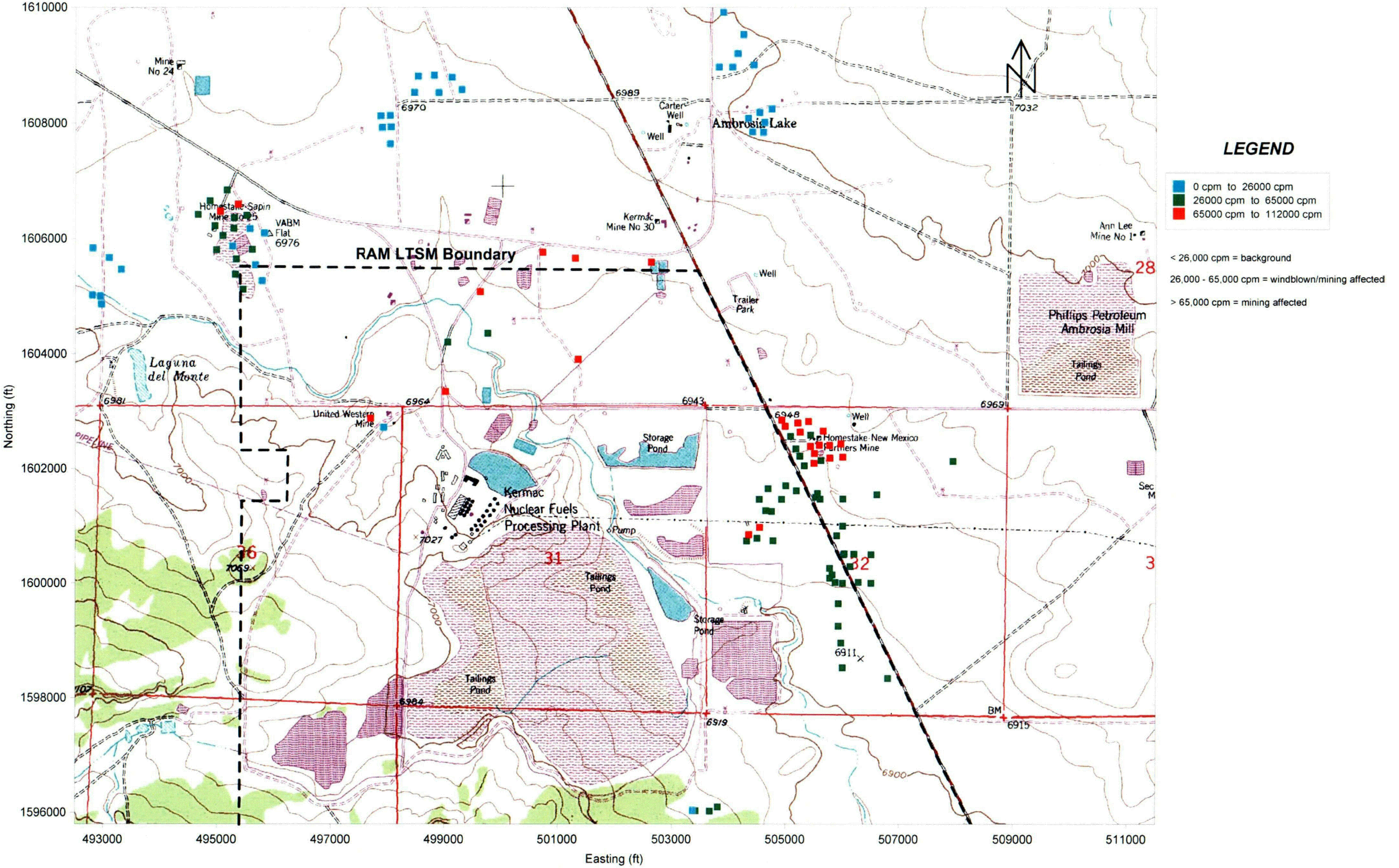
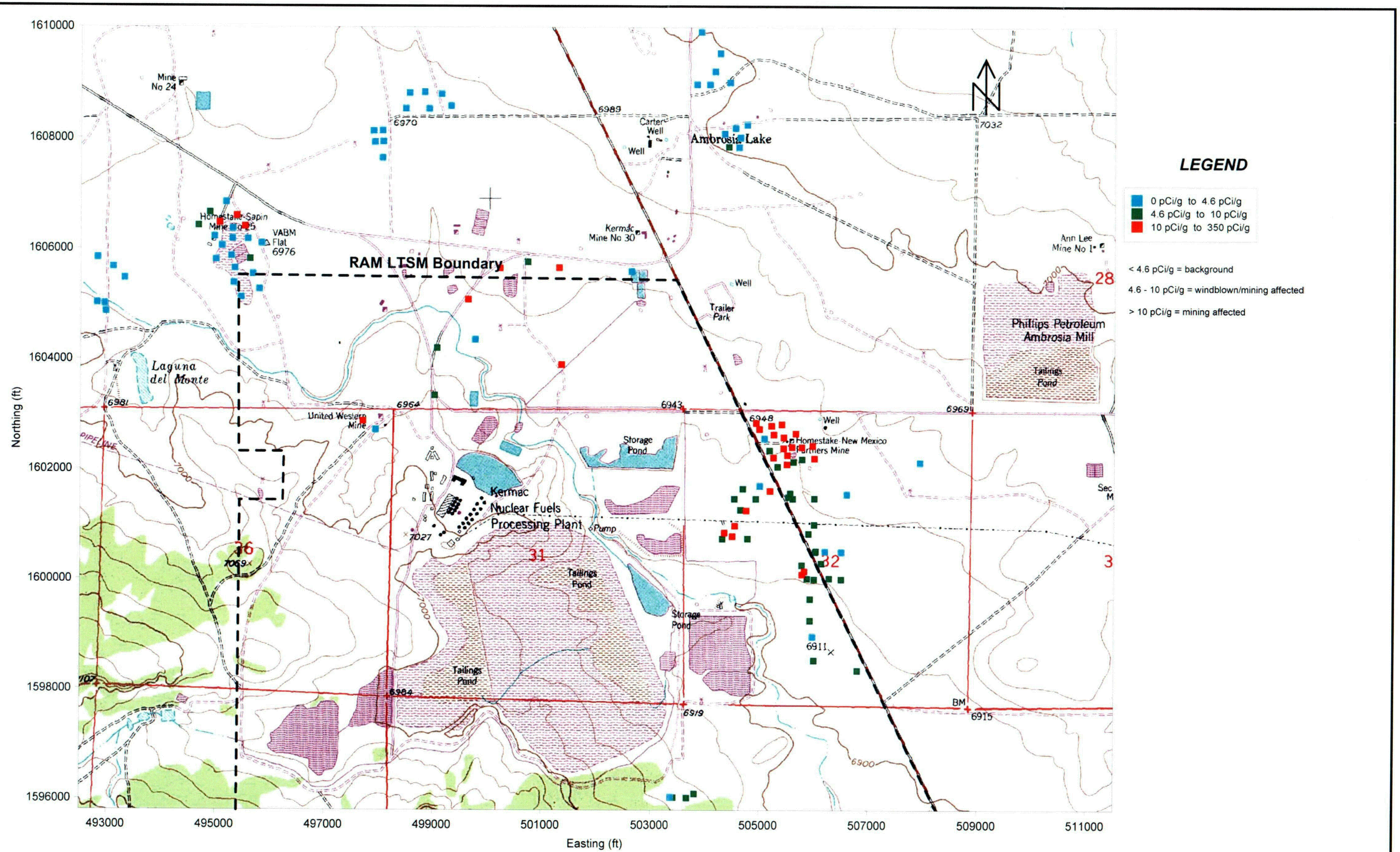


	Figure 2-4. Gamma Distribution in Soil Samples Collected to Support Gamma Correlation and Background Development	Project No: D0295A Date: 11/09/2004 File Name: P:\Ambrosia Soils\NRC Report\Figures\11 x 17.ppt	FIGURE 2-4

KOMEX

C07



KOMEX

Figure 2-5. Radium-226 Distribution in Soil Samples Collected to Support Gamma Correlation and Background Development

Project No: D0295A

Date: 11/09/2004

File Name: P:\Ambrosia Soils\NRC Report\Figures\11 x 17.ppt

FIGURE 2-5

C08

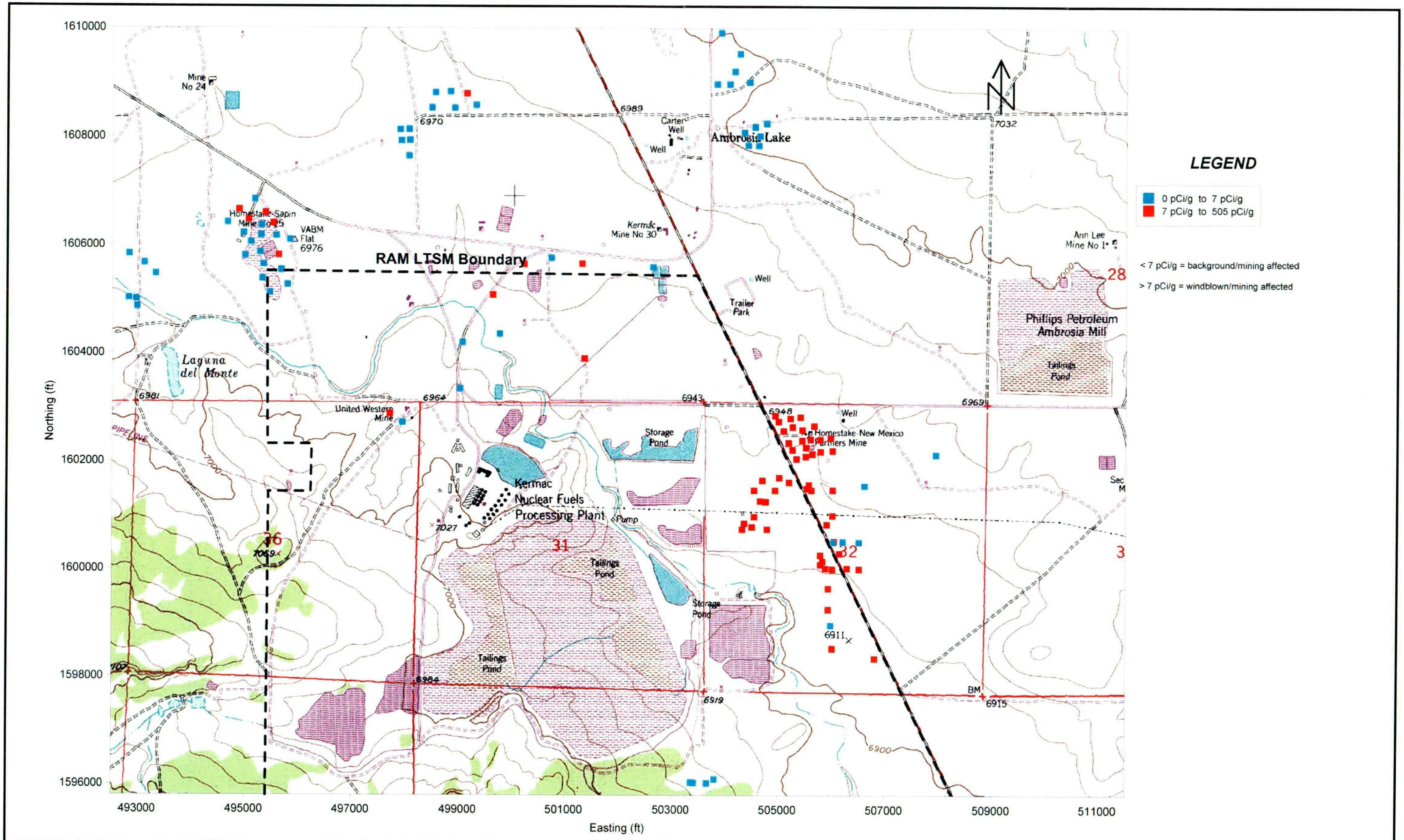


Figure 2-6. Thorium-230 Distribution in Soil Samples Collected to Support Gamma Correlation and Background Development

KOMEX

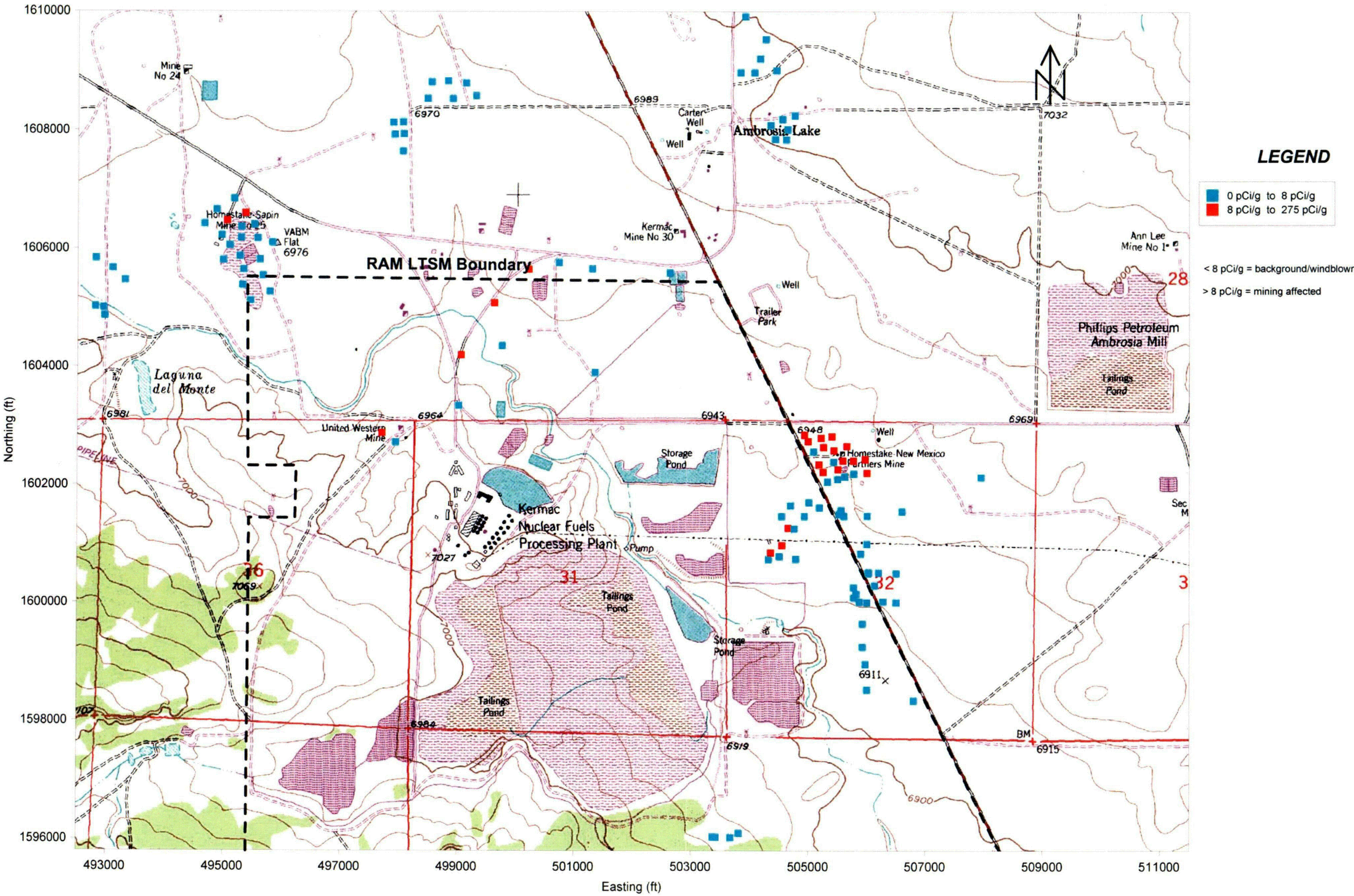
Project No: D0295A

Date: 11/09/2004

File Name: P:\Ambrosia Soils\NRC Report\Figures\11 x 17.ppt

FIGURE 2-6

C09



KOMEX

Figure 2-7. Uranium-238 Distribution in Soil Samples Collected to Support Gamma Correlation and Background Development

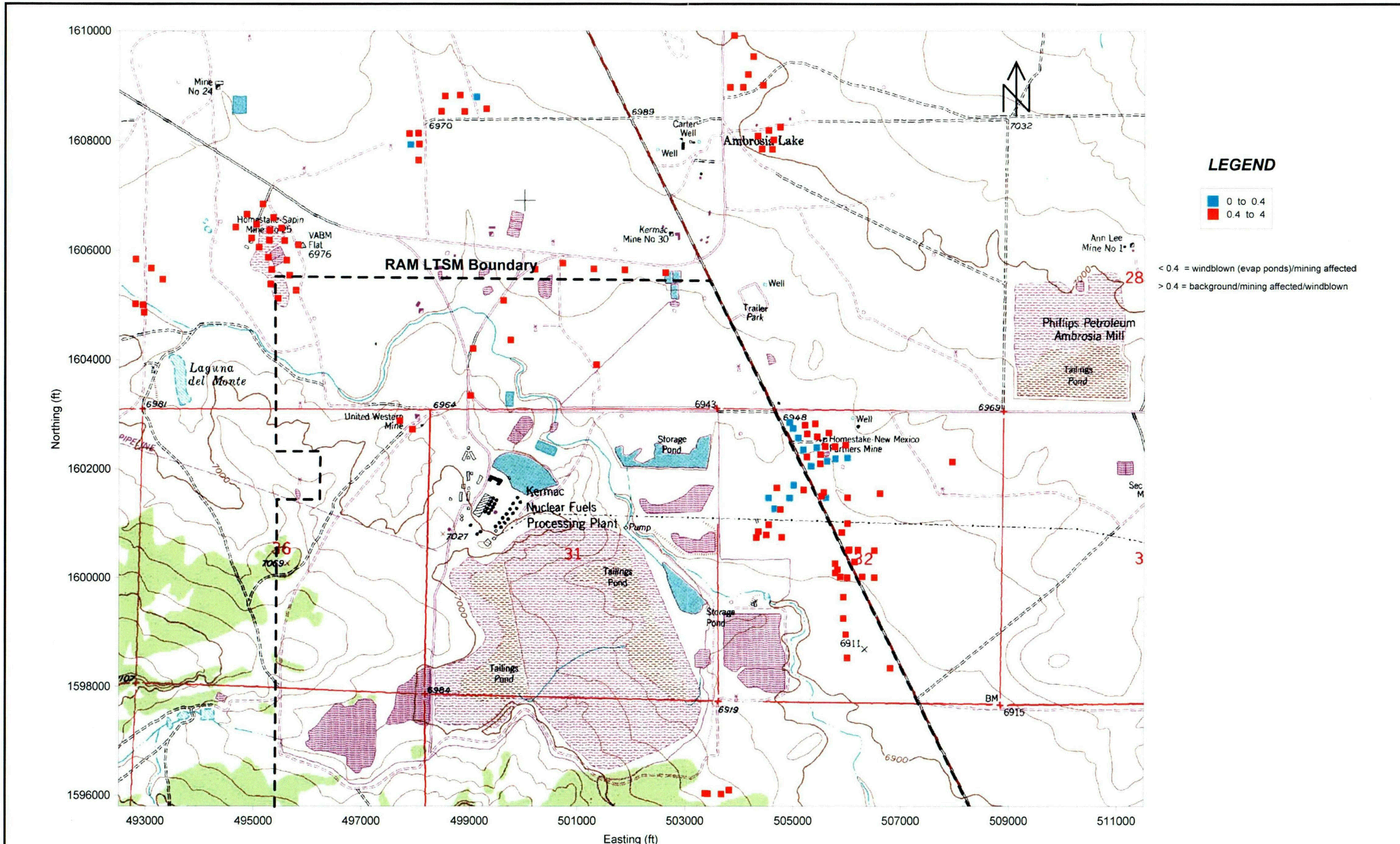
Project No: D0295A

Date: 11/09/2004

File Name: P:\Ambrosia Soils\NRC Report\Figures\11 x 17.ppt

FIGURE 2-7

C10



KOMEX	Figure 2-8. Ra-226/Th-230 Ratio in Soil Samples Collected to Support Gamma Correlation and Background Development	Project No: D0295A Date: 11/09/2004 File Name: P:\Ambrosia Soils\NRC Report\Figures\11 x 17.ppt	FIGURE 2-8

C11

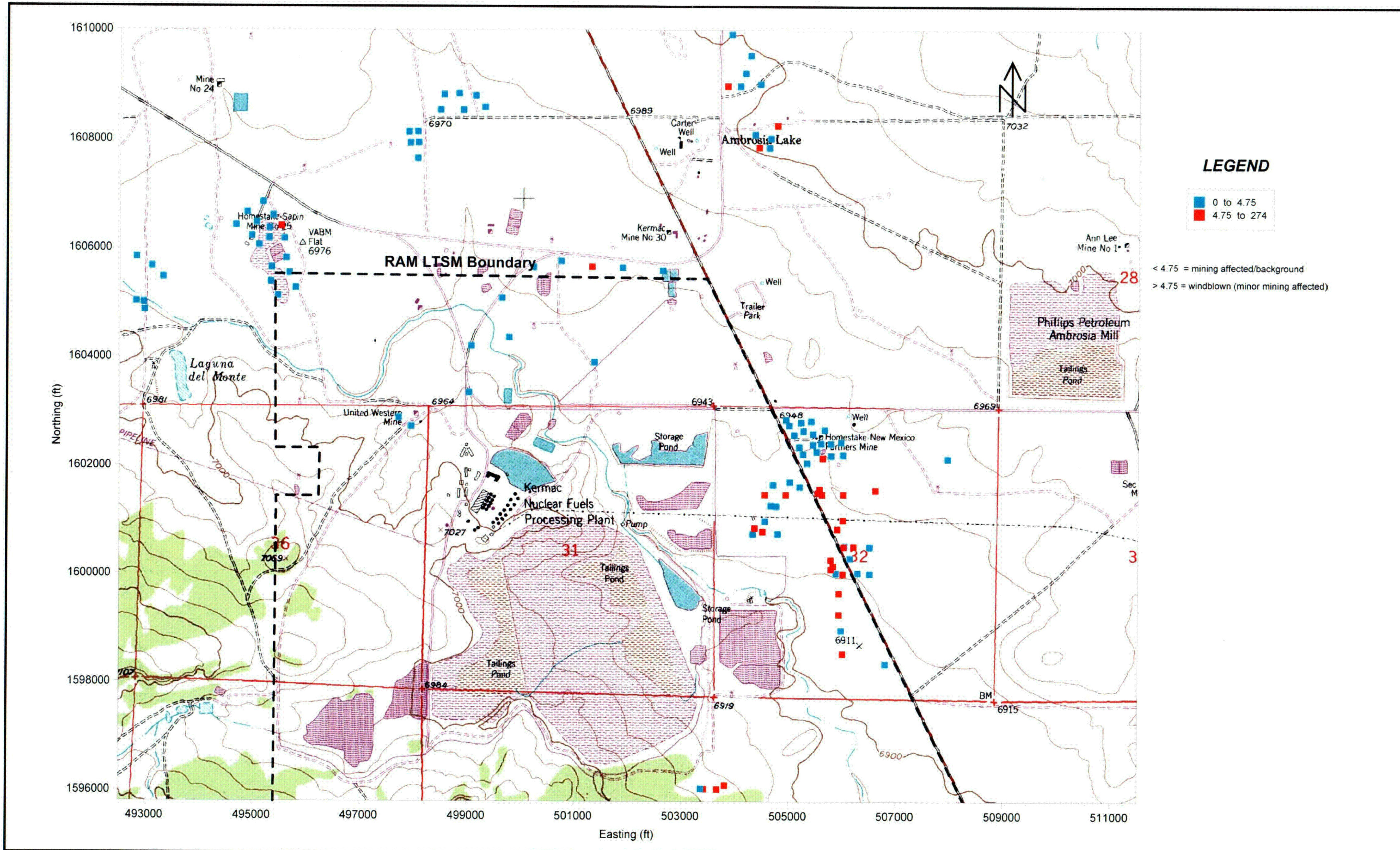


Figure 2-9. Ra-226/Unat Ratio in Soil Samples Collected to Support Gamma Correlation and Background Development

KOMEX

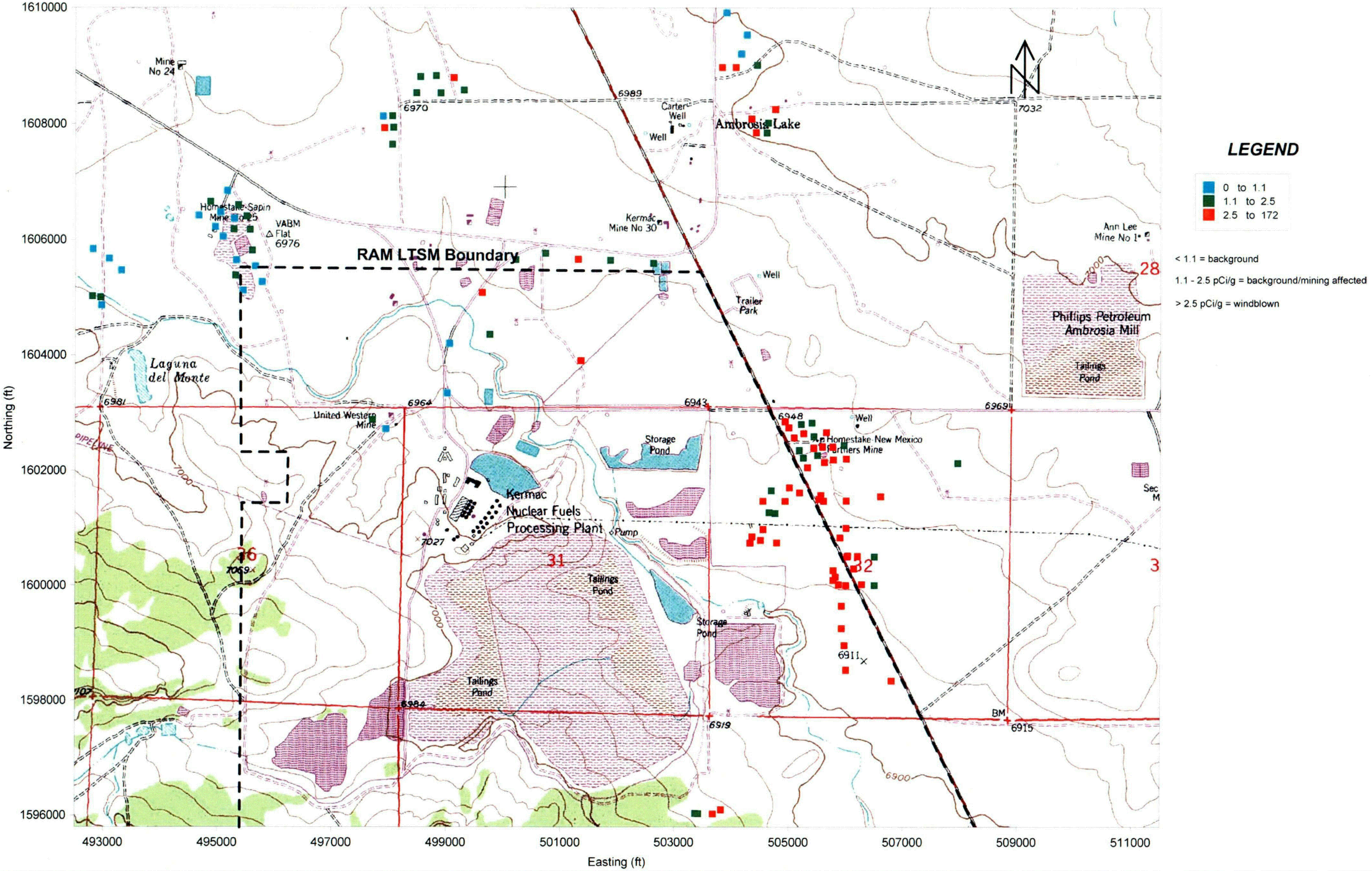
Project No: D0295A

Date: 11/09/2004

File Name: P:\Ambrosia Soils\NRC Report\Figures\11 x 17.ppt

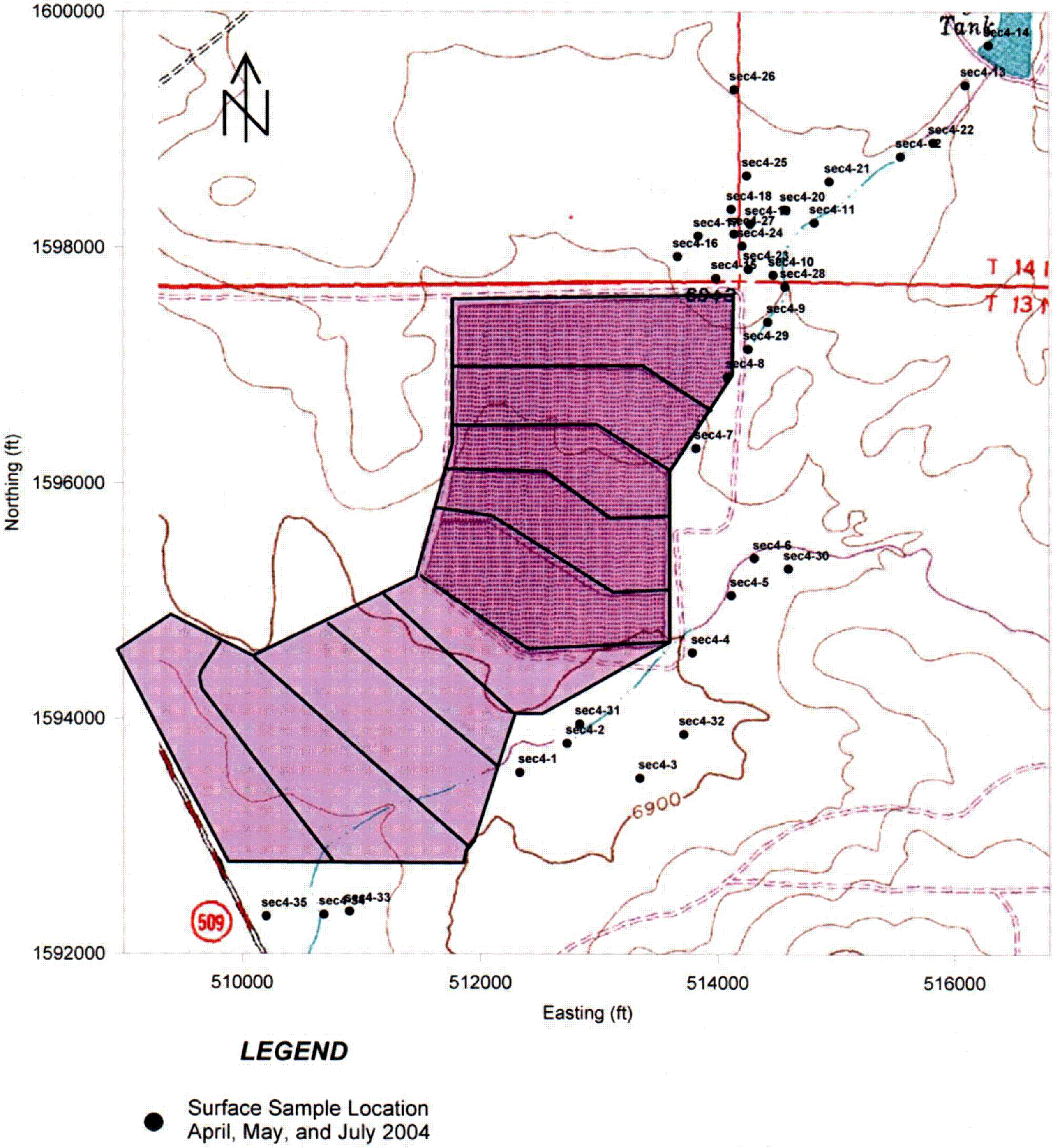
FIGURE 2-9

C12



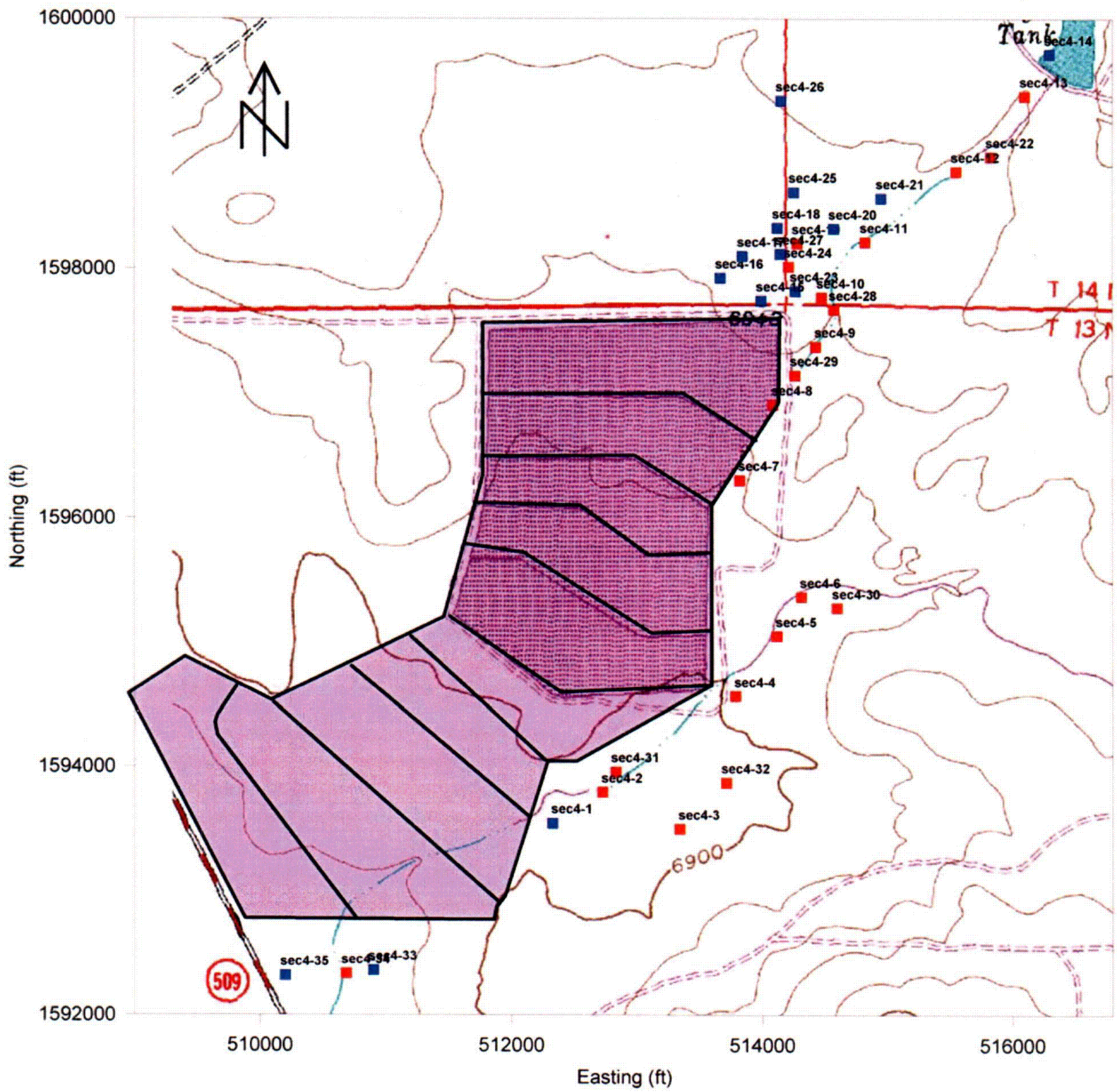
KOMEX	Figure 2-10. Th-230/Unat Ratio in Soil Samples Collected to Support Gamma Correlation and Background Development	Project No: D0295A Date: 11/09/2004 File Name: P:\Ambrosia Soils\NRC Report\Figures\11 x 17.ppt	FIGURE 2-10

C13



KOMEX	Figure 2-11. Location of Surface Soil Samples Section 4 Ponds Area	Project No. D0295A Date: 11/09/2004 File Name: 8 x 11 Portrait	**FIGURE** **2-11**

