United States Department of Energy

Remedial Action Plan and Site Conceptual Design for Stabilization of the Inactive Uranium Mill Tailings Site at Ambrosia Lake, New Mexico

Final

Volume I: Text; Appendices A, B, and C

**Appendix B of the
Cooperative Agreement
No. DE-FC04-85AL20533**

November 1991

Uranium Mill Tailings Remedial Action Project

MASTER

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U.S. Department of Energy
Agreement No. DE-FC04-85AL20533
Appendix B, Remedial Action Plan
for Ambrosia Lake, New Mexico

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REMEDIAL ACTION PLAN

AND

SITE DESIGN FOR STABILIZATION

OF THE

INACTIVE URANIUM MILL TAILINGS SITE

AT

AMBROSIA LAKE, NEW MEXICO

FINAL

APPENDIX B

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1.0 INTRODUCTION

1.1 PURPOSE

This Remedial Action Plan (RAP) has been developed to serve a dual purpose. It presents the series of activities that is proposed by the U.S. Department of Energy (DOE) to stabilize and control radioactive materials at the inactive Phillips/United Nuclear uranium processing site designated as the Ambrosia Lake site in McKinley County, New Mexico. It also serves to document the concurrence of both the State of New Mexico and the U.S. Nuclear Regulatory Commission (NRC) in the remedial action. This agreement, upon execution by the DOE and the state and concurrence by NRC, becomes Appendix B of the Cooperative Agreement.

1.2 RESPONSIBILITIES

In 1978, Congress passed Public Law 95-604 (PL95-604), the Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978, expressly finding "that uranium mill tailings located at active and inactive mill operations may pose a potential and significant radiation health hazard to the public" Title I to the UMTRCA identified sites to be designated for remedial action. On November 9, 1979, Ambrosia Lake was designated as one of those sites.

The UMTRCA charged the U.S. Environmental Protection Agency (EPA) with the responsibility for promulgating remedial action standards for inactive mill sites. The purpose of the standards is to protect public health and safety and the environment from radiological and nonradiological hazards associated with radioactive materials at the inactive sites. The final EPA standards were promulgated January 5, 1983 (48 FR 590), with an effective date of March 7, 1983.

The DOE has been commissioned to select and execute a plan of remedial action that will satisfy the EPA standards and other applicable Federal and state laws. On September 11, 1985, the DOE and the State of New Mexico entered into a cooperative agreement for remedial action at the Ambrosia Lake site. The Federal government will fund 90 percent and the state will fund 10 percent of allowable costs.

All remedial actions must be selected and performed with the concurrence of the NRC. In conformance with the UMTRCA, the required NRC concurrence with the selection and performance of proposed remedial actions, and the licensing of long-term surveillance and maintenance of disposal sites, will be to ensure compliance with the standards established by the EPA. The RAP constitutes the initial document in the licensing process. A more detailed listing of the responsibilities of the project participants is included in Section 7.0 of this report.

1.3 SCOPE AND CONTENT

This document has been structured to provide a comprehensive understanding of the remedial action proposed for the Ambrosia Lake site. It

includes both criteria and the detailed construction design for the remedial action. An extensive amount of data and supporting information has been generated for this RAP. Pertinent information and data are included in the RAP with references given to the numerous supporting documents.

Attached as part of the RAP are appendices which describe in more detail various important aspects of the remedial action.

Appendix A, Regulatory Compliance, describes in detail the permits necessary for the remedial action and the process for mitigating impacts to archaeological resources.

Appendix B, Engineering Design, which had been included in Appendix B of the draft RAP, has been superseded by the subcontract specifications, special conditions, and drawings for subcontract AMB-04 (main site construction) in Appendix F.

Appendix C, Radiological Support Plan, describes the procedures used to characterize the existing radiological conditions at the site, and the procedures to be used to control and verify the results of remedial action.

Appendix D, Site Characterization, describes site geological, geotechnical, hydrological, meteorological, and seismic conditions which affect the design.

Appendix E, Groundwater Protection Strategy, contains the approach and technical discussion of how the stabilized tailings will comply with the EPA groundwater protection standards. The supplemental standards demonstration is included as Attachment A to Appendix E.

Appendix F, Subcontract Documents, contains the final design specifications and drawings.

1.4 COLLATERAL DOCUMENTS

A collateral document for this site is the Environmental Assessment (EA) (DOE, 1987), which contains many of the existing site conditions, the proposed action and alternatives, and the environmental impacts of the proposed action.

The Uranium Mill Tailings Remedial Action (UMTRA) Project staff has prepared the Technical Approach Document (DOE, 1989a) which addresses general Project guidelines on the operating procedures, specifications, calculations, schedule and cost estimates, and design constraints to be incorporated in the final design documents. This general guidance, in conjunction with the RAP, serves as the basis or guideline for preparation of the final design documentation for the UMTRA Project sites. It is further intended to provide sufficient criteria for the reader to understand the constraints, procedures, codes, and standards to be used during the design and performance of the remedial actions at the UMTRA Project sites.

Copies of all referenced documents, supporting data, calculations, and design drawings are on file in the U.S. Department of Energy UMTRA Project Office in Albuquerque, New Mexico.

2.0 EPA STANDARDS

2.1 GENERAL

The requirements and considerations for long-term isolation and stabilization of tailings, radon control, cleanup of land and buildings, and protection of water quality have been published in the Plan for Implementing EPA Standards for UMTRA Sites (DOE, 1984). That document was used as a guide in the development of this RAP. The following discussion has been extracted from the above-referenced document.

Pursuant to the requirements of the UMTRCA, the EPA promulgated health and environmental standards to govern cleanup, stabilization, and control of residual radioactive materials at inactive uranium mill tailings sites. The promulgated standards establish requirements for long-term stability and radiation protection and provide procedures for ensuring the protection of groundwater quality.

In developing the standards, the EPA determined "that a primary objective for control of tailings should be isolation and stabilization to prevent their misuse by man and dispersal by natural forces such as wind, rain, and flood waters" and that "a second objective should be to reduce radon emissions from tailings piles." A third objective should be "the elimination of significant exposure to gamma radiation from tailings piles" (from 48 FR 594, preamble to Standards for Remedial Action at inactive Uranium Processing Sites, 40 CFR 192.) These objections were based on a determination that the most significant public health risks associated with inactive tailings were posed by exposure to people living and working in structures contaminated by relocated tailings. The EPA further concluded that the potential for groundwater and surface-water contamination should be evaluated on a site-specific basis.

On September 3, 1985, the U.S. Tenth Circuit Court of Appeals remanded the groundwater standards, 40 CFR 192.2(a)(2)-(3). The EPA issued proposed groundwater protection standards for comment on September 24, 1987. Section 2.4, Water-Quality Protection, discusses the DOE plan for implementing the proposed standards until final standards are issued.

The EPA standards are discussed in the following paragraphs and are summarized in Table 2.1.

2.2 LONG-TERM STABILITY

Isolation and stabilization of tailings in order to prevent misuse by man and dispersion by natural forces is the primary objective of the EPA Standards. Accordingly, long-term stability was emphasized in the development and promulgation of the standards. This is consistent with the guidance provided by the legislative history of the UMTRCA, which stresses the importance of avoiding remedial actions which would be effective for only a short period of time and which would require future Congressional consideration.

PART 192 - HEALTH AND ENVIRONMENTAL PROTECTION STANDARDS FOR URANIUM MILL TAILINGS

SUBPART A - Standards for the Control of Residual Radioactive Materials from Inactive Processing Sites

192.02 Standards

Control shall be designed to:

- (a) Be effective for up to one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years, and,
- (b) Provide reasonable assurance that releases of radon-222 from residual radioactive material to the atmosphere will not:
 - (1) Exceed an average release rate of 20 picocuries per square meter per second, or
 - (2) Increase the annual average concentration of radon-222 in air at or above any location outside the disposal site by more than one-half picocurie per liter.

SUBPART B - Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites

192.12 Standards

Remedial actions shall be conducted so as to provide reasonable assurance that, as a result of residual radioactive materials from any designated processing site:

- (a) The concentration of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than -
 - (1) 5 pCi/g, averaged over the first 15 cm of soil below the surface, and
 - (2) 15 pCi/g, averaged over 15 cm thick layers of soil more than 15 cm below the surface.
- (b) In any occupied or habitable building -
 - (1) The objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 W_L. In any case, the radon decay product concentration (including background) shall not exceed 0.03 W_L, and
 - (2) The level of gamma radiation shall not exceed the background level by more than 20 microroentgens per hour.

SUBPART C - Implementation (condensed)

192.20 Guidance for Implementation

Remedial action will be performed with the "concurrence of the Nuclear Regulatory Commission and the full participation of any state that pays part of the cost" and in consultation as appropriate with other government agencies.

192.21 Criteria for Applying Supplemental Standards

The implementing agencies may apply standards in lieu of the standards of Subparts A or B if certain circumstances exist, as defined in 192.21.

192.22 Supplemental Standards

"Federal agencies implementing Subparts A and B may in lieu thereof proceed pursuant to this section with respect to generic or individual situations meeting the eligibility requirements of 192.21."

- (a) "...the implementing agencies shall select and perform remedial actions that come as close to meeting the otherwise applicable standards as is reasonable under the circumstances."
- (b) "...remedial actions shall, in addition to satisfying the standards of Subparts A and B, reduce other residual radioactivity to levels that are as low as is reasonably achievable."
- (c) "The implementing agencies may make general determinations concerning remedial actions under this Section that will apply to all locations with specified characteristics, or they may make a determination for a specific location. When remedial actions are proposed under this Section for a specific location, the Department of Energy shall inform any private owners and occupants of the affected location and solicit their comments. The Department of Energy shall provide any such comments to the other implementing agencies [and] shall also periodically inform the Environmental Protection Agency of both general and individual determinations under the provisions of this section."

Ref: Federal Register, Volume 48, No. 3, January 5, 1983, 40 CFR Part 192.

TABLE 2.1 EPA STANDARDS

The EPA standard-setting process distinguished "passive controls," such as thick earthen covers, below-ground disposal, rock covers, and massive earth and rock dikes, from "active controls," such as semipermanent covers, fences, warning signs, and restrictions on land use. Active controls could be expected to need frequent replacement or other major repairs requiring the ongoing appropriation and expenditure of public funds. In setting the standards, the EPA called for designs which rely primarily on passive controls.

The EPA performance standard is framed as a longevity requirement that recognizes the difficulty in predicting very long-term performance with a very high degree of confidence. In establishing the longevity requirement, the EPA concluded that existing knowledge permits the design of control systems that have a good expectation of lasting at least 1000 years. Therefore, a design objective of 1000 years was established to be satisfied whenever reasonably achievable, but in any case a minimum performance period of 200 years must be achieved.

The standard recognizes the need for institutional controls such as custodial maintenance, monitoring, and contingency response measures. In the preamble to the standards, the EPA calls for such controls to be provided as an essential backup to the primary, passive controls.

2.3 RADON EMISSIONS CONTROL

The EPA identified a reduction of radon emissions from tailings piles as the second objective in its standards for the control of tailings. In developing the standards, it considered several alternative approaches and selected an emission limitation as the primary form of the standard. In addition, it established a concentration limit as an alternative form of the standard for use in cases where the DOE determines that the alternative was appropriate.

In establishing the emission limitation for tailings piles, the EPA sought to reduce both the maximum risk to individuals living very near to the sites and the risk to the population as a whole. With regard to individuals very near to disposal sites, the EPA estimates that exposure to radon emissions will be reduced by more than 96 percent. The radon standard of 20 picocuries per square meter per second ($\text{pCi}/\text{m}^2\text{s}$) on the disposal site or 0.5 picocuries per liter (pCi/l) outside the disposal site will limit the increase in radon concentration attributable to a pile to a small increase above the background radon level near the disposal site. Both standards are design standards with compliance to be determined on the basis of predicted rather than measured emission rates and concentrations. The EPA states that "post-remediation monitoring will not be required to show compliance, but may serve a useful role in determining whether the anticipated performance of the control system is achieved" (from 48 CFR 601, preamble to Standards for Remedial Actions at Inactive Uranium Processing Sites, 40 CFR 192). In establishing the radon standard, the EPA determined that the emission limitation could be achieved by well-designed thick earthen covers and that such control techniques would be compatible with the requirements of the EPA longevity standard.

2.4 WATER-QUALITY PROTECTION

The EPA reviewed available water-quality data from inactive tailings sites and determined that there was little evidence of recent movement of contaminants into groundwater. They also determined that any degradation of groundwater quality should be evaluated in the context of potential beneficial uses of the groundwater as determined by background water quality and the available quantity of groundwater.

Rather than establish specific numerical limitations for contaminant discharges or groundwater quality, the EPA determined that the most appropriate course of action would be to require site-specific analyses of potential future contaminant discharge and a case-by-case evaluation of the significance of such a discharge. The implementation guidelines for the EPA standards call for adequate hydrological surveys at each site to be a basis for determining whether specific water-protection measures should be applied.

Specific site assessments must include monitoring programs sufficient to establish background groundwater quality through one or more upgradient wells and to identify the present movement and extent of contaminant plumes associated with the tailings piles. The water protection standards further call for judgments of the need for restoration or prevention, or both, to be guided by the EPA's hazardous waste management system and relevant state and Federal water-quality criteria. Decisions on specific actions to protect or restore water quality are to be guided by such factors as the technical feasibility of improving the aquifer, the cost of applicable restorative or protective programs, the present and future value of the aquifer as a water source, the availability of alternative water supplies, and the degree to which human exposure is likely to occur.

The UMTRCA (PL95-604, Section 206) requires that the standards promulgated by the EPA "to the maximum extent practicable, be consistent with the requirements of the Solid Waste Disposal Act, as amended." In setting the standard, the EPA determined that the statutory requirement for the NRC to concur with the selection and performance of remedial actions and to issue licenses encompassing "monitoring, maintenance, or emergency measures necessary to protect public health and safety" was consistent with the EPA regulations implementing the Solid Waste Disposal Act (47 CFR 32274, July 26, 1982). Accordingly, the EPA established implementation procedures requiring case-by-case evaluations of potential contamination at sites. Decisions regarding monitoring or remedial actions will be guided by relevant considerations of the hazardous waste management systems.

As mentioned in Section 2.1, the EPA issued proposed groundwater protection standards for comment on September 24, 1987. Prior to promulgation of the final standards, the DOE intends to implement the provisions of Subpart A and C of the proposed standards to the extent reasonably achievable within the UMTRA Project regulatory framework. When the final EPA standards are promulgated, the DOE will re-evaluate its groundwater protection plan and undertake such action as is necessary to ensure that the revised standards are met. The need for and extent of aquifer restoration will be evaluated in a separate decision-making process under the National Environmental Policy Act.

In response to the Court's remand of the original standards, the newly proposed EPA groundwater standards involve:

- o Protection of human health, safety, and the environment.
- o Consideration of radiological and nonradiological hazards.
- o Consistency with the requirements of the Resource Conservation and Recovery Act (RCRA), as amended.
- o General standards applicable to all UMTRA Project sites (i.e., not site-specific as was the case for the remanded standards).

These items are discussed below.

Subpart A (40 CFR 192.01-192.02) consists of the requirements for control of potential contaminant releases to the groundwater at disposal sites. It incorporates the following:

- o A list of hazardous constituents.
- o Maximum concentration limits (MCLs), background limits, or alternate concentration limits (ACLs). The establishment of ACLs must be concurred in by the NRC, be as low as reasonably achievable, and satisfy the water-quality protection considerations.
- o Point of compliance at the downgradient vertical plane of the disposal facility.
- o A liner or equivalent beneath the disposal site if the tailings contain excess water.
- o Monitoring during a post-remedial action period to verify design performance.
- o Corrective action to be initiated within 18 months after monitoring indicates or projects an exceedance of the applicable concentration limits.

Subpart B (40 CFR 192.11-192.12) lists the standards applicable for remediating contaminated groundwater. It incorporates:

- o Cleanup of the listed groundwater constituents to levels specified in Subpart A.
- o Extension of the remedial period to allow for natural flushing if:
 - The groundwater is not, and is not projected to be, a public drinking water source, and
 - Institutional controls will effectively protect health and satisfy other beneficial uses, and
 - Concentration limits (40 CFR 264.94) will be met in less than 100 years.

Subpart C (40 CFR 192.20-192.22) addresses supplemental standards applicable to Subparts A and B. The supplemental standards provide for alternative actions that come as "close to meeting the otherwise applicable standards as is reasonably achievable." The NRC must concur in the application of supplemental standards. The supplemental standards may be applied if protection of human health and the environment is assured (40 CFR 192.22(d)) and:

- o Remedial actions pose a clear and present threat to workers or the public (192.21(a)).
- o The proposed action would cause more environmental harm than it would prevent (40 CFR 192.21(b)), or
- o Restoration is technically impracticable from an engineering perspective (40 CFR 192.21(f)), or
- o The groundwater is Class III (limited use) (40 CFR 192.21(g)).
- o There is no known remedial action (192.21(e)).

2.5 CLEANUP OF LANDS AND BUILDINGS

The EPA evaluated the risk associated with the dispersion of tailings off the site and concluded that the principal risk to man was the exposure to radon daughter products inside buildings. The EPA therefore stated that the objective of the cleanup of tailings from around existing structures was to achieve an indoor radon daughter concentration (RDC) of less than 0.02 working level (WL). For open lands, the purpose of removing the contamination is to remove the potential for excessive indoor radon daughter concentrations that might arise from new construction on contaminated land. The five picocuries per gram (pCi/g) and 15 pCi/g radium-226 concentration limits for 15-centimeter surface and subsurface layers, respectfully, were considered adequate to limit indoor RDCs to below 0.02 WL. A secondary concern was to limit exposure to people from gamma radiation.

