DOE/EA - 0322

Environmental Assessment

Remedial Action at the Ambrosia Lake Uranium Mill Tailings Site Ambrosia Lake, New Mexico

June, 1987

DOE/EA-0322

ENVIRONMENTAL ASSESSMENT

OF

REMEDIAL ACTION AT THE AMBROSIA LAKE

URANIUM MILL TAILINGS SITE

AMBROSIA LAKE, NEW MEXICO

TEXT

JUNE, 1987

U.S. DEPARTMENT OF ENERGY

UMTRA PROJECT OFFICE

ALBUQUERQUE, NEW MEXICO

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U.S. DEPARTMENT OF ENERGY

ABSTRACT

This document assesses and compares the environmental impacts of various alternatives for remedial action at the Ambrosia Lake uranium mill tailings site located near Ambrosia Lake, New Mexico. The designated site covers 196 acres and contains 111 acres of tailings and some of the original mill structures. The Uranium Mill Tailings Radiation Control Act (UMTRCA), Public Law 95-604, authorizes the U.S. Department of Energy to clean up the site to reduce the potential health impacts associated with the residual radioactive materials remaining at the site and at associated properties off the site. The U.S. Environmental Protection Agency promulgated standards for the remedial action (40 CFR Part 192). Remedial action must be performed in accordance with these standards and with the concurrence of the Nuclear Regulatory Commission. The proposed action is to stabilize the tailings at their present location by consolidating the tailings and associated contaminated materials into a recontoured pile. A radon barrier would be constructed over the pile and various erosion protection measures would be taken to assure the long-term stability of the pile. Another alternative which would involve moving the tailings to a new location is also assessed in this document. This alternative would generally involve greater short-term impacts and costs but would result in stabilization of the tailings at an undeveloped location. The no action alternative is also assessed in this document.

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1.0 SUMMARY

1.1 PROJECT SUMMARY

The Ambrosia Lake tailings site is located approximately 20 air miles north of the town of Grants in McKinley County, New Mexico (Figure 1.1). The site is situated in the Ambrosia Lake valley in the Grants Uranium District. In the 1970s, the Grants Uranium District was one of the most active in the U.S., having between 38 and 45 mines in operation within a 50-mile radius of Grants, New Mexico. After the collapse of the domestic uranium market in the early 1980s, the majority of mines and support operations closed. Businesses that supported the mining industry were similarly adversely affected. By the end of 1986, only two mines were in operation. Both mines, which are located within six miles of the Ambrosia Lake site, employ about 235 workers. Ore from Chevron's Mt. Taylor mine is shipped to its mill in Panna Maria, Texas; the Homestake mining operation uses its mill approximately 10 miles northwest of Grants.

The topography of the area surrounding the Ambrosia Lake site consists of broad valleys separated by elongated mesas. Small ephemeral streams drain the immediate area toward the southwest.

The Ambrosia Lake area is semi-arid with annual precipitation less than 11 inches. Plant species common to the area include Russian thistle, squirreltail grass, and snakeweed. The dominant land uses are grazing and uranium mining. The closest town is San Mateo (unincorporated) approximately 15 air miles southeast. The immediate area surrounding the tailings site is very sparsely populated. The nearest residence is more than two miles away; approximately 60 people live within a six-mile radius.

The Phillips Petroleum Company built the Ambrosia Lake mill in 1957 and began operations in 1958. United Nuclear Corporation bought the mill in 1963 and ceased operations shortly thereafter. The Ambrosia Lake mill was designed to process uranium ores by a closed-circuit carbonate leach method. During milling operations, approximately three million tons of ore were processed to produce 6536 tons of uranium concentrate (FBDU, 1981).

The Ambrosia Lake tailings site consists of the tailings pile and the mill site. The existing tailings pile is roughly square in shape with a slightly concave top. Dikes composed of native soil and tailings have been constructed around the edges of the pile, but no other measures to stabilize the pile have been undertaken. The tailings pile covers approximately 111 acres and averages approximately 17 feet in depth. Approximately 2.7 million cubic yards of tailings are contained in the pile.

The mill site includes the main mill building, offices, a laboratory, garages, and other structures and equipment (Figure 1.2). The mill structures have been abandoned and are in poor repair.

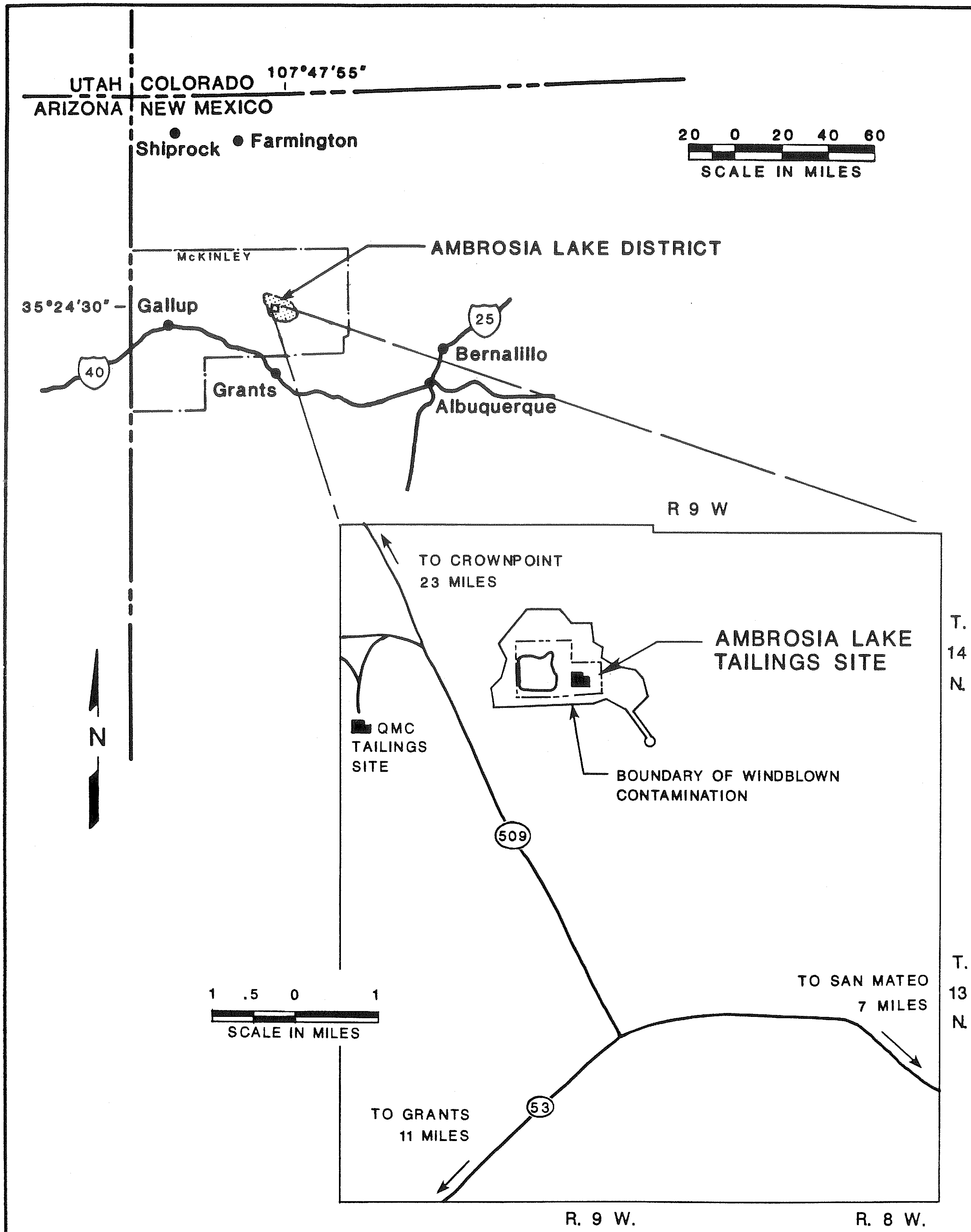


FIGURE 1.1 AMBROSIA LAKE SITE LOCATION

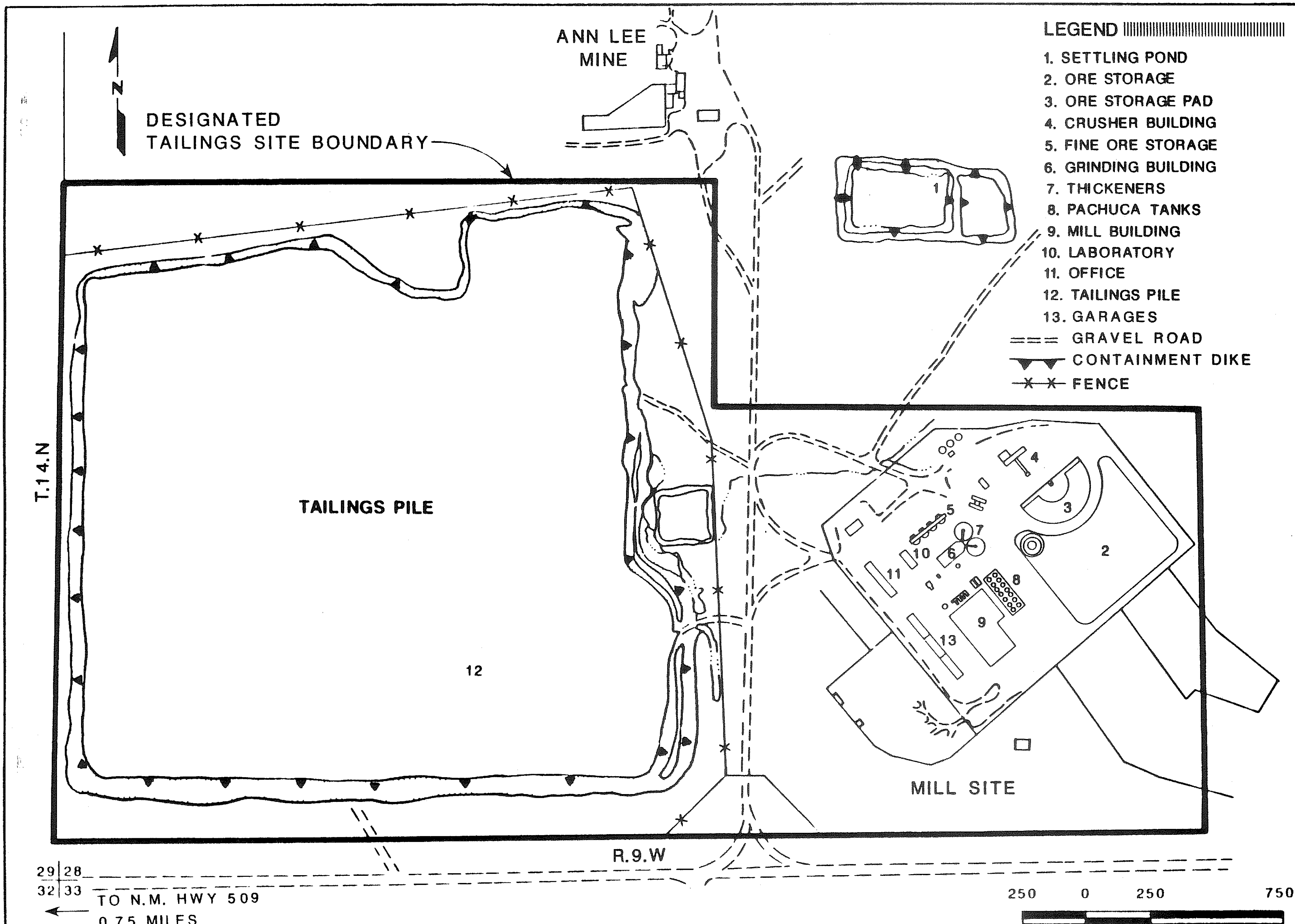


FIGURE 1.2 AMBROSIA LAKE TAILINGS SITE

Wind and water erosion have spread the contamination over approximately 570 acres surrounding the tailings pile both on and off the designated site (Figure 1.1). The main cause of erosion is from wind; however, surface water has caused some erosion of the dike on the eastern edge of the pile. The total volume of contaminated materials, including the tailings and contaminated soils beneath and around the tailings (i.e., windblown), is 4.6 million cubic yards.

Vicinity properties are properties that are located outside a designated tailings site boundary and that may have been contaminated by tailings dispersed by wind or water erosion or by removal by man before the potential hazards of the tailings were known. Vicinity properties are typically located by aerial radiological surveys or by on-site, mobile gamma ray scanning. Surveys of the Ambrosia Lake area resulted in the determination that there are no vicinity properties outside the tailings site and adjacent area contaminated by windblown tailings. Remedial action within the area of windblown contamination would be performed concurrently with cleanup of the tailings site. Environmental impacts from cleanup of windblown tailings are assessed in this document. The potential environmental impacts of remedial action at vicinity properties at other Uranium Mill Tailings Remedial Action (UMTRA) Project sites were previously assessed in a programmatic environmental report (DOE, 1985). Impacts to any vicinity properties associated with the Ambrosia Lake tailings outside the tailings site and adjacent area of windblown contamination that may be located prior to remedial action are expected to be similar to those assessed in the programmatic environmental report and are therefore not considered in this EA.

The principal potential hazard associated with the tailings results from the production of radon, a radioactive decay product of the radium contained in the pile. Radon, a radioactive gas, can diffuse through the pile and be released into the atmosphere where it and its radioactive decay products (radon daughters) may be inhaled by humans. Increased exposure to radon and its decay products over a long period of time will increase the probability that health effects (i.e., cancers) may develop in persons living and working near the pile. Exposure to gamma radiation, the inhalation of airborne radioactive particulates, the ingestion of contaminated food produced in the area around the tailings, and the ingestion of surface and ground waters contaminated by the tailings also pose potential hazards. If the tailings are not properly stabilized, erosion by wind or water or human removal of contaminated materials could spread the contamination over a much wider area and increase the potential for public health hazards.

The Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), Public Law 95-604 (PL95-604), authorized the U.S. Department of Energy (DOE) to perform remedial action at the Ambrosia Lake tailings site (as well as at many other sites) to reduce the potential public health impacts from the residual radioactivity remaining in the pile. The U.S. Environmental Protection Agency (EPA) promulgated standards (40 CFR Part 192) in March, 1983, for this remedial action.

The proposed remedial action for the Ambrosia Lake tailings is stabilization in place. All of the tailings and windblown contaminated soils would be consolidated with the existing tailings pile, and the resulting pile would be recontoured to have 20 percent sideslopes (five horizontal to one vertical) and a gently sloping top. The pile would then be covered with a layer of compacted earth to inhibit radon emanation and water infiltration. The top and sides of the pile would be covered with a layer of sand and rock to protect the pile against erosion, penetration by animals, and inadvertent human intrusion. Rubble and asbestos from demolition of the mill site would be disposed in the tailings pile in accordance with applicable State and Federal regulations. The top of the stabilized pile would average 50 feet above the surrounding terrain. Drainage swales would prevent surface runoff from concentrating on the pile. Areas disturbed by remedial action would be restored in accordance with applicable permits or approvals and released for unrestricted use.

The no action alternative would consist of taking no remedial action at the tailings site. The tailings would remain in their present location and condition and would continue to be susceptible to erosion and unauthorized removal and use by man.

Disposal of the tailings at the Section 21 alternate disposal site would involve moving all of the contaminated materials to a site approximately one mile north of the existing tailings site (Figure 1.3). This land is used primarily for low density livestock grazing. The site is approximately 2.5 miles from the nearest residence. The tailings would be placed in a partially below-grade pile and covered with compacted earth, sand, and rock; mill rubble would be buried below grade similar to stabilization in place. The existing tailings site would be restored and released for unrestricted use.

1.2 IMPACT SUMMARY

This section contains a quantitative listing of the short-term (i.e., during 18 months of remedial action) and long-term (i.e., post-remedial action) environmental impacts of the proposed action (Table 1.1) and a brief discussion of the major differences between the proposed action and the other alternatives. The impacts presented here are based on conservative impact assessment methods and represent a realistic upper limit of the severity of the potential impacts for stabilization in place.

No action alternative

Selection of the no action alternative would not be consistent with the intent of Congress in UMTRCA (PL95-604) and would not result in the DOE's compliance with the EPA standards (40 CFR Part 192). This alternative would result in the continued dispersion of the tailings over a wide area by wind and water erosion, and the tailings would not be protected against unauthorized removal by humans. Continued dispersion and unauthorized removal and use of the tailings could cause radiological contamination of other areas and could result in greater public health impacts than those calculated for this alternative.

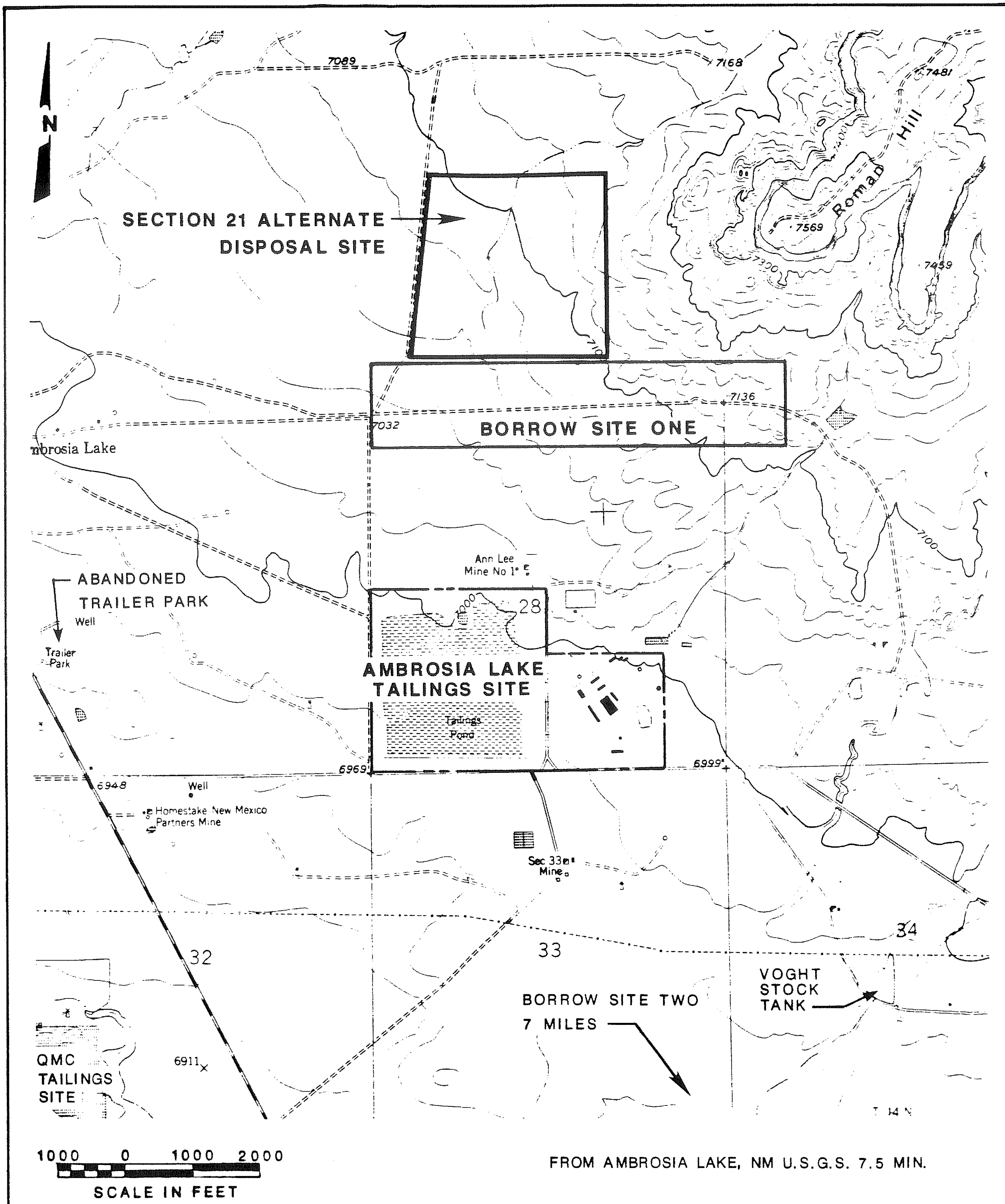


FIGURE 1.3 ALTERNATE DISPOSAL SITE LOCATION

Table 1.1 Environmental impacts of the proposed action

Environmental component	Impacts
Remedial action worker health	Estimated 0.01 fatal cancers; 3.9 injuries (equipment use only).
Public health[a]	Estimated 0.01 excess fatal cancers in first 10 years; 0.02 excess fatal cancers in 1000 years.
Mineral resources	Consumption of 993,000 cubic yards of borrow materials (earth, gravel, and rock).
Soils	97.5 acres of soils lost (95 acres occupied by stabilized tailings pile and surveillance and maintenance road and 2.5 acres of soils lost for road improvements); 671 acres of soils disturbed.
Water resources	Possibly minor impacts to water quality in Westwater Canyon Member for a short distance downgradient of Ann Lee Mine (400 feet) over 100 years.
Water consumption	29,000,000 gallons.
Air quality (nonradiological, 24-hour maximum)	359 micrograms per cubic meter increase in total suspended particulates (TSP) during remedial action at the Ambrosia Lake tailings site; exceeds state standard and Federal primary and secondary TSP standards; small increase in fuel combustion pollutants.
Wildlife	Permanent loss of 97.5 acres of habitat; temporary disruption of critical winter range for mule deer and elk.

Table 1.1 Environmental impacts of the proposed action (Continued)

Environmental component	Impacts
Vegetation	Permanent loss of 97.5 acres of vegetation.
Threatened and endangered species	None.
Aesthetic resources	Pile noticeable to persons passing by but subordinate to regional view.
Historic and cultural resources	One eligible and one potentially eligible site to be impacted.[b]
Noise	Limited potential for annoyance to residents living along transportation routes.
Land use	Restricted use of 97.5 acres; no limitation on future use of adjacent lands.
Population	Short-term increase of 15 persons; negligible increase in area population.
Employment	Average of 62 persons for 18 months; peak of 92 persons; induced employment of an additional 27 persons.
Social services	None.
Transportation networks	Maximum of 160 trips per day on New Mexico Highways 53 and 509 (two-lane, lightly traveled); 0.16 traffic fatalities; 0.59 traffic injuries; 1.60 property damage accidents.
Energy resources	Consumption of 990,000 gallons of fuel and 225,000 kilowatt-hours of electricity.

Table 1.1 Environmental impacts of the proposed action (Concluded)

Environmental component	Impacts
Construction costs ($)[c]	$15,070,000

[a]Public health impacts for the no action alternative would be 0.005 excess fatal cancers in the first 10 years and 0.5 excess fatal cancers in 1000 years. Health impacts for the no action alternative are calculated assuming that the tailings would not be dispersed in the future by natural erosion or man because there is no way to accurately predict the level or rate of dispersion. Without remedial action, dispersion would occur over time, and the actual health impacts for the no action alternative might be greater than shown. Health impacts are calculated for a constant population (see Section 4.1.3).

[b]Two archaeological sites are located within the windblown area to be decontaminated. One site is eligible for inclusion to the National Register of Historic Places (NRHP) and the other requires additional data to determine its eligibility. No cultural resource survey has been conducted at borrow site 2 and only a partial survey was conducted at borrow site 1. Prior to surface disturbance of unsurveyed areas an intensive cultural resource inventory would be undertaken. Any eligible site to be impacted by the remedial action would have an appropriate data recovery program executed prior to surface disturbance.

[c]This estimate does not include the costs of: (1) property acquisition; (2) engineering design; (3) construction management (except for field supervision); (4) overall project management; and (5) long-term surveillance and maintenance.

Section 21 disposal alternative

Tailings relocation to the Section 21 site would result in stabilization of the tailings at an undeveloped location, but would generally involve greater short-term impacts and costs.

The major differences between the Section 21 disposal and stabilization in place alternatives are as follows:

- The Section 21 disposal site is on land one mile north of the Ambrosia Lake tailings site and approximately 2.5 miles from the nearest residence.

- The Section 21 alternative would have a greater impact on remedial action worker health, nonradiological air quality, transportation networks, and the consumption of water and energy.

- The construction costs of the Section 21 alternative would exceed those for stabilization in place by more than 100 percent.

In summary, given the feasibility of the proposed action, its lesser costs and short-term impacts, and its similar long-term impacts compared to relocation to the Section 21 alternate site, the proposed action, (stabilization in place) was selected.

REFERENCES FOR SECTION 1.0

DOE (U.S. Department of Energy), 1985. Programmatic Environmental Report for Remedial Actions at the UMTRA Project Vicinity Properties, UMTRA-DOE/AL-150327.0000, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

FBDU (Ford, Bacon, and Davis, Utah, Inc.), 1981. Engineering Assessment of Inactive Uranium Mill Tailings, Phillips/United Nuclear Site, Ambrosia Lake, New Mexico, DOE/UMT-0113, FBDU 360-13, UC-70, prepared by FBDU, Salt Lake City, Utah, for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

2.0 REMEDIAL ACTION ALTERNATIVES

2.1 THE NEED FOR REMEDIAL ACTION

2.1.1 Background

In response to public concern over the potential public health hazards related to uranium mill tailings and the associated contaminated materials left abandoned or otherwise uncontrolled at inactive processing sites throughout the United States, Congress passed the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), Public Law 95-604, which was enacted into law on November 8, 1978. In the UMTRCA, Congress acknowledged the potential health hazards associated with uranium mill tailings and identified 24 sites that were in need of remedial action. The Ambrosia Lake site is one of these sites.

Title I of the UMTRCA authorized the U.S. Department of Energy (DOE) to enter into cooperative agreements with affected states or Indian tribes to clean up those inactive sites contaminated with uranium mill tailings and required the Secretary of the DOE to designate sites to be cleaned up. Title I also required the U.S. Environmental Protection Agency (EPA) to promulgate standards for these sites and defined the role of the U.S. Nuclear Regulatory Commission (NRC) (Table 2.1).

Effective September 27, 1985, the DOE and the State of New Mexico entered into a cooperative agreement under the UMTRCA. The cooperative agreement set forth the terms and conditions for the DOE and state cooperative remedial action efforts including the DOE's development of a Remedial Action Plan (to be concurred in by the State of New Mexico), the DOE's preparation of an appropriate environmental document, real estate responsibilities, and other concerns.

The EPA published an Environmental Impact Statement (EIS) (EPA, 1982) on the development and impacts of the standards (40 CFR Part 192) and issued final standards (48 FR 590-604) which became effective on March 7, 1983. In developing these standards, EPA determined "that the primary objective for control of tailings should be isolation and stabilization to prevent their misuse by man and dispersal by natural forces" and that "a secondary objective should be to reduce the radon emissions from the piles." A third objective should be "the elimination of significant exposure to gamma radiation from tailings piles." More detailed discussions of the EPA standards are provided in Appendix A, EPA Standards, of the Environmental Assessment of Remedial Action at the Shiprock Uranium Mill Tailings Site, Shiprock, New Mexico (DOE, 1984a) and the Plan for Implementing EPA Standards for UMTRA Sites (DOE, 1984b).

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 WL. In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL, 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 and affected Indian tribes.

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

All remedial actions performed at the Ambrosia Lake site under the UMTRCA must be completed in accordance with the EPA and applicable State standards, and with the concurrence of the NRC and the State of New Mexico through its designated representative, the New Mexico Environmental Improvement Division (NMEID). The NRC will issue a license to the DOE, or other Federal agency having custody of the site, to perform surveillance, maintenance, and contingency measures to ensure that the site continues to function as designed.

2.1.2 The remedial action process

The remedial action process for the Ambrosia Lake site began with site characterization and will conclude with long-term surveillance and maintenance. Preliminary radiological investigations and engineering assessments have been completed and published. Currently, a series of four related studies that address the site-specific engineering concepts, surveillance and maintenance requirements, and licensing are under preparation. The anticipated publication schedule for each of these documents is shown in Table 2.2. Remedial action is scheduled to commence in the summer of 1987.

Table 2.2 Document publication schedule

Document	Publication date
Remedial Action Plan (including Health and Safety Plan, Radiological Support Plan, Site Characterization Report, and Site Conceptual Design)	Summer, 1986
Final Design and Specifications	Spring, 1987
Site Surveillance and Maintenance Plan	Fall, 1988

2.1.3 The Ambrosia Lake tailings site

The Ambrosia Lake tailings site is located in McKinley County, New Mexico, approximately 20 air miles north of Grants, New Mexico (see Figure 1.1). The closest town is San Mateo (unincorporated) approximately 15 air miles southeast. The immediate area surrounding the tailings site is very sparsely populated. The nearest residence is more than two miles away; approximately 60 people live within six miles of the site.

The tailings site is situated in the Ambrosia Lake Valley at an elevation of approximately 7000 feet above mean sea level. The topography of the surrounding area consists of broad elongated valleys separated by basalt-capped mesas. Small ephemeral streams drain the area, with runoff near the site flowing to the southwest toward the Arroyo del Puerto. The climate of the area is semiarid with average annual precipitation of less than 11 inches. Wildlife habitat near the site is marginal due to overgrazing and is dominated by grasses, herbs, and widely scattered shrubs.

The Phillips Petroleum Company constructed the Ambrosia Lake mill in 1957 and began operation in 1958. The facility was operated until 1963. Remaining at the site are the tailings pile and the abandoned mill and office buildings and associated structures (see Figure 1.2). The tailings pile occupies 111 acres of the 196-acre designated site and contains approximately 2,700,000 cubic yards of tailings. The total amount of contaminated materials, including the tailings and soils beneath and around the tailings (approximately 800,000 cubic yards), and windblown contamination (approximately 1,100,000 cubic yards over 570 acres), is estimated to be approximately 4.6 million cubic yards.

2.1.4 The purpose of this document

This environmental assessment (EA) is prepared pursuant to the National Environmental Policy Act (NEPA) which requires Federal agencies to assess the impacts that their actions may have on the environment. This EA examines the short-term and the long-term effects of the DOE's proposed remedial action for the Ambrosia Lake site. Alternatives to the proposed action are also examined.

The DOE will use the information and analyses presented here to determine whether the proposed action would have a significant impact on the environment. If the impacts are determined to be significant, a more detailed document called an "Environmental Impact Statement" will be prepared. If the impacts are determined not to be significant, the DOE will issue a "Finding of No Significant Impact" and implement the proposed action. These procedures and documents are defined in regulations issued by the Council on Environmental Quality (CEQ) in Title 40, Code of Federal Regulations, Parts 1500 through 1508.

Section 2.0 of this document describes the proposed action and the alternatives to it. Section 3.0 discusses the present condition of the environment. Section 4.0 assesses the environmental impacts of the proposed action and the alternatives to it. This document does not contain all of the details of the studies on which it is based. The details are contained in the appendices at the end of this document and in the referenced supporting documents.

2.2 THE PROPOSED ACTION - STABILIZATION IN PLACE

The proposed action for the Ambrosia Lake tailings site is to stabilize the tailings pile at its present location. All of the tailings and windblown contaminated soils would be consolidated and covered with compacted earth to inhibit radon emanation and water infiltration. A sand and rock erosion protection barrier would be placed over the pile to inhibit wind and water erosion and discourage animal and human intrusion. Rubble and debris, including asbestos, from demolition of the mill site would be disposed in the tailings pile in accordance with applicable State and Federal regulations.

The design for stabilization in place was developed to comply with the EPA standards, and the major design features are summarized below. Details of the design and its objectives are provided in Appendix A, Engineering Summary, and in the draft Remedial Action Plan and Site Conceptual Design for Stabilization of the Inactive Uranium Mill Tailings Site at Ambrosia Lake, New Mexico (DOE, 1985).

2.2.1 Description of final conditions

The pile dimensions would be roughly rectangular in shape, and would have a maximum length of 2500 feet and a maximum width of 1550 feet (Figure 2.1). The tailings and contaminated materials would be covered with a layer of compacted earth to inhibit radon emanation and water infiltration and a layer of sand and rock for erosion protection. The stabilized tailings pile would have maximum sideslopes of 20 percent and topslopes of 2.5 percent. The average height of the pile above the surrounding terrain would be approximately 50 feet (Figure 2.2). Rubble and debris, including asbestos, from demolition or dismantling of the mill and office buildings and associated structures and equipment would be disposed in the tailings pile in accordance with applicable State and Federal regulations.

The sand and rock erosion protection barrier would tie into a rock erosion protection apron which would encircle the stabilized tailings pile. The perimeter of the area would be marked with warning signs, boundary markers, and survey monuments.

The stabilized tailings pile would occupy an area of 88 acres situated primarily within the designated site boundary. Approximately six acres outside the designated site boundary in Section 29 adjacent to the west edge of the existing tailings pile would be withdrawn to facilitate pile construction. The entire disposal area would cover 95 acres. After remedial action, disturbed areas surrounding the stabilized tailings pile would be restored in accordance with applicable permits or approvals. Approximately 107 acres of the designated site would be released for unrestricted use following the completion of remedial action.

Details of the design and features incorporated into the design to control radon emanation, ensure long-term stability, and protect ground water are detailed in Appendix A, Engineering Summary.

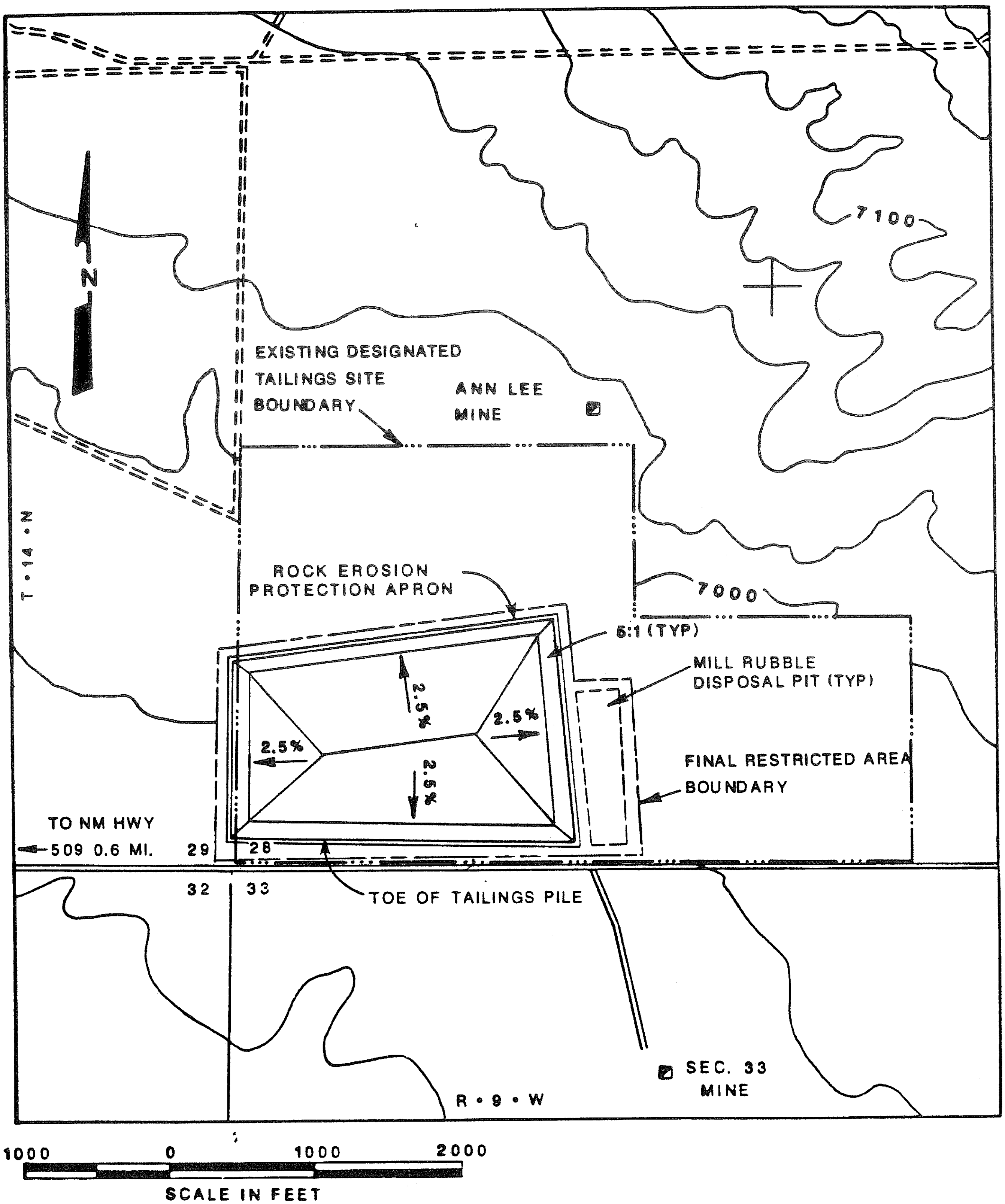


FIGURE 2.1
FINAL CONDITIONS, STABILIZATION IN PLACE

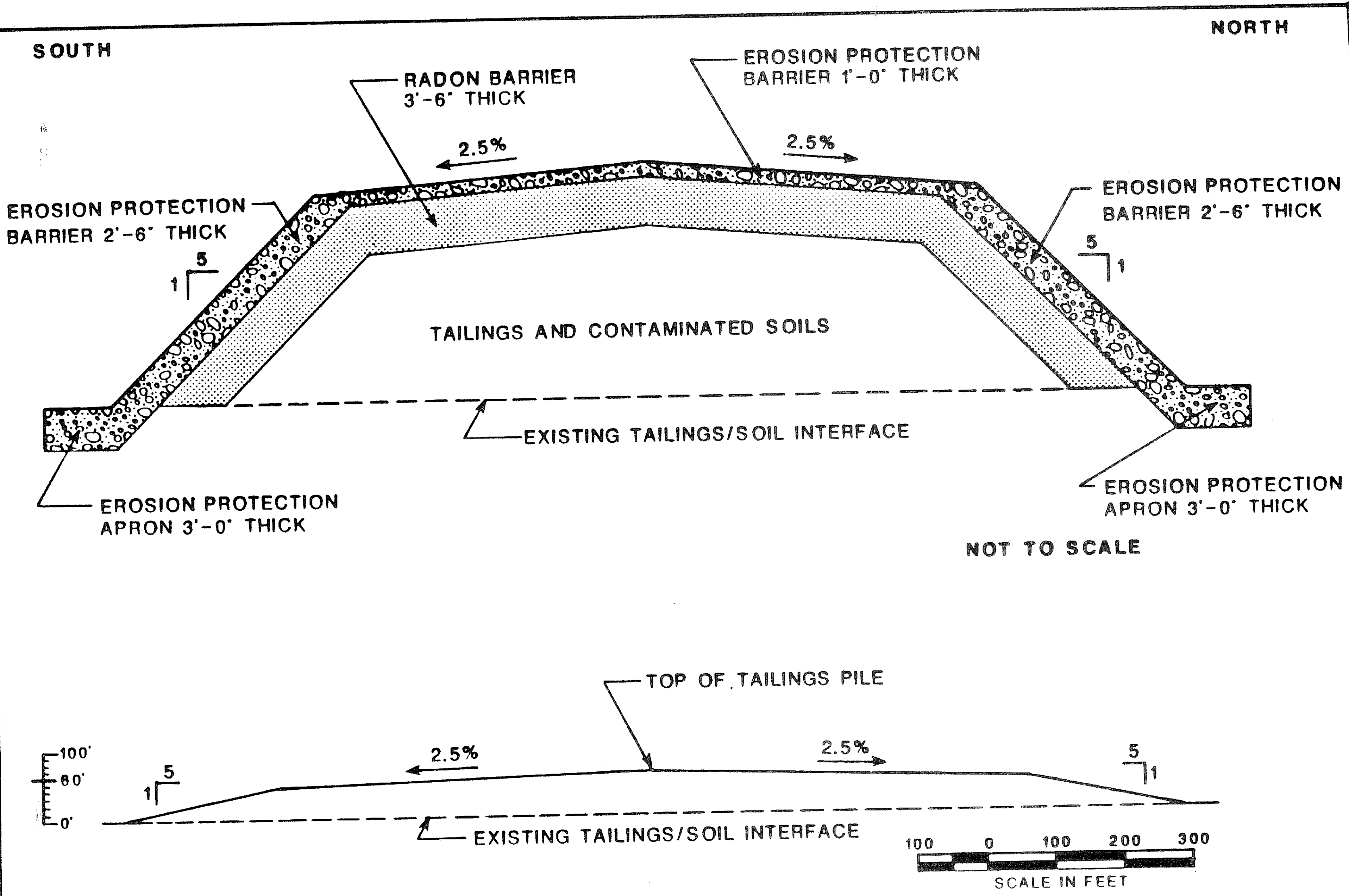


FIGURE 2.2
STABILIZATION IN PLACE, TYPICAL CROSS-SECTION

2.2.2 Major construction activities

The remedial action would be performed using conventional construction practices and technologies that comply with applicable regulations (Appendix E, Permits, Licenses, Approvals) and that would assure the safe and environmentally sound stabilization of the tailings and other contaminated materials. The major construction activities for stabilization in place would be site preparation, demolition of existing structures, construction of drainage control measures, consolidation of all of the tailings and windblown contaminated soils onto the existing tailings pile, disposal of demolition rubble, asbestos, construction and upgrading of haulage roads to the borrow sites, excavation of borrow materials, placement of cover materials onto the tailings pile, and restoration of the area surrounding the tailings pile and the borrow sites.