C14



LEGEND

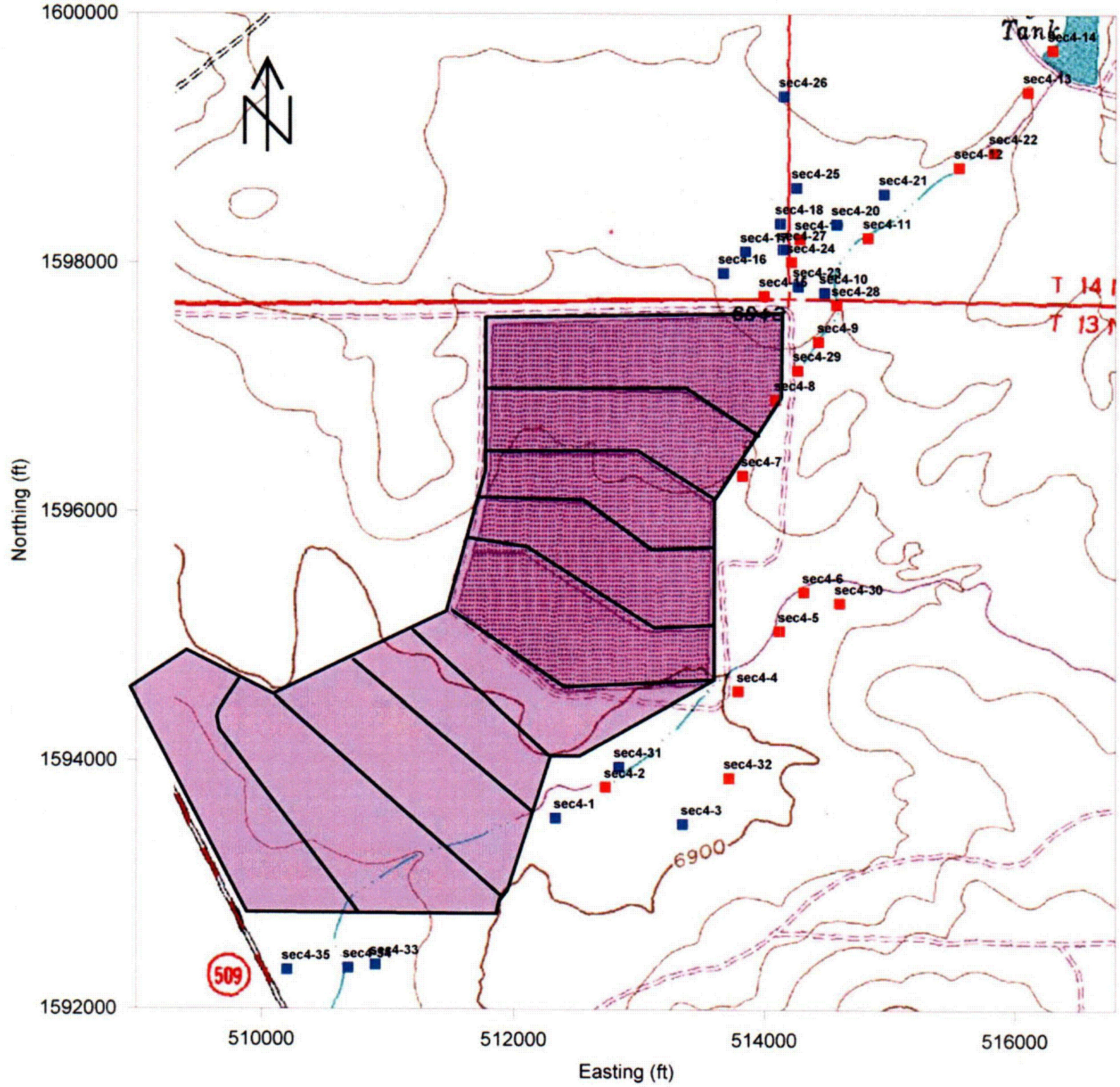
■ (blue)	0 pCi/g to 4.6 pCi/g
■ (red)	4.6 pCi/g to 99.1 pCi/g

< 4.6 pCi/g = Background

> 4.6 pCi/g = Mining Affected

KOMEX	Figure 2-12. Radium-226 Concentration in Surface Soils Section 4 Ponds Area	Project No. D0295A Date: 11/09/2004 File Name: 8 x 11 Portrait	FIGURE 2-12

C15



LEGEND

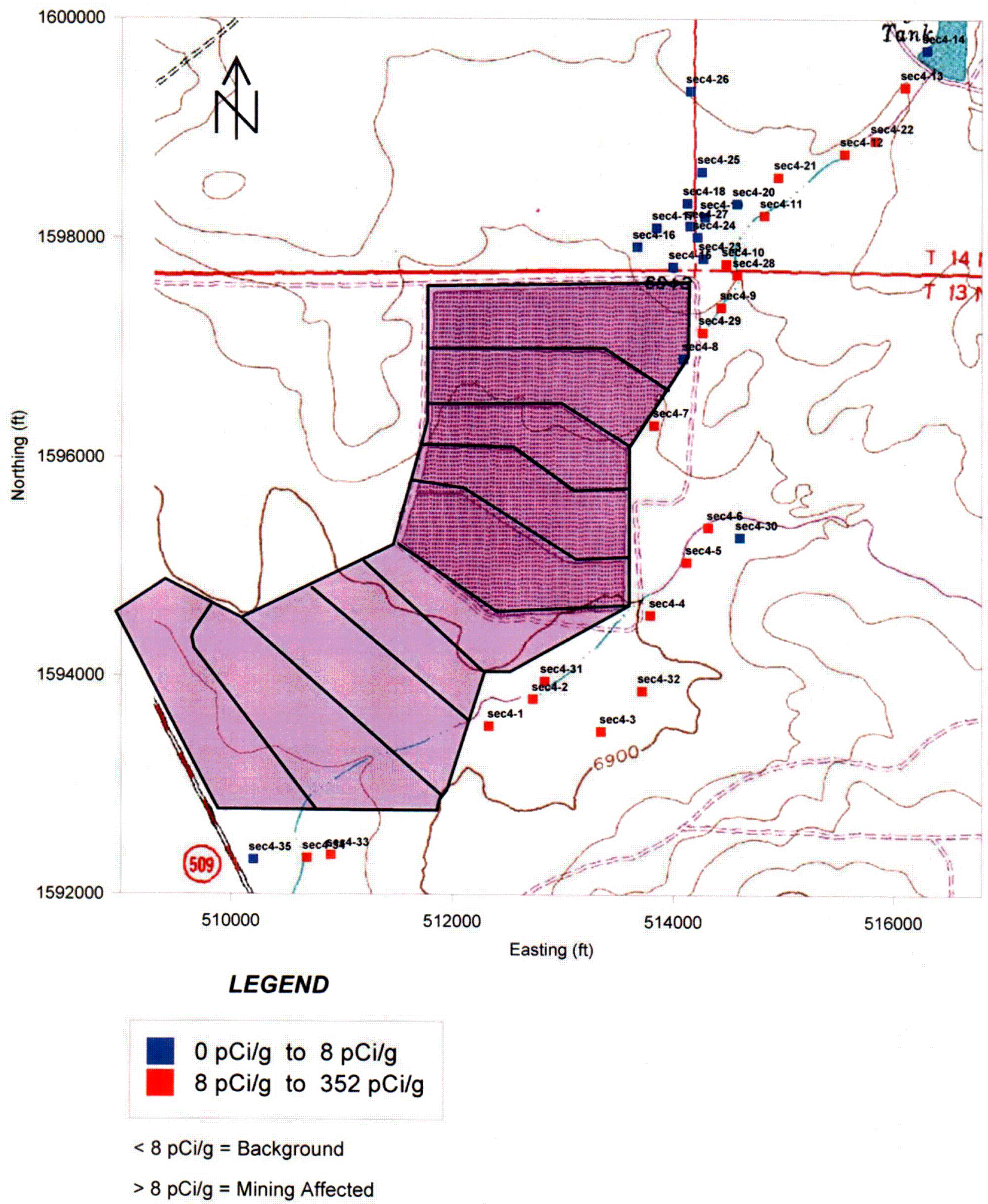
■	0 pCi/g to 3.07 pCi/g
■	3.07 pCi/g to 41.1 pCi/g

< 3.07 pCi/g = Background (Table 3-1)

> 3.07 pCi/g = Mining Affected

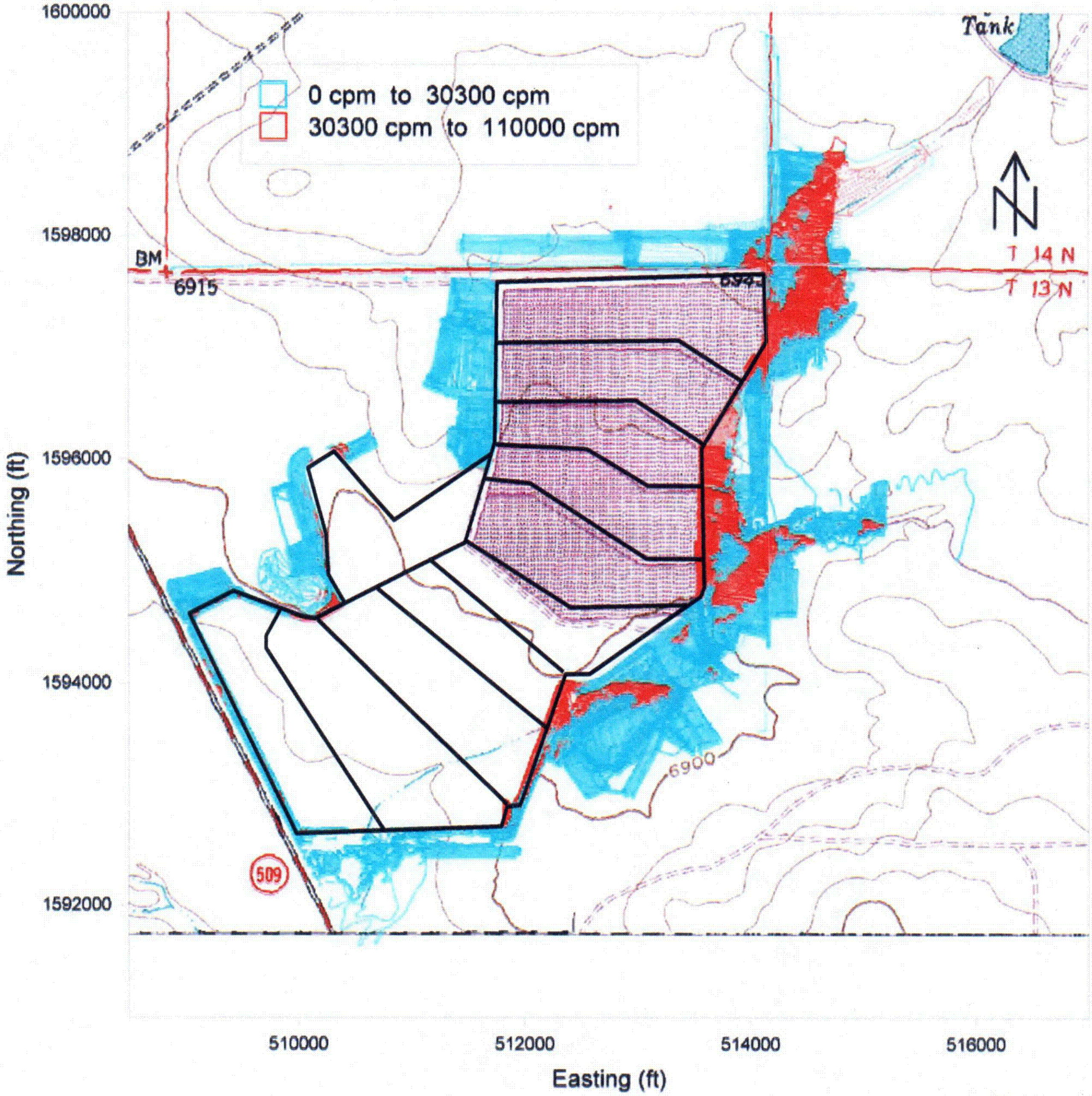
KOMEX	Figure 2-13. Thorium-230 Concentration in Surface Soils Section 4 Ponds Area	Project No. D0295A Date: 11/09/2004 File Name: 8 x 11 Portrait	FIGURE 2-13

C16



KOMEX	Figure 2-14. Uranium-238 Concentration in Surface Soils Section 4 Ponds Area	Project No. D0295A Date: 11/09/2004 File Name: 8 x 11 Portrait	FIGURE 2-14

C17



KOMEX	Figure 2-15. Gross Gamma Distribution Section 4 Ponds Area	Project No. D0295A Date: 11/09/2004 File Name: 8 x 11 Portrait	FIGURE 2-15

C18

3 SOIL BACKGROUND RADIOACTIVITY

Background surface soil concentrations have been determined using representative soil samples from areas undisturbed by licensed site activities. The windblown-affected areas are characterized geologically as alluvial valley fill. Therefore, background soil samples were obtained in areas north and northwest of the site that are geologically and chemically similar to the contaminated areas (**Figure 2-3**). Upland areas south and southwest of the site are geologically and chemically dissimilar, and were therefore not included in the background samples. The background sample locations are within 2 miles (3.2 km) of the site boundary, in areas that are generally cross-gradient to the prevailing wind direction. The samples were obtained from locations far enough from the site to be outside potential areas of contamination based on the characterization of the extent of contamination at the site (Section 2.2).

Numerous uranium mines are located near the Ambrosia Lake site and mine wastes have affected surface soils in these areas. Area soils have also been affected by drainage from the uranium mines. The presence of mine waste and mine drainage has resulted in elevated concentrations of radium-226, thorium-230, and uranium-238 in surface soils. These sources are a component of the area background levels as defined within NRC Regulations at 10 CFR Part 20. Because of the mining-related soil contamination in the area, two sets of background values must be determined for the Ambrosia Lake site. These background values will be referred to as "natural" background, representing relatively undisturbed areas near the Ambrosia Lake site, and "mining-affected" background, representing areas near the site unaffected by milling-related activities but where soils have been affected by mining-related activities (non-11e.(2) material).

Samples were collected from 124 locations to support the site background investigation and gamma correlation development (**Table 2-1**). These samples and data were collected and analyzed using the procedures planned for the final status survey (Section 8.0). Thirty grids were sampled to characterize natural background soils (Komex-21 through Komex-50) and 20 samples were collected from areas that are affected by uranium mine waste to characterize mining-affected background soils (Komex-71 through Komex-90). Additional samples were collected to provide comparable characterization data for areas potentially affected by windblown tailings (Komex-1 through Komex-20 and Komex 112 through Komex-121), the Homestake Mining area northeast of the site (Komex-51 through Komex-70, Komex-91 through Komex-100, Komex-111, and Komex-122), and the mining area north of the impoundment within or just outside the LTSM (Komex-101 through Komex-110, Komex-123, and Komex-124).

The data were analyzed using probability distribution diagrams and histograms to identify characteristics of various populations of soil sample data. This evaluation was based on gamma measurements, radium-226 concentrations, thorium-230 concentrations, and uranium-238 concentrations. Different ratios of these parameters were also examined to determine the distinguishing characteristics of the data populations. Comparison of gamma measurements obtained using a hand-held detector and an ATV-mounted detector positioned with similar geometry indicated that there was no significant difference in the results obtained using the two methods (**Figure 3-1**). Because the majority of the gamma data will be collected using an ATV-mounted detector, only the ATV-mounted data are included in the following discussion.

3.1 NATURAL BACKGROUND AND MINING-AFFECTED BACKGROUND SOILS

Gamma measurements fell into three populations (**Figure 3-2**). Examination of the histogram and the probability distribution diagram (using log-transformed data) indicated that the thresholds between these populations were approximately 26,000 cpm and 65,000 cpm. The natural background samples had gamma measurements that fell within the lowest population (< 26,000 cpm). A few of the mining-affected background samples also had gamma measurements that fell in the lowest population (Komex-74, Komex-76, Komex-77, Komex-82, Komex-90, and Komex-110). These samples can be attributed to the surface reclamation (cover placement) performed at these former mining sites. The majority of the mining-affected background samples had higher gamma measurements consistent with the middle and highest populations.

Three populations of radium-226 data were observed on a log-transformed histogram (**Figure 3-3**) and probability plot. The thresholds between the three populations were found to be approximately 4.6 pCi/g (log value of 0.66) and 10 pCi/g (log value of 1.0). The natural background samples and many of the mining-affected background samples were consistent with the two lowest-concentration populations. However, three of the mining-affected background samples (Komex-72, Komex-73, and Komex-86) fell into the highest radium-226 population. These samples, with the exception of Komex-73, also had the highest uranium concentrations of the mining background samples.

Thorium-230 data for the samples fell into two populations on a log-transformed histogram and probability plot, with a threshold between these populations of approximately 7 pCi/g (log value of 0.85, **Figure 3-4**). All natural background samples were included in the lowest-concentration population. Many of the mining-affected background samples also were

included in the lowest-concentration population, but five mining-affected background samples (Komex-72, Komex-73, Komex-75, Komex-86, and Komex-87) had thorium-230 concentrations consistent with the highest-concentration population.

Two uranium-238 populations were observed on log-transformed histograms of the data (**Figure 3-5**), with a threshold between the two populations equal to about 8 pCi/g (log value of 0.9). All of the natural background samples were included in the lowest-concentration population. Mining-affected background samples were observed in both uranium populations.

Evaluation of radium-226/thorium-230 ratios for the samples indicated the presence of two populations on log-transformed probability distribution diagrams and histograms (**Figure 3-6**). The larger population occurred at higher radium-226/thorium-230 ratios, and included all of the natural background samples except Komex-31 and all mining-affected background samples. This population had a mean ratio of 0.8 (log value of -0.1).

The radium-226/uranium-238 ratio can sometimes be used to indicate soils contaminated with uranium-mining wastes. Evaluation of log-transformed probability distribution diagrams and histograms of this ratio for the sample data indicated the presence of two populations (**Figure 3-7**). However, both the natural background and mining-affected background samples fell within the lower population (ratios of less than 4.75 or log value of 0.6), making it unlikely that this ratio can be used to distinguish mining-affected background samples from natural background samples.

Thorium-230/uranium-238 ratios were also examined using log-transformed probability distribution diagrams and histograms and three populations were observed (**Figure 3-8**). Most of the natural background and mining-affected background samples fell within the lower two populations (below a ratio of 2.5 or log value of 0.4).

3.1.1 CHARACTERIZATION OF NATURAL BACKGROUND

The gamma measurement data and radium-226, thorium-230, and uranium-238 concentrations for the natural background samples were evaluated using histograms to identify obvious outliers among the data. The thorium-230 concentration reported for Komex-36 was 9.75 pCi/g, which was almost twice as high as the next-highest thorium-230 concentration reported for the other natural background samples (**Table 2-1**). This value was also inconsistent with the observation that radium-226 concentrations were approximately equal to thorium-230 concentrations in the other natural background samples. Therefore, the thorium-230 concentration reported for Komex-36 was not included in the statistical evaluation of the data.

The reported uranium-238 concentration for Komex-40 equaled 2.99 pCi/g. However, this value was approximately three times the concentration reported for a replicate sample (Komex-40R) collected at the same time from the same grid. Other natural background samples generally had uranium-238 concentrations equal to or slightly greater than their radium-226 or thorium-230 concentrations; however, the reported uranium-238 concentration for Komex-40 was approximately three times the radium-226 and thorium-230 concentrations. Therefore, sample Komex-40R was used instead of sample Komex-40 in the statistical evaluation.

The summary statistics calculated for gamma measurements and for radium-226, thorium-230, and uranium-238 are included in **Table 3-1.** Summary statistics for different ratios of gamma measurements and radionuclide concentrations for the natural background samples are included in **Table 3-2.** For natural background samples, the mean radium-226/thorium-230 ratio was slightly less than 1, the mean radium-226/uranium-238 was slightly higher than 2 and the mean thorium-230/uranium-238 ratio was approximately equal to 3 (**Table 3-2**).

3.1.2 CHARACTERIZATION OF MINING-AFFECTED BACKGROUND

The gamma measurement data and radium-226, thorium-230, and uranium-238 concentrations for the mining-affected background samples were evaluated using histograms to identify obvious outliers among the data. No outliers were identified, so all data for the mining-affected background samples were used to calculate summary statistics (**Table 3-1**). Summary statistics for different ratios of gamma measurements and radionuclide concentrations for the mining-affected background samples are included in **Table 3-2.** The mean radium-226/thorium-230 ratio was approximately equal to 1, and the mean radium-226/uranium-238 and thorium-230/uranium-238 ratios were slightly less than 2 (**Table 3-2**).

Mean and maximum gamma measurements and concentrations of radium-226, thorium-230, and uranium-238 were higher for the mining-affected background samples than for the natural background samples (**Table 3-1**). Different mean ratios were also observed for the natural background and mining-affected background samples (**Table 3-2**). However, the ranges of the concentrations and ratios overlap significantly for the two background data sets.

3.2 DISTINGUISHING BETWEEN TAILINGS-AFFECTED, NATURAL BACKGROUND, AND MINING-AFFECTED AREAS

In this section, areas potentially affected by windblown 11e.(2) material are evaluated and compared to background soils to determine their distinguishing characteristics. This evaluation

also considers soils characteristics for differentiating between the effects of windblown 11e.(2) materials and the effects of non-11(e).2 mining-related materials. Soil characterization data used in this analysis are summarized in **Table 2-1**.

3.2.1 SOURCE CHARACTERIZATION

Analytical data for a tailings sand sample from the RAM Ambrosia Lake mill are presented in **Table 3-3**. The data indicate that mill tailings have relatively high radium-226 and thorium-230 concentrations, high ratios of radium-226 and thorium-230 to uranium-238, and relatively high ratios of radium-226 to thorium-230. Consequently, these concentrations and ratios are likely to be elevated in windblown-contaminated soils relative to background soil samples.

Comparisons of the analysis results from the various soil samples and the tailings sample were carried out to determine the effects of windblown 11e.(2) material on soils, and to determine the distinguishing characteristics of soils affected by windblown tailings and non-11e.(2) mining waste. The soils data obtained from the various groups of samples were examined using both histograms and probability plots.

3.2.2 GAMMA MEASUREMENTS AND RADIUM-226 CONCENTRATIONS

Gamma survey measurements formed three populations, with thresholds between the populations at approximately 26,000 cpm and 65,000 cpm (**Figure 3-2**). All natural background sample locations were included in the lowest-gamma population, whereas in the absence of mining-related contamination, windblown-tailings affected soils were included in the intermediate gamma population (between approximately 26,000 and 65,000 cpm). Consequently, gamma measurements may be used to help distinguish between background and windblown-affected areas in the absence of mining-related soils contamination (Section 6.0).

Although a few mining-affected background sample locations were included in the lowest gamma population as a result of mine reclamation activities, most were in the two higher-gamma populations (greater than 26,000 cpm), and several of the mining-affected background sample locations had gamma measurements near the maximum value observed (e.g., Komex-72). All Homestake Mining Area and all mining-affected samples obtained near the northern LTSM boundary (except Komex-110) were included in the two highest-gamma populations. Based on these data and examination of site-wide gamma measurements (**Figure 2-1**), it is apparent that gamma measurements alone cannot be used to distinguish between the effects of mining-related and windblown tailings contamination.

Radium-226 soils concentrations are a source of elevated gamma measurements; consequently, radium-226 concentrations formed three populations similar to the gamma measurement results (**Figure 3-3**). All natural background samples were included in the lowest-concentration population (**Figure 2-5**). Radium-226 concentrations in windblown-tailings-affected soils in the absence of mining-related contamination were mostly included in the intermediate-concentration population. Therefore, in the absence of mining-related contamination, elevated radium-226 concentrations indicate windblown tailings contamination.

Mining-affected background samples were included in all three radium-226 populations. As previously observed for the gamma measurements, some of the highest radium-226 concentrations were measured in mining-affected background samples (e.g., Komex-86). Homestake Mining Area samples and samples from the mining-affected area north of the impoundment were also included in all three radium-226 populations. Based on these data and examination of **Figure 2-5**, it is apparent that radium-226 concentrations alone cannot be used to distinguish between the effects of mining-related and 11e.(2)-related contamination.

3.2.3 THORIUM-230 AND URANIUM-238 CONCENTRATIONS

As a result of the acid leach process, the liquid fraction of the mill effluents contained the thorium-230 and was disposed in the evaporation pond system. Therefore, thorium-230 concentrations in the tailings sands were relatively low compared to radium-226 concentrations. Thorium-230 data formed two distinct populations, with the threshold between these populations at approximately 7 pCi/g (**Figure 3-4**). All natural background samples fell into the lowest-concentration thorium-230 population. Windblown-affected samples outside areas affected by mining-related waste were included only in the higher thorium-230 population (**Figure 2-6**). Therefore, in the absence of mining-related contamination, thorium-230 soil concentrations above approximately 7 pCi/g may indicate windblown-tailings contamination.

Mining-affected background samples were included in both populations of thorium-230 data, and some of the highest thorium-230 concentrations were observed in mining-affected background samples (e.g., Komex-86). In the Homestake Mining Area and the mining-affected area north of the impoundment, thorium-230 concentrations were included only in the higher-concentration population. Because elevated thorium-230 concentrations are observed in both windblown tailings and mining-affected soils, thorium-230 concentrations cannot be used to distinguish between the effects of windblown tailings and mining-related contamination. The one location where thorium-230 soil concentrations may be appropriately used to differentiate soils will be in the vicinity of the Section 4 Ponds, as they were constructed within a historic

mine drainage area. This drainage exhibits elevated levels of predominantly uranium and radium resulting from the mine discharges. Alternatively, soil contamination attributable to seepage of the lined ponds and/or windblown pond materials would be expected to contain elevated thorium concentrations.

The uranium-238 data also formed two populations, with a threshold between the populations of approximately 8 pCi/g (**Figure 3-5**). Natural background samples and soil samples from windblown-tailings affected areas fell into the lowest-concentration uranium-238 population (**Figure 2-7**). Mining-affected background areas and mining areas potentially affected by windblown tailings material had concentrations that fell into both the lower and higher-concentration populations. The inclusion of samples from mining-affected areas in the lowest-concentration population indicates that some of these samples may indicate the effects of cover placement during remediation. Because of the relatively low uranium-238 in natural background soils and in the RAM Ambrosia Lake tailings (**Table 3-3**), uranium-238 concentrations provide an excellent indication of soils affected by uranium mining waste (**Figure 2-7**).

3.2.4 RADIONUCLIDE CONCENTRATION RATIOS

The radium-226/thorium-230 ratios for the samples formed two populations. The largest population had a mean value of 0.76, and included all natural background and mining background samples. The smaller population represented only about 10% of the samples. This population had lower ratios of radium-226 to thorium-230, with a threshold between the two populations of approximately 0.4. The radium-226/thorium-230 sample ratios are illustrated in **Figure 3-6**. With the exception of background samples Komex-31 and Komex-36, samples with a radium-226/thorium-230 ratio less than 0.4 were located only in a limited area (**Figure 2-8**). These samples were mostly located in mining-affected areas near Highway 509 and in drainages from the Homestake mining-affected area. The source of the relatively low radium-226/thorium-230 ratio for background samples Komex-31 and Komex-36 is not known. Tailings material has a relative high radium-226/thorium-230 ratio (**Table 3-3**), so it is unlikely that the lower-ratio material in the vicinity of the Homestake Mining area is contaminated by windblown tailings. It is possible that the slightly reduced radium-226/thorium-230 ratios in the mining-affected samples represent the effects of small amounts of windblown evaporation pond sediments, which are relatively enriched in thorium-230.

Radium-226/uranium-238 ratios formed two populations (**Figure 3-7**). All natural background samples were included in the population with the lowest radium-226/uranium-238 ratios.

Because of the relatively high radium-226/uranium-238 ratio in the RAM Ambrosia Lake mill tailings (**Table 3-3**), windblown-tailings affected soils should have relatively high radium-226/uranium-238 ratios. As expected, most of the samples collected from the area affected by windblown tailings were included in the higher-ratio population, with ratios greater than approximately 4.75 (**Figure 3-7**). However, a number of samples with windblown tailings contamination fell into the lower radium-226/uranium-238 population (**Figure 2-9**).

All except one (Komex-73) of the mining-affected background samples were included in the population with the lowest radium-226/uranium-238 ratios. The radium-226/uranium-238 ratios for mining-affected samples in potentially windblown tailings-affected areas indicates that most samples had a ratio below 4.75. Of the six mining-affected samples with ratios in excess of 4.75 (Komex-91, Komex-94, Komex-98, Komex-100, Komex-106, and Komex-122) all except Komex-106 were located in the Homestake Mine Drainage Area (**Figure 2-9**). Therefore, based on the radium-226/uranium-238 ratios in the samples, there is little evidence of windblown contamination in the Homestake Mining and Homestake Mine Drainage areas or in the mining-affected area north of the impoundment that can be distinguished from the effects of mine waste.

Thorium-230/uranium-238 ratios formed three populations, with thresholds between the populations at ratios of approximately 1.1 and 2.5 (**Figure 3-8**). Natural background and mining-affected background samples were included in the two lowest-ratio populations; the exceptions were natural background samples Komex-31, Komex-36, Komex-42, Komex-43, Komex-45, Komex-47, and Komex-48 (**Figure 2-10**). All of the samples from the windblown-tailings-affected area were included in the two higher-ratio populations. Samples in the mining-affected area north of the impoundment and in the Homestake mining area generally had thorium-230/uranium-238 ratios greater than 1.1.

3.2.5 DIFFERENTIATING BETWEEN TAILINGS-AFFECTED AND MINING-AFFECTED AREAS

Records related to mining activities in the vicinity of the Ambrosia Lake site and visual inspection (soil color and texture) have been used to identify areas affected by non-11e.(2) uranium mining waste. Mine locations are provided in **Figure 1-2**. Both windblown-tailings-affected areas and mining-affected areas are characterized by relatively high gamma measurements, radium-226 concentrations, and thorium-230 concentrations. However, mining-affected areas can typically be differentiated from windblown-tailings affected areas by uranium-238 concentrations: uranium-238 concentrations were always less than 4.5 pCi/g in the

windblown-tailings affected samples, whereas the large majority of mining-affected samples had higher uranium-238 concentrations.

3.2.6 DIFFERENTIATING BETWEEN TAILINGS-AFFECTED AND NATURAL BACKGROUND AREAS

Comparison of the mill tailings sand sample data to mean values observed for windblown-tailings affected soils and natural background soils indicates that the radionuclide concentrations and ratios vary as expected for the different sample types (**Table 3-3**). In areas unaffected by mining-related waste, windblown tailings contamination of soils can be identified by relatively high gamma measurements, high radium-226 and thorium-230 concentrations, and high radium-226/uranium-238 and thorium-230/uranium-238 ratios when compared to natural background samples.

The ranges of gamma measurements, radionuclide concentrations, and ratios observed for the mining-affected background, Homestake Mining Area, and the mining-affected area north of the impoundment are summarized in **Table 3-4**. All ranges for the three types of locations overlap significantly. Higher gamma, radium-226, thorium-230 and uranium-238 concentrations in the Homestake Mining area and the area north of the impoundment compared to the mining-affected background areas probably reflect a greater amount of contamination by uranium mining waste (non-11e.(2)) in the Homestake Mining area and the mining area north of the impoundment.

The addition of significant quantities of windblown tailings to the mine waste in these areas could be expected to result in higher radium-226/uranium-238 ratios compared to the mining-affected background values, based on the composition of the tailings (**Table 3-2**). For the Homestake Mining Area, only samples Komex-57, Komex-91, Komex-94, Komex-98, Komex-100 and Komex-122 were above the range of radium-226/uranium-238 ratios observed for the mining-affected background samples. These sample locations are along the southern boundary of the Homestake Mining area, mostly in drainage areas, and except for Komex-100, these samples have uranium-238 concentrations that are below detection limits. Therefore, these samples may have windblown tailings contamination and may be only minimally affected by mine waste. For other samples from the Homestake mining area, the effects of windblown tailings appear to be indistinguishable from the effects of the mining waste.

Among the mining-affected samples obtained north of the impoundment, only Komex-106 had a radium-226/uranium-238 ratio greater than the range observed for the mining-affected background samples. Sample Komex-106 had a uranium-238 concentration less than the

analytical detection limit, possibly indicating that this sample may have windblown tailings contamination and may be minimally affected by mine waste. For the other samples from the mining area north of the impoundment, the effects of windblown tailings appear to be indistinguishable from the effects of the mining waste.

Table 3-1. Summary Statistics for Natural Background and Mining-Affected Background Soils Data.

Natural Background				
	Gamma ATV (cpm)	**Radium-226 (pCi/g)**	**Thorium-230 (pCi/g)**	**Uranium-238 (pCi/g)**
Number of Samples	30	30	29	30
mean	17,807	1.95	2.69	1.65
Median	18,221	1.63	2.70	1.57
standard deviation	2,481	1.09	1.20	1.22
95% UCL	18,576	2.29	3.07	2.02
Max	22,543	4.89	5.18	4.88
Min	11,447	0.65	0.69	< 0.41
Mining-Affected Background				
	Gamma ATV (cpm)	**Radium-226 (pCi/g)**	**Thorium-230 (pCi/g)**	**Uranium-238 (pCi/g)**
Number of Samples	20	20	20	20
mean	37,756	6.71	5.68	4.40
median	31,425	2.58	2.44	2.35
standard deviation	20,860	10.6	7.78	6.57
95% UCL	45,801	10.8	8.68	6.94
max	87,144	38.8	27.8	27.0
min	14,432	0.49	0.751	0.415

Table 3-2. Summary Statistics for Natural Background and Mining-Affected Background Ratios

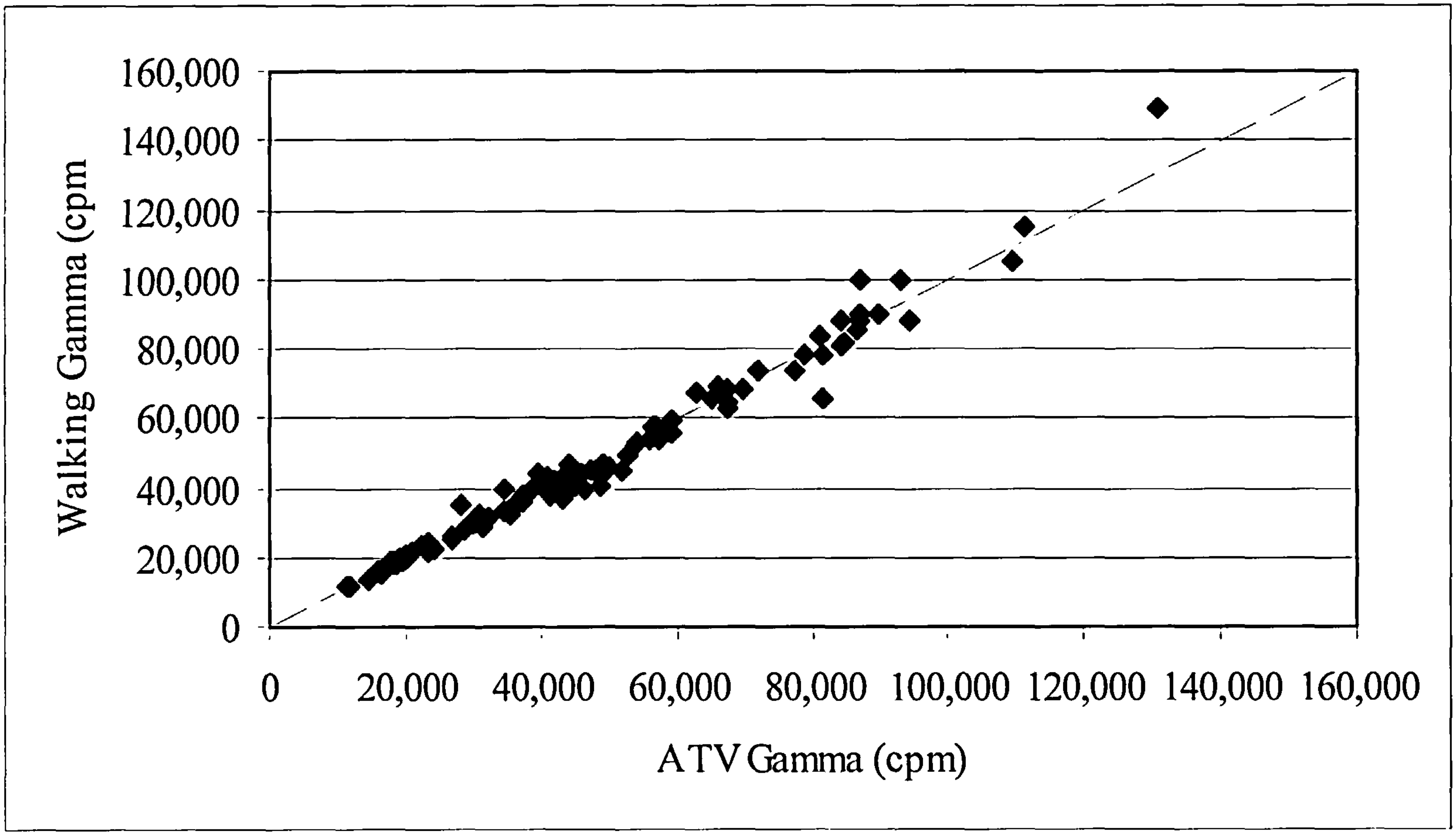
Natural Background			
	Radium-226 /Thorium-230	Radium-226 /Uranium-238	Thorium-230 /Uranium-238
Number of Samples	29	30	29
mean	0.740	2.26	2.98
median	0.748	1.14	1.63
standard deviation	0.198	3.01	3.27
95% UCL	0.803	3.19	4.01
max	1.11	13.87	14.9
min	0.338	0.305	0.492
Mining-Affected Background			
	Radium-226 /Thorium-230	Radium-226 /Uranium-238	Thorium-230 /Uranium-238
Number of Samples	20	20	20
mean	1.15	1.59	1.57
median	0.888	1.29	1.34
standard deviation	0.851	1.14	1.09
95% UCL	1.48	2.03	1.99
max	4.22	5.04	4.83
min	0.515	0.320	0.444

Table 3-3. Ambrosia Lake Mill Tailings Sand Analysis and Mean Values for Windblown Soil Samples and Background Soil Samples