The standard requires that residual radioactive materials be removed from buildings exceeding 0.03 WL. Measures such as sealants, filtration devices, or ventilation devices may be used to provide reasonable assurance of reductions to below 0.02 WL.

3.0 SITE CHARACTERIZATION

Site characterization describes the present condition of the Ambrosia Lake processing site. Appendix D, Site Characterization, contains additional supporting information.

3.1 LOCATION

The inactive Phillips/United Nuclear mill and tailings pile, known as the Ambrosia Lake site, is in McKinley County in northwest New Mexico. The site is 25 road miles north of Grants, New Mexico (Figure 3.1).

3.2 HISTORY

Constructed in 1957, the Phillips Mill was operated by Phillips Petroleum Company from June 1958 until March 1963. Three million tons of uranium ore, averaging 0.23 percent uranium oxide, were processed during the five-year operational period of the mill (FBDU, 1981). Three million tons of tailings were produced during the milling operation. An estimated 396,000 tons of tailings were removed from the site and used as underground mine fill. Following purchase by United Nuclear Corporation, all mining and milling operations were scaled back and milling ceased in April 1963.

All the ore came from nearby mines. Uranium extraction was accomplished at the Phillips Mill using alkaline pressure leach technology (NMEMD, 1979). Portions of the mill were used as a resin ion exchange facility by United Nuclear until late 1982, when all local operations ceased.

3.3 PHYSICAL DESCRIPTION

The site covers 195.6 acres, including the 111-acre tailings pile which contains 2,659,000 cubic yards of tailings. The base of the tailings pile is almost square; the surface of the tailings pile is concave. A perimeter fence has been erected around the tailings pile and windblown area. There are 1,100,000 cubic yards of soil contaminated by windblown material. Details of the extent of windblown contamination are presented in Appendix D, Site Characterization, Section D.3, Radiation Data.

The mill buildings have been demolished and the rubble has been separated into two piles. The contaminated rubble will be placed in the disposal cell during the main construction phase. The less contaminated rubble will be placed in a separate trench to be excavated northeast of the tailings disposal cell.

The site is in a valley within the Ambrosia Lake portion of the Grants mineral belt, a major uranium production region. This valley is drained by the Arroyo del Puerto, an ephemeral stream that derives most of its flow from mine-water and mill-water discharge treated elsewhere.

FIGURE 3.1
LOCATION OF AMBROSIA LAKE DESIGNATED SITE

3.4 RADIATION

Radioactive elements occur naturally throughout the earth's air, water, and soil. The concentration of these elements varies greatly throughout the United States. Baseline radioactivity levels in soils typical of the Ambrosia Lake area and not influenced by the tailings pile have been established as 1.2 ± 0.7 pCi/g for radium-226 (Ra-226) (BFEC, 1985). Background concentrations of Ra-226 in soils from areas not influenced by uranium mining and milling averaged 0.57 ± 0.08 pCi/g for Ra-226 (NMEID, 1985).

The average background gamma radiation exposure rate in the Ambrosia Lake region from both terrestrial and cosmic sources, measured at three feet above the ground, is 15.2 microR/hr (microR/hr) with a range of 12.6 to 16.5 microR/hr (BFEC, 1985).

No background radon measurements reflecting current conditions in the vicinity of the Ambrosia Lake designated site are available. However, 24-hour baseline measurements at three locations (0.5 and 0.75 mile north of the tailings pile, and one mile northwest) taken in 1976 averaged 4.3 pCi/l with a range of three to five pCi/l (FBDU, 1981). Natural background radon concentrations in undisturbed areas with similar geologic settings as Ambrosia Lake have been measured by several investigations and averaged 0.19 ± 0.02 pCi/l (NMEID, 1985; Millard and Baggett, 1984).

Soil samples from 106 drill holes on the tailings pile were analyzed by gamma spectroscopy, and computer modeling was used to determine the contaminant distribution and the average Ra-226 concentration of the pile. The resulting average Ra-226 concentration of the tailings was 571 pCi/g (BFEC, 1985). The maximum Ra-226 concentration was 1807 pCi/g.

The soil beneath the tailings pile exceeded the EPA standard of 15 pCi/g Ra-226 to an average depth of approximately 4.75 feet.

Using Schiager's estimate (Schiager, 1974) of $2.5 \text{ (microR/hr)/(pCi/g)}$, and the average tailings pile Ra-226 concentration of 571 pCi/g, the gamma exposure rate for the pile would be 1428 microR/hr. Based on an aerial survey, exposure rates ranged from 350 to 1500 microR/hr (EG&G, 1981).

The radon flux source term from the tailings pile was calculated using the RAECOM model (NRC, 1984), resulting in an estimated annual average radon flux of 556 pCi/m²s under existing conditions.

Field data (ORNL, 1980; BFEC, 1985) indicate that extensive transport of gamma-emitting contamination by wind or water erosion has occurred into the area surrounding the tailings pile. Contamination sources include residual ores and wastes from mining, and ponded slimes from mine dewatering. Analysis of the Ra-226/uranium-238 ratio in soil samples was used to delineate areas contaminated by ore from areas contaminated by windblown tailings. Five-hundred and seventy acres contaminated by windblown tailings and ore stock piles will require remedial action. Concentrations of Ra-226 ranged from five pCi/g to 4058 pCi/g.

3.5 GEOLOGY, GEOMORPHOLOGY, AND SEISMICITY

3.5.1 Introduction

Geologic, geomorphic, and seismic investigations were conducted in the area and region of the Ambrosia Lake site. Detailed findings of the studies are presented in Section D.4, Appendix D, Site Characterization. Geologic hazards with the potential to affect long-term pile stability have been identified and evaluated during UMTRA Project geologic investigations.

The investigations performed for the Ambrosia Lake designated site included:

- o Compilation and analysis of previous geologic work.
- o Review of earthquake data using the National Geophysical Data Center (NGDC) earthquake listing and other seismic net catalogs.
- o Analysis of site-specific UMTRA Project geologic data.
- o Evaluation of existing remote sensing imagery.
- o Low-sun-angle aerial reconnaissance.
- o Ground reconnaissance and mapping.

3.5.2 Geologic setting

The Ambrosia Lake site is in northwestern New Mexico, within the Navajo section of the Colorado Plateau physiographic province (Figure 3.2). Terrain in this section of the plateau is generally moderate to low relief, and is composed primarily of flat-topped, gently sloping cuestas, broad steep-scarped mesas, low-gradient pediment and fan surfaces, deeply incised canyons and arroyos, and strike valleys. The Mt. Taylor volcanic complex dominates the physiography within the 40-mile (65-kilometer) study region, rising to more than 4000 feet above surrounding the topography. Vast basalt flows and cinder cone fields cover large areas west and south of the Ambrosia Lake site.

Cenozoic tectonic and erosional processes have exposed rocks of Precambrian through Late Quaternary age in the study region (Figure 3.3). With the exception of Quaternary basalt flows, Precambrian igneous and Paleozoic sedimentary units crop out south of the tailings site in the vicinity of the Zuni Uplift. Progressively younger strata are exposed in the central and northern portions of the study area, terminating with deltaic deposits of the upper Cretaceous Fruitland Formation. Extrusive volcanic rocks of primarily Miocene and Pliocene age constitute the Mt. Taylor and Mesa Chivato physiographic features east and northeast of the existing tailings pile.

FIGURE 3.2
REGIONAL SEISMOTECTONIC SETTING AND STUDY REGION MAP

FIGURE 3.3
BEDROCK GEOLOGY OF THE AMBROSIA LAKE STUDY REGION
 (MODIFIED AFTER BALDRIDGE, et al, 1983)

LEGEND

Q	QUATERNARY (undivided): Fluvial sediments of gravel, sand and clay; alluvial fan deposits; colluvium, soils, landslides. Locally includes units mapped as Pliocene-Pleistocene.	Kdm	LOWER TO UPPER CRETACEOUS: Undifferentiated Mancos Shale and Dakota Sandstone in northwestern New Mexico.
Qb	QUATERNARY MAFIC VOLCANIC ROCKS (≤ 1.8 m.y.): Tholeiite, basanite, alkali olivine basalt, and related alkalic basaltic rocks.	Kd	LOWER TO UPPER CRETACEOUS: Dakota Sandstone.
Tpb	PLIOCENE MAFIC VOLCANIC ROCKS (1.8 - 5.0 m.y.): Tholeiite, alkali olivine basalt, basanite, and related alkalic basaltic rocks.	Jm	UPPER JURASSIC: Sandstone, mudstone, conglomerate, with nodular chert. Morrison Formation.
Tps	PLIOCENE INTERMEDIATE AND SILICIC VOLCANIC ROCKS (1.8 - 5.0 m.y.): Basaltic andesite, alkali andesite, quartz latite, dacite, rhyolite, trachyte.	Jsr	MIDDLE JURASSIC: Limestone, shale, bituminous shale, mudstone and limestone. San Raphael Group (Bluff Formation, Summerville Formation, Todilto Formation, Entrada Sandstone.
Kl	UPPER CRETACEOUS: Shale, with minor sandstone and siltstone. Lewis Shale in northwestern New Mexico.	Tr	TRIASSIC: Shale, siltstone, sandstone, conglomerate, limestone. Wingate Formation, Chinle Formation.
Kmv	UPPER CRETACEOUS: Sandstone, shale, carbonaceous shale, and coal. Mesa Verde Group (Menefee Formation, Gallup Sandstone, Crevasse Canyon Formation, Point Lookout Sandstone).	P	PERMIAN: Sandstone, siltstone, shale, limestone, gypsum, conglomeratic sandstone, orthoquartzitic sandstone. Glorieta Formation, San Andres Limestone.
Km	UPPER CRETACEOUS: Shale with minor sandstone and limestone. Mancos Shale.	Pc	PRECAMBRIAN: Phyllite, quartz schist, metaquartzite, gneiss, granite, and metavolcanic rocks. In central New Mexico also olivine gabbro, amphibolite, and granite pegmatite.

FIGURE 3.3 (CONCLUDED)
BEDROCK GEOLOGY OF THE AMBROSIA LAKE STUDY REGION

The Ambrosia Lake site lies in a northwest-trending strike valley cut into the upper Cretaceous Mancos Shale. Approximately 3000 feet (1000 meters) of Permian to Cretaceous age clastic sedimentary strata underlie the site (Figure 3.4). The sedimentary section dips northeastward at two degrees, and forms a regional homocline of the southern San Juan Basin referred to as the Chaco Slope.

Wind erosion and dispersion of the mill tailings over the past 22 years has resulted in the formation of dunes immediately east of the existing pile. Numerous locations in the Ambrosia Lake area contain localized dune fields and reflect the significance of eolian activity. The embankment design contains protective layers of earthen and rock material that will prevent future wind erosion of tailings. Pile armoring and other design features are discussed in Section 4.0, Site Design.

Gullying processes are active throughout the upland sideslope areas of the Ambrosia Lake valley. However, gullying does not have the potential to affect the tailings embankment within the proposed 1000-year design life due to the design and location of the stabilized pile. Established drainages north, south, and east of the site exhibit no evidence of active lateral erosion or headcutting.

As discussed in Section 4.0, tectonic faults are abundant in the study region and reflect multiple episodes of deformation. Most of the structures are of Laramide age, exhibiting north and northeast trends. Displacement is most commonly down to the east and on the order of a few tens of feet. In addition to the regional uplifts and monoclinial elements forming the southern margin of the San Juan Basin, numerous small-scale domes, anticlines, and synclines locally deform the otherwise uniform regional bedding orientation. Vertical displacement of the Laramide age local structures is generally less than 500 feet.

Unconsolidated alluvial and eolian deposits of late Quaternary age mantle extensive low-lying portions of the study region and site vicinity (Figure 3.5). Within the Ambrosia Lake valley, thicknesses of alluvium exceed 100 feet near Arroyo del Puerto, which is one mile southwest of the site. Valley sideslope alluvial sediments in the immediate site vicinity range in depth from five to 55 feet.

3.5.3 Geomorphology

Geomorphic processes operating in the study region were identified primarily through an analysis of regional and local landforms. A subsequent evaluation of active geomorphic processes modifying the present-day landscape was conducted.

The current geomorphic regime in the Ambrosia Lake region is dominated by fluvial and eolian erosion processes. Present

FIGURE 3.4
SOUTH TO NORTH STRATIGRAPHIC SECTION OF THE SAN JUAN BASIN
(MODIFIED FROM MOLENAAR, 1977)

FIGURE 3.5
SURFICIAL GEOLOGIC MAP OF THE AMBROSIA LAKE SITE VICINITY
(MODIFIED FROM SANTOS AND THADEN, 1966)

geomorphic conditions have persisted in the area for the past few thousand years and are not expected to change significantly during the 1000-year embankment design life. The proposed stabilized pile has been designed to preclude future disturbance of tailings by fluvial geomorphic processes, including flooding and on-pile rill and gully development.

Mass wasting and natural slope failure processes are not active in the vicinity of the Ambrosia Lake site. Potential geomorphic processes which have been eliminated as hazards with respect to long-term pile integrity are:

- o Landslides.
- o Debris flows.
- o Mudflows.
- o Rock falls.
- o Soil creep.

Mining-induced surface subsidence has occurred at several locations in the Ambrosia Lake valley. The failure of strata overlying mine voids in adjacent Section 27 has resulted in the formation of an elliptical depression 800 feet west of the edge of the existing tailings pile. Mining passages that are present beneath the southwestern edge of the tailings pile are of considerably smaller dimension and reflect a different mining method than those causing the Ambrosia Lake subsidence zones. Engineering and geologic analyses presented in Section D.4.5.4 of Appendix D, Site Characterization, and in calculations supporting Appendix F, Subcontract Documents, conclude that a collapse of the strata overlying these voids would not jeopardize the integrity of the stabilized embankment.

3.5.4 Seismicity

An area within a 120-mile (200-kilometer) radius of the Ambrosia Lake site was examined during the seismic investigation. The seismotectonic setting of the study region includes portions of the Colorado Plateau, Basin and Range, Rio Grande Rift, Western Mountains, and Great Plains seismotectonic provinces.

The Colorado Plateau province, which contains the designated site (Figure 3.6), consists of a stable interior flanked on the western, southern, and eastern sides by tectonic transition zones. In comparison to the stable interior, the transition zones exhibit elevated levels of seismic activity and contain structures that reflect the stress fields dominating adjacent provinces. The Ambrosia Lake study region constitutes a portion of the transition zone that separates the Colorado Plateau interior and the Rio Grande Rift.

The largest historical earthquake in the 120-mile study radius occurred in 1906, 105 miles (165 kilometers) southeast of the existing tailings pile in the Rio Grande Rift. Intensity effects indicate that the event had a 6.3 Richter magnitude. Smaller

FIGURE 3.6
SEISMICITY MAP OF THE COLORADO PLATEAU AND TRANSITION ZONES
1962 TO 1980 (MODIFIED FROM ZOBACH AND ZOBACH, 1980; WONG, 1984)

shocks of 4.6 and 4.2 local magnitude occurred in 1976 and 1977 near Crownpoint, New Mexico, 36 miles (58 kilometers) and 34 miles (54 kilometers) northwest of the site, respectively. The vast majority of the seismic events recorded in the study region are epicentered in the Mt. Taylor and Mesa Chivato volcanic complex. No relationship can be drawn between the dominantly microseismic data and known tectonic faults in the volcanic complex.

The Ambrosia Lake seismic study in each of the pertinent seismotectonic provinces included:

- o An evaluation of major fault systems and known capable or potentially capable structures which could possibly influence pile design.
- o An analysis of on-site acceleration effects due to the Maximum Credible Earthquake value as obtained from published seismic studies. The event was assumed to occur at the closest approach of a province to the site.
- o An examination of the seismic character of the site through the review and interpretation of historical earthquake records and journal articles related to provincial seismicity.

Structures capable of producing large magnitude earthquakes exist in seismotectonic provinces bordering the Colorado Plateau. Predicted on-site accelerations resulting from the occurrence of large earthquakes in adjacent provinces will not affect the stabilized pile.

No late Quaternary deposits in the area of investigation are tectonically offset; hence, it is concluded that all faults in the 40-mile radius surrounding the site are noncapable as defined in 10 CFR 100. The lack of capable structures in the study area requires that a floating earthquake be used to establish seismic design parameters for the proposed embankment. Such an event is independent of known tectonic structure and could occur anywhere within the Colorado Plateau seismotectonic province. A review of historical Colorado Plateau seismicity and of documented ground breakage associated with large magnitude earthquakes in the western United States prompted the specification of 6.2 local magnitude for the plateau floating earthquake. The epicenter of the floating earthquake is assumed to occur at a nine-mile (15-kilometer) distance from the site. The on-site, nonamplified, free-field Peak Horizontal Acceleration resulting from this event is 0.21g. Focal plane solutions for events in the Ambrosia Lake region suggest that the source mechanism for the design earthquake would be controlled by the prevailing northeast-southwest directed extensional stress field.

There is no potential for fault rupture at or near the Ambrosia Lake site based on intense geologic field studies conducted in the area. The tectonically induced collapse of mine workings is a remote possibility; however, its occurrence would not threaten the

structural integrity of the tailings embankment (Section D.4.5.4 of Appendix D, Site Characterization).

3.5.5 Volcanism

Extrusive volcanic rocks constitute a significant portion of the southern and eastern study area bedrock exposures (Figure 3.3). The potential for eruptions and surface flows northeast, east, and south of the site vicinity is high as evidenced by recurrent late Cenozoic volcanism in the Mt. Taylor volcanic field. The youngest basalt flows in the study region are between 800 and 1200 years old. Surface flows emanating from the Mt. Taylor area would need to greatly exceed the physical proportions of typical Quaternary flows in the study region in order to jeopardize the structural integrity of the proposed embankment. Ash falls resulting from the occurrence of explosive volcanism within the Mt. Taylor volcanic complex would not impact site stability.