2.2.3 Borrow sites

Construction of the stabilized tailings pile would require the use of borrow materials (earth, gravel, and rock). Two borrow sites have been proposed as the sources of earth and rock borrow materials for the remedial action. Borrow site 1 is located approximately one road mile north of the tailings site (Figure 2.3) and is proposed as the source of earthen materials for the radon and erosion protection barriers. Borrow site 2 is located approximately 12 road miles southeast of the tailings site (Figure 2.3) and is proposed as the source of rock and gravel for erosion protection and road construction. Although the Remedial Action Contractor (RAC) will select the borrow sites to be used for the remedial action during the final design, the impacts identified for the borrow sites included in this EA are conservative and represent a realistic upper limit on the severity of the impacts that may occur.

Details of the construction activities are contained in Appendix A, Engineering Summary.

2.2.4 Construction estimates

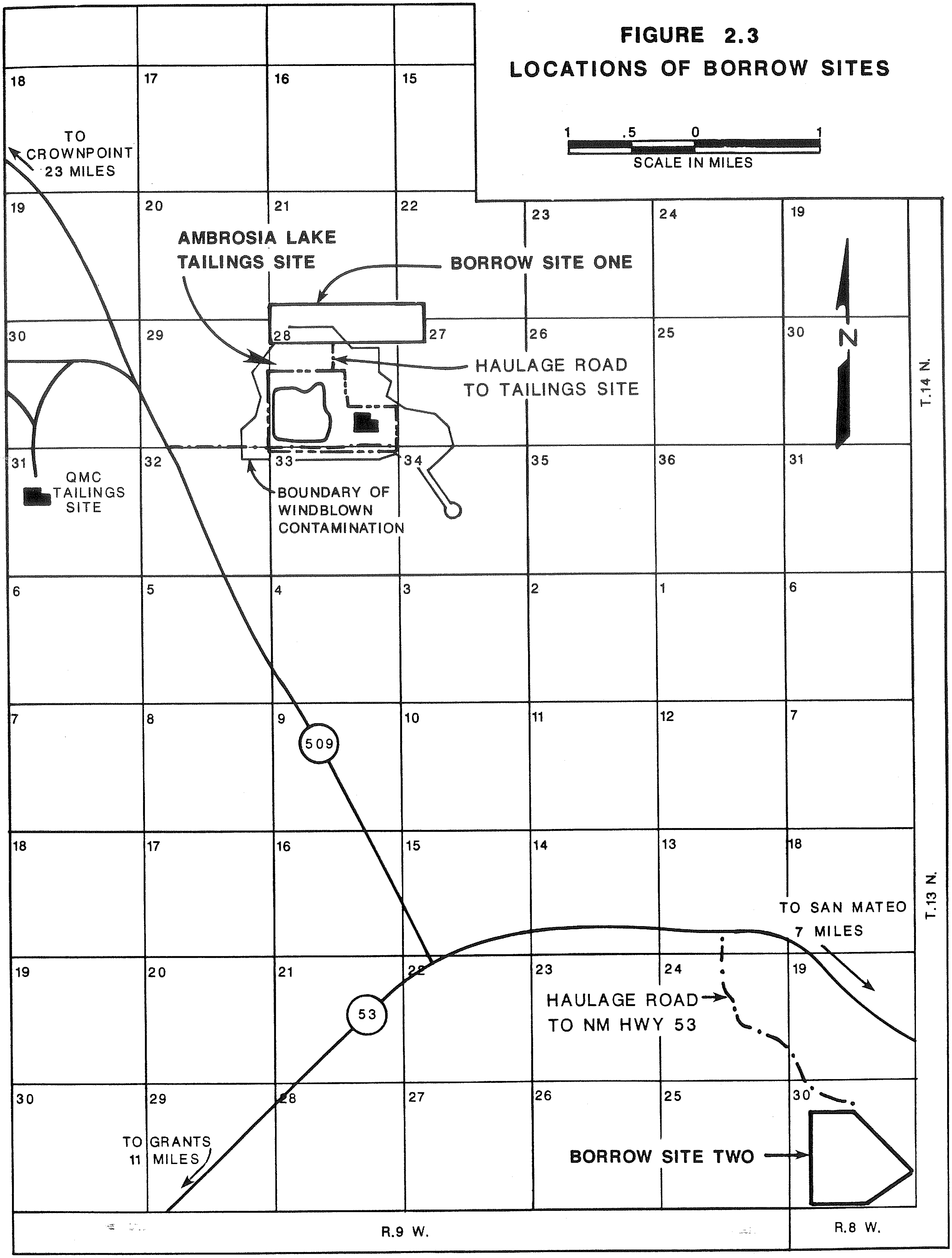
Estimates of personnel requirements, energy and water consumption, volumes of materials, and costs for stabilization in place are contained in Appendix A, Engineering Summary.

2.3 OTHER ALTERNATIVES

2.3.1 No action

This alternative consists of taking no steps toward remedial action at the tailings site or areas of windblown contamination. The tailings pile would remain in its present condition and would

FIGURE 2.3
LOCATIONS OF BORROW SITES



continue to be subject to dispersal by wind and water erosion and unauthorized removal by man. The selection of this alternative would not be consistent with the intent of Congress in the UMTRCA (PL95-604) and would not result in DOE's compliance with the EPA standards (40 CFR Part 192).

2.3.2 Disposal at the Section 21 site

An extensive process was conducted by the DOE to locate and evaluate alternate disposal sites for the Ambrosia Lake tailings (see Section 2.4). This process led to the selection of the Section 21 site (see Figure 1.3) which is located approximately one road mile north of the Ambrosia Lake tailings site. A conceptual design for disposal of the tailings at the Section 21 site has been developed and the resulting impacts are compared to those of the proposed action and the no action alternative.

The design objectives for the Section 21 disposal alternative would be identical to those selected for stabilization in place. All of the tailings and windblown contaminated soils would be moved by truck to the Section 21 site and consolidated in a partially below-grade disposal pit. The consolidated tailings and contaminated soils would be covered with compacted earth, sand, and rock, and disposal of rubble and debris from demolition of the mill site would be accomplished in a manner similar to stabilization in place. The engineering details and major construction activities for this alternative are contained in Appendix A, Engineering Summary.

The conceptual design for the alternate disposal site is based on existing published data. If this alternative was selected, additional site-specific data would be obtained before the final engineering design was prepared.

The data and information indicate that the Section 21 site is feasible (i.e., will meet EPA standards) and may alleviate potential problems with the proposed action (e.g., subsidence, settlement). However, given the feasibility of the proposed action, its lesser cost (less relocation of tailings) and short-term impacts (Section 4.0), and its similar long-term impacts compared to the relocation to Section 21 site, the proposed action was selected.

2.4 REJECTED ALTERNATIVES

2.4.1 Alternate disposal sites

An alternate disposal site selection process was conducted by the DOE in consultation with the State of New Mexico Environmental Improvement Division (NMEID) to locate and evaluate alternate disposal sites for the Ambrosia Lake tailings. This process consisted of the following phases: (1) designation of a search region;

(2) development and application of guidelines for eliminating unacceptable areas from the search region; (3) evaluation and field reconnaissance of potential sites; and (4) selection of a single disposal site for comparison with the proposed action, stabilization in place.

An area within a five-mile radius of the tailings site was designated as the initial search region.

During Phase II, published data on the search region were collected with emphasis on factors that could affect the remedial action design (e.g., location of faults, surface water, residences, mineral resources, cultural sites). These data included aerial photographs, maps, land use planning documents, and technical reports from Federal and state agencies, the University of New Mexico, and mining companies. From these data, twenty-four regional screening guidelines were developed specifically for the region surrounding the Ambrosia Lake site (Table 2.3). The guidelines were used to eliminate broad areas from consideration that, if included, might have required greater complexity in the design (e.g., steep slopes) or posed problems of a regulatory nature (e.g., cultural resource clearance). Four candidate areas were identified in the remaining areas not excluded by application of the guidelines (Figure 2.4).

The candidate disposal areas were evaluated on the basis of hydrologic, meteorologic, geologic, environmental, and economic data in the literature and field reconnaissance. Hydrologic and meteorologic conditions were assessed for erosional factors, existing water quality, drainage and flooding characteristics, precipitation, and location of aquifers. Special consideration was given to drainage basin configuration, infiltration potential, and location of recharge and discharge areas. Geologic evaluation addressed stability and soil characteristics such as the presence of slides or faults and types of unconsolidated and bedrock materials. The potential mineral resource values of the candidate sites were also considered. The environmental evaluation assessed land use potential, animal habitats, cultural resource values, proximities to population centers and dwellings, and aesthetics. Economic considerations included estimates of impacts to support facilities such as highways, distances from the Ambrosia Lake site, and the extent of anticipated site preparation and long-term maintenance.

The alternate site selection process led to the selection of a single disposal site, the Section 21 site. The three candidate disposal sites not selected, the Section 14, Section 3, and Section 1/12 sites, were determined to be suitable for tailings relocation but did not possess a greater range of desirable features than the Section 21 site. Thus these three sites are not considered in detail in this EA.

Table 2.3 Ambrosia Lake regional screening guidelines

Characteristics	Criteria definition
Faults (geologic)	Areas within 0.25 mile of mapped Quaternary geologic faulting.
Liquefaction	Within 0.25 mile of visible surface indications of disrupted drainage or broken ground.
Landslides	Areas within 0.25 mile of visible indications of slope instability.
Erosive soils	Areas of known highly erosive soils.
Slopes and escarpments	Slopes steeper than 33 percent grade; or areas from the top of an escarpment in excess of 10 feet in height established by the intersection of the ground surface with a plane inclined at a 20° angle from a horizontal plane passing through the toe of the escarpment, or 100 feet, whichever is greater.
Subsidence areas	Within 0.25 mile of areas susceptible to subsidence by natural or man-made causes.
Mineral resources	Significant known recoverable resources of oil, gas, coal, and other minerals (except uranium and gravel).
Floodplains	100-year floodplains as defined by the U.S. Department of Housing and Urban Development, or within 0.25 mile of stream centerline.
Mine workings	Areas within 1500 feet of the ground surface projection of active or abandoned underground mine workings.
Surface water	Areas within 0.25 mile of stock ponds, reservoirs, rivers, springs, or perennial streams.
Drainage area	Areas with incised drainages or drainage channels that appear to become more incised within one mile downslope of the proposed site.
Aquifer	Areas with sole-source aquifers or ground water with potential beneficial uses that is hydraulically connected to the base of the stabilized pile.

Table 2.3 Ambrosia Lake regional screening guidelines (Concluded)

Characteristics	Criteria definition
Recharge areas	Areas overlying recharge areas, meaning outcrops of developable ground-water bearing units or units that may be hydraulically connected to ground-water aquifers.
Vadose zone attenuative capacity	Areas with only minimal depth to ground-water aquifers and/or unsaturated substrata with expected minimal attenuative or assimilative capacity for contaminant transport.
Potential sources of ground-water contamination	Areas within one mile downgradient of potential or known sources of ground-water contamination and areas hydraulically connected to suspected or existing ground-water contaminant plumes.
Wetlands	Wetlands as defined by the U.S. Fish and Wildlife Service.
Communities	Areas within one mile of community limits (legal boundary).
Dwellings	Areas within 0.25 mile of existing dwellings.
Transportation and communication corridors	Areas within the rights-of-way of state, Federal or county roads, gas pipelines, or electrical transmission lines.
Cultural resources	Within 100 feet of known cultural resources and sites on the National Register of Historic Places.
Wilderness and natural areas	Within 0.25 mile of designated wilderness study areas, natural areas, areas of critical environmental concern, and features listed in the National Registry of Natural Landmarks.
Critical habitat	Within 0.25 mile of designated critical habitat for threatened or endangered species and botanically and geologically unique or sensitive areas.
Prime agricultural lands	Within 0.25 mile of soils with USDA Soil Conservation Service classification I or II.
State and National Parks	Within 0.25 mile of Parks and Monuments under Federal, state, or local jurisdiction.

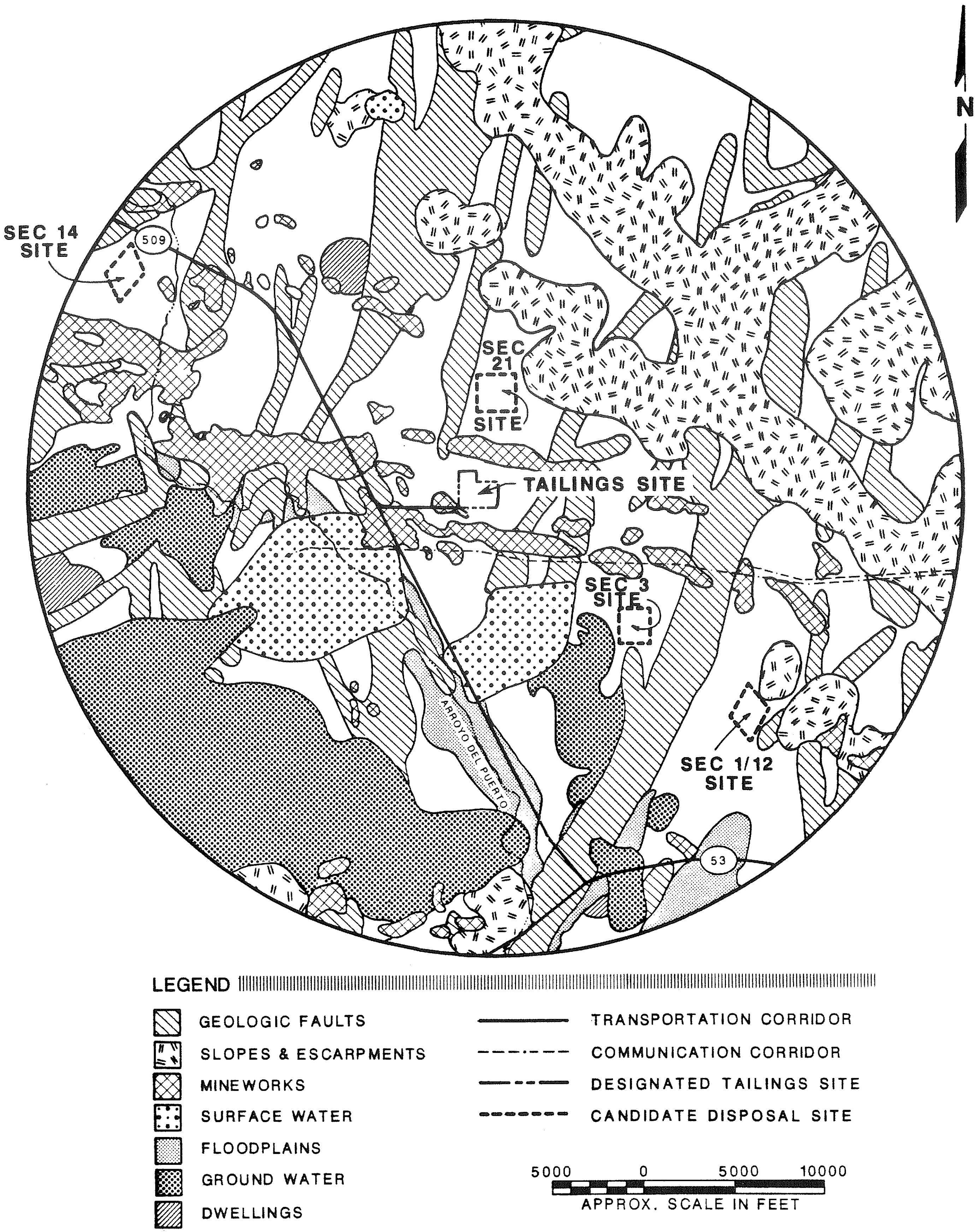


FIGURE 2.4 REGIONAL SCREENING GUIDELINES AND CANDIDATE DISPOSAL SITES, AMBROSIA LAKE

2.4.2 Relocating the tailings to the Quivira Mining Company (QMC) tailings site

Relocation of the Ambrosia Lake tailings and associated contaminated materials to the Quivira Mining Company (QMC) tailings site located approximately two miles southwest of the Ambrosia Lake tailings site was considered. The QMC tailings pile is part of a uranium processing facility under active NRC license.

Although relocation to the QMC site would allow restoration and release for unrestricted use of the existing tailings site, it would generally involve greater short-term impacts than stabilization in place. The QMC alternative would have a greater impact on remedial action worker health, nonradiological air quality, transportation networks, and the consumption of water and energy. Impacts to soils and mineral resources, flora and fauna, cultural resources, population, employment, housing, community services, and public finance would be similar to those discussed in Section 4.0 for stabilization in place. Lesser impacts to scenic resources and land use would result from tailings relocation to the QMC site relative to either the stabilization in place or Section 21 alternatives. Construction costs of the QMC alternative would be likely to exceed those of stabilization in place.

2.4.3 Reprocessing the tailings

The feasibility of reprocessing the tailings to recover residual uranium, vanadium, and molybdenum was evaluated. A drilling and sampling program was conducted to determine the total recoverable amounts of these metals in the tailings and underlying materials. Laboratory testing was then performed to determine the best reprocessing method: conventional plant processing (milling), vat leaching, or heap leaching. Finally, the economics of the best reprocessing method were evaluated (MSRD, 1982).

The evaluation concluded that although the recovery of additional uranium, vanadium, and molybdenum from the tailings is technically feasible, it would not be economical at market values existing at the time of the evaluation for these products ($34.50 per pound combined value in 1982). The combined market value for uranium, and vanadium would have to increase to $49.66 per pound for the reprocessing to "break even" (MSRD, 1982). The molybdenum content of the tailings was judged to be too low to consider recovery (MSRD, 1982).

Reprocessing of the tailings would not reduce the radium content of the tailings. Since radioactive decay of radium is the source of radon gas, there would be no reduction of the hazard from radon and radon daughters; hence, the reprocessed tailings would still require remedial action to meet the EPA standards. Reprocessing was therefore eliminated from further consideration.

2.4.4 Returning the tailings to the original mines

The ore processed at the Ambrosia Lake site came from numerous underground mines in the Ambrosia Lake area (FBDU, 1981). The technical feasibility of disposal of the tailings at these mines is uncertain as many of the mines have been abandoned and are no longer accessible. Furthermore, disposal of the tailings at any remaining active mines would restrict, and very likely prevent, future recovery of the ore at the mines. Therefore, this alternative disposal method was not considered further.

REFERENCES FOR SECTION 2.0

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DOE (U.S. Department of Energy), 1984a. Environmental Assessment of Remedial Action at the Shiprock Uranium Mill Tailings Site, Shiprock, New Mexico, DOE/EA-0232, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

DOE (U.S. Department of Energy), 1984b. Plan for Implementing EPA Standards for UMTRA Sites, UMTRA-DOE/AL-163, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

EPA (U.S. Environmental Protection Agency), 1982. Final Environmental Impact Statement for Remedial Action Standards for Inactive Uranium Processing Sites (40 CFR Part 192), EPA 520/4-82-013-1, Washington, D.C.

FBDU (Ford, Bacon, and Davis, Utah, Inc.), 1981. Engineering Assessment of Inactive Uranium Mill Tailings, Phillips/United Nuclear Site, Ambrosia Lake, New Mexico, DOE/UMT-0113, FBDU 360-13, UC-70, prepared by FBDU, Salt Lake City, Utah, for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

MSRD (Mountain States Research and Development), 1982. Economic Evaluation of Inactive Uranium Mill Tailings, Ambrosia Lake Site, Ambrosia Lake, New Mexico, UMTRA-DOE/ALO-182, prepared by MSRD, Tucson, Arizona, for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

3.0 AFFECTED ENVIRONMENT

3.1 WEATHER

The climate of the Ambrosia Lake area is characterized by low precipitation, abundant sunshine, low relative humidity, and large diurnal and annual temperature ranges. The regional climate is classified as semiarid, continental (QMC, 1983).

The New Mexico Environmental Improvement Division (NMEID) operated a meteorological monitoring station approximately 0.25 mile north of the tailings pile from June, 1978, to April, 1979. Temperature measurements show a mean daily minimum of 41°F, and a mean daily maximum of 65°F. The mean daily average of 53°F agrees reasonably well with the long-term (1962 through 1974) average of 49°F measured at the Floyd Lee Ranch (elevation 7250 feet above mean sea level) near San Mateo, approximately 15 air miles southeast of the tailings site. Extreme temperatures, as measured at a Gulf Mineral Resources Company meteorological monitoring station located near San Mateo at an elevation of 7280 feet above mean sea level (MSL) for a 12-month period of record, ranged from a maximum of 86°F in July to a minimum of 3°F in January (QMC, 1983).

Most of the precipitation in the project area occurs during the late summer thunderstorm season, although there is considerable monthly and annual variation in total rainfall. Table 3.1 presents long-term precipitation measurements made at San Mateo (Floyd Lee Ranch) and three other regional stations. The long-term annual average for San Mateo was 8.83 inches with a maximum of 13.55 inches in 1956. August was the wettest month with an average of 2.13 inches, and a maximum of 4.38 inches in 1948. Most of the winter precipitation in this area falls as snow (QMC, 1983).

Based on data from the NMEID station, the average overall wind speed was 5.8 miles per hour, and the most frequent wind directions were west (10.8 percent) and north-northwest (10.6 percent). Calm conditions occurred only 0.4 percent of the time (Table 3.2).

3.2 AIR QUALITY

National primary ambient air quality standards (NAAQS) define levels of air quality necessary, with an adequate margin of safety, to protect the public health. Federal secondary standards define levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of pollutants. Federal annual and all state standards (Table 3.3) are not to be exceeded at all, while Federal short-term standards (i.e., 24-hour) are not to be exceeded more than once a year.

The nearest air quality sampling station to the Ambrosia Lake tailings site is located approximately two miles west at the Quivira Mining Company (QMC) tailings site. There are also two total suspended particulates (TSP) monitoring stations at Milan (approximately 20 air miles south), and one each at San Mateo (approximately 13 air miles

Table 3.1 Monthly and annual average precipitation (inches) for San Mateo, Grants, Marquez, and San Fidel, New Mexico

Month	San Mateo[a]	Grants[b]	Marquez[c]	San Fidel[d]
January	0.42	0.36	0.45	0.37
February	0.38	0.39	0.49	0.46
March	0.40	0.45	0.57	0.44
April	0.43	0.36	0.67	0.65
May	0.37	0.43	0.70	0.79
June	0.47	0.69	0.73	0.79
July	1.72	1.81	1.79	1.65
August	2.13	2.18	2.71	2.02
September	1.14	1.17	1.20	1.43
October	0.75	1.07	1.31	0.61
November	0.33	0.33	0.51	0.41
December	0.44	0.62	0.55	0.47
Annual	8.83[e]	10.04	11.68	10.90

[a]Elevation 7250 feet MSL; approximately 13 air miles southeast of tailings site; period of record 1939-1974.
[b]Elevation 6480 feet MSL; approximately 20 air miles south of tailings site; period of record 1946-1960.
[c]Elevation 7620 feet MSL; approximately 30 air miles east of tailings site; period of record 1941-1970.
[d]Elevation 6160 feet MSL; approximately 27 air miles southeast of tailings site; period of record 1920-1954.
[e]Twenty-four years data available for annual mean.

Ref. QMC, 1983.

Table 3.2 Wind direction, distribution, and average speed at the Ambrosia Lake tailings site

Direction (from)	Frequency of occurrence (percent)	Average speed (miles per hour)
N	7.3	4.5
NNE	8.4	3.5
NE	4.8	3.0
ENE	3.1	3.1
E	3.8	2.7
ESE	3.4	4.6
SE	4.1	4.1
SSE	3.7	4.5
S	7.0	6.1
SSW	6.8	7.2
SW	5.3	7.5
WSW	6.5	8.8
W	10.8	8.8
WNW	6.0	8.0
NW	7.9	6.8
NNW	10.6	5.5
Calm	0.4	0.0
Overall	100.0	5.8

Ref. QMC, 1983.

Table 3.3 Federal and State of New Mexico ambient air-quality standards

Pollutant	New Mexico standard	Federal primary standard	Federal secondary standard
Total suspended particulates (TSP)			
24-hour average	150 microg/m^3[a]	260 microg/m^3	150 microg/m^3
Annual geometric mean	60 microg/m^3	75 microg/m^3	60 microg/m^3
Sulfur dioxide (SO_2)			
24-hour average	0.10 ppm[b]	0.14 ppm	--
Annual arithmetic mean	0.02 ppm	0.03 ppm	--
3-hour average	--	--	0.50 ppm
Carbon monoxide (CO)			
8-hour average	8.7 ppm	9 ppm	9 ppm
1-hour average	13.1 ppm	35 ppm	35 ppm
Ozone (O_3)			
1-hour average	0.06 ppm	0.12 ppm	0.12 ppm
Nitrogen dioxide (NO_2)			
24-hour average	0.10 ppm	--	--
Annual arithmetic mean	0.05 ppm	0.05 ppm	0.05 ppm
Lead (Pb)			
Calendar quarterly arithmetic average	--	1.50 microg/m^3	1.50 microg/m^3

[a] microg/m^3 - micrograms per cubic meter.
[b] ppm - parts per million.

Ref. NMEID, 1983; EPA, 1982.

southwest), Anaconda (approximately 15 air miles southwest), and Bluewater (approximately 12 air miles southwest). The nearest stations which measure carbon monoxide, sulfur dioxide, and nitrogen dioxide are Albuquerque (approximately 68 air miles east), Farmington (approximately 93 air miles northwest), and Socorro (approximately 110 air miles southeast). These stations are in areas that differ markedly from the Ambrosia Lake area because of much greater population, presence of pollutant sources, and physiographic features. No hydrocarbon data are available for any sites in New Mexico.

Data from the above-mentioned sites for the years 1980 through 1982 (Table 3.4) indicate that the Ambrosia Lake area experiences frequent violations of state and Federal primary and secondary standards for TSP. Despite this, the area is not listed among the nonattainment areas for TSP in New Mexico (NMEID, 1983). This is because the probable origin of this material is natural windborne fugitive dust. Concentrations of sulfur dioxide, nitrogen dioxide, and carbon monoxide should be less than standards for the Ambrosia Lake area (NMEID, 1983).

3.3 SURFACE AND SUBSURFACE FEATURES

The Ambrosia Lake site is situated within the southeast corner of the Navajo section of the Colorado Plateau physiographic province. The geologic structure of the project area is characterized by elongated domal uplifts, monoclines, and broad structural platforms. The majority of the regional structure formed during late Cretaceous (approximately 100 million years ago) to early Tertiary (58 million years ago) time (Kelly, 1963). Uplift of the Zuni Mountains, located approximately 28 miles south-southeast of the tailings site, occurred during the Laramide Orogeny (approximately 100 million years ago) and caused much of the complex structural fabric present in the local strata.

Continental arching of the region commenced in mid-Tertiary time (30 million years ago) (Kelly, 1963). Extensive stripping and erosion ensued, followed by deposition of alluvium and playa sediments over much of the region. Asymmetric cliff-bounded ridges (cuestas) formed during this period, resulting in a repeating mesa-ridge and valley physiographic texture. Volcanic activity during the Miocene/late Pliocene (approximately five million years ago) formed Mount Taylor and the resistive basalt-capped mesas characteristic of the area. Tectonic folds and faults with surface expression do not strongly influence present topography or drainage. Major topographic features in the area are the Zuni Mountains, the San Juan Basin, and the Mount Taylor volcanic complex. Elevation in the general vicinity of the tailings site ranges from approximately 6400 feet above mean sea level in the town of Grants to 11,300 feet at the top of Mount Taylor.

The stratigraphy of the project area is diverse, with rocks ranging in age from Precambrian (2500 million to 570 million years ago) through Holocene (less than 10,000 years old) within a 40-mile radius of the tailings site. Rock outcrops generally strike northwest-southeast with successively younger units exposed toward the northeast. A regional dip of approximately two to three degrees was established during the Laramide Orogeny. A geologic map of the project region is presented as Figure 3.1.

Table 3.4 Air pollutant concentrations

Pollutant/ monitoring location	Distance from site (miles)	Year 1980	Year 1981	Year 1982	Year 1980	Year 1981	Year 1982	Year 1980	Year 1981	Year 1982
Total suspended particulates (micrograms per cubic meter)		Highest 24-hour average			Second-highest 24-hour average			Annual geometric mean		
QMC	2	404	301	278	334	208	127	86	76	43
Anaconda	12	286	110	60	191	96	58	37	37	25
Bluewater	17	327	311	192	256	230	125	70	85	59
San Mateo	15	164	323	71	129	174	69	53	58	27
United Nuclear, Milan	16	384	617	170	341	581	126	79	93	45
Milan	16	430	438	315	407	353	306	197	150	93
Sulfur dioxide (parts per million, by volume)		Highest 24-hour average			Second-highest 24-hour average			Annual arithmetic mean		
Albuquerque	68	0.01	0.01	0.01	0.01	0.01	0.01	0	0	0
Farmington	93	0.02	0.01	0.02	0.01	0.01	0.01	0	0	0
Socorro	110	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
Nitrogen dioxide (parts per million, by volume)		Highest 24-hour average			Second-highest 24-hour average			Annual arithmetic mean		
Albuquerque	68	0.05	0.07	0.05	0.05	0.06	0.05	0.02	0.02	0.02
Farmington	93	0.03	0.03	0.02	0.03	0.03	0.02	0.02	0.01	0.02
Socorro	110	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.00
Carbon monoxide (parts per million, by volume)		Highest 8-hour average			Highest 1-hour average					
Albuquerque	68	10.5	11.3	10.1	19.0	19.0	18.0			
Farmington	93	5.8	6.5	6.9	13.5	15.5	20.0			

Ref. NMEID, 1983.

10 0 10 20 30

SCALE IN KILOMETERS

MODIFIED AFTER BALDRIDGE, et al., 1983

◉ AMBROSIA LAKE SITE

FIGURE 3.1
BEDROCK GEOLOGY OF THE AMBROSIA LAKE REGION

LEGEND

Q QUATERNARY (undivided): Fluvial sediments of gravel, sand and clay; alluvial fan deposits; colluvium, soils, landslides. Locally includes units mapped as Pliocene-Pleistocene.

Qb QUATERNARY MAFIC VOLCANIC ROCKS ($\leq$ 1.8 m.y.): Tholeiite, basanite, alkali olivine basalt, and related alkalic basaltic rocks.

Tpb PLIOCENE MAFIC VOLCANIC ROCKS (1.8 - 5.0 m.y.): Tholeiite, alkali olivine basalt, basanite, and related alkalic basaltic rocks.

Tps PLIOCENE INTERMEDIATE AND SILICIC VOLCANIC ROCKS (1.8 - 5.0 m.y.): Basaltic andesite, alkali andesite, quartz latite, dacite, rhyolite, trachyte.

Kl UPPER CRETACEOUS: Shale, with minor sandstone and siltstone. Lewis Shale in northwestern New Mexico.

Kmv UPPER CRETACEOUS: Sandstone, shale, carbonaceous shale, and coal. Mesa Verde Group (Menefee Formation, Gallup Sandstone, Crevasse Canyon Formation, Point Lookout Sandstone).

Km UPPER CRETACEOUS: Shale with minor sandstone and limestone. Mancos Shale.

Kdm LOWER TO UPPER CRETACEOUS: Undifferentiated Mancos Shale and Dakota Sandstone in northwestern New Mexico.

Kd LOWER TO UPPER CRETACEOUS: Dakota Sandstone.

Jm UPPER JURASSIC: Sandstone, mudstone, conglomerate, with nodular chert. Morrison Formation.

Jsr MIDDLE JURASSIC: Limestone, shale, bituminous shale, mudstone and limestone. San Raphael Group (Bluff Formation, Summerville Formation, Todilto Formation, Entrada Sandstone.

Tr TRIASSIC: Shale, siltstone, sandstone, conglomerate, limestone. Wingate Formation, Chinle Formation.

P PERMIAN: Sandstone, siltstone, shale, limestone, gypsum, conglomeratic sandstone, orthoquartzitic sandstone. Glorieta Formation, San Andres Limestone.

P€ PRECAMBRIAN: Phyllite, quartz schist, metaquartzite, gneiss, granite, and metavolcanic rocks. In central New Mexico also olivine gabbro, amphibolite, and granite pegmatite.

FIGURE 3.1 (CONCLUDED) BEDROCK GEOLOGY OF THE AMBROSIA LAKE REGION

Ambrosia Lake tailings site

The Ambrosia Lake tailings site lies adjacent to a northwest-trending cuesta capped by the resistant Cretaceous Point Lookout Sandstone. Samples of the tailings and foundation materials were collected for laboratory analyses. Drilling indicates that the pile rests on alluvial deposits that range in thickness from five to 55 feet underlain by Mancos Shale. The borehole logs and laboratory analyses are included in Appendix D of the draft RAP (DOE, 1985) and are available at the UMTRA Project Office, Albuquerque, New Mexico.

Elsewhere in the valley, the Quaternary alluvium ranges in thickness from a thin veneer to almost 100 feet near the Arroyo del Puerto (Brod, 1979). The Paleozoic and Mesozoic section beneath the tailings pile consists of continental and marine sedimentary rocks which exceed 3300 feet in thickness (LASL, 1977).

Soils of the Las Lucas-Litle-Persayo association underlie and surround the tailings pile. Generally, thin surface soil horizons are composed of calcareous loam, silty loam, silty clay loam, or clay loam. Subsoil textural classes include clay loam, silty clay loam, silty clay, and clay. Gray and olive-colored shales are the primary parent materials forming the light to moderately light-brown calcareous soils. Within the designated site, disturbance of the soils has resulted from activity associated with mill construction, exploration pit trenching, and construction of tailings impoundments.

Seismic activity in the project area has been recorded instrumentally only during the last 23 years. Since 1962, most earthquakes detected in the Grants region have had local magnitudes of less than 2.0 (Richter scale) (LANL, 1984). The largest earthquakes recorded in the region were epicentrally located approximately 33 miles northeast of the tailings site and had local magnitudes of 4.6 and 4.2 (Wong et al., 1977).

For establishing earthquake design parameters, the impact of a floating earthquake, a seismic event not associated with a known tectonic structure, was used. A floating earthquake of magnitude 6.2 (Richter scale) was estimated for the Ambrosia Lake region. An earthquake of this magnitude occurring 15 kilometers from the tailings site would generate on-site peak horizontal ground accelerations of 0.21g.

Fluvial and wind geomorphic processes are currently active in the project area. Headcutting and lateral bank failure of arroyos north and east of the tailings pile have been observed in recent decades. Eolian agents have formed isolated local dune fields and sand sheets in the Ambrosia Lake Valley, and have removed large portions of fine-grained tailings from the pile. Mass-wasting phenomena such as landslides and slope creep do not occur in the site area.

