STATE OF COLORADO

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Colorado Department
of Public Health
and Environment

October 10, 2007

Ms. Janet R. Schlueter, Director
Division of Materials Safety and State Agreements
United States Nuclear Regulatory Commission
One White Flint North, Room 3C-10
11555 Rockville Pike
Rockville, Maryland 20852

Re: Submittal of the Alternative Soils Standards Application regarding the Uravan Colorado Radioactive Materials License #660-02.

Dear Ms. Schlueter:

Enclosed for your review and approval are two copies of the Alternative Soil Standards Application for the Umetco Minerals Corporation's Uravan site located in Montrose County, Colorado. This report has been approved and accepted by us and by EPA (Appendix E of the report).

If you have any questions about the project, please call Mr. Phil Stoffey at 303-692-3452 or e-mail at philip.stoffey@state.co.us.

Sincerely,

Joseph Vranka

Joseph Vranka, Manager
Radiation Control Program
Hazardous Materials and Waste Management Division
Colorado Department of Public Health and Environment

Enclosure: Maybell Final Completion Review Report (CRR)

Cc: File 660-01 File 3.2 w/ enclosure
Rahe Junge, Umetco w/o enclosure
Dennis Sollenberger

ALTERNATIVE SOIL STANDARDS APPLICATION

URAVAN, COLORADO

Including the Mill Hillside, A-Plant North, River Ponds Areas, and County Road Y-11

Umetco Minerals Corporation
Grand Junction, Colorado

September 2007

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September 2007

EXECUTIVE SUMMARY

Alternative soil standards are requested for four locations in the Uravan area where Radium-226 is in excess of Environmental Protection Agency (EPA) and Colorado *Rules and Regulations Pertaining to Radiation Control Standards*, Criterion 6.6. The alternative standards areas are within the area to be transferred to the Department of Energy (DOE) for long-term surveillance activities and are termed the Mill Hillside, A-Plant North, River Ponds, and County Road Y-11 areas. The *Alternative Soil Standards Application* contains a description of the alternative standard areas and information to support the application for alternative soil standards in the subject areas. Development of this application utilized the DOE's Supplemental Standards Justification Checklist (1992).

Alternative standards have been applied to portions of the Uravan site as allowed by Nuclear Regulatory Commission (NRC) regulations. This application follows site Applicable or Relevant and Appropriate Requirements (ARARS) established in the Uravan Consent Decree and Remedial Action Plan. Site ARARS include the EPA requirements outlined in Title 40, Part 192.21 and 192.22 of the Code of Federal Regulations (CFR). Requirements set forth in 40 CFR 192.21 indicate that "Remedial action will generally not be necessary where radioactive materials have been placed semi-permanently in a location where site-specific factors limit their hazard and from which they are costly or difficult to remove".

Alternative soil standards for the subject areas are protective of human health and the environment by assuring that potential radiological exposures to humans are minimized such that these exposures do not pose a future heath risk to humans. Previous remedial activities have reduced exposures to the general public in the four subject areas to less than 25 millirem (0.25 mSv) per year and to a level that is as low as reasonably achievable (ALARA). These results meet the requirements for license termination set forth in Section 4.61.2 of Colorado's *Rules and Regulations Pertaining to Radiation Control*. The residual radioactive materials are located in areas which are stable and are not subject to mass wasting or other forms of rapid geomorphic erosion and dispersion into the environment. In general, the alternative soil standards prevent radiation exposures to workers and the general public, limit the potential dispersal of contaminants to the environment, and avoid environmental damage caused by additional cleanup activities. Results of the alternative soil standards evaluation demonstrate that the cost of additional remedial activities is clearly excessive in relation to the

negligible reduction in potential future exposures to humans.

Relevant and appropriate EPA criteria that can be applied to alternative standards areas at Uravan are summarized in the following table.

SUMMARY TABLE

Criteria for Applying 40 CFR 192.21 Alternative Soil Standards at Uravan, Colorado

Area	Applied 40 CFR 192.21 Criteria*
Mill Hillside	Risk to Workers or Public 192.21 (a) Excessive Environmental Harm 192.21 (b) Unreasonably High Costs vs. Benefits 192.21 (c) Absence of Other Residual Radioactive Material192.21 (h)
A-Plant North	Excessive Environmental Harm 192.21 (b) Unreasonably High Costs vs. Benefits 192.21 (c) Absence of Other Residual Radioactive Material192.21 (h)
River Ponds	Excessive Environmental Harm 192.21 (b) Unreasonably High Costs vs. Benefits 192.21 (c) Absence of Other Residual Radioactive Material192.21 (h)
County Road Y-11	Risk to Workers or Public 192.21 (a) Excessive Environmental Harm 192.21 (b) Unreasonably High Costs vs. Benefits 192.21 (c) Absence of Other Residual Radioactive Material192.21 (h)

*Refer to Section 2.0 for a description of these criteria.

A summary of findings set forth in this report supporting the application of alternative soil standard described above is as follows:

Mill Hillside: Alternative standards have been applied to the steep slopes of the northern side of the A-Plant area that contains mill related contaminants. Mill buildings, foundations and contaminated soils have been removed and potential future exposures reduced to as low as reasonably achievable in the Mill Hillside area. Alternative standards have been applied to the Mill Hillside area based on the following criteria:

- o Additional remedial action performed on the Mill Hillside would pose a clear and present risk of injury to workers due to construction hazards associated with excavation from excessively steep slopes, with some slopes exceeding a 1 to 1 ratio.
- o Additional remedial actions could destabilize the hillside slope creating a risk for uncontrolled releases of sediment to drainages and the San Miguel River from thunderstorm events with an associated degradation of the environment. Such destabilization could cause excessive harm to the environment.
- o No habitable structures can or will be constructed in the alternative standards area because of future institutional control and long-term stewardship of the area by the DOE.
- o The cost of remediation to remove additional contaminated soils in the Mill Hillside area could be in excess of $6,620,200 which would clearly be unreasonably high relative to a very small decrease in potential human exposures.
- o Previous remedial actions conducted on the site have reduced exposures to as low as reasonably achievable and potential health risks associated with the residual contamination are negligible, including radiation from elements other than radium.
- o Future land use of the area will continue to be as habitat for terrestrial species, including both small and large game species. Future use of the area for residential structures, office buildings, schools, or play grounds will be prohibited. The DOE will assume long-term stewardship of the property and will assure that future land use activities are protective of public health and safety and the environment.

A-Plant North Area: Alternative standards have been applied to the A-Plant North area where residual contamination is present in a small riparian area in the flood plain of the San Miguel River. Alternative standards have been applied to this area based on the following criteria:

- o Additional remedial actions performed in the flood plain of the San Miguel River would cause excessive environmental harm to the environmentally sensitive wetland area.
- o The residual Ra-226 contamination is relatively low and does not pose a risk to hunters, hikers, or the environment. The area is within the annual flood plain of the San Miguel River and within the DOE's long-term surveillance area. No habitable structures can or will be constructed in the alternative standards area within the flood plain of the San Miguel River.
- o The cost of future remedial actions, estimated at $1,024,000, would far exceed the benefits because potential human exposures are negligible, given the low concentration of radionuclides in the soil and the absence of future human habitation.

- Previous remedial actions conducted on the site have reduced exposures to as low as reasonably achievable and potential health risks associated with the residual contamination are negligible, including radiation from elements other than radium.
- Future land use of the area will continue to be as habitat for both aquatic and terrestrial species, including both small and large game species. Future use of the area for residential structures, office buildings, schools, or play grounds will be prohibited. The DOE will assume long-term stewardship of the property and will assure that future land use activities are protective of public health and safety and the environment.

River Ponds: Alternative standards have been applied to the River Ponds area. Residual contamination from 20 to 60 μR/hr (0.2 to 0.6 μSv/hr) existed as local hot spots in the cleanup area prior to final clean up. These areas of residual contamination were excavated and then subsequently covered by 2 to 3 feet of recent alluvial sediment and stabilized by riparian vegetation. Alternative standards applied to this area are based on the following criteria:

- Additional remedial actions would result in environmental damage to riparian vegetation and wetland areas, causing extensive environmental harm.
- Radiation risks associated with the low levels of residual contamination are negligible given that the area currently meets exposure criteria (<20 μR/hr or <0.2μSv/hr) set forth in the Uravan Remedial Action Plan and will continue to decrease with additional deposition of sediment.
- The area is within the annual flood plain of the San Miguel River and within the DOE's long-term surveillance area. No habitable structures can or will be constructed in the alternative standards area within the flood plain of the San Miguel River.
- Riprap groins and riparian vegetation currently provides protection from water and wind erosion and slows natural dispersion by providing a stabilizing cover over the residual contaminants.
- The cost of remediation to remove additional contaminated soils in the River Ponds area could be in excess of $5,120,720 which would clearly be unreasonably high relative to an extremely small decrease in potential human exposures.
- Previous remedial actions conducted on the site have reduced exposures to as low as reasonably achievable and potential health risks associated with the residual contamination are negligible, including radiation from elements other than radium.
- Future land use of the area will continue to be as habitat for both aquatic and terrestrial species, including both small and large game species. Future use of the area for residential structures, office buildings, schools, or play grounds will be prohibited. The DOE will assume long-term stewardship of the property and will

assure that future land use activities are protective of public health and safety and the environment.

County Road Y-11: Alternative standards have been applied to County Road Y-11 where contaminated soils may exist at depth beneath the roadway. Alternative standards have been applied to the County Road Y-11 based on the following criteria:

- o Potential health risks associated with the contamination are negligible because contaminated materials are only present at depths greater than 3 feet and future exposures along the roadway will be minimized by institutional controls agreed to by Montrose County, the BLM and the DOE.
- o No habitable structures can or will be constructed in the alternative standards area because the land is occupied by a county road and future land use changes will be prohibited by institutional controls.
- o The cost of remediation to remove additional contaminated soils beneath County Road Y-11 could be in excess of $3,366,000 which would clearly be unreasonably high relative to a very small decrease in potential human exposures.
- o Previous remedial actions conducted on the site have reduced exposures to as low as reasonably achievable and potential health risks associated with the residual contamination are negligible, including radiation from elements other than radium.
- o Future land use of the area will continue to be as a road connecting State Highway 141 with Bedrock, Colorado. Future use of the area for residential structures, office buildings, schools, or play grounds will be prohibited. The DOE will assume long-term stewardship of the property and will assure that future land use activities are protective of public health and safety and the environment.

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APPENCICIES

1.0 INTRODUCTION

Alternative soil cleanup standards, as allowed for by the Environmental Protection Agency and Nuclear Regulatory Commission (NRC) regulations, have been applied to portions of the Uravan site. Development of this application utilized the U. S. Department of Energy's Supplemental Standards Justification Checklist (1992). The Uravan site is located in western Colorado near the Colorado-Utah state line (Figure 1). Activities at the Uravan site began in 1914 with the construction of the Joe Junior radium mill and continued until 1984 when milling activities ceased. This application follows site ARARs (Applicable or Relevant and Appropriate Requirements) established in the Uravan Consent Decree and Remedial Action Plan. Site ARARs followed in the development of this document include Environmental Protection Agency (EPA) Standards outlined in Title 40, Part 192.21 and 192.22 of the Code of Federal Regulations (CFR).

Alternative standards are requested for four locations where radium-226 (Ra-226) is in excess of EPA Standards. Characterization and cleanup confirmation studies in these areas have verified that milling activities had not segregated or concentrated uranium or thorium radionuclides in these areas. The alternative standards areas are termed the Mill Hillside, A-Plant North, River Ponds, and County Road Y-11 areas (Figure 2). This report contains a summary of the alternative standards, along with information to support the application for alternative standards. Boundary descriptions for each of the alternative standards area is included in Appendix D and shown on figure D-1.

Alternative soil standards for the Mill Hillside, A-Plant North, River Ponds, and County Road Y-11 areas are protective of human health and the environment by assuring that future radiological exposures are minimized such that they pose no significant heath risks. Approval of the alternative soil standards will prevent injuries or radiation exposures to workers, will limit the potential dispersal of contaminants to the environment, and will minimize environmental damage caused by additional cleanup activities. Cost for postulated future cleanup actions is clearly excessive given the limited reductions to possible or future exposure to humans.

2.0 ALTERNATIVE CONCENTRATION AREAS

The Alternative Standards Application describes the residual contamination within the historic Uravan mill area and along County Road Y-11. The mill area and county road are located along the

San Miguel River near the site of the former town of Uravan in Montrose County, Colorado (Figure 1). The mill area was used in the processing of uranium bearing ores from 1914 to 1984. The Mill Hillside, A-Plant North, River Ponds, and County Road Y-11 areas are described in this report in Sections 3.0, 4.0, 5.0 and 6.0, respectively. The areas included in this application are briefly described in Table 1 and shown on Figure 2. Remedial activities conducted in these areas were established in the Uravan Consent Decree and Remedial Action Plan (Civil Action # 83-C-2384). This plan, approved by the Federal Court in 1987, and associated ARARs were followed during the cleanup of each of the areas.

Table 2.0 Total Acreages for the Individual Alternative Soil Standard Areas

Area	Area in Acres	Description
Mill Hillside	22.8	The Mill Hillside site is located within the Uravan restricted area and includes steep terrain extending from near the base of the colluvial slope in the former A-Plant area to the top of the Club Mesa rim and from the mouth of Hieroglyphic Canyon to the northwest for about 1,800 feet. Past vanadium and uranium recovery operations were located in the Mill Hillside area.
A-Plant North	2	The A-Plant North area encompasses about 2 acres located on the northwestern part of the A-Plant area adjacent to the San Miguel River. The area includes riparian habitat in the flood plain of the San Miguel River. The area was a part of former uranium and vanadium recovery operations, including the former Joe Junior radium mill.
River Ponds	10	The River Ponds were constructed of mill tailings along the main channel of the San Miguel River. There were seven ponds, two on the northeast bank of the river and five on the southwest bank. These ponds were directly north of the A-Plant area and were used in the uranium and vanadium recovery operations. The area commonly floods during spring runoff and contains diverse wildlife habitat. The area was a part of former uranium and vanadium recovery operations, including the former Joe Junior radium mill.
County Rd Y-11	8.4	The County Road Y-11 alternative standards area consists of a 5,800-foot section of road between the County Road Y-11 Bridge and the Old Iron Bridge. The area is on the southwest side of the San Miguel River, paralleling the Club Ranch Ponds area.

This application for alternative standards follows the requirements for supplemental standards set forth in EPA's regulations 40 CFR 192.21 and 192.22. Relevant and appropriate EPA criteria that can be applied to alternative standards at Uravan are summarized as follows:

<u>Risk to Workers or Public 192.21 (a)</u>: Remedial actions would pose a clear and present risk of injury to workers or to members of the public, notwithstanding reasonable measures to avoid or reduce risk.

<u>Excessive Environmental Harm 192.21 (b):</u> Remedial actions to satisfy the cleanup standards for land, §192.12(a) would, notwithstanding reasonable measures to limit damage, directly produce health and environmental harm that is clearly excessive compared to the health and environmental benefits, now or in the future.

<u>Unreasonably High Costs vs. Benefits 192.21 (c):</u> The estimated cost of remedial action is unreasonably high relative to the long-term benefits, and the residual radioactive materials do not pose a clear present or future hazard. The likelihood that buildings will be erected or that people will spend long periods of time at such a vicinity site should be considered in evaluating this hazard. Remedial action will generally not be necessary where residual radioactive materials have been placed semi-permanently in a location where site-specific factors limit their hazard and from which they are costly or difficult to remove, or where only minor quantities of residual radioactive materials are involved.

<u>Absence of Other Residual Radioactive Material 192.21 (h):</u> Radionuclides other than radium-226 and its decay products are present in sufficient quantity and concentration to constitute a significant radiation hazard from residual radioactive materials.

3.0 MILL HILLSIDE AREA

3.1 Basis for Application

Remedial actions in the Mill Hillside area (Figure 2) were conducted in accordance with the requirements set forth under the Uravan Remedial Action Plan and with the *Soil Cleanup Program Methodology for Uravan, Colorado* (Umetco, 1999). All feasible remedial activities have been completed in the Mill Hillside area to reduce exposures to as low as reasonably achievable. Concrete foundations and contaminated soils associated with a 1930's vanadium mill were removed from the Mill Hillside slope in 1999 and additional contaminated soils were excavated in 2001 and 2002. A total of approximately 46,000 cubic yards of soil and crushed foundation concrete were excavated from the Mill Hillside. Mill foundations and contaminated soils removed from key hillside areas were placed in secure repositories on Club Mesa. Where excavation changed the local natural slopes, rock mulched terraces were constructed to prevent erosion and slope de-stabilization after removal of contaminated soils. Remedial activities are fully discussed in Compliance Reports CR-418C-2, CR-418C-3 and CR-418C-4 (Umetco, 2002, 2006). Total cost for reclamation of the Mill Hillside exceeded $1,800,000.

Results of these remedial actions are described in the report titled *Uravan Mill Hillside Confirmation Investigation Report* (Umetco, 2002). The remedial actions and associated final verification report were verified in the field and approved by the Colorado Department of Public Health and Environment (CDPHE, 2003). These remedial actions reduced contamination to levels as low as reasonably achievable and resulted in the long-term protection of humans and the environment. The confirmation study showed that the remedial action at the site has mitigated the risk to human health for the most probably exposed person, a hunter/hiker.

Alternative standards have been applied to the steep slopes of the Mill Hillside that contains mill related contaminants. Alternative standards have been applied to the Mill Hillside area based on the following criteria:

- o Additional remedial action performed on the Mill Hillside would pose a clear and present risk of injury to workers due to construction hazards associated with excavation from excessively steep slopes.
- o Additional remedial actions could destabilize the hillside slope creating a risk for uncontrolled releases of sediment to drainages and the San Miguel River from

thunderstorm events with an associated degradation of the environment. Such destabilization could cause excessive harm to the environment.

- No habitable structures can or will be constructed in the alternative standards area because of future institutional control and long-term stewardship of the area by the Department of Energy (DOE).
- The cost of remediation to remove additional contaminated soils in the Mill Hillside area could be in excess of $6,620,200 (Appendix B) which would clearly be unreasonably high relative to a very small decrease in potential human exposures.
- Previous remedial actions conducted on the site have reduced exposures to as low as reasonably achievable and potential health risks associated with the residual contamination are negligible, including radiation from elements other than radium.
- Future land use of the area will continue to be as habitat for terrestrial species, including both small and large game species. Future use of the area for residential structures, office buildings, schools, or play grounds will be prohibited. The DOE will assume long-term stewardship of the property and will assure that future land use activities are protective of public health and safety and the environment.

3.2 Introduction

3.2.1 Location Description and Physical Features

Mill Hillside area is located near Uravan, Colorado in western Montrose County (Figure 1). Mill Hillside area extends along the side-slope of Club Mesa southwest of the former A-Plant mill (Figure 2). The town of Uravan and milling complex that supported the town have been decommissioned, demolished and removed from the San Miguel River Valley.

The Mill Hillside area can be characterized as remote and difficult to access by humans. The Mill Hillside area consists of steep/near vertical slopes that are the result of down cutting of the San Miguel River (Photo 1). The area is about twenty two acres in size and extends from the mesa rim to the valley floor with an elevation change of approximately 500 feet. Concrete foundations and contaminated soils were removed from the Mill Hillside in 1999, 2001, and 2002. A total of approximately 46,000 cubic yards of contaminated materials were removed from the Mill Hillside. The cost of excavation and disposal exceeded $1,800,000 including recontouring and rock armoring. Approximately 27,588 cubic yards of contaminated materials may remain in these cliff areas.

3.2.2 Land Use

The land is currently used as wildlife habitat. In the future, the land will be managed by the DOE as a part of their long-term stewardship activities.

3.2.3 Owner Input

The Mill Hillside is currently owned by Umetco. In the future, the property will be transferred to the DOE as a part of the license termination process. All future activities, including use and inspection of the property, will be conducted and controlled by the DOE while performing long-term stewardship activities. These activities include the prohibition of residential structures and restriction of the property to public access. Future exposures will be limited to hunters or hikers that trespass on the subject property.

3.3 Radiological/Health Risk Analysis

Gamma measurements at one meter above the ground surface (Colorado, 2005) give a mean exposure rate of 45.4 microroentgens per hour (μR/hr) or 0.45 μSv/hr with a maximum of 202 μR/hr (2.02 μSv/hr) for a single 10 by 10 meter grid on the Mill Hillside. Field measurements indicate an average grid concentration of 22 picocuries per gram (pCi/g) or (0.81 kBq/kg) of Ra-226 with a maximum activity of 173 pCi/g (6.4 kBq/kg) for a single 10 by 10 meter grid. The highest readings were obtained from areas with slopes too steep to permit excavation during the remediation actions. Results of exposure rates and Ra-226 soil concentrations obtained from gamma measurements are presented in Table 3.3.

In November of 1999 and March of 2002, a total of 31 confirmation soil samples were collected in the Mill Hillside area for laboratory analysis. Results from this verification showed that the average Ra-226 value is 17.1 pCi/g (0.63 kBq/kg), for the surface (0-15 cm) samples and 10.5 pCi/g (0.39 kBq/kg) for the sub-surface (15-30 cm) samples. Average Thorium-230 (Th-230) concentration is 22.6 pCi/g (0.84 kBq/kg) for the surface samples and 12.7 pCi/g (0.47 kBq/kg) for the sub-surface samples. The average Uranium 238 concentration is 20 pCi/g (0.74 kBq/kg). Soil sample results indicate that NORM materials are present within the mill hillside area which is contributing to dose for the risk assessment target groups. Radionuclides other than radium-226 and its decay products are not present in sufficient quantities that would pose a threat to public health or the environment over and above the exposures used in the risk assessment.

A risk analysis for the Mill Hillside was prepared by Umetco (2002) and is included in Appendix A. This analysis concluded that a hunter-hiker could potentially receive the highest dose from residual radioactive materials.

Four exposure pathways were analyzed for the hunter-hiker scenario. These were:

- Direct gamma exposure
- Inhalation of dust from residual radionuclides at the surface
- Ingestion of surface soil from the site
- Ingestion of venison or beef from an animal grazing part time on the hillside

The analysis assumed that the individual might spend between 1 and 8 hours on the hillside per year. Camping is not likely because of the steepness and rugged nature of the terrain. Calculations of stochastic and point dose were performed using very conservative assumptions, dose equations and current mainstream computational methods. These are presented in full in the *Confirmation Investigation Report, Mill Hillside, Uravan, Colorado* (Umetco, 2002).

Use of the site for eight hours, ten times per year, yields a calculated annual dose to the hunter-hiker of 0.3 millirem (mrem) or 3.0 μSv excluding the ingestion of meat. The estimated annual dose for the hunter-hiker including the ingestion of meat was calculated to be 4.6 mrem (0.046 mSv).

The individual using the site for hunting/hiking receives only a small fraction of a 25 mrem (0.25 mSv) per year public dose even when the most conservative assumptions are used. The hunter-hiker scenario represents use of the site that is, by its nature, occasional because of the rugged terrain and limited game animals. The scenario also requires that the individual be willing to trespass into the area despite warning signs and potential legal consequences. As such, there will be relatively few persons who might trespass on to the Mill Hillside area for recreational purposes.

The risk analysis concluded that the estimated collective annual dose to members of the public would be 0.5 person-rem or 0.005 person-sievert. The total collective dose averted for the next 1000 year period is 24 person-rem or 0.24 person-sievert. Using a total collective dose averted of 24 person-rem (0.24 person-sievert), the total benefit from averted dose for remediation to background levels is calculated at $48,000 using NUREG 1757. The estimated cost for additional remediation on the Mill Hillside is $6,620,200 (Appendix B) which is significantly greater than the estimated monetary benefit of reducing the collective exposure to members of the public to background levels. Details on the estimated cost for additional remedial actions are provided in Appendix B.

Table 3.3 Mill Hillside Radium-226 and Exposure Rate Summary

	Radium-226 (pCi/g)	Exposure Rate (uR/hr)
Maximum 10 by 10 Meter Grid	173 6.4 kBq/kg	202 2.02μSv/h
Average Concentration [a] (pCi/g)	22 0.81 kBq/kg	-
Average Exposure Rate [b] (μR/hr)	-	45.4 (0.45μSv/h)
Number of Data Points	11,740	11,225

[a] DOE pad calibration algorithm dated 8-22-2002:

pCi eRa-226/g = 0.0015(scintillometer, counts per minute) – 2.4412 and corrected for thorium-232 and potassium-40 contributions using: Ra-226 pCi/g = pCi eRa-226/g – Th-232 concentration – K-40 concentration

[b] Sodium iodide scintillometer DOE pad calibration equation: 0.0007(scintillometer, counts per minute) + 6.0632
Arithmetic mean sodium iodide scintillometer exposure error = 15%
Linear regression: 0.0007 (sodium iodide scintillometer, μR/hr) + 4.15 = PIC, μR/hr. r2 = 0.97

3.4 Remediation Alternatives

3.4.1 Alternative I – Additional Remedial Activities

3.4.1.1 Work Description

Removal of all contaminated materials from the Mill Hillside would require the excavation of approximately 27,588 cubic yards of soil from areas not previously excavated because of the steepness of the slope. Additional excavation would require the use of heavy equipment as well as scaling crews and vacuum trucks to access the materials. Excavated/vacuumed material would be transported and placed in a new disposal cell on Club Mesa. In addition, backfill and erosion control material would need to be obtained from borrow areas on Club Mesa and placed on the Mill Hillside. These remedial actions would be extremely hazardous, entail great risk to workers, and result in de-stabilization of the existing slope. The use of heavy equipment to excavate these areas might in itself destabilize the slope. In addition, de-stabilized slopes could be subject to mass wasting or rapid erosion and cause degradation of the water quality in the San Miguel River.