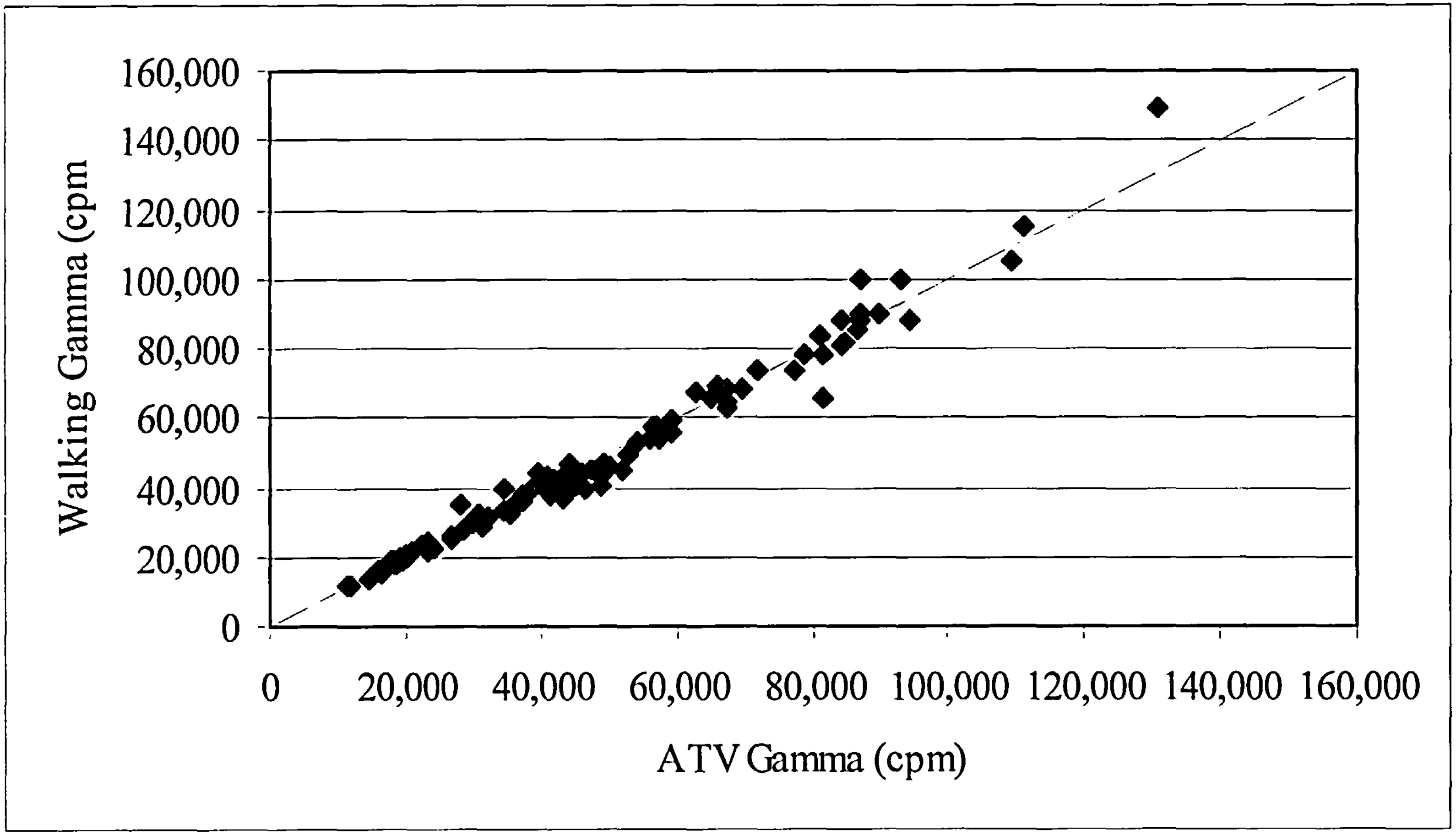
	Ambrosia Lake Mill Tailings Sands	Mean Windblown-Area Soils	Mean Natural Background Soils	Mean Mining-Affected Background Soils
Gamma ATV (cpm)	--	42,292	17,807	37,756
Radium-226 (pCi/g)	1,400	6.78	1.95	6.71
Thorium-230 (pCi/g)	240	9.72	2.69	5.68
Uranium-238 (pCi/g)	20.9	1.50	1.65	4.40
ATV Gamma/Radium-226	--	6,732	11.2	15,677
Radium-226/Thorium-230	5.83	0.770	0.740	1.15
Radium-226/Uranium-238	66.8	16.4	2.26	1.59
Thorium-230/Uranium-238	11.5	11.6	2.98	1.57

Table 3-4. Ranges of Mining-Affected Background Concentrations Compared to Homestake Mining Area and Mining-Affected Area North of the Impoundment

	Mining-Affected Background Locations	Homestake Mining Area Locations	Mining-Affected Locations North of Impoundment
Gamma ATV (cpm)	14,432 – 87,144	28,188 – 111,381	23,175 –
Radium-226 (pCi/g)	0.49 – 38.8	3.15 – 99.0	2.79 – 350
Thorium-230 (pCi/g)	0.751 – 27.8	5.50 - 149	2.46 – 505
Uranium-238 (pCi/g)	< 0.83 – 27.0	< 0.56 – 89.8	<2.18 - 275
ATV Gamma/Radium-226	2,170 – 46,813	704 – 15,339	1,362 –
Radium-226/Thorium-230	0.515 – 4.22	0.104 - 1.88	0.645 – 1.43
Radium-226/Uranium-238	0.320 – 5.0	0.425 – 45.6	0.523 – 13.1
Thorium-230/Uranium-238	0.444 – 4.83	1.37 – 50.4	0.593 – 7.66



KOMEX	Figure 3-1. Gamma Measurements Obtained Using Hand-Held (Walking) and ATV-Mounted Detectors	Project No: D0295A Date: 11/09/2004 File Name: 8x11 Landscape.ppt	FIGURE 3-1



KOMEX

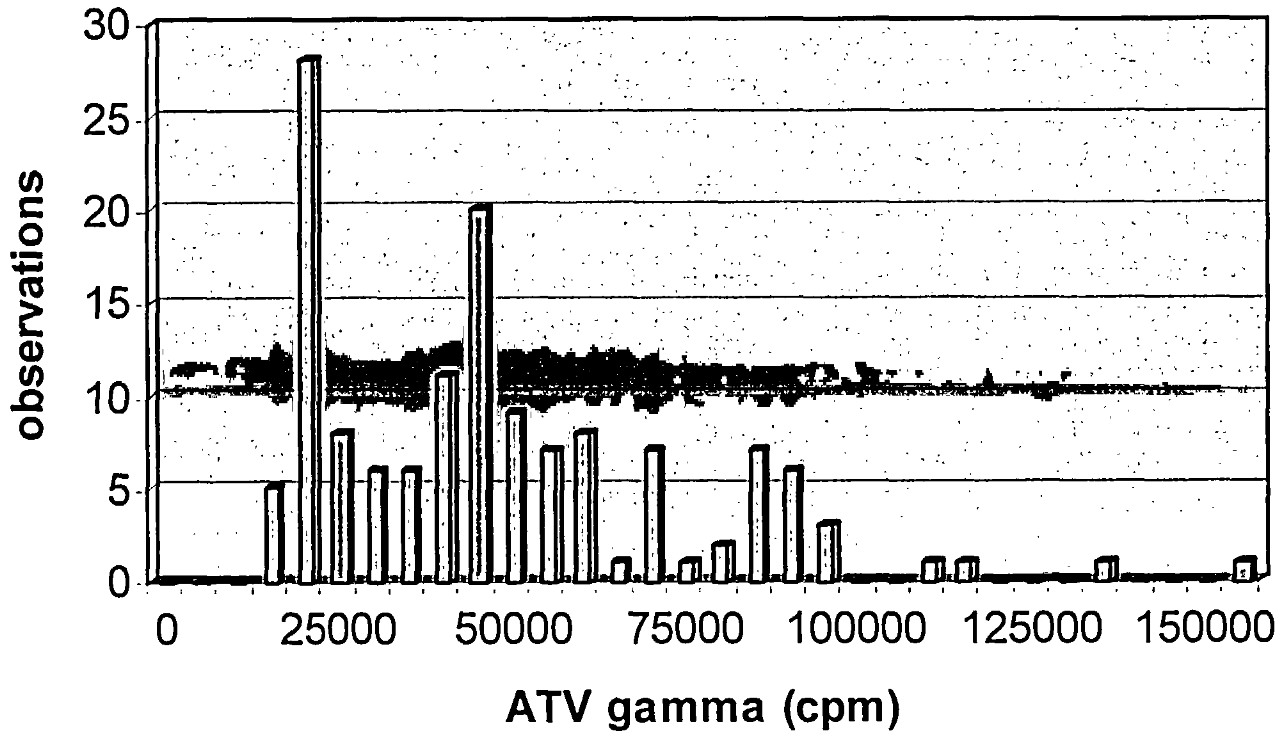
Figure 3-1. Gamma Measurements Obtained Using Hand-Held (Walking) and ATV-Mounted Detectors

Project No: D0295A

Date: 11/09/2004

File Name: 8x11 Landscape.ppt

FIGURE 3-1



KOMEX

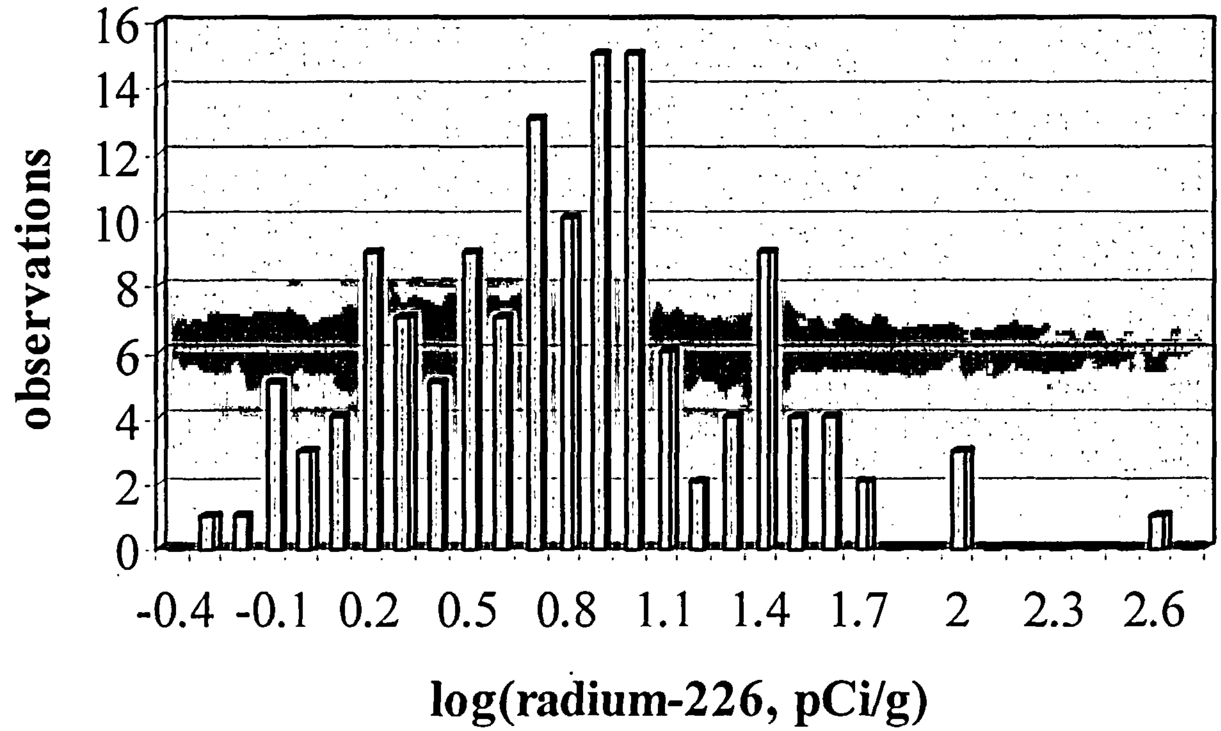
Figure 3-2. Histogram of ATV Gamma Measurements

Project No: D0295A

Date: 11/09/2004

File Name: 8x11 Landscape.ppt

FIGURE 3-2



KOMEX

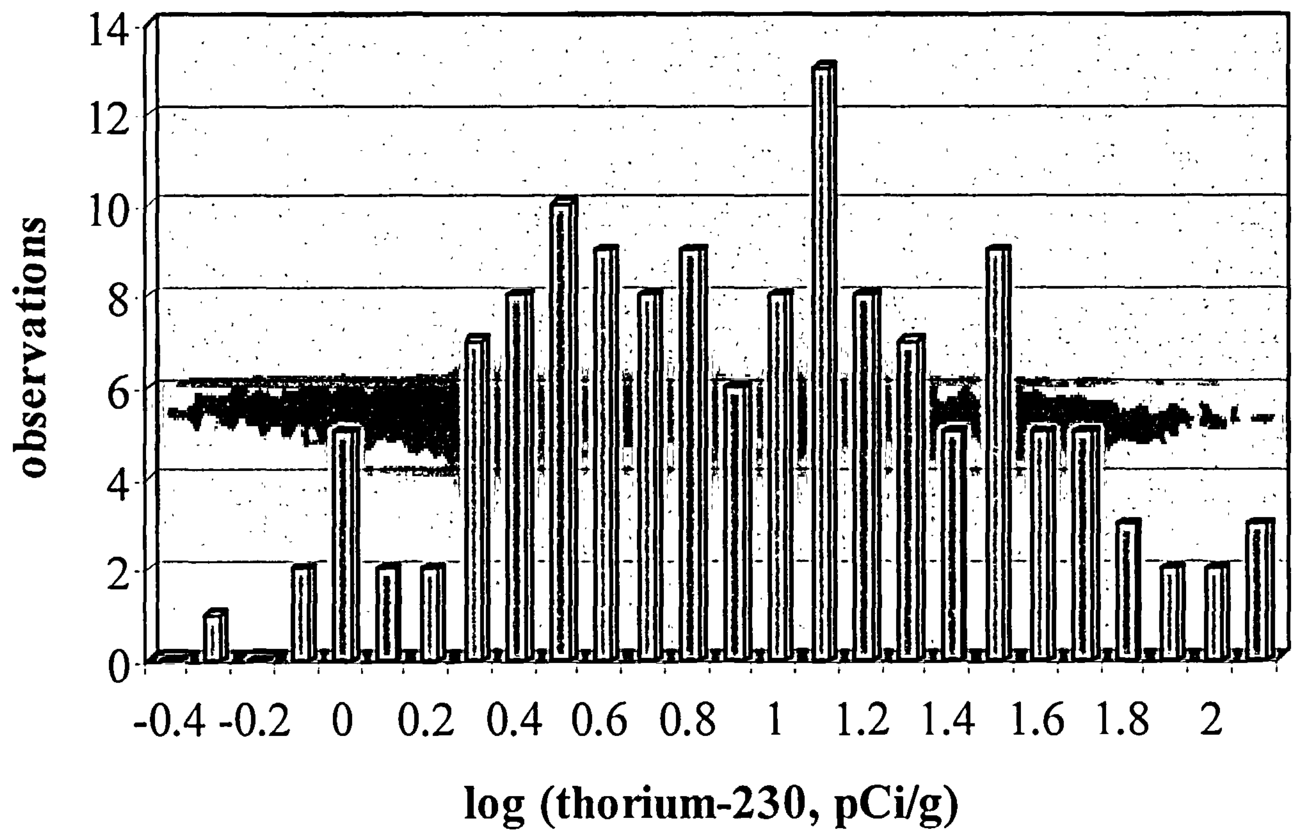
Figure 3-3. Log-transformed Histogram of Radium-226 Measurements

Project No: D0295A

Date: 11/09/2004

File Name: 8x11 Landscape.ppt

FIGURE 3-3



KOMEX

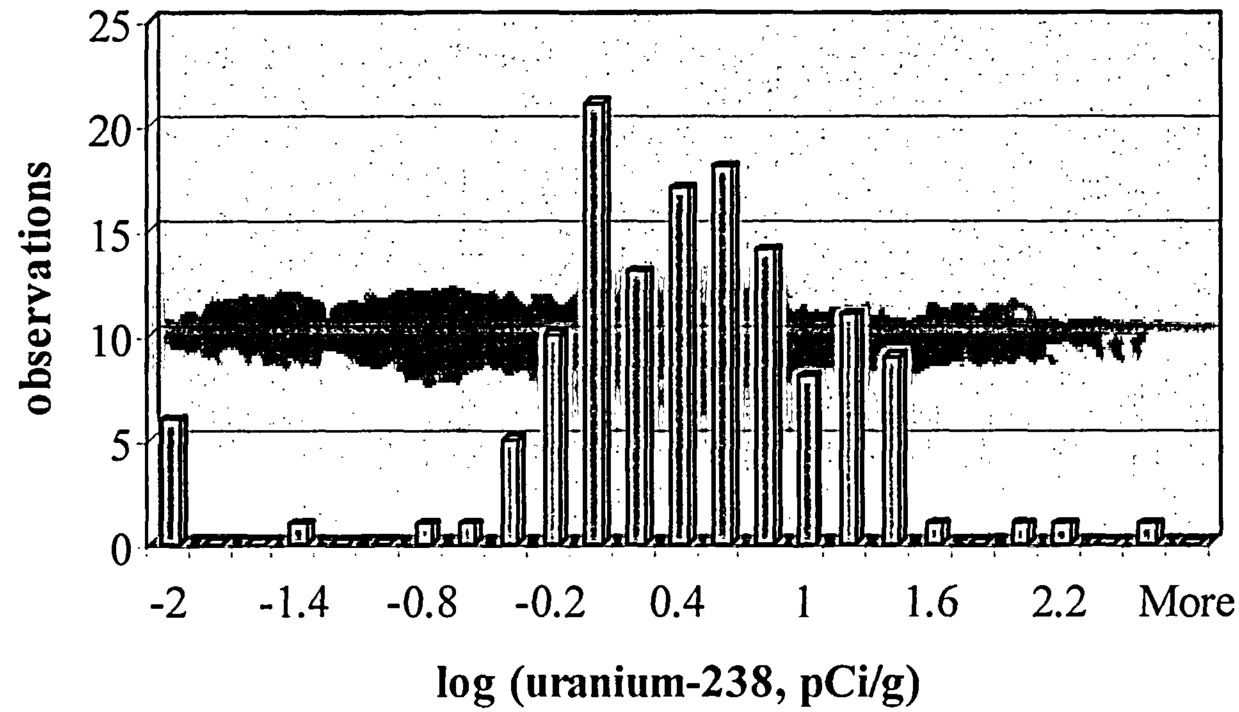
Figure 3-4. Log-transformed Histogram of Thorium-230 Measurements

Project No: D0295A

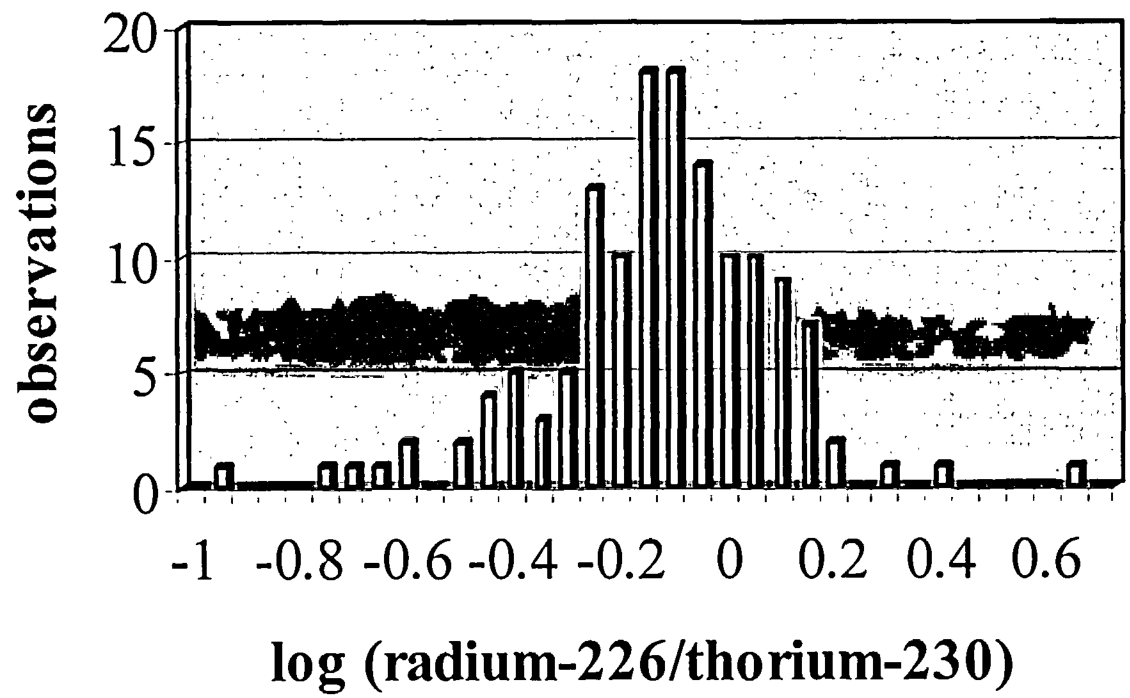
Date: 11/09/2004

File Name: 8x11 Landscape.ppt

FIGURE 3-4



KOMEX	Figure 3-5. Log-transformed Histogram of Uranium(nat) Measurements	Project No: D0295A Date: 11/09/2004 File Name: 8x11 Landscape.ppt	FIGURE 3-5



KOMEX

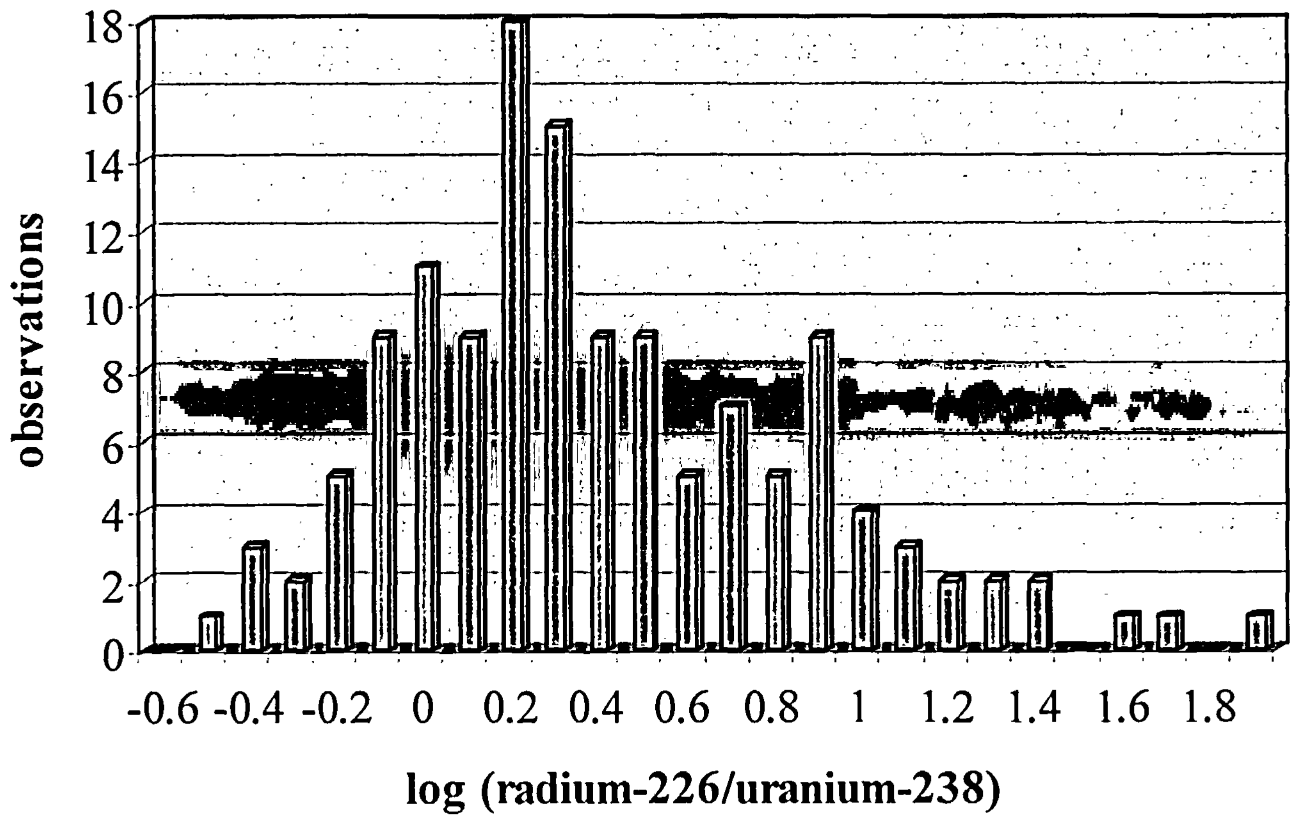
Figure 3-6. Log-transformed Histogram of Ra-226/Th-230 Ratios

Project No: D0295A

Date: 11/09/2004

File Name: 8x11 Landscape.ppt

FIGURE 3-6



KOMEX

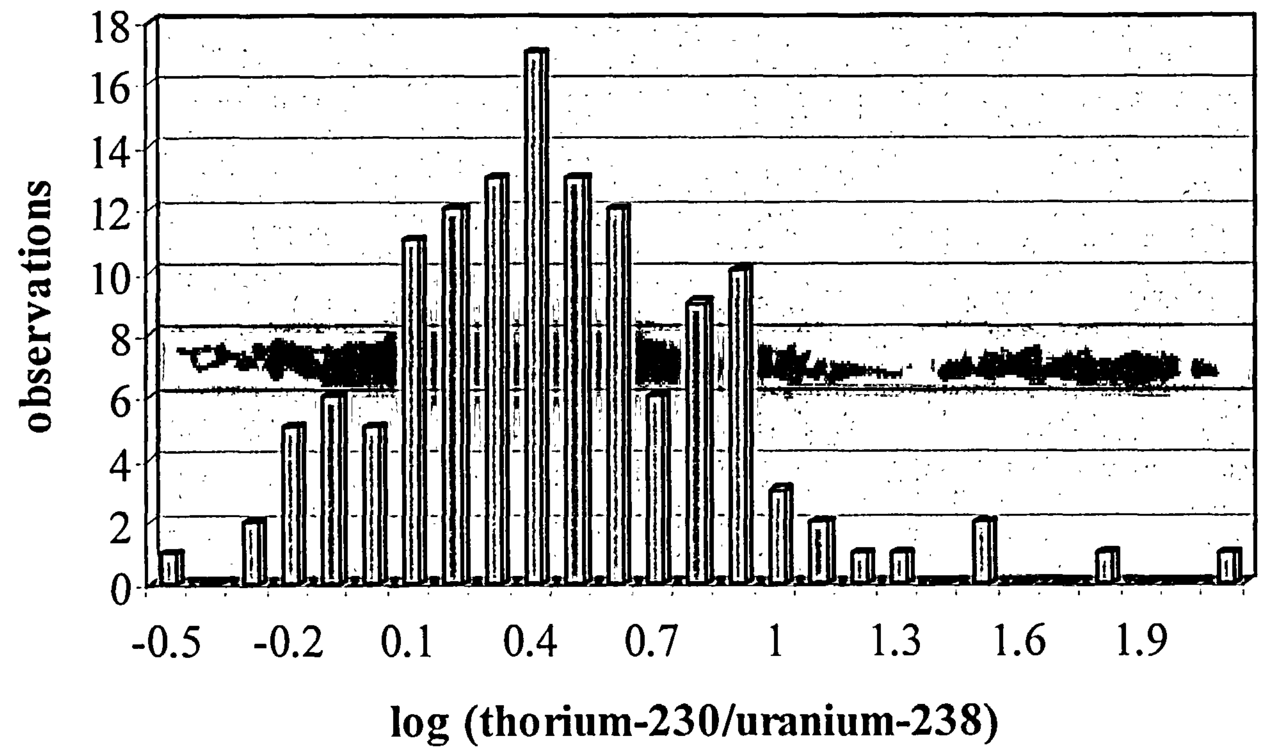
Figure 3-7. Log-transformed Histogram of Ra-226/U-238 Ratios

Project No: D0295A

Date: 11/09/2004

File Name: 8x11 Landscape.ppt

FIGURE 3-7



KOMEX	Figure 3-8. Log-transformed Histogram of Th-230/U-238 Ratios	Project No: D0295A Date: 11/09/2004 File Name: 8x11 Landscape.ppt	FIGURE 3-8

4.0 RADIUM BENCHMARK DOSE

Technical criteria[4] for termination of RAM's license include a limiting concentration of Ra-226 in soil, and limiting concentrations of other radionuclides in soil based on the equivalent dose to an average member of a group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances. The equivalent dose is termed radium benchmark dose.

4.1 IDENTIFICATION OF CONSTITUENTS OF CONCERN

The constituents of concern for the radium benchmark dose are radium-226 and lead-210.[5]

4.2 EXPOSURE METHODOLOGY

The radium benchmark dose was assessed by constructing a source term and exposure scenario, and using a computer model to simulate the release and transport of radionuclides and radiation in the environment. The assessment was performed, to the extent possible, on a site-specific basis. The assessment reflected the site-specific characteristics of the residual radioactivity (e.g. type, extent, concentration) and of the environment (e.g. soil, water movement, plant growth) at the site. Exposure pathways relevant to the exposure scenario were chosen based on this information and regulatory guidance.

The radium benchmark dose was determined using version 6.21 of the RESRAD dose modeling software.[6]

4.3 AREAS OF SURFACE SOIL CONTAMINATION (WINDBLOWN)

Prior to the covering of former tailings impoundments, areas immediately downwind of the former tailings impoundments were subject to impacts by windblown tailings. A majority of the soils impacted by windblown tailings have either been previously excavated or have

[4] 10 CFR 40, Appendix A, Criterion 6 (6)

[5] U.S. Nuclear Regulatory Commission (NRC), Final Report Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act, NUREG-1620, Revision 1, June 2003. (sections H2.1.1 & H2.1.3(2)(b))

[6] Yu, C., et. al., 1993. *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD 5.0, Working Draft for Comment*, ANL/EAD/LD-2, Argonne National Laboratory, September 1993.

minimal contamination present in the top six inches; i.e. residual radioactivity is limited to surface soil. A direct method of assessment of compliance with Criterion 6 will be used in these areas. Clean up requirements for other radionuclides in terms of soil concentration are derived in Section 5 from the radium benchmark dose. These clean up requirements are then compared to measured or estimated concentrations in soil.

The development of the radium benchmark dose is described in Appendix B. The following sections summarize development of the benchmark dose.

4.3.1 SOURCE TERM

The radium benchmark dose was determined for a Ra-226 concentration in surface soil of 5 pCi/g with 5 pCi/g Pb-210.

4.3.2 EXPOSURE SCENARIO

A ranching exposure scenario was chosen for the site. The scenario and associated exposure pathways were established primarily from NRC guidance and evaluation.[7, 8] Values for exposure pathway parameters were chosen from either the same NRC guidance or evaluation, site specific or local information, or estimates from other applicable guidance.

4.4 RADIUM BENCHMARK DOSE (APPLICATION OF THE EXPOSURE SCENARIO)

The radium benchmark dose was determined as 18 mrem per year. A sensitivity analysis was completed for the radium benchmark dose and is described in Appendix B. The sensitivity analysis did not indicate that the radium benchmark dose is overly sensitive to any particular parameter.

[7] U.S. Nuclear Regulatory Commission (NRC), Final Report Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act, NUREG-1620, Revision 1, June 2003. (Appendix H)

[8] U.S. Nuclear Regulatory Commission, Commission Paper SECY 98 084, "Status of Efforts to Finalize Regulations for Radiological Criteria for License Termination: Uranium Recovery Facilities", April 15, 1998.

5 SOIL CLEAN UP REQUIREMENTS

Criterion 6 of Appendix A of 10 CFR 40 sets concentration limits for radium-226 in soil at 5 pCi/g in the top six inches. The criterion also specifies that concentrations of radionuclides other than radium-226 in soil must not result in a Total Effective Dose Equivalent (TEDE) that exceeds the dose from radium-226-contaminated soil at specific concentration limits. This dose from Ra-226 is referred to as the radium benchmark dose. The criterion further specifies that if more than one residual radionuclide is present, the sum of the ratios for each radionuclide of concentration present to the concentration limit will not exceed unity.

NRC guidance[9] recognizes two different approaches to application of the radium benchmark dose. The conventional approach is to use the radium benchmark dose to derive soil concentration limits and, as discussed later in the SRP, apply the unity rule to determine compliance at the site. This approach is the direct method of compliance with Criterion 6.

The alternate approach is to model the current or planned future conditions at the site, calculate the dose from the residual contamination, and compare the results to the radium benchmark dose in order to demonstrate compliance. This approach incorporates the unity rule inherently as it limits the peak dose to the radium benchmark dose. This approach may allow higher initial natural uranium, thorium-230, or radium-226 concentrations than the concentration limit approach, and as such does not expressly conform to the NRC guidance on limiting thorium-230 to a value that will not exceed the radium limit at the end of the planning period. This approach is an indirect method of compliance with Criterion 6.

5.1 SURFACE SOILS

Surface soil concentration limits (SCL) were developed from the radium benchmark dose (18 mrem/y) for natural uranium and thorium-230 in accordance with NUREG-1620, Appendix H. The exposure scenario and associated inputs and model described for the radium benchmark dose were applied independently to concentrations of natural uranium in soil and thorium-230 in soil. The radionuclide concentrations in soil for natural uranium and thorium-230 that result in 18 mrem/y for the same exposure scenario are 440 pCi/g and 507 pCi/g, respectively.

[9] U.S. Nuclear Regulatory Commission (NRC), Final Report Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act, NUREG-1620, Revision 1, June 2003. (Section H2.2.1)

Conventional application of the technical criteria includes consideration of the ingrowth of radium-226 from thorium-230 over a 1000-year design period, which would limit the thorium-230 SCL to 14 pCi/g [10]. However, given a 507 pCi/g Th-230 concentration limit derived from the radium benchmark dose and the potentially large area impacted by Th-230 above the 14 pCi/g limit and subject to potential clean up, ALARA considerations dictate that a slightly higher concentration limit for Th-230 is appropriate. Current Th-230 soils data (**Table 2-1**), indicate a Th-230 concentration of 30 pCi/g is more realistic remediation objective and is also protective of human health and the environment. An SCL Th-230 of 30 pCi/g will result in the clean up of surface soils near the evaporation ponds, but will preclude more widespread remediation of windblown areas for Th-230.

The uranium concentration in surface soils of the windblown area is much less than the SCL. In that regard it is reasonable to invoke ALARA by significantly lowering the SCL for natural uranium. Current U-238 soils data (**Table 2-1**) indicate a natural uranium SCL of 35 pCi/g (17 pCi/g as U-238) is a reasonable remediation objective. The NRC has previously cited this concentration as a soil contamination level generally acceptable for unrestricted release[11].

The SCLs and applicable soil clean up levels are listed in **Table 5-1**. The applicable soil clean up levels are determined by adding respective background concentrations (**Table 3-1**) to the SCLs; i.e., 39 pCi/g natural uranium (19 pCi/g as U-238), 33 pCi/g Th-230, and 7.5 pCi/g Ra-226. In areas where uranium and thorium are not present above background, the radium-226 soil clean up level will be used. In areas where uranium and thorium-230 are present, the soil clean up level will be considered in combination to ensure that the applicable concentration objective is met; i.e. the sum of ratios of radionuclide concentration to respective soil clean up level will not exceed one.

5.2 ALTERNATE RELEASE CRITERIA (ARC) FOR DEEPER CONTAMINATION

Areas of the site affected by mill operations or seepage from the evaporation ponds possess deep soil contamination. The concentrations of radionuclides in surface and subsurface soils exceed the soil concentration limits developed for the site. The Plan does not include remediation of these areas of deep contamination. These areas are targeted for cover placement

[10] NUREG-1620, Appendix H, Section H2.2.3, (3)

[11] Cunningham, R.E., USNRC: NMSS, Policy and Guidance Directive FC 83-23: Termination of Byproduct, Source, and Special Nuclear Licenses, November 4, 1983.

and release without further clean up. The alternate approach will be used to demonstrate compliance in each case. **Figure 1-3** depicts the areas of deep contamination at the RAM site.

5.2.1 EVAPORATION PONDS

The facility utilized seven (7) evaporation ponds immediately adjacent to the mill, in addition to another eleven ponds (Section 4 Ponds) located approximately one mile southeast of the facility (**Figures 1-2 and 1-3**). All of these ponds are anticipated to be included within the area of institutional control to be transferred to the Department of Energy or the State of New Mexico upon license termination. Evaporation Ponds 4 through 8 were unlined ponds, while the remaining ponds were constructed with a synthetic liner. All unlined ponds were permanently removed from service in 1983.

Removal of the pond sediments was initiated and as excavation of the pond material progressed, delays were encountered as a result of intercepting the artificial shallow water table in the vicinity of the unlined ponds. Activities associated with the ongoing groundwater corrective actions are maintaining a groundwater mound near the tailings management area. These corrective actions can create conditions within the unlined pond area that are unsafe and unworkable for employees.

Analytical results from soil samples collected in trenches excavated within the unlined ponds indicates that up to ten feet of material may still require excavation from the ponds in order to eliminate the residual radioactive materials. Twenty five years of pond usage created a zone of residual radioactive material below the unlined ponds. Residual radioactive material that is present in these zones are radium-226, thorium-230, and uranium. The presence of this material at depth provides a significant challenge to closing these ponds in a safe, efficient, and cost-effective manner and has prompted RAM to seek ARC for the evaporation pond areas. Additionally, these areas will be included in the institutional control area for the Long-Term Surveillance Program, and unrestricted access will not be allowed. Therefore, RAM believes that exposures to the public will be minimized by covering the ponds in place and using institutional controls to restrict access to these areas by the public.

5.2.2 JUSTIFICATION FOR ARC – EVAPORATION PONDS

RAM believes that ARC is appropriate for the evaporation pond areas for the following reasons:

- Dose modeling completed for Ponds 7 and 8 is described in **Section 8.8.2** and **Appendix C.** The modeling indicates that placement of a soil cover over the evaporation pond areas

without excavating the existing pond sediments will result in a radiation dose to the average member of the critical group of 7 mrem/y. The present and future land use in the area is expected to remain as marginal ranching; and based on this limited land use, the predominant exposure pathways would be expected to be limited to external gamma and inhalation. As an ALARA consideration, modeling was performed assuming that additional exposure pathways would be present even though the likelihood is very remote. Additional pathways that were addressed in the evaluation included plant ingestion, meat ingestion, soil ingestion and drinking water. Consistent with NRC evaluation, only the aquatic, milk, and radon pathways were not included in the modeling.