In addition to uranium, mineral resources in the area include vanadium, molybdenum, sand, gravel, limestone, and basalt. The vanadium and molybdenum ores are closely associated with uranium mineralization but are present in lesser concentrations (Squyres, 1963). Exploratory drilling to determine the extent and grade of uranium reserves is currently limited to an area immediately north of Milan, New Mexico. Uranium mine workings underlie much of the area in the immediate vicinity of the Ambrosia Lake tailings site. Mine voids exist at an approximate depth of 600 feet (Westwater Canyon Member) beneath the southwestern corner of the tailings pile and in the northern half of Section 28. Surface subsidence over mine workings has occurred in Section 29, approximately 800 feet from the western edge of the tailings pile. Subsidence beneath the southwestern corner of the stabilized pile is not expected to occur. A detailed evaluation of the subsidence potential is contained in the Ambrosia Lake Remedial Action Plan (DOE, 1985). Limestone, sand, gravel, and basalt deposits are present in the area and are occasionally quarried for use in railroad and highway construction projects (Cooper and John, 1968). Claims to the mineral rights for the designated site are held by the Federal Government (DOI, 1978).

Borrow sites

Borrow site 1 is located in a geologic setting very similar to that of the existing tailings site. Surficial deposits consist of silty loam and clayey loam and are underlain by Mancos Shale. The thickness of the surficial materials is estimated to range from zero to two feet in areas devoid of alluvium. Borrow site 2 consists of colluvial basalt deposits. Mineral rights at both borrow sites are held by the Federal Government. There are no mineral development activities currently occurring at either borrow site.

3.4 WATER

This section describes characteristics of the surface water and ground water at the Ambrosia Lake tailings site and borrow sites. Additional details on surface and ground waters are provided in Appendix B, Water.

3.4.1 Surface water

Ambrosia Lake tailings site

The Ambrosia Lake tailings site lies within the drainage basin of Arroyo del Puerto, a tributary of San Mateo Creek. Arroyo del Puerto is an intermittent stream which lies approximately one mile southwest of the tailings site (Figure 3.2). Flow in Arroyo del Puerto has been sustained by mine water discharges, creating a perennial stream from the late 1950s until 1980. Flow within the arroyo recharges the alluvium along its course. This saturation in the alluvium does not extend as far as the Ambrosia Lake site. There are no permanent natural surface-water bodies at the Ambrosia Lake site. Surface runoff on top of the pile collects in a shallow pond in the depression at the southern end of the pile. Surface runoff around the tailings pile infiltrates rapidly into the alluvium. Alluvial saturation at the Ambrosia Lake site is

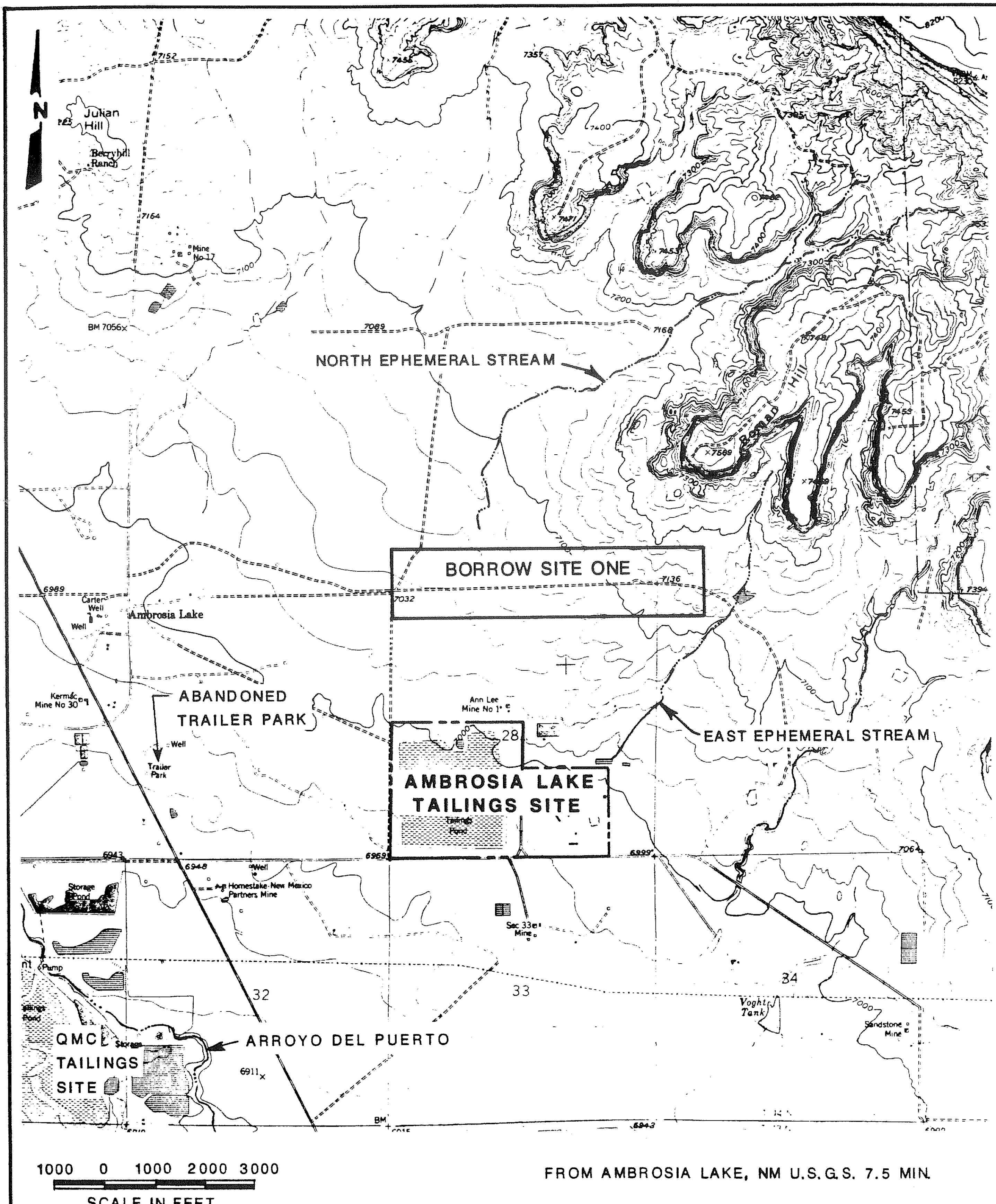


FIGURE 3.2 EXISTING DRAINAGE CONDITIONS, AMBROSIA LAKE SITE

localized and distinct from the saturation along the Arroyo del Puerto. There is very limited potential for surface runoff or subsurface seepage migration from the site to reach the Arroyo del Puerto.

Although mine discharge contributed past contamination to the alluvium of Arroyo del Puerto, the major portion of this contamination probably discharged to the arroyo during desaturation after mining discharges ceased. Residual soil contamination is probably minor and is not of concern because it is beyond the designated site boundary and did not result from the milling operation.

There are two ephemeral channels northeast of the site that carry runoff from San Mateo Mesa (see Figure B.1.2, Appendix B, Water). Runoff from the eastern drainage (approximately 450 acres) is collected in three stock tanks upstream of the tailings site or is intercepted just east of the site and diverted into Voght Tank. Runoff from the northern drainage (approximately 1550 acres) collects in a depression on the north side of the tailings pile, and has intermittently flooded the northwest flank of the pile. There are no distinct channels below the site (south and west).

Borrow sites

Surface-water conditions at borrow site 1 are very similar to those at the tailings site. The major difference is that the borrow site is located principally in the ephemeral drainage northeast of the tailings pile (Figure 3.2). No water courses exist on the site.

Borrow site 2 is bisected by a series of unnamed intermittent stream channels. No permanent water bodies occur on the site.

Surface-water quality

The water quality of the Arroyo del Puerto reflects the quality of mine water discharges from the Ambrosia Lake area. Concentrations of gross alpha, radium-226, molybdenum, selenium, uranium, and possibly chloride and/or sulfate are indications of mine water discharge.

3.4.2 Ground water

This section summarizes the hydrogeological and water resource characteristics of the Ambrosia Lake tailings site. Hydrological information available from other uranium tailings sites in the Ambrosia Lake Valley is used to assess relative impacts from the Ambrosia Lake site. Appendix B, Water, provides additional details and analyses concerning the hydrogeological and water resource characteristics of the Ambrosia Lake site.

The potentially affected hydrostratigraphic formations beneath the Ambrosia Lake site, in descending order, are the alluvium/weathered Mancos Shale, the Tres Hermanos-C, -B, and -A Sandstones, the Dakota Bluff Sandstone, and the Todilto Limestone. The Tres Hermanos-C, -B, and -A Sandstones are interlayered with the relatively low permeability Mancos Shale. The Dakota Sandstone, the Bluff Sandstone, and the Todilto Limestone should not be impacted by the Ambrosia Lake site because they are separated from the principal pathway of contaminant migration by at least 50 feet of aquitard including the Mancos Shale and the Recapture Member of the Morrison Formation.

The most likely flow paths for contaminated ground water resulting from past or present seepage from the Ambrosia Lake site are:

- Seepage from a perched mound within the tailings percolating into the alluvium/weathered Mancos Shale.

- Contaminated ground water moving to the southwest (downgradient) in the alluvium/weathered Mancos Shale.

- The ground water in the alluvium/weathered Mancos Shale encountering the subcrop of the Tres Hermanos-C Sandstone and flowing in this sandstone to the northeast (downgradient).

- The ground water in the Tres Hermanos-C Sandstone discharging to mine shafts (the Ann Lee Mine) and eventually entering the Westwater Canyon Member.

- The ground water in the Westwater Canyon Member continuing to move to the northwest (downgradient).

Contamination of the Westwater Canyon Member is of greater concern than contamination of the alluvium/weathered Mancos Shale and the Tres Hermanos-C Sandstone because the Westwater Canyon Member is an aquifer while the other two formations are not. All known water supply wells in the Ambrosia Lake Valley are completed in the Westwater Canyon Member or deeper formations except for a few wells completed in the San Mateo Creek alluvium.

Locally, the saturation in the alluvium/weathered Mancos Shale and the Tres Hermanos-C Sandstone is caused by mine water discharge, is of limited areal extent, and generally is water of relatively poor quality. Regionally, the Tres Hermanos-C Sandstone is a thin, low-yielding, often shaley sandstone and historically and presently has no known use.

Three sets of water samples representing tailings pore water, alluvium/weathered Mancos Shale ground water, and Tres Hermanos-C Sandstone ground water were collected. General observations regarding the nature and extent of ground-water contamination are:

- The shapes of the contaminant plumes support the concept of the ground-water flow regime. Regionally, prior to the mining and milling at the site, the alluvium and Tres Hermanos-C Sandstone were probably unsaturated. Locally, the alluvium/weathered Mancos Shale is saturated beneath the site because of local recharge conditions from tailings seepage. Analyses of water quality from the Tres Hermanos-C Sandstone and wells completed in the alluvium/weathered Mancos Shale also indicated that the contamination has remained localized within the site area.

- The pH decreased from alkaline (pH 12) to neutral as ground water moved downgradient; an alkaline leach process was used at the mill for uranium extraction.

- Indicators of tailings seepage included anomalously high concentrations of fluoride, molybdenum, nitrate, manganese, cobalt, iron, selenium, chromium, pH, radium, sulfate, uranium, and total dissolved solids.

- Chemical species derived from tailings seepage found in the alluvium/weathered Mancos Shale that generally exceeded Federal drinking water standards and/or New Mexico Water Quality Control Commission (WQCC) Regulations Standards (WQCC, 1986) included boron, chloride, cobalt, fluoride, gross alpha activity, nitrate, uranium, molybdenum, selenium, radium, sulfate, total dissolved solids (TDS), iron, and manganese; arsenic, cadmium, chromium, pH, and silver also exceeded standards but at only one or two wells. Water quality should not further degrade because steady state conditions are established in the alluvium and Tres Hermanos-C Sandstone and the tailings are a discontinuous source of ground-water contamination.

- Ground-water samples collected from the Tres Hermanos-C Sandstone show concentrations of boron, cobalt, chloride, fluoride, gross alpha activity, iron, molybdenum, nitrate, pH, radium, selenium, uranium, manganese, sulfate, and total dissolved solids that exceeded Federal and/or WQCC standards. The concentrations of most of these constituents have decreased during transport from the alluvium/weathered Mancos Shale to the Tres Hermanos-C Sandstone.

Since the alluvium/weathered Mancos Shale and the Tres Hermanos-C Sandstone were probably unsaturated prior to mining and milling activity, tailings seepage is representative of local background, ground-water quality. Therefore, and on the basis of consultation with NMEID, applicable WQCC Regulations consider that the concentrations of contaminants are representative of background conditions (Bostick, 1986).

Domestic and stock water supply sources are not widely used within the Ambrosia Lake mining district. The nearest municipality operating a public water supply is San Mateo located 10 miles southeast (hydraulically upgradient) of the Ambrosia Lake site. Most of the domestic wells in the Ambrosia Lake valley have been abandoned (Brod and Stone, 1981). A total of seven active wells are located hydraulically off gradient and within five miles of the site (see Table B.2.1) (Baughman, 1985a). There are five ranch headquarters in the Ambrosia Lake area; these wells are completed in the Westwater Canyon Member or San Andres Limestone, hydraulically upgradient from the Ambrosia Lake site, at depths of 500 to 3000 feet (Baughman, 1985b). There are no present or historical wells completed in the Tres Hermanos-C Sandstone in the Ambrosia Lake Valley due to its low yield and poor-quality water. Prior to mining, there was little development in the Ambrosia Lake area and limited use of ground water. The twenty-year period of uranium mining and milling activity prior to the UMTRA Project stimulated the temporary development of the valley, degraded the water quality, and reduced the quantity of ground-water resources. Future ground-water development in the valley is expected to be even more limited than pre-mining industry. Water from the Westwater Canyon Member is still used by the very few remaining mines and mills within the Grants Mineral Belt; however, some of the samples obtained from the Westwater Canyon Member have concentrations of sulfate and total dissolved solids that exceed Federal and state water-quality standards (WQCC Regulations). (Section B.2.3 contains additional information regarding ground-water use.)

3.5 FLORA AND FAUNA

Details of flora and fauna present at the Ambrosia Lake site are contained in Appendix C, Flora and Fauna.

The Ambrosia Lake tailings pile, adjacent windblown area, and borrow site 1 are located in the Great Basin Grasslands habitat. Historically, these grasslands were dominated by sod-forming grasses such as blue grama, but overgrazing has caused a breakdown in the sod cover enhancing the growth of forbs and shrubs.

The tailings pile is essentially devoid of vegetation with only a few widely scattered individuals of early successional species. The windblown contaminated area and borrow site 1 support only vestiges of the grama grass association with blue grama, bush muhly, and Fender threeawn present. Common species included narrow leaf goosefoot, alkali sacaton, galleta, and other annual herbs and grasses.

The grassland habitat is the principal wildlife habitat at the area of windblown contamination and at borrow site 1. In addition, a rocky slope-cliff habitat occurs at the west end of borrow site 1 near Roman Hill. Sixty-two species of wildlife were observed or expected to occur in the grassland habitat, while 42 may be found in the rocky slope-cliff area. Eleven species of reptiles and amphibians may occur at these two habitat types; the short-horned lizard and side-blotched lizard were the only species observed during field reconnaissance conducted in summer, 1985. The meadowlark and horned lark were the most common nesting bird species observed. An active raven nest and possible abandoned prairie falcon eyrie were observed on the cliffs near Roman Hill. Twenty-three species of mammals were observed or expected to occur in this area. Big game use is expected to be restricted to an occasional mule deer during the winter.

Borrow site 2 is located in the Great Basin conifer woodland type with pinon pine and juniper being the dominant plant species. A total of 59 species of wildlife were observed or are expected to occur at this site. Eight species of reptiles and amphibians may occur on the site; the plateau whiptail was the only species observed. Five species of raptors are among the 29 species of nesting birds that may occur on the site. During a late summer, 1985, survey, the red-tailed hawk and sparrow hawk were the only species observed. Two raptor species (ferruginous hawk and Swainson's hawk) were judged to have a very low probability of nesting in this area. Of the 22 species of mammals observed or expected to occur, the mule deer and elk are the most important from an economic standpoint. Borrow site 2 is located in critical winter habitat for these two species.

Threatened and endangered species

Consideration of Federal and state threatened or endangered species indicated that five species may occur on the site. The black-footed ferret is one of these species but does not occur at the tailings or borrow sites due to the lack of prairie dog towns. The peregrine falcon does not nest within 10 miles of the tailings site but may occur as an occasional migrant. The bald eagle does not nest or winter near the tailings site but also may occur as an occasional migrant. The rhizome fleabane does not occur in the area since this species occurs only on soils derived from Chinle Shale; this soil type does not occur at the Ambrosia Lake site. The Pecos sunflower occurs along perennial streams or irrigation ditches. This habitat type does not occur at the Ambrosia Lake site, and thus, it is highly unlikely that the Pecos sunflower inhabits the site.

3.6 RADIATION

The existing radiation levels at the Ambrosia Lake tailings site are discussed below. Appendix D, Radiation, contains a detailed discussion of radiation and radiation measurements. The term baseline refers to those radiation levels that would be present in the area if the Ambrosia Lake site did not exist. Baseline levels, therefore, include contributions from local uranium mining and milling and natural background sources.

3.6.1 Background radiation

Radioactive elements occur naturally throughout the air, water, soil, and rock of the earth. The concentrations of these elements vary greatly throughout the United States because of local mineralization.

The average background gamma radiation exposure rate for the Ambrosia Lake area from both terrestrial and cosmic sources, measured three feet above the ground, is 15.2 $\pm$ 1.3 microroentgens per hour (microR/hr) (BFEC, 1985a). Cosmic rays (radiation from the sun and other sources external to the earth) contribute approximately 8.4 microR/hr (55 percent) of the 15.2 microR/hr background gamma exposure rate.

The average outdoor baseline radon concentration in the Ambrosia Lake area is 2.9 picocuries per liter (pCi/l) based on measurements at four locations north, south, and northwest of the site (FBDU, 1977). Radon concentrations in the Ambrosia Lake area are high relative to natural background levels in the region due primarily to the influence of uranium mining and milling (Table 3.5). Natural background radon concentrations in undisturbed areas with similar geologic settings as Ambrosia Lake have been measured by several investigators and average 0.19 $\pm$ 0.02 pCi/l (NMEID, 1985; Millard and Baggett, 1984).

Table 3.5 Radon concentrations in the vicinity of the Ambrosia Lake tailings pile

Site no.	24-hour outdoor (pCi/l)	Date	Average wind speed (knots)	Average wind direction	Location
1	16.7	11/02/76	3	SW	N edge of pile
2	9.4	11/03/76	5	N	0.1 mi N of pile
3	28.0	11/09/76	5	NE	Guard station, 0.13 mi E of pile
4	5.1	11/04/76	3	W	0.3 mi N of pile
5	5.5	11/05/76	4	NE	0.5 mi N of pile
6	6.8	11/03/76	5	N	0.6 mi WNW of pile
7	7.7	11/05/76	4	NE	0.7 mi NW of pile
8	2.9	11/06/76	6	NE	0.7 mi N of pile
9	5.0	11/10/76	5	NW	0.8 mi NW of pile
10	11.5	11/10/76	5	NW	2.0 mi S of pile
11	5.0	11/09/76	5	NE	3.0 mi NW of pile, 0.5 mi S of lake bed

Ref. FBDU, 1981.

Baseline concentrations of radioactive air particulates in the Ambrosia Lake area have been measured approximately one mile west of the existing tailings site. Concentrations for the principle radionuclides of concern averaged 1.1 femtocuries per cubic meter (fCi/m^3) for U-238; 1.1 fCi/m^3 for U-234; 3.1 fCi/m^3 for Th-230; and 3.3 fCi/m^3 for Ra-226 for 26 months of continuous air sampling (NMEID, 1986). Average concentrations for air particulates for 25 months of continuous air sampling in an undisturbed background location near San Mateo were 0.4 fCi/m^3 for U-238; 0.5 fCi/m^3 for U-234; 0.3 fCi/m^3 for Th-230; and 0.7 fCi/m^3 for Ra-226 (NMEID, 1986).

Baseline radioactivity levels in soils typical of the Ambrosia Lake area which were not influenced by the tailings pile have been established as 1.2 $\pm$ 0.7 picocuries per gram (pCi/g) for Ra-226; 1.0 $\pm$ 1.0 pCi/g for Th-230; and 3.0 $\pm$ 1.0 ppm for natural uranium (2.0 $\pm$ 0.7 pCi/g) (BFEC, 1985a). Background concentrations of Ra-226 in soils from areas not influenced by uranium mining and milling averaged 0.57 $\pm$ 0.08 pCi/g (NMEID, 1985) and 0.51 $\pm$ 0.09 pCi/g for Th-230 (NMEID, 1986).

3.6.2 Radiation levels

The average Ra-226 content of the tailings pile is 571 pCi/g (see Appendix D, Section D.3, Radiation). The Ra-226 concentrations ranged from five to 1807 pCi/g (BFEC, 1985a). The average thorium-230 (Th-230) concentration of the tailings pile was measured to be 571 pCi/g, and the uranium-238 (U-238) content was measured at 37 pCi/g (BFEC, 1985a). The average depth of the tailings is 16.6 feet.

Gamma radiation exposure rates have been measured around the Ambrosia Lake tailings pile by many programs (FBDU, 1977, 1981; BFEC, 1985a,b). At a height of one meter above the surface of the tailings pile, the gamma exposure rates ranged from 190 to 1140 microR/hr, and averaged 700 microR/hr (FBDU, 1977, 1981).

Measured radon flux through the tailings at Ambrosia Lake averages 130 picocuries per square meter per second (pCi/m^2s) (FBDU, 1983). The radon flux source term was calculated using the NRC conversion factor (NRC, 1979) of one pCi/m^2s per pCi/g of Ra-226 resulting in an annual average radon flux of 724 pCi/m^2s from the bare tailings based upon an average Ra-226 concentration of 724 pCi/g in the first 2.5 feet of tailings.

The soil beneath the tailings pile exceeds the EPA standards of 15 pCi/g of Ra-226 to an average depth of approximately 4.4 feet. The concentration in this material averages 59 pCi/g (MSRD, 1982; BFEC, 1985a).

Dispersion of the tailings and ore wastes by wind and water erosion has contaminated soils adjacent to the tailings pile. A field survey of the designated tailings site and the surrounding area was conducted to determine the areal extent of contamination (BFEC, 1985a). (Contamination is defined as surface soil (zero to six inches) having concentrations of Ra-226 greater than 5 pCi/g and or/subsurface (below six inches) concentrations greater than 15 pCi/g.) Since soils contaminated with ore are not required to be cleaned up under the UMTRA Project, an effort was made to exclude those areas contaminated by uranium mining, ore transport, and windblown ore wastes. Radium-226/U-238 ratios in soils from the surrounding areas were examined to determine the presence of ore or tailings materials as discussed in the Remedial Action Plan (RAP), Volume II, Appendix D, page D-15 (DOE, 1985). Figure 3.3 shows the resulting areal extent and depth of Ra-226 soil concentrations at the Ambrosia Lake site that exceed the 5 pCi/g cleanup standard. Windblown contamination of tailings in excess of 5 pCi/g in the top six inches of soil extends over 570 acres to the north and east of the tailings site. Waterborne contamination from an on-site leaching pond is present in soils extending along a canal and in the Voght Tank empoundment southeast of the tailings site (Figure 3.3).

Six individual soil samples collected from trenches at borrow site 1 had background Ra-226 concentrations with a mean and standard error of 1.2 $\pm$ 0.2 pCi/g (Charlton, 1986). Currently, no radiation measurements have been made at borrow site 2 since a final location has not been determined. Radiation levels at borrow site 2 are expected to be characteristic of local background and appropriate measurements will be made to ensure that only background cover materials are utilized at the Ambrosia Lake tailings pile.

Additional information is available in BFEC (1985a,b), and SNL (1982).

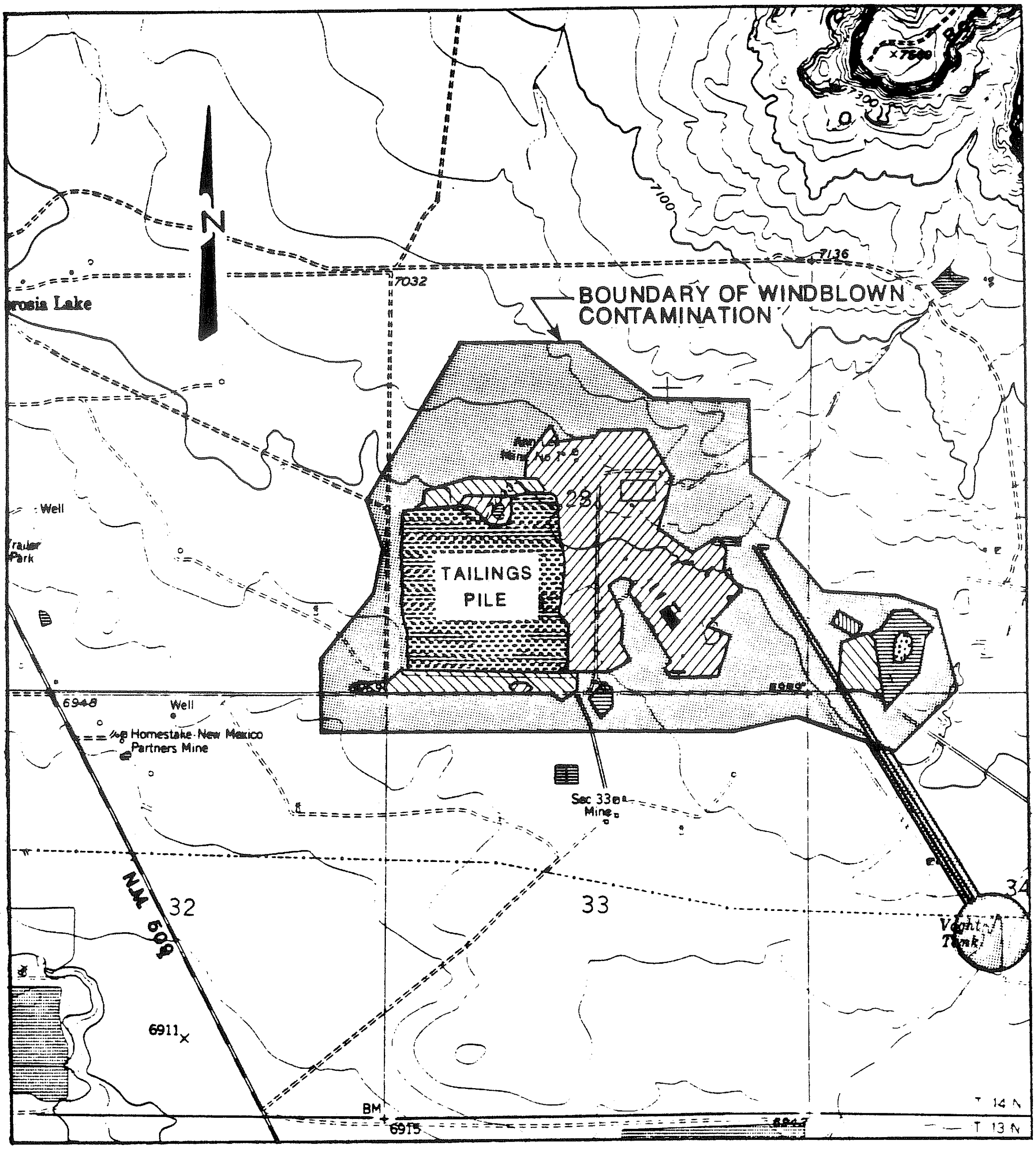
3.7 LAND USE

McKinley County is rural and sparsely populated. The city of Grants (1983 population of 8965) is the largest municipality near the Ambrosia Lake tailings site and is located approximately 20 air miles to the south. The Grants area is the largest uranium district in the United States. Uranium mining has declined dramatically since 1981, with over 90 percent of the uranium mines in the county having stopped production (Durren, 1985).

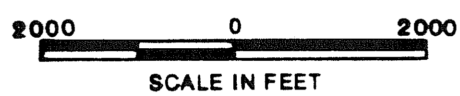
Ninety percent of the land in McKinley County is used for low-density grazing with an average of five to six animals per square mile. Commercial timber production, dryland farming, and some uranium mining and milling also occur throughout the county (FBDU, 1983). About 61 percent of the county is owned or managed by Indian tribes or the Bureau of Indian Affairs. The remainder is privately owned or controlled by state and Federal governments.

Ambrosia Lake tailings site

The land in the vicinity of the tailings site is predominately privately owned (Figure 3.4). Scattered parcels of state and Federal lands are located within a five-mile radius of the site. Grazing is the major land use and the closest active uranium mine is the Homestake Mine at Section 23 located approximately four air miles to the west.



FROM AMBROSIA LAKE USGS 7.5 MIN.



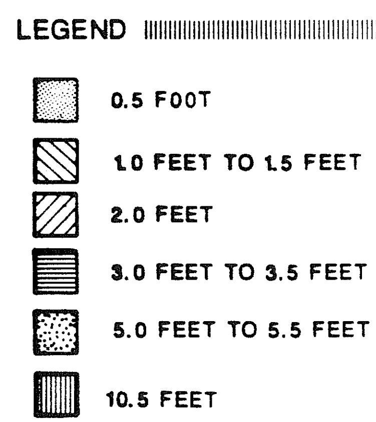


FIGURE 3.3

AREAL EXTENT AND DEPTH OF Ra-226 SOIL CONCENTRATIONS EXCEEDING 5 pCi/g

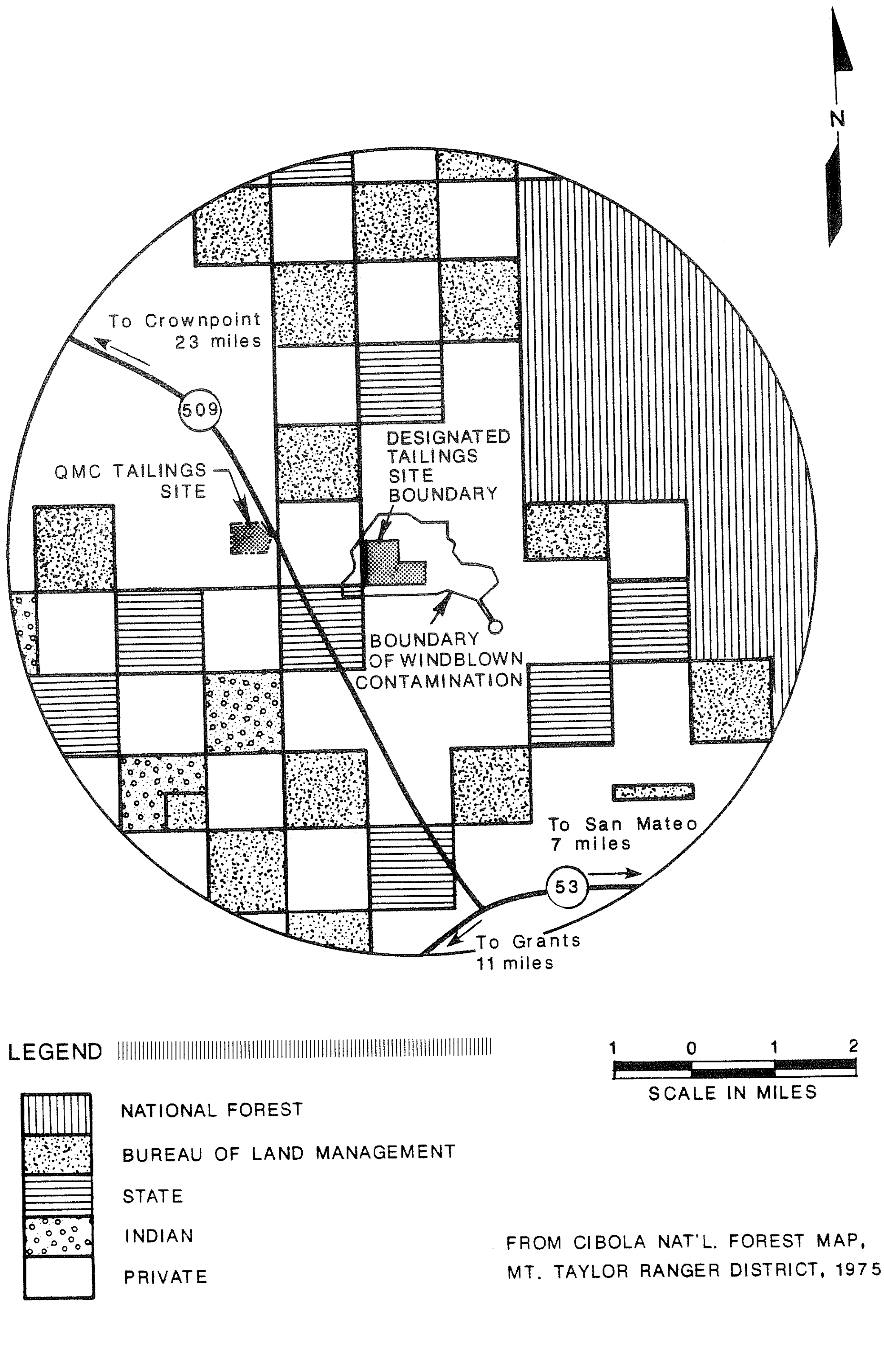


FIGURE 3.4 LAND OWNERSHIP WITHIN FIVE MILES OF THE AMBROSIA LAKE TAILINGS SITE

Borrow sites

Borrow site 1 is located on land predominately owned by United Nuclear Corporation and leased to an area resident for cattle grazing. The land in adjacent Sections 22, 27, and 28, not occupied by the designated site, is also used for grazing. Water is in short supply in this area which limits its usefulness as grazing land.

Borrow site 2 is located on U.S. Forest Service land near the abandoned San Mateo uranium mine. At present, the site is part of a grazing allotment of approximately 8000 acres, and seasonal grazing by 100 head of cattle is the primary land use (Sampson, 1985).

3.8 NOISE LEVELS

The Ambrosia Lake tailings site is located in a sparsely populated area used primarily for grazing. The nearest sensitive noise receptor (residence) is located approximately 2.5 air miles northwest of the site. New Mexico Highway 509 is approximately 4000 feet southwest of the site and is the only significant transportation noise source in the area. Based on typical values of noise levels associated with various land uses (Table 3.6), the Ambrosia Lake area day-night noise levels (L_{dn}) are probably in the 35- to 40-decibel range. The L_{dn} is a noise rating system which assigns a 10-decibel penalty to the nighttime period to account for the heightened perception to noise during that time.

Borrow site 1 is located in an undeveloped rural area. Noise measurements were not taken at this site. Based on Table 3.6, the estimated day-night noise level is 35- to 40-decibels.

Table 3.6 Typical values of day-night noise levels

Land use description	Population density (people per square mile)	L_{dn} (decibels)
Rural, undeveloped	20	35
Rural, partially developed	60	40
Quiet suburban	200	45
Normal suburban	600	50
Urban	2,000	55
Noisy urban	6,000	60
Very noisy urban	20,000	65

Ref. NAS, 1977.

Borrow site 2 is located on undeveloped forest land in the Cibola National Forest. Noise measurements were not taken at this site. This site is located approximately one air mile south of New Mexico Highway 53 and approximately 1.75 air miles from the nearest residence. Estimated noise levels for this area are 35 to 40 decibels.

3.9 SCENIC AND CULTURAL RESOURCES

Scenic resources

The scenic resources of the Ambrosia Lake tailings site are characterized by a combination of rural and industrial views. The numerous mine and mill complexes and tailings piles in the Ambrosia Lake valley contrast markedly with the open, sparsely vegetated terrain. The abandoned mill buildings and tailings pile at the Ambrosia Lake site can be seen by travelers on New Mexico Highway 509. Near the site, foreground views are dominated by scrub vegetation and features associated with mining activities (e.g., mine headframes, vent holes, mine buildings). The QMC tailings pile is visible in the middleground to the southwest of the tailings site. Forested mesas and Mount Taylor (11,301 feet MSL) provide background views to the north, east, southeast, and west. The Zuni Mountains are visible in the distance to the southwest.

Borrow site 1 is in a scenic setting very similar to the Ambrosia Lake tailings site. Prominent foreground features include the headframe and associated structures at the abandoned Ann Lee Mine to the south and the pinon and juniper covered mesas to the east. The Ambrosia Lake and QMC tailings piles are visible in the middleground and background to the south and west, respectively.

Borrow site 2 is set in variable terrain with views obstructed occasionally by topography and vegetation. Foreground views are dominated by the rough textures of the colluvial slope and previously disturbed mine area. To the north and east, open vistas of the San Mateo Creek valley are dominant. To the south, the rugged, well-forested slopes of the La Jara mesa are visible.

Historic resources

The historic period of the area began in 1540 with the arrival of Coronado, an early Spanish explorer, into New Mexico. Concurrent with Spanish exploration, the Navajo were settling northwestern New Mexico. Although early occupation of the project area is not well documented, it is probable that historic sites dating to the early 18th century are present (CASA, 1985).

Uranium was discovered in the Grants Mineral Belt in 1950 (NMEMD, 1979). Mining and milling of uranium deposits were the principal industry in the Ambrosia Lake valley until about 1980 when demand for uranium declined.

One historic site has been identified in the area adjacent to the tailings site surveyed for historic and cultural resources. The site is a Navajo pueblo dating to the 18th century and is eligible for nomination to the National Register of Historic Places (NRHP) (CASA, 1985; Merlan, 1985).

Archaeological resources

Extensive archaeological investigation of the Ambrosia Lake area has been conducted, with much of this work occurring during the last ten years in connection with energy development. Evidence of human activity indicates that the earliest occupation appears to be during the Archaic period (5500 BC to 700 BC) beginning at approximately 3000 BC. A drop in the population of the area occurred from 1 AD to 800 AD, followed by puebloan Anasazi occupation which lasted until approximately 1070 AD. After this time the area was abandoned until approximately 1540 when the area was settled by the Spanish and the Navajo Indians (CASA, 1985).