3.5.6 Mineral resources

Low-grade uranium, vanadium, and molybdenum ores exist in strata underlying the site vicinity. Extraction of these reserves is presently uneconomical except by mine water recovery. With the exception of minor quantities of sand and gravel building aggregates and mine water recovery of uranium, there are no recoverable metallic or nonmetallic resources in the Ambrosia Lake area. Continued strip mining of coal reserves north of the site area will not impact pile stability because of the distance involved. Resource exploitation beneath the disposal site will be prohibited to ensure the long-term integrity of the tailings embankment.

3.6 GEOTECHNICAL

The definition of geotechnical conditions at the processing site included the following work:

- o Definition of stratigraphy within the pile and foundations.
- o Development of design parameters for both in situ and remolded borrow materials.
- o Completion of field and laboratory tests.

The site and surrounding soils were characterized by drilling 281 borings, drilling 126 piezocone holes, and digging 25 test pits. Figures 3.7 through 3.11 show the locations of the boreholes, piezocone soundings, on-pile hydrological borings, and test pits that were sampled for geotechnical purposes. Of the 281 borings, 209 were made during previous studies. (MSRD, 1982; FBDO, 1981.) (Figure 3.7.) Bendix (BFEC, 1985) drilled and geophysically logged 43 holes to determine the depths of subsurface contamination. During 1985, DOE contractors drilled and logged

72 boreholes and pushed 126 piezocone-sounding holes on the pile, drilled 26 holes off the pile for monitor wells, and dug test pits in the radon/infiltration barrier borrow area. The lithology logs for the various characterization efforts were presented in Addendum D3 of Appendix D, Site Characterization in the May 1987 Preliminary Field RAP. These data have not been reproduced in this issue of the RAP.

3.6.1 Foundation soils

The soils underlying the site generally consist of alluvium and weathered Mancos Shale as shown in Figures 3.12 through 3.15. These figures show the cross sections and general zones for the different material types as represented in the actual pile. In order to see some of the small layers in the embankment, an exaggerated vertical scale was used in the cross sections. Figure 3.16 shows the structural contour map for the top of bedrock under the tailings embankment. The data used to construct the cross sections and structural contour maps come from piezocone soundings, geotechnical borings, and logs from the hydrologic monitor wells. The bedrock elevations shown on the cross sections are based on the bedrock contour map. The alluvium is generally thickest on the western portion of the pile, while the weathered Mancos Shale is thickest under the eastern portion of the pile. The alluvium consists of clayey or silty sands with some very sandy clays. The origin of these materials appears to be primarily from the Crevasse Canyon Formation and secondarily from the Mancos Shale.

The weathered Mancos Shale is thickest on the eastern portion of the pile, while on the southwest side of the pile the thickness of the weathered shale reduces to zero. Toward the western side of the pile it appears that the weathered shale may have been eroded away before deposition of the alluvium.

The contact between the alluvium and weathered Mancos Shale was difficult to locate because the alluvium is a clayey or silty sand while the weathered Mancos Shale is often a sandy clay. Near the east side of the pile, the Mancos Shale is at a fairly shallow depth and the tailings rest directly over the weathered Mancos Shale. The alluvium in this area may have been used for construction of the starter dike or it may simply have eroded away. In any case, the tailings over the weathered Mancos appear to cause a perched water table in the area. This perched water table and engineering properties of the foundation soils are discussed in more detail in Appendix D, Site Characterization.

3.6.2 Tailings

Materials forming the tailings can generally be put into one of three categories: sand, sand-slime mixture, and slime. The limits for classifying these materials were set at zero to 30 percent passing the No. 200 sieve for the sand, 30 to 70 percent for the sand-slime mixture, and 70 to 100 percent for the slime. Using these criteria, the laboratory tests were used to classify the tailings

FIGURE 3.7
BOREHOLE LOCATIONS FROM PREVIOUS STUDIES

FIGURE 3.8

ON-PILE GEOTECHNICAL BOREHOLE LOCATIONS AT AMBROSIA LAKE

FIGURE 3.9 ON-PILE PIEZOCONES SOUNDING LOCATIONS AT AMBROSIA LAKE

FIGURE 3.10 HYDROLOGY BOREHOLE LOCATIONS AT AMBROSIA LAKE

FIGURE 3.12
CROSS-SECTION A-A' AMBROSIA SITE

FIGURE 3.14
CROSS-SECTION C-C' AMBROSIA SITE

FIGURE 3.15
CROSS-SECTION D-D' AMBROSIA SITE

FIGURE 3.16 BEDROCK STRUCTURAL CONTOUR MAP

into one of the three categories. Carbonate leach tailings are generally finer than acid leach tailings and since the tailings at Ambrosia Lake were processed using the carbonate leach method, the tailings were predominantly sand-slime and slimes.

According to Purtymun et al. (1977), the tailings were pumped to the disposal area, which was originally surrounded on four sides by starter dikes. The tailings were discharged from pipes along the inner side of the dikes. As the impoundment filled, a second tier of dikes was constructed along the southern and western edges of the impoundment. Because the eastern edge is covered with wind-deposited tailings, it is not known if the second tier was constructed along this edge. The first tier was constructed of natural materials; however, the second tier appears to have been constructed of natural materials with some tailings.

The tailings impoundment at Ambrosia Lake was constructed using the upstream method, which involves discharging the tailings peripherally from the crest to form a beach. The upstream method of discharge encourages segregation of the grain sizes. The coarser particles occur near the outer portion of the embankment and the slimes are toward the center of the pond. Limits between the sands, sand-slime mixtures, and slimes are often difficult to locate because segregation during deposition is a gradual and continuous process. Figure 3.17 shows the conceptual material type variation for a tailings deposit constructed using the upstream method. A model developed by Kealy and Busch (1971) was used as a guide to plot the position of various types of tailings. The width of each zone depends on several different factors such as the initial proportion of sands and slime within the mill slurry, the location of the pond relative to the discharge, and whether the discharge is at a single point or distributed evenly across the embankment crest. Small slime stringers may be in the sands or vice versa; therefore, only generalizations can be made for the different zone widths.

Figure 3.18 shows a plan view of the tailings impoundment and the different material-type locations. This map was determined by plotting the different percentages of sand, sand-slime mixture, and slimes for each piezocone hole and then dividing the pile according to the largest percentage of material recorded in each piezocone hole.

The starter dike location was determined by locating what is left of the downstream toe and then assuming an upstream slope of two horizontal to one vertical. It is not known if the starter dike was constructed with compacted engineered fill or by piling loose dirt to the desired height. Some compaction is believed to have been done; however, to be conservative in the design, it is assumed that the entire starter dike was constructed of loose material.

Discharge of the tailings slurry was done on nearly all sides of the embankment, as noted by the distribution pipes currently along the crests. It appears that the major tailings discharge was done on the northern-most edge of the pile since the tailings pile slopes to the south. Some of the tailings were discharged near the

REF: KEALY & BUSCH, 1971.

FIGURE 3.17
CONCEPTUAL MODEL OF MATERIAL VARIATION WITHIN A TAILINGS DEPOSIT

FIGURE 3.18 GENERAL MATERIAL TYPE LOCATIONS FOR AMBROSIA LAKE TAILINGS

center of the impoundment, as evidenced by the present discharge pipes running from the embankment crest to the interior of the pile. Section D.7 of Appendix D, Site Characterization, discusses the engineering properties of the tailings materials.

In order to define the in situ consolidation and settlement behavior of the tailings, two trial embankments were constructed. The amount and the rate of settlement (hence consolidation) of the tailings were measured with numerous instruments at each trial embankment. A detailed description of the final embankment and the interpretation of the results are given in the calculations that accompany this report. Generally, the trial embankment showed that the rate of consolidation is greater and the amount of settlement is slightly less than predicted from laboratory tests.

3.6.3 Radon/infiltration barrier

Mancos Shale from an area one mile north of the Ambrosia Lake site will be used as a radon/infiltration barrier over the tailings. This area was chosen because the weathered Mancos Shale is near the surface and little overburden stripping would be required. The weathered Mancos Shale is a very clayey material that has been shown in laboratory tests to be efficient in controlling radon gas release. Engineering properties of the proposed radon/infiltration barrier materials are discussed in Section D.6 of Appendix D, Site Characterization.

3.6.4 Contaminated materials

Prior to placement of the radon/infiltration barrier, the pile will be covered with a layer of windblown tailings and contaminated alluvium from beneath the north part of the tailings pile. This layer will be predominately alluvium, which is composed of very silty to clayey sands. The compacted characteristics and engineering behavior of the alluvium are discussed in Appendix D, Site Characterization, Section D.5.

3.6.5 Erosion barrier

The rock proposed for erosion protection is hard, dense basalt boulders that will come from an existing quarry near the town of San Mateo, south of the processing site. The basalt will have to be drilled and blasted.

An outcrop of Dakota Sandstone 6.5 miles south of the Ambrosia Lake site and another basalt deposit were sampled and tested as part of an evaluation of alternate sources of rock for erosion protection. The sandstone rock did not meet the NRC durability requirements (NRC, 1985). Based on these findings, Dakota Sandstone in the area is not considered acceptable rock for erosion protection. The original basalt deposit was not selected because access would have required road construction though valuable big game habitat that was

disfavored by the U.S. Forest Service. Section D.6 of Appendix D, Site Characterization, describes the rock durability test results.

3.7 GROUNDWATER

The Ambrosia Lake tailings pile is underlain by alluvium which grades into weathered Mancos Shale on the eastern side of the site. The alluvium and weathered Mancos Shale are hydraulically interconnected and behave as a single hydrologic unit. The Tres Hermanos-C sandstone of the lower Mancos Shale subcrops into the alluvium beneath the western side of the tailings site. Other hydrostratigraphic units beneath the site which may be water-bearing include (in descending order) the Tres Hermanos-B and -A sandstones of the lower Mancos Shale, the Dakota Formation, and the Westwater Canyon Member of the Morrison Formation.

The condition of saturation in the alluvium/weathered Mancos Shale at the site exists due to the uranium mining activities in the area. Seepage from an unlined mill make up process water pond, discharge of mine water from the Ann Lee Mine, and seepage from the tailings have artificially recharged groundwater in the alluvium and weathered Mancos Shale. Groundwater in the area of saturation in the alluvium/weathered Mancos Shale north of the pile flows to the southwest under the tailings along the southwesterly sloping contact of the Mancos Shale under a hydraulic gradient averaging 0.025. The average hydraulic conductivity in the alluvium/weathered Mancos Shale is 3.48×10^{-4} centimeter per second (cm/s) and the average linear groundwater velocity is 6.69×10^{-5} cm/s.

The alluvium/weathered Mancos Shale and the Tres Hermanos-C sandstone are incapable of producing more than 150 gallons per day, which classifies the groundwater contained in these units as limited use (Class III) groundwater. The existing level of saturation in the alluvium/weathered Mancos Shale will probably not be sustained after remedial actions are completed. Groundwater within the Tres Hermanos-C sandstone is recharged mostly from seepage from the alluvium in the subcrop area. The extent of recharge from the alluvium will diminish after remedial action.

The Tres Hermanos-C sandstone is only basally saturated, receiving most of its recharge from the overlying alluvium/weathered Mancos Shale where it subcrops on the western side of the pile. Groundwater within the Tres Hermanos-C sandstone flows to the northeast in the direction of regional dip under a hydraulic gradient averaging 0.025. The average hydraulic conductivity in the Tres Hermanos-C sandstone is 2.67×10^{-4} cm/s and the average linear groundwater velocity is 1.37×10^{-4} cm/s.

Groundwater within the Westwater Canyon Member of the Morrison Formation flows to the northeast in the direction of regional dip under a hydraulic gradient averaging 0.026 ft/ft. The average hydraulic conductivity in the Westwater Canyon Member is 4.31×10^{-4} cm/s and the average linear groundwater velocity is 1.14×10^{-4} cm/s.

Because there was originally no saturation in the alluvium, no pre-operational water quality data is available. It is only possible to establish existing water quality as background for the isolated pocket of saturation in the alluvium and weathered Mancos Shale.

Maximum observed concentrations of chromium, molybdenum, nitrate, lead, selenium, silver, uranium, and activities of radium 226 and 228 and gross alpha in pore fluids in the tailings and unsaturated alluvium beneath the tailings exceed the proposed MCLs.

Maximum observed concentrations of chromium, molybdenum, nitrate, lead, selenium, silver, uranium, and activities of radium 226 and 228 and gross alpha in groundwater in the alluvium/weathered Mancos Shale exceed the proposed MCLs. Maximum observed concentrations of cadmium, chromium, molybdenum, nitrate, selenium, silver, uranium, and activities of radium 226 and 228 and gross alpha in groundwater in the Tres Hermanos-C sandstone member exceed the proposed MCLs.

Maximum observed concentrations of cadmium, chromium, lead, molybdenum, selenium, silver, uranium, and activities of radium-226, radium-228, and gross alpha in groundwater in the Westwater Canyon Member of the Morrison Formation exceed the proposed MCLs.

Geochemical simulation of mixing tailings pore fluids with mill makeup water suggests that groundwater in the alluvium/weathered Mancos Shale is derived largely from these two sources. Concentrations of nitrate, a conservative species, are relatively the same in groundwater in the alluvium/weathered Mancos Shale and the Tres Hermanos -C sandstone suggesting much of the groundwater in the Tres Hermanos-C sandstone is derived from seepage from the alluvium/weathered Mancos Shale.

A comparison of concentrations of hazardous constituents in the Tres Hermanos-C sandstone with those in the Westwater Canyon member of the Morrison Formation indicates that seepage down mine shafts and ventholes will not influence water quality in the Westwater Canyon Member. Concentrations of most hazardous constituents in the Tres Hermanos-C sandstone are lower than those in the Westwater Canyon Member and the relative rate of groundwater underflow in the Westwater Canyon member compared to the Tres Hermanos-C sandstone assures that no water quality impacts will occur in the Westwater Canyon Member.

3.8 SURFACE WATER

There are no natural perennial streams at the Ambrosia Lake site. The Arroyo del Puerto, the principal drainage channel for the Ambrosia Lake area, is a tributary of San Mateo Creek. Flow in the channel has been sustained by mine water discharges, creating a perennial stream from the late 1950s until 1980. Flow within the Arroyo del Puerto has been a source of recharge to the alluvium along its course toward San Mateo Creek. This saturation in the alluvium does not extend as far as the Ambrosia Lake tailings pile, and alluvial wells south of the pile are dry. Saturation at the Ambrosia Lake processing site is localized and distinct from saturation along the Arroyo del Puerto. Water quality in the Arroyo del Puerto reflects the quality of mine water discharges and contains concentrations of gross alpha, Ra-226, molybdenum, selenium, uranium, and possibly chloride and/or sulfate that exceed background levels designated from upstream samples from San Mateo Creek (Gallaher and Goad, 1981).

Ponded water on the tailings pile resulted from rainfall and collected in the depression at the south central portion of the existing pile until it was drained into a lined wastewater retention basin in 1988. Additional ponds in the vicinity of the site, all of which are usually dry, include abandoned mine ponds, abandoned sewage ponds, and various stock watering ponds northeast of the mill. Surface water-quality analyses results are included in Appendix D, Site Characterization.

None of the surface water in intermittent drainages from San Mateo Mesa or within the Arroyo del Puerto are utilized as a potable water source. However, some surface water from the Arroyo del Puerto has been diverted for stock watering.

The watershed and associated drainage network above the site were evaluated to determine the impact that intense storms and flooding would have on the site. The watershed covers 3.8 square miles and is divided into two separate ephemeral drainage pathways, one north of the site and one northeast of the site. Flood analysis included a determination of the Probable Maximum Flood conditions. This is discussed in greater detail in the surface water hydrology portion of Appendix D, Site Characterization, and in calculations supporting Appendix F, Subcontract Documents.

4.0 SITE DESIGN

4.1 INTRODUCTION

This section discusses remedial action objectives, construction features, permanent design features, and the schedule for in-place stabilization of the uranium tailings, mill structures, and windblown contamination associated with the Ambrosia Lake designated site. Maps, drawings, and tables relevant to the design are provided here and more detailed data are included in Appendix F, Subcontract Documents. The site design presented is described to demonstrate compliance with EPA standards.

The main objective of the site design is to meet the requirements of the UMTRCA and EPA standards. These standards require protection against release of contaminated materials into the environment and provide for limits on the release of radon gas and gamma radiation from radium in the tailings and other contaminated soils.

Design objectives

The following are the major design objectives:

- o Consolidate and stabilize contaminated materials on the existing site.
- o Reduce the radon flux from the stabilized tailings and associated contaminated materials to the atmosphere to levels not greater than 20 pCi/m²s.
- o Design controls to be effective for up to 1000 years to the extent achievable, and at least for 200 years.
- o Prevent inadvertent human or animal intrusion into, or disturbance of, the tailings.
- o Ensure that existing or anticipated uses of ground and surface waters are not adversely affected by the stabilized tailings and contaminated materials.
- o Reduce contaminant levels in areas to be released for unrestricted use to levels which do not exceed five pCi/g Ra-226 above background values in the top 15 centimeters (cm) of soil, and 15 pCi/g in any 15-cm layer below that depth.
- o Minimize the size of the restricted final disposal site.
- o Prevent the release of contaminants from the site during construction.
- o Minimize the area disturbed during construction.

- o Minimize exposure of workers and the general public to contaminated materials.