- Excavation of the residual radioactive material in Ponds 7 and 8, which is present at depths down to ten feet, will neither be technologically or economically feasible considering the existence of a shallow groundwater mound in the area. Excavation will result in creating a depression within each pond that will fill with water thereby making removal of the residual radioactive material impractical. RAM estimates that approximately 370,000 yd^3 of contaminated soils will have to be excavated and placed onto the top of Pond 3 and replaced with clean borrow material for a cost of approximately $2,200,000. This cost includes only the soil handling, and it does not include additional costs associated with additional cover and erosion protection for Pond 3 as a result of the increased volume of material at closure. There is no estimate of additional exposure and safety issues that may result from the excavation.

- The same dose model, except without the soil cover, indicates that leaving Ponds 7 and 8 in their current condition may result in a radiation dose of 81 mrem/y. The net reduction in dose due to excavating Ponds 7 and 8 is 74 mrem/y. The cost per unit dose is then determined as $30,000 per person-rem. This is more than ten times greater than the value NRC concedes as ALARA. The same result is found for the other evaporation pond areas since the cost estimates are based on the same unit cost parameters, and the dose modeling, other than source term and area, is based on the same exposure pathway model.

- RAM intends to close Ponds 7 and 8 in place by grading the existing contaminated soils within the ponds to create a consistent base for placement of no less than one foot of clean soil cover onto the ponds. It is estimated that 9400 yds^3 of contaminated sediments will be redistributed within the ponds and 24,000 yds^3 of clean soil would be placed on the ponds and contoured for final closure. The estimated cost is $190,000 for this option. The anticipated radiation dose to the average member of the critical group resulting from this closure scenario is presented in **Section 8.8.2** and **Appendix D.** Compared to the option of excavating all of the contaminated soils and moving them to Pond 3, RAM's plan saves

approximately \$2,000,000 and achieves an acceptable solution. Additional benefits not quantified here are reduced risk of injury and radiation dose to the construction worker.

- The same result is found for the other evaporation pond areas since the cost estimates are based on the same unit cost parameters and the dose modeling, other than source term and area, is based on the same exposure pathway model.

- Finally, the land area that encompasses the evaporation ponds will be included in the land transfer parcel to the U.S. Department of Energy upon license termination. Inclusion of this land area in the DOE transfer results in restricting public access to the area, thereby reducing or eliminating potential risks to public health and safety resulting from closure of the evaporation ponds.

5.2.3 OTHER AREAS OF POTENTIAL DEEP CONTAMINATION

There are other areas of potential deep soil contamination attributable to licensed activities. These areas include the areas adjacent to the unlined evaporation ponds, areas inaccessible due to on-going licensed activities, Pond 9, Section 4 Ponds, and the former Mill Area.

Remediation efforts that have occurred in some of these areas in the past have resulted in the excavation of over 500,000 cubic yards of contaminated soil, primarily resulting from windblown tailings. Although extensive reclamation efforts have been conducted in the affected area, there may still be a potential for some areas within the affected area to contain some residual radioactive materials.

RAM will re-evaluate the area at the time of final decommissioning of the site and ensure that any resultant exposure will be ALARA. This will be achieved by performing gamma surveys to delineate potentially contaminated areas, characterization of potentially contaminated areas to ascertain radiological concentrations via lab analysis, and revising dose modeling as necessary to determine potential exposure risk to individuals from site activities.

5.2.4 ARC METHODOLOGY

ARC will be used for areas of deeper soil contamination to demonstrate compliance with the regulatory criteria. A dose assessment will be completed for each area demonstrating that the contribution to the TEDE at the site is small. The dose assessment will be centered on the rancher scenario used to establish the radium benchmark dose. The exposure pathway modeling will be a deterministic analysis of the peak annual dose to the average member of the critical group for a rancher exposure scenario. The dose assessment will account for site-specific

information regarding the source term; critical group, scenario, and pathways identification and selection; the conceptual model; and calculations and input parameters.

The dose assessment will be developed in particular for the case of license termination. The dose assessment will be developed without consideration of any institutional controls and such that there is reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group is as low as is reasonably achievable.

The dose assessment will be completed solely with respect to dose received due to pathways related to residual radioactive material in subsurface soil. Several pathways are anticipated to not be included in the dose assessment. Some pathways will not be included because they are not applicable; e.g. drinking water. Other pathways will not be included because they cannot be considered directly by the conceptual model applied; e.g. exposure rate from the disposal cell.

The results of the dose assessment will be will be compared to the radium benchmark dose to evaluate compliance status. Dose assessments have been completed for Ponds 4 through 8 and the results are presented in Section 8.2. As soil characterization data become available, dose assessments for the Section 4 Ponds, mill area, and Ponds 9 and 10 will be developed as addenda to this Plan.

Table 5-1. Soil Concentration Limits and Clean up Levels for Radionuclides of Concern in Surface Soils

Radionuclide of Concern	Radium Benchmark Dose Soil Concentration pCi/g	Soil Concentration Limit pCi/g	Soil Cleanup Level[a] pCi/g
Natural Uranium	440	35	39[b]
Thorium-230	507	30	33
Radium-226	5	5	7.3

a – Soil Concentration Limit plus background concentration (Table 3-1)

b – Equivalent to 19.5 pCi/g U-238

6.0 GAMMA GUIDELINE VALUE

A correlation between gamma measurements and radium-226 concentrations was developed to identify areas requiring clean up during the Final Status Survey at the Ambrosia Lake site. Data used in the correlation were collected in areas representative of natural background and areas believed to be affected by windblown 11e.(2) material near the site. Areas affected by non-11e.(2) uranium mining waste and drainage were not included in the gamma correlation, because these locations will be identified using other criteria.

The data used to develop the gamma correlation are included in **Table 2-1** and identified as windblown/undisturbed and background samples, i.e., samples Komex-1 through Komex-50 and Komex-112 through Komex-121. These data, which included only the primary samples and did not include split or replicate samples from the same grid, are plotted in **Figure 6-1**. The samples were collected and analyzed using the procedures planned for the final status survey (Section 8). Sixty samples were included in the correlation development. A linear regression was carried out on the data that produced an adjusted r^2 value of 0.76. The best-fit line and the 95% prediction interval about the line are illustrated in **Figure 6-1**.

The soil clean up level for radium-226 is defined as the site background plus 5 pCi/g. The site background concentration was chosen as the upper 95% confidence limit of the mean of natural background Ra-226 concentration, or 2.3 pCi/g (**Table 3-1**). This background value yields a soil clean up concentration of 7.3 pCi/g. The horizontal line in **Figure 6-1** illustrates this radium-226 concentration. The gamma reading at which this radium-226 concentration intersects the lower prediction interval of the gamma-radium-226 correlation has been selected to be the gamma guideline level of 30,300 cpm. This intersection of the radium-226 concentration with the lower prediction interval conservatively establishes a low gamma guideline value.

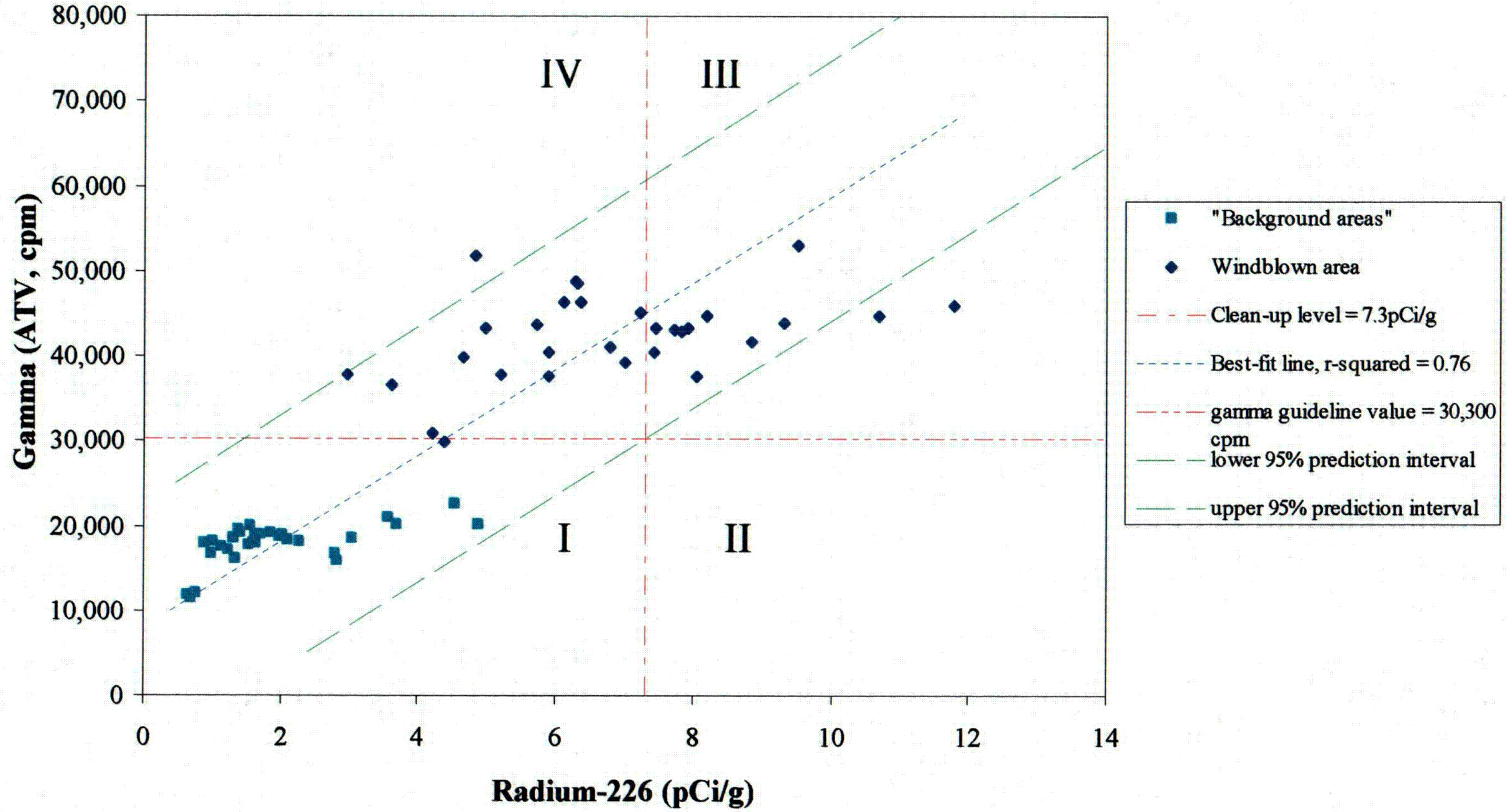
The lines formed on **Figure 6-1** by the gamma guideline level and the soil clean up concentration divide the figure into four quadrants. Soil grids having gamma readings below 30,300 cpm would not be identified for remediation. Samples that fall into quadrant I would be appropriately identified as having concentrations below the soil clean up level, whereas any samples that plot in quadrant II would be "false negative" samples that would not be identified for clean up, even though soil radium-226 concentrations would exceed the clean up level. However, when compared against the gamma guideline value, none of the samples yielded false negative results.

Soil grids with gamma readings above 30,300 cpm would be identified for remediation. Samples in quadrant III would be accurately identified as requiring remediation. However, samples in quadrant IV would be "false positive" samples.

Seventeen samples appear as false positives in **Figure 6-1** set; this number of samples represents 28% of the samples used in the correlation development and 57% of the samples from the undisturbed, windblown-affected area. This directly reflects the conservatism of the gamma guideline value. Samples Komex-12, Komex-112, and Komex-120 have radium-226 concentrations (7.2, 7.0, & 6.8 pCi/g, respectively) very close to the clean up level of 7.3 pCi/g. Also, a replicate sample of Komex-12 had a radium-226 concentration of 8.7 pCi/g (**Table 2-1**), a concentration that indicates this grid requires remediation. Thus, considering sampling and analytical error, it would be appropriate to identify these grids for remediation.

Samples Komex-3 and Komex-7 have relatively low radium-226 concentrations (3.6 and 4.9 pCi/g, respectively) compared to the other false-positive samples. These samples are located near areas that require remediation. Komex-7 is located only about 50 feet from Komex-10, which has a radium-226 concentration of 9.3 pCi/g; Komex-3 is located in an area between Komex-2 and Komex-4, which have radium-226 concentrations of 7.8 and 7.4 pCi/g, respectively. Thus, the relatively high gamma readings in these areas may be caused by contamination in adjacent grids, and it is appropriate to identify these grids for remediation.

The proposed gamma guideline value of 30,300 cpm is conservative because it does not result in any false negative values, demonstrating that this guideline will result in the identification of grids that require clean up. The guideline value identified essentially all grids in the correlation suspected of windblown contamination as requiring clean up. At low levels of contamination, samples from the windblown-affected area plot above the gamma guideline value (**Figure 6-1**). Thus, this gamma guideline value will result in contaminated grids being identified with confidence and conservatism, demonstrating that the soil clean up will be consistent with levels that are ALARA.



KOMEX

Figure 6-1. Ra-226/Gamma Correlation

Project No: D0295A

Date: 11/09/2004

File Name: 8x11 Landscape.ppt

FIGURE 6-1

C19

7 REMEDIATION STRATEGY

The remediation strategy for an area at the site is dependent on the applicable soil clean up requirements described in Section 5; i.e. surface soils or areas of deeper contamination. The remediation strategy for surface soils includes two techniques: removing the contaminated soil or reducing the concentration of radionuclides in the contaminated soil by mixing. The remediation strategy for areas of deeper contamination is to provide a physical cover for the area and applying institutional controls to restrict access.

7.1 SURFACE SOILS

Two techniques will be considered for remediation of surface soils: excavation and mixing. The two techniques are expected to be applied independently; i.e. they are not anticipated to be used together.

7.1.1 EXCAVATION

Excavation will consist of picking up contaminated soil and transporting it to the disposal cell. Excavation is expected to be limited to the top six inches of surface soil.

Excavation techniques for larger areas will include grading and/or scraping. The contaminated area may be graded to form windrows of surface soil that are subsequently picked up by scraper. Otherwise, the surface soil may be picked up directly by scraper. The excavated area will be contoured by grading as necessary after excavation to facilitate survey activities.

Excavation techniques for small areas will include grading and/or scraping. The surface soil of the contaminated area may be pushed into a pile that is subsequently picked up by bucket loader. Otherwise, the surface soil may be picked up directly by bucket loader. The excavated area will be contoured by grading or backfill with clean soil as necessary after excavation and successful surveys.

Pipelines that were used for transferring waste solutions that are outside of the footprint of the final disposal cell area will be excavated, surveyed to determine compliance with the clean-up criteria and backfilled in order to eliminate potential safety hazards.

7.1.2 SOIL MIXING

Soil mixing will be considered for areas where removal of contaminated soil is not reasonably achievable or would cause excessive risk to the safety of workers and/or citizens. Consideration will account for potential cost savings that could be a benefit, consistent with protection of the public health and safety and the environment.

The strategy for soil mixing is consistent with SECY-04-0035 [12]. Soil mixing will consist of intentional mixing of contaminated soil with underlying cleaner soil. Soil mixing is expected to be limited to the top six inches of surface soil.

The resultant footprint of the area containing the contaminated soil after soil mixing will not be greater than the original footprint of the area containing the contaminated soil attributable to licensed activities. Also, clean soil, from outside the footprint of the area containing the contaminated soil, will not be mixed with contaminated soil to lower concentrations.

Soil mixing techniques will be comparable to standard agricultural practices; e.g. disc or plow and/or harrow. The resultant area may be contoured by grading in order to facilitate final surveying.

7.2 AREAS OF DEEPER CONTAMINATION

Remediation of soils in areas of deep soil contamination will be accomplished by grading, covering, and restricting access. The area will be prepared by grading to provide a consistent base and uniform contours. Subsequently, no less than one foot of clean soil cover will be placed onto the area and contoured. Additionally, institutional controls provided as a part of the long-term site maintenance will afford an additional level of protection.

The grading and placement of cover will be completed using standard construction equipment and practices. Institutional controls will include deed of property to Department of Energy, fencing, signage, and monuments.

[12] "Results of the License Termination Rule Analysis of the Use of Intentional Mixing of Contaminated Soil", March 1, 2004.

8 FINAL STATUS SURVEY PLAN

This section describes the plan for conducting the Final Status Survey (FSS) at the site. The objective of the final status survey plan described here is to demonstrate that the final condition of the site satisfies the requirements of 10 CFR 40 Appendix A Criterion 6(6).

8.1 SURFACE SOILS

8.1.1 SURVEY DESIGN

8.1.1.1 Identification of windblown areas

The area subject to the FSS is shown as the area of surface soil contamination in **Figure 1-3.** The rationale for the boundary of areas within the scope of the FSS is provided in Section 2 and Section 3.

8.1.1.2 Radionuclides of Concern

The radionuclides of concern in the surface soils are identified in Section 2 as natural uranium, thorium-230, and radium-226.

8.1.1.3 Clean up Requirements

Soil clean up levels were determined in Section 5 to be 39 pCi/g natural uranium (19 pCi/g U-238), 33 pCi/g thorium-230, and 7.3 pCi/g radium-226.

8.1.2 SURVEY TECHNIQUES (INSTRUMENTS AND PROCEDURES)

Instruments and procedures used to generate data during the surveys can be placed into two categories commonly known as scanning surveys and soil sampling. These survey techniques will be combined in an integrated survey design.

8.1.2.1 Instrumentation

Instrumentation utilized for scanning and measurements will be calibrated and maintained in accordance with written procedures. These procedures utilize the manufacturers' guidance. Portable instruments are calibrated on an annual frequency or as required due to maintenance.

Specific requirements for instrumentation include traceability to NIST standards, daily checks for operability, daily performance checks of background and source, operation of instruments within established environmental bounds (e.g. temperature), training of individuals, calibration with radiations of energies similar to those to be measured, quality assurance tests, data review, and recordkeeping. Where applicable, activities of sources utilized for calibration are also corrected for decay. All calibration and source check records are completed, reviewed, and retained in accordance with quality assurance requirements.

8.1.2.1.1 Scanning Surveys

Land areas will be scanned for gross gamma radiations. The type of instrument used for scanning and typical performance characteristics are provided in **Table 8-1**.

8.1.2.1.2 Soil Sampling

Samples of soil will be collected and analyzed for the radionuclides of concern, as applicable. The analysis technique and typical detection limit for each radionuclide of concern is provided in Table 8-2.

8.1.2.2 Procedures

RAM will conduct survey activities and tasks in accordance with approved written procedures. The written procedures have been or will be prepared, reviewed, revised, approved and implemented in accordance with the facility source material license condition #14 and #16.

8.1.2.2.1 Scanning Survey

The scanning survey will be completed using a NaI(Tl) radiation detector coupled to a handheld scaler/ratemeter. Measurements will be collected by keeping the detector approximately eighteen (18) inches of ground surface while walking or driving over the area at a rate comparable to a casual walk. The measurements will be made along straight line paths between opposite borders of the area being surveyed. The distance between the paths will be approximately six (6) feet.

The scaler/ratemeter will be coupled to global positioning system (GPS) equipment and a data logger. A gamma measurement from the scaler/ratemeter and a location from the GPS will be recorded approximately every two seconds. The gamma measurement will be recorded as

counts per minute. The location will be recorded with respect to the reference coordinate system described in Section 8.3.

8.1.2.2.2 Soil Sampling

Soil samples will be collected in a known and consistent fashion, and with respect to the location reference system used for the scanning survey. Soil plugs will be collected from five evenly spaced locations across a 100m² grid. The soil plugs will be collected from the top six inches of soil. The five plugs from a six inch layer will be combined to create one composite soil sample.

Sample collection activities will also include documentation of sampling activities on a field log, decontamination of equipment between sample locations, and collection of replicate samples at a rate of one per 10. Chain-of-custody procedures will be applied beginning at the time of sample collection.

The composite soil samples will be prepared in a known and consistent manner for laboratory analysis. The preparation will include removing rocks and vegetation, drying (if needed), crushing, and mixing/blending. The preparation concludes with placement of the prepared soil in a container and labeling the container. Sample preparation will include splitting the sample as necessary to support analysis by radiochemistry and/or gamma spectrometry.

Sample preparation will also include documentation of preparation activities in a laboratory log, decontamination of equipment between samples, and creation of duplicate samples at a rate of one per 10. Chain-of-custody will be maintained during sample preparation.

The prepared samples will be stored indoors. The manner of storage will include an inventory system and access to allow convenient retrieval according to the sample's unique identification. Chain-of-custody will be maintained during sample storage.

Prepared samples requiring analysis for the radionuclides of concern will be shipped to an offsite laboratory. Chain-of-custody will be maintained during sample analysis. Upon termination of reclamation activities, stored samples will be disposed..

8.1.3 REFERENCE COORDINATE SYSTEM

A reference coordinate system will be used to facilitate identification of measurement and sampling locations, and to provide a mechanism for relocating a survey point. Land area scanning surveys and soil sample locations will be referenced to the New Mexico State Plane

(NAD 27 horizontal). Additionally, a site origin has been established as Easting 493500 and Northing 1593000 for the main facility area. A coordinate system for the Section 4 Pond area will also be established.

8.1.4 BACKGROUND RADIOACTIVITY

The site specific background concentrations in soil for the radionuclides of concern and the gamma scan are described in Section 3.2.

8.1.5 SURVEY DESCRIPTION AND MEASUREMENT EVALUATION

8.1.5.1 Scanning Survey

A scanning survey will be completed for all of the windblown area. The scanning survey data will be comprised of historical survey data and scanning survey data collected following remediation of contaminated areas.

8.1.5.1.1 Scanning Survey Description

The instrumentation and procedures for the scanning survey are described in Section 8.1.2.

8.1.5.1.2 Scanning Survey Measurement Evaluation

The scanning measurements will be averaged for each 100 m^2 grid. The scanning average value will be compared directly to the gamma guideline value. If the scanning average value is less than or equal to the gamma guideline value, no further scanning survey will be made of the grid. If the scanning average value is greater than the gamma guideline value, the failed grid and each surrounding grid will be remediated and another gamma scan performed.

Additionally, the number of individual survey readings in each grid will be determined. Grids not meeting the scanning density of 10 readings per grid will be subjected to additional scanning survey.

A tabular and graphic record will be compiled describing the scanning survey results relative to the gamma guideline value, remediation, and subsequent scanning survey results.

8.1.5.2 Soil Sampling

Soil sampling will be completed after evaluation of the scanning survey.

8.1.5.2.1 Soil Sampling Description

Remediation control soil sampling may be conducted to support scanning survey evaluation.

Final status survey soil sampling will be completed for two percent of the 100 m^2 grids contained within the windblown area. The locations of the final status survey soil samples will be chosen from areas where the scanning survey results are nearest the gamma guideline value. Areas that were remediated based on evaluation of scanning survey results will also be considered preferentially.

The instrumentation and procedures for remediation control and final status survey soil sampling are described in Section 8.1.2.

8.1.5.2.2 Soil Sampling Measurement Evaluation

The soil sample result will be compared to clean up levels such that the sum of the ratios for the concentration of each radionuclide of concern to the respective concentration limit will not exceed "1" (unity). If the sum of ratios is less than or equal to one, no further measurement or evaluation will be made of the 100 m^2 grid. If the sum of the ratios exceeds unity, the grid and every adjacent grid will be remediated and re-sampled.

A tabular and graphic record will be compiled describing the initial soil sample results, remediation, and subsequent soil sample results.

Results of characterization sampling and remediation control sampling of soils may be incorporated into to the final status survey data set.

If the number of failed 100 m^2 grids is greater than five per 100 the gamma guideline value will be re-evaluated and adjusted downward.

8.1.6 QUALITY ASSURANCE AND QUALITY CONTROL

RAM will implement a quality system to ensure that the final status survey decisions are supported by sufficient data of adequate quality and usability for their intended purpose, and further ensure that such data are authentic, appropriately documented, and technically defensible.

8.1.6.1 Quality assurance project procedure

A written quality assurance project procedure (QAPP) will be developed for the final status survey effort. The QAPP will be developed using a graded approach. The graded approach will base the level of control on the intended use of the results and the degree of confidence needed in their quality. The QAPP will describe the QA/QC requirements regarding survey planning, survey implementation, and results evaluation.

8.1.6.2 Data assessment

Assessment of the final status survey data will be made to determine if the data meet the objectives of the surveys, and the whether the data are sufficient to determine compliance with the soil concentration limits. The assessment will consist of three phases: data verification, data validation, and data quality assessment.

8.1.6.2.1 Data Verification

Data verification efforts will be completed to ensure that requirements stated in planning documents are implemented as prescribed. Identified deficiencies or problems that occur during implementation will be documented and reported. Activities performed during the implementation phase will be assessed regularly with findings documented and reported to management. Corrective actions will be reviewed for adequacy and appropriateness and documented in response to the findings. Data verification activities are expected to include inspections, QC checks, surveillance, and audits.

8.1.6.2.2 Data Validation

Data validation activities will be performed to ensure that the results of data collection activities support the objectives of the surveys, or support a determination that these objectives should be modified. The data validation effort will include use of the following data descriptors:

- Reports to Decision Makers of data, changes to the survey plan, and results of verification.
- Review of documentation including field records, laboratory records, and data handling records.
- Selection and use of appropriate analytical methods and associated detection limits.
- Review of data to assess data quality in terms of completeness with respect to field and laboratory data quality requirements.

- Assessment will be made of data quality indicators to determine data usability. The data quality indicators to be assessed include precision, bias, accuracy, representativeness, comparability, and completeness.

8.1.6.2.3 Data quality assessment

An assessment of data quality will be performed to determine if the data are of the right type, quality, and quantity to support their intended use. The assessment will include review of relation between survey objectives and design; an evaluation of the data using basic statistical and graphical representations, and quality assurance reports; selection of statistical tests; verifying assumptions of statistical tests; and performing the statistical tests and drawing conclusions with respect to the survey plan objective.

8.2 AREAS OF DEEPER CONTAMINATION

Seepage from evaporation ponds and areas adjacent to the tailings area has resulted in deep soil contamination. These areas are targeted for cover placement and release without further clean up by application of ARC. The adequacy of ARC for closure of the evaporation ponds (and other areas of deep soil contamination) will be demonstrated by comparing results of site specific dose modeling to the benchmark dose. Dose modeling completed for the unlined evaporation ponds is provided in this section. Dose modeling for other areas of potential deep soil contamination (the Section 4 Ponds, mill area, and Ponds 9 and 10) will be provided as additional soil characterization data becomes available.

8.2.1 CHARACTERIZATION REQUIREMENTS

An adequate characterization of existing or anticipated contamination for each area is necessary to provide a description of the source term for use in constructing a dose assessment relative to planned future conditions. Characterization data for the unlined evaporation ponds are described in Section 2.

Sampling is required to define the horizontal and vertical extent and concentration of contamination for each area to develop a radionuclide-specific source term for any given dose assessment. As a conservative measure to offset uncertainties related to site characterization, the maximum concentrations of RoCs from exiting sampling data have been utilized in the dose modeling for evaporation ponds 4 through 8 (Appendix C).

Existing characterization data may be used to develop the sampling requirements for areas of deep soil contamination. The net number of samples needed is the total sampling requirement less the existing number of samples already collected. In cases where no characterization data exists, the sampling requirements may be estimated from data for like areas or selected based on professional judgment. For purposes of the FSS, if no data are available, 30 samples will initially be collected for characterization purposes.

The sample locations may be chosen randomly or placed on a systematic grid with a random starting location. Professional judgment via visual and/or empirical examination of borehole logs will be used to identify the vertical extent of contamination. Subsequently, sample locations will be chosen randomly based on the depth of contamination and the areal boundary.

8.2.2 DOSE ASSESSMENTS

The strategy outlined above and expanded upon in Section 5.2 has been applied to two distinct geographic areas containing deep soil contamination: 1) Ponds 4, 5, & 6, and 2) Ponds 7 & 8 (**Figures 1-2 and 1-3**). The model used in the radium benchmark dose assessment was used as a starting point for the dose assessment of each area. Changes were made to the model to reflect the anticipated final condition of each area; e.g. cover placement. Finally, a dose assessment was completed for each area and the dose compared to the radium benchmark dose as a demonstration of compliance.

8.2.2.1 Dose Assessment for Ponds 4, 5, and 6

As a conservative measure, the radionuclide source term was assumed to be the maximum concentration for Ra-226, Th-230, and U-238 from the characterization data presented in Section 2. The contaminated area was modeled as equivalent to the entire area of Ponds 4, 5, and 6. Also, a cover of one foot of clean soil was placed over the entire area of Ponds 4, 5, and 6. Otherwise the dose assessment included the same parameters and inputs as the radium benchmark dose. A complete description of the dose assessment for Ponds 4, 5, and 6 is provided in Appendix C.

The dose assessment was performed to compare the residual radioactivity in subsurface soils of evaporation Ponds 4, 5, and 6 to the radium benchmark dose limit of 18 mrem per year. The result of the dose assessment was 11 mrem per year. This value is less than the radium benchmark dose; i.e. from application of the site specific soil concentration limits.

8.2.2.2 Dose Assessment for Ponds 7 & 8

As a conservative measure, the radionuclide source term was assumed to be the maximum concentration for Ra-226, Th-230, and U-238 from the characterization data presented in Section 2. The contaminated area was modeled equivalent to the entire area of Ponds 7 & 8. Also, a cover of one foot of clean soil was placed over the entire area of Ponds 7 & 8. Otherwise the dose assessment included the same parameters and inputs as the radium benchmark dose. A complete description of the dose assessment for Ponds 7 & 8 is provided in Appendix D.

The dose assessment was performed to compare the residual radioactivity in subsurface soils of evaporation Ponds 7 & 8 to the radium benchmark dose limit of 18 mrem per year. The result of the dose assessment was 11 mrem per year. This value is less than the radium benchmark dose; i.e. from application of the site specific soil concentration limits.

8.2.3 SUMMARY AND ARC COMPLIANCE DEMONSTRATION

Based on the results of dose modeling presented above, closure of the unlined evaporation ponds via cover placement and release without further clean up is appropriate and protective of human health and the environment. Results of this dose modeling, in conjunction with practical and ALARA considerations described in Section 5.2, demonstrate that the application of ARC for areas of deep soil contamination is justified and appropriate.

Table 8-1. Identification Of Radiation Detection Instruments For The Final Status Survey

Measurement	Instrumentation Detector Meter		Background[a] (cpm)	Detection Sensitivity
Scanning Survey	2" x 2" NaI(Tl) Ludlum Meas., Inc., Model 44-10	Scaler/ratemeter, Ludlum Meas., Inc., Model 2221.	18000	21000 cpm[b], 2.6 pCi/g, Ra-226[c]

[a] An average value derived from gamma scans of background soil sample locations: see Section 3.

[b] Minimum detectable count rate determined in accordance with NUREG-1575 at page 6-40.

[c] Refer to Figure 6-1 (gamma correlation) for Ra-226 concentration at minimum detectable count rate of 21000 cpm.

Table 8-2. Identification Of Radioanalytical Methods For Final Status Survey

Radionuclide Of Concern	Analytical Method	Detection Limit[a], (pCi/g)
Natural uranium	gamma spectrometry via Th-234 and Pa-234^{m}	15
	Natural uranium activity will be determined from U-238 activity by assuming activity ratios of U-238/U-235/U-234 = 0.489 /0.022 /0.489	
Thorium-230	alpha spectrometry	1
Radium-226	gamma spectrometry via in-growth of radon	0.5

[a] Maximum values

9 NON-RADIOLOGICAL HAZARDOUS CONSTITUENTS

Based on historical site operations and the available data, significant concentrations of non-radiological hazardous constituents are not expected to exist at the site. A small quantity of organic contaminated soils may be present within the mill area as a result of the solvent extraction circuit operation. This material is classified as byproduct material and will be disposed within the disposal area prior to construction of the radon attenuation barrier. Nonetheless, various control measures are in place to ensure that such hazards are addressed. For example, RAM has submitted applications for Alternate Concentration Limits (ACLs) to the NRC that address non-radiological constituents in groundwater. RAM also possesses EPA NPDES discharge permits designed to minimize the impacts of non-radiological constituents to surface water. Finally, the area of the site transferred to the U.S. Department of Energy and subject to long–term monitoring and surveillance will possess controls (e.g. fencing, placarding) designed to limit public access and prevent exposure to any non-radiological constituent.

10 DECOMMISSIONING COST ESTIMATE AND SURETY FUND

The following decommissioning cost estimate and surety fund information is based primarily upon RAM's surety renewal estimate provided to the NRC in June 2004. RAM will be revising this cost estimate as requested by the NRC in their July 28, 2004 RAI. A summary of the estimated soil decommissioning cost is provided in Table 10-1.

10.1 EVAPORATION PONDS

This section describes the current status and costs associated with all of the lined and unlined evaporation ponds at the site. Soil decommissioning costs for the evaporation ponds are summarized in Table 10-1.

10.1.1 UNLINED EVAPORATION PONDS

These ponds operated from 1957 until the early 1980's as the primary liquid effluent disposal areas for the mill. After dewatering, these ponds were excavated to remove the primary Ra-226 contamination. Characterization data indicate that there is deeper contamination of Th-230 that exceed safe excavation depth. These ponds have been closed and backfilled to grade to prevent any windblown contamination from the pond bottoms. The intent is to close these ponds using alternate release criteria within the site LTSM boundary. The status and soil decommissioning costs for the unlined ponds are summarized below:

- Pond 4 – Four to five feet of pond soils have been excavated and disposed into the Pond 3 disposal area. The pond has been backfilled to grade with soils obtained from the borrow area. The work unit cost estimates remaining are the labor and equipment costs, radiation safety, and revegetation expenses to complete the final contour and stabilize the surface.

- Pond 5 – Four to five feet of pond soils have been excavated and disposed into the Pond 3 disposal area. The pond has been backfilled to grade with soils obtained from the borrow area. The work unit cost estimates remaining are the labor and equipment costs, radiation safety, and revegetation expenses to complete the final contour and stabilize the surface.

- Pond 6 – Four to five feet of pond soils have been excavated and disposed into the Pond 3 disposal area. The pond has been backfilled to grade with soils obtained from the borrow

area. The work unit cost estimates remaining are the labor and equipment costs, radiation safety, and revegetation expenses to complete the final contour and stabilize the surface.

- Pond 7 – Excavation has been completed, and the surface has been re-contoured to grade, mulched and seeded. The work unit cost remaining covers any future reseeding and radiation surveys for final characterization.
- Pond 8 - Excavation has been completed, and the surface has been re-contoured to grade, mulched and seeded. The work unit cost remaining covers any future re-seeding and radiation surveys for final characterization
- Reclamation of Soil Borrow Areas – The locations of the borrow sites will be reclaimed, top-soil placed, and re-vegetated. There are two principle soil borrow areas. One to the north on Section 30 and one to the east of Pond 8.

10.1.2 LINED EVAPORATION PONDS

This section covers the lined evaporation ponds that are located near the tailings disposal areas, Pond 9, and the former Pond 10. Also included are the costs associated with the closure of the interceptor trench system associated with the groundwater corrective action program. The status and soil decommissioning costs of these items are summarized below:

- Pond 9 – This active disposal area was used almost exclusively for handling groundwater captured through the interceptor trench system. The plan for closure of Pond 9 includes the dewatering of the sediments, removal of the liner and sediments, and placement of these materials at the base of the main intercept trench. Costs associated with this work include the clean-up of contaminated soils, contouring of the former pond area, radiation safety, soil sampling, QA/QC, and revegetation.
- Pond 10 – This former lined evaporation pond has been reclaimed, and the work unit costs are associated with the characterization of the soils, additional cleanup of hot spots, contouring, radiation safety, and revegetation.

10.1.3 SECTION 4 LINED PONDS (11-21)

The Section 4 ponds are located southeast of the mill facility (Figure 1-2). These ponds were constructed in the late 1970's and early 1980's and constitute the primary liquid effluent disposal area for the facility. These ponds occupy about 256 acres and contain approximately 1,230,000 yards of materials. Under the anticipated closure approach, Ponds 11-21 will be

dewatered and relocated by truck haul to Impoundment 2. The material will be consolidated and compacted. Following relocation, the area will be verified clean, contoured and revegetated. The following costs for Section 4 Pond soil decommissioning are based upon contractor bids:

- Contaminated soil cleanup – This work includes the cleanup of soils contaminated by the operations of the Section 4 ponds and the cost for delineation and verification.
- Placement and contouring – This work includes labor and equipment for the placement of rock, contouring and armoring of discharge channels and QA/QC.
- Revegetation – This work includes soil stabilization of the area where former Ponds 11-21 were located and other disturbed areas related to the closure of the lined ponds. Costs cover labor and equipment, seed, mulch, and QA/QC.

10.2 WINDBLOWN AND TAILINGS-CONTAMINATED MATERIAL

This section describes the current status and costs associated with windblown and tailings-contaminated materials at the site. These areas are located north, south and east of the tailings areas and the areas adjacent to the unlined and lined evaporation ponds (Figure 1-3). The status and soil decommissioning costs associated with these areas are summarized below and in Table 10-1:

- Section 30 area – Complete.
- Section 5 area – Complete.
- Section 32 and area north of Pond 9 – Complete.
- Windblown areas – Re-surveys of previously released areas and areas re-contaminated by recent activities (e.g. windblown sediments from unlined ponds). This also includes the work for the development of background conditions and release levels. Cost includes labor and equipment, radiation safety, surveys, sampling, and QA/QC.
- Areas immediately north and east of Impoundment 1 – These areas are currently too wet to cleanup as a result of ongoing licensed activities (e.g. groundwater CAP surface discharges). The costs associated with this work include labor and equipment, radiation surveys, disposal, re contouring to grade.
- Soil verification – Gamma surveys and confirmatory soil sampling of prior cleanup. Costs include labor and equipment to conduct gamma surveys, sampling, and QA/QC.

- Revegetation of disturbed areas – Upon completion of the cleanup and verification, the disturbed areas will be re-vegetated. Costs include labor and equipment, mulch, seed and verification.

10.3 MILL DECOMMISSIONING

This work includes the cost to demolish the mill and associated buildings and dispose of the residual material into the designated disposal areas. Costs are based on current contractor quotes to conduct the work. Soil decommissioning costs associated with the mill are summarized in Table 10-1 and do not include any salvage value:

- Soil cleanup and verification – As per the tailings contaminated area, but limited to the mill area.
- Contouring and vegetation – Re-contouring of the former mill location and vegetation to provide surface stability.