There are three Chacoan outliers (i.e., independent settlement associated with the main Chacoan center) within ten miles of the tailings site. Site density at an outlier within two miles of the tailings is one site per 11.3 acres. The majority of the sites at this location are masonry pueblos occupied during the 11th century.

An intensive cultural resource survey was conducted of the Ambrosia Lake tailings site and surrounding area in the winter of 1984-85. Twenty-seven archaeological sites were identified. Twenty-six sites are from the Anasazi period (700 BC to 1300 AD) and consist of agricultural-use areas and habitation sites. The remaining site was occupied in the 17th or 18th century. Twenty-five of these Anasazi sites are related to the Chacoan outlier within two miles of the site (CASA, 1985). Ten of the 27 sites are considered eligible for nomination to the NRHP; 14 require additional data to determine eligibility and three are ineligible (Merlan, 1985).

Approximately 40 percent of borrow site 1 has been surveyed for cultural resources (Class III survey). No cultural resources were identified (CASA, 1985). Borrow site 2 has not been surveyed for cultural resources. Part of this site was previously disturbed by mining activities. It is unlikely that cultural resources are present at this site.

3.10 SOCIOECONOMIC CHARACTERISTICS

Although the Ambrosia Lake tailings site is located in southeastern McKinley County, the socioeconomic focus is primarily on Cibola County and the Grants-Milan area due to the geography and highway system configuration.

Population, employment, housing, and community services

The decline of the uranium industry in the late 1970s had a significant effect on employment in Cibola County, and in particular, the cities of Grants and Milan. Although many workers left the area, the current workforce is expected to be comprised of many unemployed individuals who remained.

As presented in Table 3.7, socioeconomic indicators for Cibola County, Grants, and Milan show a decline since 1980. Since the 1980 census, the population of Grants has declined 22 percent. Further evidence of the impact of mine closures is shown by the 28 percent drop in Cibola County employment related to mining and construction. In September, 1985, unemployment in Cibola County was among the highest in New Mexico at 18.8 percent.

As a result of the population decline, there is a surplus of available housing in Grants and Milan. As would be expected, community services such as water, sewage treatment, and schools are operating significantly below capacity.

Public finance

Revenues and disbursements for Cibola County, Grants, and Milan are presented in Table 3.8. Available revenues have not significantly changed in recent years at either the municipal or county level. Changes in revenue patterns may be attributed to factors such as the 11 percent decrease in assessed property values, the availability of capital improvement monies, or the rise in unemployment.

The gross receipts tax for the Grants area is 5.125 percent. Grants and Cibola County receive 2.35 percent and 0.375 percent of these receipts, respectively (Garcia, 1985).

Transportation

The Grants-Milan area is served by a railroad, two bus lines, and the Grants Municipal Airport. The major highway in the area is Interstate 40; average daily traffic in 1984 on Interstate 40 was approximately 10,400 vehicles for the segment between Grants and Milan. Other highways serving the Ambrosia Lake area include New Mexico Highways 53 and 509. Average daily traffic for New Mexico Highway 53 was 721 in 1984 for the segment between Milan and New Mexico Highway 509. Average daily traffic for New Mexico Highway 509 between New Mexico Highway 53 and the Ambrosia Lake site was 538 in 1984. Average daily traffic for New Mexico Highway 53 between the intersection of New Mexico Highway 509 and San Mateo was 273 vehicles in 1984. Traffic is below the capacity of these highways (Blewett, 1985).

Table 3.7 Population, employment, housing, and community services for Cibola County, Grants, and Milan

Socioeconomic indicators	Cibola County		Grants		Milan		Comments
	1980	1984	1980	1984	1980	1984	
Population	30,402[a]	25,300[b] (1983)	11,439[c]	8,965[c] (1983)	3,747[c]	2,831[c] (1983)	
Percent decline		17 percent		22 percent		24 percent	
Employment (jobs)[d,e]							
All sectors, nonagricultural	8,351	4,281	N/A[f]	N/A	N/A	N/A	
Mining-construction employment only	3,721	730	N/A	N/A	N/A	N/A	
Mining-construction employment as a percent of all nonagricultural employment	45 percent	17 percent	N/A	N/A	N/A	N/A	
Unemployment rate[g]	9.0 percent	14.1 percent	5.3 percent	N/A	3.3 percent	N/A	
Housing[h]							By 1982, 33 percent of the rental and mobile home units in Grants were unoccupied with eight percent of the single family dwellings for sale or in foreclosure. An estimated 1000 units were available for rent or purchase at the end of 1982 when the market and population stabilized (FBD, 1983).
Number of units	10,499	N/A	3,977	N/A	1,280	N/A	
Number of units vacant (percent of capacity)			422 (11 percent)		129 (10 percent)		
Schools (students)[i]							The Grants Municipal School District provides primary and secondary education for Cibola County.
Enrollment	Not applicable		6,100 (1979)	3,979 (1984-85)	Not applicable		

Table 3.7 Population, employment, housing, and community services for Cibola County, Grants, and Milan (Concluded)

Socioeconomic indicators	Cibola County 1980	Cibola County 1984	Grants 1980	Grants 1984	Milan 1980	Milan 1984	Comments
Water (potable)[j,k]							
Peak available daily pumping capacity	Not applicable		4.9 million gallons per day		2.0 million gallons per day		
Average peak daily use (percent of capacity)			2.3 million gallons (47 percent, 1985)		642,674 gallons (31 percent, 1985)		Average peak daily use reflects the average daily use calculated for the month of peak consumption (July).
Sewage[j]							
Average daily capacity	Not applicable		2 million gallons		Not applicable		Grants provides sewage treatment for Milan. The treatment system can sustain peak capacity for short periods of time only.
Peak daily capacity			4 million gallons				
Average daily flow (percent of average daily capacity)			0.9 million gallons (45 percent, 1985)				
Hospitals[l]							
Bed capacity	Not applicable		39 beds		Not applicable		Cibola General Hospital, located in Grants, services the entire county.
Average occupancy rate			40 percent				

[a]Ref. DOC, 1981a.
[b]Ref. DOC, 1984.
[c]Ref. FBDU, 1983.
[d]Ref. Middle Rio Grande Council of Governments, 1982.
[e]Ref. Blackwell, 1985.
[f]N/A - Not available.
[g]Ref. Urban, 1985.
[h]Ref. DOC, 1981b.
[i]Ref. Marquez, 1985.
[j]Ref. Lovato, 1985.
[k]Ref. Gomez, 1985.
[l]Ref. Patterson, 1985.

Table 3.8 Local government finances for Cibola County, Grants, and Milan

	1980-1981			1981-1982			1982-1983			1983-1984		
	Revenues	Disburse-ments	Net	Revenues	Disburse-ments	Net	Revenues	Disburse-ments	Net	Revenues	Disburse-ments	Net
Cibola County[a]	---	---	---	3,091,523	1,903,862	+1,187,661	2,422,602	2,468,807	-46,205	2,887,359	2,631,924	+255,435
Grants	5,733,307	9,996,685	-4,263,378	7,780,863	6,886,909	+893,954	5,873,104	7,279,924	-1,406,820	7,590,203	7,740,020	-149,817
Milan	2,244,508	1,192,024	+1,052,484	1,718,858	1,821,269	-102,411	2,002,270	2,050,957	-48,687	1,318,011	1,348,547	-30,536

[a]Cibola County was a part of Valencia County until Fiscal Year, 1981.

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4.0 ENVIRONMENTAL IMPACTS

This section discusses the impacts of the proposed action, the no action alternative, and the relocation to Section 21 site alternative. As shown in this section, given the feasibility of the proposed action, its lesser costs and short-term impacts, and its similar long-term impacts compared to relocation to the Section 21 site, the proposed action was selected. In addition, the selection of the no action alternative would not be consistent with the intent of Congress in UMTRCA and would not result in DOE's compliance with the EPA standards.

4.1 RADIATION

The following sections discuss radiation exposure pathways and the excess health effects that would occur during and after remedial action. The health effects of construction-related accidents that might occur are also considered. Exposure to gamma radiation may cause genetic health effects in addition to somatic health effects (e.g., cancer). The genetic risk is approximately two-thirds the somatic risk for gamma radiation, and a genetic health effect in general may be considered less severe (ICRP, 1977) (see Appendix D, Radiation, Section D.2). Measures taken to reduce the somatic health effects would also reduce the genetic effects. The discussions on health effects in the following sections and the excess health effects calculations in Appendix D, Radiation, reflect only the somatic health effects.

4.1.1 Exposure pathways

There are five principal radiological pathways by which individuals could be exposed during the remedial action (Figure 4.1). These are: (1) inhalation of radon and radon daughters; (2) direct exposure to gamma radiation; (3) inhalation and ingestion of, and submersion in, airborne radioactive particulates; (4) ingestion of ground and surface waters contaminated with radioactive materials; and (5) ingestion of contaminated foods produced in areas contaminated by tailings. For the calculation of health effects, only those pathways which would result in the largest radiological doses to the general public were considered in detail: inhalation of radon and radon daughters; direct exposure to gamma radiation; and ingestion of locally grown livestock.

Analyses of radiation health effects from air particulates at other UMTRA Project sites and at active uranium mill tailings sites in the vicinity of Ambrosia Lake indicate that this pathway would result in excess health effects orders of magnitude less than those from inhalation of radon daughters (DOE, 1983a; 1984; 1985a; Millard and Baggett, 1984). The water ingestion pathway has also been shown to be relatively insignificant in terms of excess health effects (DOE, 1984; 1985a). This is expected to be the case at the Ambrosia Lake site since only a few sources of

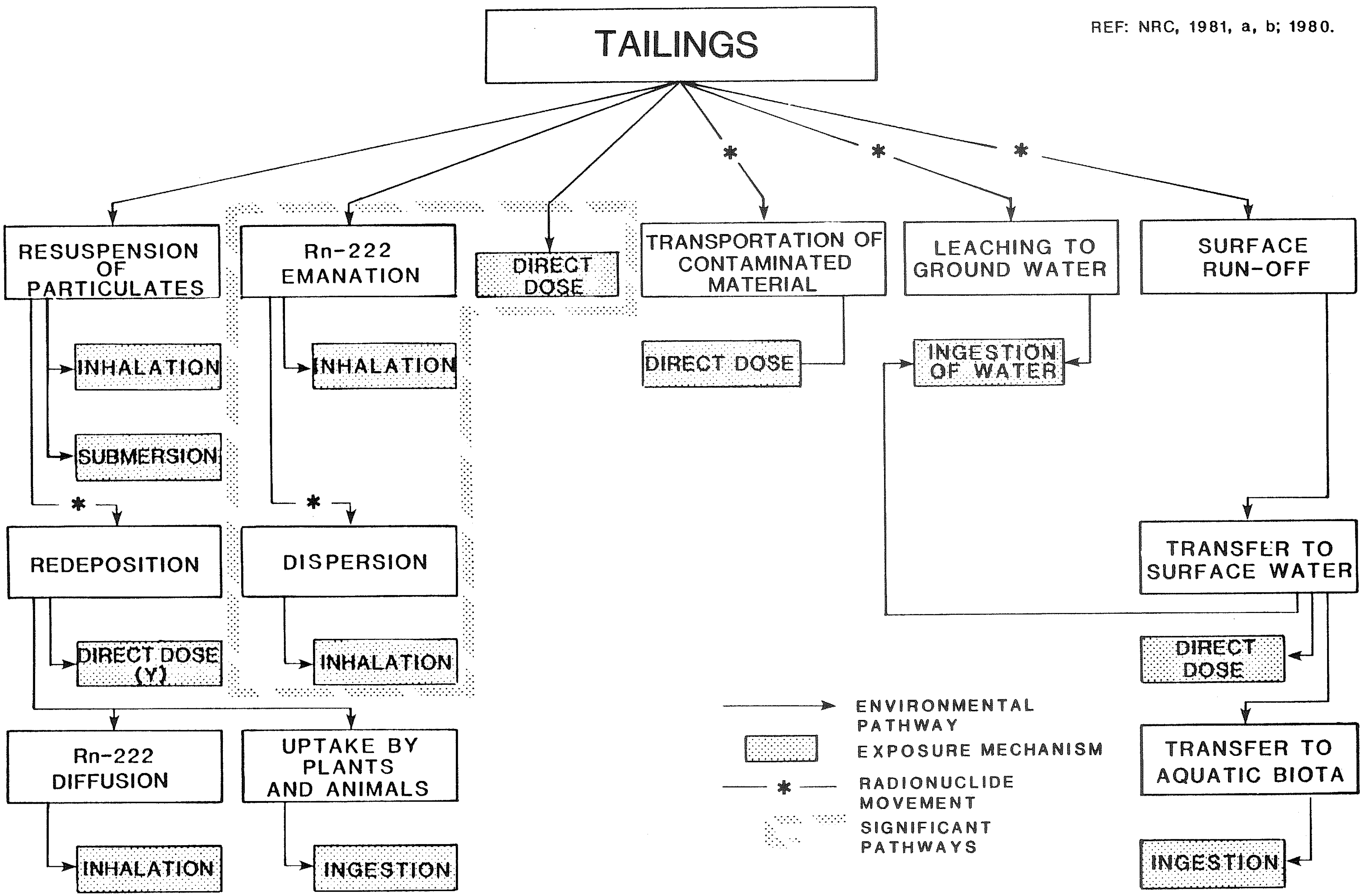

FIGURE 4.1

POTENTIAL RADIATION EXPOSURE PATHWAYS TO THE GENERAL PUBLIC AND REMEDIAL ACTION WORKERS

drinking water occur near the site and potential impacts to the aquifer in the Westwater Canyon Member will be minimal. Degradation of these wells is not expected to occur as described by analyses presented in Appendix B, Section B.2.6 of the EA. For these reasons, the air particulate and drinking water ingestion pathways will not be considered further in this section.

Consideration was not given to locally grown crops since no crops have historically been grown in the area and are not currently being produced. Agricultural use in the area consists of low density grazing. However, the continual consumption of beef cattle as a sole source of meat for local ranchers may be important (Lapham et al., 1985) and is considered further in Section 4.1.3.

4.1.2 Health effects during remedial action

The estimates of excess health effects (i.e., fatal cancers) in this section are based on the procedures discussed in Appendix D, Radiation. These procedures are based on conservative assumptions to estimate the level of excess health effects. Table 4.1 lists the estimated excess health effects that would occur during stabilization in place.

Table 4.1 Excess health effects during stabilization in place[a]

General public radon daughter health effects	General public gamma health effects	Remedial action worker radon-daughter health effects	Remedial action worker gamma health effects	Total excess health effects
0.00054	0.0	0.0084	0.0027	0.01

[a]Health effects were calculated for a 13-month stabilization period. The no action alternative would result in 0.0005 total excess health effects per 13 months.

The proposed remedial action would cause the tailings and contaminated windblown materials to be disturbed for a 13-month period. As can be seen from Table 4.1 and the no action alternative results per year in Table 4.2, remedial action would result in a slight increase in radon-daughter health effects to the general public from 0.00048 (0.00052 per 13 months) to 0.00054. Excess health effects from gamma radiation would remain at zero for the general public during remedial action, while remedial action workers would incur excess health effects of 0.0027. Total excess health effects would increase from 0.0005 per 13 months under present no action conditions, to 0.01 during remedial action. This increase is due primarily to the increased health effects predicted for radon-daughter inhalation by remedial action workers (0.0084). Although it appears that there is a 20-fold increase in predicted total health effects during stabilization in place, only a small portion of this increase would affect the general public (0.2 percent), while the remainder would affect remedial action workers. Excess health effects to remedial action workers would be greatly reduced with appropriate mitigative measures as described in the UMTRA Project Environmental, Health, and Safety Plan (DOE, 1983b). Such measures include dust suppression, protective clothing, dosimetry and bioassay programs, and respiratory protection, if necessary.

In the population of the United States, an individual has a 16 percent, or one in six, chance of contracting fatal cancer (NAS, 1980). This means that approximately 10 of the 60 persons who live within a six-mile radius of the Ambrosia Lake site may be expected to die of cancer, regardless of the presence of the unstabilized tailings pile. With the no action alternative, an additional 0.5 excess health effects would occur in a 1000-year period. That number would be reduced to less than 0.02 excess health effects following stabilization in place.

Selection of tailings relocation to the Section 21 site as the remedial action would result in a slightly higher number of total excess health effects than for stabilization in place. This is due principally to increased health effects to remedial action workers because of a longer construction period and a greater number of workers. The gamma radiation health effects to the general public from the transport of tailings to the Section 21 site would be negligible. A tailings spill resulting from a truck accident would be cleaned up immediately and would therefore cause only a short exposure time to persons near the spill. Contractors working for the DOE would be required to establish approved procedures for cleaning up spills.

4.1.3 Health effects after remedial action

Stabilization in place would result in 0.000008 total excess health effects per year after remedial action compared to 0.0005 total excess health effects per year for the no action alternative (Table 4.2). The no action alternative would result in excess health effects that are approximately 60 times greater than health effects following stabilization in place.

The excess health effects calculations for the no action alternative are underestimates since they do not consider the increased dispersal of tailings by natural forces and man or the consumption of greater quantities of contaminated livestock with time. Because there is no way to accurately predict the level or

Table 4.2 Yearly excess health effects after remedial action[a]

Alternative	General public radon daughter health effects per year	General public gamma health effects per year	Total excess health effects per year
Stabilization in place	0.0000078	0.0	0.000008
No action	0.00048	0.0	0.0005

[a]Health effects per year from consumption of contaminated livestock are not included in the no action total, but are estimated to be 0.0005 (see Section D.3.3 in Appendix D, Radiation, and Lapham et al., 1985).

rate of dispersion or consumption, the health effects calculations did not include these parameters. Without remedial action, dispersion and consumption would occur over time, and the actual total excess health effects could be much greater than 0.0005 (no action without livestock consumption) or 0.001 (with livestock consumption) per year.

Relocation of the tailings to the Section 21 alternate site would result in similar excess health effects when compared to stabilization in place following remedial action. Estimated excess health effects would be similar because of a similar cover design and potentially exposed population.

Table 4.3 lists the estimated total excess health effects for the stabilization in place and no action alternatives that would occur over time following remedial action. These numbers are the excess health effects that would occur during remedial action plus the integrated yearly excess health effects after remedial action. This analysis assumes a stable population and no dispersal of the tailings in the future. Total excess health effects would increase if the nearby population increased or the tailings were dispersed by natural forces or by man. As evidenced in Table 4.3, only after a number of years following stabilization are the health effects from the proposed action exceeded by those incurred for no action. Table 4.3 also does not account for excess health effects due to consumption of contaminated livestock. These excess health effects (see Table 4.2) may occur for no action but would return to zero for stabilization in place.

4.2 AIR QUALITY

Air quality impacts were estimated for stabilization in place. The impact assessment consisted of a detailed emissions inventory and

Table 4.3 Total excess health effects 5, 10, 100, 200, and 1000 years after remedial action[a]

	Number of years after remedial action				
Alternative	5 years	10 years	100 years	200 years	1000 years
Stabilization in place	0.01	0.01	0.01	0.01	0.02
No action	0.002	0.005	0.05	0.1	0.5

[a]Totals include excess health effects incurred during stabilization.

translation of these emissions into ambient air pollution concentrations through the use of computer simulation techniques. The modeling is conservative in nature and thus overpredicts potential impacts.

Air emissions inventory

The emissions inventory includes estimates of combustion emissions from construction equipment and fugitive dust emissions. Emissions were calculated for hydrocarbons (HC), nitrogen oxides (NO_x), sulfur oxides (SO_x), carbon monoxide (CO), and total suspended particulates (TSP). The estimates include emissions from activities occurring at the Ambrosia Lake site, from vehicles traveling on paved roads and graveled haul roads, from equipment operating at borrow sites 1 and 2, and from wind erosion of the tailings. Combustion and fugitive dust emissions were calculated based on the emission factors for heavy-duty construction equipment (EPA, 1983a).

Fugitive dust emissions would be the dominant pollutant for stabilization in place (Table 4.4). Truck movement to and from the borrow areas would be the most significant source of these emissions. Exhaust particulates would be a minor contributor to TSP. HC, NO_x, SO_x, and CO emissions would be relatively low. NO_x would attain the highest level for combustion emissions followed by CO, SO_x, HC, and TSP.

Air pollutant concentrations

Ambient air pollutant concentrations were estimated through the use of EPA-approved computer simulation models. These models translate air pollutant emissions into ambient air pollutant concentrations under conservative meteorological conditions. Emphasis was placed upon modeling of TSP emissions because TSP emissions would be much higher than combustion emissions (see Table 4.4). Furthermore, TSP is the only pollutant

Table 4.4 Total emissions during stabilization in place[a]

Activity	Combustion emissions (tons) HC	NO_x	SO_x	CO	TSP	Fugitive dust emissions (tons) TSP
Construction at tailings site	9.2	149.2	10.2	28.0	6.9	1201.0
Construction at borrow site 1	1.7	23.4	1.7	4.8	1.4	145.0
Construction at borrow site 2	0.4	6.1	0.5	1.3	0.4	60.0
Truck haulage to/from borrow site 1	0.4	2.8	0.3	1.9	0.2	1952.0
Truck haulage to/from borrow site 2	0.8	5.5	0.7	3.7	0.3	1994.0
Total	12.5	187.0	13.4	39.7	9.2	5352.0

[a]Total emissions were calculated based on fuel consumption rates, vehicle-miles traveled, vehicle speed, soil composition, the size of the area of disturbance, and the volumes of materials moved (CDH, 1981).

type for which the air quality monitored at stations near the Ambrosia Lake site either exceeds or approaches the limits of applicable air quality standards (Table 3.3).

Modeling of project-related, 24-hour TSP increments was based on the use of the Industrial Source Complex Dispersion Model for short-term applications (ISCST) (EPA, 1983b). The ISCST model is particularly appropriate for an application of this type since it considers particulate deposition and can also accomodate large area emissions sources and line emissions sources such as trucks traveling on haul roads. The emissions used as inputs to the model are shown in Table 4.5, and correspond to the project phase in which the maximum emission rates would occur.

Particulate concentrations near the Ambrosia Lake site, borrow site 1, and the connecting haulage road were modeled. Emissions from the tailings site were assumed to come from a 648,000-square-meter area, while borrow site 1 emissions came from a 243,000-square-meter area. Emissions were conservatively assumed to be constant throughout the remedial action and dust control measures were assumed to be 50 percent effective (in some instances, control methods can provide up to 90 percent reduction; this is not likely given the type of remedial action). Receptors were programmed to be placed downwind of the sites at 820-foot intervals out to a distance of 4920 feet. To estimate maximum 24-hour averages of

Table 4.5 Conservative hourly fugitive particulate emissions for stabilization in place[a]

	Tailings site	Borrow site 1
Maximum emission month (number)	6	13/14
Emissions (lbs/hr, uncontrolled)		
Compactor	21.0	--
Bulldozer	544.0	96.0
Front-end loader	18.0	34.6
Grader	32.0	--
Scraper	144.0	16.0
Water truck	21.0	--
Backhoe	1.4	--
On-site truck-haul	180.0	--
Truck dumping	42.6	--
Wind erosion	86.2	17.7
Total, uncontrolled (lbs/hr)	1090.2	164.3
Total, controlled (lbs/hr)	545.1	82.2

[a]lbs/hr - pounds per hour.

particulate concentrations, light winds (2.5 meters per second) were assumed to blow persistently from a single direction under stable meteorological conditions (Pasquil-Gifford Category F). These conditions were allowed to persist for the first six hours of the 24-hour modeling period. This approach is conservative since six consecutive hours of stable meteorological conditions during normal construction hours is highly unlikely.

The ISCST model was also used to predict short-term air quality impacts along the truck haul road between the tailings site and borrow site 1. In applying the model, peak month emissions were assumed for a 2950-foot length of the road. The wind was assumed to blow perpendicular to the road for six hours. The remaining hours were assumed to have no impact. A wind speed of 5.6 miles per hour was assumed to blow from a single direction under stable meteorological conditions (Pasquil-Gifford Category F). Receptors were programmed to be located downwind of the road at distances of 820, 1640, 2460, and 3250 meters. The truck haul route between borrow site 2 and the tailings site would feature substantially fewer trips (a peak of approximately 10 round-trips per hour versus 52 between the tailings site and borrow site 1) and impacts would be proportionately less.

Modeling indicated there would be little deterioration in air quality from exhaust pollutants and their levels would be within all applicable air quality standards. The concentration of TSP is expected to exceed the Federal and state Ambient Air Quality Standards (see Table 3.3) at the tailings site, and at borrow site 1 and its associated haul road, (Table 4.6); TSP standards along the gravelled haul road to borrow site 2 may also be exceeded. Some of the particulate impact can be attributed to wind erosion; however, most is attributable to fugitive dust generated by the construction equipment. TSP emmissions from borrow site 2 were not modeled since peak emissions from borrow site 2 would be substantially lower than at borrow site 1 due to lower equipment activity levels. Similarly, TSP emissions from the truck haul road connecting borrow site 2 with the tailings site were not modeled.

Table 4.6 Predicted maximum 24-hour TSP concentrations for stabilization in place[a]

Location	24-hour TSP increment (micrograms per cubic meter)
Ambrosia Lake tailings site	359[c]
Truck transportation route[b]	1516[c]
Borrow site 1	222[d]

[a]Does not include background concentrations of particulates.
[b]Between the Ambrosia Lake tailings site and borrow site 1.
[c]Exceeds Federal primary and secondary and New Mexico TSP standards.
[d]Exceeds Federal secondary and New Mexico TSP standards.

In addition, a supplemental modeling analysis was performed to evaluate TSP impacts under high wind conditions. To represent emissions occurring during high wind conditions more realistically, the Colorado Department of Health emission factors for wind and equipment-generated fugitive dust were assumed to be four times higher than those used in the original modeling described above. This appears to be a reasonable estimate since the original emission factors were based on a five-meters-per-second wind speed. Wind-generated fugitive dust emissions were assumed to occur for the entire 24-hour modeling period while equipment-generated fugitive dust emissions were assumed to occur for eight hours. A 50-percent reduction in fugitive dust was assumed only for the eight hours that the equipment would be operating. A 10-meter-per-second wind speed along with Pasquil-Gifford Category D stability were assumed. The wind was conservatively assumed to remain in the same 10° sector for the entire 24 hours. The predicted impact under these simulated high wind speed conditions was 287 micrograms per cubic meter, approximately 20 percent lower than that found in the original analysis and thus, the original analysis presented above represents a reasonably conservative analysis.

Estimates of annual concentrations of particulates were not calculated due to the absence of reliable meteorological information. Annual concentrations of particulates would be significantly less than the maximum 24-hour estimates. However, it is likely that some areas close to the tailings site, borrow sites, and associated haul road would exceed the annual standards.

For the no action alternative, no deterioration in air quality over existing levels would occur at the tailings site, the borrow sites, or along the truck haul routes.

If selected, disposal of the tailings at the Section 21 site would result in reduced pollutant emissions rates at the Ambrosia Lake tailings site relative to stabilization in place due to lower equipment activity levels and consequently lower maximum pollutant concentrations; however, emissions would occur over a longer period (30 months for disposal at Section 21 rather than 18 months for stabilization in place). Emissions rates and resultant maximum pollutant concentrations at the Section 21 site would be expected to be similar in magnitude to levels estimated for the Ambrosia Lake tailings site for stabilization in place. Gravelled haul road dust emission rates would be similar to rates estimated for stabilization in place; however, total emissions would be greater because of the much larger number of truck trips for disposal at the Section 21 site. It is expected that relocation of the tailings to the Section 21 site would result in overall impacts to air quality similar to impacts from stabilization in place.

4.3 SOILS

Each of the action alternatives would result in the temporary disturbance and permanent loss of soils. These impacts would result from surface disturbances caused by: (1) the excavation of contaminated soils, borrow materials, and the alternate disposal site; (2) construction and upgrading of access roads; (3) construction of staging and stockpiling areas; and (4) excavation of a disposal pit for burial of mill rubble.

Stabilization in place would result in the temporary disturbance of approximately 586 acres of soils (approximately 930,000 cubic yards) during the cleanup of areas at and around the tailings pile. This includes contaminated areas at the mill yard and the windblown tailings (570 acres). Sixteen acres of soils beneath the existing tailings pile would be excavated during pile construction. The contaminated soils would be consolidated with the tailings pile. Excavation of a disposal pit for burial of mill rubble and construction of an access road to borrow site 1 would not impact soils as these areas would be excavated during the cleanup of windblown tailings. Soils present in the area that would be occupied by the stabilized tailings pile (95 acres) would be permanently lost. The areas excavated during the cleanup of contaminated soils within and adjacent to the tailings site would be restored in accordance with applicable permits or approvals. Restoration techniques typically required include recontouring to promote surface drainage and revegetating to minimize erosion.

Stabilization in place would require the use of borrow sites 1 and 2. Borrow site 1 would be the source of earthen materials for covering the consolidated tailings and contaminated materials. Approximately

60 acres of soils would be temporarily disturbed for the excavation and stockpiling of borrow materials. Borrow site 2 would be the source of gravel and rock for access road construction and upgrading and for armoring the stabilized tailings pile. Approximately 2.5 acres of soils would be permanently lost to upgrade two miles of access road to the site, and approximately 50 acres of soils would be temporarily disturbed at borrow site 2 to obtain the required quantities of gravel and rock. The disturbed acreage would be restored to a condition compatible with the surrounding terrain and in accordance with the requirements of the Free Use Permit issued by the U.S. Forest Service (Appendix E, Permits, Licenses, Approvals).

The no action alternative would not involve remedial action; therefore, no new disturbance or loss of soils would occur. Contamination (with Ra-226) of soils adjacent to the tailings site due to dispersion of the tailings by wind and water erosion would continue. The rate of this continuing contamination cannot be accurately quantified, but 570 acres of soil have been contaminated to date.

Disposal of the tailings at the Section 21 site would result in a similar level of disturbance to soils as stabilization in place. Earthen materials excavated from the Section 21 site for partially below-grade disposal of the tailings would be used as the radon barrier, eliminating the need for borrow materials from borrow site 1. Soils present in the area that would be occupied by the stabilized tailings pile at the Section 21 site and used for an access road to the site would be permanently lost; however, soils present beneath the existing tailings pile would be reclaimed following remedial action. Both disposal at the Section 21 site and stabilization in place would involve a similar amount of disturbance to soils at borrow site 2.

4.4 MINERAL RESOURCES

All of the alternatives, except no action, would result in the consumption of borrow materials (e.g., earth, gravel, and rock). The consumption of borrow materials from the proposed local sources would have a negligible impact on the availability of these resources as all of these materials are available in large quantities throughout the Ambrosia Lake area. None of the alternatives would have an impact on other mineral resources in the area. The existing tailings site, the Section 21 alternate disposal site, and borrow sites 1 and 2 are underlain by geologic formations that contain noncommercial concentrations of uranium ore at current market values; however, future recovery of these mineral reserves would not be restricted by the proposed action.

4.5 WATER

4.5.1 Surface water

This section describes the potential surface-water impacts during remedial action. Additional details are provided in Section B.1 of Appendix B, Water.

Stabilization in place

During remedial action, the cleanup and consolidation of the tailings and other contaminated materials would result in surface disturbance. Runoff from these disturbed areas must be controlled to protect against release of waterborne contaminants and discharge of sediments. The remedial action design includes the construction of drainage controls and waste-water retention ponds during site preparation to prevent the discharge of contaminated water from the site. The drainage controls and waste-water retention ponds would be constructed according to applicable regulations (Appendix E, Permits, Licenses, Approvals). The contaminated water would be retained for evaporation or use in the compaction of the tailings and contaminated materials, and any sediments from the ponds would be consolidated with the tailings during the final reshaping of the tailings pile.

Several control features were incorporated into the remedial action design to prevent erosion of the stabilized pile and subsequent contamination of adjacent surface water. The sideslopes of the pile would be limited to five horizontal to one vertical (20 percent) and the top of the pile would be gently sloped (2.5 percent) to promote drainage away from the pile with nonerosive flow velocities. These design features would prevent impacts to surface waters by contact with the tailings after remedial action.

A rock erosion protection barrier would be placed on the top- and sideslopes of the pile to withstand the erosive forces of severe rainfall events such as a Probable Maximum Precipitation (PMP). A PMP is defined as the maximum precipitation that could occur from the most severe combination of meteorological conditions that would be reasonably possible in a region. The rock used in the erosion protection layer would be sized to withstand surface-water flow velocities resulting from flooding associated with a PMP event. Details on rock erosion protection and flood analyses are contained in Section B.2 of Appendix B, Water, and in the draft Remedial Action Plan (DOE, 1985b).

No action

The no action alternative would result in the continued erosion and transport of tailings by surface-water runoff. In addition, the potential exists for the transport of tailings by flooding in the drainages to the north and east of the site.

Disposal at the Section 21 site

If relocation were selected, the Section 21 alternative would incorporate the same erosion protection measures during remedial action as stabilization in place to prevent the release of contaminants from the sites and assure long-term stability of the pile. These control measures would include construction of drainage controls and a waste-water retention ponds at both sites, placement of a rock erosion protection barrier over the stabilized pile, and grading for drainage around the stabilized pile. Impacts on surface water after remedial action would be the same for both action alternatives.

4.5.2 Ground water

This section summarizes the predicted impacts on ground water from stabilization in place, no action, and disposal of the tailings at the Section 21 site. Also, ground-water use during remedial action and protection of aquifer users are discussed. The data and data analyses on which these evaluations are based are presented in detail in Appendix B, Water.

Stabilization in place

During remedial action, there would be no additional adverse impacts to ground-water resources. The existing localized plume of seepage beneath the tailings pile contains levels of contaminants within or below the range of the average concentrations of those species measured in wells in the alluvium/weathered Mancos Shale and Tres Hermanos-C Sandstone upgradient and cross gradient from the site (for purposes of this EA, these wells can be considered to be representative of background conditions (Bostick, 1986)). Seepage during the remedial action would be prevented by drainage controls which would direct all waste-water and storm-water runoff to a lined retention pond.

There are several potential sources of water required for construction. There should be no significant change in infiltration rate through the tailings to the ground water during construction activities. Tailings materials to be relocated from the northern portion of the pile are well drained. Grading and compaction of the tailings would be conducted in a manner that would not create any further significant degradation of the ground water in the underlying alluvium/weathered Mancos Shale.

After remedial action, impacts to ground water would be minimal. The extremely low permeability radon barrier and the recontoured pile surface would reduce the naturally existing low infiltration rate and promote runoff from the pile surface; reduction of infiltration through the tailings would facilitate dissipation of the small mound of perched water in the tailings to the foundation materials. It is estimated that with greatly reduced recharge, the perched mound will dissipate into the foundation in less than 50 years.

No action

Under the no action alternative, the tailings pile would continue to act as a recharge area thus enhancing infiltration which would continue to transport contaminants (arsenic, boron, cadmium, chloride, chromium, cobalt, fluoride, gross alpha activity, iron, manganese, molybdenum, nitrate, pH, radium, selenium, sulfate, TDS, and uranium) from the pile into the underlying alluvium and Tres Hermanos-C Sandstone. Eventually, tailings seepage would reach the Ann Lee Mine, and the Westwater Canyon Member aquifer. The sulfate plume within the Tres Hermanos-C Sandstone plume is approximately 4340 feet in length and approximately 2060 feet wide and is expected to persist for 100 years above standards within the Westwater Canyon Member aquifer.

The migration of tailings seepage through the alluvium/ weathered Mancos Shale and the Tres Hermanos-C Sandstone into the Westwater Canyon Member was simulated to determine if the Westwater Canyon Member, a viable drinking water source, would be impacted by contamination from the Ambrosia Lake tailings. The model was applied assuming present conditions (Phase II). The model provides conservative results for long-term predictions, because lesser rates of contaminant migration should occur following remedial action (Phase III). Field determined and literature values of hydraulic parameters were used as well as contaminant concentrations of sulfate. Sulfate was selected as the key indicator of contamination, because it generally moves with ground water. The simulation was evaluated with a sensitivity analysis to account for any hydrogeological uncertainties. The results of the analysis considering the most realistic case indicated that:

- Contamination in the Tres Hermanos-C Sandstone beneath the tailings pile would reach the inactive Ann Lee Mine and the Westwater Canyon Member aquifer in seven years. The Westwater Canyon Member was the major ore-producing zone in the Ambrosia Lake mining district. The Ambrosia Lake mill obtained its water from this formation.

- Sulfate concentrations in the Tres Hermanos-C Sandstone at the Ann Lee Mine would again reach "background" levels within 22 years following remedial action.

- The extent of contamination, where sulfate concentrations would reach 250 mg/l, in the Westwater Canyon Member would extend 400 feet northeast from the Ann Lee Mine. No impacts to ground-water quality are predicted beyond 400 feet from the mine shaft.

- The development of the plume in the Westwater Canyon Member (out to 400 feet) will take an estimated 120 years.

- The contamination in the Westwater Canyon Member would persist for 100 years.

Disposal at the Section 21 site

During the relocation of the tailings to the Section 21 site, there would be minimal impacts to the ground water. The Section 21 site is underlain by a thin (less than 35 feet) deposit of alluvium upon the Mancos Shale. The Mancos Shale is fairly thick and would act to limit or eliminate migration of tailings leachate to deeper hydrogeologic formations.

Water use

Water consumption during stabilization in place would be approximately 29,100,000 gallons. Water would be used for dust suppression, compaction of the tailings, cover, and other materials, vehicle washing and decontamination, and personal consumption and cleanup for remedial action workers. Tailings relocation to the Section 21 site would require greater amounts of water than stabilization in place because this alternative requires a greater amount of earth moving and use of unpaved roads. The sources of ground water would be determined during the final design, and the water would be obtained according to the applicable laws and regulations (Appendix E, Permits, Licenses, Approvals).

Aquifer restoration

Stabilization in place would reduce the rate of tailings seepage into ground water because the contouring, grading, and cover design would reduce the amount of contaminant infiltration through the tailings. The reduction of tailings seepage would eventually eliminate the perched water in the tailings. As the infiltration rate decreases, the rate at which seepage from the tailings recharges the Tres Hermanos-C Sandstone would also decrease. Therefore, concentrations of contaminants moving into the Tres Hermanos-C Sandstone under the site would decrease with time. Contamination, primarily as sulfate, would extend into the Westwater Canyon Member at concentrations above background to a distance of 400 feet downgradient of the Ann Lee Mine and would persist for approximately 100 years (Section B.2.6).