4.2 DESIGN SUMMARY

This section summarizes the remedial action and design features. Appendix F, Subcontract Documents, provides the details.

The main feature of the remedial action is the consolidation of contaminated subsoils and windblown contaminants, and their stabilization in the current location of the Ambrosia Lake tailings. Mill buildings, foundations, and other facilities (including asbestos) will be demolished. Radioactively contaminated rubble and asbestos will be buried with the tailings. Uncontaminated rubble and some slightly contaminated rubble will be buried in a trench north of the mill area. Figure 4.1 shows a cross sectional view of the final tailings pile.

Tailings and subsoils from the northern portion of the pile will be used to fill the depression on the top of the existing pile and to shape the embankment to ensure drainage. Existing tailings pile sideslopes are about 3.3 horizontal to one vertical. The existing sideslopes will be supported by a buttress with a slope of five horizontal to one vertical made of windblown material. Buttressing with windblown material rather than shaping the existing embankment will be used to avoid weak slime zones close to the pile perimeter that would be exposed in a five to one cut. The remaining windblown material will be used primarily to cover the tailings. Some windblown material may be blended with wet tailings to facilitate fill placement.

The windblown material is significantly less contaminated than the tailings and subsoils. Placement of the windblown-contaminated materials on top of the tailings directly beneath the radon/infiltration barrier will reduce the required thickness of the radon/infiltration barrier.

The radon/infiltration barrier will consist primarily of compacted weathered Mancos Shale from a borrow site one mile north of the pile and will be placed over the consolidated tailings and windblown materials. To reduce radon flux to 20 pCi/m²s or less, the initial design requires a 3.5-foot thick radon/infiltration barrier. The actual thickness will be recalculated after additional sampling and testing of the barrier materials.

Embankment erosion protection consists of rock and bedding layers designed to withstand the Probable Maximum Precipitation (PMP) on the embankment and Probable Maximum Flood (PMF) flows around the embankment.

A bedding layer will be placed on the radon/infiltration barrier to protect against erosion or migration of material at bedding interfaces with the radon/infiltration barrier and erosion protection layers. A layer of rock, the erosion protection layer, will be placed over the bedding layer. This rock layer is designed to withstand a PMP event on the surface of the embankment. Sideslopes will be covered with a layer of larger rock, which can withstand both a PMP event on the embankment sideslopes and flows

FIGURE 4.1
TYPICAL EMBANKMENT CROSS SECTION, AMBROSIA LAKE SITE

against the pile from a PMF from the watershed above the embankment. Riprap sizes based on PMP runoff from the pile are larger than rock sizes required to protect against PMF flow in the swales due to runoff from upslope watersheds.

Excavated and disturbed site areas and borrow sites will be regraded or backfilled as required to promote drainage and will be revegetated. Areas outside the final disposal site boundary will be released for unrestricted use upon completion of the remedial action.

4.2.1 Reprocessing assessment

An aspect of the project which must be addressed in order to comply with the UMTRCA is the economic and technical feasibility of reprocessing the tailings for the recovery of residual uranium and vanadium. In 1980 and 1981, Ford, Bacon & Davis Utah Inc. performed an economic evaluation of reprocessing the Ambrosia Lake tailings. Samples of the tailings were analyzed to determine the amount of recoverable uranium, vanadium, and other metals. Laboratory leaching tests were conducted on the samples to estimate extractability and the process to be applied. The evaluation compared the recoverable values of the metals versus the capital and operating costs for processing by heap leaching or conventional milling. Site excavation, haulage, and final disposal costs were not included. The results of the study indicated that reprocessing was not economical at 1980 market prices for the metals (FBDO, 1981). Since that date, market prices for uranium and vanadium have fallen and reprocessing is not expected to be feasible in the foreseeable future.

4.2.2 Site acquisition requirements

The Ambrosia Lake disposal site is on land currently owned by the State of New Mexico. Following completion of the remedial action title to the disposal site will pass from the State of New Mexico to the DOE.

4.3 PERMANENT DESIGN FEATURES

4.3.1 Introduction

Permanent design features are described below for in-place stabilization of the Ambrosia Lake tailings pile. Reasons are presented for selecting particular design solutions in preference to other possible methods of meeting EPA criteria for remedial action at UMTRA Project sites. Factors considered in the design, such as subsurface conditions, the nature of the tailings in the pile, and requirements for erosion and radon control, are described as they affect the layout and construction of the pile.

4.3.2 Pile location

In-place stabilization of the tailings is the preferred alternative. The environmental assessment for the site (DOE, 1987) provides a detailed description of alternative disposal options for the Ambrosia Lake tailings and reasons for selecting the preferred alternative. Stabilization in place is an economic solution that has the same or lesser environmental impacts than alternative disposal options considered but rejected.

4.3.3 Pile layout

A description of the pile at the completion of remedial action is provided in Section 4.2. Mill site debris will be buried in the tailings pile. The northern one-quarter to one-third and southeast corner of the pile will be relocated by placing the tailings in the depression on the present pile. The surface of the pile will be built up with the relocated tailings and windblown-contaminated soils. A planar top surface will be constructed to slope from the center of the reshaped pile to the outer perimeters to avoid flow concentrations and to minimize peak runoff flow rates for riprap size design. A buttress of compacted windblown-contaminated soil will be placed around the perimeter of the pile.

The northern portion of the pile is to be relocated for the following reasons:

- o The depth of tailings and contaminated material is sufficiently small and it is more economical to relocate these materials onto the main portion of the pile, thereby minimizing the area to be covered with radon and erosion control barriers. The depth of tailings and contaminated subsoils is lowest in the northern portion of the pile.
- o Material is required to fill the depression in the pile in order to create a crown that ensures positive drainage from the pile and avoid the development of flow concentrations. Without adequate drainage, water would continue to accumulate on the pile, seep through the tailings, and contaminate groundwater. In order to be economical it is best to use materials that are closest to the pile. The closest suitable materials are the tailings in the northern part of the pile.
- o Moving the northern portion of the pile can be accomplished concurrently with the northern swale construction. This facilitates more efficient and economical overall construction in this area.

The southern portion of the pile will not be moved as it is economically advantageous to stabilize this portion in-place. The

tailings and contaminated subsoils in this portion are sufficiently thick that it is more economical to cover them with a radon/infiltration barrier and erosion barrier than to relocate them. The relatively larger volume of very wet slimes present in the southern portion of the pile would also be difficult and costly to move.

The layout provides for a buttress to be placed around the total perimeter of the pile in order to provide stability.

Figure 4.1 illustrates the general cross section through the stabilized pile.

4.3.4 Demolition

Because of the higher expense for decontamination and the improbable chance of future usefulness, all mill buildings and other facilities have been demolished, and the resulting debris will be placed either in the stabilized tailings pile or in a trench northeast of the mill area depending on the degree of contamination. Asbestos was removed from the buildings and facilities prior to major demolition work. This was the most practical means of protecting the health and safety of the workers and for minimizing release of asbestos to the environment.

4.3.5 Subsurface conditions

Mine workings

Abandoned mine workings exist 580 feet beneath the southwest corner of the pile. An evaluation indicates that surface subsidence due to collapse of these workings would be too small to cause differential settlement that would result in cracking of the radon/infiltration barrier or surface water flow concentrations. Accordingly, the southwestern part of the pile in the area potentially affected by subsidence need not be relocated.

Geohydrological conditions

The low permeability radon/infiltration barrier will reduce infiltration of contaminants through the tailings to the groundwater. The low hydraulic conductivity and drainage slope of this barrier will preclude significant infiltration of water into the pile, through the tailings, and into the groundwater.

4.3.6 Geotechnical considerations

A portion of the tailings in the pile is relatively compressible and saturated. A test embankment was constructed to determine the in-place consolidation characteristics of the tailings. This test showed that the primary compression will be completed in a

matter of months; hence cracking of the radon/infiltration barrier from settlement should not be a problem. The tailings still contain areas of soft slimes which could, in the event of the design earthquake, decrease in strength. These facts lead to adoption of a buttress around the pile perimeter to ensure against slope instability. A special construction schedule is not needed to accommodate primary settlement since the test embankment showed primary settlement will occur during the proposed construction schedule.

Buttressing the perimeter with windblown materials makes it possible to reduce the sideslopes from 3.3:1 to 5:1 without excavating wet tailings. With 5:1 sideslopes, reasonably sized erosion protection material may be used and a stable slope created. The buttress provides increased resistance to slope movement during an earthquake, thus providing an adequate factor of safety against slope failure.

The tailings in the northern portion of the pile are also wet, i.e., well above the optimum moisture content. Therefore, it may be necessary to dry them by discing and evaporation before they can be placed and compacted to the specified density.

4.3.7 Surface hydrology

There are no perennial watercourses at the site. Flooding in the nearest perennial watercourse would not reach the pile. The only water that could affect the integrity of the pile is that which flows off the pile or from upslope watersheds north and east of the pile. Accordingly, the design includes construction of swales to the north and east of the pile, and grading of adjacent ground away from the pile on all sides.

Wide swales are preferred to narrower ditches for the following reasons:

- o Wide swales can convey the design flows with minimal erosion potential, thereby not requiring rock erosion protection.
- o Swale earthwork is easier to construct than rock-lined ditches.
- o Swales may be developed in conjunction with clearing wind-blown and off-pile contamination and relocation of tailings from the northern portion of the pile.

The swales are designed to carry frequent flows well away from the pile perimeter. Only flow from large precipitation events will flow against the pile, and erosion protection on the pile will protect against such flows. The swales are designed to reduce flow velocities below that considered to be erosive. Riprap toe protection around the pile perimeter will prevent erosion into the tailings.

4.3.8 Erosion protection

Protection against erosion will be provided by rock layers placed on the pile. Rock sizes have been designed to resist erosive forces of runoff flows from the pile and from flows in the north and east swales. In order to control erosion of natural ground around the pile, rock toe protection will be extended a suitable distance from the pile.

A natural vegetated soil cover was considered as an alternate erosion barrier but was rejected as unlikely to provide sufficient erosion protection, particularly on the sideslopes of the pile. The site area is one of sparse vegetation due to the semiarid climate and soil conditions. Ground cover could not be reliably established at the site without an unreasonably thick soil layer. An extended drought could cause the vegetation to die, which would leave the radon/infiltration barrier unprotected against erosion. Thus, a soil cover over the pile would increase the cost of remedial action.

Table 4.1 illustrates the recommended rock erosion protection requirements for final embankment topslopes and sideslopes. Rock material will be selected that satisfies the NRC criteria. An approved source of rock for erosion protection is an inactive U.S. Forest Service quarry northeast of the community of San Mateo (Figure 4.2).

4.3.9 Radon control

The EPA standards limit allowable radon emanation from the tailings pile. An uncontaminated soil radon/infiltration barrier is provided over the entire pile in order to achieve the applicable standard.

The design specifies placing less contaminated windblown soils over the combined in situ and relocated tailings. This reduces the radon emanation from the tailings and reduces the required radon/infiltration barrier thickness. The radon/infiltration barrier will consist of a layer of clean soil from a borrow area north of the site that will be placed over the pile and the relocated materials. Based on preliminary calculations, a radon/infiltration barrier 3.5 feet thick is required to reduce radon flux to the EPA limit of 20 pCi/m²s. Actual radon/infiltration barrier thickness will be determined during construction using data for in-place materials.

4.3.10 Economic considerations

To the maximum extent practicable, the design includes the formulation and adoption of methods that provide for the most economic construction consistent with meeting design standards, applicable criteria, and safe construction goals.

Table 4.1 Rock protection requirements for Ambrosia Lake tailings pile

Location	Rock size requirements (inches)	Layer thickness (feet)	Design flow (cfs) ^a	Volume (cubic yards)
Bedding	(b)	0.5		69,000
Top	$1.5 \leq D_{50} \leq 3.0$ $2.0 \leq D_{100} \leq 4.0$	0.5	0.96	98,000
Sideslopes	$3.7 \leq D_{50} \leq 5.4$ $5.0 \leq D_{100} \leq 7.0$	1.0	1.23	35,000
Riprap toe protection	$10 \leq D_{50} \leq 14$ $13 \leq D_{100} \leq 18$	2.3	1.26	31,000

^acfs - cubic feet per second.

^bA bedding layer will be provided under the rock erosion protection layer. Size and gradation of bedding material is adequate to protect against migration of materials at interfaces with radon/infiltration barrier and riprap layers.

The EPA standards can be met by stabilizing the tailings in place as described above. Stabilizing the tailings in place is less expensive and creates lesser environmental impacts than moving them to a new disposal site.

4.4 CONSTRUCTION FEATURES

4.4.1 Overview

Construction features include staging areas, decontamination facilities, temporary drainage ditches, wastewater collection and retention systems, and construction offices and facilities. A planned layout is described below to provide an overview of the implementation of remedial action. The exact location and size of construction features may be changed to facilitate construction activities.

The access control and decontamination area have been constructed near the southwest corner of the existing tailings pile, north of the existing main east-west road. The office area is south of the access control and decontamination area, across the main east-west road.

Site security has been accomplished by erecting a woven wire perimeter fence with an entrance gate at the access control and decontamination area. The perimeter fence will provide control of traffic entering and leaving the site and prevent unauthorized traffic from entering the area. Equipment will be decontaminated prior to leaving the controlled area.

FIGURE 4.2
BORROW SITE LOCATION - AMBROSIA LAKE SITE

Temporary diversion ditches on both the north and east sides of the site will prevent off-site surface water runoff from entering the site during remedial action construction. Collection ditches on the east, west, and south sides of the site will channel on-site contaminated runoff water to a wastewater retention basin.

Contaminated material on the site will be transported on temporary roads. New or existing permanent roads will not be required for transporting contaminated materials. A short temporary haul road will be required to transport the radon/infiltration barrier material. Part of this haul road will be located outside the designated site. New Mexico State Highway 59 and 53 North will provide access to the erosion protection borrow site.

Site utilities are shown in Figure 4.3. They will be protected, removed, or relocated during construction. Electricity is available from Public Service Company of New Mexico. Telephone service at the site can be obtained from USWest Communications.

An existing deep well southeast of the mill is planned to be used for a source of clean water for construction. The well was found to be usable during the demolition phase of the project.

4.4.2 Drainage, erosion control, and wastewater retention basin

Surface-water runoff from contaminated areas will be collected and drained to a retention basin. Uncontaminated water from clean areas will be diverted to off-site areas.

Runoff from contaminated areas will either be retained in the retention basin and evaporated or treated as necessary and discharged. Contaminated water will, to the extent practicable, be evaporated. Treatment and discharge may be necessary if runoff during the construction period exceeds the basin capacity, or if the water cannot be evaporated before completing radon/infiltration barrier construction. Controlled discharges from the retention basin will meet effluent limits established by a Federal point discharge permit. Emergency uncontrolled discharge will be used only as necessary to prevent failure of the retention basin.

Wastewater collection ditches will be designed to carry the peak flow from a 10-year storm event to a retention basin. Diversion ditches will be sized to carry the peak runoff flows from a 25-year storm event, thus preventing uncontaminated runoff from entering the site and possibly exceeding the retention basin capacity.

The wastewater retention basin will receive waters from:

- o Runoff over contaminated areas.
- o Minor processing site dewatering, if required.

FIGURE 4.3
UTILITY LOCATIONS AND RUBBLE DISPOSAL AREA, AMBROSIA LAKE

- o Decontamination activities including, equipment and truck washdown.
- o Washbasin and emergency shower facilities.

The retention basin at the site is sized to retain, as a minimum, runoff resulting from a 10-year, 24-hour storm event as well as wastewater generated from remedial action activities. The surface area of the basin is large enough to maximize evaporation. The retention basin has sufficient capacity to hold the total estimated sediment inflow during the project life. As a minimum, the emergency outlet from the basin will safely discharge the 25-year storm peak runoff while one foot of freeboard is maintained between the top of the embankment and the water surface with the emergency spillway when flowing at design depth.

4.4.3 Demolition

All buildings, facilities, abandoned equipment, and materials at the Ambrosia Lake mill site have been demolished; the contaminated demolition debris will be buried in the tailings pile or in a trench north of the mill area, depending on the degree of contamination. Contaminated material will not leave the site. Uncontaminated and slightly contaminated demolition debris will be disposed of in an area northeast of the mill buildings as shown in Figure 4.3. Asbestos was removed prior to major demolition activities, and was buried in the tailings pile. All demolition activities were controlled to restrict release of airborne contaminants and to protect workers. Asbestos removal in particular was also controlled by special measures to protect workers and the environment.

4.4.4 Dewatering

Dewatering of the tailings pond will be accomplished prior to or during construction. The water may be retained until it evaporates naturally or it may be treated and discharged. This water may also be used as compaction water or dust-suppression water for contaminated soils. Dewatering of tailings and borrow soil excavations is not anticipated because the groundwater depths are considerably below expected excavation depths.

4.4.5 Equipment decontamination pad

To prevent contaminated materials from being carried out of the construction areas, a decontamination pad with a holding tank and pump is provided at the access control and decontamination area to wash contaminated equipment. A washwater recycling system will be used to reduce the generation of contaminated water.

4.4.6 Dust control

Dust generated by excavation, earth movement, vehicle use, temporary materials stockpiling, and similar activities will be controlled by the use of water and/or water-based surfactants sprayed from hoses or trucks. Special care will be taken to control dust created by building decontamination or demolition and the temporary stockpiling or mixing of contaminated materials.

The sources of dust suppression water for use on contaminated areas will include recycled water from the wastewater retention basin and the tailings pond. Only uncontaminated water will be used in the uncontaminated areas.

The schedules for spraying the roads and pile areas will vary daily and will be adjusted as required. The frequency of spraying will increase when combinations of low soil moisture and high wind speed are encountered.