10.4 OTHER COSTS

Other costs associated with soil decommissioning include site management, overhead and profit, and contingency margin. These costs are summarized in Table 10-1 and include the following:

- Site management – Estimated cost for the administration of the reclamation program at the site. Based on actual costs for the site.
- Overhead and profit – Contractor overhead and profit estimated at 10% of labor and expenses.
- Contingency – Estimated at 15% of all costs.

Table 10-1. Soil Decommissioning Cost Estimate.

			WORK UNIT	Estimated Cost ($000)
A			**EVAPORATION PONDS**	
	1		**Contour and/or Cover Unlined Ponds**	
		a	Pond 4 (final contour and re-seeding)	67
		b	Pond 5 (final contour and re-seeding)	66
		c	Pond 6 (final contour and re-seeding)	66
		d	Pond 7 (re-seeding)	12
		e	Pond 8 (re-seeding)	13
		f	Reclamation of Soil Borrow Sites	140
			Un-Lined Evaporation Ponds Sub-Total	364
	2		**Lined Ponds**	
		a	Pond 9	585
		b	Pond 10	40
			Lined Evaporation Ponds Closure	625
	3		**Section 4 Ponds (Lined Evaporation Ponds 11-21)**	
		c	*Contaminated Soil Cleanup*	902
		f	Placement and contouring	104
		g	Revegetation	236
			Section 4 Ponds Sub-Total	1,242
			SUB-TOTAL (Evaporation Ponds)	**2,231**
B			**Clean Up Tailings Contaminated and Windblown Material**	
	1		Section 30 Area	Complete
	2		Section 5 Area	Complete
	3		Sec. 32 & Area N. of Pond 9	Complete
	4		Additional Survey	100
	5		Area N. and E of Pond 1	100
	6		Soils verification	115
	7		Re-vegetation of disturbed areas	150
			SUB-TOTAL (Windblown)	**465**
C			**Mill Decommissioning**	
	1		Soils Cleanup and verification	100
	2		Contouring and vegetation	200
			SUB-TOTAL (Mill Decommissioning)	**300**

Table 10-1. Soil Decommissioning Cost Estimate.

			WORK UNIT	Estimated Cost ($000)
D			Site Management	1,352
			Subtotal Direct Costs - Soil Decommissioning	4,348
E			Overhead and Profit at 10%	300
F			Contingency at 15%	697
			Total Closure Costs	5,345

APPENDIX A

COMPACT DISK CONTAINING SITE SOILS DATABASE

Notes on AmbrosiaSoils.mdb

1. All data were entered using the as-reported units. Most concentration units are pCi/gram and inches, but there are some instances of mg/kg and feet.

2. Query "qryAllData" provides a flat-file listing of the data used for the soil decommissioning plan report. The field "Historic Data Sample," if checked, indicates that the sample results were of sufficient quality for purposes of site characterization, but the data could not be used to develop a reliable gamma guideline value (correlation) or for purposes of background soil concentration development. These data are believed to be unreliable because the results were displayed significant and unacceptable variability for samples analyzed by multiple laboratories that used differing analytical procedures and methodologies.

3. Query "qryKomexGamma_Radium_Crosstab" was developed to calculate the gamma/Ra-226 ratio. The query "qryKomexGamma_Radium" is the source for the crosstab query. Concentration units are not listed in the crosstab query, but the units (as shown in the source query) are pCi/g and cpm. The crosstab query does not report below-detection-limit values, but there were no below-detection-limit values reported for the samples used in the crosstab query.

4. Query "qryEvapPondSoilsData" is the source query for the crosstab queries for evaporation ponds 4, 5, 6, 7, and 8. Units are not listed in the crosstab queries, but are shown in the source query. No below-detection-limit values were reported for the samples used in the crosstab queries.

APPENDIX B

RADIUM BENCHMARK DOSE AND SENSITIVITY ANALYSIS

DEVELOPMENT OF RADIUM BENCHMARK DOSE

Radioactive materials have been processed, used, and/or stored at RAM Ambrosia Lake facility ("the site") since 1958. Some soils on site are contaminated with radioactive material. The technical criteria for clean up of contaminated soil are provided in 10 CFR 40[12]. The technical criteria may be summarized as: 1) the concentration of radium-226 in surface soil does not exceed the background concentration by more than 5 pCi/g; and 2) concentrations of radionuclides other than radium-226 in soil must not result in a total effective dose equivalent (TEDE) exceeding the dose from clean up of radium contaminated soil to the aforementioned criteria (benchmark dose). The TEDE is applied against an average member of a group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances.

Exposure pathway modeling was used to calculate the radium benchmark dose. Exposure pathway modeling is an analysis of various exposure pathways of a given exposure scenario used to convert concentration of radioactive material in the source media into dose to a receptor.

The exposure pathway modeling completed here was a deterministic analysis of the peak annual dose to the average member of the critical group for a rancher exposure scenario. The radium benchmark dose accounted for site-specific information regarding the source term; critical group, scenario, and pathways identification and selection; the conceptual model; and calculations and input parameters.

SCOPE OF RADIUM BENCHMARK DOSE

The radium benchmark dose was developed in particular for the case of license termination. The radium benchmark dose was developed without consideration of any institutional controls. Therefore, there is reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group is as low as is reasonably achievable.

The development of the radium benchmark dose was completed solely with respect to dose received due to pathways related to residual radioactive material in surface soil. There were several pathways not included in the development of the radium benchmark dose. Some

[12] 10 CFR 40, Appendix A, Criterion 6, item (6).

pathways were not included because they are not applicable; e.g. drinking water. Other pathways were not included because they cannot be considered directly by the conceptual model applied to develop the radium benchmark dose; e.g., exposure rate from the disposal cell. These and other pathway exceptions are discussed in a following section of this Appendix.

Figure 1-3 of the Soil Decommissioning Plan shows the area to which the radium benchmark dose is applicable (surface soil contamination).

SOURCE TERM

CONFIGURATION

The radionuclides that have the potential to contribute the dose against which the dose limit criteria are compared are identified as the constituents of concern (CoC). The CoCs are specifically evaluated for the development of site-specific benchmark dose. The CoCs were determined to be radium-226 and lead-210.[14]

The source term is assumed to be uncovered contaminated soil of cylindrical shape. **Figure B-1** depicts the soil zones. The contaminated soil is modeled as a 0.15-meter thick zone of unconsolidated soil. The contaminated soil is underlain by one uncontaminated unsaturated soil zone; this zone is modeled as an 8-meter thick zone of alluvium (unconsolidated soil). The next zone is an uncontaminated saturated zone; this zone is modeled as the uppermost bedrock and is independent of thickness.

RESIDUAL RADIOACTIVITY

The CoCs are assumed homogenously distributed within the contaminated soil at concentrations of 5 pCi/g for each of Ra-226 and Pb-210.

CHEMICAL FORM

In an effort to quantify the mobility of the CoCs in soil at the site, a distribution coefficient (K_d) was selected for each of the soil units in the model. Description of the selection and application of each K_d is provided Attachment B1.

[14] U.S. Nuclear Regulatory Commission. Draft Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act. Revision 1. NUREG-1620. June 2003. (sections H2.1.1 & H2.1.3(2)(b))

CRITICAL GROUP, SCENARIO, AND PATHWAYS IDENTIFICATION AND SELECTION

SCENARIO IDENTIFICATION

The exposure scenario applied here may be described as representing a local rancher. The rancher scenario accounts for exposure involving residual radioactivity that is initially in the surface soil. A rancher periodically is present on the site and retrieves some of his diet from the site. The scenario assumes no disturbance of the disposal cell (this qualification is discussed later). The scenario is based on reasonable assumptions that tend to underestimate potential dose.

CRITICAL GROUP DETERMINATION

The average member of the critical group is the rancher. This individual is assumed to be an adult with common habits and characteristics. This individual is reasonably expected to receive the greatest exposure to residual radioactivity for the applicable exposure scenario.

EXPOSURE PATHWAYS

The starting point for exposure of the critical group to the CoCs is the contaminated soil zone. The CoCs are assumed released from the soil by erosion, plant uptake, direct ingestion, infiltration, and leaching. The CoCs may also be transported to or by groundwater to eventually be released from soil. The scenario also considers exposure to direct gamma radiation emitted by the CoCs.

The primary exposure pathways include:

- External exposure from soil;
- Inhalation of suspended soil;
- Ingestion of soil;
- Ingestion of plant products grown in contaminated soil; and
- Ingestion of animal products grown onsite using feed and surface water from potentially contaminated sources.

The exposure pathways selected for evaluation are listed in **Table B-1**. Three exposure pathways not included in the dose assessment are groundwater usage, intrusion of the disposal cell, and radon; each is discussed below.

Groundwater Usage

Potential utilization of groundwater in the Ambrosia Lake area can be divided into two categories: (1) irrigation and (2) domestic/stock watering. Neither irrigation nor domestic stock watering wells in the vicinity of the site are completed in the uppermost bedrock units. The uppermost bedrock units in the vicinity of the tailings impoundment are not capable of providing sufficient water for use because these bedrock units have been essentially dewatered downgradient of the Facility due to drainage by the numerous vent holes and mine shafts, and reduced seepage from tailings following reclamation. Historically, groundwater supply wells were not completed in the uppermost bedrock hydrogeologic units in the vicinity of the Facility because these units were only partially saturated in this location near the outcrop.[14]

Neither irrigation nor domestic stock watering wells in the vicinity of the site are competed in the Alluvium. The Alluvium is not capable of providing sufficient water for use because it is not saturated anywhere except in the vicinity of the site and the U.S. DOE tailings impoundment. Groundwater corrective action compliance and license termination was obtained by the DOE at the Ambrosia Lake site through the application of Supplemental Standards, demonstrating that the Alluvium is not, and never was, an aquifer because of limited yield.[15]

Localized areas of groundwater at the Site have been created by recharge from existing surface sources or man-made subsurface reservoirs such as utility trenches and foundation backfill areas. Once these features are removed during reclamation, these groundwater sources will disappear, thereby precluding any water pathways.

In the context of the previous description, there exists a reasonable assurance that there is no direct groundwater or surface water usage pathway, especially drinking water, resulting in exposure to CoCs at the Site.

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[14] "Corrective Action Program and Alternate Concentration Limits Petition for Uppermost Bedrock Units, Ambrosia Lake Uranium Mill Facility Near Grants, New Mexico", prepared for Quivera Mining Company by AVM Environmental Services, Inc. and Applied Hydrology Associates Inc., February 15, 2000.

[15] "Application for Alternate Concentration Limits in the Alluvial Materials at the Quivera Mill Facility Ambrosia Lake, New Mexico", prepared for Quivera Mining Company by MAXIM Technologies Inc., May 2001.

Cell Intrusion

Development of the radium benchmark dose did not consider failure of the cell's engineered cover system. Inadvertent intrusion into the cell is very unlikely. Because the outermost layer of the cover system is rip-rap (i.e. not a vegetative cover), it is not reasonable to assume it a surface conducive to placement of a structure. Finally, the cover system is designed such that erosion by surface water, resulting in exposure of a resident to the cell contents either directly or from redistribution by surface water, will not be a threat.[16]

Deliberate intrusion into the cell was not considered during development of the radium benchmark dose. Such an event implies that the intruder knows of the potential hazards but deliberately chooses to ignore them. Deliberate intrusion into the cell cannot reasonably be protected against and so is not considered further.[17]

Radon

The radon pathway was not considered because it is specifically excluded from the scope of the technical criteria.[18]

CONCEPTUAL MODEL

The conceptual model used to evaluate the previously described exposure scenario and pathways was the RESRAD[19] computer code version 6.21. RESRAD was developed, in part, to calculate site-specific concentrations for RESidual RADioactive material in soil corresponding to a radiation dose limit to a chronically exposed on-site resident. The RESRAD code considers multiple environmental transport and exposure pathways. A description of the code models, as applied here, is provided below.[20]

RESRAD models external exposure from volume sources when the individual is outside, using volume dose rate factors. Correction factors are used to account for soil density, areal extent of contamination, and thickness of contamination. When the individual is indoors, exposure from

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[16] NUREG-1727, Appendix C, Section 4.4.3

[17] NUREG-0945, page 4-13

[18] 10 CFR 40, Appendix A, Criterion 6 (6)

[19] Yu, C., et. al., 1993. *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD 5.0, Working Draft for Comment*, ANL/EAD/LD-2, Argonne National Laboratory, September 1993.

[20] NUREG-1727, Appendix C, Section 5.3.2.1.2

external radiation is modeled in a similar manner except that additional attenuation is included to account for the building. Exposure through ingestion of contaminated animal and plant products is modeled simply through the use of transfer factors.

The generic source-term conceptual model in RESRAD assumes a time-varying release rate of radionuclides into the water and air pathways. Radionuclides in the contaminant zone are assumed uniformly distributed. No transport is assumed to occur within the source zone, but account is made for radioactive transformation. The radioactive material is not assumed contained. The subject scenario does not include a cover of clean soil over the contaminated area. Release of radionuclides by water is assumed to be a function of a constant infiltration rate, time-varying contaminant zone thickness, constant moisture content, and equilibrium adsorption. The contaminant zone is assumed to decrease over time from a constant erosion rate. Particulates are assumed instantaneously and uniformly released into the air as a function of the concentration of particulates in the air, based on a constant mass-loading rate.

The RESRAD conceptual groundwater model includes two horizontal homogenous strata for the unsaturated zone. Transport in the unsaturated zone is assumed to result from steady-state, constant vertical flow, with equilibrium adsorption and decay, but no dispersion. RESRAD, for the subject case, models radionuclides in the saturated zone by a nondispersion approach. In the nondispersion approach, transport in the saturated zone is assumed to occur in a single homogenous stratum, under steady-state, unidirectional flow, with constant velocity, equilibrium adsorption, and radioactive transformation. The nondispersion model is the RESRAD default based on the size of the contaminated area.

The generic conceptual model of the surface water pathway in RESRAD assumes that radionuclides are uniformly distributed in a finite volume of water within a watershed. Radionuclides are assumed to enter the watershed at the same time and concentration as in the groundwater. Accordingly, no additional attenuation is considered as radionuclides are transported to the watershed. Radionuclides are assumed diluted as a function of the size of the contaminated area in relation to the size of the watershed. The model assumes that all radionuclides reaching the surface water are derived from the groundwater pathway. Thus transport of radionuclides overland from runoff is not considered. As well, additional dilution from overland runoff is not considered.

The generic conceptual model of the air pathway in RESRAD uses a constant mass loading factor and area factor to model radionuclide transport. The area factor, which is used to estimate the amount of dilution, relates the concentration of radionuclides from a finite area source to the concentration of radionuclides from an infinite area source. It is calculated as a

function of particle diameter, wind speed, and the side length of a square area source. The model assumes a fixed particle density, constant annual rainfall rate, and constant atmospheric stability. No radioactive decay is considered.

CALCULATIONS AND INPUT PARAMETERS

Inputs are provided for parameters of the source term configuration and exposure pathways described previously. Site-specific values were used for parameters when available. Otherwise the parameter value was assigned a default value or a value based on professional judgment.

For the source term, the inputs include site-specific values or estimates of contaminated area, thickness, density, porosity, hydraulic conductivity, hydraulic gradient, and distribution coefficient.

Particulars of the input parameters include: the rancher spends 45% of the time indoors on site, 20% of the time outdoors on site, and 35% of the time away from the site.[22] Food production is assumed to occur in the contaminated area: 5% of the resident's vegetable, grain, and fruit diet assumed produced from the contaminated area; 5% of the resident's meat diet is assumed produced from the contaminated area.[8] Neither milk nor aquatic food is included in the rancher's diet.[8] Dust levels represent ambient suspension of soil particles in air.

Vegetables, fruits, and grains are not irrigated with water from the contaminated area. Some contaminated water is used for watering livestock on site. The rancher's drinking water is assumed from an uncontaminated potable water system or uncontaminated surface water.

The walls, foundation, and floor of the resident's house reduce external exposure by 21%.[23] Indoor dust level in air is assumed to be 56% of the outdoor dust level.[24]

The parameters, associated inputs, and rationale for value, are included in **Table B-2.** Attachment B1 provides description of the rationale for the value of each parameter.

[22] SECY 98 084, Attachment 3, Table 2.

[23] NUREG-6697, Attachment C, Table 7.10-1

[24] NUREG-6697, Attachment C, Table 7.1-2

SENSITIVITY ANALYSIS

The results of the sensitivity analysis of the benchmark dose are provided in Attachment B2. The radium benchmark dose was not found to be significantly sensitive to any exposure pathway parameters.

RADIUM BENCHMARK DOSE (APPLICATION OF THE EXPOSURE SCENARIO)

The exposure scenario with associated model and inputs described above were applied to a soil concentration of 5.0 pCi/g radium-226 with 5 pCi/g lead-210.[25] The resulting dose, i.e. the radium benchmark dose, to the rancher was 18 millirem per year (mrem/y).

The results of the dose assessments determining the SCLs are provided in this appendix as a copy of the RESRAD outputs.

[25] NUREG-1620, Appendix H, Section H2.1.3, (2), (b)

Table B-1: Rancher Scenario Exposure Pathway Selections[1]

PATHWAY[2]	USER SELECTION
External Gamma	Active
Inhalation (w/o radon)	Active
Plant Ingestion	Active
Meat Ingestion	Active
Milk Ingestion	Suppressed
Aquatic Foods	Suppressed
Drinking Water	Suppressed
Soil Ingestion	Active
Radon	Suppressed

1 NUREG-1620, Section H2.1.3(2)(a)

2 These pathways match those available from the conceptual model used in the dose assessment; i.e. RESRAD version 6.21.

Table B-2: Rancher Scenario Model Selected Values

Parameter	Input	Background Information
Source		
Nuclide concentration for Ra-226 (pCi/g)	5	10 CFR 40, Appendix A, Criterion 6 (6)
Transport Distribution coefficients for Ra-226		
Contaminated zone (cm**3/g)	1	Site-specific estimate: see Attachment B1.
Unsaturated zone 1 (cm**3/g)	1	Site-specific estimate: see Attachment B1.
Saturated zone (cm**3/g)	90	Site-specific estimate: see Attachment B1.
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects use of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default
Nuclide concentration for Pb-210 (pCi/g)	5	NUREG-1620, Appendix H, Section H2.1.3, (2), (b)
Transport Distribution coefficients for Pb-210		
Contaminated zone (cm**3/g)	1	Site-specific estimate: see Attachment B1.
Unsaturated zone 1 (cm**3/g)	1	Site-specific estimate: see Attachment B1.
Saturated zone (cm**3/g)	90	Site-specific estimate: see Attachment B1.
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects use of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default
Calculation Parameters		
Basic radiation dose limit (mrem/yr)	25	RESRAD default
Times for Calculations (years)	0	RESRAD default
Times for Calculations (years)	3	RESRAD default
Times for Calculations (years)	10	RESRAD default
Times for Calculations (years)	30	RESRAD default
Times for Calculations (years)	100	RESRAD default
Times for Calculations (years)	300	RESRAD default
Times for Calculations (years)	1000	RESRAD default
Contaminated Zone Parameters		
Area of contaminated zone (m**2)	1214040	Estimate from NRC evaluation[3] (consistent with site specific estimate).
Thickness of contaminated zone (m)	0.15	Site-specific estimate: see Attachment B1.
Length parallel to aquifer flow (m)	622	Diameter of circle of area equal contaminated zone.
Cover and Contaminated Zone Hydrological Data		
Cover depth (m)	0	Planned actual conditions.
Density of cover material (g/cm**3)	--	Not available; reflects absence of cover.[1]
Cover erosion rate (m/yr)	--	Not available; reflects absence of cover.[1]
Density of contaminated zone (g/cm**3)	1.5	Site-specific estimate: see Attachment B1.
Contaminated zone erosion rate (m/yr)	1 E-05	Estimate from NRC evaluation.[3]

Parameter	Input	Background Information
Contaminated zone total porosity	0.20	Site-specific estimate: see Attachment B1.
Contaminated zone field capacity	0.05	Site-specific estimate: see Attachment B1.
Contaminated zone hydraulic conductivity (m/yr)	2002	Site-specific estimate: see Attachment B1.
Contaminated zone b parameter	1	Estimate for sand from RESRAD guidance.[2]
Humidity in air (g/cm**3)	--	Not available; reflects absence of radon pathway.[1]
Evapotranspiration coefficient	0.9	Estimate from NRC evaluation.[3]
Wind Speed (m/sec)	3.9	Site-specific estimate: see Attachment B1.
Precipitation (m/yr)	0.266	Site-specific estimate: see Attachment B1.
Irrigation (m/yr)	0	Assumed site condition.
Irrigation mode	overhead	Site specific observation (local practice).
Runoff coefficient	0.4	Estimate from RESRAD guidance.[2]
Watershed area for nearby stream or pond (m**2)	1.56 E+08	Site-specific estimate: see Attachment B2.
Accuracy for water/soil computations	0.001	RESRAD default
Saturated Zone Hydrological Data		
Density of saturated zone (g/cm**3)	2.4	Site-specific estimate: see Attachment B1.
Saturated zone total porosity	0.08	Site-specific estimate: see Attachment B1.
Saturated zone effective porosity	0.04	Site-specific estimate: see Attachment B1.
Saturated zone field capacity	0.04	Site-specific estimate: see Attachment B1.
Saturated zone hydraulic conductivity (m/yr)	67	Site-specific estimate: see Attachment B1.
Saturated zone hydraulic gradient	0.04	Site-specific estimate: see Attachment B1.
Saturated zone b parameter	1	Estimate sand from RESRAD guidance.[2]
Water table drop rate (m/yr)	1	Assume recharge from mine water stops after reclamation.
Well pump intake depth (m below water table)	0.00001	Lowest value allowed by RESRAD[1]; reflects absence of a well
Model for Water Transport Parameters		
Nondispersion (ND) or Mass-Balance (MB)	ND	RESRAD default based on size of contaminated area.[1]
Well pumping rate (m**3/yr)	0	Reflects absence of a well (no groundwater usage).
Uncontaminated Unsaturated Zone Parameters		
Unsaturated Zones	1	Site-specific condition.
Unsaturated Zone 1, Thickness (m)	8	Site-specific estimate; see Attachment B1.
Unsaturated Zone 1, Density (g/cm**3)	1.5	Site-specific estimate; see Attachment B1.
Unsaturated Zone 1, Total Porosity	0.20	Site-specific estimate; see Attachment B1.
Unsaturated Zone 1, Effective Porosity	0.15	Site-specific estimate; see Attachment B1.
Unsaturated Zone 1, Field Capacity	0.05	Site-specific estimate; see Attachment B1.
Unsaturated Zone 1, Hydraulic Conductivity (m/yr)	2002	Site-specific estimate; see Attachment B1.
Unsaturated Zone 1, b Parameter	1	Estimate for sand from RESRAD guidance.[2]

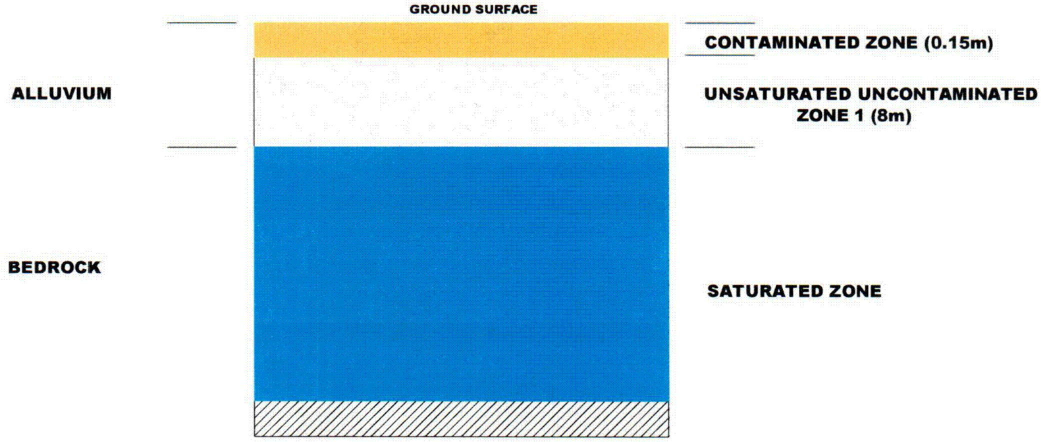
Parameter	Input	Background Information
Occupancy, Inhalation, and External Gamma Data		
Inhalation rate (m**3/yr)	8400	Recommendation from RESRAD guidance.[2]
Mass loading for inhalation (g/m**3)	0.0001	RESRAD default.
Exposure duration	1	Reflects applicable regulatory evaluation period.
Indoor dust filtration factor	0.56	Estimate from RESRAD guidance.[2]
External gamma shielding factor	0.21	Suggestion from RESRAD guidance.[2]
Indoor time fraction	0.45	Estimate from NRC evaluation.[3]
Outdoor time fraction	0.20	Estimate from NRC evaluation.[3]
Shape of the contaminated zone	circular	Assumed shape of *area of contaminated zone*.
Ingestion Pathway, Dietary Data		
Fruits, vegetables and grain consumption (kg/yr)	178	Suggestion from RESRAD guidance.[2]
Leafy vegetable consumption (kg/yr)	25	Estimate from RESRAD guidance.[2]
Milk consumption (L/yr)	--	Not available; reflects absence of milk pathway.[1]
Meat and poultry consumption (kg/yr)	63	RESRAD default.
Fish consumption (kg/yr)	--	Not available; reflects absence of aquatic pathway.[1]
Other seafood consumption	--	Not available; reflects absence of aquatic pathway.[1]
Soil ingestion (g/yr)	36.5	RESRAD default.
Drinking water intake (L/yr)	--	Not available; reflects absence of drinking water pathway.[1]
Contaminated fraction Drinking water	--	Not available; reflects absence of drinking water pathway.[1]
Contaminated fraction Household water	--	Not available; reflects absence of radon pathway.[1]
Contaminated fraction Livestock water	1	Assume all from onsite surface water.
Contaminated fraction Aquatic food	--	Not available; reflects absence of aquatic pathway.[1]
Contaminated fraction Plant food	0.05	Estimate from NRC evaluation.[3]
Contaminated fraction Meat	0.05	Estimate from NRC evaluation.[3]
Contaminated fraction Milk	--	Not available; reflects absence of milk pathway.[1]
Ingestion Pathway, Nondietary Data		
Livestock fodder intake for meat (kg/day)	68	RESRAD default
Livestock fodder intake for milk (kg/day)	--	Not available; reflects absence of milk pathway.[1]
Livestock water intake for meat (L/day)	50	RESRAD default
Livestock water intake for milk (L/day)	--	Not available; reflects absence of milk pathway.[1]
Livestock soil intake (kg/day)	0.5	RESRAD default
Mass loading for foliar deposition (g/m**3)	1 E-04	RESRAD default
Depth of soil mixing layer (m)	0.15	RESRAD default
Depth of roots (m)	0.3	Estimate from NRC evaluation.[3]
Groundwater Fractional Usage Drinking water	--	Not available; reflects absence of drinking water pathway.[1]
Groundwater fractional Usage Household water	--	Not available; reflects absence of radon pathway.[1]

Parameter	Input	Background Information
Groundwater Fractional Usage Livestock water	0	Reflects the absence of groundwater usage; e.g. *well pumping rate* equal zero.
Groundwater Fractional Usage Irrigation water	0	Reflects the absence of groundwater usage; e.g. *well pumping rate* equal zero.
Plant Factors		
Wet weight crop yield for Non-Leafy (kg/m**2)	0.7	RESRAD default
Wet weight crop yield for Leafy (kg/m**2)	1.5	RESRAD default
Wet weight crop yield for Fodder (kg/m**2)	1.1	RESRAD default
Length of growing season for Non-Leafy (years)	0.17	RESRAD default
Length of growing season for Leafy (years)	0.25	RESRAD default
Length of growing season for Fodder (years)	0.08	RESRAD default
Translocation factor for Non-Leafy	0.1	RESRAD default
Translocation factor for Leafy	1	RESRAD default
Translocation factor for Fodder	1	RESRAD default
Weathering removal constant for vegetation	20	RESRAD default
Wet foliar interception fraction for Non-Leafy	0.25	RESRAD default
Wet foliar interception fraction for leafy	0.25	RESRAD default
Wet foliar interception fraction for fodder	0.25	RESRAD default
Dry foliar interception fraction for Non-Leafy	0.25	RESRAD default
Dry foliar interception fraction for Leafy	0.25	RESRAD default
Dry foliar interception fraction for Fodder	0.25	RESRAD default

1 Yu, C., et. al. "Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0: Working Draft for Comment." Argonne, IL: Argonne National Laboratory. ANL/EAD/LD-2. September 1993.

2 U.S. Nuclear Regulatory Commission. Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes. Washington, D.C.: U.S. Nuclear Regulatory Commission. NUREG/CR-6697. December 2000.

3 U.S. Nuclear Regulatory Commission, Commission Paper SECY 98 084, "Status of Efforts to Finalize Regulations for Radiological Criteria for License Termination: Uranium Recovery Facilities", April 15, 1998.



Rio Algom Mining Corp. Soil Clean-up Work Plan	
Title: Depiction of Soil Zones Used for Development Benchmark Dose Rancher Scenario	
PREPARED BY: cem	Filename: Rio(2)
Reviewed by: RM	
Date: 06/30/03	

omega PROJECT SERVICES LLC

Figure B-1. Soil Zones Used for Development of Radium Benchmark Dose Calculation

C20

ATTACHMENT B1 (APPENDIX B)

JUSTIFICATION OF PARAMETER VALUES FOR DEVELOPMENT OF RADIUM BENCHMARK DOSE

INTRODUCTION

The following text provides the justification for the value chosen for each RESRAD parameter that required an input for development of the radium benchmark dose under a rancher scenario. The order and identification of headings, subheadings, and parameter names are aligned with the input screens of the RESRAD code.

SOURCE

TRANSPORT DISTRIBUTION COEFFICIENTS (CM^3/G)

The distribution coefficient (K_d) describes the portioning of elements or compounds (radioactive material) in a soil column between the solid (soil) and liquid (groundwater). Distribution coefficient is not a function of isotope (i.e. mass or specific activity) therefore a distribution coefficient was determined or chosen only with respect to the element and soil zone.

Radium-226

A site-specific distribution coefficient has been estimated here from a retardation factor provided elsewhere for uranium,[25,26] and from the *unsaturated zone 1 density* and *unsaturated zone 1 effective porosity* provided below. The distribution coefficients estimated here are rounded to one significant figure.

The value used in the dose assessment for the distribution coefficient of radium is 1 cm^3/g for the *contaminated zone* and *unsaturated zone 1* (alluvium).

The value used in the dose assessment for the distribution coefficient of radium is 90 cm^3/g for the *saturated zone* (uppermost bedrock).

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[25] "Corrective Action Program and Alternate Concentration Limits Petition for Uppermost Bedrock Units, Ambrosia Lake Uranium Mill Facility Near Grants, New Mexico", prepared for Quivera Mining Company by AVM Environmental Services, Inc. and Applied Hydrology Associates Inc., February 15, 2000. (Table 2-7)

[26] Rio Algom Mining Company, draft Response to Request for Additional Information, ["Corrective Action Program and Alternate Concentration Limits Petition for Uppermost Bedrock Units, Ambrosia Lake Uranium Mill Facility Near Grants, New Mexico and Application for Alternate Concentration Limits in the Alluvial Materials at the Quivera Mill Facility Ambrosia Lake, New Mexico"], March 25, 2003. (Response to Comments B.1 and B.2)

Lead

A site-specific distribution coefficient has been chosen from the distribution coefficient estimated for uranium.[4,5]

The value used in the dose assessment for the distribution coefficient of lead is 1 cm^3/g for the *contaminated zone* and *unsaturated zone 1* (alluvium).

The value used in the dose assessment for the distribution coefficient of lead is 90 cm^3/g for the *saturated zone* (uppermost bedrock).

TIME SINCE MATERIAL PLACEMENT (Y)

This parameter describes the duration between the placement of radioactive material in soil (contamination) and the performance of a radiological survey. This value is not applicable when transport distribution coefficients are available[27] as they are in this case.

The value used in the dose assessment for elapsed time since placement of contamination is the RESRAD default of zero years for all soil zones.

GROUNDWATER CONCENTRATION (pCi/L)

This parameter is a measure of the concentration of the principal radionuclide in a well located at the downgradient edge of the contaminated zone. Input values are required only if the value of the parameter *time since material placement* is greater than zero.[28] This parameter is not available in this case since *time since material placement* is zero.

The groundwater concentration of radionuclides is not used in the dose assessment.

SOLUBILITY LIMIT (MOL/L)

The solubility equilibrium concentration is the reference saturated solubility of the radionuclide in soil. A non-zero input prompts calculation of a modified distribution coefficient based on the

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[27] Yu, C., et.al. "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil." Argonne, IL: Argonne National Laboratory. ANL/EAIS-8. April 1993. (Section 49.1)

[28] Yu, C., et.al. "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil." Argonne, IL: Argonne National Laboratory. ANL/EAIS-8. April 1993. (Section 33.2)

input. This parameter is not applicable because a transport distribution coefficient is directly input to the model[29].

The value used in the dose assessment for solubility limit is the RESRAD default of zero mol/L for all soil zones.

LEACH RATE (/Y)

The leach rate is the fraction of the available radionuclide leached out from the contaminated zone per unit of time. No site-specific information is available for this parameter. In this case, an input value of zero invokes the calculation of the value for this parameter and uses the calculated value with the transport distribution coefficient provided previously.[30]

The input for the dose assessment for leach rate is the RESRAD default of zero /y for all soil zones.

CALCULATION PARAMETERS

BASIC RADIATION DOSE LIMIT (MREM/Y)

The basic radiation dose limit is the effective dose equivalent from external radiation plus the committed effective dose equivalent from internal radiation. The applicable value is the benchmark dose that is being derived here. The value supplied here does not impact the calculation of the benchmark dose.

The value used in the dose assessment for the basic radiation dose limit is the RESRAD default value.

TIMES FOR CALCULATIONS (YEARS)

These are the times in years following the radiological survey for which tabular values for single-radionuclide soil guidelines will be obtained.

The values used in the dose assessment for calculation times are the RESRAD defaults.

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[29] Yu, C., et.al. "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil." Argonne, IL: Argonne National Laboratory. ANL/EAIS-8. April 1993. (Section 32.3)

CONTAMINATED ZONE PARAMETERS

AREA OF CONTAMINATED ZONE (M^2)

This area is surface soils at the site that have been contaminated by windblown tailings from the tailings pile. This area contains the locations with radionuclide concentrations in soil clearly above background. The area does not include the mill area, the tailings pile, or the evaporation ponds. The size of this area reflects the reasonable estimate of an area that might be inhabited.[31]

The value used in the dose assessment for the area of the contaminated zone is 1214040 m^2 (300 acres).

THICKNESS OF CONTAMINATED ZONE

This value is the distance between the uppermost and lowermost soil samples in the *area of contaminated zone* that have radionuclide concentrations clearly above background. The value selected for this parameter represents an average thickness of the contaminated soil layer that will exist in the *area of contaminated zone* following reclamation.

The value used in the dose assessment for the thickness of the contaminated zone is 0.15 meters (0.5 foot).

LENGTH PARALLEL TO AQUIFER FLOW (M)

This parameter describes the maximum horizontal distance measured in the contaminated zone, from its upgradient edge to the downgradient edge, along the direction of the groundwater flow in the underlying water bearing formation.

The length chosen here is equal to the diameter of a circle of 300 acres, the *area of contaminated zone*. It is intended to represent the condition that there will be a large area of contaminated surface soil upgradient of the modeled area and therefore may lead to insignificant dilution from uncontaminated groundwater flowing into the contaminated zone.

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[30] Yu, C., et.al. "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil." Argonne, IL: Argonne National Laboratory. ANL/EAIS-8. April 1993. (Section 34.2)

[31] U.S. Nuclear Regulatory Commission, Commission Paper SECY 98 084, "Status of Efforts to Finalize Regulations for Radiological Criteria for License Termination: Uranium Recovery Facilities", April 15, 1998. (Attachment 3, Table 1)

The value used in the dose assessment for the length of the contaminated zone parallel to the aquifer flow is 622 meters.

COVER AND CONTAMINATED ZONE HYDROLOGICAL DATA

COVER DEPTH (M)

This parameter describes the distance from ground surface to the top of the contaminated soil. In some areas at the site, the contaminated soil will not be covered with clean soil after remediation; i.e. no cover.

The value used in the dose assessment for the depth of cover is zero meter.

DENSITY OF COVER MATERIAL (G/CM^3)

This value describes the dry (bulk) density of the cover material. This parameter is not applicable since *cover depth* is zero meters.

The density of the cover material is not used in the dose assessment.

COVER EROSION RATE (M/Y)

This value represents the average depth of soil that is removed from the ground surface per year due to weather conditions (e.g. running water, wind). This parameter is not applicable since *cover depth* is zero meters.

The erosion rate of the cover is not used in the dose assessment.

DENSITY OF CONTAMINATED ZONE (G/CM^3)

This value describes the dry (bulk) density of the contaminated soils. The value for this parameter is estimated from RESRAD guidance for the alluvium, a typical unconsolidated sand or silty sand.[32]

The value used in the dose assessment for density of the contaminated zone is 1.5 g/cm^3.

[32] U.S. Nuclear Regulatory Commission. Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes. Washington, D.C.: U.S. Nuclear Regulatory Commission. NUREG/CR-6697. December 2000. (Attachment C, Section 3.1)

CONTAMINATED ZONE EROSION RATE (M/Y)

This value represents the average depth of soil that is removed from the ground surface per year due to weather conditions (e.g. running water, wind). The value for this parameter is chosen from an evaluation suggesting an erosion rate for the rancher scenario[33].