3.4.1.2 Sources of Risk

There are two sources of risk to workers from additional remedial activities on the Mill Hillside Slope. First, there is a severe risk associated with construction hazards on the steep slope, notwithstanding reasonable measures to avoid or reduce risk. This risk includes injuries related to falling, injuries from excavation related slope failure, and injuries from upset or overturned heavy equipment. Second, in cases where contaminated soils must be removed by hand excavation, there is risk of exposure to gamma radiation, and inhalation or ingestion of radionuclides. This risk is exacerbated by the working conditions on a steep slope and the difficulty of transporting the excavated soil to a point that it can be placed in containers or loaded for transport to the point of disposal. A clear and present danger to workers is posed in both cases.

3.4.1.3 Alternative Specific Issues

Additional remedial activities including material excavation, transportation, disposal and reclamation of the area are estimated to cost $6,620,200 based on the removal of 27,588 cubic yards of material and stabilization of the area with a similar amount of riprap (Appendix B). These remedial actions could potentially reduce gamma exposures by 3 mrem for an exposed recreational hiker or hunter. This cost is clearly excessive in relationship to minimal reduction in human exposure.

3.4.1.4 Engineering Data

No areas of contamination would remain in place in Alternative I. Approximately 27,588 cubic yards of contaminated soils and earthen materials would need to be removed during the implementation of this alternative. Plans and specifications would need to be prepared to implement these remedial activities. Engineering a stable slope following the removal of contaminated soils from the steepest parts of the Mill Hillside may not be feasible.

3.4.2 Alternative II - No Further Remediation (Alternative Standards Applied)

3.4.2.1 Work Description

No further work would be required under this alternative.

3.4.2.2 Sources of Risk

Health risks associated with Alternative II are discussed in Section 3.3. No additional health risks would result from this alternative.

3.4.2.3 Alternative Specific Issues

Issues related to Alternative I include excessive risk to construction workers, de-stabilization of the existing slope, and potential erosion the materials and degradation of the San Miguel River.

3.4.2.4 Engineering Data

No further engineering would be required under this alternative.

3.5 Mill Hillside Summary

Remedial activities in the Mill Hillside area have been conducted to the maximum extent feasible without generating unacceptable environmental impacts and incurring unreasonable cost for a negligible reduction in exposures. Further excavation of contaminated soils from the steep slopes of the Mill Hillside poses an unacceptable risk to workers and threatens to de-stabilize the naturally stable slope. The cost of additional remedial actions is clearly excessive in relation to the insignificant reduction in potential future exposures to humans.

The data in Sections 3.3 and 3.4 indicates that there are no significant heath risks if the Alternative Standards Application (No Remediation) is approved. The most likely exposed person is a trespassing hunter or hiker whose level of exposure is well below 25 mrem (0.25 mSv) per year acceptable dose to the general public, even if that person were to visit the site numerous times a year. The DOE will monitor and control the Mill Hillside area as a part of their long-term stewardship activities.

4.0 A-PLANT NORTH AREA

4.1 Basis for Application

Remedial actions in the A-Plant area were conducted in accordance with the requirements set forth under the Uravan Remedial Action Plan and with the *Soil Cleanup Program Methodology for Uravan, Colorado* (Umetco, 1999). All feasible remedial activities have been completed in the A-Plant area to reduce exposures to as low as reasonably achievable. Mill decommissioning, begun in June 1994, required the demolition, removal and disposal of 91 mill buildings and assorted mill processing equipment. Approximately 23,500 cubic yards of building debris were sized and placed in Tailings Pile 2. Between March 1995 and June 1999, approximately 480,000 cubic yards of contaminated soils were removed from the A-Plant area and placed in Tailings Pile 2. Almost the entire mill area was stripped to bedrock and reclaimed using uncontaminated soil. Remedial activities are fully discussed in Compliance Report CR-413-6 (Umetco, 2003). Total cost for the 1995 – 1999 reclamation of the A-Plant area exceeded $7,250,000. Results of this remedial action are described in the report titled *Confirmation Investigation Report A-Plant, Uravan, Colorado* (Umetco, 2002). The remedial activities were inspected in the field and approved by the Colorado Department of Public Health and Environment (CDPHE, 2003). In 2006, remediation in the northern part of the A-Plant area was undertaken to remove additional contaminated soils in areas identified by post remediation surveys (Umetco, 2007). This activity removed an additional 43,000 cubic yards of contaminated soils at a cost of about $300,000. The remedial actions for the A-Plant North area were verified in the field and the associated compliance report approved by the Colorado Department of Public Health and Environment (CDPHE, 2007). These remedial actions reduced contaminant levels as low as reasonably achievable and assured the long-term protection of human health and the environment.

Alternative Standards have been applied to the A-Plant North area where residual contamination is present in soils in a small riparian area (2 acres) in the flood plain of the San Miguel River (Photo 3). A description of the area is included in Appendix D. Alternative standards have been applied to this area based on the following criteria:

- Additional remedial actions performed in the flood plain of the San Miguel River would cause excessive environmental harm to the environmentally sensitive wetland area.
- The residual Ra-226 contamination is relatively low and does not pose a risk to hunters, hikers, or the environment. The area is within the annual flood plain of the San Miguel River and within the DOE's long-term surveillance area. No habitable structures can or will be constructed in the alternative standards area within the flood plain of the San Miguel River.
- The cost of future remedial actions, estimated at $1,024,000 (Appendix B), would far exceed the benefits because potential human exposures are negligible, given the low concentration of radionuclides in the soil and the absence of future human habitation.
- Previous remedial actions conducted on the site have reduced exposures to as low as reasonably achievable and potential health risks associated with the residual contamination are negligible.
- Future land use of the area will continue to be as habitat for both aquatic and terrestrial species, including both small and large game species. Future use of the area for residential structures, office buildings, schools, or play grounds will be prohibited. The DOE will assume long-term stewardship of the property and will assure that future land use activities are protective of public health and safety and the environment.

4.2 Introduction

4.2.1 Location Description and Principal Physical Features

The A-Plant area is within the San Miguel River Valley and is principally located on a rock cut terrace above the river. The A-Plant area is located on the San Miguel river valley floor adjacent to steep valley walls that extend to Club Mesa (Figure 2). The area hosted former uranium and vanadium recovery operations including the former Joe Junior radium mill. Mill decommissioning and contaminated soil removal occurred between March 1995 and June 1999. Subsequent remediation in the A-Plant North area was undertaken in 2006 to remove additional contaminated soil in areas identified by post remediation surveys (Umetco, 2007). This activity removed an additional 43,000 cubic yards of contaminated soils; however approximately 10,000 cubic yards of elevated soils remain within a riparian area in the flood plain of the San Miguel River (Figure 2). This area of contaminated soils is included in this application.

4.2.2 Land Use

Wildlife values dominate the A-Plant area. In the future, the DOE will assume stewardship of the area as a part of their long-term surveillance activities and will continue to protect the area as wildlife habitat.

4.2.3 Land Owners Input

The A-Plant area is currently owned by Umetco. In the future, the property will be transferred to the DOE as a part of the license termination process. All future activities, use and inspection of the property will be conducted and controlled by the DOE during long-term stewardship of the property. Stewardship activities include the prohibition of residential structures and restriction of the property to public access. Future exposures will be limited to hunters, hikers or fishermen that trespass on the subject property.

4.3 Radiological/Health Risk Analysis

In December of 2006, 7 confirmation soil samples were collected in the A-Plant North area for laboratory analysis. The average Ra-226 value was 2.54 pCi/g (0.09 kBq/kg) for the surface samples and 2.88 pCi/g (0.11 kBq/kg) for the sub-surface samples. Average Thorium-230 concentrations were 5.36 pCi/g (0.20 kBq/kg for the surface samples and 5.27 pCi/g (0.20 kBq/kg) for the sub-surface samples. These samples indicate that the majority of the A-Plant North area has been cleaned up to appropriate regulatory standards. Radionuclides other than radium-226 and its decay products are not present in sufficient quantities that would pose a threat to public health or the environment.

Monitoring of water in the San Miguel River has been conducted quarterly since 1987 at stations above and below the A-Plant North area. This monitoring, presented in Appendix C, indicates that the A-Plant North area does not contribute any significant contaminants to the San Miguel River (Umetco, 2006) and that there are no impacts to the river system from residual materials in the area.

A small riparian area in the A-Plant North area contains elevated 11e.(2) materials. Gamma exposure measurements collected in the riparian area at one meter above the ground surface average 21.47 μR/hr (0.21μSv/h) with a maximum of 45.1 μR/hr (0.45 μSv/h) for a single 10 by 10 meter grid. Field measurements indicate an average grid concentration of 5.37 pCi/g (0.2 kBq/kg) Ra-226 with a maximum activity of 28.38 pCi/g (1.05 kBq/kg) Ra-226 for a single 10 by 10 meter grid. Results of exposure and soil concentrations obtained from gamma measurements are presented in

Table 4.3.

Risk analyses prepared by Shepherd Miller (1998) and MFG (2004) for County Road Y-11 can be directly applied to the riparian area along the San Miguel River because Ra-226 and exposure data are similar for the two areas and both areas have the same exposure scenarios. The risk assessment, presented in Appendix A, shows that the maximum exposure would be to a fisherman (1.28 mrem per year) who fishes along the river bank and that the estimated collective annual dose to members of the public would be 0.11 person-rem (0.001 person-sievert). The total collective dose averted for the next 1000 year period is 5.08 person-rem (0.051 person-sievert). Using a total collective dose averted of 5.08 person-rem (0.051 person-sievert), the total benefit from averted dose for remediation to background levels is calculated at $10,161 using NUREG 1757. The estimated cost for additional remediation on the A-Plant North area is $1,024.000 (Appendix B). The cost for remediation is 201,603 dollars per person-rem averted which is far greater than the 20,000 dollar per person-rem (0.01 per person-sievert) averted level that is considered to be prohibitively expensive. Dose inputs for the risk assessment came from confirmation gamma data. The highest average grid average was used as the dose input and represents the most conservative possible situation for the A-Plant North area. Details on the estimated risk for additional remedial actions are provided in Appendix A.

Table 4.3 A-Plant North Area Radium-226 and Exposure Rate Summary

	Radium-226 (pCi/g)	Exposure Rate (uR/hr)
Maximum 10 by 10 Meter Grid	28.38 1.05 kBq/kg	45.1 0.45 μSv/h
Average Concentration [a] (pCi/g)	5.37 0.20 kBq/kg	-
Average Exposure Rate[b] (μR/hr)	-	21.47 0.21 μSv/h
Number of Data Points	8164	8118

[a] DOE pad calibration algorithm (9-21-2006): pCi eRa-226/g = 0.0015(scintillometer, counts per minute) – 2.4412 and corrected for thorium-232 and potassium-40 contributions using: Ra-226 pCi/g = pCi eRa-226/g – Th-232 concentration – K-40 concentration

[b] NaI DOE pad calibration equation: 0.0007(NaI, cpm) + 6.0632
NaI = sodium iodide scintillometer
Arithmetic mean NaI exposure error = 15%
Linear regression: 0.0007 (NaI, μR/hr) + 4.15 = PIC, μR/hr. r2 = 0.97

4.4 Remediation Alternatives

4.4.1 Alternative I – Additional Remedial Activities

4.4.1.1 Work Description

No areas of contamination would remain in place in Alternative I. Remedial activities would include the removal of all wetland vegetation and excavation of 9,680 cubic yards of contaminated soils. Associated with these removal activities would be the construction of runoff and runon control structures and a truck decontamination facility. If necessary, a dewatering system would be installed to facilitate excavation below the river level. Contaminated materials would be transported and placed in a new repository on Club Mesa and rock groins would be placed across the area to promote future sediment deposition in the area.

4.4.1.2 Sources of Risk

Risks associated with this alternative would include additional worker exposures during construction. Additional exposures to the general public should be minimal.

4.4.1.3 Alternative Specific Issues

Excavation of contaminated soils would necessitate the removal of all riparian vegetation from the banks of the San Miguel River. Destruction of the wetlands would directly cause excessive environmental harm.

Additional remedial activities are estimated to cost $1,024,000 based on soil removal and disposal volumes (Appendix B). Such removal would likely reduce gamma exposure rates for a potentially exposed trespassing hiker, hunter or fisherman to background levels; however, the remedial costs are excessive in relationship to a minimal reduction in human exposure.

4.4.1.4 Engineering Data

No areas of contamination would remain in place in Alternative I. Approximately 9,680 cubic yards of soils and earthen materials would need to be moved during the implementation of this alternative. Plans and specifications would need to be prepared to implement these remedial activities.

4.4.2 Alternative II – No Further Remediation (Alternative Standards Applied)

4.4.2.1 Work Description

No further work would be required under this alternative.

4.4.2.2 Sources of Risk

Health risks associated with Alternative II are discussed in Section 4.3. No additional health risks would result from this alternative.

4.4.2.3 Alternative Specific Issues

The no further remediation alternative would preserve the wetlands area along the San Miguel River.

4.4.2.4 Engineering Data

No further engineering would be required under this alternative.

4.5 A-Plant North Summary

Remedial activities in the A-Plant North area have been conducted to the maximum extent feasible without generating unacceptable environmental impacts and incurring unreasonable cost for a negligible reduction in exposures. The data in Sections 4.3 and 4.4 suggests there are no significant heath risks if the Alternative Standards Application (No Remediation) is approved. The most likely exposed person is a trespassing hunter, hiker or fisherman whose level of exposure is well below 25 mrem per year acceptable public dose even if that person were to visit the site several times a year. Contaminated soils left in the A-Plant North area pose no significant hazard to on-site workers and the public. The cost of additional remedial actions for the removal and disposal of the contaminated soil and revegetation of the area is clearly excessive in relation to the negligible reduction in potential future exposures to humans. In addition, excavation of contaminated soils from the wetland area would destroy the riparian habitat and directly cause excessive harm to the environment. The DOE will monitor and control the A-Plant North area as a part of their long-term stewardship activities.

5.0 RIVER PONDS AREA

5.1 Basis for Application

Remedial actions in the River Ponds area were conducted in accordance with the requirements set forth under the Uravan Remedial Action Plan. All feasible remedial activities have been completed in the River Ponds area. The River Ponds consisted of seven ponds constructed of mill tailings mantled with uncontaminated soil. Remedial activities included the excavation of uranium mill tailings, sludges, and contaminated soils. The contaminated materials were transported to secure repositories on Club Mesa. Excavation was conducted during winter low-flows in the river and extended into natural soils beneath the tailings material (Photos 4 & 5). These actions assured that the maximum amount of contaminated soils were removed and exposures reduced to as low as reasonable achievable. Excavation ceased when river water flooded the excavation areas.

Approximately 332,500 cubic yards of material were excavated from the River Ponds area. Riprap dikes or groins two to three feet high were constructed across the excavated areas to the limits of the river channel. These groins protected the area against future erosion and promoted alluviation in the former River Ponds area. These remedial activities are fully discussed in Compliance Report CR-402-2 (Umetco, 1990). Total cost for reclamation of the River Ponds area exceeded $4,000,000.

Results of these remedial actions are described in the report titled *Final Construction Report for the River Ponds* (Umetco, 1994). The remedial actions were reviewed in the field by state personnel (CDPHE, 1990) and the final construction report was approved by the CDPHE (CDPHE, 1994). These remedial actions have reduced contaminant levels as low as reasonably achievable and resulted in the long-term protection of humans and the environment. The confirmation study shows that the remedial action at the site has mitigated the risk to human health for the most probably exposed person, a hunter/hiker or fisherman.

Alternative standards are being applied to the River Ponds area because residual materials may exist beneath the recently deposited alluvial sediments. Residual contamination from 20 to 60 μR/hr existed as local hot spots in the cleanup area prior to final excavation and river alluviation. Final verification surveys were not possible because the excavation was flooded before a survey could be conducted. Areas of residual contamination were subsequently covered by 2 to 3 feet of recent alluvial sediment and stabilized by riparian vegetation. The River Ponds area is a classic wetlands defined by the U.S. Army Corps of Engineers as those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (photo5). Wetlands generally include swamps, marshes, bogs, and similar areas.

The alternative standards applied to this area, as described in Appendix D, are based on the following criteria:

- o Additional remedial actions would result in environmental damage to riparian vegetation and wetland areas, causing extensive environmental harm.
- o Radiation risks associated with the low levels of residual contamination are negligible given that the area currently meets exposure criteria (<20 μR/hr or <0.20 μSv/h) set forth in the Uravan Remedial Action Plan.
- o The area is within the annual flood plain of the San Miguel River and within the DOE's long-term surveillance area. No habitable structures can or will be constructed in the alternative standards area within the flood plain of the San Miguel River.
- o Riprap groins and riparian vegetation currently provides protection from water and wind erosion and slows natural dispersion by providing a stabilizing cover over the residual contaminants.
- o The cost of remediation to remove additional contaminated soils in the River Ponds area could be in excess of $5,120,720 (Appendix B) which would clearly be unreasonably high relative to an extremely small decrease in potential human exposures.
- o Previous remedial actions conducted on the site have reduced exposures to as low as reasonably achievable and potential health risks associated with the residual contamination are negligible, including radiation from elements other than radium.
- o Future land use of the area will continue to be as habitat for both aquatic and terrestrial species, including both small and large game species. Future use of the area for residential structures, office buildings, schools, or play grounds will be prohibited. The DOE will assume long-term stewardship of the property and will assure that future land use activities are protective of public health and safety and the environment.

5.2 Introduction

5.2.1 Location and Physical Features

The River Ponds were situated along the banks of the San Miguel River in the area shown on Figure

2. The ponds were constructed of mill tailings adjacent to the main channel of the San Miguel River. There were seven ponds, two on the northeast bank of the river and five on the southwest bank. The ponds were removed and contaminated soils excavated to below the level of the river during winter low flows. The River Ponds area was graded to contours that promoted stability and rock groins were constructed of rip-rap to protect against erosion and to promote sediment deposition (Photo 4). The River Ponds area currently has well developed riparian vegetation, including trees of medium size and is well within the annual flood plain of the river. The area commonly floods during spring runoff and forms a unique and diverse wildlife habitat (Photo 5) in western Colorado.

5.2.2 Land Use

The River Ponds area is currently wildlife habitat for aquatic life as well as and for various bird and game species. It supports dense riparian vegetation and is subject to alluvial deposition of natural river sediment during flood cycles. In the future, the DOE will assume ownership of the area as a part of their long-term stewardship activities. In the future, the highest and best use for the land will be as wildlife habitat.

5.2.3 Owners Input

The River Ponds area is currently owned by Umetco. In the future, the property will be transferred to the DOE as a part of the license termination process. All future activities, including use and inspection of the property, will be conducted and controlled by the DOE during long-term stewardship of the property. Stewardship activities include the prohibition of residential structures and restriction of the property to public access.

5.3 Radiological/Health Risk Assessment

Excavation of the River Ponds Area to depths below the river level and subsequent deposition of river sediments reduced gamma exposure rates to background ranges. During the seasonal low-water period of the San Miguel River in 2007, a random walking survey was conducted in the north and south river ponds areas (Figure 2). This survey measured gamma ray exposure rates at an elevation of one meter above the ground surface and Ra-226 equivalent concentrations at 1 foot above ground surface. The exposures ranged from 13.7 to 17.9 μR/hr (0.137 to 0.179 μSv/h) in the North Pond area and between 14.4 and 17.2 μR/hr (0.144 and 0.172 μSv/h) in the South Pond area. Ra226 equivalent concentrations ranged from 2.4 to 5.8 pCi/g (0.089 to 0.21 kBq/kg) in the North Pond area and between 3.8 and 6.9 pCi/g (0.15 and0.26 kBq/kg) in the South Pond area. The results of the survey show that there are no sources of significant radiation at the surface in the reclaimed pond areas and that exposure rates and Ra-226 concentrations are within background ranges. The River Ponds did not contain materials that were the result of segregation of thorium or consentration of uranium. Radionuclides other than radium-226 and its decay products are not present in sufficient quantities that would pose an threat to public health or the environment.

Monitoring of water in the San Miguel River has been conducted quarterly since 1987 at stations above and below the River Ponds. Monitoring results, included in Appendix C, indicate that the River Ponds area does not contribute any significant contaminants to the San Miguel River (Umetco, 2006) and that there are no impacts from residual materials from the area. Because current exposure rates are within background ranges there is no incremental health risk to the general public or future site workers from residual radiological materials within the River Ponds area.

Risk analyses prepared by Shepherd Miller (1998) and MFG (2004) for County Road Y-11 can be directly applied to the River Ponds area because Ra-226 concentration and exposure rate data in the subject area are less that those used in the County Road Y-11 analysis and both areas have the same exposure scenarios. The risk assessment, presented in Appendix A, shows that the maximum exposure would be to a fisherman (2.04 mrem or 0.02 mSv per year) who fishes along the river bank and that the estimated collective annual dose to members of the public would be 0.1 person-rem (0.001 person-sievert). The total collective dose averted for the next 1000 year period is 4.7 person-rem (0.047 person-sievert). Using a total collective dose averted of 4.7 person-rem (0.47 person-sievert), the total benefit from averted dose for remediation to background levels is calculated at $9,371 using NUREG 1757. The estimated cost for additional remediation in the River Ponds area is $5,120,720 (Appendix B). The cost for remediation is 1,091,837 million dollars per person-rem (0.01 person-sievert) averted which is far greater than the 20,000 dollar per person-rem (0.01 person-sievert) averted level that is considered to be prohibitively expensive. Dose inputs for the risk assessment came from pre-remediation gamma data and represent the most conservative possible situation for the River Ponds area. Details on the estimated risk for additional remedial actions are provided in Appendix A.

Table 5.3 River Ponds Area Radium-226 and Exposure Rate Summary

	Radium-226 (pCi/g)	Exposure Rate (uR/hr)
Maximum 10 by 10 Meter Grid	6.8 0.25 kBq/kg	17.9 0.179 μSv/h
Average Concentration [a] (pCi/g)	4.7 0.17 kBq/kg	-
Average Exposure Rate[b] (μR/hr)	-	15.8 0.158 μSv/h

[a] DOE pad calibration algorithm (9-21-2006): pCi eRa-226/g = 0.0015(scintillometer, counts per minute) – 2.4412 and corrected for thorium-232 and potassium-40 contributions using: Ra-226 pCi/g = pCi eRa-226/g – Th-232 concentration – K-40 concentration

[b] NaI DOE pad calibration equation: 0.0007(NaI, cpm) + 6.0632
NaI = sodium iodide scintillometer
Arithmetic mean NaI exposure error = 15%
Linear regression: 0.0007 (NaI, μR/hr) + 4.15 = PIC, μR/hr. r2 = 0.97

5.4 Remedial Alternatives

5.4.1 Alternative I - Additional Remedial Activities

5.4.1.1 Work Description

Addition remedial actions would include the stripping the area of all riparian vegetation and excavating and stockpiling approximately 2 to 3 feet of clean alluvial sediments. A cutoff wall or withdrawal wells would need to be installed so that the entire area could be dewatered and the presence of residual contaminants confirmed and then removed. Excavation and disposal of an estimated 48,400 cubic yards of contaminated materials could then be conducted All activities would require the construction on runon and runoff control features as well as the building of a wheel wash facility for equipment decontamination. Proximity of the remedial activities to the San Miguel River would make this a difficult and costly exercise.

5.4.1.2 Sources of Risk

Risks associated with this alternative would include additional worker exposures during construction. Additional exposures to the general public should be minimal.

5.4.1.3 Alternative Specific Issues

Excavation of contaminated soils would necessitate the removal of all riparian vegetation from the banks of the San Miguel River. Destruction of the wetlands would directly cause excessive environmental harm.

Additional remedial activities including material excavation, transportation, disposal and reclamation of the area are estimated to cost $5,120,720 based on the removal of 48,400 cubic yards of material and dewatering of the construction site. Such removal would not reduce gamma exposures to a potentially exposed hiker/hunter or fisherman. This cost is clearly excessive in relationship to a zero reduction in human exposure.

5.4.1.4 Engineering Data

No areas of contamination would remain in place in Alternative I. Approximately 48,400 cubic yards of contaminated materials would need to be removed during the implementation of this alternative. The existing surface treatment, including mantling, groins and re-vegetation would have to be reestablished after any additional remediation. Plans and specifications would need to be prepared to implement these remedial activities.

5.4.2 Alternative II – No Further Remediation (Alternative Standards Applied)

5.4.2.1 Work Description

No further work would be required under this alternative.

5.4.2.2 Sources of Risk

Health risks associated with Alternative II are discussed in Section 5.3. No additional health risks would result from this alternative.

5.4.2.3 Alternative Specific Issues

None

5.4.2.4 Engineering Data

No further engineering would be required under this alternative.

5.5 River Ponds Summary

Remedial activities in the River Ponds area have been conducted to the maximum extent feasible and ALARA without generating unacceptable environmental impacts and incurring unreasonable cost for a negligible reduction in exposures. The data in Sections 5.3 and 5.4 suggests there are no heath risks if the Alternative Standards Application (No Remediation) is approved. The removal of contaminated materials from the River Ponds area and subsequent alluviation in the area has reduced the radiation levels to background ranges. Contaminated soils left in the River Ponds area pose no significant hazard to future workers. Excavation of contaminated soils from the wetland area would destroy the riparian habitat and directly cause excessive harm to the environment. The cost of additional remedial actions for the removal and disposal of the contaminated soil and revegetation of the area is clearly excessive in relation to the negligible reduction in potential future exposures to humans. The DOE will monitor and control the River Ponds area as a part of their long-term stewardship activities.

6.0 COUNTY ROAD Y-11

6.1 Basis for Application

Remedial actions on County Road Y-11 were conducted in accordance with the requirements set forth under the Uravan Remedial Action Plan and with the *Soil Cleanup Program Methodology for Uravan, Colorado* (Umetco, 1999). Remedial activities have been conducted along County Road Y-11. Uranium mill tailing and associated contaminated soils have been removed from beneath the roadway. Removal activities were initiated in 1998 as a part of the cleanup of the Town Dump area and additional contaminated soils were excavated in 2006. A total of approximately 8,200 cubic yards of contaminated materials were removed from the roadway and transported to a disposal cell on Club Mesa. The road was plated with Class 6 material as a part of the reclamation program. Remedial activities are fully discussed in Compliance Report CR-418D-2 (Umetco, 2007). Total cost for reclamation of the County Road Y-11 exceeded $500,000. These previous remedial activities have been conducted to assure that routine maintenance along the roadway can be conducted without creating worker exposures. The remedial activities were inspected in the field and approved by the CDPHE (CDPHE, 2007).