The remanded EPA ground-water protection standards provide guidance that the costs of aquifer restoration should be limited to the value of the resource and the impact on public health and the environment. The contamination of ground water at the Ambrosia Lake site is clearly a case where the cost of ground-water restoration is not supported by its limited benefit. Aquifer restoration is not a realistic alternative for the contaminated ground water downgradient of the Ambrosia Lake site because:

- o The alluvium/weathered Mancos Shale is not an aquifer, and will probably "dry-up" as mine discharge ceases.

- The Tres Hermanos-C Sandstone is not an aquifer due to low yields, naturally poor water quality, and the possibility that the formation will not remain saturated.

- The Westwater Canyon Member is a viable aquifer; however, solute transport calculations indicate that the effects of contamination to the aquifer should impact only a small area (400 feet downgradient of the Ann Lee Mine shaft in the most conservative estimate) and for a time frame of 100 years.

Regardless, when the EPA issues revisions to the ground-water protection standards, the DOE will reevaluate the ground-water issues at the Ambrosia Lake site to assure that the revised standards are met. Performing remedial actions to stabilize the tailings prior to the EPA issuing new standards will not affect the measures that are ultimately required to meet the revised EPA water protection standards. The DOE has characterized conditions at the Ambrosia Lake site and does not anticipate that any substantial changes to the remedial actions will be required. However, after the EPA re-issues the water protection standards, the DOE will determine the need for institutional controls, aquifer restoration, or other controls and take such appropriate action so as to comply with the re-issued standards.

4.6 FLORA AND FAUNA

Terrestrial ecosystems would be impacted directly and indirectly by remedial actions. Direct impacts result from excavation of contaminated soils, disposal of tailings, construction and upgrading of haulage roads, and borrow activities. Indirect impacts include increased fugitive dust emissions, elevated noise levels, and human activities at and adjacent to the direct impact area. Direct impacts can either be long term or short term, while indirect impacts are short term (i.e., for the duration of remedial action). The impacts discussed in this section are detailed in Appendix C, Flora and Fauna.

Stabilization in place

Direct impacts from remedial action would result from remedial action activities at the tailings and borrow sites. The impact of this activity on the 111-acre tailings pile would be minimal since this area is essentially devoid of vegetation and wildlife.

A total of 631 acres of land in the area of windblown contamination and at borrow site 1 would be impacted directly. This grassland plant community has been overgrazed and is considered marginal wildlife habitat. In addition, there are no concentration areas for economically important species and no threatened or endangered species are known to occur.

Borrow site 2 is located in a pinon-pine forest and represents good wildlife habitat. Consultation with the New Mexico Game and Fish

Department indicated that this area is located in critical mule deer or elk wintering habitat and the clearing of this site would result in the temporary loss of approximately 50 acres of wintering habitat (Isler and Middleton, 1985).

Indirect impacts of fugitive dust, noise, and human disturbance were analyzed at the tailings site, windblown area, and borrow sites. It was determined that noise impacts (70 plus decibels) would extend out approximately 2000 feet from the windblown area and 1000 feet from borrow site 2. This would impact additional grassland habitat adjacent to the area of windblown contamination and borrow site 1. In addition, approximately 3000 feet of rocky slope-cliff habitat near Roman Hill would be impacted. This impact would be short term, lasting for the duration of the project (18 months). The impact of noise and dust around borrow site 2 would temporarily prevent the use of habitat surrounding the site to a distance of 700 feet for wintering mule deer and elk. This short-term impact would last for approximately nine months.

The direct and indirect impacts associated with this project would not be expected to affect any threatened or endangered species since none are known to occur at or near the tailings site, windblown contaminated area, borrow sites, or haulage roads.

No action

The no action alternative would result in the continuing contamination of flora through windblown dispersion of tailings. Fauna that feeds on the vegetation would continue to be exposed to contaminants.

Disposal at the Section 21 site

The direct impacts of remedial action on flora and fauna for disposal at the Section 21 site would be similar to that described for stabilization in place in that approximately the same amount of land would be disturbed. Indirect impacts associated with dust, noise, and other disturbances would be greater since this alternative would require a 30-month construction period versus an 18-month construction period for stabilization in place.

4.7 LAND USE

Stabilization in place

The final restricted area containing the stabilized tailings pile (88 acres) would encompass 95 acres, and other use of these 95 acres would be permanently precluded. The stabilized tailings site would be under the direct control of the Federal Government and would be permanently restricted from any development. However, the remaining contaminated acreage at and around the site (586 acres) would be decontaminated, restored, and released for unrestricted use. Stabilization in place would result in a net increase of 101 acres of unrestricted land since the present 196-acre designated site would be reduced to the 95-acre restricted stabilized tailings site.

Approximately 60 acres would be disturbed at borrow site 1. Borrow activities on this acreage would disturb livestock grazing for approximately 14 months. The borrow activities at borrow site 2 would disturb approximately 50 acres over a period of nine months. This disturbance would prevent the seasonal use of grazing land and wildlife habitat present at the site. The acreage disturbed at the borrow sites would be reclaimed to a condition compatible with the surrounding terrain and according to the requirements of the Free Use Permit issued by the U.S. Forest Service or other applicable approval (Appendix E, Permits Licenses, Approvals).

Activities during remedial action would have little impact on land use in the surrounding area. Impacts to livestock grazing would be negligible because of the large areas nearby which are available for grazing. After remedial action, use of lands in the area adjacent to the stabilized tailings pile for grazing would not be impacted. Future mining activities would not be restricted by the proposed action. The potential for future development of areas surrounding the stabilized tailings pile would be improved by decontamination and reclamation of the existing tailings pile and adjacent areas.

No action

The no action alternative would allow the tailings pile to continue to affect existing land use patterns. The acreage presently occupied by the tailings site (196 acres) would not be available for alternative uses. Livestock would continue to graze on contaminated lands and dispersion of the tailings by wind and water erosion would continue to contaminate lands adjacent to the pile. The rate of this continuing contamination cannot be accurately quantified, but 570 acres have been contaminated to date.

Disposal at the Section 21 site

If selected as the remedial action alternative, the final restricted area containing the stabilized tailings pile at the Section 21 site would be approximately the same size as stabilization in place, and other uses of this acreage at the Section 21 site would be permanently precluded. Relocation of the tailings to the Section 21 site would allow release of the existing tailings site for unrestricted use. The Section 21 alternative would involve a similar level of disturbance at borrow sites 1 and 2 as stabilization in place.

4.8 NOISE LEVELS

Remedial action would involve the daytime operation of heavy equipment. This section describes the impacts of noise associated with this equipment on land uses adjacent to construction activities.

Stabilization in place

For stabilization in place, a noise prediction model (Kessler et al., 1978) was used to estimate the maximum A-weighted equivalent noise levels emitted from construction activities at the Ambrosia Lake site, the two borrow sites, and transportation corridors. Noise levels typically generated by the types of equipment used during remedial action are presented in Table 4.7. The noise-level model is conservative as no attenuation for air absorption, berms, or foliage is considered in the model. In addition, the model tends to overpredict noise levels since it assumes a clustering of equipment. In reality, the equipment would be located over a number of acres.

Table 4.7 Noise levels for equipment used for remedial action

Equipment	Maximum noise level at 50 feet (decibels)
Compactor	87
Bulldozer	89
Front-end loader	86
Grader	83
Scraper	87
Water truck	89
Crane	86
Forklift	85
Backhoe	85
Haul truck	86

Ref. Kessler et al., 1978.

The maximum potential equivalent sound level at the tailings site would be about 96 decibels at a distance of 100 feet from the area of activity. The maximum equivalent noise levels would be about 73 decibels at a distance of 0.25 mile, decreasing to about 61 and 55 decibels at distances of one and two miles, respectively. Noise emissions would only occur during daytime construction periods. There should be no adverse effects because there are no sensitive land uses within 2.5 miles of the tailings site.

The maximum equivalent noise levels at borrow sites 1 and 2 would be about 89 and 86 decibels, respectively, at a distance of 100 feet. Noise levels would decrease to a maximum of 55 and 49 decibels at distances of one and two miles, respectively, from borrow site 1, and 52 and 46 decibels at distances of one and two miles, respectively, from borrow site 2. There would be no adverse effects near borrow site 1, because there are no noise-sensitive land uses within several miles. An infrequently used residence approximately 1.4 miles from borrow site 2 would be exposed to up to 48 decibels, which would be slightly audible but not loud enough to cause annoyance.

The transport of borrow materials would involve substantial truck traffic in the vicinity of the Ambrosia Lake site. Trucks would be expected to produce noise levels of about 80 decibels at a distance of 100 feet, and up to 74 decibels at 200 feet. There would be up to 104 truck trips per hour between borrow site 1 and the tailings site; however, no sensitive land uses would be adversely affected. The corridor between the tailings site and borrow site 2 would be subjected to up to 20 truck pass-bys per hour for a nine-month period. An infrequently used residence located 500 feet from the borrow site 2 access road would be subjected to outdoor noise levels of up to 66 decibels as the trucks pass by. This noise level is greater than levels determined by the EPA to cause annoyance from outdoor activities (55 decibels) but less than the 70-decibel level established for the protection of hearing (EPA, 1979). Three residences occur within 200 feet of the road at the intersection of New Mexico Highways 509 and 53, and noise levels up to 73 decibels would occur. This level is above the level established for the protection of hearing and may prove annoying to occupants of these residences. These noise levels would occur relatively briefly when the trucks pass by and only during daylight hours.

<u>No action</u>

No action would result in no noise impacts.

<u>Disposal at the Section 21 site</u>

Tailings disposal at the Section 21 site would involve substantially reduced noise emissions at the Ambrosia Lake site due to lower equipment levels. Noise levels at the Section 21 site would be similar to those described for the tailings site under the stabilization in place alternative. Increased noise levels would occur between the tailings site and the Section 21 site as a large number of truck trips would be made for hauling tailings and other contaminated material. Noise emissions at borrow site 2 would be approximately the same for either action alternative. These noise levels would occur over a longer time period due to a longer construction period for disposal at Section 21.

4.9 SCENIC AND CULTURAL RESOURCES

<u>Scenic resources</u>

Stabilization in place would have a minor impact on scenic resources. The new shape and height of the stabilized pile and the demolition of the existing mill structures would cause a permanent but slight change in the immediate viewshed around the tailings pile. During the decontamination activities, the removal of vegetation and surficial materials would temporarily alter the foreground views around the pile. Cleanup of the areas of windblown tailings would result in a large area devoid of vegetation that would be clearly visible in the foreground and middleground to people traveling along New Mexico Highway 509. After remedial action, restoration of the excavated areas surrounding the stabilized tailings pile to a level compatible with the surrounding terrain would reduce the impacts to the viewshed. Once vegetation is reestablished, the excavated areas would not be noticeable. Both the permanent and temporary changes in the views would be subordinate to the regional view. No scenic landmarks would be affected by the remedial action.

During stabilization in place, the removal of vegetation and borrow materials at borrow sites 1 and 2 would temporarily alter the elements of color, texture, and contrast at the sites. Dust emissions at borrow site 1 would be visible in the middleground from New Mexico Highway 509 during excavation of borrow site materials. Alteration in color and texture due to borrow activities at borrow site 2 would be evident when viewed from some segments of New Mexico Highway 53. Portions of borrow site 2 have been disturbed previously by mining activities. Borrow activities would not be visible from any permanent residences in the area. Both sites would be restored to a level compatible with the surrounding terrain and land use and in accordance with any reclamation requirements specified in the Free Use Permit issued by the U.S. Forest Service or other applicable approval (Appendix E, Permits, Licenses, Approvals).

The no action alternative would not involve any remedial action and, therefore, would have no impact on existing scenic resources.

Disposal of the tailings at the Section 21 site would result in similar impacts to scenic resources as stabilization in place.

Cultural resources

No historic sites would be impacted by remedial action activities at the existing tailings site. Two prehistoric sites (one eligible to the NRHP, and one needing additional data to determine eligibility) would be impacted by cleanup of the area of windblown contamination. The eligible site(s) would be the subject of a data recovery plan implemented in accordance with the National Historic Preservation Act (Appendix E, Permits, Licenses, Approvals). An additional four cultural sites exist within 500 feet of the area of decontamination activities. These sites would be avoided during remedial action and would not be impacted.

A partial cultural resource survey of borrow site 1 has been conducted (CASA, 1985). No cultural resources were identified in the area surveyed. Borrow site 2 has not been surveyed for cultural resources. An intensive cultural resource inventory would be conducted at the remaining area of borrow site 1 and at borrow site 2 prior to initiating surface disturbance activities.

No cultural resources have been recorded at the Section 21 site. Prior to surface disturbance, an intensive cultural resource survey would be conducted at the Section 21 site if the tailings relocation alternative were selected.

4.10 POPULATION AND EMPLOYMENT

Stabilization in place would require an average employment of 62 workers over a period of 18 months, and a peak employment of 92 workers. Throughout the construction period, it is assumed that six supervisory personnel and one health physicist would be obtained from outside the local area. Other employment categories such as truck drivers, equipment operators (and supervisors), health technicians, laborers, surveyors, and security personnel would be available locally. In-migration would be negligible since the existing present level of high unemployment suggests that a workforce for construction projects is readily available (see Table 3.6). In-migration would consist of the seven supervisors relocating to the area (some with families) for a total of 17 in-migrants. Impacts to the local workforce and population are presented in Table 4.8. The induced employment shown in Table 4.7 may not occur at the indicated levels since many businesses in Grants and Milan are currently under-utilized.

No action would result in no impacts on the Cibola County population and workforce.

Table 4.8 Project employment: local and in-migrant workers

	Average employment			Peak employment		
	Local	In-migrant	Total	Local	In-migrant	Total
Number of project workers[a]	55	7	62	85	7	92
Number of additional in-migrants[b]		10			10	
Induced employment (workers)[c]	45			64		

[a]The seven in-migrant workers would consist of a project manager, engineering field supervisors, and health physicist provided by the remedial action contractor; the number of these positions would remain constant throughout the project, whereas other job categories such as truck drivers and equipment operators would vary during the project.

[b]In-migrants are determined as follows: the number of in-migrant workers (seven) multiplied by 60 percent (the number of workers bringing families) (Mountain West Research, 1979), multiplied by 3.43 (State of New Mexico average family size) (DOC, 1981), plus the number of in-migrants without families (three).

[c]Induced employment refers to those jobs which are created as payments to project workers circulate through the local economy or are created by demands from new residents. Grants uses a multiplier of 0.7 to predict induced employment (Lotman, 1985). Therefore, 62 direct project related jobs times 0.7 yields an estimated 43 new jobs (92 direct jobs during peak employment times 0.7 yields 64 induced jobs).

Disposal at the Section 21 site would employ more workers than stabilization in place for a longer period of time. The number of supervisory positions which would require in-migrants would remain the same as stabilization in place. In comparison to the stabilization in place alternative, disposal at the Section 21 site would create more direct and induced employment but the level of in-migration would remain the same.

4.11 HOUSING AND COMMUNITY SERVICES

Housing and community services in the project area are currently under-utilized. The addition of 17 in-migrants (seven workers plus families) would have a negligible effect on the existing availability of housing and on community services. Both Grants and Milan have a surplus in all areas of in-migrant needs.

No action would result in no impact on housing or community services.

Disposal at the Section 21 site would add the same number of in-migrants as stabilization in place; the effects on Grants and Milan, although positive, would be negligible.

4.12 PUBLIC FINANCE

Each of the action alternatives would have a direct impact on the Cibola County economy as payments are made to project laborers and to project equipment and material suppliers. Indirect impacts from remedial action would result as project dollars spent locally circulate through the economy in the form of expenditures on other goods and services.

Stabilization in place is estimated to cost $15,070,000. Of this total, local labor expenditures account for $2,130,000, and local equipment and material purchases account for $9,560,000. These local expenditures would create additional local income as the dollars circulate through the local economy. Research on the impacts of energy projects on rural areas in the western United States suggests an appropriate income multiplier of 1.23 (Mountain West Research, 1979). Applying this multiplier to local project spending yields an estimated $2,688,700 in additional indirect income generated in Cibola County.

It is anticipated that Grants would be the main source for materials, equipment, and supplies. If 80 percent of all such purchases were made in Grants, the city of Grants would be refunded 2.35 percent of the gross receipts ($9,560,000), or $224,660 over the eighteen-month project term. Additional unknown revenues would also return to Grants from indirect project expenditures and new expenditures made by local residents who had been previously un- or underemployed. Cibola County revenues would be similarly affected but to a lesser degree. Cibola County would receive 0.375 percent of the gross receipts received by the city of Grants for project-related expenditures, or, using the above example, $35,850. In comparison to the existing Grants and Cibola County revenues (see Table 3.7), project-related expenditures which would return to city or county governments would have a negligible effect on overall budgets.

In summary, the local project labor expenditures of $2,130,000 and local material and equipment purchases of $9,560,000 would generate income in Cibola County totaling $14,378,700.

No action would result in no impact on the local economy.

Selection of tailings disposal at the Section 21 site would cost approximately twice as much as stabilization in place. These monies would enter the local economy over a longer period of time than stabilization in place (30 months versus 18 months).

4.13 TRANSPORTATION

Table 4.9 shows the changes in daily traffic volume related to project activities. In all cases, project-related traffic is below capacity.

Table 4.9 Daily project related traffic on New Mexico Highways 53 and 509

Activity	NM 53: Milan to NM 509[a]	NM 53: intersection with NM 509 to borrow site 2[b]	NM 509: tailings site to NM 53[c]
Project-related (daily)			
Worker commuting	184	--	172
Truck trips to borrow site 2	--	140	140
Total project-related	184	140	312
Total daily projected traffic[d]	905	413	850

[a]Conservative analysis occurs during month six when the employment peaks at 92. There are no trucks using this segment of the highway on a daily basis.

[b]Conservative analysis occurs during month 12 when trucks transport borrow materials from borrow site 2. Employees do not use this segment of road to commute to work.

[c]Conservative analysis occurs during month 12 when trucks transport borrow materials from borrow site 2. Employment decreases to 86 workers.

[d]Total daily project-related traffic does not include miscellaneous trips to Grants, Milan, or to borrow site 2. The unknown number of miscellaneous trips would be offset by the unknown number of workers who would carpool to the tailings site. It is unlikely that workers would make many miscellaneous trips due to the distance from the tailings site to Grants (approximately 25 road miles).

There would be no impact on the transportation network if no remedial action were taken.

In comparison with stabilization in place, disposal at the Section 21 site would require a larger peak work force (more daily worker commute trips) and more truck trips to obtain rock borrow materials. The effect on New Mexico Highways 53 and 509 would still be considered negligible.

4.14 ENERGY AND WATER CONSUMPTION

Each of the action alternatives would require the use of electricity, fuel, and water for remedial action activities. Electricity would be needed for the field offices, showers, and laundry. Fuel consumption would be primarily related to operation of the various pieces of equipment necessary for the remedial action. Water is needed for compaction of the tailings, cover, and other materials, for washdown of haul trucks and employee showers, and for dust control.

Under the stabilization in place alternative, estimated electricity, fuel, and water requirements would be 225,000 kilowatt hours, 990,000 gallons, and 29,000,000 gallons, respectively. These figures do not include the energy requirements of the workers and their families who may relocate to the area for the period of work on this project. In all cases, energy consumption for the Section 21 alternative would be greater than for stabilization in place, varying from 30 to 140 percent greater energy and water demand than the proposed action.

Appendix A, Engineering Summary, provides greater detail on energy and water consumption.

4.15 ACCIDENTS NOT INVOLVING RADIATION

The remedial action alternatives would involve the extensive use of heavy construction equipment (e.g., dozers, scrapers, front-end loaders) and many heavy truck trips as tailings, other contaminated materials, and borrow materials are transported between the final tailings disposal site and borrow sites. Project workers would also be commuting between their homes and the work site. Because a high proportion of the project workforce is expected to be available locally, an average commuting distance of 25 miles (one-way) is assumed for project workers for both remedial action alternatives.

The construction equipment used and transportation activities associated with each alternative pose the risk of accidents and resulting injuries and fatalities. Based on nationwide data from the mining and construction industries, it is estimated that there would be an accident rate of 475 fatal accidents and 42,200 injury accidents (leading to loss of worktime) per million man-years of labor (DOC, 1983). Stabilization in place would require 92 man-years of labor resulting in 0.04 fatal and 3.89 injury accidents.

The average total accident rate for the potentially affected segments of New Mexico Highways 509 and 53 over the 1978 through 1984 period was 1.13 accidents per million vehicle-miles traveled. This composite rate included a fatal accident rate of 0.079 fatal accidents per million vehicle-miles traveled, an injury accident rate of 0.28 injury accidents per million vehicle-miles traveled, and a property damage rate of 0.77 property damage accidents per million vehicle-miles traveled (NMTSD, 1985). Stabilization in place would require approximately 2,082,000 vehicle-miles traveled, and therefore would result in an estimated 0.16, 0.59, and 1.60 fatal, injury, and property damage accidents, respectively.

The no action alternative would have no impacts in terms of construction or transportation accidents.

Relocation of the tailings and associated contaminated materials would require much greater off-site vehicular traffic than stabilization in place because the tailings would be transported from the existing tailings site to the Section 21 site. In addition, the Section 21 alternative would involve a greater manpower requirement. Consequently, approximately 1.5 times as many project-related injuries, fatalities, and property damage accidents would be expected to result from tailings disposal at the Section 21 site as stabilization in place.

4.16 MITIGATIVE MEASURES

As stated in Section 2.3, the engineering conceptual design for the Section 21 alternative is based on existing, published data. If this alternative were selected, additional site-specific data would be obtained before the final engineering design is made. This could necessitate the incorporation of mitigative measures that are not discussed in this document.

The following mitigative measures were incorporated into the design and approach for each of the remedial action alternatives in order to reduce the environmental impacts:

- Establishment of a site security system at each site to control traffic entering and leaving each site.
- Construction of drainage controls and waste-water retention ponds at each site to prevent contaminated waste water and surface water from leaving the site during remedial action.
- Removal of all contaminated soils (consistent with EPA standards) adjacent to the tailings pile and consolidation of the contaminated soils with the tailings.
- Application of water and chemical dust suppressants and anchored straw or jute netting to dirt and graveled haul roads to inhibit dust emissions.

- Immediate cleanup of any off-site spills of contaminated materials in compliance with applicable regulations.

- Selection of borrow sites which are as close to the disposal sites as possible to reduce costs and eliminate the impacts of long haulage distances.

- Stockpiling of the surface soils encountered at the borrow sites for future reclamation of the sites.

- Reclamation, including recontouring and revegetation of borrow sites.

- Design of the stabilized tailings to withstand a Maximum Design Earthquake.

- Implementation of cover designs to inhibit plant root penetration, burrowing by animals, and inadvertent human intrusion after remedial action.

- Construction of compacted, earthen tailings covers to inhibit radon emanation (consistent with EPA standards) and surface-water infiltration.

- Construction of a rock cover on the stabilized tailings pile to assure that the stabilized pile would withstand the erosive effects of a Probable Maximum Precipitation (PMP).

- Construction of drainage controls to direct surface runoff around and away from the stabilized tailings pile and prevent long-term erosion.

- Construction of security fencing with locked gates and warning signs to restrict human access to the stabilized tailings.

- Cleanup of any equipment used before release to prevent the spread of contaminated materials.

- Use of local labor whenever possible to reduce the sociological impacts to the local communities and to provide economic benefits.

- Conducting operations only during normal work hours to minimize noise disturbance to local residents.

- Maintaining close communications with the local population through an established public information task force.

The following mitigative measures were incorporated into the stabilization in place alternative:

- Consolidation of the tailings and contaminated materials in the southern half of the existing tailings site to minimize the area occupied by the stabilized tailings pile.

- o Construction of a riprap apron around the stabilized tailings pile to protect the stabilized pile against the erosive forces of a Probable Maximum Flood (PMF).
- o Backfilling, grading, and revegetating as required in the areas disturbed during the cleanup and consolidation of the tailings and contaminated materials.

Mitigative measures taken to ensure remedial action worker protection and the long-term stability of the tailings are described in the UMTRA Project Health and Safety Plan (DOE, 1983b); the draft Remedial Action Plan (DOE, 1985b); and the UMTRA Project Surveillance and Maintenance Plan (DOE, 1985c).

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GLOSSARY

alluvium	Fluvially deposited sediment.
ambient	Surrounding on all sides, encompassing.
aquifer	A formation containing sufficiently saturated permeable material to yield significant quantities of water to wells and springs.
attenuate	To reduce the level of radiation emitted from a source.
A-weighted scale	Sound pressure level scale which most closely matches the response of the human ear. This scale is most commonly used to measure environmental noise and is often supplemented by the time and duration of the noise to determine the total quantity of sound affecting people.
background radiation	Radiation arising from radioactive material other than that under consideration. Background radiation due to cosmic rays and natural radioactivity is always present, and there is always background radiation due to the presence of radioactive substances in building materials and the like.
basalt	A dark-colored, dense igneous rock that commonly forms volcanic flows.
below grade	Below ground surface, as in a pit or excavation.
borrow material	Earthen materials obtained or "borrowed" from another site or source. Examples would include both the radon cover and erosion protection materials which can be obtained.
calcareous	Said of a substance that contains calcium carbonate.
carbonate leaching	A method of extracting metals from the host rock, using a basic solution in contact with finely ground ore in pressurized tanks.
Chacoan Outlier	An established center of socioeconomic and cultural activity remote from the major Chacoan population centers.
Class III archaeological surveys	Relates to an archaeological investigation of probable occurrence of cultural resources within a given locale. A Class III survey is an in-depth inspection of an area to determine the presence of archaeological materials where the likelihood of their occurrence is high, based on the history of the area.

colluvium	Loose and incoherent soil material and/or rock fragments primarily transported by gravity to the base of hillslopes.
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.
confining layer	A stratum immediately above or below an aquifer with a hydraulic conductivity less than that of the aquifer.
cuesta	An elongate, asymmetric ridge of resistive rock bounded by cliffs on one side and a gentle dip-slope on the other.
curie (Ci)	The unit of radioactivity of any nuclide, defined as precisely equal to 3.7×10^{10} disintegrations per second.
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.
decibels (dB)	A unit used to express power or intensity ratios in electrical or acoustical technology.
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.
design earthquake	The seismic event employed during the engineering design phase of UMTRA Project remedial actions. For each designated site, the design earthquake may be associated with a specific capable structure or considered to be independent of tectonic structure.
disposal	The planned, safe, permanent placement of radioactive waste.
diurnal	Daily.
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.

dosimetry	The measurement of radiation doses.
ecosystem	All the interacting aspects of the physical and biological worlds.
eolian	Pertaining to the wind.
ephemeral stream	A watercourse that contains flowing water only during brief periods of localized precipitation.
epicenter	The point on the earth's surface that is directly above the focus of an earthquake.
evapotranspiration	Loss of water from a land area through transpiration of plants and evaporation from the soil.
eyrie	A nest site for cliff-nesting birds of prey.
excess health effects	Adverse physiological response from radiation exposure (in this report, one health effect is defined as one cancer death from exposure to radioactivity in addition to the normal occurrence of fatal cancer).
exposure	The presence of gamma radiation that may deposit energy in an individual; given in units of roentgens.
external dose	The absorbed dose that is due to a radioactive source external to the individual as opposed to radiation emitted by inhaled or ingested sources.
fault	A fracture or zone of fractures in the earth's crust along which stratigraphic separation has occurred.
femtocurie	A unit of radioactivity defined as 0.000037 disintegrations per second. There are 1000 femtocuries per picocurie.
flux, radon	The emission of radon gas from the earth or other material, usually measured in units of picocuries per square meter per second.
forbs	Non-grass herbaceous plants.
fugitive dust	Dust particles which are dispersed from a construction site or from trucks during hauling.
gamma	A high-energy and deep-penetrating form of radiation.
gamma dose	Radiation dose caused by gamma radiation.
gamma ray	High energy electromagnetic radiation emitted from some radiation radionuclides. The energy levels are specified for different radionuclides.

ground water	Water below the land surface which occupies the voids within a geologic unit or formation.
half-life	The time required for 50 percent of the quantity of a radionuclide to decay into its daughters.
health physics	The study of radiation safety.
inert gas	One of the chemically unreactive gases: helium, neon, argon, krypton, xenon, and radon.
in-migrant	A person that moves into an area from outside the local area.
in-situ	In the natural or original position.
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.
Laramide Orogeny	A regional mountain building event typically recorded in the eastern Rocky Mountains beginning in late Cretaceous time and ending during the Paleocene.
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. It will include a finding that the site does not and will not constitute a danger to the public health and safety.
loam	A rich, permeable, commonly organic soil composed of roughly equal proportions of silt, sand, and clay.
man-rem	Unit of population exposure obtained by summing individual dose-equivalent values for all people in the population. Thus, the number of man-rems attributed to one person exposed to 100 rems is equal to that attributed to 100 people each exposed to one rem.
Mean Sea Level (MSL)	The average height of the surface of the sea for all stages of the tide over a 19-year period.
Mesozoic	An era of geologic time from approximately 225 million years ago to about 65 million years ago.
micro	A prefix meaning one millionth (x 1/1,000,000 or 10^{-6}).
milli	A prefix meaning one thousandth (x 1/1000 or 10^{-3}).

monitor	To observe and make measurements to provide data for evaluating the performance and characteristics of the stabilized tailings pile.
monocline	A local steepening in an otherwise gentle uniform dip.
National Register of Historic Places	Established by the Historic Preservation Act of 1966. The Register is a listing of archaeological, historical, and architectural sites nominated for their local, state, or national significance by state and Federal agencies and approved by the Register staff.
nuclide	A general term applicable to all atomic forms of the elements; nuclides comprise all the isotopic forms of all the elements. Nuclides are distinguished by their atomic number, atomic mass, and energy state.
Pachuca tank	Large vessel used for air agitation of uranium ore during batch leaching.
Paleozoic	An era of geologic time considered to have begun approximately 570 million years ago and ending about 225 million years ago.
perched ground water	Ground water separated from an underlying body of ground water by unsaturated rock.
permissible dose	That dose of ionizing radiation that is considered acceptable by standards-setting bodies such as the EPA.
person-rem	Same as man-rem.
physiographic	Said of or pertaining to the surface features of the earth.
physiographic province	A region of climates and structures that are similar and share a common geomorphic history.
pico	A prefix meaning one trillionth (1 x 1/1,000,000,000,000 or 10^{-12}).
picocurie	A unit of radioactivity defined as 0.037 disintegrations per second.
playa sediments	Detrital material that occupies the topographically lowest portions of poorly drained arid basins.
Precambrian	All geologic time prior to approximately 570 million years ago.
Probable Maximum Flood (PMF)	The maximum flood which would result from a Probable Maximum Precipitation (PMP) event in a given watershed.

proton	An electrically positive elementary particle found in the nucleus of an atom. Also, the nucleus of a hydrogen atom.
rad	A unit of measure for the absorbed dose of radiation. It is equivalent to 100 ergs per gram of material.
radioactive decay chain	A succession of nuclides each of which transforms by radioactive disintegration into the next until a stable nuclide results.
radioactivity (radioactive decay)	The property of some nuclides of spontaneously emitting particles of gamma radiation or of spontaneous fission.
radioisotope	A radioactive isotope of an element with which it shares almost identical chemical properties.
radionuclide	A radioactive nuclide.
radium-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	The gaseous radioactive daughter product of radium-226; it has a half-life of 3.8 days.
radon-daughter product	One of several short-lived radioactive daughter products of radon-222. All are solids.
raptor	Bird of prey.
recharge	The process by which water is absorbed by surficial soils or geologic units and is added to the zone of saturation.
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.
rhizome	A prostrate underground stem or branch which roots at the nodes.
Richter scale	A logarithmic scale ranging from one to 10 used to express the magnitude or total energy of an earthquake.
roentgen	A unit of measure of ionizing radiation in air; one roentgen in air is approximately equal to one rad and one rem in tissue.

sedimentary	Descriptive term for rock formed of sediment, especially: (1) clastic rocks (e.g., conglomerate, sandstone, shale) formed of fragments of other rock transported from their sources and deposited by water or wind, and (2) rocks formed by precipitation from solution (e.g., gypsum) or from secretions of organisms (e.g., limestone).
seismic	Pertaining to an earthquake or earth vibration.
shale	A fine grained, detrital, sedimentary rock, formed by the consolidation of clay, silt, or mud.
sideslope	The slope of the sides of the tailings pile or stabilized tailings embankment. This slope can be expressed as a ratio equal to five feet horizontal per one foot vertical, as a percentage equal to 20 percent, or as an angle.
soil infiltration rate	The rate at which water enters the soil surface and moves vertically.
soil percolation rate	The rate at which water moves through soil in all directions.
somatic	Radiation health effects to the body of an individual, as opposed to genetic health effects to future generations.
stabilization	The reduction of radioactive contamination in an area to a level predetermined by a standards-setting board such as the EPA by encapsulating or covering the contaminated material.
strata	Tabular or sheet-like layers of sedimentary rock.
stratigraphy	The physical arrangement of strata.
surveillance	The observation of the stabilized tailings pile for purposes of visual detection of need for custodial care, evidence of intrusion, and compliance with other license and regulatory requirements.
tailings, uranium-mill	The wastes remaining after most of the uranium has been extracted from uranium ore.
tectonic	Said of or pertaining to the forces involved in, or the resulting structures or features of the broad architecture of the outer part of the earth.
thorium-230	A radioactive daughter product of uranium-238; it has a half-life of 80,000 years and is the parent of radium-226.

topslope — The slope of the top of the tailings pile or stabilized embankment. This slope is typically expressed as a percentage, or feet of vertical change per 100 feet horizontal.

UMTRA Project — Uranium Mill Tailings Remedial Action Project of the U.S. Department of Energy.

uranium-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 Ambrosia Lake site, and which is determined by the DOE to require remedial action.

viewshed — The geographic area visible from a specified location.

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.

windblown — Off-pile tailings transported by wind or water erosion.

ABBREVIATIONS AND ACRONYMS

AD	Anno Domini
BC	Before Christ
BIA	Bureau of Indian Affairs
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
Ci	Curie
cm	Centimenter
cfs	Cubic feet per second
cfs/ft	Cubic feet per second per foot
CO	Carbon monoxide
COE	U.S. Army Corps of Engineers
cy	Cubic yard
dBA	Decibels on the A scale; a logarithmically based unit of sound intensity weighted to account for human auditory responses
DOE	U.S. Department of Energy
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
°F	Degrees Farenheit
g	The force of gravity which is an acceleration of 32 feet per second per second
gpd	Gallons per day
HC	Hydrocarbon
ISCST	Industrial Source Complex Dispersion Model for Short-Term Application
L_{dn}	Day-night sound level, measured in decibels
lb/cy	Pounds per cubic yard
lb/hr	Pounds per hour
lb/mile	Pounds per mile
MCE	Maximum Credible Earthquake
mg/m^3	Milligram per cubic meter
microg	Microgram; a millionth of a gram
mph	Miles per hour
$microg/m^3$	Microgram per cubic meter
microR/hr	Microroentgens per hour
NA	Not available
NEPA	National Environmental Policy Act of 1969 (PL91-190)
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
NRC	U.S. Nuclear Regulatory Commission
NRHP	National Register of Historic Places
O_3	Ozone
OSHA	Occupational Safety and Health Administration
pCi/g	Picocuries per gram
pCi/l	Picocuries per liter
pCi/m^2s	Picocuries per square meter per second
PL	Public law
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
ppm	Parts per million
RAC	Remedial Action Contractor

ABBREVIATIONS AND ACRONYMS (Concluded)

RAECOM	Radon Attenuation Effectiveness and Cover Optimization with Moisture
Ra-226	Radium-226
SCS	Soil Conservation Service
SO_x	Any oxide of sulfur
TAC	Technical Assistance Contractor
T&E	Threatened and endangered
Th-230	Thorium-230
TLD	Thermoluminescent dosimeter
TSP	Total suspended particulate
U-238	Uranium-238
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act of 1978 (PL 95-604)
USGS	U.S. Geological Survey
WL	Working level (a measure of radon-daughter-product concentration)

Agencies, organizations, and persons consulted

Agency/organization	Person	Subject
Homestake Mining Co. Grants, New Mexico	Austin Glover	Mine maps
United Nuclear Corp. Churchrock, New Mexico	Jim Fletcher	Mine maps
New Mexico Employment Security Commission Santa Fe, New Mexico	Vera Peralta	Employment base, agricultural sector
U.S. Department of Agriculture SCS, Grants, New Mexico	Pete Losito	Frost penetration
New Mexico Environmental Improvement Division Santa Fe, New Mexico	Mike Taylor Eloy Montoya Kent Bostick	Licenses, meteoro- logical data, flood analysis
Milan Fire Department Milan, New Mexico	George Knotts	Fire protection at Ambrosia Lake
Bureau of Mines Inspection Albuquerque, New Mexico	Manuel Duran	Permits
New Mexico Energy and Minerals Department Santa Fe, New Mexico	Alan Hall	Permits
New Mexico State Historic Preservation Office Santa Fe, New Mexico	Nancy Wood	Cultural resource clearance
U.S. Forest Service Grants, New Mexico	Stan Wyche	Riprap source for Ambrosia Lake
Los Alamos National Laboratory Los Alamos, New Mexico	S. Baldridge D. Cash K. Olsen	Seismicity of Ambrosia Lake region
Soil Conservation Service Grants, New Mexico	K. Walker	Soils
United Nuclear Corporation Ambrosia Lake, New Mexico	Jim Fletcher	Subsurface features
Sergent, Hauskins and Beckwith Phoenix, Arizona	R. Weeks P. Smith	Geomorphology

Agencies, organizations, and persons consulted (Concluded)

Agency/organization	Person	Subject
Homestake/United Nuclear Corporation Ambrosia Lake, New Mexico	Ed Kennedy	Hydrochemistry information
New Mexico Game and Fish, Albuquerque, New Mexico	Randy Isler	Big game
New Mexico Natural Resources Department Santa Fe, New Mexico	Leo Griego Leslie Price Ann Cully Paul Knight Lynn Martinez	T and E plants
U.S. Fish and Wildlife Service Albuquerque, New Mexico	Peggy Olwell Tom O'Brien John Peterson	T and E species/ Wildlife
New Mexico Game and Fish Santa Fe, New Mexico	John Hubbard	T and E species
New Mexico Game and Fish Grants, New Mexico	Steve Middleton	Wildlife
U.S. Forest Service Cibola National Forest	Larry Sampson	Wildlife
Office of the State Engineer Santa Fe, New Mexico	Larry Funs Steve Schwebke	Surface water, flood analysis
Office of the State Engineer Albuquerque, New Mexico	Charles Wohlenberg	Surface water/ Ground water
Quivira Mining Co. Grants, New Mexico	Art Gebeau	Mine maps/ Mine workings
Kerr McGee Corporation Oklahoma City, Oklahoma	Hal Whitacre	Mine maps, hydrologic data

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Beranich, Sandra	Jacobs-Weston	Socioeconomic
Bierley, Denise	Jacobs-Weston	Scenic, Historic, Cultural
Burt, Charles	Jacobs-Weston	Flora and Fauna
Butler, David	Jacobs	Transportation
Caldwell, Jack	Jacobs-Weston	Manager, Engineering Services
Cox, Steven	Jacobs-Weston	Graphics
Goepel, James	Jacobs	Air Quality
Hobbs, Brian	Jacobs-Weston	Surface and Subsurface
Hoopes, Jack	Jacobs-Weston	NEPA Management
Kennedy, Bruce	Jacobs-Weston	Engineering, Surface Water
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Longmire, Patrick	Jacobs-Weston	Ground Water
Meunier, Gary	Jacobs	Air Quality/Noise
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Parrott, Laura	Jacobs-Weston	Editing
Peel, Robert	Jacobs-Weston	Site Manager
Petersen, Reta	Jacobs-Weston	Editing
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Sheth, Dilip	Jacobs-Weston	Engineering
Solow, Alan	Jacobs-Weston	Radiation Services
Thackston, John	Jacobs-Weston	Manager, Hydrology
Wooding, Donna	Jacobs-Weston	Radiation, Transportation

DOE/EA-0322

ENVIRONMENTAL ASSESSMENT

OF

REMEDIAL ACTION AT THE AMBROSIA LAKE

URANIUM MILL TAILINGS SITE

AMBROSIA LAKE, NEW MEXICO

APPENDICES

JUNE, 1987

U.S. DEPARTMENT OF ENERGY

UMTRA PROJECT OFFICE

ALBUQUERQUE, NEW MEXICO

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ENGINEERING SUMMARY

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A.1 INTRODUCTION

A.1.1 PURPOSE

This appendix provides the information needed to understand the conceptual designs for the remedial action alternatives addressed in this environmental assessment. This appendix is intended to provide sufficient detail for the reader to evaluate the feasibility and assess the impacts of each remedial action alternative. However, this appendix is not intended to provide the detailed engineering necessary to implement the alternatives.