4.4.7 Borrow areas

Rock and soil borrow sites are shown in Figure 4.2. Sand, gravel, and cement are also available from local commercial sources.

4.4.8 Archeological sites

There are numerous archeological sites near the tailings pile and in areas to be disturbed during construction. These sites have been surveyed as required by state authorities according to Federal regulations. Mitigative measures will be taken at significant sites, or those sites will be protected during construction. Cultural resource clearance will be obtained for all areas to be disturbed during construction.

4.4.9 Construction sequence

The following construction sequence is probable for the remedial action within constraints. The construction subcontractor will be allowed some flexibility in executing the work; therefore, the actual construction sequence may differ from the following.

Initial construction activities have been completed and included sealing abandoned wells and providing temporary fencing, utilities, and associated facilities to be used for the remainder of the construction period. Wastewater retention basin and collection ditches were also constructed. Some of the uncontaminated materials excavated during construction of these facilities were stockpiled for later use as backfill, or used as fill during embankment construction. Temporary access and haul roads were constructed or upgraded at this time. Asbestos removal was accomplished prior to

major mill site demolition; the asbestos was buried in the pile. A perimeter fence and diversion ditches were also constructed.

Embankment construction is the next major construction phase at the site. This will include the following activities:

- o Disposing of all debris from demolished mill buildings and facilities in the pile, or in a trench north of the mill area, depending on the degree of contamination.
- o Shaping and buttressing the southern portion of the pile.
- o Relocating the northern portion of the pile to the southern portion.
- o Excavating and placing the remaining windblown-contaminated soils and other off-pile contaminated soils in the pile.

All work will conform with the detailed requirements for sequence of excavation and placement of contaminated materials given in the construction documents.

The final stages of remedial action will involve placement of the radon/infiltration barrier, bedding, and rock layers over the embankment; overall site grading; and restoration and revegetation of disturbed areas at the site and borrow area. A small area of the embankment will be left open temporarily for placement of the minor amount of contaminated materials cleaned-up during demobilization.

Demobilization will consist of removal of the staging areas, wastewater retention basin, decontamination pad, and temporary drainage ditches. Water remaining in the basins will be treated, if contaminated, and discharged. The contaminated sediments, sludges, and the bottom and sides of the basin and ditches will be excavated and incorporated into the tailings pile. The decontamination area and staging area will be destroyed and all contaminated items will be either cleaned for salvage or buried. All equipment used on the site will be inspected and decontaminated before removal from the site.

4.5 CONSTRUCTION SCHEDULE

The construction schedule presented in Figure 4.4 is based on a continuous construction effort of 18 months. The schedule reflects construction requirements and constraints discussed above in this section. The site preparation, asbestos removal, and demolition have been completed; however, the main tailings construction has been delayed until Federal funding becomes available in 1990.

FIGURE 4.4
REMEDIAL ACTION SCHEDULE - AMBROSIA LAKE SITE

5.0 GROUNDWATER PROTECTION

Groundwater in the uppermost aquifer at the Ambrosia Lake disposal site qualifies for supplemental standards (40 CFR Part 192.11 (e)). The supplemental standard application is based on the insufficient yield of the alluvium/weathered Mancos Shale and Tres Hermanos-C Sandstone that comprise the uppermost aquifer beneath the Ambrosia Lake site. The uppermost aquifer is incapable of producing 150 gallons per day or more for a sustained period of time which classifies it as limited use (class III) groundwater (Section D.8.4 of Appendix D). In addition to insufficient yield, the water contained in the alluvium/weathered Mancos Shale and Tres Hermanos-C Sandstone is of poor quality and cannot be used for drinking or other beneficial purposes.

The hazardous constituents within the tailings pore fluids at Ambrosia Lake are mostly metal and metalloid elements associated with the uranium milling process. Concentrations of arsenic, barium, cadmium, lead, molybdenum, nitrate, selenium, silver, uranium, and activities of gross alpha, radium-226 and -228 exceed the Maximum Concentration Limits (MCLs) established by the U.S. Environmental Protection Agency (EPA) in at least one tailings pore field sample collected from lysimeters or well points. Antimony, cobalt, copper, cyanide, fluoride, nickel, tin, vanadium, and zinc are inorganic hazardous constituents without MCLs, but were present in tailings pore fluid at concentrations higher than the laboratory method detection limit. No organic hazardous constituents were above laboratory method detection limits.

For this supplemental standards application, no concentration limits or point of compliance have been specified. This is justified considering that uranium processing activities established the condition of saturation in the alluvium/weathered Mancos Shale and the Tres Hermanos-C Sandstone. As part of the supplemental standards application, a risk assessment was performed to evaluate whether supplemental standards would protect human health and the environment from the consumption of groundwater in the uppermost aquifer. The risk assessment considered the hypothetical use of the uppermost aquifer as a source of drinking water. The results of the risk assessment indicate that there would be non-carcinogenic health effects associated with the long-term consumption of the groundwater. In addition, short and long-term carcinogenic health effects may occur. The concentration of uranium in the groundwater was the major contributor to carcinogenic risk. However, the likelihood of consumption of groundwater from the alluvium/weathered Mancos Shale and Tres Hermanos-C Sandstone is negligible because groundwater cannot be developed due to insufficient yield. Furthermore, the area of saturation is covered mostly by the tailings and the confines of the site boundaries, providing positive institutional control over the use of groundwater. A review of land and water use patterns in the site vicinity supports the application of supplemental standards. An engineering evaluation of the proposed remedial action design determined that the disposal cell protects human health and the environment by incorporate design features that are as close to meeting the otherwise applicable standard as is reasonably achievable.

Consumption of groundwater from the Westwater Canyon Member may also result in carcinogenic and non-carcinogenic health effects. Contaminated groundwater may have migrated down mine shafts and vent holes into the Westwater Canyon Member. The Westwater Canyon Member is a source of drinking water in the area,

but due to mining in the region, water quality has already deteriorated to the extent that there is some risk to human consumption. Groundwater in the Westwater Canyon Member exceeds the MCLs for cadmium, chromium, lead, molybdenum, selenium, silver, and uranium and activities of radium -226 and -228. However, mixing of contaminated groundwater from the Ambrosia Lake site with the Westwater Canyon Member groundwater has negligible effect on water quality in the Westwater and results in no additional risk to humans.

The proposed disposal cell cover at the Ambrosia Lake site is a low hydraulic conductivity clay radon barrier (saturated hydraulic conductivity of 1×10^{-7} centimeters per second (cm/s)), overlain by a high hydraulic conductivity (0.1 cm/s) filter layer and an erosion protection layer. The radon barrier will limit steady state vertical seepage (flux) through the tailings to between 1×10^{-6} and 1×10^{-7} cm/s. This flux is lower than the drainage capacity of the alluvium/weathered Mancos Shale, preventing tailings seepage from perching on the contact between the base of the tailings and the alluvium/weathered Mancos Shale. Because this flux is approximately equal to natural recharge at the Ambrosia Lake site, tailings seepage will not create a condition of saturation in the alluvium/weathered Mancos Shale at the contact with the Mancos Shale.

Following closure of the disposal cell, active maintenance of the cell will be minimized because it will be built with durable, natural materials meeting the longevity requirements of 40 CFR Part 192.02. Furthermore, the disposal cell is designed to accommodate natural forces such as erosion and frost heave.

A surveillance and maintenance (S&M) plan will be developed to address the various monitoring needs of the disposal cell, including biointrusion and soil erosion. The data collected will be used to evaluate the performance of the disposal cell.

The need for and extent of groundwater restoration at the Ambrosia Lake site will be based on the extent of existing contamination, the potential for current or future use of the alluvium/weathered Mancos Shale and Tres Hermanos-C Sandstone for drinking water supplies, and the technical practicability of restoring the aquifer. Studies are currently underway to develop plans, guidance materials, and procedures for aquifer restoration activities. Implementation will be through a separate Department of Energy (DOE) project after the EPA groundwater standards are finalized.

6.0 ENVIRONMENTAL, HEALTH, AND SAFETY

6.1 POLICY

The UMTRA Project health and safety policy requires the DOE and its contractors to take all reasonable precautions in the performance of the remedial action work to protect the environment and ensure the health and safety of employees and the public. The DOE and its contractors will comply with all applicable Federal and state health and safety regulations and requirements including but not limited to those established pursuant to the Occupational Safety and Health Act (OSHA).

The site Remedial Action Contractor (RAC) is responsible for implementing a site-specific health and safety program. The program should include an on-site professional radiation health staff responsible for implementing monitoring, sampling, training, and reporting procedures. The surrounding community and the on-site workers must be protected to prevent accidents and radiation exposure. The RAC will comply with the requirements of the UMTRA Project Environmental, Health, and Safety Plan (DOE, 1989b).

6.2 SITE CONDITIONS AFFECTING HEALTH AND SAFETY PLANNING

The remedial actions at the Ambrosia Lake site will require special attention to potential hazards because of the wide range of activities conducted at the site during its operation, the various toxic and hazardous materials which remain at the site, and the physical hazards that exist at the site and the nearby mines. This section describes those conditions known or suspected to exist at the site that will require special attention as remedial action activities proceed at the site.

Site utilities, as described in Appendix D, Site Characterization, Section D.11, Land Survey Data, can present a significant health and safety hazard if located within the area of potential disturbance. Gas and power lines and buried fuel storage tanks are present at the Ambrosia Lake site. A buried gas line exists, marked with yellow-flagged stakes and white signs spaced 0.25 mile apart. Unmarked gas lines feeding the individual mill buildings may exist around the mill yard. Electric power lines are above the ground, leading to a substation at the site. Buried power lines exist between the former mill area and the nearby Ann Lee Mine, and from the substation to the individual mill areas. The buried lines have been disconnected by locking out the breaker at the substation. Electrical transformers of unspecified age and coolant type are present at the designated site. Thus, the potential for polychlorinated biphenyls (PCBs) to be present exists.

Some containers of potentially hazardous materials were present on the site. The RAC prepared and implemented a plan for removal and/or safe disposal of these hazardous or toxic wastes that were not removed from the site by the site owner prior to the remedial action. This effort was conducted in accordance with requirements of the New Mexico Environmental Improvement Division and the EPA.

A fueling station is near the mechanics' shop and buried fuel tanks probably exist in that area. An additional underground gasoline tank has been reported near the Ann Lee Mine, 300 yards northwest of the mill site.

As with most remote, uninhabited sites in the Southwest, poisonous snakes may be encountered.

A number of abandoned mines exist near the site, presenting potential falling and cave-in hazards to intruders. Also, mine spoils stored nearby contain materials with elevated levels of radioactivity, and may contain undetonated explosives.

Elevated concentrations of airborne radionuclides have been documented during on-pile characterization activities. Gross alpha measurements of air filters have exceeded the Maximum Permissible Concentration for soluble Th-230 by factors of up to 800, and a problem with dust generation is expected during remedial activities when tailings are moved. Workers may be required to wear respirators if engineering controls cannot reduce airborne dust and radionuclide concentrations to acceptable levels.

The nearest emergency response facilities are in Grants, New Mexico, 30 minutes from the site. There is a hospital with 24-hour emergency service available at 1212 Bonita Ave. in Grants, as shown on the map in Figure 6.1. Phone numbers for local emergency response organizations are listed below:

Ambulance	1-287-7446
Cibola General Hospital	1-287-4446
Fire Department	1-287-4404
Police/Sheriff	1-287-4404

FIGURE 6.1
MAP SHOWING THE LOCATION OF CIBOLA GENERAL HOSPITAL, GRANTS, NM

7.0 RESPONSIBILITIES OF PROJECT PARTICIPANTS

7.1 INTRODUCTION

The following defines the various responsibilities of the DOE UMTRA Project Office, the NRC, and the State of New Mexico during design and remedial action, and through the initiation of custodial surveillance and maintenance. The State of New Mexico's responsibilities will be administered and coordinated by the New Mexico Environmental Improvement Division (NMEID).

Major areas of responsibility for future actions by the DOE, the State of New Mexico, and the NRC are summarized as follows:

- o DOE:
 - Manage and coordinate project.
 - Obtain permits and approvals.
 - Prepare detailed designs and specifications.
 - Prepare quality assurance plan.
 - Prepare Remedial Action Inspection Plan (RAIP).
 - Prepare and implement public participation and public information plans.
 - Provide funds.
 - Conduct remedial action.
 - Audit remedial action.
 - Prepare surveillance and maintenance plan.
 - Certify remedial action.
 - Conduct surveillance and maintenance.
- o State of New Mexico:
 - Review and concur in the RAP.
 - Assist DOE in acquiring or extinguishing the interests of land-owners or others with property interests at the designated disposal site.
 - Assist in obtaining local government approvals.
 - Issue state permits or approvals.
 - Assist in public participation and information.
 - Convey to the Federal government title to residual radioactive materials stabilized at the site.
 - Provide funds.
- o NRC:
 - Review and concur in the RAP including supplemental standards for groundwater protection.
 - Concur with the DOE on acquisition and disposition of lands and materials.
 - Review and concur in the RAIP.
 - Review and concur in the surveillance and maintenance plan.
 - Review and concur in the final certification report.

7.2 DETAILED RESPONSIBILITIES

Detailed responsibilities of project participants in the areas of permitting, licensing, land acquisition, detailed design, construction, health and safety, public information, radiological support, quality assurance, and custodial surveillance and maintenance are defined in the following text.

7.2.1 Regulatory compliance

Requirements for regulatory compliance, identified by Federal and state agencies, will be incorporated into the final design specifications as directed by the DOE. Revisions to the design and specifications resulting from internal DOE reviews will be incorporated prior to the agencies' review for permits.

The RAC will submit permit applications and supporting details to the Federal and state agencies for permit issuance.

During the remedial action, the DOE will audit construction activities for compliance with the provisions of the permits and approvals. (Permitting agencies may independently audit relevant activities consistent with normal practice.) Summary audit reports will be prepared by the DOE and submitted to appropriate Federal and state agencies as required. Depending upon agency comments, revisions to construction compliance activities may be made.

Upon completion of the permitted action, the DOE will conduct a final review and will prepare a close-out report for submittal to the Federal and state agencies as required. Permits will then be terminated.

7.2.2 Licensing

The NRC plans to issue a general license for post-remedial maintenance of Title I sites by amendment to 10 CFR 40 as proposed in the NRC advanced notice of proposed rule making of August 25, 1988. The NRC's concurrence in the site-specific surveillance and maintenance plan will render the site licensed. A draft site surveillance and maintenance plan will be submitted to the NRC prior to certification. Based on NRC comments, a final surveillance and maintenance plan will be prepared by the DOE and submitted to the NRC. The final plan will contain the site-specific surveillance and maintenance program, legal description of the site, site ownership, subsurface mineral ownership, and reporting and record keeping requirements.

7.2.3 Land acquisition

The State of New Mexico will assist the DOE in acquiring or extinguishing the interests of landowners, permittees, lessees, and

sublessees of, or other individuals with property interests in the processing and disposal sites. Upon NRC concurrence with DOE's certification of completion of the remedial action, legal title to the disposal site and attendant residual radioactive materials will be conveyed to the Federal government.

7.2.4 Detailed design

The RAC will prepare preliminary engineering drawings for review by the DOE. Based upon this review, the RAC will prepare final design drawings, specifications, and bid packages. Once finalized and approved by the DOE, the bid packages will be issued to prospective bidders pursuant to Federal regulations and a construction subcontractor selected.

Final design and specifications will be available to the NRC and the state upon request.

7.2.5 Construction

The DOE prepares guideline documents to comply with health and safety, security, quality assurance, public information, and other regulatory requirements. The RAC will prepare a site-specific remedial action inspection plan that will be reviewed and concurred upon by the DOE and NRC prior to the initiation of construction activities.

The RAC acquires the necessary permits and approvals from the appropriate agencies.

Site mobilization and initiation of construction activities will occur in accordance with the DOE-approved construction schedule.

Construction activities will be audited by the DOE. These audits will be provided to the NRC and the State of New Mexico, and to other regulatory agencies upon request. The state, NRC, and other regulatory agencies may also perform an independent audit of the remedial action. Revisions to the remedial action resulting from site audits will be incorporated into the as-built design and the remedial action plan by the DOE as necessary.

Upon completion of the remedial action, the site will be certified by the DOE. The NRC will review and concur in the final site certification report.

7.2.6 Health and safety

The environmental, health, and safety plan for the Ambrosia Lake site is found in Section 6.0 and was prepared in conformance with the UMTRA Project Environmental, Health, and Safety Plan (DOE,

1989b). Based upon this guidance, site-specific implementation procedures will be developed by the RAC. As part of the implementation procedures, the RAC institutes radiation control and environmental monitoring, and develops response procedures for severe weather and medical emergencies.

Construction contractors will comply with approved procedures and file reports with the DOE that record the results of monitoring, and report accidents and illnesses. Records will be maintained by the DOE following remedial action construction.

Employee and public complaints will be investigated by the DOE.

7.2.7 Public information

The DOE will establish a local site manager who will provide information to the public and local media. Prior to and during construction, the DOE, with assistance from the State of New Mexico officials and local citizens, will conduct public information meetings to inform the interested public of key aspects and current progress of the remedial action. Concurrent with the public meetings, the DOE will provide status and progress reports to the State of New Mexico and other agencies (e.g., NRC and EPA).

7.2.8 Radiological support

The DOE will prepare and implement a radiological support plan (Appendix C), and take measures to independently assure the quality of the analyses and their compliance with established procedures for site decontamination, verification, data and sample management, and certification.

After remedial action, the DOE will prepare a completion report, conduct a final verification survey, and provide a recommendation for site certification. The NRC will concur in the final site certification report.