The remedial activities have reduced contaminant levels as low as reasonably achievable and assure the long-term protection of human health and the environment. Exposure readings along the roadway after reclamation activities were complete are within background ranges and pose no additional or incremental risk to human health for people traveling on the road.

Alternative standards have been applied to County Road Y-11 because contaminated soils may exist at depth beneath the roadway. The area boundary is described in Appendix D. Alternative standards have been applied to the County Road Y-11 based on the following criteria:

- Potential health risks associated with the contamination are negligible because contaminated materials are only present at depths greater than 3 feet and future exposures along the roadway will be minimized by institutional controls agreed to by Montrose County, the Bureau of Land Management and the DOE.
- No habitable structures can or will be constructed in the alternative standards area because the land is occupied by a county road and future land use changes will be prohibited by institutional controls.

- The cost of remediation to remove additional contaminated soils beneath County Road Y-11 could be in excess of $3,366,000 (Appendix B) which would clearly be unreasonably high relative to a very small decrease in potential human exposures.
- Previous remedial actions conducted on the site have reduced exposures to as low as reasonably achievable and potential health risks associated with the residual contamination are negligible, including radiation from elements other than radium.
- Future land use of the area will continue to be as a road connecting State Highway 11 with Bedrock, Colorado. Future use of the area for residential structures, office buildings, schools, or play grounds will be prohibited. The DOE will assume long-term stewardship of the property and will assure that future land use activities are protective of public health and safety and the environment.

6.2 Introduction

6.2.1 Location Description and Physical Features

County Road Y-11 area is located in Montrose County along the southwestern side of the San Miguel River and connects Uravan with Bedrock in the Paradox Valley. The roadway subject to this application is from the Town Dump area through the A-Plant area (Figure 2). County Road Y-11 is composed of natural earthen materials that were used in construction of the road. The roadway is relatively flat and follows the gentle down gradient direction of the San Miguel River (Photo 5). The surface area of the roadway is about 9 acres.

6.2.2 Land Use

The land is currently used as a county road. No future changes in land use are anticipated.

6.2.3 Owner Input

The County Road Y-11 is currently owned by Montrose County. Institutional controls agreed to by Montrose County, Bureau of Land Management and DOE will control future use of the land. All future activities, including the use and inspection of the property, will be conducted and controlled by the DOE during long-term stewardship activities at Uravan site. Stewardship activities include the prohibition of residential structures.

6.3 Radiological/Health Risk Analysis

Gamma exposure surveys were conducted along County Road Y-11 in 2006 after the removal of contaminated materials. This survey measured gamma ray exposure rates at an elevation of one meter above the ground surface and Ra-226 concentrations at one foot above ground surface. The results of the survey, shown in Table 6.3, indicate that there are no significant sources of radiation at the surface of County Road Y-11. Removal of the uranium mill tailings and contaminated soils followed by plating the road with Class 6 material reduced gamma exposure rates and Ra-226 concentrations to levels as low as reasonably achievable. Gamma exposure measurements at one meter above the ground surface range from 13.9 to 36.8 μR/hr (0.139 to 0.369 μSv/h) on County Road Y-11 and Ra-226 concentrations ranged from 0 to 20.2 pCi/g (0 to 0.20 μSv/h) (Table 6.3). Radionuclides other than radium-226 and its decay products are not present in sufficient quantities that would pose an threat to public health or the environment over and above the exposures used in the risk assessment.

Table 6.3 County Road Y-11 Ra-226 and Exposure Summary

	Radium-226 (pCi/g)	Exposure Rate (uR/hr)
Maximum 10 by 10 Meter Grid	20.2 0.75 kBq/kg	36.8 0.368 μSv/h
Average Concentration [a] (pCi/g)	4.6 0.17 kBq/kg	-
Average Exposure Rate[b] (μR/hr)	-	20.6 0.206 μSv/h
Number of Data Points	1802	1888

[a] DOE pad calibration algorithm (9-21-2006): pCi eRa-226/g = 0.0015(scintillometer, counts per minute) – 2.4412 and corrected for thorium-232 and potassium-40 contributions using: Ra-226 pCi/g = pCi eRa-226/g – Th-232 concentration – K-40 concentration

[b] NaI DOE pad calibration equation: 0.0007(NaI, cpm) + 6.0632
NaI = sodium iodide scintillometer
Arithmetic mean NaI exposure error = 15%
Linear regression: 0.0007 (NaI, μR/hr) + 4.15 = PIC, μR/hr. r2 = 0.97

A risk analysis was prepared by Shepherd Miller (1998) and an ALARA Analysis was completed by MFG (2004) for County Road Y-11. This risk analysis is included in Appendix A. Five exposure scenarios were analyzed for the risk assessment:

- Fisherman on the bank of the San Miguel adjacent to the road

- Hiker using the road
- Mountain Biker using the road
- Commuter vehicle use
- Road Maintenance Worker

Three exposure pathways were analyzed for the scenarios. These were:

- Direct gamma exposure
- Inhalation of dust from residual radionuclides at the surface
- Ingestion of water and fish from the San Miguel River.

The estimated annual dose for the Commuter, Road Worker and Biker combined is only 0.5 mrem (5.0 μSv). The individual using the site for hiking would receive only a small 0.95 mrem (9.5 μSv) per year dose even when the most conservative assumptions are used. The hiker scenario represents a use of the site that is, by its nature, occasional due to the remoteness of the area and limited recreational opportunity in the one mile section of roadway. The risk assessment shows that the maximum exposure would be to a fisherman (1.36 mrem or 13.6 μSv per year) who uses the road to access the river bank and then fishes along the river bank.

These analyses concluded that the estimated collective annual dose to members of the public would be 0.15 person-rem (0.0015 person-sievert). The total collective dose averted for a 1000 year period is 7.1 person-rem (0.071 person-sievert). Using the total collective dose averted calculated in accordance with NUREG 1757, the total benefit from averted doses for remediation to background levels is $14,200. This calculation is based on pre-remediation exposure surveys and as such is very conservative. The total estimated monetary cost of total remediation is $3,366,000 which is significantly greater than the estimated monetary benefit of reducing the collective exposure to members of the public to background levels. Details on the estimated cost for additional remedial actions are provided in Appendix B.

These risks are based on pre-reclamation data. Future risk to the general public will remain insignificant during the post-reclamation long-term stewardship activities of the DOE.

6.4 Remediation Alternatives

6.4.1 Alternative I – Additional Remedial Activities

6.4.1.1 Work Description

Removal of all contaminated material from the County Road Y-11would require the excavation and stockpiling of about 50,000 cubic yards of clean material with the subsequent excavation of an estimated two feet (27,000 cubic yards) of contaminated soil from areas that were not previously excavated. This material would need to be transported and placed in a new repository on Club Mesa. In addition, the road would need to be reconstructed with approximately 27,000 cubic yards of back fill and Class 6 plating gravel.

6.4.1.2 Sources of Risk

Risks associated with this alternative would include additional worker exposures during construction and risks associated with the use of heavy equipment on a narrow roadway. Additional exposures to the general public should be minimal.

6.4.1.3 Alternative Specific Issues

Additional remedial activities are estimated to cost $3,366,000 based on the removal and replacement of 27,000 cubic yards of earthen material. These remedial actions would not reduce future gamma exposures to an exposed member of the public. This cost is excessive in relationship to minimal reduction in human exposure.

6.4.1.4 Engineering Data

No areas of contamination would remain in place in Alternative I. Approximately 27,000 cubic yards of contaminated soils and earthen materials would need to be removed and 27,000 cubic yards of material replaced during the implementation of this alternative. Plans and specifications would need to be prepared to implement Alternative I.

6.4.2 Alternative II - No Further Remediation (Alternative Standards Applied)

6.4.2.1 Work Description

No further work would be required under this alternative.

6.4.2.2 Sources of Risk

Health risks associated with Alternative II are discussed in Section 6.3. No additional health risks would result from this alternative.

6.4.2.3 Alternative Specific Issues

No specific issues have been identified for this alternative.

6.4.2.4 Engineering Data

No further engineering would be required under this alternative.

6.5 County Road Y-11Summary

Remedial activities on County Road Y-11 have been conducted to the maximum extent feasible without generating unacceptable environmental impacts and incurring unreasonable cost for a negligible reduction in exposures. The data in Sections 6.3 and 6.4 suggests there are no significant heath risks if the Alternative Standards Application (No Remediation) is approved. The most likely exposed person is a fisherman whose level of exposure is below the 25 mrem (0.25 mSv) per year acceptable public dose even if that person were to visit the area several times annually. The cost of additional remedial actions is clearly excessive in relation to the negligible reduction in potential future exposures to humans. The DOE will monitor County Road Y-11 as a part of their long-term stewardship activities

7.0 APPLICATION SUMMARY

Requirements set forth in 40 CFR 192.21 indicate that "Remedial action will generally not be necessary where radioactive materials have been placed semi-permanently in a location where site-specific factors limit their hazard and from which they are costly or difficult to remove". This application for alternative standards for soils at Uravan includes the Mill Hillside, the River Ponds, the A Plant North area and County Road Y-11 and demonstrates that the average radiation levels for the entire area are low and present no future risk to humans or the environment.

Alternative soil standards for the Mill Hillside, A-Plant North, River Ponds and County Road Y-11 areas are protective of human health and the environment and assure that future radiological exposures to humans are minimized. The residual contaminated materials are located in areas which are stable and not subject to mass wasting or other forms of rapid geomorphic erosion and dispersion into the environment. In general, the alternative soil standards assure that excess radiation exposures to workers and the general public are prevented, that the potential dispersal of contaminants to the environment is minimized, and that environmental damage caused by additional cleanup activities is avoided. Postulated future cleanup actions are clearly excessive in relation to the negligible reduction in potential future exposures to humans.

8.0 REFERENCES

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State of Colorado, 1994, Colorado's Acceptance of the Umetco Final Construction Report for the River Ponds, Letter, April, 19, 1994.

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Umetco Minerals Corporation, 2002, Confirmation Investigation Report, Mill Hillside, Uravan, Colorado

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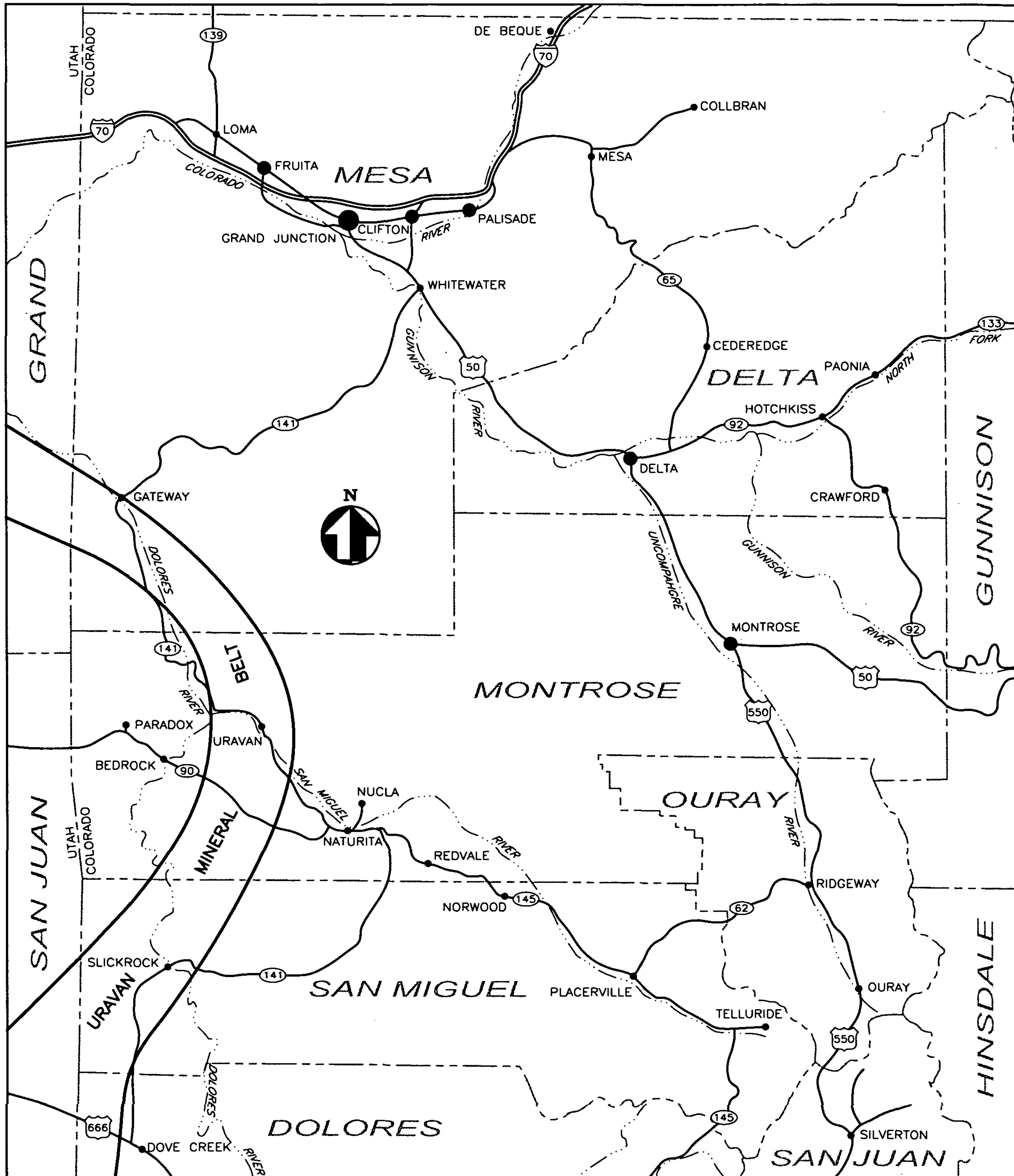
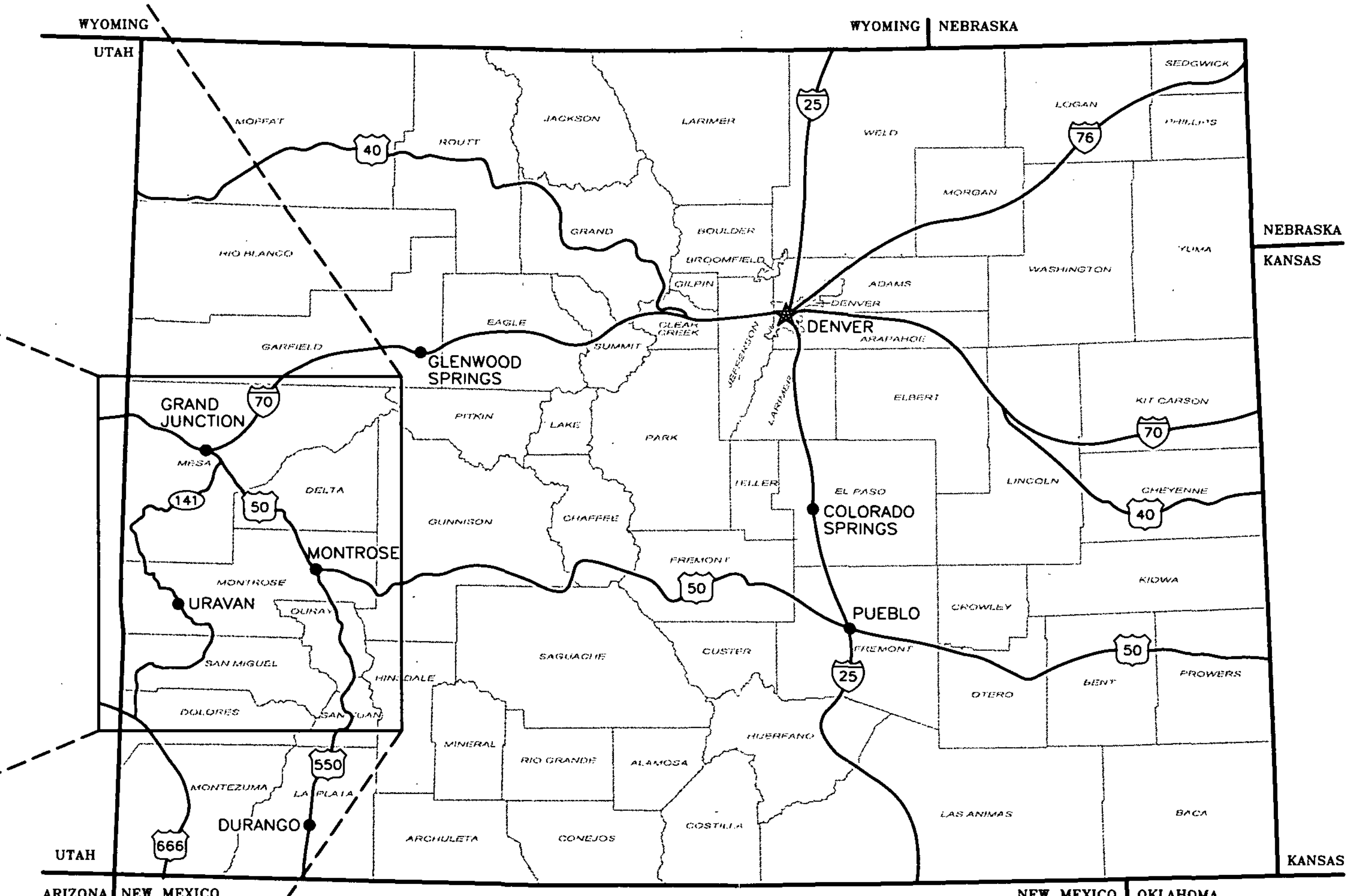
United States Department of Energy, 1992, Supplemental Standards Justification Checklist.



REGIONAL MAP

SCALE: 1" = 12.5 MILES



COLORADO

SCALE: 1" = 56 MILES

UMETCO MINERALS CORPORATION

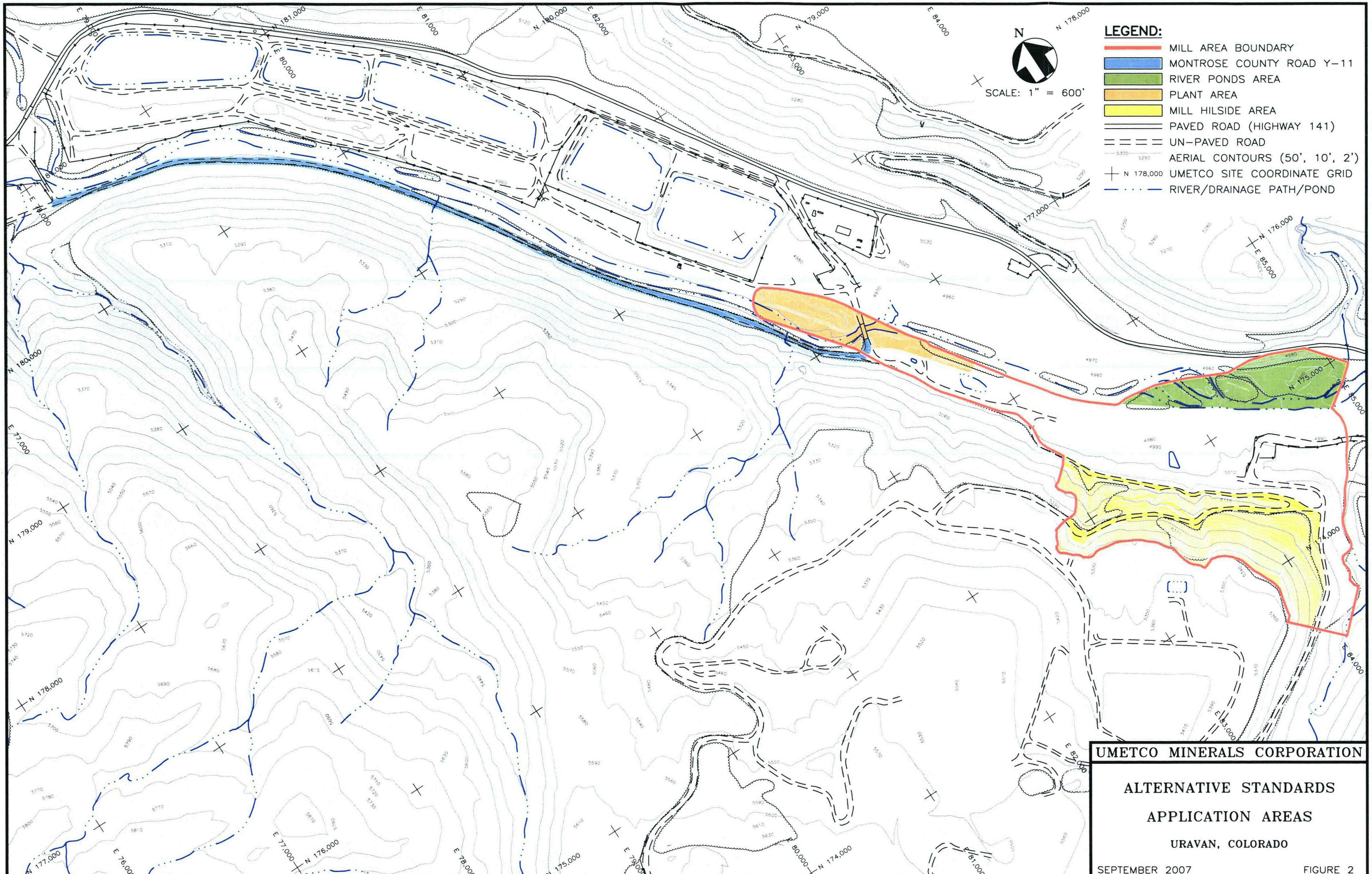
LOCATION MAP

URAVAN, COLORADO

SEPTEMBER 2007

FIGURE 1

VIN-MAP.DWG


LEGEND:
MILL AREA BOUNDARY
MONTROSE COUNTY ROAD Y-11
RIVER PONDS AREA
PLANT AREA
MILL HILSIDE AREA
PAVED ROAD (HIGHWAY 141)
UN-PAVED ROAD
AERIAL CONTOURS (50', 10', 2')
N 178,000 UMETCO SITE COORDINATE GRID
RIVER/DRAINAGE PATH/POND
N
SCALE: 1" = 600'
UMETCO MINERALS CORPORATION
ALTERNATIVE STANDARDS
APPLICATION AREAS
URAVAN, COLORADO
SEPTEMBER 2007
FIGURE 2
ALT-STAN.DWG

PHOTOGRAPHS

Photo 1 Typical Mill Hillside area looking Southwest from Highway 141.

This view is of the Mill Hillside area shown after removal of the mill buildings foundations and 46,000 cubic yards of contaminated soils and materials.

Photo 2 Typical Mill Hillside area looking South.

This photo shows the Mill Hillside with the typical steep rock rim and loose talus slope. Additional remedial activities on these steep slopes would pose a significant hazard to construction workers.

Photo 3 A-Plant North Riparian Area

This photo shows the riparian area in the A-Plant North with typical vegetative growth for the San Miguel River. This area is inundated in the spring with run off. These riparian areas are used by all types of wildlife for food, shelter and travel ways.

Photo 4 River Pond Area 1990 Post Remediation

The River Ponds area in 1990 post-remediation with rock groins prior to inundation, siltation and vegetative growth.