The value used in the dose assessment for erosion rate of the contaminated zone is 0.00001 m/y.

CONTAMINATED ZONE TOTAL POROSITY (DIMENSIONLESS)

This value represents the ratio of the pore volume to the total volume for the contaminated soils. The value for this parameter is taken from site-specific geotechnical information for the alluvium.[34]

The value used in the dose assessment for total porosity of the contaminated zone is 0.2.

CONTAMINATED ZONE FIELD CAPACITY (DIMENSIONLESS)

Field capacity is the volumetric moisture content of soil at which (free) gravity drainage ceases. This is the amount of moisture that will be retained in a column of soil against the force of gravity. The field capacity is used as the lower bound of the moisture content in the soil layer. The field capacity of the alluvium is estimated as the difference between the *contaminated zone total porosity* and the *unsaturated zone 1 effective porosity.*

The value used in the dose assessment for field capacity of the contaminated zone is 0.05.

CONTAMINATED ZONE HYDRAULIC CONDUCTIVITY (M/Y)

This parameter measures a soil's ability to transmit water when subjected to a *hydraulic gradient.* The value used in the dose assessment represents the vertical component of the hydraulic

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[33] U.S. Nuclear Regulatory Commission, Commission Paper SECY 98 084, "Status of Efforts to Finalize Regulations for Radiological Criteria for License Termination: Uranium Recovery Facilities", April 15, 1998. (Attachment 3, Table 1)

[34] "Application for Alternate Concentration Limits in the Alluvial Materials at the Quivera Mill Facility Ambrosia Lake, New Mexico", prepared for Quivera Mining Company by MAXIM Technologies Inc., May 2001. (Section 2.2.3.2)

conductivity.[35] The value for this parameter is an estimate for the alluvium from site-specific geotechnical information.[36]

The value used in the dose assessment for hydraulic conductivity of the contaminated zone is 2002 m/y.

CONTAMINATED ZONE B PARAMETER (DIMENSIONLESS)

The soil-specific b parameter is an empirical parameter used to evaluate the saturation ratio of the soil. The value used in the dose assessment is the mean value recommended for sand (i.e. alluvium) as an input for RESRAD.[37]

The value used in the dose assessment for the contaminated zone b parameter is 1.

HUMIDITY IN AIR (G/CM^3)

This parameter is used only for the computation of tritium concentration in air.[38] Since tritium is not a constituent of concern, this parameter is not applicable to the dose assessment.

The humidity in air is not used in the dose assessment.

EVAPOTRANSPIRATION COEFFICIENT (DIMENSIONLESS)

This parameter is the ratio of the total volume of water leaving the ground as a result of evapotranspiration to the total volume of water available within the root zone of the soil. The

[35] Yu, C., et.al. "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil." Argonne, IL: Argonne National Laboratory. ANL/EAIS-8. April 1993. (Section 5.3)

[36] "Application for Alternate Concentration Limits in the Alluvial Materials at the Quivera Mill Facility Ambrosia Lake, New Mexico", prepared for Quivera Mining Company by MAXIM Technologies Inc., May 2001. (Section 2.2.3.2)

[37] U.S. Nuclear Regulatory Commission. Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes. Washington, D.C.: U.S. Nuclear Regulatory Commission. NUREG/CR-6697. December 2000. (Attachment C, Section 3.5)

[38] Yu, C., et. al. "Users Manual for RESRAD Version 6", Argonne, IL: Argonne National Laboratory. ANL/EAD-4. July 2001. (Section 4.4.6)

value for this parameter is chosen from an evaluation suggesting an evapotranspiration coefficient for the rancher scenario.[39]

The value used in the dose assessment for evapotranspiration coefficient is 0.9.

WIND SPEED (M/S)

This value is the average wind speed for a one-year period. The value used here is a ten-year annual average from a local monitoring station.[40]

The value used in the dose assessment for wind speed is 3.9 meters per second.

PRECIPITATION (M/Y)

This value is the average rainfall for a one-year period. The value used here is an almost 50-year annual average from a local monitoring station.[41]

The value used in the dose assessment for precipitation is 0.266 meters per year.

IRRIGATION (M/Y)

This parameter describes the average volume of water applied to the soil, per unit of surface area, per year. The value for this parameter is chosen from an evaluation suggesting an irrigation rate for the rancher scenario.[42]

The value used in the dose assessment for irrigation is zero meters per year.

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[39] U.S. Nuclear Regulatory Commission, Commission Paper SECY 98 084, "Status of Efforts to Finalize Regulations for Radiological Criteria for License Termination: Uranium Recovery Facilities", April 15, 1998. (Attachment 3, Table 1)

[40] Western Regional Climate Center, Historical Climate Information, Average Wind Speeds by State, New Mexico, Grants Airport (www.wrcc.dri.edu)

[41] Western Regional Climate Center, Historical Climate Information, Western U.S. Historical Summaries, New Mexico, Grants Airport, Average Total Precipitation (www.wrcc.dri.edu)

[42] U.S. Nuclear Regulatory Commission, Commission Paper SECY 98 084, "Status of Efforts to Finalize Regulations for Radiological Criteria for License Termination: Uranium Recovery Facilities", April 15, 1998. (Attachment 3, Table 1)

IRRIGATION MODE (OVERHEAD OR DITCH)

This parameter indicates the predominant method of irrigation. The method of irrigation used in the dose assessment was chosen based on observation of local irrigation practices.

Overhead irrigation is the irrigation mode used in the dose assessment.

RUNOFF COEFFICIENT (DIMENSIONLESS)

This parameter represents the fraction of precipitation, in excess of the deep percolation and evapotranspiration that becomes surface flow and ends up in surface water bodies. An estimate of the runoff coefficient for the site was made in accordance with the RESRAD guidance for "Rolling land ..." and "Open sandy loam".[43]

The value used in the dose assessment for runoff coefficient is 0.4.

WATERSHED AREA FOR NEARBY STREAM OR POND (M^2)

The watershed area parameter represents the area of the region draining into the nearby stream or pond located at the Facility. The watershed area is determined from site-specific information.[44]

The value used in the dose assessment for the watershed area is 1.56E+08 m^2.

ACCURACY FOR WATER/SOIL COMPUTATIONS

The RESRAD default is used for this dose assessment.

SATURATED ZONE HYDROLOGICAL DATA

DENSITY OF SATURATED ZONE (G/M^3)

This value describes the dry (bulk) density of the saturated zone. The bulk density of consolidated rock can be significantly higher than the same unconsolidated sediments. The

[43] U.S. Nuclear Regulatory Commission. Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes. Washington, D.C.: U.S. Nuclear Regulatory Commission. NUREG/CR-6697. December 2000. (Attachment C, Table 4.2-1)

[44] RAM

estimated bulk density of a clean fine-medium sandstone (i.e. uppermost bedrock) is calculated from a solid quartz density of 2.65 g/cm3 and a total porosity of 0.08.

The value used in the dose assessment for density of the saturated zone is 2.4 g/cm^3.

SATURATED ZONE TOTAL POROSITY (DIMENSIONLESS)

This value represents the ratio of the pore volume to the total volume for the saturated zone. The value for this parameter is a site-specific estimate for the saturated soils at the site.[45]

The value used in the dose assessment for total porosity of the saturated zone is 0.08.

SATURATED ZONE EFFECTIVE POROSITY (DIMENSIONLESS)

This value represents the ratio of the part of the pore volume where water can circulate to the total volume for the saturated soils. The value for this parameter is an average for the uppermost bedrock from site-specific information.[46]

The value used in the dose assessment for effective porosity of the saturated zone is 0.04.

SATURATED ZONE FIELD CAPACITY (DIMENSIONLESS)

Field capacity is the volumetric moisture content of soil at which (free) gravity drainage ceases. This is the amount of moisture that will be retained in a column of soil against the force of gravity. The field capacity is used as the lower bound of the moisture content in the soil layer. The field capacity of the uppermost bedrock is estimated as the difference between the *saturated zone total porosity* and the *saturated zone effective porosity*.

The value used in the dose assessment for field capacity of the saturated zone is 0.04.

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[45] "Corrective Action Program and Alternate Concentration Limits Petition for Uppermost Bedrock Units, Ambrosia Lake Uranium Mill Facility Near Grants, New Mexico", prepared for Quivera Mining Company by AVM Environmental Services, Inc. and Applied Hydrology Associates Inc., February 15, 2000. (page 2-26)

[46] "Corrective Action Program and Alternate Concentration Limits Petition for Uppermost Bedrock Units, Ambrosia Lake Uranium Mill Facility Near Grants, New Mexico", prepared for Quivera Mining Company by AVM Environmental Services, Inc. and Applied Hydrology Associates Inc., February 15, 2000. (page 2-26).

SATURATED ZONE HYDRAULIC CONDUCTIVITY (M/Y)

This parameter measures a formation's ability to transmit water when subjected to a *hydraulic gradient*. The value used in the dose assessment represents the horizontal component of the hydraulic conductivity.[47] The value for this parameter is an average for the uppermost bedrock from site-specific information.[48]

The value used in the dose assessment for hydraulic conductivity of the saturated zone is 67 m/y.

SATURATED ZONE HYDRAULIC GRADIENT (DIMENSIONLESS)

The hydraulic gradient is the change in hydraulic head per unit of distance of the groundwater flow in a given direction. The value for this parameter is chosen from site-specific information.[49]

The value used in the dose assessment for hydraulic gradient of the saturated zone is 0.04.

SATURATED ZONE B PARAMETER (DIMENSIONLESS)

The formation-specific b parameter is an empirical parameter used to evaluate the saturation ratio of the formation. Input for the parameter is only required if the *water table drop rate* is greater than zero.[50] The value used in the dose assessment is the mean value recommended for sand as an input for RESRAD.[51]

The value used in the dose assessment for the saturated zone b parameter is 1.

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[47] Yu, C., et.al. "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil." Argonne, IL: Argonne National Laboratory. ANL/EAIS-8. April 1993. (Section 5.3)

[48] "Corrective Action Program and Alternate Concentration Limits Petition for Uppermost Bedrock Units, Ambrosia Lake Uranium Mill Facility Near Grants, New Mexico", prepared for Quivera Mining Company by AVM Environmental Services, Inc. and Applied Hydrology Associates Inc., February 15, 2000. (page 2-26).

[49] "Corrective Action Program and Alternate Concentration Limits Petition for Uppermost Bedrock Units, Ambrosia Lake Uranium Mill Facility Near Grants, New Mexico", prepared for Quivera Mining Company by AVM Environmental Services, Inc. and Applied Hydrology Associates Inc., February 15, 2000. (page 2-26).

[50] Yu, C., et.al. "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil." Argonne, IL: Argonne National Laboratory. ANL/EAIS-8. April 1993. (Section 13.3)

WATER TABLE DROP RATE (M/Y)

The water table drop rate describes the fluctuation in the level of the water table due to temporal variations of the processes in the hydrologic cycle as well as extra use of water from the system. The value of this parameter is estimated from the conditions of a groundwater system that was initially created by anthropogenic charge but recharge is stopped after reclamation.

The value used in the dose assessment for water table drop rate is one m/y.

WELL PUMP INTAKE DEPTH (M BELOW WATER TABLE)

This parameter represents the screened depth of a well within the saturated zone. The value for this parameter is determined by the assumption that groundwater is not used (i.e. no withdrawal).

The value used in the dose assessment for well pump intake depth is 0.00001 m corresponding to the lowest value allowed by the RESRAD code.[52]

MODEL FOR WATER TRANSPORT PARAMETERS (NONDISPERSION OR MASS-BALANCE)

This parameter selects which of the two models will be used for water/soil concentration ratio calculations. The RESRAD recommendation, based on the size of the contaminated area, is the nondispersion model.[53]

The model for water transport used in the dose assessment is the nondispersion model.

[51] U.S. Nuclear Regulatory Commission. Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes. Washington, D.C.: U.S. Nuclear Regulatory Commission. NUREG/CR-6697. December 2000. (Attachment C, Section 3.5)

[52] Yu, C., et. al. "Users Manual for RESRAD Version 6", Argonne, IL: Argonne National Laboratory. ANL/EAD-4. July 2001. (input screen message)

[53] Yu, C., et. al. "Users Manual for RESRAD Version 6", Argonne, IL: Argonne National Laboratory. ANL/EAD-4. July 2001. (Section E.3.1)

WELL PUMPING RATE (M^3/Y)

The well pumping rate is the total volume of water obtained annually from the well for use by humans and livestock and for agricultural and other purposes. The value for this parameter is determined by the assumption that groundwater is not used, i.e. no withdrawal.

The value used in the dose assessment for well pumping rate is zero.

UNCONTAMINATED UNSATURATED ZONE PARAMETERS

UNSATURATED ZONES

The uncontaminated and unsaturated zone is the portion of the uncontaminated zone that lies below the bottom of the contaminated zone and above the groundwater table (i.e. saturated zone). The dose assessment here assumes one unsaturated zone: the uncontaminated alluvium overlying the uppermost bedrock.

UNSATURATED ZONE 1, THICKNESS (M)

This parameter describes the thickness of the uncontaminated unsaturated soil below the *contaminated zone* and above the *saturated zone.* The value is an average thickness of soil in the *area of contaminated zone* minus the *thickness of the contaminated zone.* The selection of the subject thickness is an estimate from site specific information.

The value used in the dose assessment for thickness of unsaturated zone 1 is 8 meters.

UNSATURATED ZONE 1, DENSITY (G/M^3)

This value describes the dry (bulk) density of unsaturated zone 1. The value for this parameter is equivalent to that of the contaminated zone.

The value used in the dose assessment for density of unsaturated zone 1 is 1.5 g/cm^3.

UNSATURATED ZONE 1, TOTAL POROSITY (DIMENSIONLESS)

This value represents the ratio of the pore volume to the total volume for the unsaturated zone 1. The value for this parameter is equivalent to that of the contaminated zone.

The value used in the dose assessment for total porosity of the unsaturated zone 1 is 0.20.

UNSATURATED ZONE 1, EFFECTIVE POROSITY (DIMENSIONLESS)

This value represents the ratio of the part of the pore volume where water can circulate to the total volume for the unsaturated zone 1 soils. The value for this parameter is an average for the alluvium from site-specific information.[54]

The value used in the dose assessment for effective porosity of the saturated zone is 0.15.

UNSATURATED ZONE 1, FIELD CAPACITY (DIMENSIONLESS)

Field capacity is the volumetric moisture content of soil at which (free) gravity drainage ceases. This is the amount of moisture that will be retained in a column of soil against the force of gravity. The field capacity is used as the lower bound of the moisture content in the soil layer. This value is equivalent to that of the contaminated zone.

The value used in the dose assessment for field capacity of the unsaturated zone is 0.05.

UNSATURATED ZONE 1, HYDRAULIC CONDUCTIVITY (M/Y)

This parameter measures a formation's ability to transmit water when subjected to a *hydraulic gradient*. This value is equivalent to that of the contaminated zone.

The value used in the dose assessment for hydraulic conductivity of the unsaturated zone 1 is 2002 m/y.

UNSATURATED ZONE 1, B PARAMETER (DIMENSIONLESS)

The formation-specific b parameter is an empirical parameter used to evaluate the saturation ratio of the formation. This value is equivalent to that of the contaminated zone.

The value used in the dose assessment for the unsaturated zone 1 b parameter is 1.

[54] "Application for Alternate Concentration Limits in the Alluvial Materials at the Quivera Mill Facility Ambrosia Lake, New Mexico", prepared for Quivera Mining Company by MAXIM Technologies Inc., May 2001. (Section 2.2.3.2)

OCCUPANCY, INHALATION, AND EXTERNAL GAMMA DATA

INHALATION RATE (M^3/Y)

The inhalation rate used in the dose assessment represents the annual average breathing rate of the average rancher.[55]

The value used in the dose assessment for inhalation rate is 8400 m^3/y.

MASS LOADING FOR INHALATION (G/M^3)

This parameter represents the concentration of soil particles in air.

The value used in the dose assessment for mass loading for inhalation is the RESRAD default of 0.0001 g/m^3.

EXPOSURE DURATION (Y)

The exposure duration is the span of time, in years, during which an individual is expected to spend time on site. This parameter is evaluated as one since the results of the dose assessment are expressed dose per year.

The value used in the dose assessment for exposure duration is one year.

INDOOR DUST FILTRATION FACTOR (DIMENSIONLESS)

This parameter is also termed the shielding factor for inhalation pathway. This factor is the ratio of airborne dust concentration indoors on site to the concentration outdoors on site. It is based on the fact that a building provides shielding against entry of wind-blown dust particles. The value chosen is an estimate derived from an average of mean values from RESRAD guidance.[56]

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[55] U.S. Nuclear Regulatory Commission. Draft Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act (Draft Revision 1). NUREG-1620. January 2002. (Section H2.1.3(2)(h))

[56] U.S. Nuclear Regulatory Commission. Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes. Washington, D.C.: U.S. Nuclear Regulatory Commission. NUREG/CR-6697. December 2000. (Attachment C, Table 7.1-2)

The value used in the dose assessment for indoor dust filtration factor is 0.56.

EXTERNAL GAMMA SHIELDING FACTOR (DIMENSIONLESS)

This factor is the ratio of the external gamma radiation level indoors on site to the radiation level outdoors on site. It is based on the fact that a building provides shielding against penetration of gamma radiation. The value used here represents a frame house constructed with a slab[57]; i.e. a reasonable guess (comparable to stucco on slab) of type of home construction on site based on current construction practices.

The value used in the dose assessment for external gamma shielding factor is 0.21.

INDOOR TIME FRACTION (DIMENSIONLESS)

The fraction of time indoors on site is the average fraction of time in a year during which an individual stays inside a house on site. The value for this parameter is chosen from an evaluation suggesting an indoor time fraction for the rancher scenario. [58]

The value used in the dose assessment for indoor time fraction is 0.45.

OUTDOOR TIME FRACTION (DIMENSIONLESS)

The fraction of time outdoors on site is the average fraction of time in a year during which an individual stays outside on site. The value for this parameter is chosen from an evaluation suggesting an outdoor time fraction for the rancher scenario.[59]

The value used in the dose assessment for outdoor time fraction is 0.2.

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[57] U.S. Nuclear Regulatory Commission. Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes. Washington, D.C.: U.S. Nuclear Regulatory Commission. NUREG/CR-6697. December 2000. (Attachment C, Table 7.10-1)

[58] U.S. Nuclear Regulatory Commission, Commission Paper SECY 98 084, "Status of Efforts to Finalize Regulations for Radiological Criteria for License Termination: Uranium Recovery Facilities", April 15, 1998. (Attachment 3, Table 2)

[59] U.S. Nuclear Regulatory Commission, Commission Paper SECY 98 084, "Status of Efforts to Finalize Regulations for Radiological Criteria for License Termination: Uranium Recovery Facilities", April 15, 1998. (Attachment 3, Table 2)

SHAPE OF THE CONTAMINATED ZONE

The shape factor is used to correct for a noncircular-shaped contaminated area on the basis of an ideally circular zone. The shape of the contaminated area is assumed to be circular.

The choice of circular is made in the dose assessment for the shape of the contaminated zone.

INGESTION PATHWAY, DIETARY DATA

FRUITS, VEGETABLES (NONLEAFY) AND GRAIN CONSUMPTION (KG/Y)

This parameter describes the total quantity of these food items (contaminated and uncontaminated) consumed per year per individual. It is a composite value obtained by summing individual consumption rates for each of the food items.[60]

The value used in the dose assessment for fruit, vegetables (nonleafy) and grain consumption is 178 kg/y.

LEAFY VEGETABLE CONSUMPTION (KG/Y)

This parameter describes the total quantity of this food item (contaminated and uncontaminated) consumed per year per individual. The value for this parameter was estimated to be 0.33 of a total vegetable consumption rate.[61]

The value used in the dose assessment for leafy vegetable consumption is 25 kg/y.

MILK CONSUMPTION (L/Y)

The milk consumption rate is the amount of fluid milk (beverage) consumed per year. The milk pathway is not active in this dose assessment therefore this parameter is not available.[62]

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[60] U.S. Nuclear Regulatory Commission. Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes. Washington, D.C.: U.S. Nuclear Regulatory Commission. NUREG/CR-6697. December 2000. (Attachment C, Table 5.4-2)

[61] U.S. Nuclear Regulatory Commission. Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes. Washington, D.C.: U.S. Nuclear Regulatory Commission. NUREG/CR-6697. December 2000. (Attachment C, Section 5.4 and Table 5.4-2)

The milk consumption rate is not used in the dose assessment.

MEAT AND POULTRY CONSUMPTION (KG/Y)

This parameter describes the annual consumption of homegrown beef, poultry, and eggs. The RESRAD default was chosen as the input.

The value used in the dose assessment for meat and poultry consumption is 63 kg/y.

FISH CONSUMPTION (KG/Y)

This parameter describes the amount of fresh fish consumed per year. The aquatic pathway is not active in this dose assessment therefore this parameter is not available.[63]

The fish consumption rate is not used in the dose assessment.

OTHER SEAFOOD CONSUMPTION

This parameter describes the annual average rate for consumption of nonfish seafood. The aquatic pathway is not active in this dose assessment therefore this parameter is not available.

The other seafood consumption rate is not used in the dose assessment.

SOIL INGESTION (G/Y)

This parameter describes the accidental ingestion rate of soil from outdoor activities. The RESRAD default was chosen as the input.

The value used in the dose assessment for soil ingestion is 36.5 g/y.

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[62] U.S. Nuclear Regulatory Commission. Draft Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act (Draft Revision 1). NUREG-1620. January 2002. (Section H2.1.3(2)(a))

[63] U.S. Nuclear Regulatory Commission. Draft Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act (Draft Revision 1). NUREG-1620. January 2002. (Section H2.1.3(2)(a))

DRINKING WATER INTAKE (L/Y)

The drinking water intake rate is the average amount of water consumed by an adult per year. The drinking water pathway is not active therefore this parameter is not available.

The drinking water intake rate is not used in the dose assessment.

CONTAMINATED FRACTION DRINKING WATER (DIMENSIONLESS)

This parameter specifies the fraction of *drinking water intake* that is drawn from [groundwater] sources on site and is assumed contaminated. The balance of drinking water is assumed to be from off site sources and uncontaminated. The drinking water pathway is not active therefore this parameter is not available.

The contaminated fraction drinking water is not used in the dose assessment.

CONTAMINATED FRACTION HOUSEHOLD WATER (DIMENSIONLESS)

This parameter allows specification of the contaminated fraction of household water for use in calculating radon exposure. The radon pathway is not active therefore this parameter is not available.[64]

The contaminated fraction household water is not used in the dose assessment.

CONTAMINATED FRACTION LIVESTOCK WATER (DIMENSIONLESS)

This parameter specifies the fraction of livestock drinking water that is drawn from sources on site and is assumed contaminated. The value chosen for this parameter reflects the worst-case assumption that all livestock water is from contaminated on site sources.

The value used in the dose assessment for contaminated fraction livestock water is one.

CONTAMINATED FRACTION IRRIGATION WATER (DIMENSIONLESS)

This parameter specifies the fraction of *irrigation* water that is drawn from sources on site and is assumed contaminated. The value chosen for this parameter reflects the assumption that no irrigation occurs on site.

[64] 10 CFR 40, Appendix A, Criterion 6(6)

The value used in the dose assessment for contaminated fraction irrigation water is zero.

CONTAMINATED FRACTION AQUATIC FOOD (DIMENSIONLESS)

This parameter specifies the fraction of *fish consumption* that is from sources on site and is assumed contaminated. The aquatic pathway is not active in this dose assessment therefore this parameter is not available.

The fish consumption rate is not used in the dose assessment.

CONTAMINATED FRACTION PLANT FOOD (DIMENSIONLESS)

This parameter allows specification of the fraction of contaminated intake for the *fruits, vegetables and grain consumption,* and *leafy vegetable consumption* pathways. The balance is from off site sources assumed to be uncontaminated. The value for this parameter is chosen from an evaluation suggesting a contaminated fraction plant food for the rancher scenario.[65]

The value used in the dose assessment for contaminated fraction plant food is 0.05.

CONTAMINATED FRACTION MEAT (DIMENSIONLESS)

This parameter allows specification of the fraction of contaminated intake for the *meat and poultry consumption* pathway. The balance is from off site sources assumed to be uncontaminated. The value for this parameter is chosen from an evaluation suggesting a contaminated fraction meat for the rancher scenario.[66]

The value used in the dose assessment for contaminated fraction meat is 0.05.

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[65] U.S. Nuclear Regulatory Commission, Commission Paper SECY 98 084, "Status of Efforts to Finalize Regulations for Radiological Criteria for License Termination: Uranium Recovery Facilities", April 15, 1998. (Attachment 3, Table 2)

[66] U.S. Nuclear Regulatory Commission, Commission Paper SECY 98 084, "Status of Efforts to Finalize Regulations for Radiological Criteria for License Termination: Uranium Recovery Facilities", April 15, 1998. (Attachment 3, Table 2)

CONTAMINATED FRACTION MILK (DIMENSIONLESS)

This parameter allows specification of the fraction of contaminated intake for the *milk consumption* pathway. The balance is from off site sources assumed to be uncontaminated. The milk pathway is not active in this dose assessment therefore this parameter is not available.

The contaminated fraction milk is not used in the dose assessment.

INGESTION PATHWAY, NONDIETARY DATA

LIVESTOCK FODDER INTAKE FOR MEAT (KG/D)

This is the daily intake of fodder for livestock kept for *meat and poultry consumption*. The value used here is the RESRAD default.

The value used in the dose assessment for livestock fodder intake for meat is 68 kg/d.

LIVESTOCK FODDER INTAKE FOR MILK (KG/D)

This is the daily intake of fodder for livestock kept for *milk consumption*. The milk pathway is not active in this dose assessment therefore this parameter is not available.

The livestock fodder intake for milk is not used in the dose assessment.

LIVESTOCK WATER INTAKE FOR MEAT (L/D)

This is the daily intake of water for livestock kept for meat and poultry consumption. The value used here is the RESRAD default.

The value used in the dose assessment for livestock water intake for meat is 50 L/d.

LIVESTOCK WATER INTAKE FOR MILK (KG/D)

This is the daily intake of water for livestock kept for *milk consumption*. The milk pathway is not active in this dose assessment therefore this parameter is not available.

The livestock water intake for milk is not used in the dose assessment.

LIVESTOCK SOIL INTAKE (KG/D)

This is the daily intake of soil for livestock kept for *meat and poultry consumption* or *milk consumption*. The value used here is the RESRAD default.

The value used in the dose assessment for livestock soil intake is 0.5 kg/d.

MASS LOADING FOR FOLIAR DEPOSITION (G/M^3)

This is the air/soil concentration ratio, specified as the average mass loading of airborne contaminated soil particles in a garden during the growing season. The value used here is the RESRAD default.

The value used in the dose assessment for mass loading for foliar deposition is 0.0001g/m^3.

DEPTH OF SOIL MIXING LAYER (M)

The depth of soil mixing layer is used in calculating the depth factor for the dust inhalation and soil ingestion pathways and for foliar deposition for the ingestion pathway. The value used here is the RESRAD default.

The value used in the dose assessment for mass loading for depth of soil mixing layer is 0.15 m.

DEPTH OF ROOTS (M)

This parameter represents the average root depth of various plants grown in the contaminated zone. The value used here is from NRC guidance.[67]

The value used in the dose assessment for mass loading for depth of roots is 0.3 meter.

GROUNDWATER FRACTIONAL USAGE DRINKING WATER (DIMENSIONLESS)

This parameter allows distinction between the groundwater and surface water scenarios with respect to *drinking water*. This parameter is not available, reflecting the absence of the drinking water pathway on site (see also *contaminated fraction drinking water*).

[67] U.S. Nuclear Regulatory Commission. Draft Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act (Draft Revision 1). NUREG-1620. January 2002. (Section H2.1.3(2)(j))

The groundwater fractional usage drinking water is not used in the dose assessment.

GROUNDWATER FRACTIONAL USAGE HOUSEHOLD WATER (DIMENSIONLESS)

This parameter allows distinction between the groundwater and surface water scenarios with respect to *household water.* This parameter is not available, reflecting the absence of the radon pathway on site (see also *contaminated fraction household water*).

The contaminated fraction household water is not used in the dose assessment.

GROUNDWATER FRACTIONAL USAGE LIVESTOCK WATER (DIMENSIONLESS)

This parameter allows distinction between the groundwater and surface water scenarios with respect to *livestock water.* The value of the parameter is chosen to reflect the condition that there is no groundwater usage at the site (see also *contaminated fraction livestock water* and *well pumping rate*).

The value used in the dose assessment for groundwater fractional usage livestock water is zero.

GROUNDWATER FRACTIONAL USAGE IRRIGATION WATER (DIMENSIONLESS)

This parameter allows distinction between the groundwater and surface water scenarios with respect to *irrigation.* The value of the parameter is chosen to reflect the condition that there is no irrigation on site (see also *contaminated fraction irrigation water* and *well pumping rate*).

The value used in the dose assessment for groundwater fractional usage irrigation water is zero.

PLANT FACTORS

WET WEIGHT CROP YIELD FOR NON-LEAFY (KG/M^2)

This is the mass (wet weight) of the edible portion of non-leafy vegetable plant food produced from a unit land area. The value used here is the RESRAD default.

The value used in the dose assessment for wet weight crop yield for non-leafy vegetables is 0.7 kg/m2.

WET WEIGHT CROP YIELD FOR LEAFY (KG/M^2)

This is the mass (wet weight) of the edible portion of leafy vegetable plant food produced from a unit land area. The value used here is the RESRAD default.

The value used in the dose assessment for wet weight crop yield for leafy vegetables is 1.5 kg/m^2.

WET WEIGHT CROP YIELD FOR FODDER (KG/M^2)

This is the mass (wet weight) of the edible portion of livestock plant food produced from a unit land area. The value used here is the RESRAD default.

The value used in the dose assessment for wet weight crop yield for fodder is 1.1 kg/m^2.

LENGTH OF GROWING SEASON FOR NON-LEAFY (Y)

This is the exposure time of the non-leafy plant food to contamination during the growing season. The contaminants can get to the edible portion of the plant food through foliar deposition, root uptake and water irrigation. The value used here is the RESRAD default.

The value used in the dose assessment for length of growing season of non-leafy vegetables is 0.17 year.

LENGTH OF GROWING SEASON FOR LEAFY (Y)

This is the exposure time of the leafy plant food to contamination during the growing season. The contaminants can get to the edible portion of the plant food through foliar deposition, root uptake and water irrigation. The value used here is the RESRAD default.

The value used in the dose assessment for length of growing season of leafy vegetables is 0.25 year.

LENGTH OF GROWING SEASON FOR FODDER (Y)

This is the exposure time of the livestock plant food to contamination during the growing season. The contaminants can get to the edible portion of the plant food through foliar deposition, root uptake and water irrigation. The value used here is the RESRAD default.

The value used in the dose assessment for length of growing season of fodder is 0.08 year.

TRANSLOCATION FACTOR FOR NON-LEAFY (DIMENSIONLESS)

This is the contaminant non-leafy foliage-to-food transfer coefficient. A fraction of the contaminant that retains on the foliage of the plant food will be absorbed and transferred to the edible portion of the plant food. The value used here is the RESRAD default.

The value used in the dose assessment for translocation factor for non-leafy is 0.1.

TRANSLOCATION FACTOR FOR LEAFY (DIMENSIONLESS)

This is the contaminant leafy foliage-to-food transfer coefficient. A fraction of the contaminant that retains on the foliage of the plant food will be absorbed and transferred to the edible portion of the plant food. The value used here is the RESRAD default.

The value used in the dose assessment for translocation factor for leafy is 1.

TRANSLOCATION FACTOR FOR FODDER (DIMENSIONLESS)

This is the contaminant fodder foliage-to-food transfer coefficient. A fraction of the contaminant that retains on the foliage of fodder will be absorbed and transferred to the edible portion of the plant food. The value used here is the RESRAD default.

The value used in the dose assessment for translocation factor for fodder is 1.

WEATHERING REMOVAL CONSTANT FOR VEGETATION (DIMENSIONLESS)

The weathering process removes contaminants from foliage of the plant food. This process is characterized by a removal constant that accounts for reduction of the amount of contaminants on foliage during the exposure period. The value used here is the RESRAD default.

The value used in the dose assessment for weathering removal constant for vegetation is 20.

WET FOLIAR INTERCEPTION FRACTION FOR NON-LEAFY (DIMENSIONLESS)

This is the fraction of contaminant deposited by irrigation water that retains on the foliage of non-leafy plant food. The value used here is the RESRAD default.

The value used in the dose assessment for wet interception fraction for non-leafy is 0.25.

WET FOLIAR INTERCEPTION FRACTION FOR LEAFY (DIMENSIONLESS)

This is the fraction of contaminant deposited by irrigation water that retains on the foliage of leafy plant food. The value used here is the RESRAD default.

The value used in the dose assessment for wet interception fraction for leafy is 0.25.

WET FOLIAR INTERCEPTION FRACTION FOR FODDER (DIMENSIONLESS)

This is the fraction of contaminant deposited by irrigation water that retains on the foliage of fodder The value used here is the RESRAD default.

The value used in the dose assessment for wet interception fraction for fodder is 0.25.

DRY FOLIAR INTERCEPTION FRACTION FOR NON-LEAFY (DIMENSIONLESS)

This is the fraction of contaminant deposited by airborne particulate that retains on the foliage of non-leafy plant food. The value used here is the RESRAD default.

The value used in the dose assessment for dry interception fraction for non-leafy is 0.25.

DRY FOLIAR INTERCEPTION FRACTION FOR LEAFY (DIMENSIONLESS)

This is the fraction of contaminant deposited by airborne particulate that retains on the foliage of leafy plant food. The value used here is the RESRAD default.

The value used in the dose assessment for dry interception fraction for leafy is 0.25.

DRY FOLIAR INTERCEPTION FRACTION FOR FODDER (DIMENSIONLESS)

This is the fraction of contaminant deposited by airborne particulate that retains on the foliage of fodder. The value used here is the RESRAD default.

The value used in the dose assessment for dry interception fraction for fodder is 0.25.

ATTACHMENT B2 (APPENDIX B)

SENSITIVITY ANALYSISOF RADIUM BENCHMARK DOSE

SENSITIVITY ANALYSIS

INTRODUCTION

To ensure that the radium benchmark dose described in Appendix B is unlikely to significantly overestimate potential dose, the analyses used a realistic scenario and conceptual model, and site-specific inputs or prudent estimates were used for key parameters. A sensitivity analysis of the benchmark dose was subsequently completed for which the primary objective was to identify input parameters that were major contributors to variation in the calculated dose.

The sensitivity analysis was of a deterministic technique; i.e. the change in the output result of peak dose was determined with respect to a change in the independent input parameters. The sensitivity analysis was performed after completing the RESRAD calculations used to determine the radium benchmark dose. The sensitivity analysis was performed by taking each parameter and repeating the RESRAD calculation with the parameter under test set at two previously chosen extremes. Only one parameter is varied at a time. The results of the sensitivity analyses for the radium benchmark dose described in Appendix B are discussed in the following sections. The input parameters analyzed, the two extremes analyzed for the respective parameter, and the effect on the peak dose are described in **Tables B.2-1 through B.2-4**.

DESCRIPTION

The sensitivity analysis of the rancher scenario was completed only for radium-226 since the benchmark concentrations are based directly on this radionuclide.

The RESRAD parameters available for input to evaluate the rancher scenario are listed in **Table B.2-1**. The parameters evaluated in the sensitivity analysis are marked accordingly in **Table B.2-1**.

Several parameters, although available to the RESRAD sensitivity analysis, were not evaluated. Each such parameter and the reason it was not evaluated is included in **Table B.2-2**.

Several parameters were not available to the sensitivity analysis provided by the RESRAD software: they were either turned off by the software based on the active exposure pathways (e.g. "Density of cover material"; there is no cover in the model), or the software did not allow a

sensitivity analysis of the parameter (e.g. "Plant Factors Wet weight crop yield"). The parameters not available to the RESRAD sensitivity analysis are listed in **Table B.2-3**.

RESULTS

The results of the sensitivity analysis completed for the benchmark dose are summarized in **Table B.2-5**.

The results of the sensitivity analysis of the rancher scenario, as presented in the aforementioned tables, are discussed in the following sections. The sensitivity analysis did not indicate the change of any input value to cause the resulting dose to be less than the benchmark dose (18 mrem/y) by a significant amount (more than 25%; i.e. the dose was less than 13 mrem/y).