7.2.9 Quality assurance

The Quality Assurance (QA) Plan for the Ambrosia Lake site is presented in Section 9.0 and has been prepared in conformance with guidelines established in the UMTRA Project QA plan (DOE, 1986). The DOE will audit and document the construction activities through audit reports.

7.2.10 Surveillance and maintenance

The DOE will prepare and submit to the NRC the site surveillance and maintenance plan (summarized in Section 8.0). The NRC will review and concur with the plan, and the DOE (or responsible

Federal agency designated) will ensure that the plan is implemented. Once the NRC concurs in the plan, the general license and its provisions will be in effect per the requirements of 10 CFR 40.

8.0 SURVEILLANCE AND MAINTENANCE

8.1 INTRODUCTION

The objective of the custodial surveillance and maintenance program is to ensure that the disposal site continues to function as designed. The custodial surveillance and maintenance program will be defined jointly by the DOE and the NRC in the proposed surveillance and maintenance plan and concurrence process. Following are the basic elements that may be included in this program.

8.2 SURVEILLANCE

8.2.1 Site inspections

Site inspections constitute a visual and definitive verification that the disposal site continues to function as designed. Inspections will consist of two phases: Phase I, a systematic walk-over designed to evaluate qualitatively the conditions of the disposal site and monitoring of displacement monuments; and Phase II, an investigation to assess quantitatively changes in the disposal site that could lead to functional failure of the design in the absence of custodial maintenance.

The Phase I walk-over will be conducted on a specific schedule, such as annually, by a team of qualified professionals. The inspection team will review as-built drawings, engineering details, available aerial photographs, and supporting documents. A site walk-over will then be performed to evaluate any changes at the site with regard to factors such as erosion, slope/cover stability, settlement, displacement, plant or animal intrusion, and access control. As part of the Phase I inspection, displacement monuments will be surveyed on a schedule to be determined during remedial action.

Based upon the evaluation and recommendations of the inspection team, a Phase II evaluation may be conducted to quantitatively determine the magnitude and rate of effect of changes in the above factors. From these studies, the need for corrective action (i.e., custodial maintenance) would be ascertained.

8.2.2 Aerial photographs

Aerial photographs may be used to supplement site inspections. The objectives will be to identify changes in site conditions (e.g., patterns of developing erosion that may affect the function of the design), provide visual documentation of long-term variation in site conditions, and identify activities (e.g., road conditions, storm drainage construction) adjacent to the site that may affect its function.

Aerial photographs may also be taken on a periodic schedule. Photographs will be taken at both low (i.e., high resolution) and high (i.e., for adjacent activities) altitudes, and at oblique and vertical angles. The type of film, ground control, camera specifications, amount of aerial overlap, interpretative keys, and other requirements will be established prior to completion of remedial action.

8.2.3 Reporting

Summary reports that evaluate the results of surveillance activities and recommend needed custodial maintenance (i.e., corrective actions), along with future surveillance and monitoring requirements, will be prepared. Reports and supporting documentation will be placed on file with the DOE, NRC, and State of New Mexico.

8.3 CUSTODIAL MAINTENANCE

The need for custodial maintenance (i.e., corrective action) can only be determined following site inspection and monitoring. However, it is anticipated that custodial maintenance will consist primarily of the following:

- o Limited soil/rock replacement due to unanticipated erosion, human or animal intrusion, or cover disturbance--these activities are expected to be required infrequently.
- o Control of deep-rooted plants by infrequent application of herbicides or physical removal as required.
- o Mechanical repairs to warning signs, when necessary.

8.4 CONTINGENCY PLANS

Procedures will be developed to inspect and perform custodial maintenance of the disposal site upon the occurrence of severe meteorological events (e.g., extreme rainfall), seismic events, or unusual human intrusion.

9.0 QUALITY ASSURANCE

9.1 GENERAL

The RAC shall provide and maintain an effective QA program and procedural system to ensure that all work, materials, supplies, and services required under the contract conform to contract requirements, whether constructed or processed by the RAC or its subcontractors or procured by subcontractors or vendors. The RAC shall perform or have performed adequate inspections and tests to ensure and substantiate that all work, materials, supplies, and services conform to contract requirements.

The RAC shall furnish a QA test and inspection plan that defines the health, safety, and environmental activities to be incorporated into the design and/or performed during construction to ensure contract compliance and site certification. Test and inspection requirements shall be approved by the DOE prior to the start of any physical job site construction work under this contract. If the RAC revises the plan, the RAC shall concurrently furnish a copy of the revision to the DOE for approval prior to implementing the revision on work under the contract.

9.2 QUALITY ASSURANCE PLAN

Before construction operations are started, the RAC shall meet with the authorized DOE QA representative to review and discuss the RAC's proposed QA plan. The meeting shall develop mutual understanding relative to details of the individual site plan requirements, including the formats to be used for recording and reporting tests and inspections, administration of the plan, personnel assignments, and the interrelationship between the RAC and the DOE QA representative. The RAC shall furnish a list of the procedures required to implement the project plan. This list shall include, at a minimum, procedures for data collection, analyzing samples, inspection, and testing, and formats of reports to be used.

9.3 DAILY INSPECTION REPORT

The RAC shall prepare a daily report for every day worked and a weekly summary report covering the RAC's and/or subcontractor's operations in an appropriate format. These daily reports shall be maintained at the site until work is complete. These reports shall provide complete and factual evidence that continuous, effective quality control construction inspections and tests have been performed, including but not limited to: (1) the type and number of inspections and tests involved; (2) the results of inspections and tests; (3) the nature of deficiencies requiring corrections; and (4) the corrective actions taken or to be taken.

The RAC shall maintain current records of all inspections and shall furnish, as part of the files at the end of the project, copies of the inspection reports and all other files appropriate to each individual subcontract. The reports of inspection shall cover all work placement

subsequent to the previous report and shall be verified by the RAC's designated QA representative.

9.4 MEASURING AND TEST EQUIPMENT CALIBRATION AND CONTROL

The RAC shall provide measuring and test equipment having the precision and accuracy needed to establish conformance with specified quality assurance requirements. Calibrations shall be in accordance with nationally recognized standards. The RAC shall identify procedures for calibrating and recalling test equipment.

9.5 NONCONFORMANCE

A nonconformance and change procedure system shall be developed by the RAC and approved by the DOE.

9.6 RECORDS CONTROL

The RAC shall be responsible for generating, retaining, and retrieving legible records that provide objective evidence of conformance to the specified quality requirements. These records shall be considered valid only if they are completed and signed or otherwise authenticated and dated by authorized personnel. These records should include, but are not limited to:

- o Data on radionuclides in soil.
- o Air monitoring data.
- o Design review files.
- o Water contaminant analysis.
- o Data on personnel radiation exposure.
- o As-built drawings.
- o Test and inspection reports.
- o Engineering specifications.
- o Material certifications.
- o Certificates of compliance.
- o Reports and corrective action requests.
- o Operating procedures.
- o Change orders.
- o Reports of unusual occurrence.

All records shall be available to the DOE for review upon request. All personnel radiation exposure records shall be turned over to the DOE upon completion of the remedial action.

9.7 CODES AND STANDARDS

The RAC shall have on the job site, no later than three weeks after site mobilization, the applicable quality assurance codes and standards available for ready reference by all personnel. The RAC shall maintain at

the job site copies of all approved-for-construction drawings, specifications, and other documents that describe the remedial action.

9.8 RECORD DRAWINGS

The RAC shall develop QA procedure systems to ensure the use of authorized (approved-for-construction) drawings and specifications and the maintenance of current record drawings. Two full-sized sets of contract drawings shall be used by the RAC for this purpose. All variations from the contract drawings shall be depicted. Generally, the drawings shall reflect only changes and/or corrections to data and dimensions shown on contract drawings. Where the contract specifications or drawings permit a choice in material or equipment, the type of material or equipment used shall be shown on the drawings. The drawings shall be maintained in a current condition at all times, and shall be made available for review by the DOE at all times. Variations from the contract drawings shall be shown in the contract working drawings and shall be incorporated into the record drawings. Upon physical completion of the contract work, two reproducible copies of these drawings shall be furnished to DOE.

9.9 MATERIAL CERTIFICATION

The technical specifications may require that certain materials be certified. Two types of certifications that may be specified are:

- o Certificate of compliance.
- o Certified material test report (CMTR). When a CMTR is requested from the RAC or its subcontractors, it shall be accompanied by a certificate of compliance certifying that the tested material is actually that material incorporated in the work.

9.10 QUALITY ASSURANCE PROGRAM VERIFICATION

The DOE may verify that the QA Program is being implemented by:

- o Review of daily or weekly summary reports.
- o On-site inspections and surveillances.
- o Periodic audits.
- o Acceptance of DOE QA recommendations based on DOE QA audits of RAC activities.
- o Any combination of the above.

9.11 REMEDIAL ACTION FIELD CHANGES

During the course of remedial action, design changes are expected to occur. Some of these changes may impact compliance with EPA Standards, but most changes are expected to be unrelated to critical design elements of the stabilized tailings pile. The following sections define three classes of changes and establish guidelines to be used when implementing changes.

9.11.1 Class 1 changes

A Class 1 change is a change which may affect compliance with the EPA Standards (40 CFR Part 192). Class 1 changes will be reflected in a Modification to the RAP, which will ultimately result in a change to the appropriate State Cooperative Agreement. The NRC and the affected state will be required to concur on all Class 1 changes.

Class 1 changes include, but are not limited to, the following:

- o Discovery of unusually high levels of residual radioactive materials which will change the radon emission concentrations post-remedial action according to the final design as presented within the final RAP.
- o Disposal of hazardous/mixed wastes within the disposal cell.
- o Changes in the radon/infiltration barrier thickness or permanent erosion protection.
- o Adjustments to contract specifications which affect the major aspects of design such as infiltration, radon flux, stability, or groundwater contamination.

9.11.2 Class 2 changes

A Class 2 change is a change to any permanent construction feature which does not clearly affect compliance with the EPA Standards. Class 2 changes will be forwarded to the NRC and the affected state for informative purposes. At any time that the NRC and/or state feel a change has been incorrectly designated as Class 2, the change may be redesignated as Class 1 upon verification of error. By approaching Class 2 in such a manner, construction delays will be avoided, and the NRC and state will consistently be aware of all changes affecting the RAP. Class 2 changes will not require cooperative agency concurrence, and will not require a modification to the RAP or Cooperative Agreement.

Class 2 changes include, but are not limited to, the following:

- o Adjustments to specifications which will not affect the major aspects of design, such as permeability, infiltration, radon flux, or groundwater contamination.
- o Requests for additional well sealing for newly discovered wells.
- o Changes in disposal cell perimeter access road.
- o Changes in location of permanent fencing.
- o Changes in location of monuments.
- o Changes in location of construction/excavation materials.
- o Changes to contract specifications which do not affect compliance with the EPA standards.

9.11.3 Class 3 changes

A Class 3 change is a change to temporary features which have no impact on the design for the stabilization of the tailings pile. Class 3 changes will not require cooperative agency concurrence and may be approved by a representative of the Remedial Action Contractor (RAC) of appropriate supervisory position.

Class 3 changes include, but are not limited to, the following:

- o Change in location of temporary fencing.
- o Alteration of temporary drainage facilities, roads, or site office facilities.
- o Changes in stockpile location of construction/excavation materials.

9.11.4 General requirements

The general requirements which are to be fully understood and commonly interpreted by all parties (DOE, NRC, state) in utilization of the above classification of changes are as follows:

- o All changes will be logged on a Project Interface Document (PID), which will be initiated by the Remedial Action Contractor (RAC) and forwarded to the DOE Project Office (PO). The DOE PO will then forward copies of the PID and supporting data, if required, to the NRC and the affected state as outlined below.
- o Each change will be classified promptly by the RAC and concurred upon by the DOE PO, with input from the TAC if

needed, immediately following notification from the field. Contact for DOE concurrence will be documented in the space provided on the PID.

- o For all Class 1 changes, the DOE will notify the NRC and state no later than one working day after notification by the RAC. The NRC and the state will then be copied on all pertinent data necessary for review and concurrence or comment within one working day after receipt of same by the DOE PO. This may be transmitted verbally or telefaxed prior to formal issuance.
- o RAP Modifications may be handled as a group as opposed to separate issuance of individual modifications for each Class 1 change.
- o For all Class 2 changes, appropriate justification data will be forwarded to the NRC and state as submitted to the DOE PO by the RAC. This may be transmitted following verbal or telefaxed notification as noted under the third general requirement above. Written justification will be forwarded by the DOE PO within five working days after receipt.
- o For all Class 1 changes requiring immediate approval to avoid impacting construction, the DOE/state/NRC shall give that change top priority for expeditious review and approval as necessary to avoid delay.
- o Comment or non-occurrence by the state or NRC will be accompanied by a technical evaluation supporting the area in question.
- o For all Class 3 changes, the PID will be forwarded to the NRC and the affected state within a reasonable time.
- o The RAC shall maintain an up-to-date record of all changes for all sites. In addition, the DOE PO will maintain an up-to-date file of all PIDs.

10.0 PUBLIC INFORMATION AND PARTICIPATION

10.1 INTRODUCTION

Section III of the UMTRCA states,

In carrying out the provisions of this title, including the designation of processing sites, establishing priorities for such sites, the selection of remedial action and the execution of cooperative agreements, the Secretary (of Energy), the Administrator (of the Environmental Protection Agency), and the (Nuclear Regulatory) Commission shall encourage public participation and, where appropriate, the Secretary shall hold public hearings relative to such matters in the state where processing sites and disposal sites are located.

It is the intent of the public information and public participation program to inform the interested public fully and use the feedback in the decision-making processes and remedial action activities related to the Ambrosia Lake site. The following sections describe the actions the DOE and the State of New Mexico will take and have taken to encourage the participation of an informed public in this project.

10.2 PUBLIC PARTICIPATION

The National Environmental Policy Act (NEPA) of 1969 requires an evaluation of the environmental impacts of major Federal actions that may significantly affect the environment. Before remedial action construction began, an EA was completed for the Ambrosia Lake site. Public participation is an important part of the preparation of the EA; the participation requirements are detailed in the Council on Environmental Quality Regulations (effective July 1979) for implementing the provisions of the NEPA, and in the DOE guidelines of 1980 for NEPA compliance.

In preparing the EA, the DOE conducted individual meetings with community officials, interest groups, and private citizens to discuss the purpose of the proposed remedial actions and ascertain the extent of public interest in this project. At these meetings the public was given the opportunity to express their concerns and identify what they believe to be significant issues.

The identified issues were documented in the EA and incorporated into the decision-making process. The DOE accepted written comments for a 30-day period after publication of the EA. The EA was discussed at a public meeting held after publication of the EA and prior to the close of the comment period.

In addition to meetings on the EA, the DOE continues to hold public information meetings in the area to describe the progress on the project.

Informal meetings and briefings are held to provide information and project status updates and solicit public participation in the project

activities. The DOE, state and local officials, and interested citizens are involved in frequent discussions regarding remedial action construction schedules, radiation monitoring reports, groundwater protection plans, and other project activities.

10.3 PUBLIC INFORMATION

In order for public participation to be effective, the public must be informed concerning the remedial action project at the Ambrosia Lake designated site. Several methods of information dissemination are used by the DOE. Press releases, background statements, media briefings, or other necessary types of information dissemination are provided for the general public and appropriate officials at an early stage in the implementation of any new task or activity of interest.

Information is provided to interested persons in the Federal government, state administration, and private citizens in the Ambrosia Lake area. The names and addresses of individuals, media representatives, and Federal, state, and local officials are contained in a computerized list for information dissemination purposes. A continuing effort is made to update and expand the mailing list.

A public preconstruction meeting was conducted by the DOE. Principal topics of discussion included the remedial action plan and construction methods and schedules.

An on-site representative will be designated by the DOE to respond to public inquiries during the remedial action main construction. This representative provides information and meets frequently with the public throughout the construction period.

A variety of printed materials have been prepared concerning the UMTRA Project and the Ambrosia Lake designated site. These include project fact sheets, a site fact sheet, and EA. As they are printed, these materials and other fact sheets and documents are sent to interested individuals and made available in local public libraries, local governmental offices, and the New Mexico Environmental Improvement Division. The same materials are also available at DOE-designated libraries nationwide.

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Zoback, M. L., and M. Zoback, 1980. "State of Stress in the Western United States," U.S. Geological Survey Open File Report, 80-801, pp. 359-408.