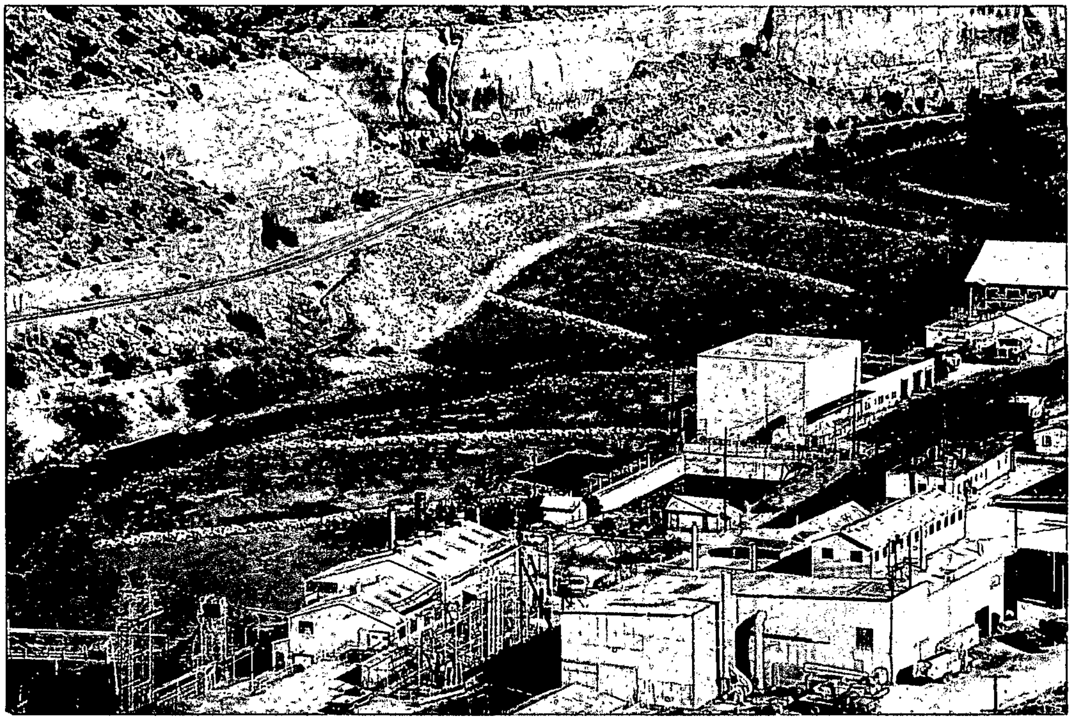


Photo 5 River Pond Area 2007 after Alluvial Deposition and Vegetative Growth

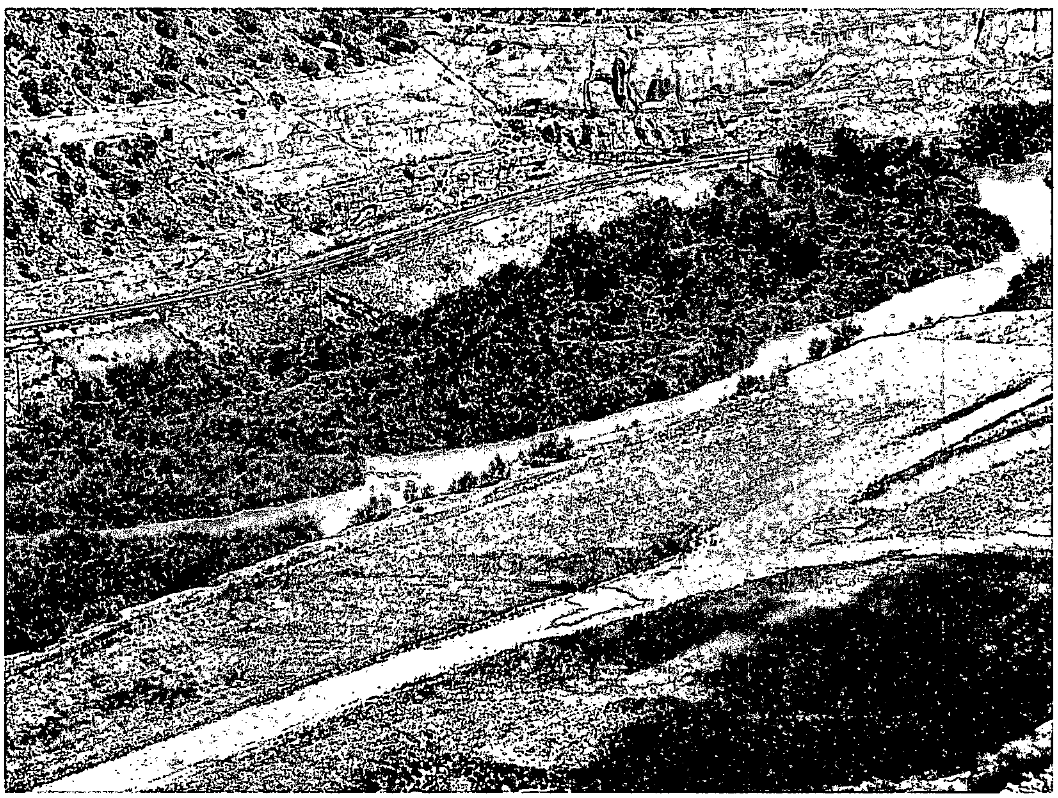


Photo 6 County Road Y-11 Riparian Area

This photo shows the typical riparian habitat along Montrose County Road Y-11 with steep embankments and dense vegetative growth.

Appendix A

Health Risk Assessments

Mill Hillside Dose Assessment

4.0 RISK ASSESSMENT

Radiation doses and risks to members of the general public from residual radioactive materials on the Mill Hillside at the Uravan site were calculated using the data generated during the post-remediation site surveys. These surveys included direct gamma exposure rate measurements, in situ measurement of Ra-226 concentrations in soil, and laboratory analysis of soils collected from randomly selected locations on the hillside.

As noted in previous sections of this report, the Mill Hillside is situated between the old A-Plant area and Club Mesa and extends northwest from EE 22 Road for approximately 2000 feet. The total area of the hillside is approximately 20 acres. It is steep, rocky terrain, unsuited for residential construction. The only reasonable future use for this portion of the area is recreational, i.e., hiking and hunting. This dose and risk assessment is based on an individual hiking or hunting on the site.

The potential annual radiation dose to an offsite member of the public was also calculated assuming an individual might spend time hiking or biking along EE 22 Road. In addition, the potential radiation dose from radon emanating from the site was estimated.

All doses calculated in this assessment are effective doses.

4.1 Potential Exposure Pathways

The potential exposure pathways for a hunter or hiker on the site are as follows:

- Direct gamma exposure
- Inhalation of dust from residual radionuclides at the surface.
- Ingestion of surface soil from the site
- Ingestion of venison or beef from an animal grazing part time on the hillside

Exposure pathways not considered in the analysis include inhalation of radon decay products, consumption of vegetation grown on the hillside, and ingestion of water from sources on the hillside. The area is small and radon gas would diffuse off-site before a significant concentration of radon decay products could build in. There is no edible vegetation on the hillside. It is highly unlikely that the area could be used to grow edible plants due to its rocky and steep terrain.

The only potential exposure pathway for an off-site individual who does not hunt or hike on the Mill Hillside would be from radon decay products. As with the hunter/hiker scenario, the terrain of the hillside is not conducive to raising edible plants. An individual hiking on EE 22 Road would be exposed only through direct gamma radiation. Inhalation of radon decay products and radionuclides in airborne dust would not be significant even if the individual made two daily trips on the road beside the impacted area.

The ICRP 72 dose coefficients (ICRP 1996) were used for inhalation and ingestion dose calculations. The coefficients are given in Table 4.1. The coefficients for U-238 and its immediate decay products as well as the dose coefficients for U-235 and its decay products were summed and applied to the U-238 intake. The sum of the dose coefficients for U-235 was multiplied by a factor of 0.045 to account for the fact that, at its natural abundance of 0.72 percent by mass, the activity of U-235 is equal to approximately 4.5 percent of the U-238 activity. The coefficients for Ra-226 and its decay products, Po-201 and Pb-210, were summed and applied to the Ra-226 intake.

Table 4.1 ICRP 72 Dose Coefficients for Uranium and Its Decay Products

Nuclide	Inhalation Dose Coefficient (Sv/Bq)*	Ingestion Dose Coefficient (Sv/Bq)
U-238	8.0E-6	4.5E-8
Th-234	7.7E-9	3.4E-9
U-234	9.4E-6	4.9E-8
Adjusted Sum U-235+D (see below)	5.6E-6	8.4E-8
Sum U-238+D and U-235+D	2.3E-5	1.8E-7
U-235	8.5E-6	4.7E-8
Pa-231	3.4E-5	7.1E-7
Ac-227	7.2E-5	1.1E-6
Th-227	1.0E-5	8.8E-9
Sum U-235+D	1.3E-4	1.9E-6
Adjusted Sum U-235+D = Sum U235+D x 0.045	5.6E-6	8.4E-8
Th-230	1.4E-5	2.1E-7
Ra-226	9.5E-6	2.8E-7
Pb-210	5.6E-6	6.9E-7
Po-210	4.3E-6	1.2E-6
Sum Ra-226+D	1.9E-5	2.2E-6

* (Assumes least soluble class and 1 μm AMAD)

4.2 Methods of Analysis for the Hunter/Hiker Scenario

4.2.1 Dose Equations and Stochastic Dose Estimate

The range and distribution of potential total effective doses to a hunter/hiker crossing the Mill Hillside were calculated using a Monte Carlo analysis with Crystal Ball® software. The measured gamma exposure rates and soil radionuclide concentrations were assumed to be represented by log-normal probability distributions. The data used in the analysis included the gamma exposure rate measurements (approximately 11,000 data points). The average background exposure rate of 15 μR/hr was subtracted from each measured exposure rate. Soil concentration values were derived from measured radionuclide concentrations in the 31 confirmation soil samples.

4.2.1.1 Dose Equations

The total dose to a hiker/hunter is described by:

$D_T = D_G + D_D + D_S + D_M$

Where:

D_T = total dose

D_G = dose from direct radiation exposure

D_D = dose from inhalation of radionuclides in airborne dust
D_S = dose from soil ingestion
D_M = dose from meat ingestion

The basic equations for calculating the dose by each exposure pathway are as follows:

Direct radiation exposure:

$$D_G = [X][0.7\ \text{mrem/mR}][t][1.0\text{E-3}\ \text{mR}/\mu\text{R}]$$

Where:
X = measured exposure rate (μR/hr)
t = time of exposure (hr)

The conversion factor for exposure (mR) to dose (mrem) was derived from the values given in the most recent UNSCEAR Report (UNSCEAR 2000). The factor of 0.7 for an adult takes into account self-shielding of critical organs by the body.

For the purpose of calculating the direct gamma radiation dose it was assumed that an individual might spend between 1 and 8 hours hiking or hunting directly on the hillside. It is not likely that anyone would camp on the hillside due to the rough terrain. The dose was calculated for a one-time event. The time distribution was assumed to be uniform, i.e., a 1 hour exposure time is just as likely as any other exposure time within the range.

Inhalation of dust:

$$D_D = [t][I_{inh}][C_d][\Sigma\ (C_{si})(DC(inh)_i)][2.5][3.7\text{E-3 Bq/pCi}][1\text{E-5 mrem/Sv}]$$

Where:
I_{inh} = inhalation rate = 1.7 m3/hr
C_d = total dust concentration in air (g/m3)
C_{si} = concentration of radionuclide i in soil (pCi/g)
$DC(inh)_i$ = ICRP72 inhalation dose coefficient for radionuclide i for an adult (Sv/Bq)

An enhancement factor of 2.5 was used in the analysis to account for the fact that the radionuclide concentrations in airborne dust may be greater than the concentrations in soil. This factor is used in the dose analyses performed by the MILDOS code.

The ICRP 72 dose coefficients (ICRP 1996) were used for inhalation and ingestion dose calculations. The coefficients are given in Table 4.1. The coefficients for U-238 and its immediate decay products as well as the dose coefficients for U-235 and its decay products were summed and applied to the U-238 intake. The coefficients for Ra-226 and its decay products, Po-201 and Pb-210, were summed and applied to the Ra-226 intake.

For the purpose of the Monte Carlo calculations, the concentrations of the radionuclides in soil were assumed to be log-normally distributed. The geometric means and standard deviations for Ra-226, Th-230, and U-238 are given in Table 4.2. The soil concentration values given for uranium were in mg/kg. The concentrations were converted to pCi/g U-238 by multiplying by the specific activity of U-238, 330 pCi/mg.

The mass concentration of airborne dust was assumed to be a log-normally distributed parameter with a geometric mean of 0.1 mg/m3 and a geometric mean of 2. The RESRAD dose calculation code uses a mass dust concentration of 0.1 mg/m^3.

Table 4.2 Parameter Values and Distributions Used in the Uncertainty Analysis

Parameter*	Type of Distribution	Range	Geometric mean	Geometric Standard Deviation
Time of exposure	Uniform	1 – 8 hours	Na	Na
Soil Ingestion	Log-normal	Na	0.1 g/day	2
Airborne dust concentration	Log-normal	Na	1E-4 g/m3	2
U-238 concentration	Log-normal	4.29 – 201 pCi/g	10.96 pCi/g	2.73
Th-230 Concentration	Log-normal	0.1 – 101 pCi/g	13.2 pCi/g	3.57
Ra-226 concentration	Log-normal	1.97 – 103.5	10.71	2.55
Net exposure rate – 15 uR/hr background subtracted	Log-normal	0.18 – 346.8 uR/hr	22.2 uR/hr	2.32

*Values for parameters in italics are assumed; Values for radiological parameters are based on sampling data.

The log-normal distributions were verified by plotting the cumulative frequency on a log-probability scale. The distributions did not fit exact log-normal distributions, but were determined to be the most appropriate choices.

The equation used in the Monte Carlo analysis was developed such that the exposure time assumed for the inhalation of radionuclides in dust would be the same as the exposure time for direct gamma radiation. The airborne dust concentration was assumed to be log-normally distributed with a geometric mean of 0.1 mg/m3 and a geometric standard deviation of 2. This means that the median concentration was assumed to be 0.1 mg/m3 and that 68 percent of the values would be between 2 times the geometric mean and ½ the geometric mean or 0.05 mg/m3 and 0.2 mg/m3. Approximately 95 percent of the time the concentration would be between 0.025 mg/m3 and 0.4 mg/m3. Because of the shape of the log-normal distribution, the arithmetic mean would be higher than the geometric mean.

The concentrations of U-nat, Th-230, and Ra-226 in soil were measured. The concentrations of their immediate decay products were assumed to be equal to the parent concentration. That is, the concentrations of U-234 and Th-234 were assumed to be equal to the concentration of U-238. The concentrations of U-235 and its decay products were assumed to be equal to 4.5 percent of the U-238 concentration based on a natural abundance of U-235 of 0.72 percent by weight. The dose coefficients for U-235 and its decay products were added and the sum multiplied by 0.045. As noted above, the product was added to the sum of the U-238, Th-234, and U-234 dose coefficients to obtain an overall dose coefficient that could be applied to the U-238 intake. The concentrations of Po-210 and Pb-210 were assumed to be equal to the Ra-226 concentration. The dose coefficients were summed and applied to the Ra-226 intake. These values are given in Table 4.1.

Ingestion of soil:

The hunter/hiker was assumed to ingest a small amount of soil during his/her time on the hillside. The dose due to soil ingestion was calculated as follows:

$$D_S = [I_{ing}][\Sigma\,(C_{si})(DC(ing)_i)][3.7E\text{-}3\ Bq/pCi][1E\text{-}5\ mrem/Sv]$$

Where:

I_{ing} = soil ingestion rate (g/day)
C_{si} = concentration of radionuclide i in soil (pCi/g)
$DC(ing)_i$ = ICRP 72 ingestion dose coefficient for radionuclide i for an adult (Sv/Bq)

The radionuclide concentrations in soil were assumed to be log-normally distributed as in the dust inhalation calculation. ICRP 72 ingestion dose coefficients were used in the calculation. For the purpose of the Monte Carlo analysis, the amount of soil ingested during the time the hunter/hiker spends on the hillside was assumed to be log-normally distributed with a geometric mean of 0.1 g/day, the daily soil ingestion rate generally assumed for adults, and a geometric standard deviation of 2. The parameters for which distributions were assumed are given in Table 4.2 and 4.3.

Ingestion of meat:

Ingestion of venison or beef from animals grazing part of the year on the Mill Hillside was not included in the stochastic dose analysis but was calculated separately as a point estimate.

4.2.1.2 Monte Carlo Analysis

An estimate of dose for a hypothetical hunter/hiker under the conditions described here involves considerable uncertainty. It is difficult to develop a reliable single estimate of the range of dose uncertainty, given that a significant number of variables each contribute to that uncertainty. One approach to understanding the overall uncertainty in the dose estimate is to define these variables as probability distributions, then use a Monte Carlo-based approach to calculating a distribution of dose results. Such a distribution provides useful information as to the overall uncertainty in the dose estimate.

For the Monte Carlo analysis the probability distribution of each variable is defined as shown in Table 4.2. Except for the uniform distribution, each variable is defined in terms of distribution type, range, geometric mean and geometric standard deviation. A code developed by Decisioneering Inc., called Crystal Ball®, automates the Monte Carlo process, and runs inside Microsoft Excel®. Once the distributions and dose equation are entered into the code, Crystal Ball randomly samples values from within each distribution based on their probability of occurrence, as defined by each distribution. That is, a value far out on the "tail" of a log-normal distribution is much less likely to be selected in any given cycle than is a value toward the heart of the distribution with a higher probability of occurrence. For each sampling cycle, the code calculates the value of the dose equation, producing an estimate of hunter/hiker dose for that specific set of selected values. This estimate is stored and the code cycles again, using a different, randomly-selected set of values. The code in this case was run for 10,000 cycles, producing as output a probability distribution defining the hunter/hiker dose estimate.

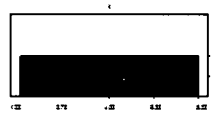
The distributions as defined within the Crystal Ball code run, and the output screen presenting the Excel® equation used in the hunter/hiker run, are provided below. Assumptions used to define the input variable distributions are shown:

Assumptions

Assumption: t **Cell: B1**

Uniform distribution with parameters:

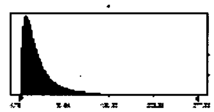
Minimum	1.00
Maximum	8.00



Assumption: x **Cell: B3**

Lognormal distribution with parameters:

Geometric Mean	22.20
Geometric Std. Dev.	2.32

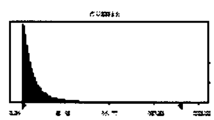


Selected range is from 0.18 to 346.80

Assumption: C U238 Inh **Cell: B7**

Lognormal distribution with parameters:

Geometric Mean	10.96
Geometric Std. Dev.	2.73



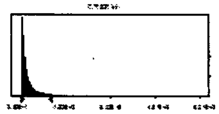
Selected range is from 4.29 to 201.00

Assumption: C Th230 Inh **Cell: B9**

Lognormal distribution with parameters:

Geometric Mean	1.32E+01
Geometric Std. Dev.	3.57E+00

Selected range is from 1.00E-1 to 1.01E+2

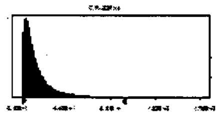


Assumption: C Ra226 Inh **Cell: B11**

Lognormal distribution with parameters:

Geometric Mean	1.07E+01
Geometric Std. Dev.	2.55E+00

Selected range is from 1.97E+0 to 1.03E+2

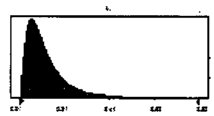


Assumption: Is **Cell: B12**

Lognormal distribution with parameters:

Geometric Mean	0.10
Geometric Std. Dev.	2.00

Selected range is from 0.00 to +Infinity

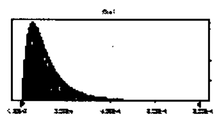


Assumption: Dust **Cell: B5**

Lognormal distribution with parameters:

Geometric Mean	1.00E-04
Geometric Std. Dev.	2.00E+00

Selected range is from 0.00E+0 to +Infinity

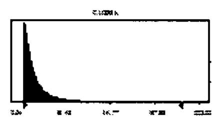


Assumption: C U238 Is **Cell: B15**

Lognormal distribution with parameters:

Geometric Mean	10.96
Geometric Std. Dev.	2.73

Selected range is from 4.29 to 201.00

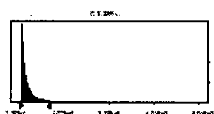


Assumption: C Th230 Is **Cell: B17**

Lognormal distribution with parameters:

Geometric Mean	1.32E+01
Geometric Std. Dev.	3.57E+00

Selected range is from 1.00E-1 to 1.01E+2

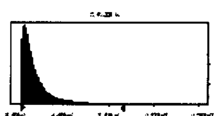


Assumption: C Ra226 Is **Cell: B19**

Lognormal distribution with parameters:

Geometric Mean	1.07E+01
Geometric Std. Dev.	2.55E+00

Selected range is from 1.97E+0 to 1.03E+2



End of Assumptions

4.2.2 Point Estimate of Dose

Point estimates for dose to a hunter/hiker from direct gamma radiation, inhalation of airborne radionuclides in dust, and ingestion of soil were calculated using the equations given in Section 4.2.1. The arithmetic mean radionuclide concentrations in soil and the arithmetic mean net exposure rate were used in the analysis. These values are given in Table 4.3. An estimated background value of 0.015 mR/hr was subtracted from each of the exposure rate measurements to obtain an exposure rate due to the residual radionuclides.

The total dose to a hiker/hunter would be as follows:

$D_T = D_G + D_D + D_S + D_M$

Where :

D_T = total dose

D_G = dose from direct radiation exposure

D_D = dose from inhalation of radionuclides in airborne dust

D_S = dose from soil ingestion

D_M = dose from meat ingestion

Table 4.3 Parameter Values and Distributions Used in the Point Estimate of Risk

Parameter*	Type of Distribution	Range	Arithmetic mean	Arithmetic Standard Deviation
Time of exposure	Uniform	1 – 8 hours	4.5 hours	Na
Soil Ingestion	Log-normal	Na	0.15 g/day	Na
Airborne dust concentration	Log-normal	Na	1.5E-4 g/m3	Na
U-238 concentration	Log-normal	4.29 – 201 pCi/g	20.01 pCi/g	35.75 pCi/g
Th-230 Concentration	Log-normal	0.1 – 101 pCi/g	22.57 pCi/g	24.01 pCi/g
Ra-226 concentration	Log-normal	1.97 – 103.5	17.26 pCi/g	21.84 pCi/g
Net exposure rate – 15 uR/hr background subtracted	Log-normal	0.18 – 346.8 uR/hr	30.4 uR/hr	24.8 uR/hr

*Values for parameters in italics are assumed; values for radiological parameters are based on sample data.

Dose from Meat Ingestion

As noted above, the dose from ingestion of meat from animals (deer or cattle) grazing on the hillside for part of the year was not included in the stochastic analysis but was calculated as a point estimate. The animal was assumed to graze on the hillside 25 percent of the time. This is a very conservative assumption as it is unlikely that any animal would obtain a significant part of its diet from that area. It was assumed that the uptake of radionuclides in deer meat would be about the same as that for beef cattle.

The average concentration of each radionuclide in meat was calculated as follows:

$$C_{mi} = [IF][C_{si}][TC_f][TC_m][1E3\ g/kg]$$

Where:

IF = forage intake rate (kg/day)
C_{si} = concentration of radionuclide i in soil (pCi/g)
TC_f= transfer coefficient for soil to forage (unitless)
TC_m= transfer coefficient for forage to meat
C_{mi} = concentration in meat (pCi/kg)

The transfer coefficients are given in Table 4.4.

Table 4.4 Transfer Coefficients from NCRP Report No. 123I (NCRP 1996)

Element	TC_f Soil to Forage (unitless)	TC_m Forage to Meat (d/kg)
Uranium	0.1	8E-4
Thorium	0.1	1E-4
Radium	0.2	1E-3
Polonium	0.1	5E-3
Lead	0.1	8E-4

NCRP Report No. 123I gives a value of 12 kg of dry forage per day for the intake rate for beef cattle. For the purpose of calculating the meat concentration, on average the animal was assumed to consume one-fourth of its daily forage intake (3 kg/day) on the hillside year round. This is a very conservative assumption because the quality and quantity of forage, the terrain, and the availability of forage elsewhere make it unlikely that an animal would forage for any length of time on the hillside.

The dose was calculated using the following equation:

$$Dm = [I_m][\Sigma (C_{mi})(DC(ing)_i)][3.7E\text{-}2 \text{ Bq/pCi}][1E5 \text{ mrem/Sv}]$$

Where:

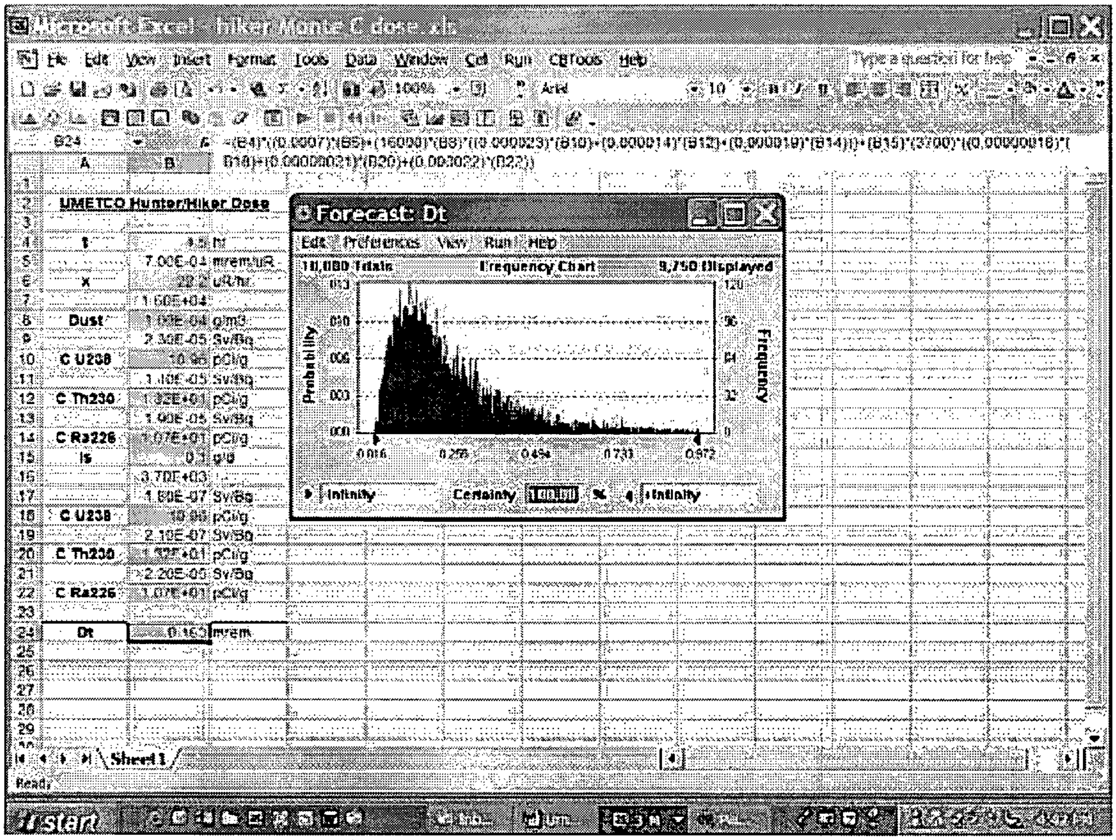
$DC(ing)_i$ = ICRP 72 ingestion dose coefficient for radionuclide i for an adult (Sv/Bq)
I_m = Annual average intake of meat from animals grazing on the hillside

In contrast to the dust inhalation and soil ingestion dose calculations, the specific transfer coefficients and dose coefficients for uranium, thorium, radium, polonium, and lead were applied separately.