The conceptual details (e.g., radon barrier thickness, soil characteristics) of the proposed action are based upon field studies, laboratory testing, and various modeling techniques. Details of these data and calculations are available in the draft Remedial Action Plan (DOE, 1985). The conceptual details will be refined during preparation of the final design and specifications. For the alternative design, assumptions regarding various factors (e.g., soil type and availability) have been made based upon the data and calculations applicable to the proposed action.

A.1.2 CONCEPT OBJECTIVES

The purpose of the remedial action is to stabilize and control the uranium mill tailings (residual radioactive wastes) and other contaminated materials in a manner which complies with the U.S. Environmental Protection Agency (EPA) standards (40 CFR Part 192). Consistent with this purpose and the EPA standards, the following major design objectives have been established:

- Reduce the average radon flux from the site to 20 picocuries per square meter per second (pCi/m^2s) or 0.5 picocuries per liter (pCi/l) above background outside the disposal site.

- Design controls to be effective for up to 1000 years, to the extent reasonably achievable, and, in any case, for at least 200 years.

- Prevent inadvertent human intrusion into the stabilized tailings.

- Minimize burrowing by animals and plant root penetration into the stabilized tailings.

- Ensure, to the extent practicable, that potential uses of surface water and ground water are not adversely affected.

- Reduce contaminant levels of Ra-226 in areas released for unrestricted use to five picocuries per gram (pCi/g) averaged in the first 15 centimeters (cm) of soil below the surface and 15 pCi/g averaged in 15-cm-thick layers of soil more than 15 cm below the surface.

- Make a reasonable effort to achieve, in any occupied or habitable building, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 working level (WL). In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL, and the level of gamma radiation shall not exceed the background level by more than 20 microroentgens per hour.
- Minimize the land area to be occupied by the stabilized tailings.
- Protect against releases of contaminants from the site during construction.
- Minimize the areas disturbed during construction, and minimize human exposure to contaminated materials.

A.2 PROPOSED ACTION - STABILIZATION IN PLACE

A.2.1 PRESENT CONDITIONS

The designated Ambrosia Lake tailings site covers 196 acres and contains the tailings pile and the buildings, structures, and equipment associated with the former uranium milling operations (Figure A.2.1). The tailings pile covers 111 acres and contains approximately 2.7 million cubic yards of tailings. Dispersion of the tailings by wind and water has contaminated approximately 570 acres of land adjacent to the tailings pile and outside the designated site boundary. The total volume of contaminated materials, including the tailings and soils beneath and around the tailings, is estimated to be approximately 4.6 million cubic yards.

The roughly square tailings pile averages 17 feet in thickness, and rests on gently sloping alluvial soils underlain by shale. Containment dikes were constructed around the pile to form sideslopes of 33 percent (three horizontal to one vertical); surface-water runoff has partially eroded the dike along the east edge of the pile. The top of the pile is slightly concave, and surface-water runoff collects in a shallow depression at the southern end of the pile.

All of the buildings and structures and much of the equipment associated with the former uranium milling operations (e.g., office building, mill building, pachuca tanks, ore storage pad) remain at the site. Access to the site is restricted by a fence surrounding the site and a locked gate across the access road.

A.2.2 FINAL CONDITIONS

All of the tailings and contaminated materials would be stabilized at the location of the existing tailings pile. The tailings and wind-blown contaminated soils would be consolidated and contoured to maximum sideslopes of 20 percent (five horizontal to one vertical) and top-slopes of 2.5 percent. The tailings and contaminated soils would be covered with an estimated 3.5 feet of compacted earth and 0.5 foot of sand. The topslopes and sideslopes would be covered with an estimated 0.5- and two-foot-thick layers of rock, respectively. The roughly rectangular stabilized tailings pile would cover approximately 88 acres measuring 2500 feet in length in the east-west direction and 1550 feet in width in the north-south direction (Figure A.2.2). The top of the pile would be approximately 50 feet (average) above the surrounding terrain (Figure A.2.3).

A gently sloping (0.5 percent grade away from the pile) rock erosion protection apron approximately three feet thick would extend out approximately 20 feet along the north and east toe and 12 feet along the south and west toe of the stabilized tailings pile. All of the buildings, structures, and equipment (including asbestos) associated with the former milling operations would be demolished or

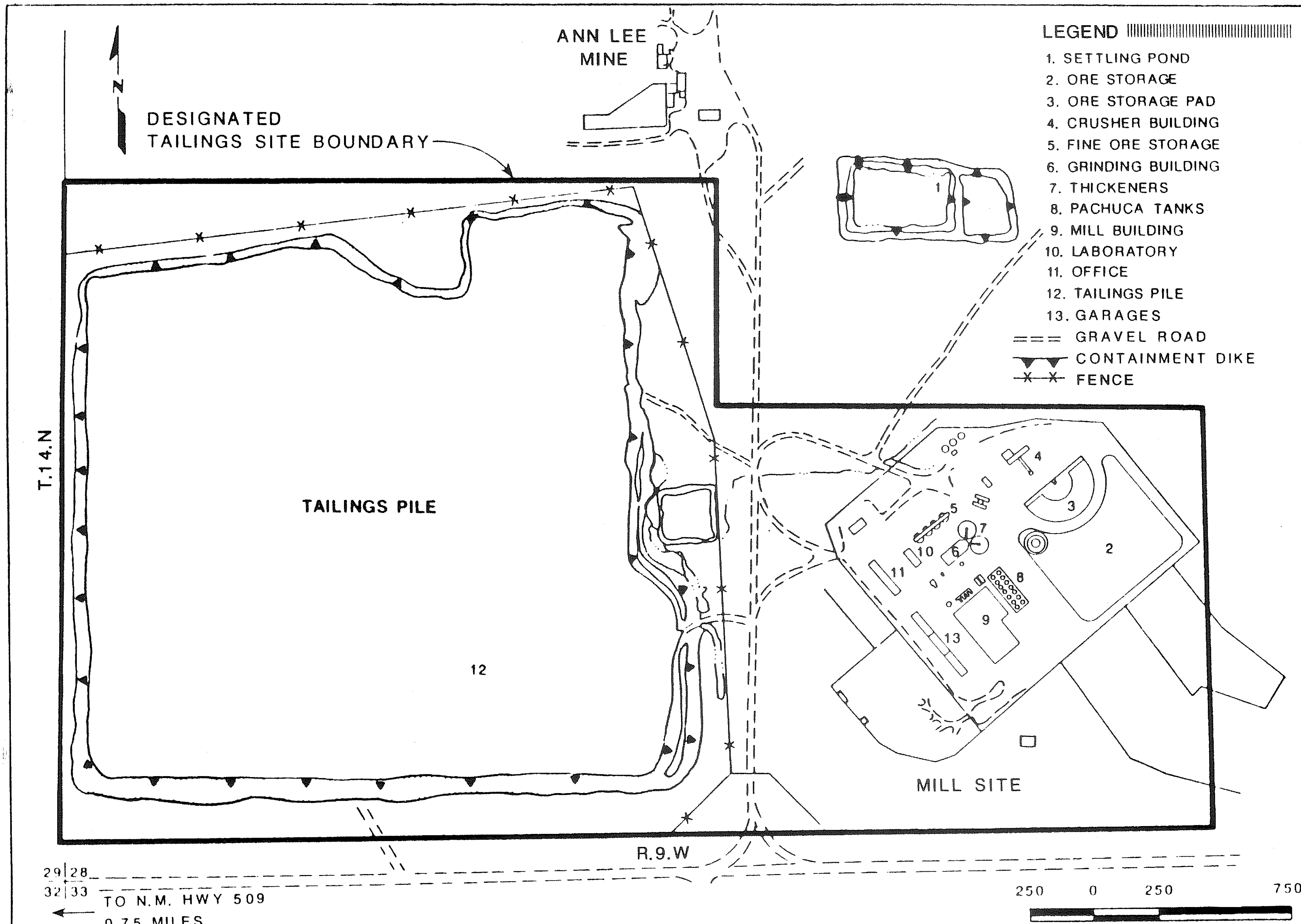


FIGURE A.2.1 AMBROSIA LAKE TAILINGS SITE

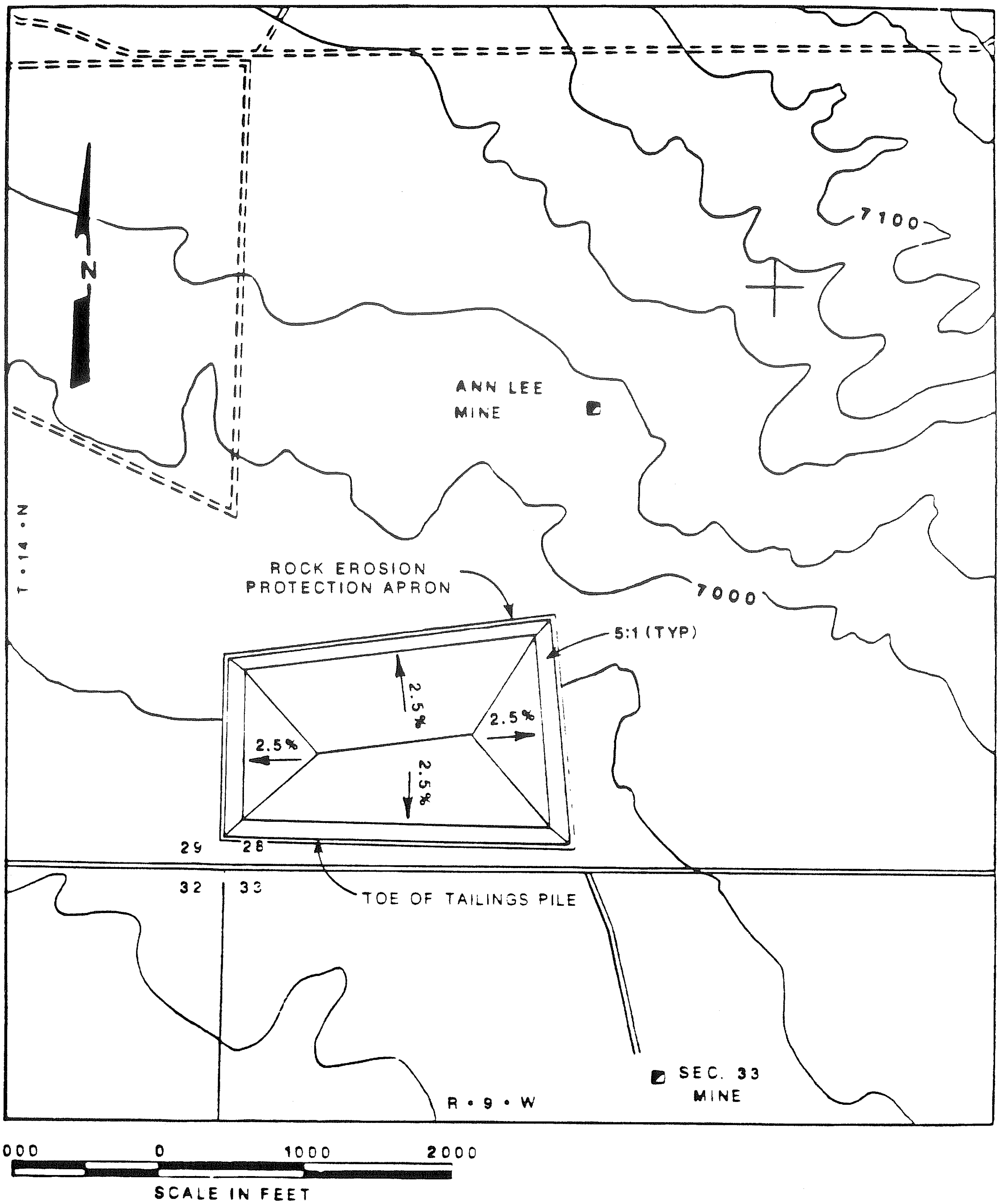


FIGURE A.2.2
FINAL CONDITIONS, STABILIZATION IN PLACE

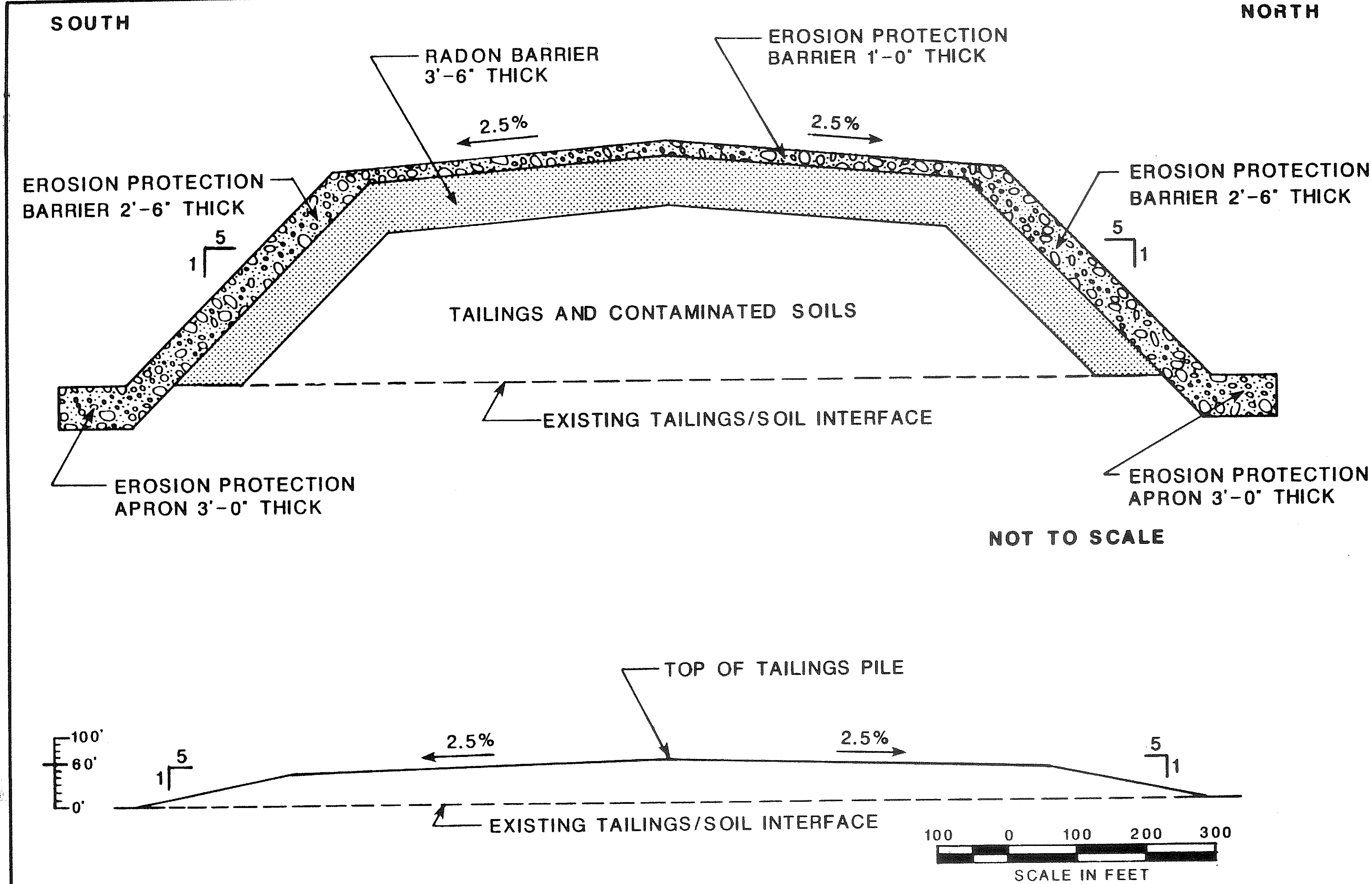


FIGURE A.2.3
STABILIZATION IN PLACE, TYPICAL CROSS-SECTION

dismantled and would be disposed in the pile in accordance with applicable State and Federal regulations. The disposal pit would occupy approximately two acres, and the demolition rubble and debris would be covered with compacted earth to approximately the original grade.

The final restricted area (including the rock erosion protection apron and disposal pit) would cover approximately 95 acres. This includes approximately six acres outside the designated site boundary in Section 29 adjacent to the west edge of the existing tailings pile which would be purchased from the current owner (Kerr-McGee Corporation) to facilitate pile construction. The perimeter of the area would be marked with warning signs, boundary markers, and survey monuments. The areas surrounding the stabilized tailings pile disturbed by the remedial action would be backfilled as required and graded to control surface drainage. Approximately 107 acres of the 196-acre designated tailings site would be released for unrestricted use.

A.2.3 MAJOR CONSTRUCTION ACTIVITIES

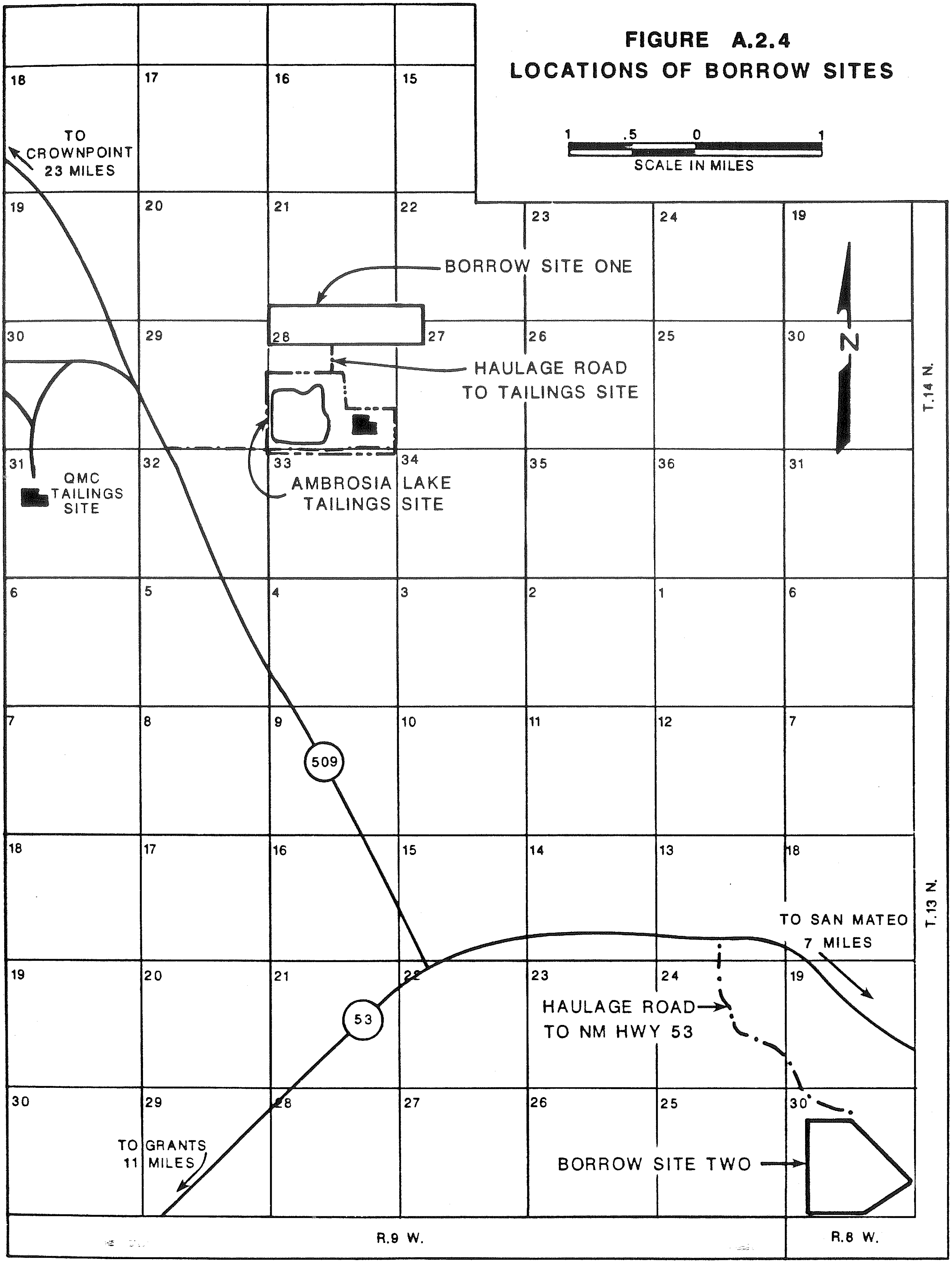
The major feature of the proposed action is the stabilization of all the tailings and other contaminated materials within the area occupied by the existing tailings pile. The tailings and contaminated soils from the area of windblown tailings would be consolidated with the pile and would be covered with a layer of earthen materials (i.e., radon barrier) to inhibit radon emanation, water infiltration, and plant root penetration. Borrow site 1, located on private land approximately one road mile north of the tailings site (Figure A.2.4), has been tentatively selected as a source for the radon barrier. The radon barrier would be covered with sand and rock (i.e., erosion protection barrier) to inhibit water and wind erosion and penetration by burrowing animals. The sand would be obtained from borrow site 1. Borrow site 2, located on Federal land approximately 12 road miles southeast of the tailings site (Figure A.2.4), has been tentatively selected as a source of rock for the erosion protection barrier. Borrow site 2 would be the source of gravel for the haulage roads to the borrow sites.

For the purposes of this concept, stabilization in place would require the following major construction activities:

<u>Site preparation</u>

- Excavation of windblown tailings from the existing graveled haulage road adjacent to the tailings site to the south, and reconstruction of the affected portion of the road (approximately 0.5 mile).
- Clearing and grubbing (as necessary).
- Erection of a temporary security fence.

FIGURE A.2.4
LOCATIONS OF BORROW SITES



- Demolition or dismantling of all remaining buildings, structures, and equipment (including asbestos) associated with the former milling operations in accordance with applicable State and Federal regulations.

- Construction or upgrading of approximately three miles of graveled haulage roads to borrow sites 1 and 2 (see Figure A.2.4).

- Construction of a lined waste-water retention pond.

- Construction of drainage control measures to direct all generated waste-water and storm-water runoff to the retention pond.

- Installation of erosion control measures for all disturbed areas.

<u>Disposal of contaminated materials</u>

- Consolidation of all of the tailings and soils contaminated by windblown and waterborne tailings (includes contaminated sediments from retention pond) onto and around the southern portion of the existing tailings pile.

- Placement of demolition rubble in the pile.

<u>Radon barrier</u>

- Excavation, haulage, and placement of an estimated 3.5-foot-thick, compacted earthen cover over the consolidated tailings and contaminated soils.

<u>Erosion protection</u>

- Excavation, haulage, and placement of an estimated 0.5-foot-thick layer of sand over the radon barrier.

- Excavation, haulage, and placement of rock over the sand filter layer (approximately 0.5 foot thick on the top and two feet thick on the sideslopes).

- Excavation, haulage, and placement of an estimated three-foot-thick rock apron around the base of the stabilized tailings pile.

- Contouring of drainage swales approximately 500 feet from the north and east edge of the stabilized tailings pile (see Figure A.2.2).

<u>Site restoration</u>

- Backfilling, recontouring, and revegetating areas excavated (includes retention pond) during remedial action, including the borrow sites, as required by the appropriate permits and approvals.

- o Installation of warning signs, monuments, and benchmarks around the stabilized tailings pile.

A remedial action schedule for stabilization in place is shown in Figure A.2.5.

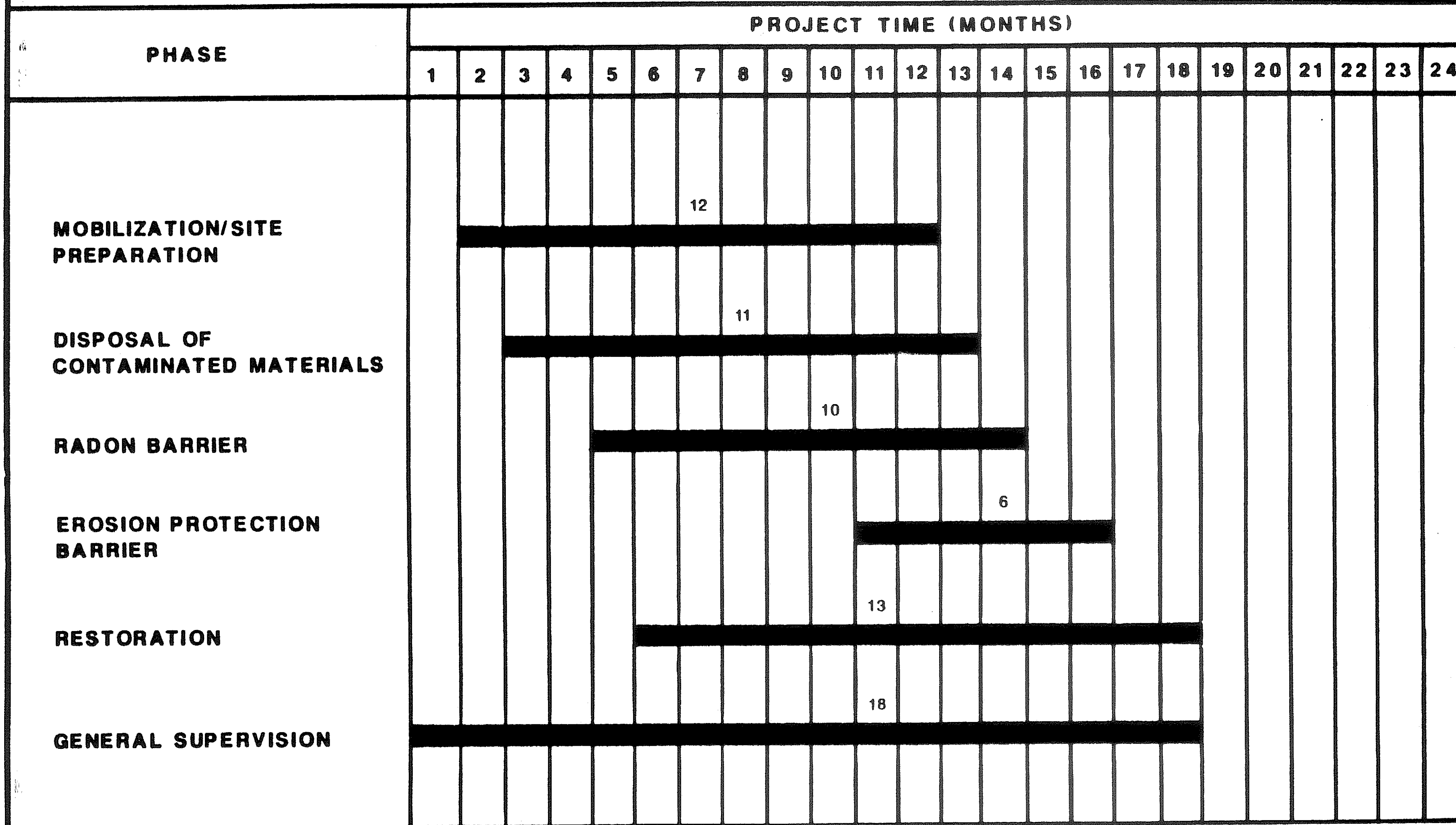
A.2.4 MAJOR CONCEPT CONSIDERATIONS

Major factors considered in the development of an optimum concept for stabilization in place included pile stability, drainage, and radon control. Appropriate engineering techniques were evaluated to determine the most cost-effective method of ensuring the long-term stability of the tailings. The existing configuration of the tailings pile and the physical properties of the tailings controlled the range of engineering options considered. Initially, several concepts were developed which would minimize disturbance to the pile and result in a final pile configuration that would conform to a great extent with the present shape of the pile. However, the existing pile sideslopes would have to be recontoured to form more stable, relatively flat sideslopes. Unstable materials within the pile would be exposed during pile recontouring. Additionally, the final pile configuration would be such that concentrations of precipitation runoff on the pile topslopes and sideslopes would be minimized. The volumes of borrow materials required to ensure pile stability and promote drainage would be much greater for these concepts than for the proposed action.

The proposed concept for stabilization in place was developed to minimize the volumes of borrow materials required to meet the objectives of ensuring long-term stability of the tailings and promoting drainage away from the pile. This was accomplished by placing windblown contaminated soils around the pile to buttress the existing steep sideslopes and form relatively flat sideslopes (five horizontal to one vertical) and by consolidating the tailings at the southern portion of the pile to fill the existing depression on the top of the pile. Also, placing lesser contaminated materials as the outermost layer of contaminated materials would minimize the thickness of the radon barrier required to meet the EPA standard for radon control as the windblown materials are of lower radium content than the tailings. Reducing the area occupied by the pile would result in reduced erosion protection requirements for the same design events than for the concepts considered initially. These measures would minimize the volumes of borrow materials required to meet the design criteria for the radon and erosion protection barriers thereby providing for the long-term stability of the tailings at the least cost.

Another major design objective was to meet the design effectiveness period of 200 to 1000 years (40 CFR Part 192). The erosion protection was analyzed using criteria proposed by the NRC for the 1000-year life (NRC, 1986). Slope stability and subsidence were analyzed using parameters such as strength that are not time dependent and therefore exceed the 1000-year limit. The seismic risk analyses use a design earthquake that is the largest that is ever expected to occur at the

FIGURE A.2.5 REMEDIAL ACTION SCHEDULE: STABILIZATION IN PLACE



site; this also exceeds the 1000-year recurrence interval that would be expected. The engineering analyses for all factors of concern either meet or exceed the 1000-year period.

Radon control

Data on the distribution of radium in the tailings, soils beneath the tailings, and windblown materials, and the physical properties of the locally available earthen materials (borrow site 1) were used in the computerized RAECOM model (NRC, 1984) to estimate the thickness of the radon barrier necessary to control radon emanation to the EPA standard. According to this analysis, radon emanation could be controlled to the standard by using a combination of the following techniques:

- Decontamination of a large portion of the site by excavating and placing contaminated materials from the northern portion of the pile onto the southern portion of the pile.
- Placing windblown and waterborne tailings and lesser contaminated soils over and around the reshaped tailings.
- Placing an estimated 3.5-foot-thick, compacted earthen cover at optimum moisture content over the consolidated tailings and contaminated materials.

Long-term stability

The stabilized tailings pile has been designed to withstand the effects of several natural events as discussed below.

Water and wind erosion

Severe precipitation events could have the potential to erode the erosion protection barrier and eventually damage the radon barrier. One such event is the Probable Maximum Precipitation (PMP) which is defined as the maximum precipitation that could occur from the most severe combination of meteorological conditions that are reasonably possible in a region. For the Ambrosia Lake site, the PMP was calculated to be 10.67 inches of rain in one hour (NOAA, 1984) with a maximum intensity of 70.4 inches per hour. This PMP would generate sheet flow rates of 0.80 and 1.13 cubic feet per second per foot of slope width (cfs/ft) on the pile topslopes (2.5 percent) and sideslopes (20 percent), respectively (TAC, 1985a). An erosion protection barrier comprised of a 0.5-foot-thick sand filter layer and a 0.5- to two-foot-thick layer of rock would be placed over the stabilized tailings pile. The rock erosion protection required to withstand sheet erosion during a PMP event is shown in Table A.2.1.

Due to the final shape and height of the stabilized tailings pile, high winds also could erode the pile. The rock erosion

Table A.2.1 Estimated rock erosion protection for stabilization in place

Location	PMP sheet flow rates (cfs/ft)[a]	Mean diameter of rock (inches)	Rock thickness (feet)
Pile topslopes	1.13	2.0	0.5
Pile sideslopes and apron	0.80	7.0	2.0

[a]cfs/ft - cubic feet per second per foot of slope width.

protection barrier would also protect the pile against wind erosion because the erosive forces caused by high winds would be much less than those caused by a PMP.

Flood protection and geomorphology

The closest established watercourse to the tailings pile is the Arroyo del Puerto, an intermittent stream approximately one mile southwest, and 80 feet below, the tailings site. Due to the stabilized pile's distance from and height above the arroyo, flooding and channel migration (meander) of the stream would not pose hazards to the pile.

Two drainage basins above (northeast) the tailings site were identified as source areas for flood flows which could pose potential hazards to the pile. Computer modeling was used to predict runoff during flooding associated with a PMP event occurring over these drainage areas (COE, 1981; SCS, 1975). Maximum flood flows were used to determine erosion protection requirements for the stabilized pile. As a result of this analysis, drainage swales would be contoured approximately 300 to 500 feet from the north and east edges of the pile to reduce the concentration of flood flows on the pile. The swales are intended only to assist in channeling runoff during extreme flooding to prevent the direct impact of flood flows on the pile. The swales would not alter the current surface-water drainage patterns and therefore would have no impact on the existing ephemeral streams north and east of the site.

A geomorphic evaluation of the tailings site (TAC, 1985b) indicated that existing ephemeral arroyos on the south and west sides of the stabilized tailings pile could advance headward and undercut the base of the stabilized pile. To protect against this headcutting, an estimated three-foot-thick rock erosion protection apron would be placed around the toe of the stabilized pile.

Liquefaction

Liquefaction could be a problem in the sand portions of the tailings where the perched water table exists. Liquefaction would not occur in the slimes since they possess limited cohesion and would not increase in density upon vibration. The liquefaction would be very limited since the amount of sands in the perched water table is not extensive. Once the perched water table dissipates following placement of the radon barrier, liquefaction potential would be nonexistent. Although the probability of a large earthquake occurring during the less than 50-year time period before the perched water table dissipates is extremely small, liquefaction was still analyzed. The results of this analysis are presented in Appendix B, Section B.3 of the draft RAP. The analysis showed that if liquefaction did occur, the tailings would be buttressed by the placement of off-pile compacted, contaminated material around the pile. Therefore, slope failure would not occur. Some sand boils on the surface could occur during remedial action but their extent and magnitude would be small.

Slope stability and seismic risk

Slope failure due to instability under static and seismic loading would affect the stabilized tailings pile. The physical properties of the materials that would comprise the stabilized tailings pile and the pile configuration were used to determine the driving and resisting forces of the pile under static conditions. The strength parameters used for short-term stability change with time while the long-term parameters do not change with time and represent expected conditions over the 1000-year design life of the disposal site. Analyses showed that the disposal site will remain stable for 1000 years and longer.

Seismic loading conditions were evaluated by applying the horizontal ground acceleration resulting from a floating earthquake (a seismic event not associated with a known tectonic structure) of magnitude 6.2 (Richter scale). Such an earthquake occurring 15 kilometers from the tailings site would generate an on-site peak horizontal ground acceleration of 0.21g. This is called the design earthquake and is the largest earthquake which produces the most severe effects upon the site. This is, in essence, the largest earthquake ever that could impact the tailings embankment. The design earthquake is discussed in greater detail in Appendix B, Section B.10 of the RAP (DOE, 1985). The factors of safety for the pile sideslopes under static and seismic loading exceed the generally accepted limits of 1.5 and 1.0, respectively (COE, 1970).

The principal seismic hazard to the stabilized pile would be the potential for slope failure due to seismically-induced liquefaction of the tailings or underlying soils. For liquefaction to occur, a soil must be loose, noncohesive, and saturated. Soils beneath the tailings are not loose and noncohesive and therefore do not possess the properties required for liquefaction to occur. The tailings, however, contain some saturated slimes and sand-slime mixtures which could liquefy under seismic stress. With the use of relatively flat (five horizontal to one vertical) sideslopes, the pile would be stable under all loading conditions.