GLOSSARY

absorbed dose, radiological	The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad. One rad equals 100 ergs per gram.
alluvium	Unconsolidated sediments composed of sands, silts, clays, and gravels deposited by late Quaternary fluvial systems.
alpha particle	A positively charged particle emitted from certain radionuclides. It is composed of two protons and two neutrons, and is identical to the helium nucleus.
aquifer	A formation containing sufficiently saturated permeable material to yield significant quantities of water to wells and springs.
background radiation	Levels of radiation or concentration of radionuclides that are typical of an undisturbed area, or an area not affected by residual radioactive material.
beta particle	Charged particle emitted from the nucleus of an atom, with mass and charge equal to those of an electron.
bioassay	A method for quantitatively determining the concentration of radionuclides in a body by measuring the quantities of those radionuclides that are eliminated from the body, usually in the urine or the feces.
confined aquifer	An aquifer bounded above, and possibly below, by continuous beds or strata of much lower permeability. In general, a confined aquifer contains water under pressure that is significantly greater, or less than, the normal hydrostatic pressure gradient of water created by the force of gravity.
contamination	In this report, the presence of radioactive material in undesirable concentrations and in undesirable locations.
daughter product(s)	A nuclide resulting from radioactive disintegration of a radionuclide, formed either directly or as a result of successive transformations in a radioactive series; it may be either radioactive or stable.
decay, radioactive	Disintegration of the nucleus of an unstable nuclide by spontaneous emission of charged particles, photons, or both.
decontamination	The reduction of radioactive contamination from an area to a predetermined level, set by a standards-setting body such as the EPA, by removing the contaminated material.
DOE	U.S. Department of Energy.
disintegrations per minute or second	The number of radioactive decay events occurring per minute or second.

disposal	The planned, safe, permanent placement of radioactive waste.
dose	A general term denoting the quantity of radiation or energy absorbed, usually by a person. For special purposes, it must be qualified; if unqualified, it refers to absorbed dose.
dose, absorbed	The amount of energy imparted to matter by ionizing radiation per unit mass of irradiated material at the point of interest; given in units of rads.
dose commitment	The cumulative dose equivalent that results and will result from exposure to radioactive materials over a discrete time period; given in units of rems.
dose equivalent	The quantity that expresses all kinds of radiation on a common scale for calculating the effective absorbed dose, defined as the product of the absorbed dose in rads and modifying factors, especially the qualifying factor; given in terms of rems. Often abbreviated "dose."
dose, external	The absorbed dose that is due to a radioactive source external to the individual as opposed to radiation emitted by inhaled or ingested sources.
dose, internal	The absorbed dose or dose commitment resulting from inhaled or ingested radioactivity.
EA	Environmental Assessment.
EIS	Environmental Impact Statement.
EPA	U.S. Environmental Protection Agency.
exposure	A measure of the ionization produced in air by X or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of the air in the volume element. The unit of exposure is the roentgen (R).
floodplain	Lowland or relatively flat areas that are subject to a one percent or greater probability of flooding in any given year (i.e., a 100-year or more frequent floods).
flux, radon	The emission of radon gas from the earth or other material, usually measured in units of picocuries per square meter per second (pCi/m ² s).
gamma dose	Radiation dose caused by gamma radiation.
gamma logging (or logs)	A technique for determining gamma radiation levels at various depths in a borehole.

gamma ray or radiation	High-energy electromagnetic radiation emitted from some radionuclides. The energy levels are specified for different radionuclides.
gamma spectral analysis (gamma spectroscopy)	An analytical technique for identifying radionuclides based on their different gamma energy levels.
groundwater	Water below the land surface that occupies the voids within a geologic unit or formation.
half-life	The time required for a radioactive substance to lose 50 percent of its activity by decay. Each radionuclide has a unique half-life.
hydraulic conductivity	The volume of groundwater that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow.
hydraulic gradient	The change in hydraulic head per unit of distance in a given direction. If not specified, the direction is generally understood to be in the maximum rate of decrease in hydraulic head.
internal dose	The absorbed dose or dose commitment resulting from inhaled or ingested radioactivity.
isotopes	Nuclides having the same number of protons in their nuclei, but differing in the number of neutrons; the chemical properties of isotopes of a particular element are almost identical.
licensing	In this report, the process by which the NRC will, after the remedial actions are completed, approve the final disposition and controls over a disposal site.
maintenance, custodial	The repair of fencing, repair or replacement of monitoring equipment, revegetation, minor additions to soil cover, and general disposal site upkeep such as mowing grass.
Modified Mercalli (scale)	A standard scale for the evaluation of the local intensity of earthquakes based on observed phenomena such as the resulting level of damage. Not to be confused with magnitude, such as measured by the Richter scale, which is a measure of the comparative strength of earthquakes at their sources.
monitor	To observe and make measurements resulting in data for evaluation of the performance and characteristics of the disposal site.
NEPA	National Environmental Policy Act.
NRC	U.S. Nuclear Regulatory Commission.
OSHA	Occupational Safety and Health Administration.

pachuca tank	Large vessel used for air agitation of uranium ore during batch leaching.
passive institutional controls	Those controls that require action by a governmental agency to preclude human contact with the waste or require a continuing social order. Examples include Federal ownership of a disposal site, monuments on the site, records with agencies, and physical barriers (e.g., riprap covers, vegetation, waste burial).
PERM	Passive environmental radon monitor. A radon monitoring device, which, when placed at a point for a period of time, responds proportionally to the average radon concentration in the air.
permeability	A measure of the relative ease with which a porous medium can transmit a liquid under a potential gradient. It is a property of the medium alone and independent of the liquid properties and the force field causing movement. Technically, the permeability of a medium is the volume of liquid of unit kinematic viscosity that will move in unit time under a unit potential gradient through a unit area at right angles to the direction of flow.
permissible dose	The dose of ionizing radiation that is considered acceptable by standards-setting bodies such as the EPA. Also, the dose of radiation that may be received by an individual within a specified period with the expectation of no substantially harmful result.
person-rem	Unit of population exposure obtained by summing individual dose-equivalent values for all people in the population. Thus, the number of person-rem attributed to one person exposed to 100 rems is equal to that attributed to 100 people each exposed to one rem.
picocurie	A unit of radioactivity defined as 0.037 disintegrations per second.
piezometric surface	An imaginary surface that represents the static level of the water (hydraulic head) in one specified aquifer.
promulgate	To make known by open declaration; proclaim.
PSCR	Processing Site Characterization Report.
rad	A unit of measure for the absorbed dose of radiation. It is equivalent to 100 ergs per gram of material.
radioisotope	A radioactive isotope of an element with which it shares almost identical chemical properties.
radionuclide	A radioactive nuclide.
radium-226 (Ra-226)	A radioactive daughter product of uranium-238. Radium is present in all uranium-bearing ores; it has a half-life of 1620 years.

radon-222 (Rn-222)	An inert gas continuously generated by the decay of Ra-226 in rock and soil with a half-life of 3.8 days generating a series of non-gaseous radioactive decay products.
radon daughter product	One of several short-lived radioactive daughter products of radon-222. All are solids.
RAC	Remedial Action Contractor
RAP	Remedial Action Plan.
RDC	Radon daughter concentration.
recharge	The process by which water is absorbed by surficial soils or geologic units and is added to the zone of saturation.
ROD	Record of Decision; final decision document of the NEPA process.
rem	A unit of dose equivalent equal to the absorbed dose in rads times quality factor times any other necessary modifying factor. It represents the quantity of radiation that is equivalent in biological damage to one rad of X-rays.
soil infiltration rate	The rate at which water enters the soil surface and moves vertically downward.
soil percolation rate	The rate at which water moves through soil in all directions.
stabilization	The reduction of radioactive contamination in an area to a predetermined level by a standards-setting board such as the EPA, by encapsulating or covering the contaminated material.
standard Proctor	A test procedure to measure moisture-density relationship (ASTM D698).
surveillance	The observation of the disposal site for purposes of visual detection of need for custodial care, evidence of intrusion, and compliance with other license and regulatory requirements.
TAC	Technical Assistance Contractor.
tailings, uranium-mill	The waste material remaining after most of the uranium has been extracted from uranium ore.
thorium-230 (Th-230)	A radioactive daughter product of uranium-238; it has a half-life of 80,000 years and is the parent of radium-226.
transmissivity, hydraulic	A measure of the ability of an aquifer to transmit water. The value of transmissivity is equal to the product of the hydraulic conductivity and the thickness of the aquifer.
UMTRA	Uranium Mill Tailings Remedial Action.
UMTRCA	Uranium Mill Tailings Radiation Control Act of 1978.

unconfined aquifer	An aquifer that has a water table.
uranium-238 (U-238)	A naturally occurring radioisotope with a half-life of 4.5 billion years; it is the parent of uranium-234, thorium-230, radium-226, radon-222, and others.
vicinity property	A property in the vicinity of the Ambrosia Lake site that is determined by the DOE, in consultation with the NRC, to be contaminated with residual radioactive material derived from the site, and which is determined by the DOE to require remedial action.
water table	The upper surface in an unconfined groundwater body (i.e., unconfined aquifer) at which the pressure is equal to atmospheric pressure. This surface is defined by the level to which water will rise in a well penetrating the upper portion of an unconfined aquifer.
working level (WL)	A measure of radon daughter product concentrations. Technically, it is any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of alpha particles with a total energy of 130,000 MeV.
working-level month (WLM)	Exposure to a worker resulting from inhalation of air with a concentration of one WL of radon daughters for 170 working hours. Continuous exposure of a member of the general public to one WL for one year results in approximately 51.5 WLM.

This printing of the Ambrosia Lake final Remedial Action Plan (RAP) contains revisions based on review comments received by the Uranium Mill Tailings Remedial Action (UMTRA) Project Technical Assistance Contractor since the RAP was last published. These revisions have been incorporated into the current text.

AMBROSIA LAKE REMEDIAL ACTION PLAN (RAP) ERRATA LISTING
Dated 11/01/91

Page	Section # Paragraph/Sentence	Errata/Correction/Change
Executive Summary	Executive Summary	Deleted entirely.
Covers	Volumes I and II, Inside and outside covers	Changed date on inside and outside covers of Volumes I and II to November 1991.
1	Last paragraph, last sentence	Corrected Section reference to Section 7.0.
2	Paragraph 4	Corrected to: "...Engineering Design, which had been included in Appendix B of the draft RAP, has been superseded by the subcontract specifications, special conditions, and drawings for subcontract AMB-04 (main site construc- tion) in Appendix F."
2	Last paragraph, sentence 1	Corrected the reference "DOE,1989" to "DOE, 1989a"
21	Paragraph 4, last sentence	Corrected to: "...Appendix F, <u>Subcontract</u> <u>Documents</u> ,..."
38	Figure 3.18, Title	Changed to: "...Ambrosia <u>Lake</u> Tailings".
40	Paragraph 4, sentence 3	Deleted "foot per foot".
40	Paragraph 4, sentence 2	Deleted "ft/ft."
51	Figure 4.2	Figure changed to show that the rock borrow site is not on private land.
58	Figure 4.4	Changed to reflect new 36- month schedule.
60	Paragraph 2, sentence 1	Corrected "c/ms" to "cm/s."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
60	Paragraph 2, sentence 2	Changed to: "...through the tailings to <u>between 1 x 10⁻⁶ and 1 x 10⁻⁷ cm/s....</u> "
61	Paragraph 2, last sentence	Deleted quotation marks and added underlining to: <u>UMTRA Project Environmental, Health, and Safety Plan.</u>
61	Paragraph 5	Changed to: "Some containers of potentially hazardous materials <u>were</u> present on the site. The RAC prepared and implemented a plan for removal and/or safe disposal of <u>these</u> hazardous or toxic wastes that <u>were</u> not removed from the site by the site owner prior to the remedial action. This effort <u>was</u> conducted..."
67	Section 7.2.3, last sentence	Changed to: "Upon <u>NRC concurrence with DOE's certification of....</u> "
67	Paragraph 1, sentence 1	Deleted quotation marks and added underlining to: <u>UMTRA Project Environmental, Health, and Safety Plan.</u>
77	Third bulleted item	Changed to: "Changes <u>in</u> disposal cell perimeter access road."
80	Last bulleted item, second sentence	Changed to: "In addition, the DOE PO will maintain <u>an</u> up-to-date file of all PIDs."
81	Reference	Changed "DOE, 1989" to "DOE, 1989a."
81	References	On references for DOE, 1989b and DOE, 1984, changed document numbers from "UMT-" to " <u>UMTRA-</u> ."
81	References	Deleted reference for "Haywood et al., 1980."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
82	References	Added reference for: "ORNL (Oak Ridge National Laboratory), 1980. <u>Radiological Survey of the Inactive Uranium Mill Tailings at Ambrosia Lake, New Mexico</u> , ORNL-5458, Health and Safety Research Division, Oak Ridge, Tennessee."
D-51	Paragraph 2, sentence 2	Corrected reference date to: "(Purtymun et al., 1977)".
D-51	Paragraph 3, last sentence	Corrected reference to: "Hunt (1934)..."
D-52	Paragraph 3, last sentence	Corrected reference to: "(Kelley, 1963)."
D-59	Paragraph 1, sentence 2	Corrected spelling of "terraces."
D-62	Paragraph 1, sentence 1	Clarified abbreviation "mm/yr" by adding "millimeters per year."
D-62	Paragraph 2, sentence 2	Corrected reference to "(Smith, 1978)."
D-63	Paragraph 1, sentence 2	Deleted USCGS.
D-63	Paragraph 2, sentence 1	Corrected "(DuBois et al., 1982)" to "(Dubois et al., 1982)".
D-64	Paragraph 2, sentence 6	Corrected reference to: "(Plate 2)."
D-73	Paragraph 3, sentence 2	Corrected to: "Appendix F, Subcontract Documents, discusses in detail potential flood events and their relation to remedial action design."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
D-76	Paragraph 2, sentence 3	Corrected to: "Appendix F, Subcontract Documents, discusses in detail the geological and engineering aspects of the mine void problem and quantifies the long-term potential for subsidence."
D-78	Paragraph 4, sentence 4	Corrected to: "Two levels of room and pillar type workings underlie the southwest corner of the tailings pile at a depth of 580 feet (Appendix F, Subcontract Documents)."
D-79	Paragraph 3, last sentence	Corrected to: "Alternative quantifications of potential subsidence are discussed in calculations accompanying Appendix F, Subcontract Documents."
D-85	Paragraph 3, sentence 1	Corrected references to: "... (Kelley, 1963; Santos, 1970; Smith and Peterson, 1980)."
D-86	Paragraph 1, last sentence	Deleted.
D-86	Paragraph 2, sentence 1	Corrected to: "As discussed above, a floating earthquake would produce an on-site PHA of 0.21g were it to occur at a distance of nine miles (15 km) from the site."
D-86	Paragraph 3, sentence 1	Corrected to: "Derived from the field studies of Thaden et al. (1967c)..."
D-88	Paragraph 3, sentence 1	Corrected to: "...performed by Santos (1966a,b), Thaden et al., (1967a,b), and Maxwell (1977a-d)."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
D-88	Paragraph 3, sentence 5	Corrected to: "...; however, field inspection of the mesa edges and fault scarps indicates that, on these <u>structures</u> ,..."
D-93	Paragraph 3, last sentence	Corrected to: "The liquefaction potential of the site and tailings material <u>is</u> evaluated in <u>Appendix F, Subcontract Documents.</u> "
D-115	Table D.4.2, Paragraph 2, sentence 7	Corrected spelling of: "abundant."
D-127	Table D.4.9, Reference	Corrected spelling in reference to: "Bonilla."
D-130	Section D.5.1.2, paragraph 3, sentence 2	Clarified acronym "pcf" by adding: "pounds per cubic foot (pcf)."
D-132	Paragraph 6, sentence 1	Clarified acronym "psf" by adding: "pounds per square foot (psf)."
D-151	Section D.6.1.1, paragraph 1, sentence 2	Added reference: "(DOE, 1988)..."
D-178	Paragraph 4, sentence 3	Clarified acronym "SPT" by adding: "Standard Penetration Test (SPT)"
D-178	Paragraph 5, sentence 3	Corrected reference date to: "...Nelson et al. (1983 b)..."
D-201	Section D.8.1, paragraph 1, last sentence	Corrected reference date to: "(DOE, 198 9):"
D-202	Summary section, paragraph 3, sentence 3	Deleted "foot per foot."
D-203	Paragraph 1, sentence 1	Deleted "ft/ft."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
D-203	Paragraphs 3 through 5	Corrected "radium 226 and 228" to "radium-226 and -228..."
D-207	Paragraph 1, sentence 1	Deleted "ft/ft."
D-208	Paragraph 4, sentence 1	Corrected spelling of reference: "... (Thompson and Heggen, 1981)."
D-208	Paragraph 4, sentence 2	Corrected spelling of reference: "... (Ganus, 1980)."
D-208	Paragraph 5, Last sentence	Corrected spelling of reference to: "...Thompson and Heggen, 1981)."
D-221	Section D.8.9, paragraph 3, sentence 3	Corrected spelling of: "quantity."
D-235	Figure D.8.12, title correction	Corrected to: "Equipotential map for Tres Hermanos-C2 sandstone, Ambrosia Lake site, New Mexico."
D-237	Figure D.8.14, reference	Corrected to: "NMEID, 1980."
D-239	Figure D.8.16 reference	Corrected: "Kelly, 1981" to "Kelly, 1980."
D-241	Figure D.8.18, reference	Corrected: "Kelly, 1981" to "Kelly, 1980."
D-254	Table D.8.2, Footnote "a"	Corrected to: "Figure D.8.20."
D-260	Table D.8.8, Title	Changed to: "...Quivira Mining Company...."
D-273	Table D.8.21, Footnote "a"	Corrected to: "Figure D.8.27."
D-282	Section D.9.6, sentence 3	Corrected to: "(Locito, 1985)."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
D-290	Paragraph 3, last sentence	Changed to: "The transport of tailings by water erosion has occurred in all directions from the pile (ORNL, 1980)."
D-291	Section D.10.4, paragraph 1, sentence 2	Clarified acronym "HEC" by adding: "Hydrology Engineering Center (HEC)"
D-291	Section D.10.4, paragraph 4, sentence 2	Changed to: "Additional PMP calculations to support the final design in Appendix F, Subcontract Documents, have been prepared by the RAC."
D-292	Section D.10.4 paragraph 5, last sentence	Changed to: "Additional PMF calculations to support the final design in Appendix F, Subcontract Documents, have been prepared by the RAC."
D-292	Section D.10.5, paragraph 1, sentence 1	Corrected first reference to: "(<u>FBD</u> , 1983)."
D-300	Table D.10.3, references	Corrected references to: " <u>40 CFR 192</u> ; <u>WOCC</u> , 1986."
D-305	Section D.12.1, paragraph 2, last sentence	Corrected reference to: "(<u>FBD</u> , 1983)."
D-305	Section D.12.1, paragraph 3, last sentence	Corrected reference to: "(<u>FBD</u> , 1983)."
D-307	Section D.12.5, paragraph 1, sentence 1	Corrected reference to: "(<u>FBD</u> , 1983)."
D-309	References	Corrected the order of Abel, J.F., 1985 and Abel, J.F., and F.T. Lee, 1984.
D-309	Reference	Corrected spelling of "Arabasz", 1979.