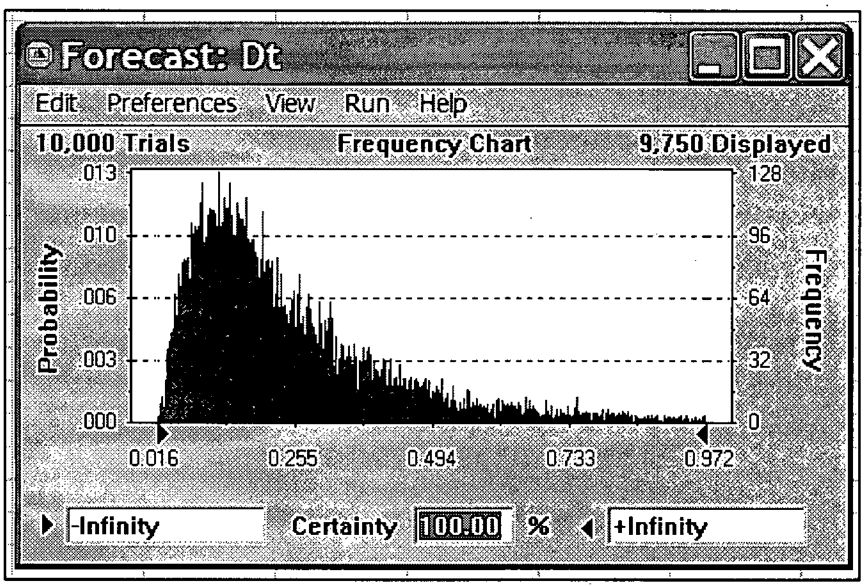
4.3 Results of the Dose Calculations

4.3.1 Stochastic Estimate of Dose

The Excel/Crystal Ball output screen for the hunter/hiker dose calculation is shown below:



An enlarged image of the output probability distribution is provided below:



The mean value for the Monte Carlo calculated probability distribution is 0.277 mrem, with the following distribution statistics:

Forecast: Dt

Edit Preferences View Run Help

Cell B23 Statistics

Statistic	Value
Trials	10,000
Mean	0.277
Median	0.201
Mode	---
Standard Deviation	0.267
Variance	0.071
Skewness	4.44
Kurtosis	44.81
Coeff. of Variability	0.96
Range Minimum	0.016
Range Maximum	5.206
Range Width	5.190
Mean Std. Error	0.003

4.3.2 Point Estimates of Dose

Point estimates of the doses to the hunter/hiker were calculated as described in Section 4.2.2 using the arithmetic mean parameter values given in Table 4.3.

Direct radiation exposure:

D_G = [X][0.7 mrem/mR][t][1.0E-3 mR/μR] = 0.096 mrem.

Where:

X=30.4 uR/hr
T = 4.5 hr.

Inhalation of dust:

D_D = [t][I_{inh}][C_d][Σ (C_{si})(DC(inh)$_i$)][2.5][3.7E-3 Bq/pCi][1E-5 mrem/Sv] = 4.7E-4 mrem.

Where:

T = 4.5 hours
I_{inh} = inhalation rate = 1.7 m^3/hr
C_d = total dust concentration in air = 1.5 E-4 g/m^3
C_{si} = arithmetic mean concentration of radionuclide i in soil (pCi/g)
C(U-238) = 20.01 pCi/g
C(Th-230) = 22.57 pCi/g
C(Ra-226) = 17.26 pCi/g
DC(inh)$_i$ = ICRP 72 inhalation dose coefficient for radionuclide i for an adult (Sv/Bq)
U-238: 2.3E-5 Sv/Bq
Th-230: 1.4E-5 Sv/Bq
Ra-226: 1.9E-5 Sv/Bq

D_D = [4.5 h][1.7 m^3/h][1.5E-4 g/m^3][2.5][3.7E-2 Bq/pCi][1E5 mrem/Sv][(20.01 pCi/g)(2.3E-5 Sv/Bq) + (22.57 pCi/g)(1.4E-5 Sv/Bq) + (17.26 pCi/g)(1.9E-5 Sv/Bq)]

Ingestion of soil:

D_S = [I_{ing}][Σ (C_{si})(DC(ing)$_i$)][3.7E-3 Bq/pCi][1E-5 mrem/Sv] = 0.21 mrem

Where:

I_{ing} = soil ingestion rate = 0.150 g/d
C_{si} = arithmetic average of radionuclide i in soil (pCi/g)
C(U-238) = 20.01 pCi/g
C(Th-230) = 22.57 pCi/g
C(Ra-226) = 17.26 pCi/g
DC(ing)$_i$ = ICRP 72 ingestion dose coefficient for radionuclide i for an adult (Sv/Bq)
U-238: 1.8E-7 Sv/Bq
Th-230: 2.1E-7 Sv/Bq
Ra-226: 2.2E-6 Sv/Bq

D_S = [0.15 g][3.7E-3 Bq/pCi][1E-5 mrem/Sv][(20.01 pCi/g)(1.8E-7 Sv/Bq) + (22.57 pCi/g)(2.1E-7 Sv/Bq) + (17.26 pCi/g)(2.2E-6 Sv/Bq)]

Ingestion of venison or beef

The dose due to ingestion of meat from animals grazing on the site was calculated in two steps. The concentration of each radionuclide in meat was calculated according to the following equation:

C_{mi} = [IF][C_{si}][TC_f][TC_m][1E3 g/kg]

Where:

If = forage intake rate = (12 kg/day)(0.25) = 3 kg/day
C_{si} = concentration of radionuclide i in soil (pCi/g)
C(U-238) = 20.01 pCi/g
C(Th-230) = 22.57 pCi/g
C(Ra-226) = 17.26 pCi/g
C(Po-210) = 17.26 pCi/g
C(Pb-210) = 17.26 pCi/g
TC_f= transfer coefficient for soil to forage (unitless) given in table 4.4
TC_m= transfer coefficient for forage to meat given in Table 4.4
C_{mi} = concentration in meat (pCi/kg)

Using the above equation and the transfer coefficients, the calculated meat concentrations are as follows:

C_m(U-238) = 4.8 pCi/kg
C_m(Th-230) = 0.68 pCi/kg
C_m(Ra-226) = 10.3 pCi/kg
C_m(Po-210) = 25 pCi/kg

C_m(Pb-210) = 4.1 pCi/kg

The dose due to ingestion of meat was calculated assuming an individual could get as much as 25 percent of his/her red meat intake from an animal grazing on the hillside. This is a highly conservative assumption. The dose was calculated as follows:

$$Dm = [I_m][\Sigma (C_{mi})(DC(ing)_i)][3.7E\text{-}2\ Bq/pCi][1E5\ mrem/Sv]$$

Where:

$DC(ing)_i$ = ICRP 72 ingestion dose coefficient for radionuclide i for an adult (Sv/Bq)

I_m = Annual average intake of meat from animals grazing on the hillside = 25 kg/y

$DC(ing)_i$ = ICRP 72 ingestion dose coefficient for radionuclide i for an adult (Sv/Bq)

U-238: 1.8E-7 Sv/Bq
Th-230: 2.1E-7 Sv/Bq
Ra-226: 2.8E-7 Sv/Bq
Po-210: 1.2E-6 Sv/Bq
Pb-210: 6.9E-7 Sv/Bq

Using the calculated concentrations in meat and the dose conversion factors, the calculated doses were as follows:

U-238 = 0.08 mrem
Th-230 = 0.01 mrem
Ra-226 = 0.23 mrem
Po-210 = 3.7 mrem
Pb-210 = 0.26 mrem
Total = 4.3 mrem

As noted above, this is a unlikely scenario.

Total Point Estimate of Dose to Hunter/Hiker

$$D_T = D_G + D_D + D_S + D_M$$

D_G = 0.10 mrem
D_D = 4.7 E-4 mrem
D_S = 0.21 mrem
Total excluding meat ingestion = 0.3 mrem

D_M = 4.3 mrem
Total including meat ingestion = 4.6 mrem

4.4 Radon Decay Product Concentration at the Mill Hillside Boundary

The concentration of radon decay products at the edge of the Mill Hillside, attributable to the residual Ra-226 in surface soil, was calculated using the method described in Radiation Data Reports, *Analysis of Radiation Exposure on or Near Uranium Mill Tailings Piles* (Schiager, 1972).

Radon Concentration (pCi/m^3) = $[(\varphi)(x)]/[(\sigma_z)(u)]$

Where:
φ = radon flux (pCi/m^2-s)
x = downwind distance (m)
σ_z = vertical dispersion coefficient at half the distance from the boundary (m)
u = average wind speed (m/s)

The point of maximum exposure is the boundary in the predominant downwind direction. As can be seen from the equation, the greater the downwind distance across the area of concern, the greater the radon concentration. The longest dimension of the Mill Hillside is approximately 600 meters.

For the purpose of this calculation, the wind was assumed to blow in the direction of the point of maximum exposure 25 percent of the time. The average wind speed was assumed to be 4 m/s. The atmospheric stability was assumed to be Pasquill-Gifford Class D half of the time and Class E the remainder of the time. The vertical dispersion coefficients were obtained from the Schiager paper.

The radon flux was assumed to be numerically equal to the Ra-226 concentration in soil, the assumption made in the MILDOS dose assessment code. The arithmetic average Rn-226 concentration in surface soils on the Mill Hillside is 17.26 pCi/g. The Ra-226 concentration in sub-surface soils was assumed to be essentially the same as the average surface soil concentration.

The vertical dispersion coefficients for Class D and Class E at a distance of 300 meters are 11 m and 9 m respectively. The estimated maximum radon concentration at the edge of the Mill Hillside was calculated as follows:

Rn-222 concentration = [(0.25)(0.50)(17.26 pCi/m2-s)(600 m)]/[(4 m/s)(11 m)] +
[(0.25)(0.50)(17.26 pCi/m2-s)(600 m)]/[(4 m/s)(9 m)]

Rn-222 concentration = 65.4 pCi/m^3

Because of the short time period between emanation of the radon and arrival at the edge of the Mill Hillside, the radon decay products would not have time to equilibrate. The estimated equilibrium fraction, assuming an average travel time of 1.25 minutes [300 m/(4 m/s)(60 s/m)] is 0.04 (Schiager, 1972). Therefore, the radon decay product concentration in working level (WL) would be as follows:

WL = [(pCi/m^3 Rn-222)(EF)]/[(100 pCi/L-WL)(1E3 L/m^3)]

Where:
EF = equilibrium fraction = 0.04
[Rn-222] = 65.4 pCi/m^3

WL = [(65.4 pCi/m^3)(0.04)]/[1E5 pCi/m^3-WL] = 2.6 E-5 WL

The radon decay product exposure and dose would be directly proportional to the time spent at the downwind boundary.

4.5 Dose to a Hiker/Biker Using EE 22 Road

The Mill Hillside borders the EE 22 Road. The road may be used by hikers and bikers for recreation. The potential dose pathways for such use are limited to direct gamma radiation, inhalation of radionuclides in airborne dust, and inhalation of radon decay products. The dose from airborne dust would be negligible based on the calculated dose to a hiker/hunter given in Section 4.3.

The estimated radon decay product exposure (working level months) to a hiker/biker using the road, assuming he/she uses the road for one hour per week, would be as follows:

WLM = [WL][t]/[170 WLh/WLM]

Where:

WL = radon decay product exposure in working level
t = time of exposure in hours = 1 h/wk x 52 wk/y
WLM = radon decay product exposure

WLM = [2.6E-5 WL][52 h/y]/[170 WLh/WLM] = 8.0 E-6 WLM/y

The effective dose from a radon decay product exposure 1 WLM was assumed to be 400 mrem (ICRP 1993). Therefore, the radon decay product dose to a hiker/biker would be approximately 3 E-3 mrem.

The dose from direct gamma radiation was calculated based on the measured exposure rates adjacent to EE 22 Road. The exposure rates for the grids that intersected the road were averaged to give an estimated measured exposure rate of 21 μR/hr. Assuming a background exposure rate of 15 μR/h, the net exposure rate would be 6 μR/hr. The estimated dose, assuming the individual spends five hours per week, fifty weeks per year, on the road is 1.5 mrem.

Therefore, the dose to a hiker/biker using EE 22 Road would be approximately 1.5 mrem.

4.6 Dose from Consumption of Groundwater or San Miguel River Water

There are no groundwater wells used for drinking water in the vicinity of the Mill Hillside. Therefore, there is no complete exposure pathway for this source.

The Mill Hillside has been reclaimed with terraces established to reduce erosion. Therefore, the potential for exposure to members of the public from transport of residual radionuclides from the Mill Hillside to the San Miguel River is negligible. There are no other surface water sources that could be used routinely for drinking water.

4.7 Conclusion

The most probable future use, if any, of the hillside area is hiking and perhaps hunting. The above calculations demonstrate that the dose to any individual using the site would be a small fraction of the 25 mrem per year decommissioning standard even when very conservative assumptions are used. While the dose calculation was based on a one-time event, even if an individual were to use the site ten times per year, the dose excluding meat consumption would be less than 3 mrem. The dose from ingestion of meat is independent of the number of times a hunter/hiker uses the site. Monte Carlo analysis of the hunter/hiker dose, excluding meat ingestion, provides further detail as to the likelihood that this point estimate is an over- or under-estimate. The Monte Carlo analysis indicates a high probability that potential doses to hunters/hikers will fall well within the allowable limit.

There is no current evidence that radiation doses below 10 rem increase the risk of cancer to humans. However, the Interagency Steering Committee on Radiation Standards (ISCORS) recently published guidance for estimating risk from effective dose equivalent. The ISCORS guidance recommends use of a conversion factor of 6×10^{-4} fatal cancers per TEDE rem (6×10^{-7} fatal cancers per mrem). Applying that conversion to the dose from a single event calculated above would lead to a fatal cancer risk to the hunter/hiker of 1.8×10^{-7}, or approximately 2 chances in ten million.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Remedial actions at the Mill Hillside site were successful in removing highly contaminated mill structures and soils from the hillside. The average penetrating radiation exposure rate at the Mill Hillside site, based on more than 11,200 field measurements, was reduced to 35.1 μR/hr, with a single-measurement maximum of 272.8 μR/hr. These data show a two-fold increase in the number of readings below the RAP exposure guideline of 20 μR/hr relative to the exposure survey conducted in January 2001. The average concentration of Ra-226 in surface soil, determined by more than 11,700 field measurements, was reduced to 22.0 pCi Ra-226/g, and the single-reading maximum observed is 446.4 pCi Ra-226/g. Similar to exposure data, surface Ra-226 concentrations show a site average decrease of 2 pCi Ra-226/g in response to intensive site remediation in safely accessible areas relative to 2001 survey data. The maximum individual Ra-226 results from laboratory analyses for surface soil samples is 103.5 pCi Ra-226/g and for subsurface soil samples 96.2 pCi Ra-226/g.

The decrease of 2 pCi Ra-226/g was accomplished by removing about 46,000 cubic yards of contaminated materials at a cost of $400,000. Such a reduction in associated exposure is clearly not cost effective from an ALARA standpoint.

Results of the soil confirmation investigation indicate that residual levels of radionuclides and heavy metals on hillside soils do not pose a significant risk to humans in the future. This low risk (coupled with excessive environmental damage) strongly suggests that additional soil removal from the Mill Hillside is not warranted. Future use of the area will be under control of the federal government, and, thus, potential future exposures will be maintained ALARA through institutional control.

The risk assessment indicates that the average values for uranium, arsenic, cadmium, lead, molybdenum, nickel, selenium, vanadium, and zinc are all below Category 2 soil cleanup objectives. Category 2 objectives are risk-based values for a residential land use scenario. Radium and thorium exceed the Category 2 (residential) objectives but do not exceed Category 3 values. Category 3 soil cleanup objectives are based upon a recreational visitor occupying the site for 24 hours each day for 14 days per year. This is an extremely conservative approach since camping on the steep hillside for two weeks is extremely unlikely. In addition, the risk assessment presented in Section 4.0 demonstrates that the potential dose to any individual is a small fraction of the 25 mrem decommissioning standard even when conservative assumptions are used in hiker/hunter scenarios.

6.0 REFERENCES

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A-Plant North Dose Assessment

A-Plant North Dose Risk Estimate

Table 1: Estimated Total Excess Dose

	Direct Gamma Dose mrem/yr	Inhalation Dose mrem/yr	Total Dose mrem/yr
Commuter	0.256 2.56 (μSv/yr)	0.03 0.30 (μSv/yr)	0.286 2.86 (μSv/yr)
Hiker	0.5 5.0 (μSv/yr)	0.03 0.3 (μSv/yr)	0.53 5.30 (μSv/yr)
Biker	0.1 1.0 (μSv/yr)	0.007 0.07 (μSv/yr)	0.107 1.07 (μSv/yr)
Fisherman	1.28 12.8 (μSv/yr)	0.16 1.6 (μSv/yr)	1.44 14.4 (μSv/yr)
Total Excess Dose			2.363 23.63 (μSv/yr)

Direct gamma doses are from field collected gamma measurements and reflect the maximum measurement obtained and therefore represent the most conservative scenario for this risk assessment.

Table 2: Estimated Annual Collective Dose

	Estimated Individual Annual Dose (mrem/y)	Number of Exposed Individuals	Estimated Collective Annual Dose (person-rem)
Commuter	0.286 2.86 (μSv/yr)	100	0.0286 0.00029 (person-sievert)
Hiker	0.53 5.30 (μSv/yr)	100	0.053 0.00053 (person-sievert)
Biker	0.107 1.07 (μSv/yr)	100	0.0107 0.00011 (person-sievert)
Fisherman	1.44 14.40 (μSv/yr)	10	0.0144 0.00014 (person-sievert)
Total Annual Collective Dose			0.1067 0.00107 (person-sievert)

Table 3: Collective Dose Averted

Years	Annual Collective Dose (mrem/yr)	Residual Activity	$1-e^{-rN}$	r	Present Worth of Future Dose Averted (person-rem)
1-100	0.1067 0.0011 (μSv/yr)	1	1.00	0.07	1.52 0.0152 (person-sievert)
100-1000	0.1067 0.0011 (μSv/yr)	1	1.00	0.03	3.56 0.0356 (person-sievert)

Where r = monetary discount rate in units per year

N = number of years over which collective dose will be calculated

Calculation is derived from NUREG 1757 equation

Table 4: Estimated Cost of Remediation of Per person-rem Averted

Total Collective Dose Averted to Year 1000	5.08 0.0508 (person-sievert)
Benefit From Averted Dose In U.S. Dollars	$10,161.90
Estimated Cost Of Remediation	$1,024,144.00
Cost Per person-rem Averted	$201,565.37
Estimated cost of remediation exceeds the NUREG 1757 per person-rem averted level by a factor of	5

River Ponds Area Dose Assessment

River Ponds Dose Risk Estimate

Table 1: Estimated Total Excess Dose

	Direct Gamma Dose mrem/yr	Inhalation Dose mrem/yr	Total Dose mrem/yr
Hiker	0.75 7.5 μSv/yr	0.03 0.3 μSv/yr	0.78 7.8 μSv/yr
Fisherman	1.88 18.8 μSv/yr	0.16 1.6 μSv/yr	2.04 20.4 μSv/yr
Total Excess Dose			2.82 28.2 μSv/yr

Direct gamma doses are from field collected gamma measurements and reflect the maximum measurement obtained and therefore represent the most conservative scenario for this risk assessment.

Table 2: Estimated Annual Collective Dose

	Estimated Individual Annual Dose (mrem/y)	Number of Exposed Individuals	Estimated Collective Annual Dose (person-rem)
Hiker	0.78 7.8 μSv/y	100	0.078 0.0008 person-sievert
Fisherman	2.04 20.4 μSv/y	10	0.0204 0.0002 person-sievert
Total Annual Collective Dose			0.0984 0.001 person sievert

Table 3: Collective Dose Averted

Years	Annual Collective Dose	Residual Activity	$1\text{-}e^{-rN}$	r	Present Worth of Future Dose Averted (person-rem)
1-100	0.0984 0.001	1	1.00	0.07	1.41 0.014 person-sievert
100-1000	0.0984	1	1.00	0.03	3.28 0.033 person-sievert

Where r = monetary discount rate in units per year

N = number of years over which collective dose will be calculated

Calculation is derived from NUREG 1757 equation

Table 4: Estimated Cost of Remediation of Per person-rem Averted

Total Collective Dose Averted to Year 1000	4.69 (0.047 person-sievert)
Benefit From Averted Dose In U.S. Dollars	$9,371.43
Estimated Cost Of Remediation	$5,120,720.00
Cost Per person-rem Averted	$1,092,836.62
Estimated cost of remediation exceeds the NUREG 1757 per person-rem averted level by a factor of:	5

Y-11 Dose Assessment

RISK ASSESSMENT FOR COUNTY ROAD Y-11

URAVAN, COLORADO

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March 11, 1998

SHEPHERD MILLER
INCORPORATED

EXECUTIVE SUMMARY

A radiation risk assessment has been performed for a section of Montrose County Road Y-11 at Uravan, Colorado. This assessment is intended to describe potential radiation doses and human health risks from elevated concentrations of uranium and its decay products in and along side of the road bed in the area immediately northwest of the Umetco uranium mill site. The Y-11 road connects State Highway 90 to State Highway 141 and is used by individuals residing in the area, including the towns of Paradox and Bedrock. It may also be used for recreational purposes such as hiking, mountain biking, and as access for fishing in the San Miguel River.

Umetco conducted a survey during 1996 and 1997 to evaluate the gamma radiation exposure rates and radium-226 (Ra-226) activity concentrations in surface material along the Y-11 road between the uranium mill site and the landfill. These measurements were used in the risk assessment. Since the landfill area, including the road, will be cleaned up to meet regulatory standards, only the road section between the existing bridge and the inactive bridge adjacent to the old landfill was included in the risk assessment.

The potential excess radiation doses to individuals using the road were estimated using reasonable exposure assumptions and measured gamma radiation exposure rates. The potential exposure pathways to road users include direct gamma radiation exposure and inhalation of dust containing elevated concentrations of uranium and its decay products. The excess radiation dose to a commuter was estimated to be approximately 0.2 mrem per year. Excess radiation doses to potential recreational users were estimated to be as follows: hiker, 0.4 mrem per year; mountain biker, 0.09 mrem per year; and fisherman, 1 mrem per year. The maximum estimated excess annual dose, 1 mrem, is:

- 1 percent of the allowable radiation dose to a member of the general public from an nuclear facility,
- less than 0.2 percent of the natural background doses people in the area receive,

- half of the radiation dose an airline passenger receives in traveling from Denver to New York and
- less than 20 percent of the dose received in a dental x-ray.

The excess radiation doses an individual might receive due to the elevated concentrations of uranium decay products along the Y-11 road are negligible and well within accepted limits.

RISK ASSESSMENT FOR COUNTY ROAD Y-11

URAVAN, COLORADO

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1.0 INTRODUCTION

A radiation risk assessment has been performed for a section of Montrose County Road Y-11 at Uravan, Colorado. This assessment is intended to describe potential radiation doses and human health risks from elevated concentrations of uranium and its decay products in and along side of the road bed in the area immediately northwest of the Umetco uranium mill. The area of interest for this assessment includes the section of the road from the Umetco uranium mill site north to the old landfill, a distance of approximately one mile.

Montrose County Road Y-11 extends from the Umetco uranium mill site to State Highway 90 (see Figure 1). The road follows the west bank of the San Miguel River to its confluence with the Dolores River, then follows the south bank of the Dolores River to State Highway 90. Road Y-11 provides access to State Highway 141 for ranchers and residents of this general area, which includes the towns of Bedrock and Paradox.

The road was used to haul materials from the village of Uravan and the mill to a landfill approximately 1.5 miles north west of the mill site, and may also have been used to haul ore for processing. In addition, materials with elevated concentrations of uranium and its decay products may have been used in road construction and repair. Elevated gamma exposure rates and naturally occurring radionuclide concentrations have been measured in and beside the road between the mill site and the landfill.

The road passes between an historic landfill site and the landfill used in the more recent past. The landfills and the road in the vicinity of the landfills will be cleaned up and reclaimed to meet regulatory standards which are based on acceptable risks. This risk assessment is limited to gamma radiation exposure rates and elevated radionuclide concentrations along the section of road between the existing bridge over the San Miguel River and the old, inactive bridge, adjacent to the landfill.

2.0 POTENTIAL ROAD USE AND EXPOSURE SCENARIOS

The section of the road of concern for this risk assessment is approximately one mile long and follows the bank of the San Miguel River. The small strip of land on the north and east side of the road is adjacent to the river and is in an area likely to be flooded during high run-off periods. The south and west side of the road abuts a steep bank. The only flat area adjacent to the road, which is large enough to permit construction, is a river bank encompassing approximately one acre. Due to its location and potential for flooding, it is highly unlikely that any residences or even temporary camping spots would be established along this portion of the road. Therefore, the only reasonable routine use for the road is vehicle access to State Highway 141. The road also may be used for recreational purposes, such as hiking, mountain biking, or access to the river for fishing.

2.1 Commuter Vehicle Use

Assuming an individual commutes from one of the towns on State Highway 90, or from a ranch in the area, to State Highway 141 at a vehicle speed of 25 miles per hour, the time he or she would spend traversing this section of the road is approximately 0.04 hours per trip. If an individual makes 2 trips per day for 250 days per year, the total time spent on this portion of the road would be 20 hours per year.

2.2 Hiker/Mountain Biker

The Y-11 road could be an attractive route for hikers and mountain bikers. However, it is unlikely that an individual would make more than 20 hikes per year, along the section of road of concern. If the individual is hiking at a slow pace of 2 miles per hour, the total time spent on the road, assuming he or she returns by the same route, would be 1 hour, for a total annual exposure time of 20 hours per year. A mountain biker would spend less time along the road than a hiker. Assuming he or she bikes the road 20 times per year at a speed of 5 miles per hour, the total annual exposure time would be 4 hours.

2.3 Fisherman

A fisherman, using the Y-11 road for access to the San Miguel River, might spend as much as 4 hours fishing in one area. It is not likely that he or she would be in this area more than 25 times per year, for a total annual exposure time of 100 hours.

3.0 EXPOSURE PATHWAYS

The only potential exposure pathways for road users include external gamma radiation and inhalation of airborne particulate radionuclides. Inhalation of radon decay products would not be a significant contributor to dose. Radon emanating from the Ra-226 in the road would be dispersed rapidly, before the build up of significant concentrations of radon decay products. Since the radon gas itself produces very little radiation dose, it is of no importance to this dose assessment.