Differential settlement and subsidence

Differential settlement of the tailings and contaminated materials would occur during consolidation of the tailings and windblown material and placement of the radon barrier. Settlement of earthen materials is a difficult parameter to quantify under laboratory conditions and becomes even more difficult to quantify under field conditions due to the different degrees of saturation throughout the pile. Because of these analytical problems and the importance of the integrity of the radon barrier, field monitoring of the settlement will occur. By using data gathered during field monitoring, any settlement could be observed and properly remedied before the radon barrier is placed. This method would provide a high level of confidence in the long-term integrity of the radon barrier.

Settlement monitoring devices would be installed during construction to determine the rate and amount of settlement. If settlement resulted in cracking of the radon barrier or undesirable changes in pile configuration, measures such as recompaction, replacement, or regrading would be implemented. To preclude adverse effects on the stabilized tailings pile, appropriate engineering measures (e.g., installation of wicks to remove moisture from pile materials) would be adopted or adjustments in the construction schedule would be considered.

The possibility of subsidence due to settlement of strata over underground mine workings hypothetically could cause cracking of the radon barrier due to tensile forces; this phenomenon was fully analyzed. The effects of subsidence on the pile were evaluated using maps of underground mine workings and lithologic data. The areal and vertical extent of subsidence and the resultant stresses on the cover system were calculated. The stresses in cover materials as a result of the maximum theoretical subsidence values were compared to established stresses that have been shown to crack soils in tension. This evaluation showed that stresses resulting from subsidence would be considerably less than those required to crack soils similar to the borrow materials proposed for use in the radon barrier. Hence, subsidence, if it occurs, would not affect the integrity of the stabilized tailings pile. Further, this same conclusion was reached independently by Dr. John Abel, Jr., of the Colorado School of Mines, using the same set of conditions (Abel, 1986).

In addition, hypothetical effects of subsidence of deep underground mine workings on the stabilized tailings pile were considered in the conceptual design. Using parameters which would tend to predict larger subsidence values, the analyses still indicated that even if a larger amount of subsidence did occur, it would not affect the integrity of the pile. Therefore, no additional design features to mitigate the potential affects of deep mine subsidence were required.

Frost heave and solifluction

Frost heave and solifluction are natural processes that could affect the long-term performance of the stabilized tailings pile. Frost heave is the expansion of soils toward the surface from the freeze-thaw cycle during the change from winter to summer; the process requires that adequate soil moisture be present to form ice lenses at boundaries in fine-grained soil. Associated frost creep or frost sloughing occurs in fine-grained sediments on slopes and can be mitigated by using an aggregate (rock) cover (Linell and Lobacz, 1980). Solifluction is the action of slow flowage in saturated soils in periglacial regions. Only the surface layer is affected, and very low slopes can flow if saturated (Ritter, 1978).

The climatic conditions (warm temperatures and low precipitation) at the tailings site do not favor the occurrence of frost heave or solifluction. In addition, the use of a sufficiently impermeable radon barrier (earthen materials) and a sufficiently porous rock erosion protection barrier would inhibit the ice lens formation and saturation which are required for these processes.

Penetration by plants and animals

Due to the sparse vegetation and limited numbers of burrowing animals in the vicinity of the tailings site, penetration of the stabilized tailings pile by plant roots or animals would not be expected to affect the stability of the pile or promote dispersion of the tailings. The use of a sufficiently impermeable, compacted radon barrier and a sufficiently thick rock erosion protection barrier would further inhibit penetration of the stabilized tailings pile by plants and animals.

Ground-water protection

Water in the alluvium underlying the tailings pile contains contaminated water originating from the tailings pile and recharge of mine dewatering effluents. These artificial recharge sources have created a limited zone of saturation in the alluvium in the site area which under pre-mining and milling activity was probably dry.

The alluvium does not constitute an existing or potential ground-water resource (see Appendix B, Water) because it yields little water which is of poor quality. Contaminated water migrates from the tailings into the alluvium, then moves downgradient until it encounters the Tres Hermanos-C Sandstone beneath the southwest corner of the pile.

The Tres Hermanos-C Sandstone is considered a saturated formation within the site vicinity; historically there have been no withdrawals because of its low yield of poor quality water. Available water-quality data from the Tres Hermanos-C Sandstone at the Ambrosia Lake site show that selenium, pH, chloride, sulfate, boron, fluoride, gross alpha activity, chromium, cobalt, iron, manganese, nitrate, radium, total dissolved solids, uranium, and molybdenum exceed Federal and/or state water-quality standards (WQCC, 1986).

There are no present or historical wells completed in the Tres Hermanos-C Sandstone in the Ambrosia Lake valley. All known water supply wells in the Ambrosia Lake Valley are completed in the Westwater Canyon Member or deeper formations except for a few wells completed in the San Mateo Creek alluvium. There does not appear to be a pathway for tailings-derived contamination in the Tres Hermanos-C Sandstone from the Ambrosia Lake site to reach humans or livestock as analyses estimated that tailings derived contamination in the Westwater Canyon Member would extend 400 feet northeast from the Ann Lee Mine.

Consolidation and compaction of the tailings during remedial action would not result in further significant degradation of the water quality in the alluvium or Tres Hermanos Sandstone units. Covering the tailings and other contaminated materials with a low-permeability earthen layer should reduce water infiltration through the pile and limit contaminant migration.

Construction measures utilized to protect ground water include: construction of waste-water collection ditches and a lined waste-water retention pond(s), construction of runoff interceptor ditches to prevent uncontaminated runoff water from entering the site, covering the pile with a low-permeability earthen layer to restrict infiltration, and use of the contaminated water for compaction and dust control on the tailings pile.

Sections B.2.1 and B.2.6 of Appendix B present a discussion of applicable regulations and ground-water restoration, respectively.

A.2.5 CONSTRUCTION ESTIMATES

Estimates of equipment and personnel requirements; fuel, energy, and water consumptions; major earthwork volumes; and construction costs for stabilization in place are summarized in Tables A.2.2 through A.2.8.

Table A.2.2 Equipment use - stabilization in place[a,b]

Type of equipment	Pieces of equipment per month of project time																		Total equipment months per type of equipment
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
D-8 dozer	0	2	7	16	14	19	19	15	15	8	9	10	10	5	5	4	3	0	161
Front-end loader	0	1	1	4	4	8	8	8	8	8	8	8	8	8	5	3	0	0	90
18-cy trucks	0	0	5	5	9	15	12	12	12	12	13	21	16	18	12	12	0	0	174
Grader	1	1	1	1	1	1	1	1	2	2	5	5	5	5	2	0	0	0	34
Scraper	0	1	6	6	10	10	10	4	4	4	5	5	1	1	0	0	0	0	67
Compactor	0	0	1	2	2	3	3	3	3	3	3	3	3	3	1	1	0	0	34
Water truck	0	0	1	2	2	3	3	3	3	3	3	3	3	3	3	3	3	0	41
Crane	0	0	3	3	3	3	3	3	3	3	3	3	0	0	0	0	0	0	30
Forklift	0	0	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	20
Backhoe	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	5
Shredder	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	2	0	7
Total pieces of equipment per month of project time	1	5	28	42	48	65	62	51	52	45	51	60	46	44	30	25	8	0	663

[a]cy - cubic yard.
[b]Average = 663/total equipment - month/18 months = 37 pieces of equipment per month.

Table A.2.3 Personnel requirements - stabilization in place[a]

Type of personnel	Number of personnel per month of project time																		Total man-months per type of personnel
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Truck drivers	0	0	6	7	11	18	15	15	15	15	16	24	19	21	15	15	3	0	215
Equipment operators	1	5	22	35	37	47	47	36	37	30	35	36	27	24	16	11	9	0	455
Operator supervisors	1	1	3	5	5	7	7	6	6	5	6	6	5	5	3	3	1	0	75
Security, survey, and laborers	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	126
General supervisors, engineers, and managers	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	108
Health physics personnel	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	126
Total man-months per month of project time	22	26	51	67	73	92	89	77	78	70	77	86	71	70	54	49	33	20	1105

[a]Peak employment = 92 people; average employment - 1105 total man-months/18 months = 62 people; personnel requirements based on an eight-hour shift per day, 19.25 days per month.

Table A.2.4 Fuel consumption - stabilization in place[a]

Type of equipment	Fuel consumption (gallons)
D-8 dozer	272,800
Front-end loader	124,776
18-cy trucks	268,000
Grader	31,440
Scraper	134,160
Compactor	73,360
Water truck	25,280
Crane	18,496
Forklift	15,400
Backhoe	12,416
Hydromulcher	10,800
	986,928

[a]cy - cubic yard.

Table A.2.5 Power consumption - stabilization in place

Facility	Kilowatt-hours (x 1000)
Field offices	27
Change/shower trailer(s)	120
Laundry	60
Waste-water treatment plant	11
Total	218

Table A.2.6 Water consumption - stabilization in place

Water use	Gallons x 1000
Compaction	
o Site preparation	1074
o Tailings pile construction	9875
o Radon and erosion protection barriers	12,740
o Restoration	1870
Compaction total	25,559
Decontamination	113
Dust control	2772
Potable (laundry, showers, consumption)	660
Total consumption	29,104

Table A.2.7 Summary of major earthwork volumes - stabilization in place

Activity	Estimated in-place volumes (cubic yards)
Site preparation	
o Excavate, screen, haul, and place gravel for haul roads	30,700
o Excavate and spoil waste-water retention pond	16,200
o Excavate and spoil temporary ditches	72,000
o Demolish mill buildings and associated structures and equipment	20,000
Tailings pile construction	
o Excavate, haul, spread, and compact contaminated materials	1,460,000
Radon cover	
o Excavate, stockpile, haul, spread, and compact earth	738,000
Erosion protection	
o Excavate, stockpile, haul, and place sand and rock	204,500
Restoration	
o Backfill excavations as required	180,200

Table A.2.8 Summary of construction costs - stabilization in place

Activity	Cost $ x 1000
Mobilization/site preparation	$ 2460
Disposal of contaminated materials	4140
Radon barrier	2790
Erosion protection barrier	1690
Restoration	1240
General supervision	2750
Total	15,070

These estimates do not include the costs of:

- o Property acquisition.
- o Engineering design.
- o Construction management (except for field supervision).
- o Overall project management.
- o Long-term surveillance and maintenance.

A.3 DISPOSAL AT THE SECTION 21 SITE

A.3.1 PRESENT CONDITIONS

The Section 21 alternate disposal site is located approximately one air mile north of the existing tailings site (Figure A.3.1). The land at the site is owned by United Nuclear Corporation and is currently used for low-density livestock grazing.

A.3.2 FINAL CONDITIONS

The stabilized tailings pile would be roughly square in shape with sides measuring approximately 2160 feet in length. Other final conditions (i.e., radon and erosion protection barriers, topslopes, sideslopes, rock erosion protection apron, rubble disposal pit, and warning signs) would be identical or very similar to those for the proposed action (Figure A.3.2). The average depth of excavation for partially below grade disposal would be 14 feet. The stabilized tailings pile would cover approximately 108 acres and would average 22 feet above the surrounding terrain (Figure A.3.3). The final restricted area, including the rock erosion protection apron and the disposal pit, would cover approximately 111 acres.

Areas disturbed during remedial action, including borrow site 2, would be restored in accordance with applicable permits and approvals by backfilling as required, recontouring to control surface drainage, and revegetation to control erosion. The entire 196-acre designated tailings site would be reclaimed and released for unrestricted use.

A.3.3 MAJOR CONSTRUCTION ACTIVITIES

The major feature of this remedial action alternative is the relocation of all of the tailings and contaminated materials at the existing tailings site to the Section 21 alternate disposal site. This alternative would require the same major construction activities as the proposed action (see Section A.2.3) except that all of the tailings and contaminated materials would be trucked to the Section 21 site, and a pit would be excavated for partial below-grade disposal of the consolidated tailings and contaminated soils. Earthen materials excavated from the Section 21 site would be stockpiled for use in the radon and erosion protection barriers; excavation of borrow materials from borrow site 1 would not be required. A remedial action schedule for disposal at the Section 21 site is shown in Figure A.3.4.

A.3.4 MAJOR CONCEPT CONSIDERATIONS

<u>Assumptions</u>

The concept for disposal at the Section 21 site was based on the following assumptions:

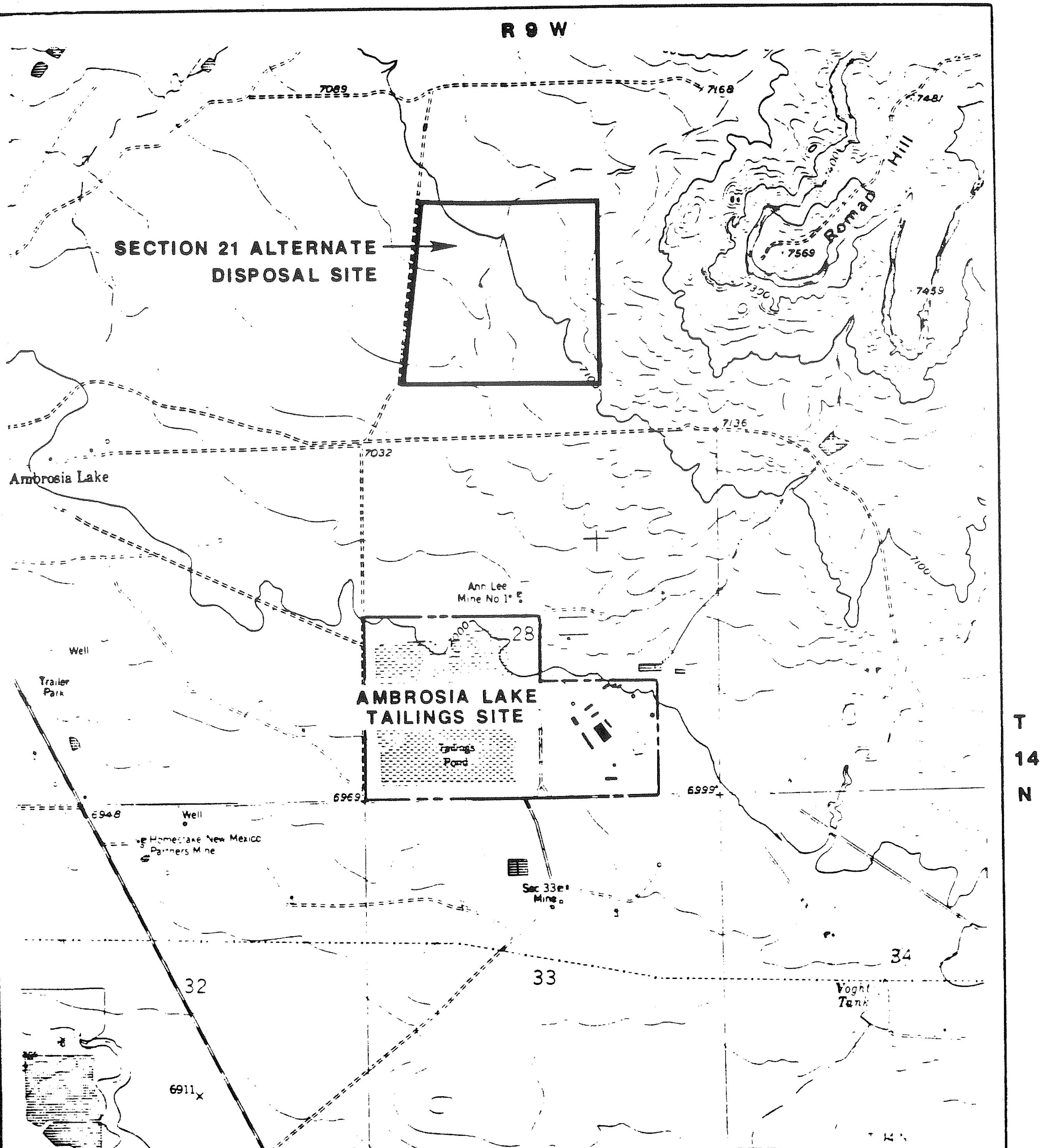


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FIGURE A.3.1
ALTERNATE DISPOSAL SITE LOCATION

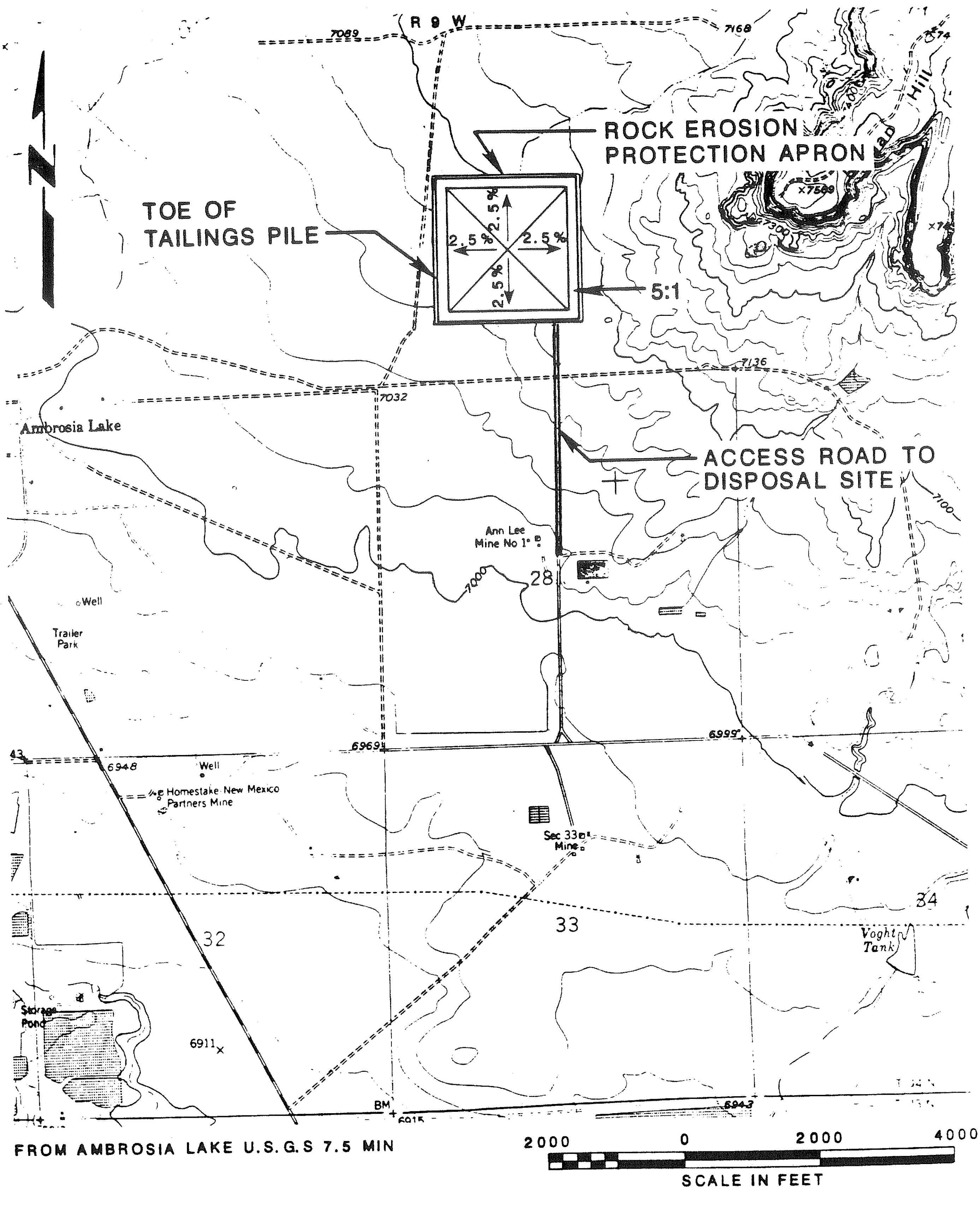


FIGURE A.3.2
FINAL CONDITIONS, SECTION 21 SITE

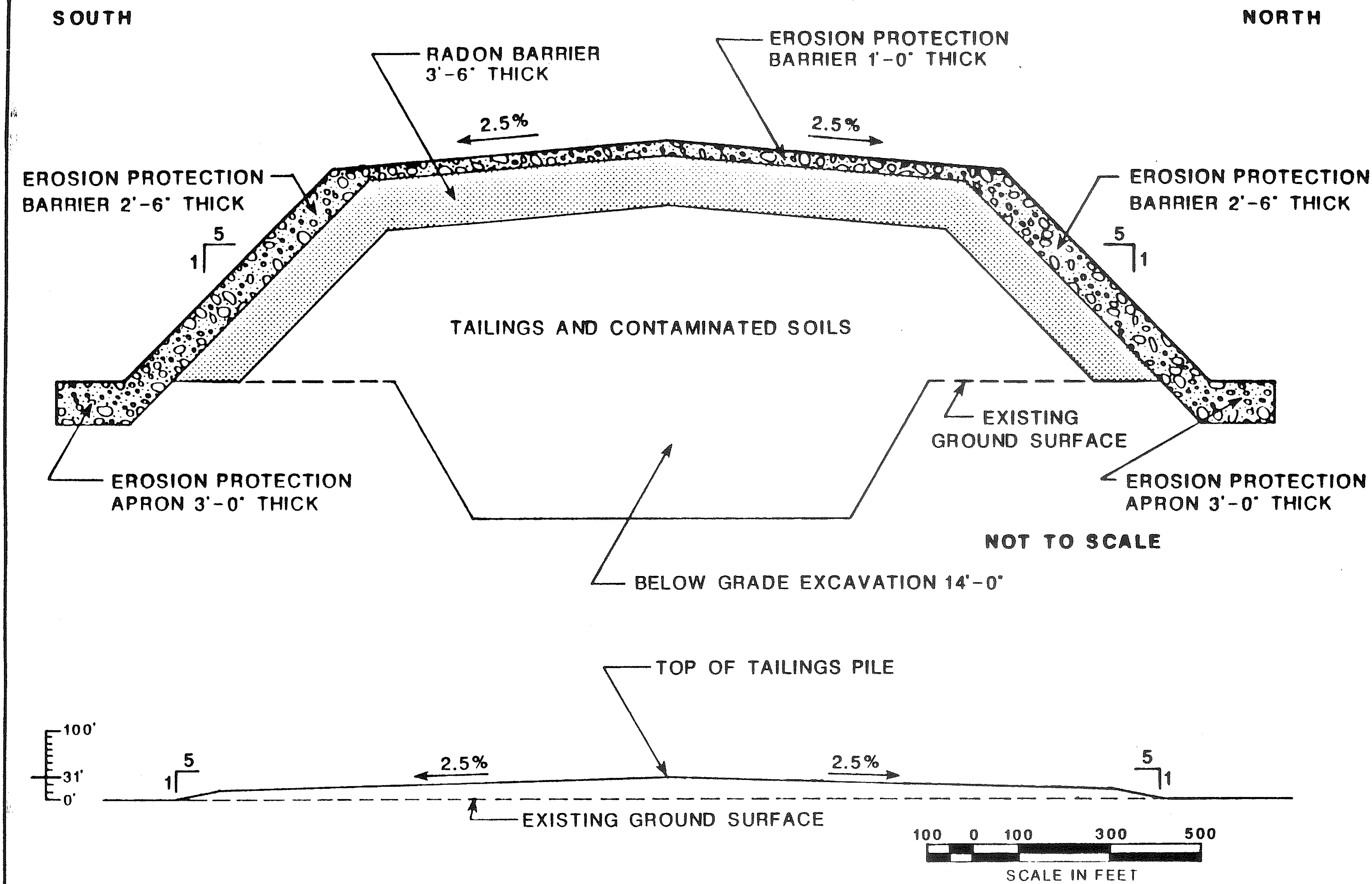
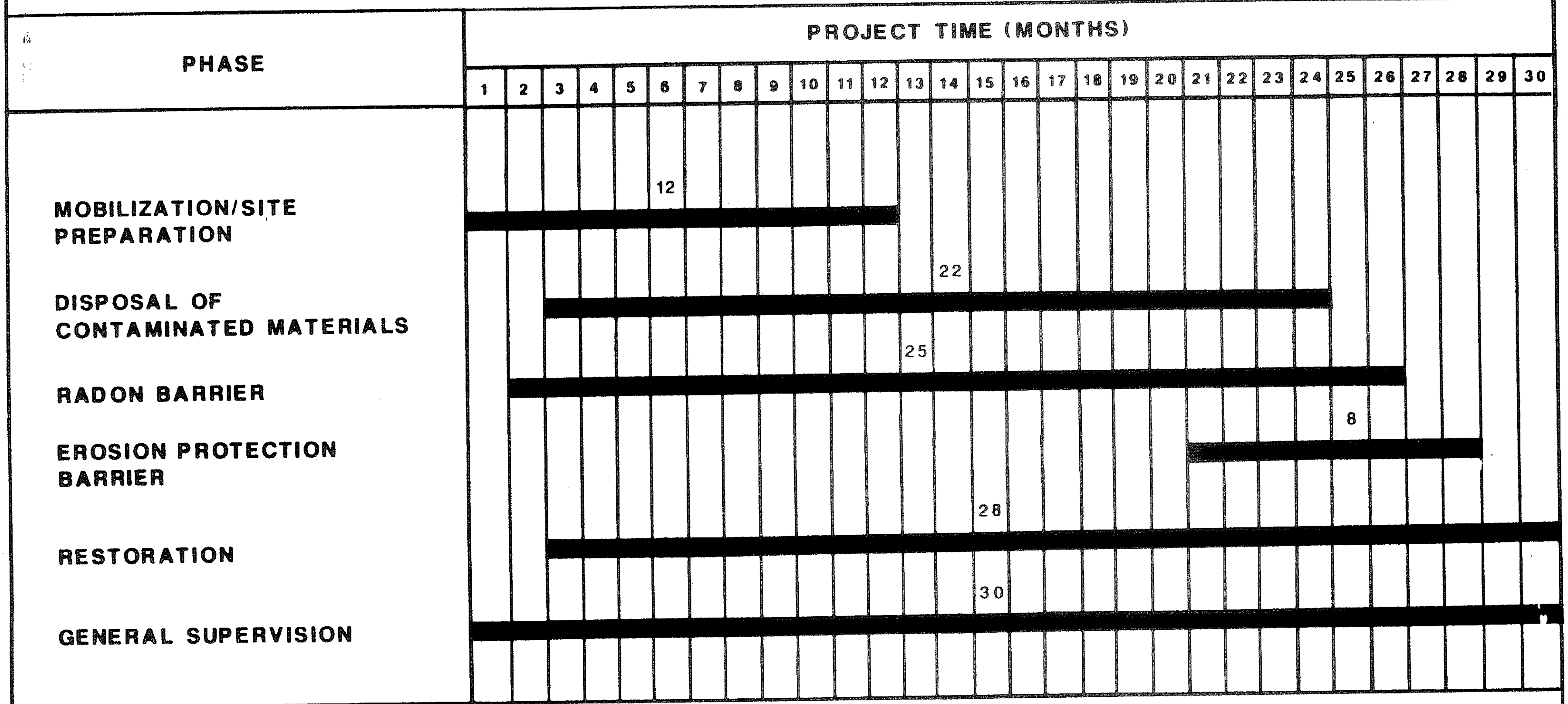


FIGURE A.3.3
SECTION 21 SITE, TYPICAL CROSS SECTION

FIGURE A.3.4 REMEDIAL ACTION SCHEDULE: DISPOSAL AT THE SECTION 21 SITE



- Approximately 4.6 million cubic yards of tailings and contaminated materials would be relocated.

- Requirements for the radon and erosion protection barriers and the erosion protection apron would be the same as for stabilization in place.

- All earthen materials for the radon and erosion protection barriers would be obtained from excavation of the partially below-grade disposal area.

- The remedial action would be conducted in 8-hour days, five days per week over 30 months (19.25 days per month).

Most of the concept considerations for disposal at the Section 21 site (e.g., radon control, wind and water erosion, flood protection and geomorphology, ground-water protection) were the same as or very similar to those for the proposed action (see Section A.2.4). The major differences between the concept considerations for the proposed action and this alternative are discussed below.

Long-term stability

Slope stability and seismic risk. Consolidation of all of the tailings and contaminated soils would tend to more evenly distribute the slimes and sand-slime mixtures contained in the tailings. This would result in a stabilized tailings pile at or near optimum moisture content, greatly reducing the potential for slope failure under static or seismic loading conditions.

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APPENDIX B

WATER

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B.1 SURFACE WATER

B.1.1 INTRODUCTION

The following sections address surface-water conditions at the Ambrosia Lake tailings and borrow sites. A general description of the watershed and surface-water occurrences is included for each site, along with analyses of flood potential and surface-water quality.

B.1.2 SURFACE-WATER FEATURES

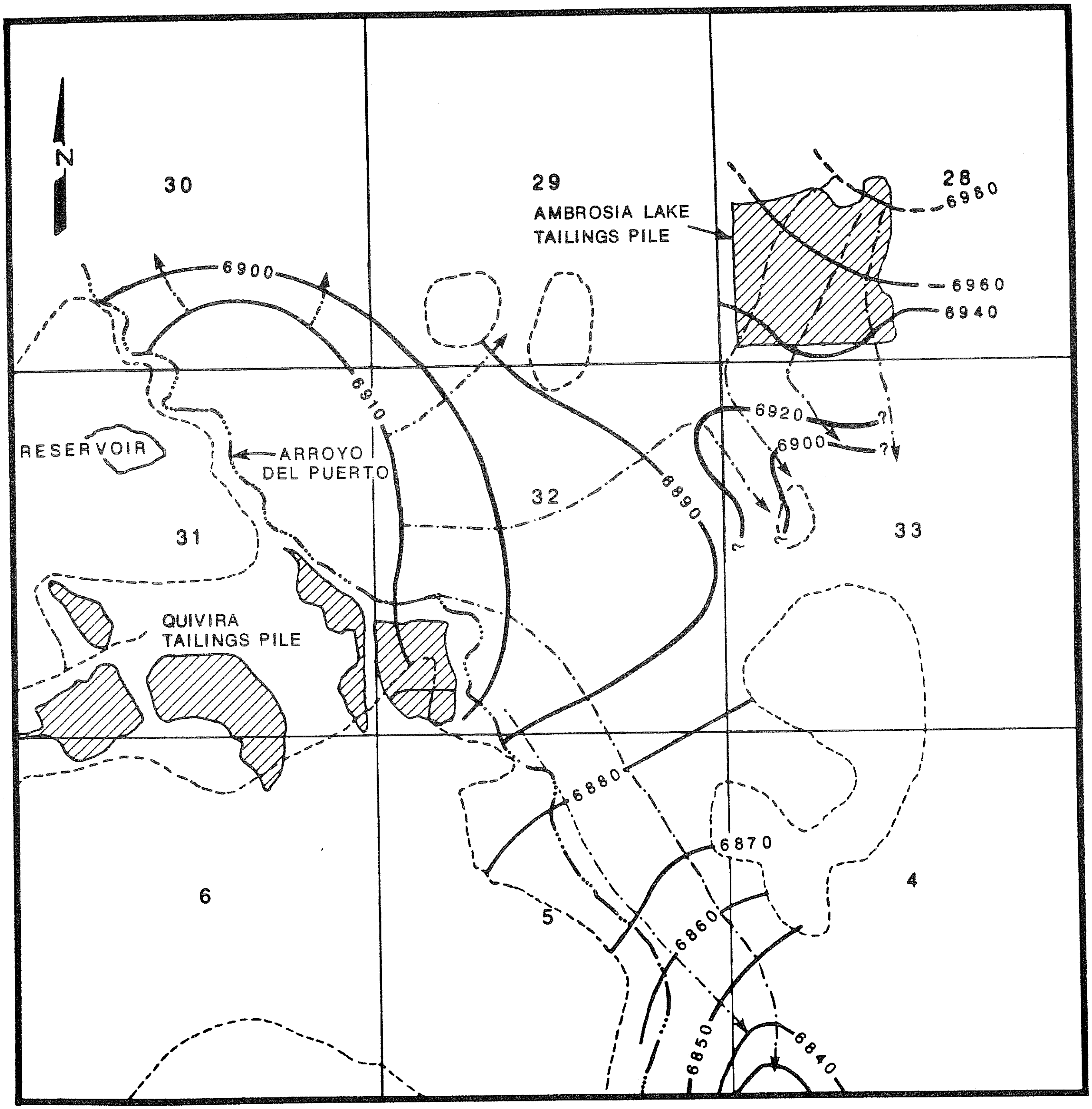
B.1.2.1 <u>Ambrosia Lake tailings site</u>

The Ambrosia Lake tailings site lies in the drainage basin of Arroyo del Puerto, an intermittent tributary of San Mateo Creek (see Figure 3.2). The Arroyo del Puerto is a southeast-trending channel and runs within one mile of the site. Perennial flow had been sustained in the arroyo from the late 1950s until 1980 by mine water discharge (Brod and Stone, 1981) although the arroyo has since reverted to an intermittent stream due to a reduction in mining activity.

Flow in the Arroyo del Puerto is a line source of recharge to the alluvium along its course (Figure B.1.1). The saturated alluvium does not extend to the Ambrosia Lake tailings site; however, saturation of the alluvium is localized and distinct from the saturated alluvium along Arroyo del Puerto. There are no existing pathways for contaminants to move from the tailings site to the Arroyo del Puerto.

Two unnamed drainage channels originate on the west (north ephemeral stream) and east (east ephemeral stream) flanks of Roman Hill (Figure B.1.2; also see Figure 3.2). The north channel drains an area of approximately 1550 acres with slopes ranging from 11.5 percent in the upper portion to 1.9 percent in the last two miles of flow. This drainage terminates in a broad, gently sloping area north of the existing tailings and shows no indication of draining to the Arroyo del Puerto. The north drainage can flow up against the north side of the existing tailings pile (FBDU, 1981). However, no well-defined channels exist within 0.5 mile of the tailings.

The east channel drains approximately 450 acres and has an average slope of 4.4 percent (Figure B.1.2). Its flow is intercepted just east of the Ambrosia Lake site and is diverted into Voght tank, a stock watering pond. Overflow from the Voght tank enters a drainage channel which discharges into the Arroyo del Puerto approximately 2.5 miles south of the Ambrosia Lake tailings site.



LEGEND

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—6890— CONTOUR SHOWING WATER TABLE ELEVATION IN QUATERNARY ALLUVIUM/ WEATHERED MANCOS SHALE (? WHERE ESTIMATED) MODIFIED FROM GANUS, 1980

ARROYO DEL PUERTO

ALLUVIUM/ WEATHERED MANCOS SHALE (SANTOS AND THADEN, 1966)

GROUND-WATER FLOW LINES IN QUATERNARY ALLUVIUM

TAILINGS PILE

FIGURE B.1.1 ARROYO DEL PUERTO DRAINAGE BASIN NEAR THE AMBROSIA LAKE TAILINGS SITE

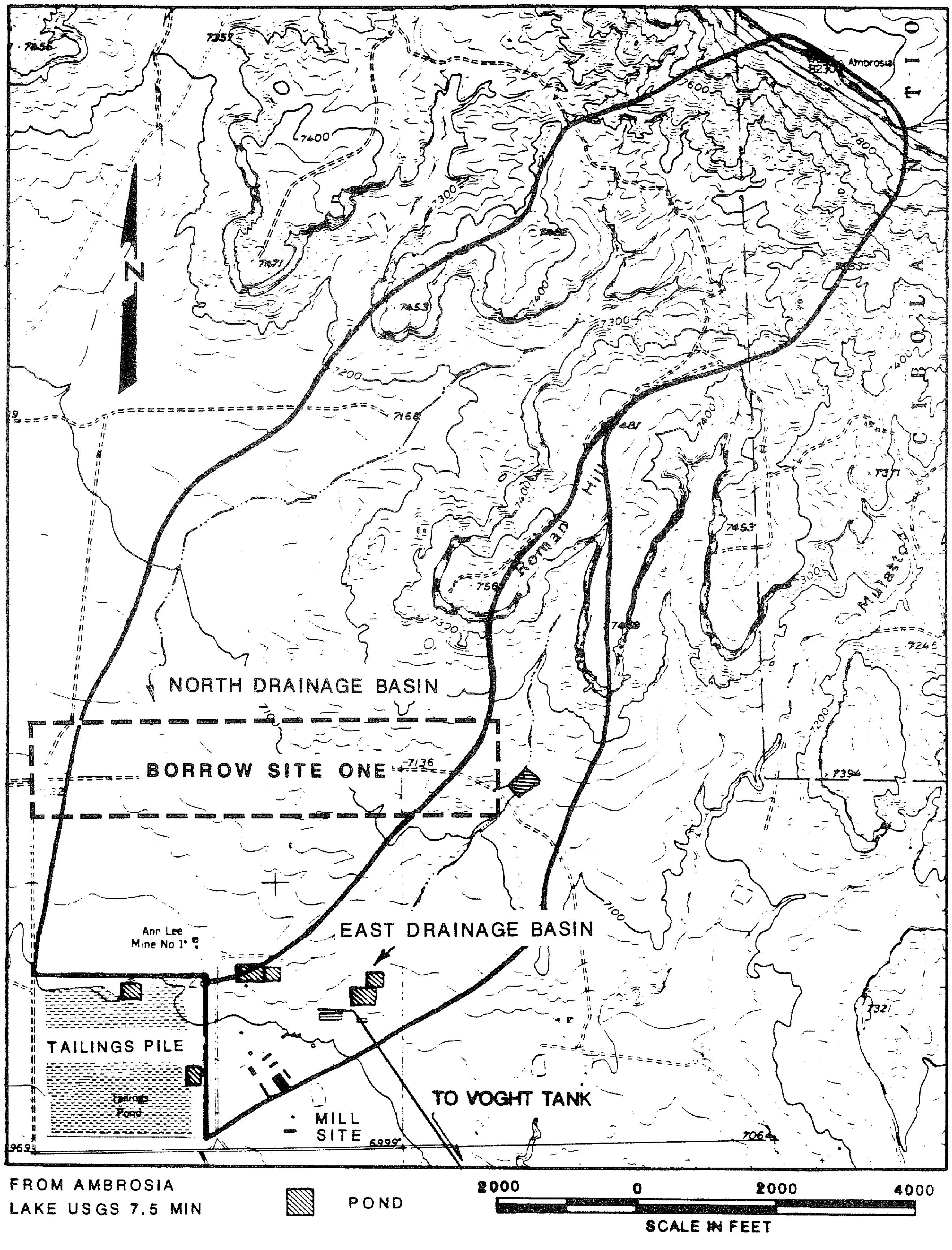


FIGURE B.1.2 EXISTING DRAINAGE BASINS, BORROW SITE ONE

Prior to construction of the Ambrosia Lake facility, the north and east drainages met in Section 28 and drained into the Arroyo del Puerto approximately one mile south of the site (DOI, 1978). No historical flow data exist for either drainage.