Page	Section # Paragraph/Sentence	Errata/Correction/Change
D-312	Reference	Inserted: "CASA (Complete Archaeological Service Associates), 1985. <u>Cultural Resource Inventory, Ambrosia Lake, New Mexico Tailings Site</u> , prepared for Jacobs Engineering Group, Inc., Albuquerque, New Mexico."
D-315	Reference	Inserted: "DOE (U.S. Department of Energy), 1988. <u>Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings at Ambrosia Lake, New Mexico</u> , UMTRA-DOE/AL-050516.0000, DOE UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico."
D-313	Reference	For "DOE, 1986", added: " <u>Albuquerque Operations Office</u> ."
D-313	Reference	For "DOE, 1983", deleted comma from "...DOE, UMTRA..."
D-316	Reference	Deleted: "Haywood et al., 1980."
D-317	Reference	Inserted: "Hunt, C.B., 1967. <u>Physiography of the United States</u> , W. H. Freeman and Company, San Francisco, California."
D-317	Reference	Deleted: "Kelley, V.C., 1963," and deleted "b" from Kelley, V.C., 1963b.

Page	Section # Paragraph/Sentence	Errata/Correction/Change
D-318	Reference	Corrected to: "Kelley, V.C., and N.J. Clinton, 1960. "Fracture Systems and Tectonic Elements of the Colorado Plateau," University of New Mexico, published in <u>Geology</u> , No. 6."
D-318	Reference	Corrected to: "Kelly et al. (T.E. Kelly, R.L. Link, and M.R. Schipper), 1980. 'Effects of Uranium Mining on Ground Water in the Ambrosia Lake Area, New Mexico,' in <u>Geology and Mineral Technology of the Grants Uranium Region 1979</u> , C.A. Rautman, ed.; New Mexico Bureau of Mines and Mineral Resources Memoir 38, pp. 313-319.
D-320	Reference	Inserted: "Menges, C.M., 1983. 'The Neotectonic Framework of Arizona: Implications for the Regional Character of Basin-Range Tectonism,' State of Arizona, Bureau of Geology and Mineral Technology, Open-File Report 83-19."
D-320	Reference	Inserted: "Merlan, T., 1985. New Mexico State Historic Preservation Officer, Santa Fe, New Mexico, personal communication to John Themelis, Project Manager, DOE UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico, dated September 25, 1985."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
D-321	Reference	Inserted: "Molenaar, C.M., 1977. 'Stratigraphy and Depositional History of Upper Cretaceous Rocks of the San Juan Basin Area, New Mexico and Colorado, with a Note on Economic Resources,' New Mexico Geological Society <u>Guidebook</u> , 28th Field Conference, San Juan Basin III."
D-321	Reference	Added: "NMEID (New Mexico Environmental Improvement Division), 1983. Unpublished 'Water Quality Data for United Nuclear Corporation and Quivira Mining Company,' Groundwater Section, Santa Fe, New Mexico."
D-322	Reference	Added "a" and "b" to the two references "Nelson et al., 1983."
D-322	Reference	Inserted: "New Mexico Geological Society, 1982. 'Physiographic Map of New Mexico,' in New Mexico Highway Geologic Map, scale 1:3,500,000."
D-324	Reference	On second line of reference for "Sanford et al., 1979," deleted open quotation marks before <u>micity</u> ; typographical error.
D-325	Reference	In reference for Santos, E.S., and R.E. Thaden, 1966c, deleted the "c."
D-326	Reference	Changed order to: "Smith, R.B., 1978," then "Smith, D.A., and R.J. Peterson, 1980."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
D-329	Reference	Changed reference for Wells et al. ..., 1985, to <u>1983a</u> and deleted "1983" after "eds.,"
D-329	Reference	Changed reference for Wells et al. ..., 1983, to <u>1983b</u> and deleted "1983" after "eds.,"
D-329	Reference	Moved "Wells, S.G., and T.W. Gardner, 1985" to precede "Wells, S.G., and A.A. Gutierrez, 1982."
D-329	Reference	Deleted: "Wells et al., 1983."
D-329	Reference	In "Zoback, M.L., and M.D. Zoback, 1980a", deleted the "a."
D-329	Reference	Deleted: "Zoback, M.L., and M.D. Zoback, 1980b."
E-i	Table of Contents, E.2	Corrected Section E.2 heading to: "CONCEPTUAL DISPOSAL CELL DESIGN FEATURES TO PROTECT WATER RESOURCES."
E-ii	List of Figures, Figure E.2.1	Corrected to: "Typical <u>embankment</u> cross section [delete of disposal cell], Ambrosia Lake site [delete , New Mexico]"
E-4	Figure E.2.1	Replaced with updated Figure E.2.1.
E-9	Paragraph 1, sentence 2	Inserted acronym "(PMP)" after "Probable Maximum Precipitation."
E-11	Section E.3, title	Aligned title.
E-17	Section E.3.1.2, paragraph 1, sentence 3	Corrected to: "The supplemental standards application is presented in Addendum A to Appendix E..."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
E-20	Section E.3.2, sentence 6	Corrected to: "The findings of these are summarized in Section E.3.2.3 and presented in detail in Addendum A to Appendix E."
E-23	Paragraph 1, last sentence	Corrected to: "The complete risk assessment is provided in Addendum A to Appendix E."
E-24	Section E.3.3, paragraph 3, sentence 1	Corrected to: "Sections <u>E.2.1</u> and E.3.2..."
E-24	Section E.3.3, paragraph 6	Corrected to: "...tailings embankment from runoff resulting from a [deleted Probable Maximum Precipitation] <u>PMP</u> event or a [deleted Probable Maximum Flood] <u>PMF</u> event."
E-26	Table E.3.4, appearance	Added horizontal lines before and after text to enhance appearance. Deleted periods after listed items.
E-26	Table E.3.4, third scenario	Corrected spelling of "desiccation".
E-27	Reference	Inserted: "EPA (U.S. Environmental Protection Agency), 1989. Draft-final 'Standard for Remedial Actions at Inactive Processing Sites, Ground-water Protection Standards,' Office of Radiation Programs, EPA, dated March 8, 1989, Washington, D.C."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
E-27	Reference	Inserted: "NMEID (New Mexico Environmental Improvement Division), 1983. Unpublished 'Water Quality Data for United Nuclear Corporation and Quivira Mining Company,' Groundwater Section, Santa Fe, New Mexico."
E-27	References	"NRC, 1988," and "Rush et al., 1982," last lines, corrected to Washington, D.C."
Addendum A; -ii-	List of Figures, heading	Corrected to "Figure," as there is only one figure.
Addendum A; -ii-	List of Tables, Table A2.6	Corrected to: "Table A2.6 Formula for calculating potency factors"
Addendum A; -1-	Section A1.0, bulleted item 2	Corrected to: "The groundwater has widespread ambient contamination not caused by <u>the</u> UMTRA Project site [delete <u>1</u>] that cannot be cleaned up using methods reasonably employed by public water supply systems."
Addendum A; -1-	Section A1.0, paragraph 3, last sentence	Changed to: "...could include stock watering <u>or</u> industrial uses (EPA, 1989)."
Addendum A; -1-	Section A1.0, last paragraph, sentence 1	Changed to: "The hydro-stratigraphic units at the Ambrosia Lake site <u>of interest for this discussion</u> are, in descending order,..."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
Addendum A; -3-	Section A1.0, paragraph 3 sentence 2	Inserted 2: "The presence of the Quivira tailings pile updip of the Ambrosia Lake site, to the southwest, has caused groundwater contamination in the Tres Hermanos Sandstones and the Dakota Sandstone. The uranium ore body that was mined in the Ambrosia Lake region is in the Westwater Canyon Member. Uranium mineralization in the Westwater Canyon Member is responsible for high background concentrations of hazardous constituents in the aquifer. Mine stope backfilling and old stope leaching in ore zones within the Westwater Canyon Member have also raised background concentrations of hazardous constituents within the aquifer. Mine water discharges to the Arroyo del Puerto have also resulted in elevated concentrations in alluvial groundwater along the arroyo."
Addendum A; -3-	Section A1.0, paragraph 5, sentence 1	Corrected to: "... (see Attachment 1, Land and Water Use, of this addendum)."
Addendum A; -3-	Section A1.0, paragraph 6, sentences 1 and 2	Corrected to: "Ninety percent of the land in McKinley County is used for low-density grazing, since the rangeland <u>supports only</u> five to six cattle per square mile; the historic land use was also for low-density grazing. Uranium milling and ... (see Attachment 1 of this addendum)."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
Addendum A; -4-	Section A1.0, paragraph 1, sentence 1	Corrected to: "The potential human and environmental exposure pathways for possible contact with hazardous <u>constituents</u> were examined."
Addendum A; -4-	Section A1.0, paragraph 1, sentence 2	Inserted as sentence 2: "Because the tailings cell is designed to prevent surface seepage of tailings fluids and there is no discharge of contaminated groundwater to surface water or water in the unsaturated zone within the site vicinity, there is no potential surface water pathway for exposure to hazardous constituents."
Addendum A; -4-	Section A1.0, paragraph 1, sentence 4	Changed to: "Furthermore, due to <u>the</u> limited yield and poor <u>water</u> quality, the water...
Addendum A; -4-	Section A1.0, paragraph 1, sentence 5	Changed to: "...weathered Mancos Shale extends <u>only</u> marginally..."
Addendum A; -4-	Section A1.0, paragraph 1, sentence 8	Changed to: "...However, dilution of the contaminated groundwater with <u>water in</u> the Westwater Canyon Member..."
Addendum A; -4-	Section A1.0, paragraph 1, sentence 10	Changed to: "However, due to mine dewaterings and mine shafts in the area, the Westwater <u>Canyon Member</u> is incapable..."
Addendum A; -4-	Section A1.0, paragraph 4, sentence 3	Changed to: "...would be harmful to human health and to help substantiate that the proposed supplemental standards for <u>the</u> Ambrosia Lake <u>site</u> are protective..."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
Addendum A; -5-	Section A1.0, paragraph 1, last sentence	Changed to: "Similar conclusions would be...conducted for the Westwater <u>Canyon Member</u> water quality, since..."
Addendum A; -5-	Section A1.0 paragraph 2, sentence 1	Changed to: "Various design and engineering options... for disposal of the tailings at <u>the Ambrosia Lake site</u> (see discussions in text Section 4.0 and Appendix F)."
Addendum A; -5-	Section A1.0, paragraph 2, sentence 3	Corrected to: "Additional options...were rejected for various reasons (see Section <u>A3.3</u> of this discussion)."
Addendum A; -5-	Section A1.0, paragraph 2, sentence 4	Changed to: "...infiltration to <u>between 1 x 10⁻⁶ and 1 x 10⁻⁷ centimeters....</u> "
Addendum A; -5-	Section A1.0; last paragraph, sentence 2	Corrected to: "By limiting infiltration through the tailings, <u>further</u> contamination [delete 'source'] will be substantially decreased."
Addendum A; -7-	Section A2.1, paragraph 1, sentence 1	Changed to: "A qualitative risk...scope of <u>a</u> more comprehensive..."
Addendum A; -7-	Section A2.2, paragraph 1, sentence 1	Changed to: "Indicator chemicals represent those..., and therefore those <u>that are</u> of greatest concern at a site."
Addendum A; -8-	Section A2.3.1, sentence 1	Changed to: "As was discussed in...for this assessment <u>was</u> the ground-water pathway."
Addendum A; -8-	Section A2.3.1, sentence 3	Changed to: "As a result,...if contaminated groundwater <u>were</u> recovered for use."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
Addendum A; -8-	Section A2.3.2, sentence 1	Changed to: "As indicated by the water use discussion...Mancos Shale <u>or</u> Tres Hermanos-C <u>Sandstone</u> ."
Addendum A; -8-	Section A2.3.2, sentence 2	Changed to: "Therefore, in order to characterize...is considered <u>in</u> this discussion."
Addendum A; -8-	Section A2.3.3, paragraph 1, sentence 2	Changed to: "The first scenario...shallow well [delete 'of'] approximately 0-50 feet <u>deep</u> ,..."
Addendum A; -8-	Section A2.3.3, paragraph 1, sentence 3	Changed to: "The second scenario...ingestion of groundwater from a deep well [delete 'of']...50-150 feet <u>deep</u> ..."
Addendum A; -10-	Section A2.3.3, paragraph 1, sentence 2	Changed to: "An exposure dose was...calculating the unit carcinogenic risk <u>did</u> not allow..."
Addendum A; -9-	Tables A2.1 & A2.2	Added extra space between Tables A2.1 and A2.2.
Addendum A; -9-	Table A2.2, Title	Changed to: "...dose <u>through</u> ..."
Addendum A; -9-	Table A2.2	Changed reference to: "EPA, 1986 <u>a</u> " and added period to end of reference.
Addendum A; -10-	Paragraph 2, sentence 2	Changed to: "An ingestion rate of two liters [delete /] <u>per</u> day..."
Addendum A; -10-	Paragraph 1, sentence 2	Changed reference to: "(EPA, 1986 <u>a</u>)".
Addendum A; -12-	Table A2.4	Changed second source to: "EPA, 1986 <u>b</u> " and changed note to delete "... <u>From</u> <u>Federal</u> ... p. 34843."
Addendum A; -12-	Table A2.6	Changed note to: "Ref: EPA, 1986 <u>a</u> ."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
Addendum A; -13-	Table A2.7,	Added horizontal line above table text "Scenario B."
Addendum A; -17-	Section A3.1, paragraph 1, sentence 1	Corrected to: "... (see discussion in text Section 4.0, Site Design, [deleted <u>Appendix B, Engineering</u> <u>Design.</u>] and Appendix F, Subcontract Documents)."
Addendum A; -18-	Section A3.3, paragraph 3, last sentence	Changed to: "...is large compared to the small reduction in retention time of <u>stormwater</u> [delete 'runoff off'] <u>on</u> the pile."
Addendum A; -21-	References	Spelled out all state names (i.e., PA to Pennsylvania; NM to New Mexico; DC to D.C., and MD to Maryland) throughout reference list.
Addendum A; -21-	Reference	Changed to: "EPA ... 1986 <u>a</u> "
Addendum A; -21-	References	Added: " <u>EPA (Environmental Protection Agency), 1986b. 'Water Pollution Control; National Primary Drinking Water Regulations; Radionuclides,' 40CFR Part 141 (51 FR 34836, 9-30-86), Washington, D.C.</u> "
Addendum A; -22-	References	Changed "Storms, E., 1989," to: "...communication <u>with</u> Peter..", and initially capitalized the 'e' and 's' to correct title to Environmental Specialist.
Addendum A; -22-	References	"Vanderslice, B., 1989," initially capitalized the 'e' and 's' to correct title to Environmental Specialist.
Add. A, Attach. 1 pg. -7-	Section 4.0 paragraph 2, last sentence	Changed to: "...land use in the area and will not gene- rate significant <u>population</u> changes."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
Add. A, Attach. 1 pg. -9-	Section 5.1, paragraph 1, sentence 2	Changed to: "Ninety percent of the land [delete 'use'] in the county is <u>used</u> for this purpose."
Add. A, Attach. 1 pg. -9-	Section 5.1, paragraph 1, sentence 3	Changed to: "Some land is also <u>used</u> ..."
Add. A, Attach. 1 pg. -9-	Section 5.1, paragraph 1, sentence 4	Changed to: "Commercial timber operations <u>used</u> approximately seven percent of the land."
Add. A, Attach. 1 pg. -9-	Section 5.2, paragraph 1, all	Changed to: "The Federal government...equally between the [delete 'U.S.']. . ." and "Some BLM and <u>U.S.</u> Forest Service land..."
Add. A, Attach. 1 pg. -23-	Addendum A, Attach. 1, References	Spelled out all state name abbreviations (i.e., NM to New Mexico; DC to D.C.) throughout reference list.
Add. A, Attach. 1 pg. -23-	Reference	Inserted: "BLM (Bureau of Land Management), 1981. <u>State of New Mexico - Land Ownership and Public Management</u> , prepared by the U.S. Department of the Interior, Bureau of Land Management, Washington, D.C."
Add. A, Attach. 1 pg. -24-	Reference	Corrected "FBDU, 1981" to: <u>Engineering Assessment of Inactive Uranium Mill Tailings, Phillips/ Nuclear Site, Ambrosia Lake, New Mexico</u> , DOE/UMTRA-0113, FBDU 360-13, UC-70, <u>Contract No. DE-AC04-76GJ016758</u> , prepared by FBDU, Salt Lake City, Utah, for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico."

Page	Section # Paragraph/Sentence	Errata/Correction/Change
Add. A, Attach. 2 pg. -7-	References	Spelled out all state name abbreviations (i.e., GA to Georgia; WY to Wyoming) throughout reference list.
Add. A, Attach. 2 pg. -7-	Reference	Corrected reference listing for TSDR to " <u>ATSDR</u> ."
Add. A, Attach. 2 pg. -8-	Reference	Changed "Stokinger,... 1981" to: "...Sons, New York, <u>New York</u> ."
Add. A, Attach. 3 pg. -7-	References	Spelled out all state name abbreviations (i.e., MN to Minnesota; FL to Florida) throughout reference list.
Add. A, Attach. 4	No corrections	No corrections in Addendum A, Attachment 4.