The are no potential routes of ingestion which would result in a significant intake of radionuclides attributable to the elevated concentrations in and along the road. Erosion of road surface materials, containing elevated concentrations of uranium and its decay products, could introduce radionuclides into the river. However, the rate of erosion compared to the rate of dilution would result in negligible increases in radionuclide concentrations in river water. Therefore, neither direct ingestion of river water nor ingestion of fish from the river would result in a significant intake of radionuclides attributable to the road. Direct ingestion of soil does not apply to this situation because individuals are only passing through, either on foot or in vehicles.

4.0 ESTIMATED RADIONUCLIDE CONCENTRATIONS AND EXPOSURE RATES

Umetco measured gamma radiation exposure rates and Ra-226 concentrations in surface materials along the road in 1996 and 1997. The results of these surveys are presented in Figures 2 and 3. The distributions of the measurements are given in Figures 4 and 5. The average measured gamma exposure rate for the section of the Y-11 road between the current and old bridges was 0.0358 milliroentgen per hour (mR/hr). The average Ra-226 concentration was estimated to be 19.4 picocuries per gram (pCi/g) based on shielded gamma radiation measurements. These values were used in estimating potential doses to individuals using the road.

The measured exposure rate for a commuter was modified to take into account shielding by the vehicle. Measurements were made at 0.1 mile intervals along the road inside and outside of a standard sport utility vehicle. (see Table 1.) The exposure rates inside the vehicle were divided by the exposure rates outside the vehicle to obtain an average shielding factor of 0.51. That is, shielding provided by a typical vehicle used by a commuter would reduce the average exposure rate inside to approximately 51 percent of the outside exposure rate. The shielded exposure rate was used to calculate annual dose to a commuter.

The average estimated Ra-226 concentration in materials in and along the road was used to estimate the average radionuclide concentrations in airborne particulate matter that an individual walking or biking along the road might breathe.

Table 1 Y-11 Exposure Rate Measurements

	Exposure Rate (μR/hr) Background (13μR/hr)		
Distance From Bridge (miles)	Inside Car (Lap)	Outside (at ~ 1 m beside car)	Ratio of Exposure Rate Inside (Lap) to Exposure Rate Outside
0.1	32	-	-
0.2	30	55	0.55
0.3	20	29	0.69
0.4	18	43	0.42
0.5	26	42	0.62
0.6	50	75 230 (under car)	0.22
0.7	21	50	0.42
0.8	22	40	0.55
0.9	14	25	0.56
1.0	21	40	0.53
Average	**25.4**	**55.4**	**0.51**

5.0 ESTIMATED ANNUAL DOSES AND RISKS

The estimated annual doses and risks to commuters and recreational users of the road were calculated using the average gamma exposure rate measured during the 1996-1997 survey and the average estimated Ra-226 concentration on, and beside, the road. As noted previously, the average gamma exposure rate for the commuter was adjusted to account for shielding by the vehicle.

The background exposure rate measured at the Umetco Uravan office was 0.013 mR/hr. This value, a reasonable average for the Uravan area, was used to determine the excess direct gamma exposure rate due to elevated radionuclide concentrations in the road. For the purpose of this analysis, it was assumed that the vehicle shields background gamma radiation to the same extent as the gamma radiation attributable to the elevated radionuclide concentrations on, and beside, the road.

5.1 Commuter

The estimated excess annual dose for the commuter, attributable to elevated radionuclide concentrations in and along the Y-11 road, was calculated as follows:

Dose = (T)(X - B)(S)(D)

where: T = time of exposure = 20 hours/ year

X = measured average exposure rate = 0.036 mR/hr

B = average background exposure rate = 0.013 mR/hr

S = shielding factor = 0.51

D = conversion from exposure rate to dose rate = 0.8 mrem/mR

Dose = (20 hours/yr)(0.036 mR/hr - 0.013 mR/hr)(0.51)(0.8 mrem/mR) = 0.2 mrem/yr

5.2 Recreational User

5.2.1 Direct Gamma Radiation Dose

The direct gamma radiation dose to a recreational user of the site was calculated in the same manner as the dose to the commuter except that no credit was taken for shielding.

The estimated excess dose to a hiker due to direct gamma radiation attributable to elevated radionuclide concentrations was calculated as follows assuming an exposure time of 20 hours per year:

Dose = (20 hours/yr)(0.036 mR/hr - 0.013 mR/hr)(0.8 mrem/mR) =0.4 mrem/yr

If the exposure time is assumed to be 52 hours per year the estimated dose due to direct gamma radiation would be 1.0 mrem/yr.

The estimated dose to an individual riding a mountain bike along the road 20 times during the year would be approximately 0.08 mrem/yr.

The estimated maximum direct gamma radiation dose to a fisherman using the road and the river in the area of concern was calculated using the average measured gamma exposure rate for the road. The exposure rate at the river bank or in the river would be 50 percent or less of the measured exposure rate on the road due to the source geometry. That is, the source is only on one side of the receptor (fisherman). In addition, even using 50 percent of the average measured gamma exposure rate overestimates the dose since the exposure rates close to the river bank are generally lower than the exposure rates in the road.

Dose = (100 hrs/yr)(0.036 mR/hr - 0.013 mR/hr)(0.8 mrem/mR)(0.5) = 0.9 mrem/yr.

5.2.2 Dose Due to Inhalation of Airborne Particulate Radionuclides

All of the radionuclides in the U-238 decay series were assumed to be present at activity concentrations equal to the estimated Ra-226 concentration, 19.4 pCi/g. The dose conversion factors from EPA Guidance #11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion* (EPA 1988) for these radionuclides were summed to obtain a dose conversion factor for the U-238 decay series. The dose conversion factors for the U-235 decay series radionuclides were also summed to obtain a total dose conversion factor. The sum was multiplied by 0.023 to account for the fact that, for natural uranium, the activity concentration of U-235 is equal to 2.3 percent of the activity concentration of U-238. The Inhalation Dose Conversion Factors for radionuclides in the U-238 and U-235 decay series are shown in Table 2. The total dose conversion factor for natural uranium (including the U-238 and U-235 decay series), in mrem per pCi U-238, is as follows:

Effective total DCF = U-238 DCF + 0.023 x U-235 DCF

Effective total DCF = 0.608 mrem/pCi + (0.023)(2.69 mrem/pCi)

Effective total DCF = 0.671 mrem/pCi U-238

Table 2 Dose Conversion Factors for U-238 and U-235 Decay Series Nuclides

Nuclide	Dose Conversion Factor (mrem/pCi)
U-238	0.118
U-234	0.132
Th-234	<0.001
Th-230	0.326
Ra-226	0.009
Pb-210	0.014
Po-210	0.009
Total U-238 Series	0.608
U-235	0.123
Pa-231	1.28
Ac-227	1.29
Total U-235 series	2.69

The inhalation dose conversion factors used in this assessment are conservative in that they are based on a particle size of 1.0 micrometer. In fact, the particle size in dust from the road would be likely to be larger. The dose per unit activity from particles larger than 1.0 micrometers would be somewhat lower.

The dose due to inhalation of airborne particulate radionuclides in dust from the road is applicable to recreational users. The estimated average dust concentration used in the calculation is 100 micrograms per cubic meter (0.1 mg/m^3). This is the default dust concentration used in the U.S. Department of Energy computer code RESRAD which is used for estimating dose from residual radioactivity in soil (Yu 1997).

The estimated dose to a hiker due to inhalation of radionuclides attributable to the elevated concentrations in and beside the road was calculated as follows:

Dose = (DCF)(V)(T)(C[dust])(A)(10^{-3} g/mg)

where: DCF = effective dose conversion factor = 0.671 mrem/pCi

V = volume of air breathed per unit time = 1.25 m^3/hr

T = time of exposure = 20 hours/yr

C[dust] = estimated concentration of dust in air = 0.1 mg/m^3

A = activity concentration in the dust = 19.4 pCi/g

Dose = (0.671 mrem/pCi)(1.25 m^3/hr)(20 hr/yr)(0.1 mg/m^3)(19.4 pCi/g)(10^{-3} g/mg)

Dose = 0.03 mrem/yr

This is a generally conservative estimate of the dose since it is applicable to extensive areas of residual soil radioactivity where significant dust emissions might be expected. The area of elevated radionuclide concentrations in the case of the Y-11 Road is limited. However, the potential for dust emissions from the road due to mechanical disturbance such as the passage of vehicles, is greater than it would be for the surrounding areas. Therefore, it is reasonable to assume that a large fraction of the dust a recreational user of the road might inhale would come from the road.

The dose to a mountain biker due to inhalation would be approximately 0.007 mrem/yr. Since the fisherman is assumed to be exposed for a period of 100 hours per year, the dose due to inhalation would be 5 times that for the hiker, or 0.16 mrem per year.

The effective dose conversion factor used in the dose calculation assumes that all radionuclides in the U-238 decay series are in equilibrium. This assumption was based on the history of the road. During the 1997 survey, boreholes were drilled in and beside the road at selected locations. The Ra-226 concentrations at the surface and at various depths were measured in the field using a borehole gamma scintillation system. In addition, samples were taken at various depths for laboratory analysis for total uranium, Ra-226, and Th-230. The borehole locations are shown in Figure 6. Radionuclide activity concentration data are given in Table 3. The ratios of radionuclide concentrations did not show that the U-238 decay products were in equilibrium. However, no consistent pattern was seen in the data. Lacking definitive information to the contrary, the nuclides were assumed to be in equilibrium. If the nuclides in the U-238 decay series are not in equilibrium, the potential inhalation doses may be higher. However, since the principal pathway for radiation dose attributable to use of the Y-11 road is direct gamma exposure, the uncertainty introduced into the dose calculation by the state of equilibrium for the U-238 decay products would not affect the total dose significantly.

Table 3 Estimated Radionuclide Concentrations in Boreholes

		Radionuclide Concentrations (pCi/g)			
		Ra-226		Th-230	U-nat
Borehole	Depth (ft)	Logger	Lab	Lab	Lab[1]
B-11	Surface	42			
	0 - 0.5	30			
	0.5 - 1.0	40			
	1.0 - 1.5	22			
	1.5 - 2.0	13			
B-12	Surface	32			
	0 - 0.5	30	34	163	116
	0.5 - 1.0	27			
	1.0 - 1.5	7.5	98	104	82
	1.5 - 2.0	3.3			
B-13	Surface	42			
	0 - 0.5	22	61	111	184
	0.5 - 1.0	5.7	8.8	6.4	17
	1.0 - 1.5	3.6			
	1.5 - 2.0	2.5			
B-15	Surface	140			
	0 - 0.5	64	6.4	5.6	12
	0.5 - 1.0	36			
	1.0 - 1.5	11	7.6	7.2	17
	1.5 - 2.0				
B-16	Surface	54			
	0 - 0.5	36	57	82	116
	0.5 - 1.0	18			
	1.0 - 1.5	9	7.8	9.7	22
	1.5 - 2.0	3.8	7.8	9.7	22
B17	Surface	37			
	0 - 0.5	23			
	0.5 - 1.0	19			
	1.0 - 1.5	14			
	1.5 - 2.0	5.7			
B-18	Surface	320			
	0 - 0.5	240			
Elevated	0.5 - 1.0	370			
gamma to	1.0 - 1.5	370	674/152[2]	698/702	1904/1768
7.5 ft.	1.5 - 2.0	360			

Table 3 Estimated Radionuclide Concentrations in Boreholes (Cont'd.)

		Radionuclide Concentrations (pCi/g)			
		Ra-226		Th-230	U-nat
Borehole	Depth (ft)	Logger	Lab	Lab	Lab[1]
B-19	Surface	220			
	0 - 0.5	140	195	461	640
	0.5 - 1.0	130			
	1.0 - 1.5	48			
	1.5 - 2.0	17			
B20	Surface	220			
	0 - 0.5	160	465	546	387
Elevated	0.5 - 1.0	150			
gamma to	1.0 - 1.5	95			
3.5 ft.	1.5 - 2.0	56			
B-21	Surface	53			
	0 - 0.5	35	36	305	46
	0.5 - 1.0	11			
	1.0 - 1.5	6.7			
	1.5 - 2.0	4.4			
B-22	Surface	490			
	0 - 0.5	280	529/565	1940/1480	2788/2312
	0.5 - 1.0	78			
	1.0 - 1.5	28			
	1.5 - 2.0	11	54	40	46
B-23	Surface	490			
Elevated	0 - 0.5	280	580	203	37
gamma	0.5 - 1.0	300			
(constant conc.)	1.0 - 1.5	210	65	2040	340
to > 4.5 ft.	1.5 - 2.0	260			
B-24 (C-24?)	Surface	36			
	0 - 0.5	36			
Gamma	0.5 - 1.0	27			
increased	1.0 - 1.5	29			
2.0 to 3.5 ft.	1.5 - 2.0	65			
Lab Ra-226 = 365 pCi/g at 2.5 - 3.0 ft.					
B-25	Surface	49			
	0 - 0.5	34			
	0.5 - 1.0	34			
	1.0 - 1.5	10			
	1.5 - 2.0	4.3			

Table 3 Estimated Radionuclide Concentrations in Boreholes (Cont'd.)

		Radionuclide Concentrations (pCi/g)			
		Ra-226		Th-230	U-nat
Borehole	Depth (ft)	Logger	Lab	Lab	Lab(1)
B-26	Surface	27			
	0 - 0.5		3.2	4.6	75
	0.5 - 1.0				
Bedrock at	1.0 - 1.5				
0.4 ft.	1.5 - 2.0				
B-27	Surface	59			
	0 - 0.5	24	92	105	204
	0.5 - 1.0	23			
Bedrock at	1.0 - 1.5				
1.0 ft.	1.5 - 2.0				
B-34	Surface	370			
	0 - 0.5	290	705	363	442
	0.5 - 1.0	250	334/252(2)	172/164	401/306
	1.0 - 1.5	97			
	1.5 - 2.0	36			

(1) Converted from mg/g using specific activity of 0.68 pCi/mg
(2) Duplicate samples analyzed
(3) Average from 0.5 to 2.0 ft.

5.3 Total Estimated Doses Due to Elevated Radionuclide Concentration

The total estimated potential excess annual doses to individuals using the Y-11 road are given in Table 4. All doses are very small fractions of average natural background radiation doses which range from 300 mrem per year for the United States, up to 700 mrem per year for the Rocky Mountain region. The maximum calculated excess annual dose due to use of the Y-11 road is 1 mrem or approximately half of the dose an individual would receive in making one cross-country airplane flight per year.

Table 4 Estimated Total Excess Dose Due to Use of the Y-11 Road

Type of Use	Direct Gamma Dose	Inhalation Dose	Total Dose
Commuter	0.2 mrem/yr	0.03 mrem/yr	0.2 mrem/yr
Hiker	0.4 mrem/yr	0.03 mrem/	0.4 mrem/yr
Biker	0.08 mrem/yr	0.007 mrem/yr	0.09 mrem/yr
Fisherman	0.9 mrem/yr	0.16 mrem/yr	1 mrem/yr

5.4 Estimated Risks from Use of the Y-11 Road

Assuming a risk coefficient of 7.6×10^{-7} per mrem and a total exposure duration of 30 years, (i.e., the individual hikes, commutes, or fishes in this area for 30 years), the estimated maximum lifetime risk of cancer incidence attributable to the elevated radionuclide concentration in the road is 2×10^{-5} for a fisherman; 5×10^{-6} for the commuter, 9×10^{-6} for the hiker, and 2×10^{-6} for the mountain biker. The risk coefficient for external radiation was derived from EPA Federal Guidance Report No. 12 (EPA 1993) and EPA Federal Guidance Report No. 13 (EPA 1998). These risks are within the EPA acceptable risk range of 1×10^{-4} to 1×10^{-6}.

5.5 Estimated Y-11 Road Doses in Perspective

The radiation risk assessment demonstrates that for users of the Y-11 road, the excess radiation doses, attributable to elevated concentrations of uranium and its decay products are likely to be less that 1 mrem per year. One mrem per year is:

- 1 percent of the allowable radiation dose to a member of the general public from an nuclear facility,
- less than 0.2 percent of the natural background doses people in the area receive,
- half of the radiation dose an airline passenger receives in traveling from Denver to New York and
- less than 20 percent of the dose received in a dental x-ray.

The excess radiation dose an individual might receive due to the elevated concentrations of uranium decay products along the Y-11 road are negligible and well within accepted limits.

6.0 REFERENCES

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RESPONSE TO CDPHE COMMENTS
AND ALARA ANALYSIS FOR
THE COUNTY ROAD Y-11, URAVAN, RISK ASSESSME

MAY 17, 2004

MFG

consulting
scientists and
engineers

RESPONSE TO CDPHE COMMENTS AND ALARA ANALYSIS FOR THE COUNTY ROAD Y-11, URAVAN, RISK ASSESSMENT

MAY 17, 2004

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1.0 INTRODUCTION

Montrose County Road Y-11 between State Highway 141 and 90 in Paradox, Colorado has been affected by historic uranium recovery operations at the Uravan site as indicated by elevated radiation exposure rates and Ra-226 concentrations observed during site surveys. The extent of the impact has been quantified and reported to the Colorado Department of Public Health and Environment (CDPHE) in several documents submitted to the agency over the past decade, including site characterization data and risk assessments.

The Risk Assessment for County Road Y-11, Uravan, Colorado (1998 Risk Assessment), prepared by Shepherd Miller, Inc. (SMI, 1998), demonstrated maximum reasonable projected doses to individual members of the public that did not exceed 2 mrem per year (SMI, 1998). The exposure scenarios and the results of the analyses are summarized in Section 2.0. The bases for the original exposure calculations are not repeated in this Addendum unless they were revised in response to CDPHE concerns.

In April 2003, the CDPHE conducted a review of the 1998 Risk Assessment and concluded the following:

- The risk assessment demonstrated that the risks from residual radioactive materials are less than the limits proscribed by the regulations.
- The risk assessment assumed all radionuclides are in equilibrium, however some of the data indicated that Th-230 concentrations are elevated relative to Ra-226 concentrations.
- Demonstration of a minor risk does not relieve Montrose County from future liability related to the tailings remaining in place along the road.
- Umetco must demonstrate that the no-action alternative is ALARA

The following sections of this Report were prepared to respond to the CDPHE concerns expressed in its April 29, 2003 letter to UMETCO Minerals Corporation.

2.0 RISK ASSESSMENT RESULTS

This Report is intended to respond to questions posed by CDPHE after its review of the 1998 Risk Assessment. The exposure scenarios used in the 1998 document were considered appropriate and were not changed. The CDPHE review of the risk assessment did not dispute the validity of the exposure scenarios or the parameters used in the risk assessment. The CDPHE review found a concern with the assumption of equilibrium among U-238 and its decay products. Therefore, the inhalation and ingestion doses were re-calculated without the assumption of equilibrium among all decay products. The available measurement data were used to develop ratios of Th-230 and U-nat to Ra-226.

2.1 Exposure Scenarios

The exposure scenarios postulated in the 1998 risk assessment were as follows:

- Commuter vehicle use
- Hiker/mountain biker using the road
- Fisherman on the bank of the San Miguel River adjacent to the road
- Road maintenance worker

The commuter vehicle use included only direct gamma dose. The road maintenance worker was assumed to ingest soil and to be exposed to airborne radionuclides including particulate matter and radon decay products. The 1998 Risk Assessment assumed the road maintenance worker would be exposed for two hours per year during routine maintenance. The hiker, biker, and fisherman were assumed to be exposed to airborne radionuclides, and except for the biker, were also assumed to ingest soil. In addition, the dose from ingestion of fish caught in the San Miguel River near the Y-11 Road was calculated for the fisherman. The estimated doses from the 1998 Risk Assessment are summarized below in Table 2.1.

Table 2.1 Original Estimated Potential Doses to Members of the Public

Scenario	Estimated Annual Dose Rate (mrem/y) By pathway			Total Dose Rate (mrem/y)
	Direct Gamma	Inhalation (part. + RnD)	Ingestion (soil, water, fish)	
Commuter	0.2	0	0	0.2
Road Worker	0.02	0.02	0.02	0.06
Hiker	0.3	0.07	0.2	0.6
Biker	0.06	0.01	0	0.07
Fisherman	0.9	0.2	0.6	1.7

2.2 Estimated Doses Recalculated Assuming Disequilibrium and 2001 ICRP Dose Coefficients

As noted in the CDPHE letter, the doses were initially calculated assuming equilibrium among the long-lived decay products of uranium, with the concentration of each decay product equal to the measured Ra-226 concentration. For this analysis, the borehole data presented in Table 3 of the 1998 Risk Assessment were used to obtain an average ratio of Th-230 and U-nat concentration to the Ra-226 concentration. The data for which isotopic analyses were available are given Table 2.2.

Table 2.2 Ratio of Th-230 and U-nat Concentrations to Ra-226 Concentration

Borehole	Depth feet)	Ra-226 pCi/g)	Th-230 pCi/g)	U-nat pCi/g)	Th-230/Ra-226	U-nat/Ra-226
B-12	0 – 0.5	34	163	116	4.79	3.41
B-12	1.0 – 1.5	98	104	82	1.06	0.84
B-13	0 – 0.5	61	111	184	1.82	3.02
B-13	0.5 – 1.0	8.8	6.4	17	0.73	1.93
B-15	0 – 0.5	6.4	5.6	12	0.88	1.88
B-15	1.0 – 1.5	7.6	7.2	17	0.95	2.24
B-16	0 – 0.5	57	82	116	1.44	2.04
B-16	1.0 – 1.5	7.8	9.7	22	1.24	2.82
B-16	1.5 – 2.0	7.8	9.7	22	1.24	2.82
B-18	1.0 – 1.5	674	698	1904	1.04	2.82
B-19	0 – 0.5	195	461	640	2.36	3.28
B-20	0 – 0.5	465	546	387	1.17	0.83
B-21	0 – 0.5	36	305	46	8.47	1.28
B-22	0 – 0.5	529	1940	2788	3.67	5.27
B-22	1.5 – 2.0	54	40	46	0.74	0.85
B-23	0 – 0.5	580	203	37	0.35	0.06
B-23	1.0 – 1.5	65	2040	340	31.38	5.23
B26	0 – 0.5	3.2	4.6	75	1.44	23.44
B-27	0 – 0.5	92	105	204	1.14	2.22
B-34	0 – 0.5	705	363	442	0.51	0.63
B-34	0.5 – 1.0	334	172	401	0.51	1.20
Average					**3.19**	**3.24**

The average ratio of Th-230 concentration to Ra-226 concentration is 3.19. The average ratio of U-nat concentration to Ra-226 concentration is 3.24. Since U-238 and U-234 are present at equal activity concentrations in nearly all soils and uranium ores, the average ratio of U-238 to Ra-226 would be half that value, or 1.62.

2.2.1 Dose Conversion Factors

The inhalation and ingestion doses were re-calculated using the Th-230 to Ra-226 and U-nat to Ra-226 average ratios for the data set. The most recent ICRP dose coefficients, given in Table 2.3, were used in the re-analysis. The original analysis used Federal Guidance No. 11 dose conversion factors. Based on the recommendations of the ICRP, a particle size of 5.0 micrometers AMAD was assumed for inhalation. The U and Th were assumed to be clearance class S (slow). Radium was assumed to be clearance class M (moderate). For the purpose of ingestion calculations, the ingestion dose coefficients for the most soluble forms listed in the ICRP Tables were used.

The direct gamma doses were based on actual measurements so need no adjustment for disequilibrium conditions.

Table 2.3 ICRP Dose Coefficients (ICRP 2001)

Nuclide	Clearance Class	Ingestion Dose Coeff. (Sv/Bq)	Inhalation Dose Coeff. (Sv/Bq)
U-238	S	4.4 E-8	5.7 E-6
Th-234 + Pa-234m	S	3.9 E-9	6.4 E-9
U-234	S	4.9 E-8	6.8 E-6
Total for U-238		9.7 E-8	1.3 E-5
U-235	S	4.6 E-8	6.1 E-6
Pa-231	S	7.1 E-7	1.7 E-5
Ac-227	S	1.1 E-6	4.7 E-5
Total for U-235		1.9 E-6	7.0 E-5
Th-230	S	2.1 E-7	7.6 E-6
Ra-226	M	2.8 E-7	2.2 E-6
Pb-210	F	6.8 E-7	1.1 E-6
Po-210	F	2.4 E-7	7.1 E-7
Total for Ra-226		1.2 E-6	4.0 E-6

2.2.2 Re-calculated Doses to Recreational Users of the Y-11 Road and Road Maintenance Workers

2.2.2.1 Inhalation Doses

The 1998 Risk Assessment assumed a total dust inhalation intake by a hiker of 2.5 mg based on an estimated dust concentration of 0.1 mg/m^3, breathing rate of 1.25 m^3/hour, and a total annual exposure time on the impacted portion of the road of 20 hours. As noted in the 1998 Risk Assessment, the average Ra-226 activity concentration in dust was estimated to be 19.4 pCi/g, based on all of the measurements made along the Y-11 Road. The total Ra-226 intake then would be as follows:

$$\text{Ra-226 intake} = 2.5\text{ E-3 g/y} \times 19.4\text{ pCi/g} \times 0.037\text{ Bq/pCi} = 1.8\text{ E-3Bq/y}$$

Assuming the Th-230 concentration is 3.19 times the Ra-226 concentration, the estimated inhalation intake of Th-230 would be as follows:

Th-230 intake = 1.8 E-3 Bq/y x 3.19 = 5.7 E-3 Bq/y

In the same manner, the U-238 intake would be equal to the ratio of U-238 to Ra-226 or 1.62 times 1.8 Bq/y which equals 2.9 E-3 Bq/y.