Table B.2-1. Parameters of Rancher Scenario Available for Sensitivity Analysis

PARAMETER CATEGORY	PARAMETER DESCRIPTION	SENSITIVITY ANALYSIS PERFORMED
Soil Concentrations	Transport Distribution coefficient: contaminated zone	√
	Transport Distribution coefficient: unsaturated zone	
	Transport Distribution coefficient: saturated zone	√
	Transport Solubility Limit	
	Transport Leach Rate	
Contaminated Zone	Area of contaminated zone	√
	Thickness of contaminated zone	
	Length parallel to aquifer flow	√
Cover and Contaminated Zone Hydrological Data	Cover depth	
	Density of contaminated zone	√
	Contaminated zone erosion rate	√
	Contaminated zone total porosity	√
	Contaminated zone field capacity	√
	Contaminated zone hydraulic conductivity	√
	Contaminated zone b parameter	√
	Evapotranspiration coefficient	√
	Wind speed	√
	Precipitation	√
	Irrigation	
	Runoff coefficient	√
	Watershed area for nearby stream or pond	
	Accuracy for soil/water computations	
Saturated Zone Hydrological Data	Density of saturated zone	√
	Saturated zone total porosity	√
	Saturated zone effective porosity	√
	Saturated zone field capacity	√
	Saturated zone hydraulic conductivity	√
	Saturated zone hydraulic gradient	√
	Saturated zone b parameter	√
	Water table drop rate	
	Well pump intake depth	
	Well pumping rate	

Table B.2-1 (continued). Parameters of Rancher Scenario Available for Sensitivity Analysis

PARAMETER CATEGORY	PARAMETER DESCRIPTION	SENSITIVITY ANALYSIS PERFORMED
Uncontaminated Unsaturated Zone Parameters	Unsaturated Zone Thickness	√
	Unsaturated Zone Density	
	Unsaturated Zone Total Porosity	
	Unsaturated Zone Effective Porosity	
	Unsaturated Zone Field Capacity	
	Unsaturated Zone Hydraulic Conductivity	
	Unsaturated Zone b Parameter	
Occupancy, Inhalation, And External Gamma Data	Inhalation rate	√
	Mass loading for inhalation	√
	Exposure duration	
	Indoor dust filtration factor	√
	External gamma shielding factor	√
	Indoor time fraction	√
	Outdoor time fraction	√
Ingestion Pathway, Dietary Data	Fruit, vegetable, and grain consumption	√
	Leafy vegetable consumption	√
	Meat and poultry consumption	√
	Soil ingestion	√
	Contaminated fraction Livestock water	
	Contaminated fraction Irrigation water	
	Contaminated fraction Plant food	√
	Contaminated fraction Meat	√
Ingestion Pathway, Nondietary Data	Livestock fodder intake for meat	√
	Livestock water intake for meat	√
	Livestock intake of soil	√
	Mass loading for foliar deposition	√
	Depth of soil mixing layer	√
	Depth of roots	√
	Groundwater Fractional Usage Livestock Water	
	Groundwater Fractional Usage Irrigation Water	

Table B.2-1 (continued). Parameters of Rancher Scenario Available for Sensitivity Analysis

PARAMETER CATEGORY	PARAMETER DESCRIPTION	SENSITIVITY ANALYSIS PERFORMED
Ingestion Pathway, Nondietary Data (continued)	Plant Factors Wet weight crop yield	
	Plant Factors Length of growing season	
	Plant Factors Translocation factor	
	Plant Factors Weathering removal constant	
	Plant Factors Wet foliar interception fraction	
	Plant Factors Dry foliar interception fraction	
Storage Times Before Use Data	Fruits, non-leafy vegetables, and grain	
	Leafy vegetables	
	Meat	
	Well water	
	Surface water	
	Livestock fodder	

Table B.2-2. Parameters of Rancher Scenario Available for Sensitivity Analysis but not Evaluated

Transport Solubility Limit:	This parameter was not used by RESRAD since a distribution coefficient was provided.
Transport Leach Rate:	This parameter was not used by RESRAD since a distribution coefficient was provided.
Thickness of Contaminated zone:	This parameter is fixed by 10 CFR 40, Appendix A, Criterion 6(6).
Cover depth:	The dose assessment included the actual condition that no cover will be applied.
Irrigation:	This parameter is not applicable to conditions of the scenario.
Watershed area ...	The dose assessment included the actual value for this parameter.
Accuracy ... computations:	A sufficient value for accuracy was chosen.
Water table drop rate:	The dose assessment included the actual condition that the groundwater system is unconfined.
Well pump intake depth:	Changing the value of this parameter from near zero would contradict the condition that groundwater is not an exposure pathway as a volumetric source of water.
Well pumping rate:	Changing the value of this parameter from zero would contradict the condition that groundwater is not an exposure pathway as a volumetric source of water.
Unsaturated zone parameters:	These parameters affect only the time until exposure and not the degree of exposure under the given exposure scenario.
Exposure duration:	This parameter is not applicable since the model result is evaluated as peak dose and not total dose or risk.

Table B.2-2. Parameters of Rancher Scenario Available for Sensitivity Analysis but not Evaluated (contd).

Contaminated fraction:	
Livestock water:	The model input for this parameter is 1, which is the maximum or conservative assumption.
Contaminated fraction:	
Irrigation water:	The model input for this parameter is 0, which is the most likely actual condition.
Groundwater fraction:	
Usage Livestock:	
Water:	Changing the value of this parameter from zero would contradict the condition that groundwater is not an exposure pathway as a volumetric source of water.
Groundwater fraction:	
Usage Irrigation:	
Water:	Changing the value of this parameter from zero would contradict the condition that irrigation water is not an exposure pathway as a volumetric source of water.
Plant Factors (all):	No site specific information is available to contraindicate use of the RESRAD defaults.
Storage Times Before Use:	These parameters are not applicable since the radionuclides of interest do not appreciably transform during the modeled time period.
Carbon-14:	Carbon-14 is not a radionuclide of interest in the subject dose assessment.

Table B.2-3. Parameters of Rancher Scenario NOT available for Sensitivity Analysis

PARAMETER CATEGORY	PARAMETER DESCRIPTION
Soil Concentrations	Transport Time since material placement
	Transport Groundwater concentration
Calculation Parameters	Basic Radiation Dose Limit
	Times for Calculation
Cover and Contaminated Zone Hydrological Data	Density of cover material
	Cover erosion rate
	Humidity in air
	Irrigation mode
Saturated Zone Hydrological Data	Saturated zone b parameter
	Model for Water Transport Parameters
Occupancy, Inhalation, And External Gamma Data	Shape of the contaminated zone
Ingestion Pathway, Dietary Data	Milk consumption
	Fish consumption
	Other seafood consumption
	Drinking water intake
	Contaminated fraction Drinking water
	Contaminated fraction Household water
	Contaminated fraction Aquatic food
	Contaminated fraction Milk
	Contaminated fraction Household water
Ingestion Pathway, Nondietary Data	Livestock fodder intake for milk
	Livestock water intake for milk
	Groundwater Fractional Usage Drinking water
	Groundwater Fractional Usage Household water

Table B.2-4. Value and Basis of Multiplier for Sensitivity Analysis Range

DOSE ASSESSMENT PARAMETER	VALUE OF PARAMETER MODEL	MULTIPLIER
Transport Distribution coefficient all zones, Ra-226,Pb-210	1	500,270
Basis for value of multiplier	An available value.[1]	
Area of contaminated zone, m^2	4048000	3
Basis for value of multiplier	An upper bound based on size of the site.	
Length parallel to aquifer flow, m	2270	3
Basis for value of multiplier	An upper bound based on size of the site.	
Density of contaminated zone, g/cm^3	1.5	1.5
Basis for value of multiplier	A maximum expected variation.	
Contaminated zone erosion rate, m/y	0.00001	10
Basis for value of multiplier	Arbitrary as an order of magnitude.	
Contaminated zone total porosity, dimensionless	0.2	5
Basis for value of multiplier	A maximum possible variation.	
Contaminated zone field capacity, dimensionless	0.05	4
Basis for value of multiplier	A maximum possible variation.	
Contaminated zone hydraulic conductivity, m/y	2002	2
Basis for value of multiplier	A maximum expected variation.	
Contaminated zone b parameter, dimensionless	1	10
Basis for value of multiplier	A maximum expected variation.	
Evapotranspiration coefficient, dimensionless	0.9	1.5
Basis for value of multiplier	A maximum expected variation.[1]	
Wind Speed, m/s	3.9	1.5
Basis for value of multiplier	A maximum expected variation.	
Precipitation, m/y	0.266	1.5
Basis for value of multiplier	A maximum expected variation.	
Runoff coefficient, dimensionless	0.4	2
Basis for value of multiplier	A maximum expected variation.[1]	
Density of saturated zone, g/m^3	2.4	1.5
Basis for value of multiplier	A maximum expected variation.	
Saturated zone total porosity, dimensionless	0.08	12.5
Basis for value of multiplier	A maximum possible variation.	
Saturated zone effective porosity, dimensionless	0.04	25
Basis for value of multiplier	A maximum possible variation.	

Table B.2-4 (continued). Value and Basis of Multiplier for Sensitivity Analysis Range

DOSE ASSESSMENT PARAMETER	VALUE OF PARAMETER MODEL	MULTIPLIER
Saturated zone field capacity, dimensionless	0.04	25
Basis for value of multiplier	A maximum possible variation.	
Saturated zone hydraulic conductivity, m/y	67	2
Basis for value of multiplier	A maximum expected variation.	
Saturated zone hydraulic gradient, dimensionless	0.04	2
Basis for value of multiplier	A maximum expected variation.	
Saturated zone b parameter, dimensionless	1	10
Basis for value of multiplier	A maximum expected variation.	
Unsaturated zone 1 thickness, m	8	4
Basis for value of multiplier	A maximum expected variation.	
Inhalation rate, m^3/y	8400	1.56
Basis for value of multiplier	A maximum expected variation.[1]	
Mass loading for inhalation, g/m^3	0.0001	10
Basis for value of multiplier	A maximum expected variation.[2]	
Indoor dust filtration factor, dimensionless	0.56	1.78
Basis for value of multiplier	A maximum expected variation.[1]	
External gamma shielding factor, dimensionless	0.21	3.86
Basis for value of multiplier	A maximum expected variation.[1]	
Indoor time fraction, dimensionless	0.45	1.5
Basis for value of multiplier	A maximum expected variation.	
Outdoor time fraction, dimensionless	0.20	1.5
Basis for value of multiplier	A maximum expected variation.	
Fruit, vegetable, and grain consumption, kg/y	178	1.2
Basis for value of multiplier	A maximum expected variation.[1]	
Leafy vegetable consumption, kg/y	25	2
Basis for value of multiplier	Arbitrary.	
Meat and poultry consumption, kg/y	63	2
Basis for value of multiplier	Arbitrary.	
Soil ingestion, g/y	36.5	2
Basis for value of multiplier	A maximum expected variation.[1]	
Contamination fraction Plant food, dimensionless	0.05	2
Maximum Dose, mrem/y	A maximum expected variation.	
Contamination fraction Meat, dimensionless	0.05	2
Maximum Dose, mrem/y	A maximum expected variation.	

Table B.2-4 (continued). Value and Basis of Multiplier for Sensitivity Analysis Range

DOSE ASSESSMENT PARAMETER	VALUE OF PARAMETER MODEL MULTIPLIER		
Livestock fodder intake for meat, kg/d		68	2
Basis for value of multiplier	Arbitrary.		
Livestock water intake for meat, L/d		50	2
Basis for value of multiplier	Arbitrary.		
Livestock intake of soil, kg/d		0.5	2
Basis for value of multiplier	Arbitrary.		
Mass loading for foliar deposition, g/m^3		0.0001	10
Basis for value of multiplier	Arbitrary as an order of magnitude.		
Depth of soil mixing layer, m		0.15	4
Basis for value of multiplier	A maximum expected variation.[1]		
Depth of roots, m		0.3	4
Basis for value of multiplier	A maximum expected variation.[1]		

[1] U.S. Nuclear Regulatory Commission. Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes. Washington, D.C.: U.S. Nuclear Regulatory Commission. NUREG/CR-6697. December 2000. (Attachment C)

[2] Yu, C., et.al. "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil." Argonne, IL: Argonne National Laboratory. ANL/EAIS-8. April 1993.

Table B.2-5. Summary of Sensitivity Analysis for Rancher Scenario

Ra-226 = Pb-210 = 5.0 pCi/g

DOSE ASSESSMENT PARAMETER	VALUE OF PARAMETER LOW	MODEL	HIGH
Transport Distribution coefficient all zones Ra-226,Pb-210	--	1	500, 270
Maximum Dose, mrem/y	--	18	18
Area of contaminated zone, m^2	1349333	4048000	1.2E+7
Maximum Dose, mrem/y	18	18	18
Length parallel to aquifer flow, m	757	2270	6810
Maximum Dose, mrem/y	18	18	18
Density of contaminated zone, g/cm^3	1	1.5	2.25
Maximum Dose, mrem/y	15	18	20
Contaminated zone erosion rate, m/y	0.000001	0.00001	0.0001
Maximum Dose, mrem/y	18	18	18
Contaminated zone total porosity, dimensionless	0.04	0.2	1
Maximum Dose, mrem/y	18	18	18
Contaminated zone field capacity, dimensionless	0.0125	0.05	0.2
Maximum Dose, mrem/y	18	18	18
Contaminated zone hydraulic conductivity, m/y	1001	2002	4004
Maximum Dose, mrem/y	18	18	18
Contaminated zone b parameter, dimensionless	0.1	1	10
Maximum Dose, mrem/y	18	18	18
Evapotranspiration coefficient, dimensionless	0.6	0.9	1
Maximum Dose, mrem/y	17	18	19
Wind Speed, m/s	2.6	3.9	5.9
Maximum Dose, mrem/y	18	18	18
Precipitation, m/y	0.177	0.266	0.399
Maximum Dose, mrem/y	18	18	18
Runoff coefficient, dimensionless	0.2	0.4	0.8
Maximum Dose, mrem/y	18	18	18
Density of saturated zone, g/m^3	1.6	2.4	3.6
Maximum Dose, mrem/y	18	18	18
Saturated zone total porosity, dimensionless	0.0064	0.08	1
Maximum Dose, mrem/y	18	18	18
Saturated zone effective porosity, dimensionless	0.0016	0.04	1
Maximum Dose, mrem/y	18	18	18

Table B.2-5 (continued). Summary of Sensitivity Analysis for Rancher Scenario

Ra-226 = Pb-210 = 5.0 pCi/g

DOSE ASSESSMENT PARAMETER	VALUE OF PARAMETER LOW	MODEL	HIGH
Saturated zone field capacity, dimensionless	0.0016	0.04	1
Maximum Dose, mrem/y	18	18	18
Saturated zone hydraulic conductivity, m/y	33.5	67	134
Maximum Dose, mrem/y	18	18	18
Saturated zone hydraulic gradient, dimensionless	0.02	0.04	0.08
Maximum Dose, mrem/y	18	18	18
Saturated zone b parameter, dimensionless	0.1	1	10
Maximum Dose, mrem/y	18	18	18
Unsaturated zone 1 thickness, m	2	8	32
Maximum Dose, mrem/y	18	18	18
Inhalation rate, m^3/y	5385	8400	13000
Maximum Dose, mrem/y	18	18	18
Mass loading for inhalation, g/m^3	0.00001	0.0001	0.001
Maximum Dose, mrem/y	18	18	18
Indoor dust filtration factor, dimensionless	0.3	0.56	1
Maximum Dose, mrem/y	18	18	18
External gamma shielding factor, dimensionless	0.054	0.21	0.8
Maximum Dose, mrem/y	14	18	30
Indoor time fraction, dimensionless	0.3	0.45	0.68
Maximum Dose, mrem/y	15	18	20
Outdoor time fraction, dimensionless	0.13	0.2	0.3
Maximum Dose, mrem/y	14	18	22
Fruit, vegetable, and grain consumption, kg/y	148	178	214
Maximum Dose, mrem/y	17	18	19
Leafy vegetable consumption, kg/y	12.5	25	50
Maximum Dose, mrem/y	18	18	18
Meat and poultry consumption, kg/y	32	63	126
Maximum Dose, mrem/y	18	18	18
Soil ingestion, g/y	18.25	36.5	73
Maximum Dose, mrem/y	18	18	18
Contamination fraction Plant food, dimensionless	0.025	0.05	0.1
Maximum Dose, mrem/y	15	18	20
Contamination fraction Meat, dimensionless	0.025	0.05	0.1
Maximum Dose, mrem/y	18	18	18

Table B.2-5 (continued). Summary of Sensitivity Analysis for Rancher Scenario

Ra-226 = Pb-210 = 5.0 pCi/g

DOSE ASSESSMENT PARAMETER	VALUE OF PARAMETER LOW	MODEL	HIGH
Livestock fodder intake for meat, kg/d	34	68	136
Maximum Dose, mrem/y	18	18	18
Livestock water intake for meat, L/d	25	50	100
Maximum Dose, mrem/y	18	18	18
Livestock intake of soil, kg/d	0.25	0.5	1
Maximum Dose, mrem/y	18	18	18
Mass loading for foliar deposition, g/m^3	0.00001	0.0001	0.001
Maximum Dose, mrem/y	18	18	18
Depth of soil mixing layer, m	0.0375	0.15	0.6
Maximum Dose, mrem/y	18	18	18
Depth of roots, m	0.075	0.3	1.2
Maximum Dose, mrem/y	15	18	20

APPENDIX C

DOSE ASSESSMENT FOR PONDS 4, 5, AND 6

INTRODUCTION

Several lined and unlined evaporation ponds at the site were used to evaporate the liquid mill effluents that contained natural uranium, thorium 230, and radium 226. The concentrations of these radionuclides in evaporation ponds exceed the likely soil concentration limits that would be established for the site.

The Reclamation Plan does not include complete excavation of the evaporation ponds. A dose assessment, described below, has been completed demonstrating that the contribution to total effective dose equivalent (TEDE) at the site is small. The dose assessment is centered on the rancher scenario used to establish the benchmark dose.

Exposure pathway modeling was used to calculate the dose to the rancher from the planned final condition of evaporation Ponds 4, 5, and 6. Exposure pathway modeling is an analysis of various exposure pathways of a given exposure scenario used to convert dose into concentration of radioactive material in the source media.

The exposure pathway modeling completed here was a deterministic analysis of the peak annual dose to the average member of the critical group for a rancher exposure scenario. The dose assessment accounted for site-specific information regarding the source term; critical group, scenario, and pathways identification and selection; the conceptual model; and calculations and input parameters.

SCOPE OF DOSE ASSESSMENT

The dose assessment was developed in particular for the case of license termination. The dose assessment was developed without consideration of any institutional controls and such that there is reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group is as low as is reasonably achievable.

The dose assessment was completed solely with respect to dose received due to pathways related to residual radioactive material in subsurface soil at an evaporation pond. There were several pathways not included in the dose assessment. Some pathways were not included because they are not applicable; e.g. drinking water. Other pathways were not included because they cannot be considered directly by the conceptual model applied; e.g. exposure rate from the disposal cell. These and other pathway exceptions are discussed in a following section of this appendix.

SOURCE TERM

CONFIGURATION

The physical layout of evaporation Ponds 4, 5, and 6 is shown in **Figures 1-2 and 1-3**. The figure includes approximate boundaries of each of the distinct soil units in the area; i.e. surface soils, halos, and pond footprints.

The radionuclides that have the potential to contribute the dose against which the dose limit criteria are compared are identified as the radionuclides of concern (RoC). The RoCs are specifically evaluated for the development of site-specific dose assessment. The RoCs were chosen based on historical information and findings of site investigations[69]. The RoCs were determined to be natural uranium, thorium-230, and radium-226. The contamination levels are described in Table C-1.

The source term is assumed to be covered contaminated soil of cylindrical shape. The cover is 0.3 meter of uncontaminated alluvial soil. The contaminated soil is modeled as a 2-meter thick zone of unconsolidated soil. The contaminated soil is known underlain by one uncontaminated unsaturated soil zone; this zone is modeled as a 6-meter thick zone of alluvium (unconsolidated soil). The next zone is an uncontaminated saturated zone; this zone is modeled as the uppermost bedrock and is independent of thickness. The source term is shown in Figure C-1.

RESIDUAL RADIOACTIVITY

The RoCs are assumed homogenously distributed within the contaminated soil at concentrations equivalent to the maximum concentration provided in tables 2-9, 2-10, and 2-11.

CHEMICAL FORM

In an effort to quantify the mobility of the RoCs in soil at the site, a distribution coefficient (K_d) was respectively selected for each of the soil units in the model. Description of the selection and application of the K_d is provided in Appendix B, Attachment B2.

[69] Rio Algom Mining Corporation, site characterization data.

CRITICAL GROUP, SCENARIO, AND PATHWAYS IDENTIFICATION AND SELECTION

SCENARIO IDENTIFICATION

The exposure scenario applied here may be described as representing a local rancher. The rancher scenario accounts for exposure involving residual radioactivity that is initially in the subsurface soil at the locations of the lined and unlined evaporation ponds. A rancher periodically is present on the site and retrieves some of his diet from the site. The scenario assumes no disturbance of the subsurface soils.

CRITICAL GROUP DETERMINATION

The average member of the critical group is the rancher. This individual is assumed to be an adult with common habits and characteristics. This individual is reasonably expected to receive the greatest exposure to residual radioactivity for the applicable exposure scenario.

EXPOSURE PATHWAYS

The starting point for exposure of the critical group to the RoCs is the contaminated soil zone. The RoCs are assumed potentially released from the soil by erosion, plant uptake, direct ingestion, infiltration, and leaching. The RoCs may also be transported to or by groundwater to eventually be released from soil. The scenario also considers exposure to direct gamma radiation emitted by the RoCs.

The primary exposure pathways include:

- External exposure from soil;
- Inhalation of suspended soil;
- Ingestion of soil;
- Ingestion of plant products grown in contaminated soil; and
- Ingestion of animal products grown onsite using feed and surface water from potentially contaminated sources.

Three exposure pathways not included in the dose assessment are groundwater usage, intrusion of the subsurface soils, and radon; each is discussed below.

Groundwater Usage

Groundwater usage includes use of groundwater for irrigation, livestock water supply, and drinking water. Groundwater usage was not considered a pathway applicable to the exposure scenario.

Limited yield of groundwater wells is typical throughout this part of New Mexico and has resulted in the reliance on surface water as their source(s).

Localized areas of groundwater at the Site have been created by recharge from existing surface sources or man-made subsurface reservoirs such as utility trenches and foundation backfill areas. Once these features are removed during reclamation, these groundwater sources will disappear.

In the context of the previous description, there exists a reasonable assurance that there is no direct groundwater usage pathway, especially drinking water, resulting in exposure to RoCs at the Site.

Subsurface Soil Intrusion

Deliberate intrusion into the subsurface soil was not considered during development of the dose assessment.

Radon

The radon pathway was not considered because it is specifically excluded from the scope of the technical criteria.[69]

CONCEPTUAL MODEL

The conceptual model used to evaluate the previously described exposure scenario and pathways was the RESRAD[70] computer code version 6.21. RESRAD was developed, in part, to

[69] 10 CFR 40, Appendix A, Criterion 6 (6)

[70] Yu, C., et. al. "Users Manual for RESRAD Version 6", Argonne, IL: Argonne National Laboratory. ANL/EAD-4. July 2001.

calculate site-specific concentrations for RESidual RADioactive material in soil corresponding to a radiation dose limit to a chronically exposed on-site resident. The RESRAD code considers multiple environmental transport and exposure pathways. A description of the code models, as applied here, is provided below.[71]

RESRAD models external exposure from volume sources when the individual is outside, using volume dose rate factors. Correction factors are used to account for soil density, areal extent of contamination, and thickness of contamination. When the individual is indoors, exposure from external radiation is modeled in a similar manner except that additional attenuation is included to account for the building. Exposure through ingestion of contaminated animal and plant products is modeled simply through the use of transfer factors.

The generic source-term conceptual model in RESRAD assumes a time-varying release rate of radionuclides into the water and air pathways. Radionuclides in the contaminant zone are assumed uniformly distributed. No transport is assumed to occur within the source zone, but account is made for radioactive transformation. The radioactive material is not assumed contained. The subject scenario does not include a cover of clean soil over the contaminated area. Release of radionuclides by water is assumed to be a function of a constant infiltration rate, time-varying contaminant zone thickness, constant moisture content, and equilibrium adsorption. The contaminant zone is assumed to decrease over time from a constant erosion rate. Particulates are assumed instantaneously and uniformly released into the air as a function of the concentration of particulates in the air, based on a constant mass loading rate.

The RESRAD conceptual groundwater model includes two horizontal homogenous strata for the unsaturated zone. Transport in the unsaturated zone is assumed to result from steady-state, constant vertical flow, with equilibrium adsorption, and decay, but no dispersion. RESRAD, for the subject case, models radionuclides in the saturated zone by a nondispersion approach. In the nondispersion approach, transport in the saturated zone is assumed to occur in a single homogenous stratum, under steady-state, unidirectional flow, with constant velocity, equilibrium adsorption, and radioactive transformation. The nondispersion model is the RESRAD default based on the size of the contaminated area.

The generic conceptual model of the surface water pathway in RESRAD assumes that radionuclides are uniformly distributed in a finite volume of water within a watershed. Radionuclides are assumed to enter the watershed at the same time and concentration as in the groundwater. Accordingly, no additional attenuation is considered as radionuclides are

[71] NUREG-1727, Appendix C, Section 5.3.2.1.2

transported to the watershed. Radionuclides are assumed diluted as a function of the size of the contaminated area in relation to the size of the watershed. The model assumes that all radionuclides reaching the surface water are derived from the groundwater pathway. Thus transport of radionuclides overland from runoff is not considered. As well, additional dilution from overland runoff is not considered.

The generic conceptual model of the air pathway in RESRAD uses a constant mass loading factor and area factor to model radionuclide transport. The area factor, which is used to estimate the amount of dilution, relates the concentration of radionuclides from a finite area source to the concentration of radionuclides from an infinite area source. It is calculated as a function of particle diameter, wind speed, and the side length of a square area source. The model assumes a fixed particle density, constant annual rainfall rate, and constant atmospheric stability. No radioactive decay is considered.

CALCULATIONS AND INPUT PARAMETERS

Inputs are provided for parameters of the source term configuration and exposure pathways described previously. Site-specific values were used for parameters when available. Otherwise the parameter value was assigned a default value or a value based on professional judgment.

For the source term, the inputs include site-specific values or estimates of contaminated area, thickness, density, porosity, hydraulic conductivity, hydraulic gradient, and distribution coefficient.

Particulars of the input parameters include: the rancher spends 45% of the time indoors on site, 25% of the time outdoors on site, and 35% of the time away from the site.[72] Food production is assumed to occur in the contaminated area: 5% of the resident's vegetable, grain, and fruit diet assumed produced from the contaminated area; 5% of the resident's meat diet is assumed produced from the contaminated area.[8] Neither milk nor aquatic food is included in the rancher's diet.[8] Dust levels represent ambient suspension of soil particles in air.

Vegetables, fruits, and grains are not irrigated with water from the contaminated area. Some contaminated water is used for watering livestock on site. The rancher's drinking water is assumed from an uncontaminated potable water system or uncontaminated surface water.

[72] SECY 98 084, Attachment 3, Table 1.

The walls, foundation, and floor of the resident's house reduce external exposure by 21%. Indoor dust level in air is assumed to be 56% of the outdoor dust level.

The parameters, associated inputs, and rationale for value, are included in Table C-1.

Appendix B, Attachment B2 provides description of the rationale for the value of each parameter.

SENSITIVITY ANALYSIS

A sensitivity analysis was not performed for this dose assessment.

COMPLIANCE WITH REGULATORY CRITERIA

This dose assessment was performed to compare the residual radioactivity in subsurface soils of Evaporation Ponds 4, 5, and 6 to the radium benchmark dose limit of 18 mrem per year. The result of the dose assessment for Evaporation Ponds 4, 5, and 6 was 11 mrem per year. This value is less than the radium benchmark dose, therefore stabilization in place of Evaporation Ponds 4, 5, and 6 is an approvable alternative to application of soil concentration limits.

Table C-1: Selected Model inputs for Evaporation Ponds 4, 5, & 6		
Parameter	**Input**	**Background Information**
Source		
Nuclide concentration for U-238 (pCi/g)	24	A maximum determined from site characterization information.
Transport Distribution coefficients for U-238		
Contaminated zone (cm**3/g)	1	Site-specific estimate.
Unsaturated zone 1 (cm**3/g)	1	Site-specific estimate.
Saturated zone (cm**3/g)	90	Site-specific estimate.
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects availability of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default
Nuclide concentration for U-235 (pCi/g)	1	A maximum determined from site characterization information.
Transport Distribution coefficients for U-235		
Contaminated zone (cm**3/g)	1	Site-specific estimate.
Unsaturated zone 1 (cm**3/g)	1	Site-specific estimate.
Saturated zone (cm**3/g)	90	Site-specific estimate.
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects availability of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default
Nuclide concentration for Pa-231 (pCi/g)	--	Estimated from *nuclide concentration for U-235.*
Transport Distribution coefficients for daughter Pa-231		
Contaminated zone (cm**3/g)	380	Assigned by RESRAD guidance.[2]
Unsaturated zone 1 (cm**3/g)	380	Assigned by RESRAD guidance.[2]
Saturated zone (cm**3/g)	380	Assigned by RESRAD guidance.[2]
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects availability of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default
Nuclide concentration for Ac-227 (pCi/g)	--	Estimated from *nuclide concentration for U-235.*

Table C-1: Selected Model inputs for Evaporation Ponds 4, 5, & 6		
Parameter	**Input**	**Background Information**
Transport Distribution coefficients for daughter Ac-227		
Contaminated zone (cm**3/g)	825	Assigned by RESRAD guidance.[2]
Unsaturated zone 1 (cm**3/g)	825	Assigned by RESRAD guidance.[2]
Saturated zone (cm**3/g)	825	Assigned by RESRAD guidance.[2]
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects availability of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default
Nuclide concentration for U-234 (pCi/g)	24	A maximum determined from site characterization information.
Transport Distribution coefficients for U-234		
Contaminated zone (cm**3/g)	1	Site-specific estimate.
Unsaturated zone 1 (cm**3/g)	1	Site-specific estimate.
Saturated zone (cm**3/g)	90	Site-specific estimate.
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects availability of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default
Nuclide concentration for Th-230 (pCi/g)	4470	A maximum determined from site characterization information.
Transport Distribution coefficients for Th-230		
Contaminated zone (cm**3/g)	1	Site-specific estimate.
Unsaturated zone 1 (cm**3/g)	1	Site-specific estimate.
Saturated zone (cm**3/g)	90	Site-specific estimate.
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects availability of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default
Nuclide concentration for Ra-226 (pCi/g)	62	A maximum determined from site characterization information.
Transport Distribution coefficients for Ra-226		
Contaminated zone (cm**3/g)	1	Site-specific estimate.

Table C-1: Selected Model inputs for Evaporation Ponds 4, 5, & 6		
Parameter	**Input**	**Background Information**
Unsaturated zone 1 (cm**3/g)	1	Site-specific estimate.
Saturated zone (cm**3/g)	90	Site-specific estimate.
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects availability of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default
Nuclide concentration for Pb-210 (pCi/g)	62	Estimated from *nuclide concentration for Ra-226.*
Transport Distribution coefficients for Pb-210		
Contaminated zone (cm**3/g)	1	Site-specific estimate.
Unsaturated zone 1 (cm**3/g)	1	Site-specific estimate.
Saturated zone (cm**3/g)	90	Site-specific estimate.
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects availability of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default
Calculation Parameters		
Basic radiation dose limit (mrem/yr)	25	RESRAD default
Times for Calculations (years)	0	RESRAD default
Times for Calculations (years)	3	RESRAD default
Times for Calculations (years)	10	RESRAD default
Times for Calculations (years)	30	RESRAD default
Times for Calculations (years)	100	RESRAD default
Times for Calculations (years)	300	RESRAD default
Times for Calculations (years)	1000	RESRAD default
Contaminated Zone Parameters		
Area of contaminated zone (m**2)	465000	Site-specific value.
Thickness of contaminated zone (m)	2	Estimate from site characterization data.
Length parallel to aquifer flow (m)	769	Diameter of circle of area equal contaminated zone.
Cover and Contaminated Zone Hydrological Data		
Cover depth (m)	0.3	Planned actual conditions: equivalent to one foot alluvium cover.

Table C-1: Selected Model inputs for Evaporation Ponds 4, 5, & 6		
Parameter	**Input**	**Background Information**
Density of cover material (g/cm**3)	1.5	Site-specific estimate.
Cover erosion rate (m/yr)	1 E-05	Estimate from NRC evaluation.[3].
Density of contaminated zone (g/cm**3)	1.5	Site-specific estimate.
Contaminated zone erosion rate (m/yr)	1 E-05	Estimate from NRC evaluation.[3]
Contaminated zone total porosity	0.20	Site-specific estimate.
Contaminated zone field capacity	0.05	Site-specific estimate.
Contaminated zone hydraulic conductivity (m/yr)	2002	Site-specific estimate.
Contaminated zone b parameter	1	Estimate for sand from RESRAD guidance.[2]
Humidity in air (g/cm**3)	--	Not available; reflects absence of radon pathway.[1]
Evapotranspiration coefficient	0.9	Estimate from NRC evaluation.[3]
Wind Speed (m/sec)	3.9	Site-specific estimate.
Precipitation (m/yr)	0.266	Site-specific estimate.
Irrigation (m/yr)	0	Assumed site condition.
Irrigation mode	overhead	Site specific observation (local practice).
Runoff coefficient	0.4	Estimate from RESRAD guidance.[2]
Watershed area for nearby stream or pond (m**2)	1.56 E+08	Site-specific estimate.
Accuracy for water/soil computations	0.001	RESRAD default
Saturated Zone Hydrological Data		
Density of saturated zone (g/cm**3)	2.4	Site-specific estimate.
Saturated zone total porosity	0.08	Site-specific estimate.
Saturated zone effective porosity	0.04	Site-specific estimate.
Saturated zone field capacity	0.04	Site-specific estimate.
Saturated zone hydraulic conductivity (m/yr)	67	Site-specific estimate.
Saturated zone hydraulic gradient	0.04	Site-specific estimate.
Saturated zone b parameter	1	Estimate sand from RESRAD guidance.[2]
Water table drop rate (m/yr)	1	Assume recharge from mine water stops after reclamation.
Well pump intake depth (m below water table)	0.00001	Lowest value allowed by RESRAD[1]; reflects absence of a well
Model for Water Transport Parameters		
Nondispersion (ND) or Mass-Balance (MB)	ND	RESRAD default based on size of contaminated area.[1]

Table C-1: Selected Model inputs for Evaporation Ponds 4, 5, & 6		
Parameter	**Input**	**Background Information**
Well pumping rate (m**3/yr)	0	Reflects absence of a well (no groundwater usage).
Uncontaminated Unsaturated Zone Parameters		
Unsaturated Zones	1	Site-specific condition.
Unsaturated Zone 1, Thickness (m)	6	Site-specific estimate.
Unsaturated Zone 1, Density (g/cm**3)	1.5	Site-specific estimate.
Unsaturated Zone 1, Total Porosity	0.20	Site-specific estimate.
Unsaturated Zone 1, Effective Porosity	0.15	Site-specific estimate.
Unsaturated Zone 1, Field Capacity	0.05	Site-specific estimate.
Unsaturated Zone 1, Hydraulic Conductivity (m/yr)	2002	Site-specific estimate.
Unsaturated Zone 1, b Parameter	1	Estimate for sand from RESRAD guidance.[2]
Occupancy, Inhalation, and External Gamma Data		
Inhalation rate (m**3/yr)	8400	Recommendation from RESRAD guidance.[2]
Mass loading for inhalation (g/m**3)	0.0001	RESRAD default.
Exposure duration	1	Reflects applicable regulatory evaluation period.
Indoor dust filtration factor	0.56	Estimate from RESRAD guidance.[2]
External gamma shielding factor	0.21	Suggestion from RESRAD guidance.[2]
Indoor time fraction	0.45	Estimate from NRC evaluation.[3]
Outdoor time fraction	0.20	Estimate from NRC evaluation.[3]
Shape of the contaminated zone	circular	Assumed shape of *area of contaminated zone.*
Ingestion Pathway, Dietary Data		
Fruits, vegetables and grain consumption (kg/yr)	178	Suggestion from RESRAD guidance.[2]
Leafy vegetable consumption (kg/yr)	25	Estimate from RESRAD guidance.[2]
Milk consumption (L/yr)	--	Not available; reflects absence of milk pathway.[1]
Meat and poultry consumption (kg/yr)	63	RESRAD default.
Fish consumption (kg/yr)	--	Not available; reflects absence of aquatic pathway.[1]
Other seafood consumption	--	Not available; reflects absence of aquatic pathway.[1]
Soil ingestion (g/yr)	36.5	RESRAD default.
Drinking water intake (L/yr)	--	Not available; reflects absence of drinking water pathway.[1]

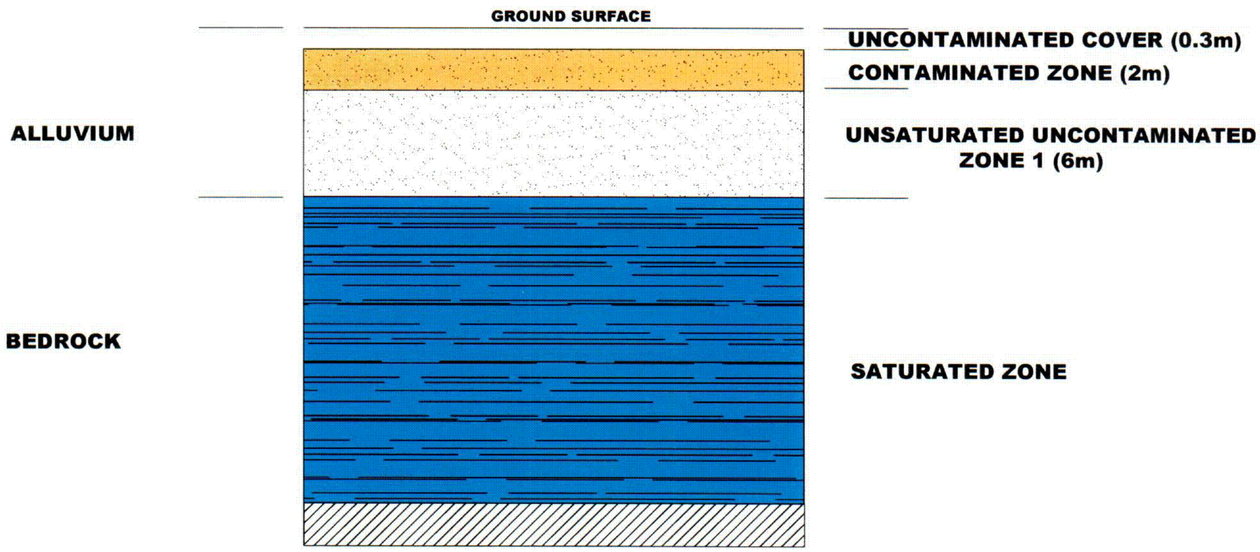
Table C-1: Selected Model inputs for Evaporation Ponds 4, 5, & 6		
Parameter	**Input**	**Background Information**
Contaminated fraction Drinking water	--	Not available; reflects absence of drinking water pathway.[1]
Contaminated fraction Household water	--	Not available; reflects absence of radon pathway.[1]
Contaminated fraction Livestock water	1	Assume all from onsite surface water.
Contaminated fraction Irrigation water	0	Reflects absence of irrigation.
Contaminated fraction Aquatic food	--	Not available; reflects absence of aquatic pathway.[1]
Contaminated fraction Plant food	0.05	Estimate from NRC evaluation.[3]
Contaminated fraction Meat	0.05	Estimate from NRC evaluation.[3]
Contaminated fraction Milk	--	Not available; reflects absence of milk pathway.[1]
Ingestion Pathway, Nondietary Data		
Livestock fodder intake for meat (kg/day)	68	RESRAD default
Livestock fodder intake for milk (kg/day)	--	Not available; reflects absence of milk pathway.[1]
Livestock water intake for meat (L/day)	50	RESRAD default
Livestock water intake for milk (L/day)	--	Not available; reflects absence of milk pathway.[1]
Livestock soil intake (kg/day)	0.5	RESRAD default
Mass loading for foliar deposition (g/m**3)	1 E-04	RESRAD default
Depth of soil mixing layer (m)	0.15	RESRAD default
Depth of roots (m)	0.3	Estimate from NRC evaluation.[3]
Groundwater Fractional Usage Drinking water	--	Not available; reflects absence of drinking water pathway.[1]
Groundwater fractional Usage Household water	--	Not available; reflects absence of radon pathway.[1]
Groundwater Fractional Usage Livestock water	0	Reflects the absence of groundwater usage; e.g. *well pumping rate* equal zero.
Groundwater Fractional Usage Irrigation water	0	Reflects the absence of groundwater usage; e.g. *well pumping rate* equal zero.
Plant Factors		
Wet weight crop yield for Non-Leafy (kg/m**2)	0.7	RESRAD default
Wet weight crop yield for Leafy (kg/m**2)	1.5	RESRAD default

Table C-1: Selected Model inputs for Evaporation Ponds 4, 5, & 6		
Parameter	**Input**	**Background Information**
Wet weight crop yield for Fodder (kg/m**2)	1.1	RESRAD default
Length of growing season for Non-Leafy (years)	0.17	RESRAD default
Length of growing season for Leafy (years)	0.25	RESRAD default
Length of growing season for Fodder (years)	0.08	RESRAD default
Translocation factor for Non-Leafy	0.1	RESRAD default
Translocation factor for Leafy	1	RESRAD default
Translocation factor for Fodder	1	RESRAD default
Weathering removal constant for vegetation	20	RESRAD default
Wet foliar interception fraction for Non-Leafy	0.25	RESRAD default
Wet foliar interception fraction for leafy	0.25	RESRAD default
Wet foliar interception fraction for fodder	0.25	RESRAD default
Dry foliar interception fraction for Non-Leafy	0.25	RESRAD default
Dry foliar interception fraction for Leafy	0.25	RESRAD default
Dry foliar interception fraction for Fodder	0.25	RESRAD default

[1] Yu, C., et. al. "Users Manual for RESRAD Version 6", Argonne, IL: Argonne National Laboratory. ANL/EAD-4. July 2001.

[2] U.S. Nuclear Regulatory Commission. Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes. Washington, D.C.: U.S. Nuclear Regulatory Commission. NUREG/CR-6697. December 2000.

[3] U.S. Nuclear Regulatory Commission, Commission Paper SECY 98 084, "Status of Efforts to Finalize Regulations for Radiological Criteria for License Termination: Uranium Recovery Facilities", April 15, 1998.



Rio Algom Mining Corp. Soil Decommissioning Plan	
Title: Depiction of Soil Zones Used for Dose Assessment of Ponds 4, 5 and 6	
PREPARED BY: cem	Filename: Rio(3)
Reviewed by: RM	Figure No. C-1
Date: 10/15/04	

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APPENDIX D

DOSE ASSESSMENT FOR PONDS 7 AND 8

INTRODUCTION

Several lined and unlined evaporation ponds at the site were used to evaporate the liquid mill effluents that contained natural uranium, thorium 230, and radium 226. The concentrations of these radionuclides in evaporation ponds exceed the likely soil concentration limits that would be established for the site.

The Reclamation Plan does not include complete excavation of the evaporation ponds. A dose assessment, described below, has been completed demonstrating that the contribution to total effective dose equivalent (TEDE) at the site is small. The dose assessment is centered on the rancher scenario used to establish the benchmark dose.

Exposure pathway modeling was used to calculate the dose to the rancher from the planned final condition of Evaporation Ponds 7 and 8. Exposure pathway modeling is an analysis of various exposure pathways of a given exposure scenario used to convert dose into concentration of radioactive material in the source media.

The exposure pathway modeling completed here was a deterministic analysis of the peak annual dose to the average member of the critical group for a rancher exposure scenario. The dose assessment accounted for site-specific information regarding the source term; critical group, scenario, and pathways identification and selection; the conceptual model; and calculations and input parameters.

SCOPE OF DOSE ASSESSMENT

The dose assessment was developed in particular for the case of license termination. The dose assessment was developed without consideration of any institutional controls and such that there is reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group is as low as is reasonably achievable.

The dose assessment was completed solely with respect to dose received due to pathways related to residual radioactive material in subsurface soil at an evaporation pond. There were several pathways not included in the dose assessment. Some pathways were not included because they are not applicable; e.g. drinking water. Other pathways were not included because they cannot be considered directly by the

conceptual model applied; e.g. exposure rate from the disposal cell. These and other pathway exceptions are discussed in a following section of this Appendix.

SOURCE TERM

CONFIGURATION

The radionuclides that have the potential to contribute the dose against which the dose limit criteria are compared are identified as the radionuclides of concern (RoC). The RoCs are specifically evaluated for the development of site-specific dose assessment. The RoCs were chosen based on historical information and findings of site investigations[74]. The RoCs were determined to be natural uranium, thorium-230, and radium-226.

The source term is assumed to be covered contaminated soil of cylindrical shape. The contaminated soil is modeled as a 2-meter thick zone of unconsolidated soil. The contaminated soil is known underlain by one uncontaminated unsaturated soil zone; this zone is modeled as a 6-meter thick zone of alluvium (unconsolidated soil). The next zone is an uncontaminated saturated zone; this zone is modeled as the uppermost bedrock and is independent of thickness.

RESIDUAL RADIOACTIVITY

The RoCs are assumed homogenously distributed within the contaminated soil at concentrations equivalent to the maximum concentration provided in tables 2-12 and 2-13.

CHEMICAL FORM

In an effort to quantify the mobility of the RoCs in soil at the site, a distribution coefficient (K_d) was respectively selected for each of the soil units in the model. Description of the selection and application of the K_d is provided in Appendix B, Attachment B2.

[74] Rio Algom Mining Corporation, site characterization data.

CRITICAL GROUP, SCENARIO, AND PATHWAYS IDENTIFICATION AND SELECTION

SCENARIO IDENTIFICATION

The exposure scenario applied here may be described as representing a local rancher. The rancher scenario accounts for exposure involving residual radioactivity that is initially in the subsurface soil at the locations of the lined and unlined evaporation ponds. A rancher periodically is present on the site and retrieves some of his diet from the site. The scenario assumes no disturbance of the disposal cell or the subsurface soils (this qualification is discussed later).

CRITICAL GROUP DETERMINATION

The average member of the critical group is the rancher. This individual is assumed to be an adult with common habits and characteristics. This individual is reasonably expected to receive the greatest exposure to residual radioactivity for the applicable exposure scenario.

EXPOSURE PATHWAYS

The starting point for exposure of the critical group to the RoCs is the contaminated soil zone. The RoCs are assumed potentially released from the soil by erosion, plant uptake, direct ingestion, infiltration, and leaching. The RoCs may also be transported to or by groundwater to eventually be released from soil. The scenario also considers exposure to direct gamma radiation emitted by the RoCs.

The primary exposure pathways include:

- External exposure from soil;
- Inhalation of suspended soil;
- Ingestion of soil;
- Ingestion of plant products grown in contaminated soil; and
- Ingestion of animal products grown onsite using feed and surface water from potentially contaminated sources.

Three exposure pathways not included in the dose assessment are groundwater usage, intrusion of the subsurface soils, and radon; each is discussed below.

Groundwater Usage

Groundwater usage includes use of groundwater for irrigation, livestock water supply, and drinking water. Groundwater usage was not considered a pathway applicable to the exposure scenario.

Limited yield of groundwater wells is typical throughout this part of New Mexico and has resulted in the reliance on surface water as their source(s).

Localized areas of groundwater at the Site have been created by recharge from existing surface sources or man-made subsurface reservoirs such as utility trenches and foundation backfill areas. Once these features are removed during reclamation, these groundwater sources will disappear.

In the context of the previous description, there exists a reasonable assurance that there is no direct groundwater usage pathway, especially drinking water, resulting in exposure to RoCs at the Site.

Subsurface Soil Intrusion

Deliberate intrusion into the subsurface soil was not considered during development of the dose assessment.

Radon

The radon pathway was not considered because it is specifically excluded from the scope of the technical criteria.[74]

CONCEPTUAL MODEL

The conceptual model used to evaluate the previously described exposure scenario and pathways was the RESRAD[75] computer code version 6.21. RESRAD was developed, in

[74] 10 CFR 40, Appendix A, Criterion 6 (6)

[75] Yu, C., et. al. "Users Manual for RESRAD Version 6", Argonne, IL: Argonne National Laboratory. ANL/EAD-4. July 2001.

part, to calculate site-specific concentrations for RESidual RADioactive material in soil corresponding to a radiation dose limit to a chronically exposed on-site resident. The RESRAD code considers multiple environmental transport and exposure pathways. A description of the code models, as applied here, is provided below.[76]

RESRAD models external exposure from volume sources when the individual is outside, using volume dose rate factors. Correction factors are used to account for soil density, areal extent of contamination, and thickness of contamination. When the individual is indoors, exposure from external radiation is modeled in a similar manner except that additional attenuation is included to account for the building. Exposure through ingestion of contaminated animal and plant products is modeled simply through the use of transfer factors.

The generic source-term conceptual model in RESRAD assumes a time-varying release rate of radionuclides into the water and air pathways. Radionuclides in the contaminant zone are assumed uniformly distributed. No transport is assumed to occur within the source zone, but account is made for radioactive transformation. The radioactive material is not assumed contained. The subject scenario does not include a cover of clean soil over the contaminated area. Release of radionuclides by water is assumed to be a function of a constant infiltration rate, time-varying contaminant zone thickness, constant moisture content, and equilibrium adsorption. The contaminant zone is assumed to decrease over time from a constant erosion rate. Particulates are assumed instantaneously and uniformly released into the air as a function of the concentration of particulates in the air, based on a constant mass loading rate.

The RESRAD conceptual groundwater model includes two horizontal homogenous strata for the unsaturated zone. Transport in the unsaturated zone is assumed to result from steady-state, constant vertical flow, with equilibrium adsorption, and decay, but no dispersion. RESRAD, for the subject case, models radionuclides in the saturated zone by a nondispersion approach. In the nondispersion approach, transport in the saturated zone is assumed to occur in a single homogenous stratum, under steady-state, unidirectional flow, with constant velocity, equilibrium adsorption, and radioactive transformation. The nondispersion model is the RESRAD default based on the size of the contaminated area.

[76] NUREG-1727, Appendix C, Section 5.3.2.1.2

The generic conceptual model of the surface water pathway in RESRAD assumes that radionuclides are uniformly distributed in a finite volume of water within a watershed. Radionuclides are assumed to enter the watershed at the same time and concentration as in the groundwater. Accordingly, no additional attenuation is considered as radionuclides are transported to the watershed. Radionuclides are assumed diluted as a function of the size of the contaminated area in relation to the size of the watershed. The model assumes that all radionuclides reaching the surface water are derived from the groundwater pathway. Thus transport of radionuclides overland from runoff is not considered. As well, additional dilution from overland runoff is not considered.

The generic conceptual model of the air pathway in RESRAD uses a constant mass loading factor and area factor to model radionuclide transport. The area factor, which is used to estimate the amount of dilution, relates the concentration of radionuclides from a finite area source to the concentration of radionuclides from an infinite area source. It is calculated as a function of particle diameter, wind speed, and the side length of a square area source. The model assumes a fixed particle density, constant annual rainfall rate, and constant atmospheric stability. No radioactive decay is considered.

CALCULATIONS AND INPUT PARAMETERS

Inputs are provided for parameters of the source term configuration and exposure pathways described previously. Site-specific values were used for parameters when available. Otherwise the parameter value was assigned a default value or a value based on professional judgment.

For the source term, the inputs include site-specific values or estimates of contaminated area, thickness, density, porosity, hydraulic conductivity, hydraulic gradient, and distribution coefficient.

Particulars of the input parameters include: the rancher spends 45% of the time indoors on site, 25% of the time outdoors on site, and 35% of the time away from the site.[77] Food production is assumed to occur in the contaminated area: 5% of the resident's vegetable, grain, and fruit diet assumed produced from the contaminated area; 5% of the resident's meat diet is assumed produced from the contaminated area.[8] Neither milk nor aquatic food is included in the rancher's diet.[8] Dust levels represent ambient suspension of soil particles in air.

[77] SECY 98 084, Attachment 3, Table 1.

Vegetables, fruits, and grains are not irrigated with water from the contaminated area. Some contaminated water is used for watering livestock on site. The rancher's drinking water is assumed from an uncontaminated potable water system or uncontaminated surface water.

The walls, foundation, and floor of the resident's house reduce external exposure by 21%. Indoor dust level in air is assumed to be 56% of the outdoor dust level.

The parameters, associated inputs, and rationale for value, are included in Table D-1.

Appendix B, Attachment B2 provides description of the rationale for the value of each parameter.

SENSITIVITY ANALYSIS

A sensitivity analysis was not performed for this dose assessment.

COMPLIANCE WITH REGULATORY CRITERIA

This dose assessment was performed to compare the residual radioactivity in subsurface soils of Evaporation Ponds 7 and 8 to the radium benchmark dose limit of 18 mrem per year. The result of the dose assessment for Evaporation Ponds 7 and 8 was seven mrem per year. This value is substantially smaller than the radium benchmark dose, therefore stabilization in place of Evaporation Ponds 7 and 8 is an approvable alternative to application of soil concentration limits.

Table D-1. Model Selected Values for Evaporation Ponds 7 & 8		
Parameter	**Input**	**Background Information**
Source		
Nuclide concentration for U-238 (pCi/g)	11	A maximum determined from site characterization information.
Transport Distribution coefficients for U-238		
Contaminated zone (cm**3/g)	1	Site-specific estimate.
Unsaturated zone 1 (cm**3/g)	1	Site-specific estimate.
Saturated zone (cm**3/g)	90	Site-specific estimate.
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects availability of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default
Nuclide concentration for U-235 (pCi/g)	0.5	A maximum determined from site characterization information.
Transport Distribution coefficients for U-235		
Contaminated zone (cm**3/g)	1	Site-specific estimate.
Unsaturated zone 1 (cm**3/g)	1	Site-specific estimate.
Saturated zone (cm**3/g)	90	Site-specific estimate.
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects availability of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default
Nuclide concentration for Pa-231 (pCi/g)	--	Estimated from *nuclide concentration for U-235.*
Transport Distribution coefficients for daughter Pa-231		
Contaminated zone (cm**3/g)	380	Assigned by RESRAD guidance.[2]
Unsaturated zone 1 (cm**3/g)	380	Assigned by RESRAD guidance.[2]
Saturated zone (cm**3/g)	380	Assigned by RESRAD guidance.[2]
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects availability of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default

Table D-1. Model Selected Values for Evaporation Ponds 7 & 8		
Parameter	**Input**	**Background Information**
Nuclide concentration for Ac-227 (pCi/g)	--	Estimated from *nuclide concentration for U-235.*
Transport Distribution coefficients for daughter Ac-227		
Contaminated zone (cm**3/g)	825	Assigned by RESRAD guidance.[2]
Unsaturated zone 1 (cm**3/g)	825	Assigned by RESRAD guidance.[2]
Saturated zone (cm**3/g)	825	Assigned by RESRAD guidance.[2]
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects availability of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default
Nuclide concentration for U-234 (pCi/g)	11	A maximum determined from site characterization information.
Transport Distribution coefficients for U-234		
Contaminated zone (cm**3/g)	1	Site-specific estimate.
Unsaturated zone 1 (cm**3/g)	1	Site-specific estimate.
Saturated zone (cm**3/g)	90	Site-specific estimate.
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects availability of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default
Nuclide concentration for Th-230 (pCi/g)	2070	A maximum determined from site characterization information.
Transport Distribution coefficients for Th-230		
Contaminated zone (cm**3/g)	1	Site-specific estimate.
Unsaturated zone 1 (cm**3/g)	1	Site-specific estimate.
Saturated zone (cm**3/g)	90	Site-specific estimate.
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects availability of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default

Table D-1. Model Selected Values for Evaporation Ponds 7 & 8		
Parameter	**Input**	**Background Information**
Nuclide concentration for Ra-226 (pCi/g)	78	A maximum determined from site characterization information.
Transport Distribution coefficients for Ra-226		
Contaminated zone (cm**3/g)	1	Site-specific estimate.
Unsaturated zone 1 (cm**3/g)	1	Site-specific estimate.
Saturated zone (cm**3/g)	90	Site-specific estimate.
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects availability of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default
Nuclide concentration for Pb-210 (pCi/g)	78	Estimated from *nuclide concentration for Ra-226.*
Transport Distribution coefficients for Pb-210		
Contaminated zone (cm**3/g)	1	Site-specific estimate.
Unsaturated zone 1 (cm**3/g)	1	Site-specific estimate.
Saturated zone (cm**3/g)	90	Site-specific estimate.
Time since material placement (yr)	0	RESRAD default
Groundwater concentration (pCi/L)	--	Not available; reflects availability of distribution coeff.[1]
Solubility Limit (mol/L)	0	RESRAD default
Leach Rate (/yr)	0	RESRAD default
Calculation Parameters		
Basic radiation dose limit (mrem/yr)	25	RESRAD default
Times for Calculations (years)	0	RESRAD default
Times for Calculations (years)	3	RESRAD default
Times for Calculations (years)	10	RESRAD default
Times for Calculations (years)	30	RESRAD default
Times for Calculations (years)	100	RESRAD default
Times for Calculations (years)	300	RESRAD default
Times for Calculations (years)	1000	RESRAD default
Contaminated Zone Parameters		
Area of contaminated zone (m**2)	265000	Site-specific value.
Thickness of contaminated zone (m)	2	Estimate from site characterization data.

Table D-1. Model Selected Values for Evaporation Ponds 7 & 8		
Parameter	**Input**	**Background Information**
Length parallel to aquifer flow (m)	581	Diameter of circle of contam zone
Cover and Contaminated Zone Hydrological Data		
Cover depth (m)	0.3	Planned actual conditions: equivalent to one foot alluvium cover.
Density of cover material (g/cm**3)	1.5	Site-specific estimate.
Cover erosion rate (m/yr)	1 E-05	Estimate from NRC evaluation.[3].
Density of contaminated zone (g/cm**3)	1.5	Site-specific estimate.
Contaminated zone erosion rate (m/yr)	1 E-05	Estimate from NRC evaluation.[3]
Contaminated zone total porosity	0.20	Site-specific estimate.
Contaminated zone field capacity	0.05	Site-specific estimate.
Contaminated zone hydraulic conductivity (m/yr)	2002	Site-specific estimate.
Contaminated zone b parameter	1	Estimate for sand from RESRAD guidance.[2]
Humidity in air (g/cm**3)	--	Not available; reflects absence of radon pathway.[1]
Evapotranspiration coefficient	0.9	Estimate from NRC evaluation.[3]
Wind Speed (m/sec)	3.9	Site-specific estimate.
Precipitation (m/yr)	0.266	Site-specific estimate.
Irrigation (m/yr)	0	Assumed site condition.
Irrigation mode	overhead	Site specific observation (local practice).
Runoff coefficient	0.4	Estimate from RESRAD guidance.[2]
Watershed area for nearby stream or pond (m**2)	1.56 E+08	Site-specific estimate.
Accuracy for water/soil computations	0.001	RESRAD default
Saturated Zone Hydrological Data		
Density of saturated zone (g/cm**3)	2.4	Site-specific estimate.
Saturated zone total porosity	0.08	Site-specific estimate.
Saturated zone effective porosity	0.04	Site-specific estimate.
Saturated zone field capacity	0.04	Site-specific estimate.
Saturated zone hydraulic conductivity (m/yr)	67	Site-specific estimate.
Saturated zone hydraulic gradient	0.04	Site-specific estimate.
Saturated zone b parameter	1	Estimate sand from RESRAD guidance.[2]
Water table drop rate (m/yr)	1	Assume recharge from mine water stops after reclamation.
Well pump intake depth (m below water table)	0.00001	Lowest value allowed by RESRAD[1]; reflects absence of a well

Table D-1. Model Selected Values for Evaporation Ponds 7 & 8		
Parameter	**Input**	**Background Information**
Model for Water Transport Parameters		
Nondispersion (ND) or Mass-Balance (MB)	ND	RESRAD default based on size of contaminated area.[1]
Well pumping rate (m**3/yr)	0	Reflects absence of a well (no groundwater usage).
Uncontaminated Unsaturated Zone Parameters		
Unsaturated Zones	1	Site-specific condition.
Unsaturated Zone 1, Thickness (m)	6	Site-specific estimate.
Unsaturated Zone 1, Density (g/cm**3)	1.5	Site-specific estimate.
Unsaturated Zone 1, Total Porosity	0.20	Site-specific estimate.
Unsaturated Zone 1, Effective Porosity	0.15	Site-specific estimate.
Unsaturated Zone 1, Field Capacity	0.05	Site-specific estimate.
Unsaturated Zone 1, Hydraulic Conductivity (m/yr)	2002	Site-specific estimate.
Unsaturated Zone 1, b Parameter	1	Estimate for sand from RESRAD guidance.[2]
Occupancy, Inhalation, and External Gamma Data		
Inhalation rate (m**3/yr)	8400	Recommendation from RESRAD guidance.[2]
Mass loading for inhalation (g/m**3)	0.0001	RESRAD default.
Exposure duration	1	Reflects applicable regulatory evaluation period.
Indoor dust filtration factor	0.56	Estimate from RESRAD guidance.[2]
External gamma shielding factor	0.21	Suggestion from RESRAD guidance.[2]
Indoor time fraction	0.45	Estimate from NRC evaluation.[3]
Outdoor time fraction	0.20	Estimate from NRC evaluation.[3]
Shape of the contaminated zone	circular	Assumed shape of *area of contaminated zone.*
Ingestion Pathway, Dietary Data		
Fruits, vegetables and grain consumption (kg/yr)	178	Suggestion from RESRAD guidance.[2]
Leafy vegetable consumption (kg/yr)	25	Estimate from RESRAD guidance.[2]
Milk consumption (L/yr)	--	Not available; reflects absence of pathway.[1]
Meat and poultry consumption (kg/yr)	63	RESRAD default.
Fish consumption (kg/yr)	--	Not available; reflects absence of aquatic pathway.[1]

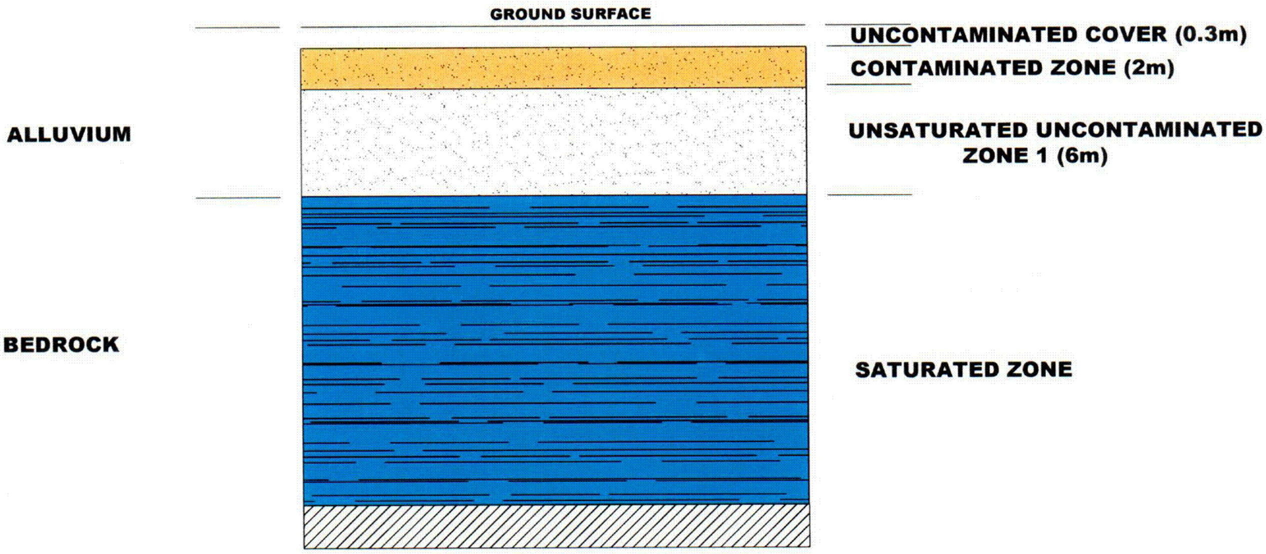
Table D-1. Model Selected Values for Evaporation Ponds 7 & 8		
Parameter	**Input**	**Background Information**
Other seafood consumption	--	Not available; reflects absence of aquatic pathway.[1]
Soil ingestion (g/yr)	36.5	RESRAD default.
Drinking water intake (L/yr)	--	Not available; reflects absence of drinking water pathway.[1]
Contaminated fraction Drinking water	--	Not available; reflects absence of drinking water pathway.[1]
Contaminated fraction Household water	--	Not available; reflects absence of radon pathway.[1]
Contaminated fraction Livestock water	1	Assume all from onsite surface water.
Contaminated fraction Irrigation water	0	Reflects absence of irrigation.
Contaminated fraction Aquatic food	--	Not available; reflects absence of aquatic pathway.[1]
Contaminated fraction Plant food	0.05	Estimate from NRC evaluation.[3]
Contaminated fraction Meat	0.05	Estimate from NRC evaluation.[3]
Contaminated fraction Milk	--	Not available; reflects absence of milk pathway.[1]
Ingestion Pathway, Nondietary Data		
Livestock fodder intake for meat (kg/day)	68	RESRAD default
Livestock fodder intake for milk (kg/day)	--	Not available; reflects absence of milk pathway.[1]
Livestock water intake for meat (L/day)	50	RESRAD default
Livestock water intake for milk (L/day)	--	Not available; reflects absence of milk pathway.[1]
Livestock soil intake (kg/day)	0.5	RESRAD default
Mass loading for foliar deposition (g/m**3)	1 E-04	RESRAD default
Depth of soil mixing layer (m)	0.15	RESRAD default
Depth of roots (m)	0.3	Estimate from NRC evaluation.[3]
Groundwater Fractional Usage Drinking water	--	Not available; reflects absence of drinking water pathway.[1]
Groundwater fractional Usage Household water	--	Not available; reflects absence of radon pathway.[1]
Groundwater Fractional Usage Livestock water	0	Reflects the absence of groundwater usage
Groundwater Fractional Usage	0	Reflects the absence of groundwater usage;

Table D-1. Model Selected Values for Evaporation Ponds 7 & 8		
Parameter	**Input**	**Background Information**
Irrigation water		e.g. *well pumping rate* equal zero.
Plant Factors		
Wet weight crop yield for Non-Leafy (kg/m**2)	0.7	RESRAD default
(continued, 7 of 7)		
Wet weight crop yield for Leafy (kg/m**2)	1.5	RESRAD default
Wet weight crop yield for Fodder (kg/m**2)	1.1	RESRAD default
Length of growing season for Non-Leafy (years)	0.17	RESRAD default
Length of growing season for Leafy (years)	0.25	RESRAD default
Length of growing season for Fodder (years)	0.08	RESRAD default
Translocation factor for Non-Leafy	0.1	RESRAD default
Translocation factor for Leafy	1	RESRAD default
Translocation factor for Fodder	1	RESRAD default
Weathering removal constant for vegetation	20	RESRAD default
Wet foliar interception fraction for Non-Leafy	0.25	RESRAD default
Wet foliar interception fraction for leafy	0.25	RESRAD default
Wet foliar interception fraction for fodder	0.25	RESRAD default
Dry foliar interception fraction for Non-Leafy	0.25	RESRAD default
Dry foliar interception fraction for Leafy	0.25	RESRAD default
Dry foliar interception fraction for Fodder	0.25	RESRAD default

[1] Yu, C., et. al. "Users Manual for RESRAD Version 6", Argonne, IL: Argonne National Laboratory. ANL/EAD-4. July 2001.

[2] U.S. Nuclear Regulatory Commission. Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes. Washington, D.C.: U.S. Nuclear Regulatory Commission. NUREG/CR-6697. December 2000.

[3] U.S. Nuclear Regulatory Commission, Commission Paper SECY 98 084, "Status of Efforts to Finalize Regulations for Radiological Criteria for License Termination: Uranium Recovery Facilities", April 15, 1998.



Rio Algom Mining Corp. Soil Decommissioning Plan	
Title: Depiction of Soil Zones Used for Dose Assessment of Ponds 7 and 8	
PREPARED BY: cem	Filename: Rio(4)
Reviewed by: RM	Figure No. D-1
Date: 10/15/04	

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ATTACHMENT 1

QUALITY ASSURANCE PROGRAM DESCRIPTION

QUALITY ASSURANCE PROGRAM DESCRIPTION

QUALITY ASSURANCE

Decommissioning and decontamination activities will be performed under the provisions of the Quality Assurance Program (QAP). The requirements and guidance contained in the QAP are based on the principle that work shall be planned, documented, performed under controlled conditions, and periodically assessed to established work item quality and process effectiveness and promote improvement. The requirements described in the QAP reflect the responsibilities assigned to management and personnel of all departments and their responsibility for planning, achieving, verifying, and assessing quality and promoting continuous improvement. The QAP further delineates the quality contributions of all personnel and encourages their active participation in accomplishing the quality objectives.

ORGANIZATION

The day-to-day implementation of the QAP is the responsibility of the Project Manager. Appropriately trained and qualified personnel assigned to specific activities perform technical work, including quality-related work.

The Quality Assurance Manager is responsible for designing and implementing quality assurance procedures; for monitoring, auditing and inspecting to confirm that quality is being achieved; and for verifying that corrective action, when required, has been effective. The Quality Assurance Manager is independent of project cost and schedule to guarantee objectivity, and reports directly to the Project Manager.

The Project Manager, General Manager, Manager of Radiation Safety and Environmental Affairs, Quality Assurance Manager, Radiation Safety Officer, and field personnel have the authority to stop work for just cause, real or suspected. Any employee can make work stoppage recommendations to any other, and when there is an imminent danger all employees have the authority to stop work. Work will not resume until the concern is addressed and appropriately resolved.

Personnel and organizations not directly responsible for managing or performing the work verify the achievement of quality.

QUALITY ASSURANCE PROGRAM

Methods of quality assurance are used during the planning, design, procurement, installation, operation, maintenance, remediation and decontamination/ decommissioning of structures, systems, and components. The QAP is documented and maintained in accordance with applicable standards and sound management practices. Activities affecting quality are identified and are made subject to the QAP in the documentation.

DOCUMENT CONTROL

Documents that specify quality-related requirements and instructions are identified, reviewed, approved, issued, distributed, and maintained as controlled documents in accordance with written procedures. A listing of the type of documents to be maintained as controlled documents will be identified by procedure. The controlled document list will be updated as needed, to ensure it is comprehensive, current, and complete.

Changes to controlled documents are reviewed and approved by the same organization that reviewed and approved the documents originally, or by other designated qualified organizations. Disposition of superseded and modified documents is controlled in accordance with written procedures. A master list of controlled documents is maintained to identify the current revision number of instructions, procedures, specifications, drawings, and procurement documents. The list is distributed periodically to those individuals or organizations responsible for maintaining the applicable controlled documents, to prevent the use of outdated or obsolete documents.

Appropriate controlled documents are available in work areas before initiation of and during the performance of activities affecting quality. This availability is verified periodically by the Quality Assurance Manager. Changes or revisions to controlled documents are verbally communicated to affected individuals and a required reading program assures awareness of the change.

DOCUMENT CONTROL - INSTRUCTIONS, PROCEDURES, AND DRAWINGS

Quality-related activities shall be prescribed by and accomplished in accordance with documented and approved instructions, procedures, or drawings. These instructions, procedures and drawings shall contain the necessary detail required by the activity and include or reference appropriate acceptance criteria.

DOCUMENT CONTROL – RESPONSIBILITY

The Quality Assurance Manager is responsible for verifying implementation of all quality-related work outlined in controlled documents, procedures, or drawings.

Employees and subcontractors are responsible for implementing the QAP and applicable instructions, procedures, and drawings.

The cognizant managers and appropriate supervisors are responsible for developing and implementing all quality-related technical documents or procedures.

Technical supervisors are responsible for developing, securing approval for, conducting, and reporting on elements of the work program affecting quality in accordance with the QAP and applicable instructions, procedures and drawings. The cognizant managers are responsible for ensuring development of all technical documents dealing with quality-related work under their cognizance, and for ensuring compliance with those documents.

DOCUMENT CONTROL – IMPLEMENTATION

Written procedures and instructions governing implementation of the QAP shall be developed. These documents address requirements concerning scope and purpose, applicability, responsibilities, and records. They are issued and maintained as controlled documents. Approval of the Project Manager and Quality Assurance Manager are required before these documents may be issued or revised.

Activities affecting quality are controlled and authorized by documents (e.g. procedures, instructions, drawings). These documents are reviewed as necessary by authorized personnel having appropriate technical, quality, and administrative expertise to ensure adequacy and completeness. Written procedures clearly outline the actions to be accomplished in the preparation, review, approval, and control of procedures, instructions and drawings.

Drawings initiated by subcontractors are controlled in accordance with the QAP. Project Management is responsible for the control of drawings developed by subcontractors. The Quality Assurance Manager verifies compliance through normal audit procedures.

Any errors or deficiencies in instructions, procedures, and drawings are corrected upon discovery. Revisions or changes are made, reviewed, approved, and documented in accordance with written procedures before the revision or change is implemented.

CONTROL OF MEASURING AND TEST EQUIPMENT

The technical staff will use appropriate procedures to ensure adequate control of measuring and test equipment that affect site characterization and the quality of design, construction, or operation. The procedures describe calibration technique, frequency, maintenance, and control of measuring and test equipment.

Measuring and test equipment is labeled, tagged, or otherwise identified and documented to indicate the next calibration due date, as well as to provide traceability to calibration test data. Before measuring and test equipment is used, it is checked by the user to have a current calibration. Equipment is calibrated at specific intervals based on manufacturer's recommendations or on required accuracy and equipment history of drifting, precision, purpose, or any other characteristics that could affect accuracy. If a piece of equipment is found to be out of calibration, evaluations are made to determine the validity and acceptability of any measurements performed subsequent to the last calibration. If items are measured with equipment found to be out of calibration, the items are re-inspected.

Standards for calibration are determined with appropriate reference to nationally accepted standards, manufacturers' instructions, intended uses, and other factors. If national standards do not exist, the basis for calibration is documented. Calibrations are performed immediately prior to use when such action is necessary to maintain or ensure accurate measurements and tests.

Documented calibration records are maintained as Quality Assurance records, in accordance with applicable procedures. Calibration instructions are maintained as controlled documents.

CORRECTIVE ACTION

Corrective actions are accommodated through written procedures that implement an audit tracking system. Conditions adverse to quality are evaluated via the audit tracking system, and if found to be significant, are investigated to determine root causes, to decide on immediate corrective actions, to project preventive actions, and to define follow-up needs. The evaluations are documented within the audit tracking system.

Follow-up verification by the Quality Assurance Manager or designee ensures that the audit tracking system actions have been implemented in a timely manner and are effective. The Quality Assurance Manager monitors progress and closes audit tracking system actions in a timely manner.

The Quality Assurance Manager reports on audit tracking system actions pending and closed, and on trends related to Nonconformance Reports and Corrective Action Reports, at each Management Review meeting.

Documentation will be maintained of Corrective Action Reports, actions taken to resolve the condition, and any follow-up audits or actions.

RECORDS

A records management system for items with quality assurance requirements includes, in part, the following: operating logs, results of reviews, inspections, tests, audits, monitoring of work performance, and material analyses. Records also include closely related data such as qualifications of personnel, training, procedures, equipment records (including calibrations), evaluations and analyses of a quality-related nature.

The types and locations of quality assurance records are identified in a subject-oriented records list. Individual records are classified, designated, validated, and stored in accordance with written procedures. Quality assurance documents are traceable to relevant items and activities, and are identifiable and retrievable. Record retention is in accordance with applicable regulatory requirements.

AUDITS AND SURVELLIANCES

Audits and surveillances are planned and scheduled according to the type and status of work being performed. Unannounced audits and surveillances are performed as necessary.

The results of audits and surveillances shall be documented. The Quality Assurance Manager is responsible for ensuring that audit findings and observations are monitored and closed out in a timely manner. Audit results are documented and reviewed by management personnel who are responsible for the audited area.

Management personnel take appropriate action to identify root causes, correct deficiencies, prevent recurrences, and determine impacts of audit findings in their area of responsibility. Follow-up actions are performed as necessary to ensure that appropriate corrective actions have been implemented in a timely manner and are effective.

PROGRAM CHANGES

Changes to the key elements of the QAP will be submitted to the U.S. Nuclear Regulatory Commission for review and approval prior to implementation.

The NRC will be notified of any changes to the organizational elements within 30 days after the announcement of the change is made.

Editorial changes or personnel reassignments of a non-substantive nature do not require NRC notification.