Using the dose conversion factors in Table 2.3, the following doses were calculated:

Ra-226 + decay products dose = 1.8 E-3 Bq/y x 4.0 E-6 Sv/Bq x 1 E5 mrem/Sv = 7.2 E-4 mrem/y

Th-230 dose = 5.7 E-3 Bq/y x 7.6 E-6 Sv/Bq x 1 E5 mrem/Sv = 4.3 E-3 mrem/y

U-238 + decay products dose = 2.9 E-3 Bq/y x 7.0 E-5 Sv/Bq x 1 E5 mrem/Sv = 2.0 E-2 mrem/y

The U-235 concentration was assumed to be equal to 4.5 percent of the U-238 concentration.

U-235 + decay products dose = 2.9 E-3 Bq/y x 0.045 x 7.0 E-5 Sv/Bq x 1 E-5 mrem/Sv = 9.1 E-4 mrem/y

Total annual inhalation dose for a hiker = 2.6 E-2 mrem/y

The exposure time for a mountain biker traveling over the impacted section of the Y-11 road was assumed to be 4 hours per year so the dose to that individual from dust inhalation would be a factor of five less than the estimated dose to a hiker based on his/her 20 hours per year exposure. Therefore, the estimated inhalation dose to a mountain biker was estimated to be 5.2 E-3 mrem/year.

A fisherman was assumed to be exposed for a period of 120 hours per year, or six times the exposure for a hiker. However, since he/she would be on the riverbank, the dust concentration from the impacted road was assumed to be half the concentration on the road. His/her annual inhalation dose was estimated to be 7.8 E-2 mrem.

The commuter was assumed to be in a closed vehicle with little or no exposure to dust.

The road maintenance worker performing routine work was assumed to be exposed to a dust concentration of 0.4 mg/m^3 based on average occupational dust levels. Where the 1998 Risk Assessment assumed the road worker would be exposed for two hours per year during routine maintenance, his/her exposure time was assumed to be approximately 10 hours per year for the revised calculations resulting in a total annual inhalation dose as follows:

Road worker dose = 2.6 E-2 mrem/y x 10 hours/20 hours x 0.4 mg/m^3/0.1 mg/m^3 = 5.2 E-2 mrem/y

2.2.2.2 Ingestion Dose to Hiker and Road Worker

The hiker using the road was assumed to ingest a total of 1.0 grams of soil per year based on an ingestion rate of 0.05 g/day, half of the average adult soil ingestion rate of 0.1 g/d, 20 days per year. The Ra-226 ingestion rate, based on the measured average Ra-226 soil concentration would be as follows:

Soil ingestion rate = 19.4 pCi/g x 1.0 g/y x 0.037 Bq/pCi = 7.2 E-1 Bq/y

Using the dose conversion factors in Table 2.3, the following soil ingestion doses were calculated:

Ra-226 + decay products dose = 7.2 E-1 Bq/y x 1.2 E-6 Sv/Bq x 1 E5 mrem/Sv = 8.6 E-2 mrem/y

The soil concentration for Th-230 was assumed to be a factor of 3.19 greater than the Ra-226 soil concentration based on isotopic analyses.

Th-230 dose = 7.2 E-1 Bq/y x 3.19 x 2.1 E-7 Sv/Bq x 1 E5 mrem/Sv = 4.8 E-1 mrem/y

The U-238 soil concentration was assumed to be a factor of 1.62 greater than the Ra-226 concentration based on the isotopic analyses.

U-238 + decay products dose = 7.2 E-1 Bq/y x 1.62 x 9.7 E-8 Sv/Bq x 1 E5 mrem/Sv = 1.1 E-2 mrem/y

The U-235 activity concentration is 4.5 percent of the U-238 concentration; therefore, the U-235 concentration was assumed to be a factor of 0.045 x 1.62 or 0.073 times the Ra-226 concentration.

U-235 + decay products dose = 7.2 E-1 Bq/y x 0.073 x 1.9 E-6 Sv/Bq x 1 E5 = 1.0 E-2 mrem/yr

The total estimated soil ingestion dose for the hiker is 5.9 E-1 mrem/y. The soil ingestion rate assumption is extremely conservative. A more reasonable value would be 10 percent of the average daily soil intake rather than 50 percent.

The biker was not considered to have significant soil exposure.

Assuming a road maintenance worker scrapes the road once per month for 12 months of the year and that he/she contacts soils from the impacted section of the road each time the road is scraped such that he/she ingests 10 percent of the average daily soil ingestion for adults, or 0.01 g/d, the total soil ingestion would be 0.12 g. The total Ra-226 ingestion would be as follows:

Ra-226 ingestion rate (Bq/y) = 0.12 g x 19.4 pCi/g x 0.037 Bq/pCi = 8.6 E-2 Bq/y

The estimated annual dose can be calculated by comparison to the dose to a hiker ingestion 0.72 Bq/y as follows:

Soil ingestion dose to road worker = [0.086 Bq/y/0.72 Bq/y] x 5.9 E-1 mrem/y = 7.0 E-2 mrem/y

2.2.2.3 Ingestion Dose to a Fisherman

The 1998 risk assessment assumed that a fisherman could receive a radiation dose from soil ingestion, water ingestion, and from ingestion of fish from the San Miguel River. Based on the conservative erosion calculations presented in the 1998 risk assessment, the estimated incremental Ra-226 concentration in the San Miguel River was 0.18 pCi/L. Assuming the other radionuclides would erode into the river at the same rate as the Ra-226, the incremental isotopic concentrations in the San Miguel River would be as shown in Table 2.4.

Table 2.4 Total Annual Radionuclide Ingestion for a Fisherman

Nuclide	Concentration Multiplier	Concentration in Water (pCi/L)	Bioaccumulation Factor(1) (L/kg)	Concentration in Fish(2) (pCi/kg)	Fish Ingestion(3) (pCi/y)	Total Ingestion(4) (Bq/y)
U-238	1.62	0.29	10	2.9	4.6	0.49
U-234	1.62	0.29	10	2.9	4.6	0.49
Th-230	3.19	0.57	100	57	91.2	4.0
Ra-226	1.00	0.18	50	9	14.4	0.73
Po-210	1.00	0.18	100	18	28.8	1.3
Pb-210	1.00	0.18	300	54	86.4	3.4
U-235	0.07	0.013	10	0.13	0.2	0.02
Pa-231	0.07	0.013	10	0.13	0.2	0.02
Ac-227	0.07	0.013	15	0.20	0.3	0.03

(1) Bioaccumulation factors were taken from the 1998 Risk Assessment
(2) The calculated concentration in fish is equal to the bioaccumulation factor multiplied by the concentration in water as described in the 1998 Risk Assessment
(3) Fish ingestion rate assumes an annual consumption of 1.6 kg/year as described in the 1998 Risk Assessment.
(4) Total ingestion includes fish ingestion and water ingestion at a rate of 1 L/day for 30 days/year converted to Bq.

The ingestion dose to a fisherman was calculated by multiplying the total ingestion for each nuclide by its dose coefficient as shown in Table 2.5.

Table 2.5 Estimated Annual Ingestion Dose to a Fisherman

Nuclide	Annual Intake (Bq)	Dose Coefficient (Sv/Bq)	Annual Dose (mrem/y)
U-238	0.49	4.4 E-8	2.2 E-3
U-234	0.49	4.9 E-8	2.4 E-3
Th-230	4.0	2.1 E-7	8.4 E-2
Ra-226	0.73	2.8 E-7	2.0 E-2
Pb-210	1.3	6.8 E-7	8.8 E-2
Po-210	3.4	2.4 E-7	8.2 E-2
U-235	0.02	4.8 E-8	<1 E-3
Pa-231	0.02	7.1 E-7	<1 E-3
Ac-227	0.03	1.1 E-6	3.3 E-3
Total Est. Dose			**2.8 E-1**

2.3 Summary of Potential Doses to Members of the Public from the Y-11 Road

The potential annual doses to members of the public from routine use and maintenance of the Y-11 road are summarized in Table 2.6. The estimated annual doses from direct gamma exposure are no different from the doses calculated in the 1998 risk assessment.

Table 2.6 Summary of Potential Doses to Members of the Public

Exposure Scenario	Estimated Annual Radiation Doses (mrem/y)				
	Ingestion	Inhalation		Direct Gamma[1]	Total
		Part.	RnD[2]		
Commuter	0.0	0.0	0.0	0.2	0.2
Road Worker	0.07	0.05	0.02	0.10	0.24
Hiker	0.59	0.03	0.03	0.3	0.95
Biker	0.0	0.005	0.006	0.06	0.07
Fisherman	0.28	0.08	0.10	0.9	1.36

(1) Direct gamma radiation doses were taken from the 1998 Risk Assessment with the exception that the road worker was assumed to spend 10 hours per year on routine maintenance

(2) Radon decay product doses taken from the 1998 Risk Assessment

2.4 Potential Doses from Rebuilding the Road or Excavating Contaminated Soil

The potential dose to a worker doing extensive work on the Y-11 Road was calculated assuming it takes 4 weeks (20 work days, 160 work hours). The direct gamma dose rate was taken from the 1998 Risk Assessment. The direct gamma exposure, inhalation and ingestion doses were assumed to be proportional to the doses calculated for routine maintenance of the road. The estimated dose from road construction would be as follows:

$$\text{Dose} = 0.24 \text{ mrem}/10 \text{ hours} \times 160 \text{ hours} = 3.8 \text{ mrem}$$

Assuming major road work is performed once every ten years, the pro-rated annual dose would be 0.38 mrem.

3.0 ALARA ANALYSIS

The U.S. Nuclear Regulatory Commission's (NRC) Office of Nuclear Material Safety and Safeguards (NMSS) published its guidance on ALARA demonstrations in September 2002 in a draft document, Consolidated NMSS Decommissioning Guidance, Characterization, Survey, and Determination of Radiological Criteria, Appendix N (NUREG-1757, Volume 2), Office of Nuclear Material Safety and Safeguards (NMSS). Previous guidance was published in Draft Regulatory Guide DG-4006. While Volume 1 of NUREG 1757 has been finalized, Volume 2 is still in draft form. However, the guidance in the document provides a reasonable method for demonstrating that a particular clean-up alternative, including the no-action alternative, results is ALARA.

The guidance provides direction in regard to balancing potential benefits with costs related to decommissioning. The table below, adapted from NUREG 1757 for this ALARA assessment, lists the costs and potential benefits applicable to the no-action alternative for the Y-11 Road.

Potential Benefits	Costs
Collective radiation dose averted	Remediation costs
Regulatory costs avoided	Additional occupational/public dose
Changes in land values	Occupational non-radiological risks
Esthetics	Public non-radiological risks
Reduction in public opposition	Transportation costs and risks
	Environmental and esthetic impacts
	Temporary loss of use of the road

3.1 Potential Benefits

The only potential benefit of excavating impacted soils from the Y-11 road is collective radiation dose averted. At the present time, it is not anticipated that there will be regulatory costs associated with a no-action alternative for the Y-11 Road, nor does there appear to be significant public opposition. Esthetics dictate that the road be left as it is since excavation of the impacted road sections would adversely affect the esthetic value, at least temporarily.

The calculations presented in the 1998 Risk Assessment and in Section 2 of this report demonstrate that the potential doses to individual members of the public are well below any regulatory limit. The collective dose averted was calculated using the method described in the Draft Volume 2 of NUREG 1757, adapted for the special case of the Y-11 Road, in order to demonstrate that leaving the material in place is consistent with the ALARA.

The total collective annual dose including all members of the public likely to be exposed to radiation from residual radionuclides exceeding background on the Y-11 road is given in Table 3.1 along with the assumptions used in the collective dose calculation.

Table 3.1 Collective Annual Dose to Members of the Public

Exposure Scenario	Estimated Individual Annual Dose (mrem/y)	Number of Individuals Exposed	Estimated Collective Annual Dose (person-rem)
Commuter	0.2	100	0.02
Road Worker engaged in routine maintenance	0.24	2	0.0004
Non-routine road maintenance over a ten year period	0.38	4	0.015
Hiker	0.95	100	0.095
Biker	0.07	100	0.007
Fisherman	1.36	10	0.014
Total Annual Collective Dose			0.15

NUREG 1757 provides an equation for determining the present worth of future collective dose averted.

$$PW(AD_{collective})=P_D \times A \times 0.025 \times F \times Conc./DCGL_w \times (1-e^{-(r+\lambda)N}/\ r+\lambda)$$

Where: P_D = population density
A = area
0.025 = dose
F = fraction of residual radioactivity removed
Conc. = average concentration of residual activity
$DCGL_w$ = Derived Concentration Guideline Level for an annual dose of 0.025 mrem
r = monetary discount rate in units per year = 0.07 for the first 100 years: 0.03 thereafter
λ = radiological decay constant
N = number of years over which the collective dose will be calculated = 1000 years

For the Y-11 road analysis, the equation can be simplified. The estimated annual collective dose for the Y-11 Road under existing conditions, calculated above, is equal to the product [P_D x A x 0.025 x Conc./$DCGL_w$] in the NUREG 1757 equation. The basis for collective dose averted in this analysis is that the road would be cleaned up to background so F is set equal to 1.0. The decay constant is very small compared to the monetary discount rate. Therefore, the above equation simplifies to the following:

$$PW(AD_{collective}) = (\text{annual collective dose}) \times (1.0) \times (1 - e^{-rN}/\ r)$$

$$PW(AD_{collective}) \text{ for years } 1 - 100 = (0.15 \text{ person-rem})(1.0)(1 - e^{-0.07\times100})/0.07 = 2.1 \text{ person-rem}$$

$$PW(AD_{collective}) \text{ for years } 100 - 1000 = (0.15 \text{ person-rem})(1.0)(1 - e^{-0.03\times900})/0.03 = 5.0 \text{ person-rem}$$

Total collective dose averted to year 1000 = 7.1 person-rem

The monetary value can be calculated using the equations provided in NUREG 1757:

$$B_{AD} = \$2000 \times PW(AD_{collective})$$

Where: B_{AD} = benefit from averted dose for a remediation action, in current US dollars

$$B_{AD} = \$2000 \times 7.1 \text{ person-rem} = \$14{,}200$$

3.2 Monetary Costs of Excavation of Impacted Material from the Y-11 Road

The estimated volume of soil that would need to be excavated to reduce the residual radionuclide concentrations along the Y-11 Road to background levels is approximately 12,000 cubic yards (9200 cubic meters) (Umetco, 2004). The cost of excavation and transport to a disposal cell is $15 per cubic yard based on Umetco's historic costs. The additional cost of replacing the excavated soil with clean fill would be an additional $15 per cubic yard (Umetco, 2004). In addition to the direct costs of excavation and replacement of soils, the cost for traffic control during construction and project management are expected to add 15 percent and 20 percent respectively to the direct costs associated with the project. Therefore, the total estimated monetary cost of remediation would be approximately $486,000. This is a factor of 35 greater than the estimated monetary benefit of reducing the collective exposure to members of the public to background levels. The estimated monetary cost of remediation exceeds by more than a factor of three the $20,000 per person-rem averted level that is considered to be prohibitively expensive, an unreasonable expenditure for dose reduction below the decommissioning standard, 0.25 mSv (0.025 rem) per year.

3.2.1 Additional Occupational/Public Dose

The estimated dose to a worker from excavation, monitoring, packaging, and handling soil was calculated assuming a total volume of 9200 cubic meters. NUREG 1757 (NRC 2002) estimates a time requirement of 1.62 person-hours per cubic meter of soil excavated and replaced. A more reasonable estimate for the Uravan site, based on Umetco experience would be 0.35 person-hours per cubic meter of soil. This activity could be completed during one calendar year and would require a crew of 10 individuals working for eight weeks (3200 person-hours). The total estimated dose per individual based on the doses calculated for the road maintenance scenario would be as follows:

$$\text{Dose} = [0.24 \text{ mrem}/10 \text{ hours}][9{,}200 \text{ m}^3 \times 0.35 \text{ person-hours/m}^3]/10 \text{ persons} = 7.8 \text{ mrem per worker.}$$

The total person rem for workers would be 0.078. Since it would be incurred during the year excavation takes place, no projection for future doses is necessary. The monetary detriment for this exposure was calculated as follows:

$$\text{Monetary cost} = 0.078 \text{ person-rem} \times \$2000/\text{person-rem} = \$156$$

No additional public radiation dose would be expected from remediation of the road.

3.2.2 Occupational Non-radiological Risks

The non-radiological occupational risks were calculated assuming a workplace accident rate of 4.2 E-8 per hour (NRC, 2002). The accident risk was calculated as follows:

$$\text{Risk} = 9{,}200 \text{ m}^3 \times 0.35 \text{ person-hours/m}^3 \times 4.2 \text{ E-8} = 1.3 \text{ E-4}$$

The monetary cost for that risk was estimated assuming the accident rate given in the NUREG 1757 represents a risk of fatality is \$3,000,000 x 1.3 E-3 or \$390.

3.2.3 Public Non-radiological Risks

The primary non-radiological risk to a member of the public is the extra car-miles needed to be driven by commuters while the road is being remediated. Assuming the following:

- 100 individuals use the road daily for commuting,
- the road is not usable for 60 days, and
- the extra commuting distance is 50 miles,

the total extra person–miles driven would be 300,000.

The 2002 fatality rate per 100 million vehicle miles of travel was 1.51; the injury rate, 103 (NCSA, 2003). Therefore, the total fatality risk would be as follows:

$$\text{Risk} = 300{,}000 \text{ vehicle miles} \times 1.51/1.0 \text{ E8 vehicle miles} = 4.5 \text{ E-3}$$
$$\text{Cost} = 4.5 \text{ E-3} \times \$3{,}000{,}000 \text{ per fatality} = \$13{,}600$$

The cost of injury was not calculated but would add significantly to the total monetary detriment.

In addition, the time required to detour 50 miles would exceed one hour per day per commuter for a total of nearly 6,000 person-hours.

3.2.4 Environmental and Esthetic Impacts

Excavation of impacted materials along the Y-11 Road would have a temporary detrimental effect on the wetlands adjacent to the San Miguel River. The cost of that detriment has not been included in this analysis.

3.2.5 Total Cost of Remediation

Table 3.2 Cost of Remediation

Factor	Cost
Monetary cost of remediation	$486,000
Occupational dose	$160
Non-radiological (accident) fatality risk	$400
Public non-radiological risk	$13,600
Total	**$502,000**
Value of total estimated averted person-rem	**$14,200**

4.0 SUMMARY

The calculated doses to hypothetical individual members of the public from the residual radioactivity above background on and along the Y-11 Road are all less than 10 percent of the decommissioning dose limit of 25 mrem/year. An ALARA analysis demonstrates that remediation is not required or advisable for this site. The estimated total cost of remediation is approximately 35 times the monetary benefit assuming a value of $2,000 per person-rem averted and is a factor of three greater than the $20,000 per person-rem considered prohibitively expensive.. In fact, the cost in terms of risk of fatality from using a detour during road construction is approximately the same as the calculated benefit of the dose averted.

Additional costs for remediation, including the cost of vehicle accident injuries, and environmental degradation, even though temporary, were not taken into account quantitatively in this analysis. Consideration of such other costs would increase the ratio of cost to benefit.

As noted previously, CDPHE reviewed the 1998 Risk Assessment in April 2003 and concluded based on the risk assessment that the potential doses to members of the public from residual radioactive materials in and along the Y-11 road are less than the limits proscribed by state regulations. However, in its letter dated April 29, 2003 CDPHE requested further information and analysis to demonstrate that the potential doses to members of the public would be ALARA under a no action alternative. Based on the calculations included in this Addendum to the 1998 Risk Assessment, the no-action alternative for the Y-11 Road is not only ALARA, but is the most protective of human health and the environment when all costs and risks are considered..

5.0 REFERENCES

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Umetco (Heck, J. and Schierman, M.). May 14, 2004. Personal Communication.

Appendix B

Cost Estimate Summary for Additional Remedial Actions

Appendix B - Cost Estimate Summary for Additional Remedial Actions

Uravan Alternative Soil Standards
Cost Estimate for Additional Remedial Actions

Area	Acres	Average Estimated Depth of Contamination (Feet)	Contaminanted Material Volume (Cubic Yards)	Cost Per Cubic Yard*	Total Removal Costs		Replacemet Volume	Cost Per Cubic Yard	Total Replacement Cost	Total Cost of Additional Remedial Actions	Engineering and QA/QC @ 15%	Grand Total
A-Plant North	2	3	9,680	$92.00	$890,560		0		$0	$890,560	$133,584	$1,024,144
River Ponds	10	3	48,400	$92.00	$4,452,800		0		$0	$4,452,800	$667,920	$5,120,720
Y-11	8.4	2	27,104	$92.00	$2,493,568		27,104	$16.00	$433,664	$2,927,232	$439,085	$3,366,317
Mill Hillside	22.8	0.75	27,588	$184.00	$5,076,192		18,392	$37.00	$680,504	$5,756,696	$863,504	$6,620,200

* Per unit costs Include excavation, transportation and disposal for estimated quantities of contaminanted materials

Appendix C

Water Quality Data, San Miguel River

Figure C-1 Total Dissolved Solids Data for the San Miguel River

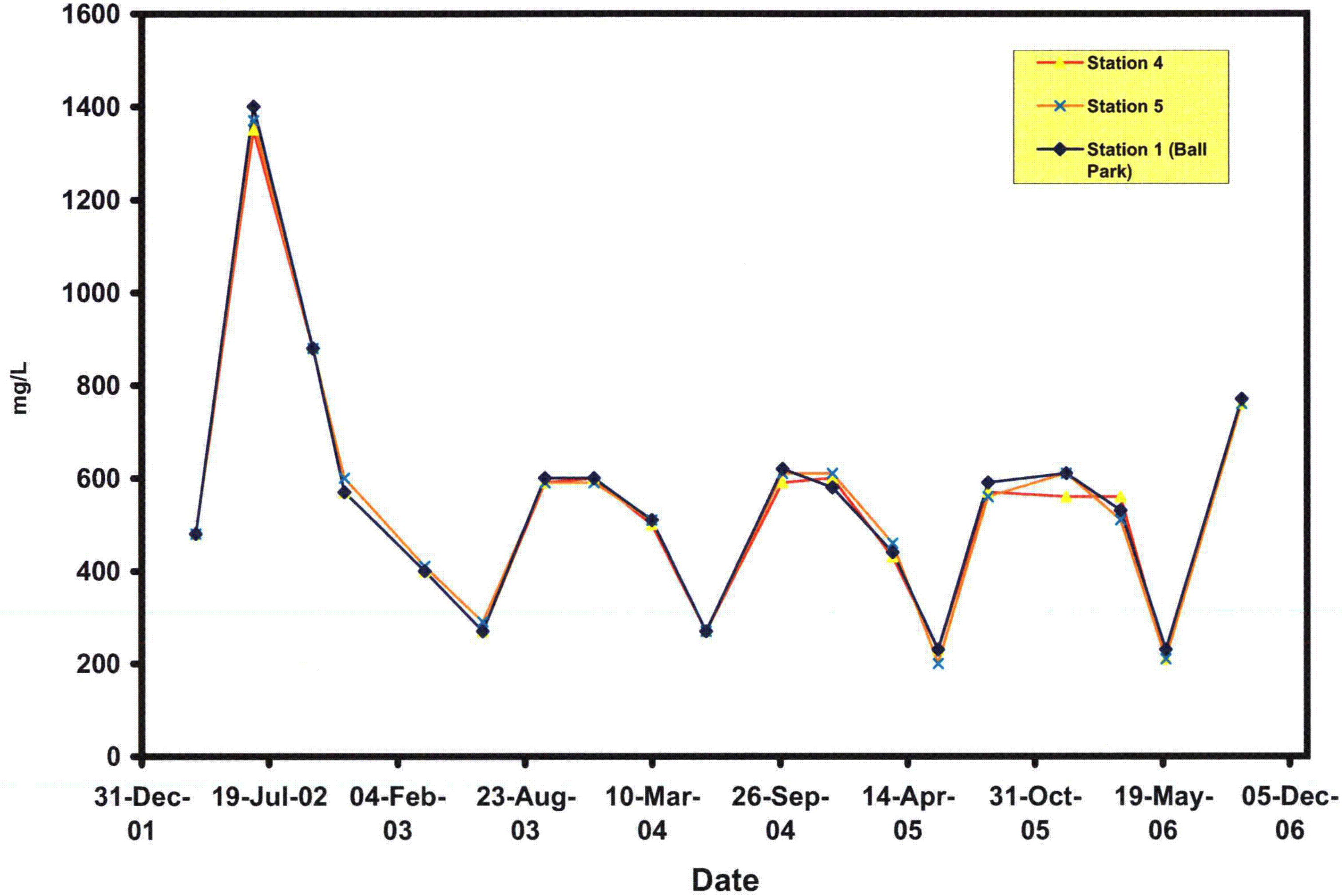


Figure C-2 Total Selenium Data for the San Miguel River

(Background Subtracted)

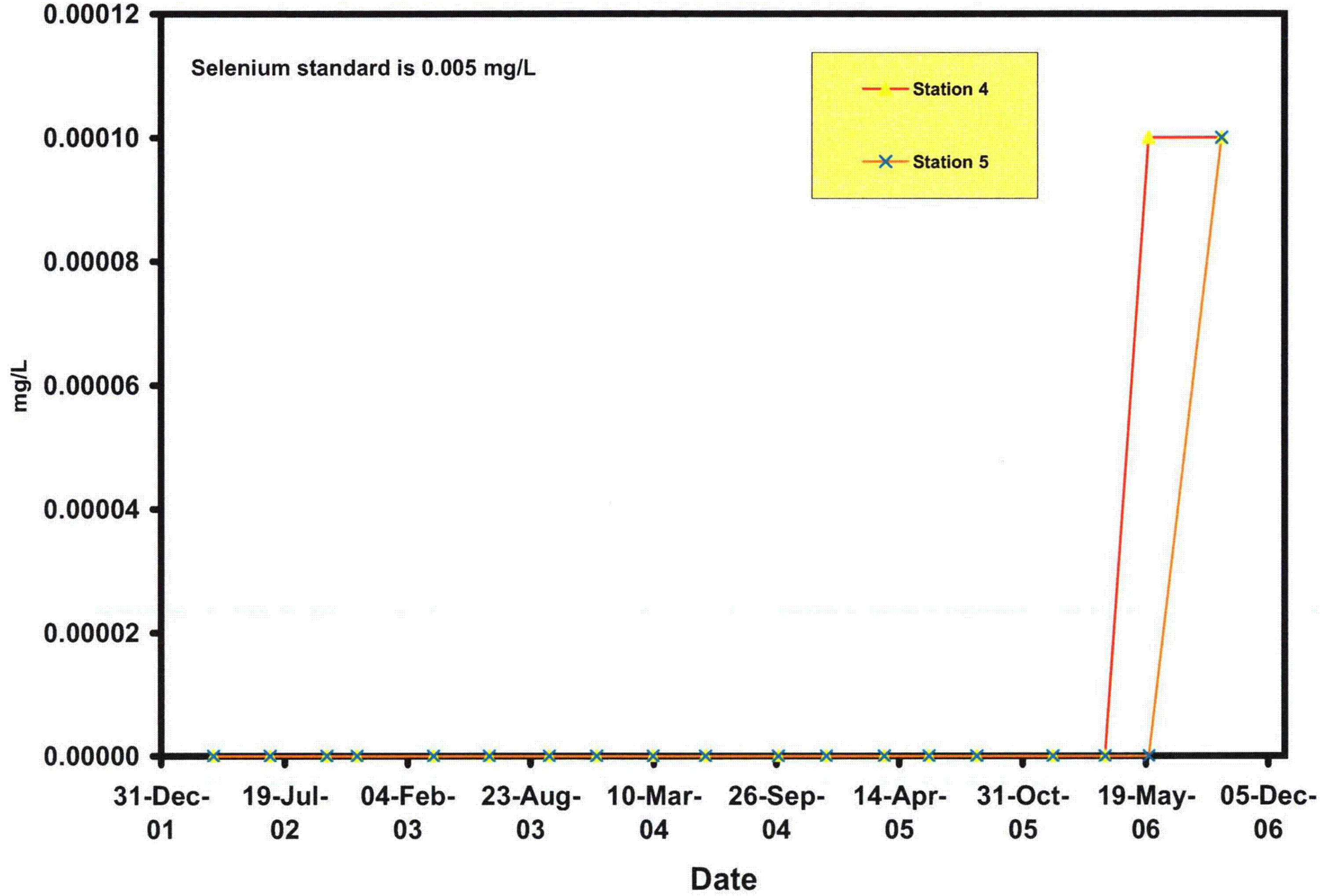


Figure C-3 Total Uranium Data for the San Miguel River
(Background Subtracted)

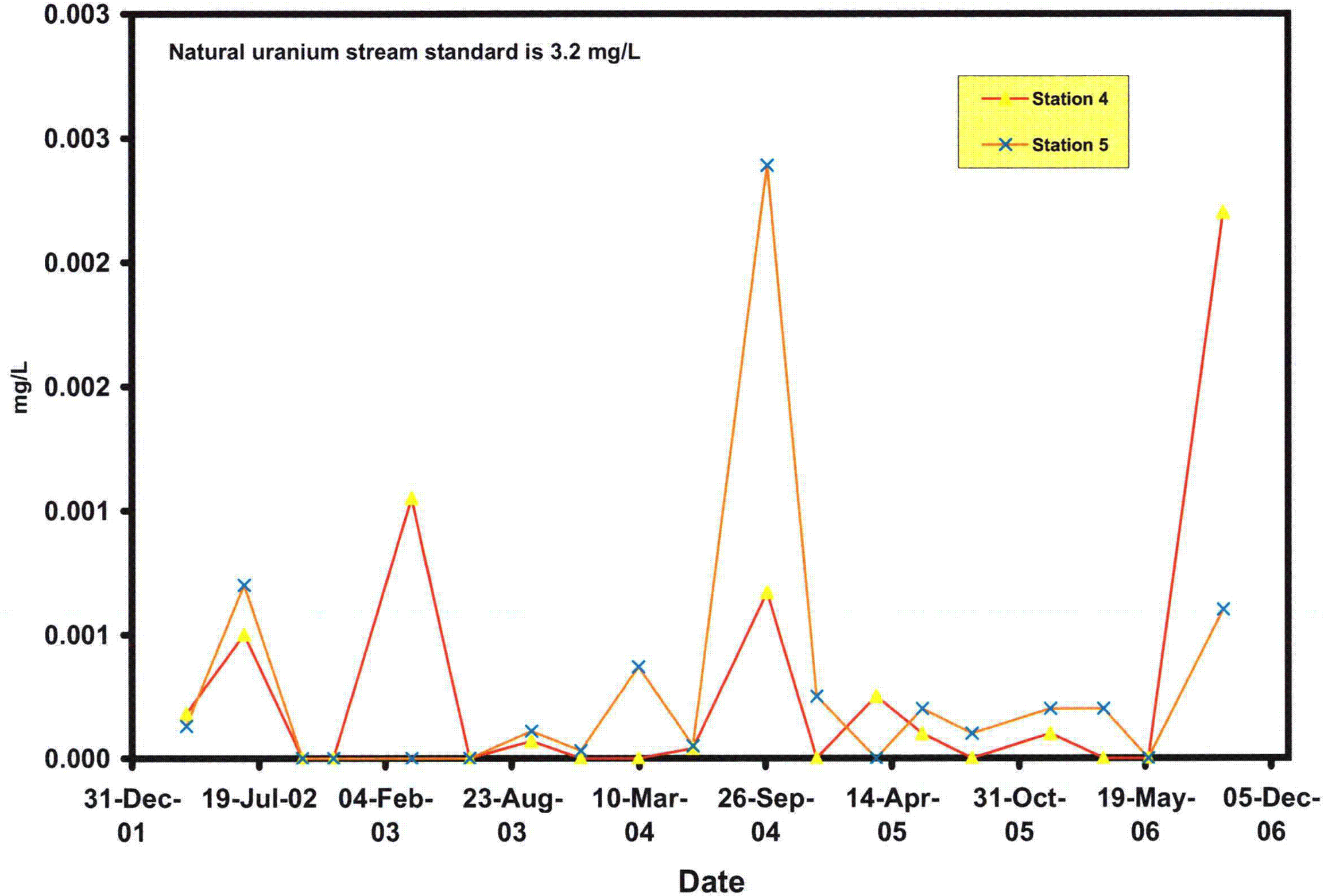
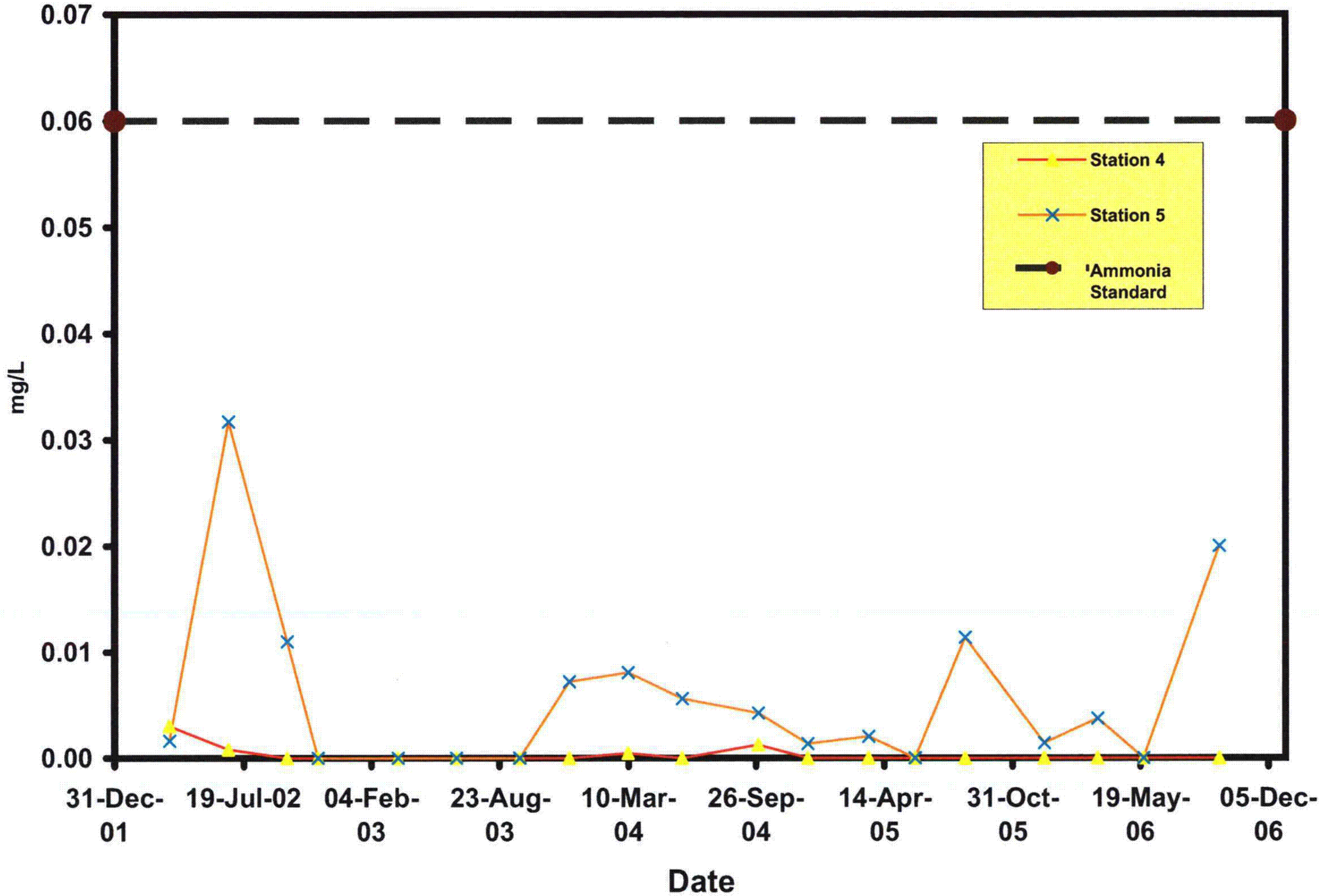


Figure C-4 Un-ionized Ammonia Data for the San Miguel River
(Background Subtracted) Un-ionized values calculated from the ammonium value



Appendix D

Legal Descriptions of Alternative Soil Standard Areas

Boundary descriptions for the Alternative Standards application areas are as follows:

RIVER PONDS AREA

A parcel of land situate in Section 34, Township 48 North, Range 17 West of the New Mexico Principal Meridian, in the County of Montrose, State of Colorado, said parcel of land being more particularly described as follows:

Commencing at a Bureau of Land Management alloy cap and pipe for the Northwest Corner of Section 34, Township 48 North, Range 17 West of the New Mexico Principal Meridian, from whence an alloy cap for the Southwest Corner of said Section 34 bears S00°10'16"W; thence S20°41'00"E a distance of 1992.09 feet to the Point of Beginning; thence S69°22'46"E a distance of 218.78 feet; thence S64°26'20"E a distance of 300.17 feet; thence S86°28'26"E a distance of 173.80 feet; thence S69°29'22"E a distance of 311.77 feet; thence S60°48'24"E a distance of 262.61 feet; thence S23°26'09"E a distance of 136.68 feet; thence S25°34'39"W a distance of 153.30 feet; thence S65°12'27"W a distance of 203.17 feet; thence N56°31'30"W a distance of 568.30 feet; thence N52°40'36"W a distance of 225.01 feet; thence N59°55'13"W a distance of 240.92 feet; thence N53°53'11"W a distance of 215.88 feet; thence N55°12'03"W a distance of 249.07 feet; thence S84°24'34"E a distance of 286.43 feet to the Point of Beginning. Said description contains 9.476 acres more or less.

HILLSIDE AREA

A parcel of land situate in Section 33 and Section 34, all in Township 48 North, Range 17 West of the New Mexico Principal Meridian, in the County of Montrose, State of Colorado, said parcel of land being more particularly described as follows:

Commencing at a Bureau of Land Management alloy cap and pipe for the Northwest Corner of Section 34, Township 48 North, Range 17 West of the New Mexico Principal Meridian, from whence an alloy cap for the Southwest Corner of said Section 34 bears S00°10'16"W; thence S09°50'49"W a distance of 2360.07 feet to the Point of Beginning; thence N37°15'31"E a distance of 562.15 feet; thence S43°10'56"E a distance of 136.88 feet; thence S11°42'27"W a distance of 171.62 feet; thence S46°18'31"E a distance of 729.99 feet; thence S63°00'00"E a distance of 80.00 feet; thence S54°41'41"E a distance of 413.81 feet; thence S41°00'00"E a distance of 318.00 feet; thence S22°27'58"E a distance of 139.58 feet; thence S28°52'36"W a distance of 491.00 feet; thence S47°54'25"W a distance of 120.45 feet; thence N87°25'08"W a distance of 394.09 feet; thence N37°31'07"E a distance of 354.83 feet; thence N33°02'32"W a distance of 490.65 feet; thence N43°44'07"W a distance of 426.43 feet; thence N54°38'27"W a distance of 278.09 feet; thence N70°20'47"W a distance of 403.77 feet; thence N24°38'56"E a distance of 181.02 feet to the Point of Beginning. Said description contains 22.829 acres more or less.

PLANT AREA

A parcel of land situate in the Southeast 1/4 of Section 28 and the Northeast 1/4 of Section 33, all in Township 48 North, Range 17 West of the New Mexico Principal Meridian, in the County of Montrose, State of Colorado, said parcel of land being more particularly described as follows:

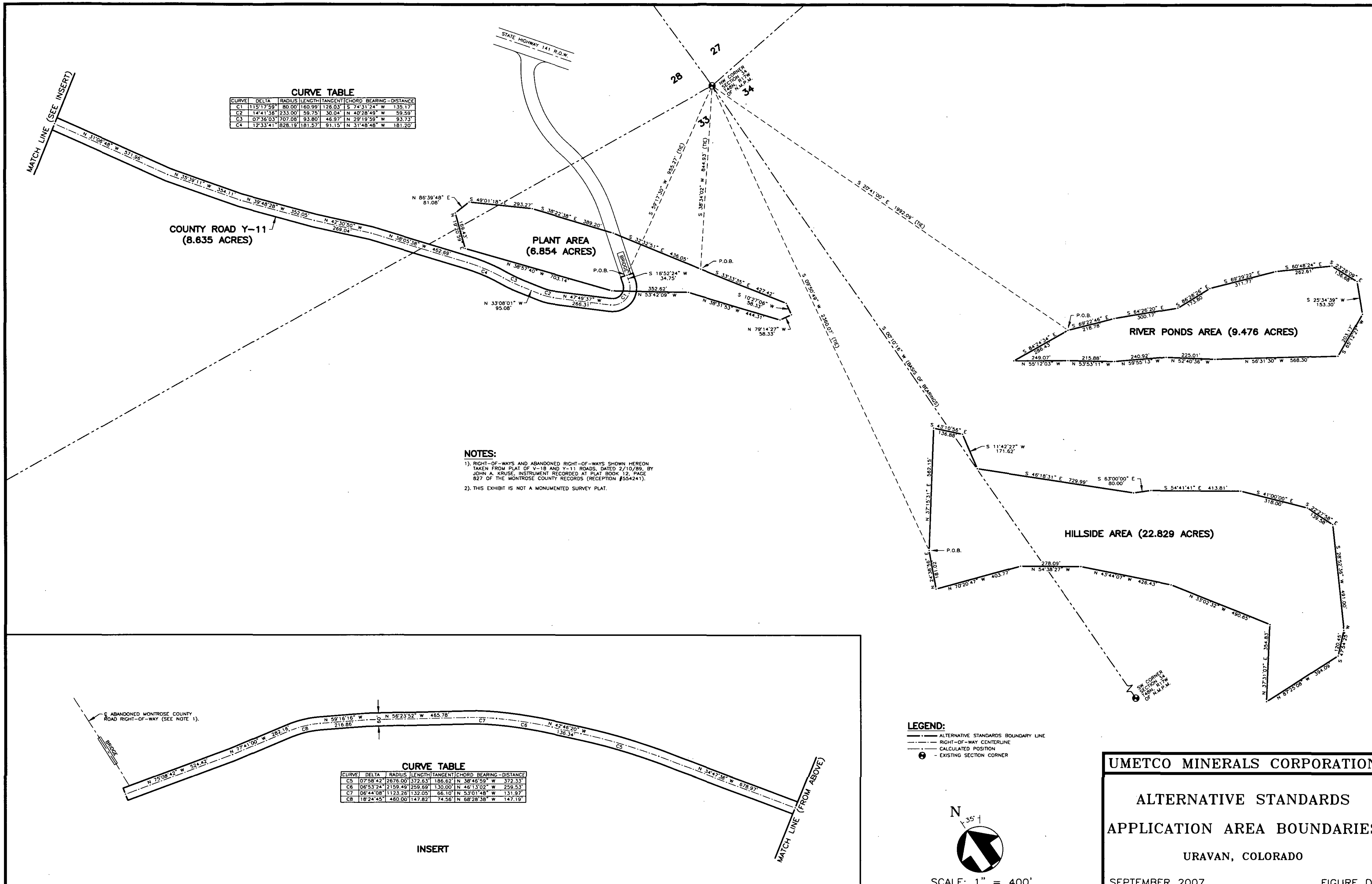
Commencing at a Bureau of Land Management alloy cap and pipe for the Northwest Corner of Section 34, Township 48 North, Range 17 West of the New Mexico Principal Meridian, from whence an alloy cap for the Southwest Corner of said Section 34 bears S00°10'16"W; thence S38°34'02"W a distance of 844.93 feet to the Point of Beginning; thence S33°33'35"E a distance of 427.42 feet; thence S10°27'06"W a distance of 58.33 feet; thence N79°14'27"W a distance of 58.33 feet; thence N38°31'53"W a distance of 444.31 feet; thence N53°42'09"W a distance of 352.62 feet; thence N38°57'40"W a distance of 703.14 feet; thence N19°20'59"E a distance of 169.43 feet; thence N86°39'48"E a distance of 81.08 feet; thence S49°01'18"E a distance of 293.27 feet; thence S38°22'38"E a distance of 389.20 feet; thence S32°32'51"E a distance of 436.05 feet to the Point of Beginning. Said description contains 6.854 acres more or less.

COUNTY ROAD Y-11

A strip of land 60 feet wide situate in Section 28 and the Northeast 1/4 of Section 33, all in Township 48 North, Range 17 West of the New Mexico Principal Meridian, in the County of Montrose, State of Colorado, said strip of land having been located by a map of survey for V-18 and Y-11 Roads prepared by John Kruse, Montrose County Surveyor and recorded in Book 12 at Page 827 in the office of the Montrose County Clerk and Recorder, the centerline of said strip of land being more particularly described as follows:

Commencing at a Bureau of Land Management alloy cap and pipe for the Northwest Corner of Section 34, Township 48 North, Range 17 West of the New Mexico Principal Meridian, from whence an alloy cap for the Southwest Corner of said Section 34 bears S00°10'16"W; thence S59°17'30"W a distance of 955.27 feet to a point on the south end of the bridge crossing the San Miguel River, said point also being on the centerline of Montrose County Road V-18 and the Point of Beginning; thence S16°52'24"W a distance of 34.75 feet to a point of curvature; thence 160.99 feet along the arc of an 80.00 foot radius curve to the right (the central angle of which is 115°17'59" and the chord of which bears S74°31'24"W a distance of 135.17 feet); thence N47°49'37"W a distance of 266.31 feet to a point of curvature; thence 59.75 feet along the arc of a 233.00 foot radius curve to the right (the central angle of which is 14°41'36" and the chord of which bears N40°28'49"W a distance of 59.59 feet); thence N33°08'01"W a distance of 95.08 feet to a point of curvature; thence 93.80 feet along the arc of a 707.08 foot radius curve to the right (the central angle of which is 07°36'03" an a chord of which bears N29°19'59"W a distance of 93.73 feet); thence 181.57 feet along the arc of a 828.19 foot radius curve to the left (the central angle of which is 12°33'41" and a chord of which bears N31°48'48"W a distance of 181.20 feet); thence

N38°05'38"W a distance of 462.69 feet; thence N42°30'50"W a distance of 269.04 feet; thence N39°48'28"W a distance of 352.05 feet; thence N35°39'11"W a distance of 354.11 feet; thence N31°06'48"W a distance of 571.96 feet; thence N34°47'38"W a distance of 678.97 feet to a point of curvature; thence 372.63 feet along the arc of a 2676.00 foot radius curve to the left (the central angle of which is 07°58'42" and the chord of which bears N38°46'59"W a distance of 372.33 feet); thence N42°46'20"W a distance of 136.34 feet to a point of curvature; thence 259.69 feet along the arc of a 2159.49 foot radius curve to the left (the central angle of which is 06°53'24" and the chord of which bears N46°13'02"W a distance of 259.53 feet); thence 132.05 feet along the arc of a 1123.26 foot radius curve to the left (the central angle of which is 06°44'08" and the chord of which bears N53°01'48"W a distance of 131.97 feet); thence N56°23'52"W a distance of 465.78 feet; thence N59°16'16"W a distance of 216.86 feet to a point of curvature; thence 147.82 feet along the arc of a 460.00 foot radius curve to the left (the central angle of which is 18°24'45" and the chord of which bears N68°28'38"W a distance of 147.19 feet); thence N77°41'00"W a distance of 282.16 feet; thence N75°08'42"W a distance of 524.42 feet to the end of said 60 foot wide strip of land. Said description contains 8.635 acres more or less.



CURVE TABLE

CURVE	DELTA	RADIUS	LENGTH	TANGENT	CHORD BEARING-DISTANCE
C1	115°17'59"	80.00'	160.99'	126.03'	S 74°31'24" W 135.17'
C2	14°41'36"	233.00'	59.75'	30.04'	N 40°28'49" W 59.59'
C3	07°36'03"	707.08'	93.80'	46.97'	N 29°19'59" W 93.73'
C4	12°33'41"	828.19'	181.57'	91.15'	N 31°48'48" W 181.20'

NOTES:

1). RIGHT-OF-WAYS AND ABANDONED RIGHT-OF-WAYS SHOWN HEREON TAKEN FROM PLAT OF V-18 AND Y-11 ROADS, DATED 2/10/89, BY JOHN A. KRUSE, INSTRUMENT RECORDED AT PLAT BOOK 12, PAGE 827 OF THE MONTROSE COUNTY RECORDS (RECEPTION #554241).

2). THIS EXHIBIT IS NOT A MONUMENTED SURVEY PLAT.

CURVE TABLE

CURVE	DELTA	RADIUS	LENGTH	TANGENT	CHORD BEARING-DISTANCE
C5	07°58'42"	2676.00'	372.63'	186.62'	N 38°46'59" W 372.33'
C6	06°53'24"	2159.49'	259.69'	130.00'	N 46°13'02" W 259.53'
C7	06°44'08"	1123.26'	132.05'	66.10'	N 53°01'48" W 131.97'
C8	18°24'45"	460.00'	147.82'	74.56'	N 68°28'38" W 147.19'

LEGEND:

- ALTERNATIVE STANDARDS BOUNDARY LINE
- RIGHT-OF-WAY CENTERLINE
- CALCULATED POSITION
- EXISTING SECTION CORNER

SCALE: 1" = 400'

UMETCO MINERALS CORPORATION

ALTERNATIVE STANDARDS APPLICATION AREA BOUNDARIES

URAVAN, COLORADO

SEPTEMBER 2007

FIGURE D1

ALT-STAN-BOUND.DWG

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
http://www.epa.gov/region08

September 26, 2007

Mr. Rahe Junge
Umetco Minerals Corporation
P.O. Box 1029
Grand Junction, Colorado 81502

Re: Uravan Superfund Site
Alternative Soil Standards Application

Dear Rahe:

Thank you for the opportunity to review and comment upon the Alternative Soils Standards Application for the Uravan Remedial Action Project. We have received the final Alternative Soil Standards Application, submitted September 18, 2007, and we concur that the application of alternative soil standards is appropriate for the four specific areas identified in the document.

We understand that you intend to submit the application, incorporating this concurrence letter, to the Nuclear Regulatory Commission, for their approval. We look forward to moving this remediation project nearer completion.

Sincerely,

Rebecca J. Thomas

Rebecca J. Thomas
Project Manager

Bill Ritter, Jr., Governor
James B. Martin, Executive Director

Dedicated to protecting and improving the health and environment of the people of Colorado

4300 Cherry Creek Dr. S.
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Laboratory Services Division
8100 Lowry Blvd.
Denver, Colorado 80230-6928
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http://www.cdphe.state.co.us

Colorado Department of Public Health and Environment

September 26, 2007

Umetco Minerals Corporation
2754 Compass Drive, Suite 280
Grand Junction, Colorado 81506
Attention: Rahe Junge, Project Manager

Re: Uravan RML 660-02: Acceptance of the *Alternative Soil Standards Application*

Dear Mr. Junge:

The Colorado Department of Public Health and Environment received the *Alternative Soil Standards Application, Uravan, Colorado* dated September 2007. This application addressed elevated residual radioactive soils in Uravan at the Mill Hillside, A-Plant North, the River Ponds Area and County Road Y-11. CDPHE staff has reviewed the final application after commenting on drafts of the report. Umetco has fully addressed comments by CDPHE and EPA and incorporated responses to these comments into the final report.

Previous remedial activities conducted in the Mill Hillside, A-Plant North, River Ponds and County Road Y-11 areas reduced exposures to as low as reasonably achievable (ALARA) and minimized future radiological exposures to humans. The Colorado Department of Public Health and Environment finds that the proposed alternative soil standards do not pose a future heath risk and are fully protective of human health and the environment. The *Alternative Soil Standards Application* is complete and is acceptable as written.

Sincerely,

Philip S. Stoffey

Philip S. Stoffey
Uravan On-site Coordinator
Remediation Management Program
Hazardous Materials and Waste Management Division
Colorado Department of Public health and Environment

File copy: 660-02, file 3.2
cc: Judge Richard Dana, Special Master
Rebecca Thomas, EPA
Tom Pauling, DOE