B.1.2.2 Borrow sites

Borrow site 1 is located on top of a low ridge which separates the north and east drainages above the Ambrosia Lake site (Figure B.1.2). No established channels originate in, or pass through, the borrow site; drainage is generally to the southwest. The drainage area above the borrow site is less than 200 acres.

Borrow site 2 is located on a north-facing slope of the La Jara Mesa and drains into San Mateo Creek through a series of small unnamed intermittent stream channels. The size of the drainage area above borrow site 2 is dependent upon the exact location of the site. The drainage area would be less than 100 acres due to the numerous arroyos which would intercept the flow.

B.1.3 FLOOD ANALYSIS

B.1.3.1 Ambrosia Lake tailings site

Possible flood events at Arroyo del Puerto and the two drainage basins were analyzed regarding possible impacts on the stabilized tailings pile. Since a stream-gauging station is not maintained near the site, the Probable Maximum Flood (PMF) study performed for the Arroyo del Puerto as part of the Kerr-McGee mill licensing process and verified by the New Mexico State Engineer's Office (Schwebke, 1985) was used. This study indicated that a six-hour Probable Maximum Precipitation (PMP) would generate a PMF which would reach an elevation of 6926.3 feet at a location some 4000 feet southwest of the site. This elevation is approximately 43 feet below the base of the tailings pile and, therefore, flooding of Arroyo del Puerto would not impact the pile.

In addition, PMF data were generated for both the north and east drainages above the tailings pile. These data came from Hydrometeorological Report (HMR) Number 55 (DOC, 1977), and were analyzed with the Hydrology Engineering Center HEC-1 computer modeling program (COE, 1981) to predict flow rates. Flow rates were then used to generate flow velocities and depths at various design points around the tailings pile. This information was used to determine rock size, layer thickness, and amounts of rock to be used in the final design. These methods and results are discussed in depth in Appendix B, Engineering Design, of the Remedial Action Plan (DOE, 1985).

B.1.3.2 Borrow sites

Flooding is not considered to be a hazard at either of the borrow sites. This is due to the small drainage areas and long distances from perennial streams.

B.1.4 SURFACE-WATER QUALITY

Water quality was analyzed from nine locations near the Ambrosia Lake tailings site, and along San Mateo Creek and Arroyo del Puerto (FBDU, 1983; NMEID, 1980; Gallaher and Goad, 1981) (Figure B.1.3). Thirty constituents were analyzed from samples near the tailings pile, Arroyo del Puerto, and San Mateo Creek (Table B.1.1) and a second set of eight constituents was sampled from the Arroyo del Puerto and San Mateo Creek (Table B.1.2). Differences in water chemistry between San Mateo Creek and Arroyo del Puerto are shown on a trilinear diagram (Figure B.1.4). Arroyo del Puerto and downstream sections of the San Mateo Creek are affected by seepage from the Quivira Mine tailings ponds and mine water discharges from the Ambrosia Lake area as evidenced by high calcium and sulfate content in surface waters (Table B.1.1). Because flow in Arroyo del Puerto is sustained almost entirely by ground-water discharge from mines, definition of surface-water quality is not applicable to the Arroyo del Puerto.

Surface water that could be potentially affected by contamination from the Ambrosia Lake tailings site, only occurs occasionally as ponded runoff during excessive precipitation events. There was no ponded water near the site to be sampled during the October, 1985, investigation. A sample (665) from the surface pond on the tailings was collected in May, 1986. Chemical analyses of this sample are presented in Table B.1.1.

Samples 604, 605, and 606 were collected from intermittent surface-water ponds at the Ambrosia Lake tailings site, which are presently dry. At the time of sampling (1981), localized ponded water at the site contained levels of arsenic, iron, selenium, and, in one case, cadmium, which exceeded state or Federal water-quality standards (Table B.1.3).

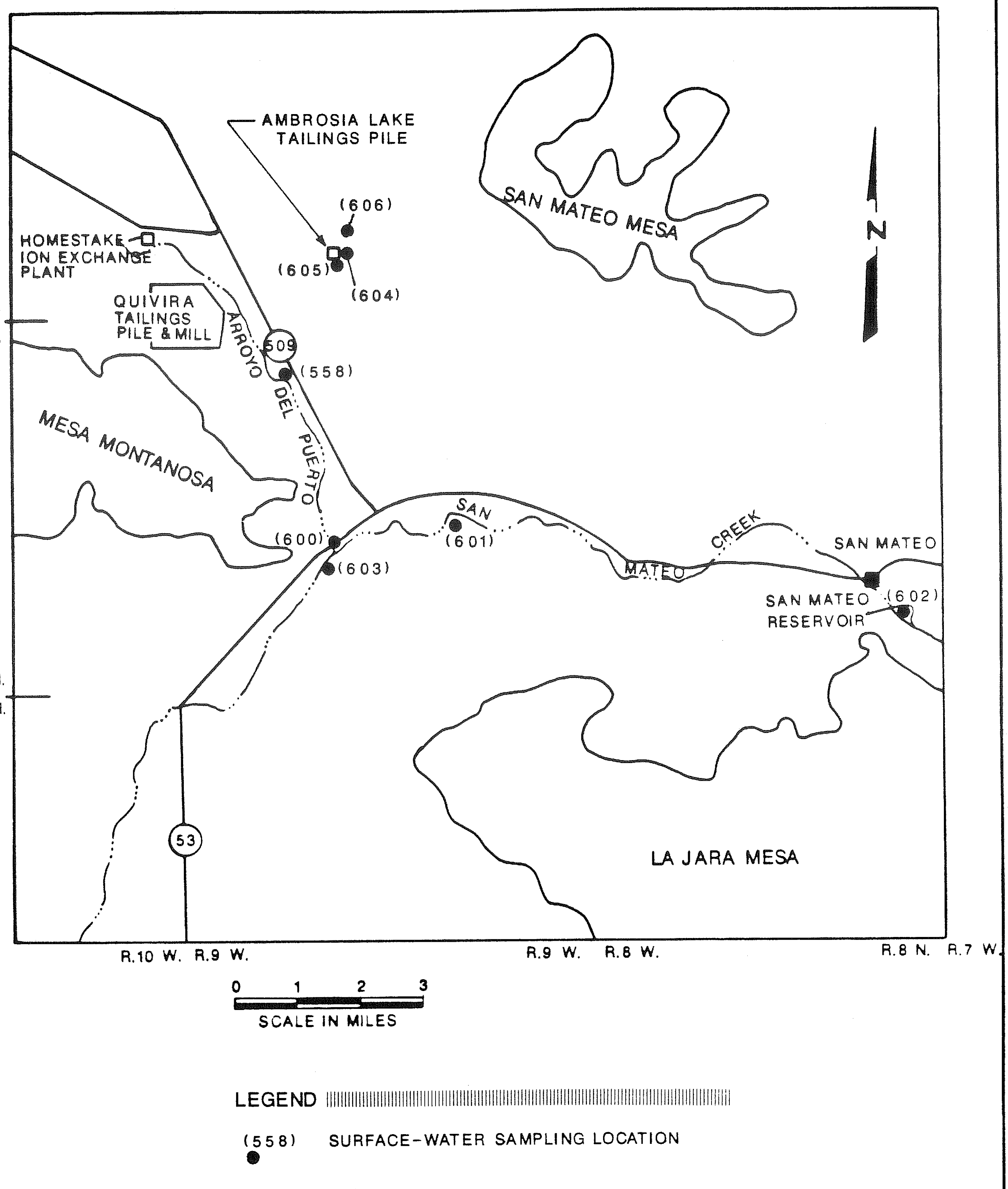


FIGURE B.1.3 APPROXIMATE LOCATIONS OF SURFACE-WATER SAMPLING SITES

Table B.1.1 Surface-water quality data from the Ambrosia Lake area

PARAMETER	UNIT OF MEASURE[a]	LOCATION ID - SAMPLE ID AND LOG DATE: 558-01[b] 09/01/83 PARAMETER VALUE+/-UNCERTAINTY	600-01 03/05/80 PARAMETER VALUE+/-UNCERTAINTY	601-01 06/24/81 PARAMETER VALUE+/-UNCERTAINTY	602-01 04/02/81 PARAMETER VALUE+/-UNCERTAINTY	603-01 08/03/82 PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	-[c]	84.00	82.00	32.00	41.00
ALUMINUM	MG/L	-	-	-	-	-
ARSENIC	MG/L	-	0.005	0.009	0.005	0.005
BARIUM	MG/L	0.018	0.479	0.10	0.10	0.20
BICARBONATE	MG/L	-	205.00	200.00	78.00	100.00
BORON	MG/L	-	-	-	-	-
CADMIUM	MG/L	-	0.001	0.001	0.001	0.001
CALCIUM	MG/L	156.00	186.40	50.80	12.80	22.30
CHLORIDE	MG/L	173.00	144.00	22.00	3.00	12.00
CHROMIUM	MG/L	-	-	-	-	-
COBALT	MG/L	0.02	-	-	-	-
CONDUCTANCE	UMHO/CM	1850.00	2327.00	747.00	140.00	-
FLUORIDE	MG/L	-	-	-	-	-
IRON	MG/L	0.06	-	-	-	-
LEAD	MG/L	-	0.005	0.005	0.005	0.006
MAGNESIUM	MG/L	71.00	67.50	13.90	3.60	4.80
MANGANESE	MG/L	0.01	-	-	-	-
MOLYBDENUM	MG/L	0.60	0.976	0.328	0.005	0.067
NICKEL	MG/L	0.02	-	-	-	-
NITRATE	MG/L	-	-	-	-	-
PH	SU	7.50	8.20	7.80	8.30	7.40
POTASSIUM	MG/L	11.00	14.00	3.90	3.90	9.00
SELENIUM	MG/L	0.64	0.425	0.032	0.005	0.011
SILCON	MG/L	3.30	-	-	-	-
SODIUM	MG/L	260.00	255.30	112.70	9.20	69.80
STRONTIUM	MG/L	4.15	-	-	-	-
SULFATE	MG/L	860.00	862.00	213.00	6.00	104.70
TEMPERATURE	C - DEGREE	-	-	23.50	12.00	-
TOTAL SOLIDS	MG/L	-	1794.00	528.00	111.00	-
U-234	PCI/L	-	2.275	1.10	0.006	0.10
URANIUM	MG/L	1.44	-	-	-	-
VANADIUM	MG/L	0.20	0.029	0.024	0.005	0.01
ZINC	MG/L	-	0.25	0.10	0.10	0.05

Table B.1.1 Surface-water quality data from the Ambrosia Lake area (Concluded)

		LOCATION ID - SAMPLE ID AND LOG DATE				
		604-01 08/01/81	605-01 08/01/81	606-01 08/01/81	665-S1[d] 05/14/86	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	-	-	-	2441.	
ALUMINUM	MG/L	-		-	-	
ARSENIC	MG/L	0.11	0.15	0.152	< 0.01	
BARIUM	MG/L	0.61	0.04	0.078	-	
BICARBONATE	MG/L	-	-	-	-	
BORON	MG/L	-	-	-	0.2	
CADMIUM	MG/L	0.047	< 0.001	< 0.001	< 0.001	
CALCIUM	MG/L	-	-	-	21.	
CHLORIDE	MG/L	-	-	-	220.	
CHROMIUM	MG/L	0.034	0.025	< 0.001	0.04	
COBALT	MG/L	-	-	-	0.13	
CONDUCTANCE	UMHO/CM	-	-	-	13000.	
FLUORIDE	MG/L	-	-	-	16.	
IRON	MG/L	11.60	1.03	0.30	7.09	
LEAD	MG/L	0.006	0.10	0.12	-	
MAGNESIUM	MG/L	-	-	-	7.95	
MANGANESE	MG/L	-	-	-	0.1	
MOLYBDENUM	MG/L	-	-	-	101.	
NICKEL	MG/L	-	-	-	-	
NITRATE	MG/L	-	-	-	< 1.	
PH	SU	-	-	-	9.81	
POTASSIUM	MG/L	-	-	-	47.8	
SELENIUM	MG/L	0.0457	0.56	0.66	< 0.005	
SILCON	MG/L	-	-	-	-	
SODIUM	MG/L	-	-	-	4390.	
STRONTIUM	MG/L	-	-	-	0.1	
SULFATE	MG/L	-	-	-	6720.	
TEMPERATURE	C - DEGREE	-	-	-	25.	
TOTAL SOLIDS	MG/L	-	-	-	12700.	
U-234	PCI/L	-	-	-	-	
URANIUM	MG/L	-	-	-	88.5	
VANADIUM	MG/L	< 0.01	0.25	0.18	1.91	
ZINC	MG/L	-	-	-	-	

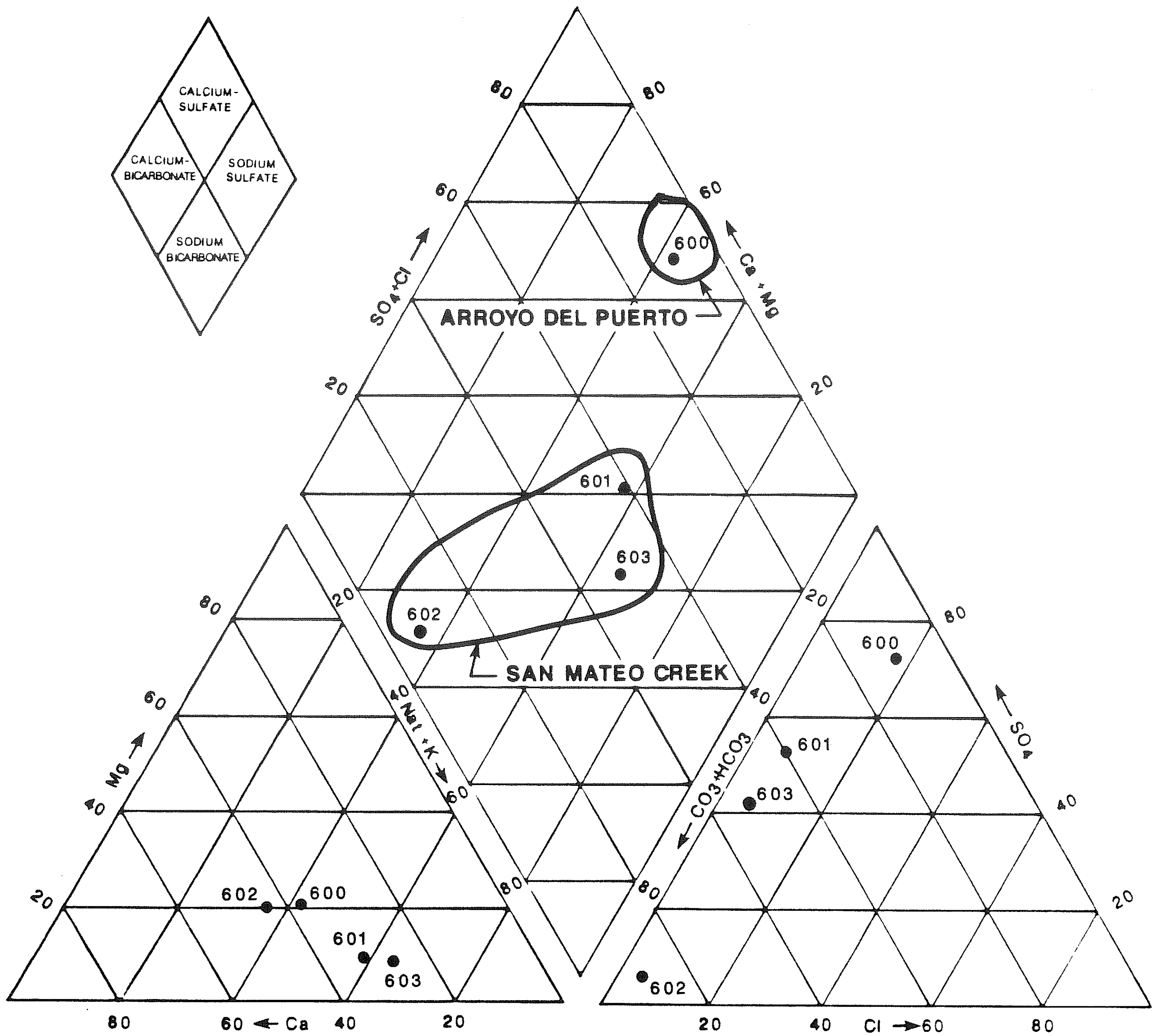
[a]mg/l = milligrams per liter; micromho/cm = micromho per centimeter; SU = standard unit; pCi/l = picocurie per liter.
[b]Water sampling locations shown on Figure B.1.3.
[c]Dashed line indicates water-quality constituent was not analyzed.
[d]Pond water sample (Figure B.2.14).
Ref. FBDU, 1981; NMEID, 1980.

Table B.1.2 Surface-water quality at Ambrosia Lake monitoring stations at Arroyo del Puerto (station 600) and San Mateo Creek (stations 601 and 603)[a]

Constituent	Unit of measure[b]	Surface-water quality: Background station (601) Minimum	Background station (601) Maximum	Downstream stations (603) Minimum	Downstream stations (603) Maximum	Downstream stations (600) Minimum	Downstream stations (600) Maximum
Gross alpha	pCi/l	0.0 ± 2.5	3.0 ± 0.7	250 ± 40	740 ± 40	310 ± 40	1410 ± 60
Radium-226	pCi/l	<0.04	0.43 ± 0.1	1.06 ± 0.02	3.7 ± 0.2	1.7 ± 0.1	7.5 ± 0.1
Molybdenum	mg/l	<0.005	<0.01	0.02	0.45	0.45	1.0
Selenium	mg/l	<0.005	0.006	0.02	0.04	0.07	0.45
Uranium-natural	mg/l	<0.005	0.02	0.58	1.1	1.2	2.3
Sulfate	mg/l	5	20	230	550	350	950
Chloride	mg/l	3	8	13	20	70	165
Total dissolved solids	mg/l	125	300	600	970	800	1860

[a]Sampled during the time period April, 1978, to October, 1980.
[b]pCi/l = picocuries per liter; mg/l = milligrams per liter.

Ref. Gallaher and Goad, 1981.



● SURFACE-WATER SAMPLE

FIGURE B.1.4 TRILINEAR DIAGRAM OF SURFACE-WATER SAMPLES FROM SAN MATEO CREEK AND ARROYO DEL PUERTO

Table B.1.3 State and Federal ground-water standards

Constituent	Units of measure[a]	Federal drinking water standards	State of New Mexico WQCC ground-water standard
Arsenic	mg/l	0.05[b]	0.10[c]
Barium	mg/l	1.0[b]	1.0[c]
Cadmium	mg/l	0.01[b]	0.01[c]
Chromium	mg/l	0.05[b]	0.05[c]
Cyanide	mg/l	0.05	0.20[c]
Fluoride	mg/l	1.40-2.40[b]	1.60[c]
Lead	mg/l	0.05[b]	0.05[c]
Mercury	mg/l	0.002[b]	0.002[c]
Nitrate	mg/l	10.0[b]	10.0[c]
Selenium	mg/l	0.01[b]	0.05[c]
Silver	mg/l	0.05[b]	0.05[c]
Uranium	mg/l	-	5.00[c]
Radium-226 + Radium-228	pCi/l	5.0[d]	30.0[c]
Gross alpha	pCi/l	15.0[d]	-
Chloride	mg/l	250.0[e]	250.0[f]
Copper	mg/l	1.00[e]	1.00[f]
Iron	mg/l	0.30[e]	1.00[f]
Manganese	mg/l	0.05[e]	0.20[f]
Sulfate	mg/l	250.0[e]	600.0[f]
Total dissolved solids	mg/l	500.0[e]	1000.0[f]
Zinc	mg/l	5.0[e]	10.0[f]
pH	S.U.	6.5-8.5 S.U.[e]	6.0-9.0[f]
Aluminum	mg/l	-	5.0[g]
Boron	mg/l	-	0.75[g]
Cobalt	mg/l	-	0.05[g]
Molybdenum	mg/l	-	1.00[g]
Nickel	mg/l	-	0.20[g]

[a]mg/l - milligrams per liter; pCi/l - picocuries/liter; S.U. - Standard Units.
[b]Primary drinking water standards.
[c]Human health standards.
[d]Standards for management of uranium by-product materials.
[e]Secondary drinking water standards.
[f]Other standards for domestic water supply.
[g]Standards for irrigation use.

Ref. EPA, 1985; WQCC, 1986; EPA, 1983.

B.2 GROUND WATER

B.2.1 INTRODUCTION

The Ambrosia Lake mining and milling district has been receiving uranium industry effluents since the early 1950s from many different mines and several processing sites. Effluents which have migrated in shallow ground-water systems in this area include not only mill process effluents (tailings seepage) but also mine dewatering and ion exchange effluents and nonpoint source effluents such as precipitation runoff from ore piles, haulage roads, and mill yards.

The purposes of the hydrologic investigations conducted at the Ambrosia Lake tailings site (also known as the Phillips-United Nuclear site) are to characterize the local hydrogeological regime and to assess ground-water impacts from the site in relation to and distinct from other possible local contaminant sources. Hydrological data will be used in the design of the remedial action plan for evaluating the present impacts of tailings seepage upon present and projected ground-water uses, for evaluating the feasibility and cost/benefit of aquifer protection/restoration, and for prediction of future impacts following remedial action. The investigation is guided by relevant Federal and State of New Mexico regulations.

Relevant state and Federal water-quality criteria

The State of New Mexico has made provisions for assessing "existing" ground-water quality in ground-water discharge plans submitted by the active mills in Ambrosia Lake. The State of New Mexico Water Quality Control Commission (WQCC) Regulations (WQCC, 1986), state that "if the existing concentration of any water contaminant in ground water is in conformance with the ground-water standards (Section 3-103, WQCC Regulations), degradation of the ground water up to the limit of the standard will be allowed" (Table B.1.3, column 2) (WQCC, 1986). In the case where "the existing concentration of any water contaminant in ground water exceeds the standard of Section 3-103, no degradation of the ground water beyond the existing concentration will be allowed" (WQCC, 1986). The WQCC numerical ground-water standards are established at the point of present or foreseeable ground-water use (Bostick, 1986).

The U.S. Environmental Protection Agency (EPA) standards (40 CFR Part 192) require characterization of the hydrogeologic regime at and around each Uranium Mill Tailings Remedial Action (UMTRA) Project site. These regulations state that "judgements on the possible need for remedial or protective actions for ground-water aquifers should be guided by relevant considerations described in EPA's hazardous waste management system (47 FR 32274)." Based on these two sets of requirements, it has been determined that 14 primary items must be addressed during ground-water characterization at an UMTRA Project site (Brinkman et al., 1985). These items are as follows:

- Applicable water-quality standards.

- Characterization of the potentially affected hydrogeologic environment.
- Proximity of the site to surface water.
- Physical and chemical characterization of waste in terms of contaminant migration in ground water and hydraulically connected surface water.
- Effect of climate on the movement of contaminants.
- Impact of contaminant sources other than those attributable to the UMTRA Project site.
- Proximity, withdrawal rates, uses, and sources of presently used water.
- Present value of affected water resource.
- Availability of alternative water supplies.
- Potential and expected use of affected resource.
- Future value of affected water resource.
- Potential health risks to humans and potential damage to crops, vegetation, and wildlife caused by exposure to contaminants in ground or surface water.
- Persistence and permanence of adverse effects.
- Aquifer restoration or protection.

The EPA standards recognized that the inactive mill tailings sites were not regulated and were not originally designed to protect ground-water resources and that ground-water contamination may be extensive at such sites. EPA also recognized that once an aquifer becomes contaminated, it will remain polluted for a long period of time and it may be extremely difficult to restore the quality of the water in the aquifer (47 FR 32203). For these reasons, the EPA developed the inactive mill standards to allow decisions regarding the need for ground-water protection to be made based on such factors as technical feasibility of improving the aquifer in its hydrogeological setting, the present and future value of the aquifer as a water resource, the availability of alternative water supplies, and the degree to which human exposure is likely to occur. Thus, rather than establish specific numerical limitations for contaminant discharges or ground-water quality, the EPA determined that the most appropriate courses 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 and geochemical surveys at each site as a basis for determining whether specific water-protection measures should be applied.

On September 3, 1985, the United States Tenth Circuit Court of Appeals set aside the EPA standard applicable to the protection of waterways and ground water, 40 CFR Part 192.20(a)(2)-(3). The water protection standard was remanded to the EPA for further consideration in light of the court's opinion that the water standard promulgated by the EPA on March 7, 1983, was site specific rather than of general application as required by the legislation. The EPA has not identified a date for re-issuance of 40 CFR Part 192.20(a)(2)-(3), and it is anticipated that such re-issuance will not occur until after remedial action has been initiated at the Ambrosia Lake site.

When the EPA issues revisions to the water protection standards, the DOE will re-evaluate the ground-water issues at the Ambrosia Lake site to assure that the revised standards are met. Performing remedial action to stabilize the tailings prior to the EPA issuing new standards will not affect the measures that are ultimately required to meet the revised EPA water protection standards. The DOE has characterized conditions at the Ambrosia Lake site and does not anticipate that any substantial changes to the remedial action will be required. However, after the EPA re-issues the water protection standards, the DOE will determine the need for institutional controls, aquifer restoration, or other controls and take such appropriate action so as to comply with the re-issued standards.

The water quality standards applicable to affected or potentially affected ground-water systems at this site are contained in the National Primary and Secondary Drinking Water Regulations (Table B.1.3) for public water systems (EPA, 1982a,b). The primary regulations are for contaminants in drinking water that affect public health. The secondary regulations are for contaminants in drinking water that primarily affect aesthetic qualities relating to the public acceptance of drinking water (e.g., odor, color).

Summary of hydrogeological characterization, Ambrosia Lake site

This appendix addresses the hydrogeological and water resource characteristics of the Ambrosia Lake tailings site. Hydrological information available from other sites in the Ambrosia Lake valley is used to assess relative impacts from the Ambrosia Lake site.

The following paragraphs summarize the data, interpretation of analyses, and conclusions found in the remainder of this appendix. The remaining sections of Appendix B provide in detail the hydrogeological investigations conducted at the Ambrosia Lake field site. The methods for drilling and sampling monitor wells are outlined in the Jacobs Engineering Standard Operations Procedures Manual which is available in the UMTRA Project Office, Albuquerque, New Mexico.

It has been documented (Cravens and Hammock, 1958) from water-level measurements that the alluvium/weathered Mancos Shale at the Ambrosia Lake tailings site is not a continuously saturated aquifer. Furthermore, the ground water perched within the alluvium/weathered Mancos Shale and the Tres Hermanos-C Sandstone at the site has been the result of recharge induced by the local uranium industry. This artificially created and limited zone of saturation is not a present or foreseeable future ground-water resource.

In a previous ground-water discharge permit assessment for the Quivira mill located 2.5 miles southwest of the Ambrosia Lake site (Bostick, 1985), the State of New Mexico included the Tres Hermanos-A, -B, and -C Sandstones as water-bearing in the vicinity of the Quivira site. In addition, the conclusion of the Quivira Mining Company (QMC) discharge permit states that when these units (the Tres Hermanos Sandstones) become repressurized, they will contain water within limits of quality standards. This permit was approved by the New Mexico Environmental Improvement Division (NMEID) (Bostick, 1985). According to the New Mexico WQCC Regulations (WQCC, 1986), the Tres Hermanos-C Sandstone is the "point of present or foreseeable future ground-water use where numerical ground-water standards must apply." At the site, background water quality can be considered as present water quality because the Tres Hermanos-C Sandstone probably was unsaturated prior to mining and milling (Bostick, 1986; WQCC, 1986).

The potentially affected hydrostratigraphic formations beneath the Ambrosia Lake site, in descending order, are the alluvium/weathered Mancos Shale, the Tres Hermanos-C, -B, and -A Sandstones, the Dakota Sandstone, the Westwater Canyon Member of the Morrison Formation, the Bluff Sandstone, and the Todilto Limestone. The Tres Hermanos-A, -B, and -C Sandstones are separated by a relatively low permeability Mancos Shale. The Dakota Sandstone, the Bluff Sandstone, and the Todilto Limestone should not be impacted by the Ambrosia Lake site, because they are separated from the principal pathway of contaminant migration by at least 50 feet of aquitard including the Mancos Shale and the Recapture Member of the Morrison Formation.

The most likely flow path for contaminated ground water resulting from past or present seepage from the Ambrosia Lake site is:

- Seepage percolating into the alluvium/weathered Mancos Shale.
- Contaminated ground water moving to the southwest (downgradient) in the alluvium/weathered Mancos Shale.
- The water in the alluvium/weathered Mancos Shale encountering the subcrop of the Tres Hermanos-C Sandstone and flowing in this sandstone to the northeast (downgradient).
- The ground water in the Tres Hermanos-C Sandstone discharging to mine shafts (the Ann Lee Mine) and eventually entering the Westwater Canyon Member.
- The ground water in the Westwater Canyon Member continuing to move to the northeast (downgradient).

Contamination of the Westwater Canyon Member is of greater concern than contamination of the alluvium/weathered Mancos Shale and the Tres Hermanos-C Sandstone, because the Westwater Canyon Member is an aquifer while the other two formations are not aquifers. All known water supply wells in the Ambrosia Lake Valley are completed in the Westwater Canyon

Member or deeper formations except for a few wells completed in the San Mateo Creek alluvium. Locally, the saturation in the alluvium/weathered Mancos Shale and Tres Hermanos-C Sandstone is caused by mine water discharge, is of limited areal extent, and generally is water of relatively poor quality. Regionally, the Tres Hermanos-C Sandstone is a thin, low-yielding, often shalely sandstone and historically and presently has no known use.

Three sets of water samples representing tailings pore water, alluvium/weathered Mancos Shale ground water, and Tres Hermanos-C Sandstone ground water were collected. General observations regarding the nature and extent of ground-water contamination are:

- o The shapes of the contaminant plumes support the concept of the ground-water flow regime. Regionally, prior to mining and milling at the site, the alluvium and Tres Hermanos-C Sandstone were probably unsaturated. Locally, the alluvium/weathered Mancos Shale is saturated beneath the site because of local recharge conditions from tailings seepage.

- o The pH decreases from alkaline to neutral as ground water moves downgradient; an alkaline leach process was used at the mill for uranium extraction.

- o Indicators of tailings seepage include anomalously high concentrations of fluoride, molybdenum, nitrate, manganese, cobalt, iron, selenium, chromium, radium, sulfate, uranium, and total dissolved solids.

- o Chemical species derived from tailings seepage found in the alluvium/weathered Mancos Shale are arsenic, chloride, cobalt, fluoride, gross alpha activity, nitrate, uranium, molybdenum, radium, sulfate, and total dissolved solids. Also, higher concentrations of boron, iron, manganese, and selenium are observed in the alluvium/weathered Mancos Shale than in the tailings. Water quality should not further degrade because steady state conditions are established in the alluvium and Tres Hermanos-C Sandstone.

- o Ground-water samples collected from the Tres Hermanos-C Sandstone show variable concentrations of boron, chloride, cobalt, chromium, fluoride, gross alpha activity, iron, nitrate, pH, radium, selenium, uranium, manganese, molybdenum, sulfate, and total dissolved solids that exceed Federal and New Mexico WQCC standards.

The migration of tailings seepage through the alluvium/weathered Mancos Shale and the Tres Hermanos-C Sandstone into the Westwater Canyon Member was simulated using field-determined and literature values of hydraulic parameters and contaminant concentrations of sulfate. Sulfate was selected as the key indicator of contamination because it generally moves conservatively with ground water. The simulation was evaluated with a sensitivity analysis to account for any hydrogeological uncertainties. The results of the analysis considering the most realistic case indicated that:

- Contamination in the Tres Hermanos-C Sandstone beneath the tailings pile would reach the inactive Ann Lee Mine and the Westwater Canyon Member aquifer in seven years. The Westwater Canyon Member was the major ore-producing zone in the Ambrosia Lake mining district. The Ambrosia Lake mill obtained its water from this formation.

- Sulfate concentrations in the Tres Hermanos-C Sandstone at the Ann Lee Mine would again reach "background" levels within 22 years following remedial action.

- The extent of contamination, where sulfate concentrations would reach 250 mg/l, in the Westwater Canyon Member would extend 400 feet northeast from the Ann Lee Mine. No impacts to ground-water quality are predicted beyond 400 feet from the mine shaft.

- The development of the plume in the Westwater Canyon Member (out to 400 feet) will take an estimated 120 years.

- The contamination in the Westwater Canyon Member would persist for 100 years.

B.2.2 HYDROSTRATIGRAPHY

The following hydrostratigraphic units listed in descending stratigraphic order are potential aquifers in the site vicinity: alluvium (Quaternary)/weathered Mancos Shale (Cretaceous), Tres Hermanos Sandstones of the lower Mancos Shale (Cretaceous), the Dakota Sandstone (Cretaceous), and the Westwater Canyon Member of the Morrison Formation (Jurassic). The Tres Hermanos Sandstones consist of three coarsening upward units; in ascending order, they are the Tres Hermanos-A, -B, and -C Sandstones. Each of these units grade into Mancos Shale toward the base. Deeper aquifers (greater than 800 feet deep) include the Bluff Sandstone and Todilto Limestone. These units are beyond the influence of local uranium mining disturbance because the 150 feet of shale, siltstone, and sandstone of the Recapture Member of the Morrision Formation separate the deeper units from the overlying disturbed units.

The hydrostratigraphic units impacted by seepage migration from the Ambrosia Lake tailings pile are the alluvium/weathered Mancos Shale, and Tres Hermanos-C Sandstone, which in this report will be split into the -C1 and -C2 units where appropriate. The -C1 and -C2 units are separated by a layer of Mancos Shale 10 to 15 feet thick. The Tres Hermanos-A, -B, and -C Sandstones, Dakota Sandstone, and Westwater Canyon Member have been extensively dewatered and ground-water quality within these formations also has been impacted from mining activities throughout the Ambrosia Lake mining district. However, hydrostratigraphic units beneath the Tres Hermanos-C Sandstone are not impacted by seepage from the Ambrosia Lake tailings site because they lie beneath various tongues of the lower Mancos Shale. These tongues include up to 130 feet of shale having extremely low permeability. The Mancos Shale is an aquitard (Brod, 1979). Thomson and Heggen (1981) considered the Mancos Shale a potential pond liner due to its low permeability and its high ion exchange capacity. They state "the low permeability of this strata is important in preventing contamination of deeper, confined aquifers." The Westwater Canyon Member is overlain by approximately 120 feet of green-gray shale of the Brushy Basin Member of the Morrison Formation.

The principal bedrock aquifer in the Ambrosia Lake mining district is the Westwater Canyon Member; it has been extensively mined for uranium ore, which has resulted in aquifer dewatering. The Dakota Sandstone is a secondary aquifer, approximately 75 feet thick, yielding less than 10 gallons per minute (gpm). The water quality is inferior to the Westwater Canyon Member, because it contains higher concentrations of sodium, bicarbonate, sulfate, and total dissolved solids (TDS) (600 to 1400 milligrams per liter) (Brod and Stone, 1981).

The locations of the monitor wells and cross sections for the Ambrosia Lake pile are shown on Figure B.2.1. Hydrogeological cross sections from beneath the Ambrosia Lake site were developed from lithologic logs, borehole geophysical logs, and core samples obtained during the installation of monitor wells (Figures B.2.2 through B.2.5). Cross sections A-A' and B-B' are oriented southwest to northeast across the pile, running parallel to the topographic slope (Figures B.2.2 and B.2.3). Cross sections C-C' and D-D' trend from the north-northwest to the south-southeast across the pile (Figures B.2.4 and B.2.5).

The tailings pile is underlain by clayey alluvium/weathered Mancos Shale, which varies in thickness from several feet on the east side to 40 to 50 feet on the west side (Figure B.2.1). On the east side of the pile, the weathered Mancos Shale appears to form an erosional bench caused by recent stream flow. Perched water in the tailings was observed in 1.25-inch well points in Transect C (Figure B.2.6), which corresponds to the Mancos Shale bench shown in Figure B.2.2. Almost all other well points installed within the tailings west of this area and proximal to the body of ponded surface water were dry (Figure B.2.6). Figures B.2.3 and B.2.5 show that perched alluvial/weathered Mancos Shale ground water does not occur where the underlying Mancos Shale is truncated, and ground water flows into the Tres Hermanos-C1 and -C2 Sandstones subcropping beneath the alluvium. Dry wells in Figure B.2.7 show the approximate extent of saturation within the alluvium and weathered Mancos Shale. Note that the weathered Mancos Shale is saturated in the immediate vicinity of the tailings pile. The extent of saturation in the alluvium southwest of the site toward the Arroyo del Puerto is not known.

Figure B.2.7 was constructed from water levels measured in wells completed in the alluvium/weathered Mancos Shale beneath the pile. The approximate location of the Tres Hermanos-C Sandstone subcrop, as determined from subsurface geological data, is also shown on Figure B.2.7.

The approximate subcrop of the Tres Hermanos-C Sandstone below the alluvium is shown in Figure B.2.7. The alluvium downdip of this contact is unsaturated from the downward migration of water into the Tres Hermanos-C Sandstone. Monitor wells 794 and 796 completed at the base of the alluvium are both dry. Monitor well 781 (see Figure B.2.3), completed near the top of the Tres Hermanos-C2 Sandstone, shows the

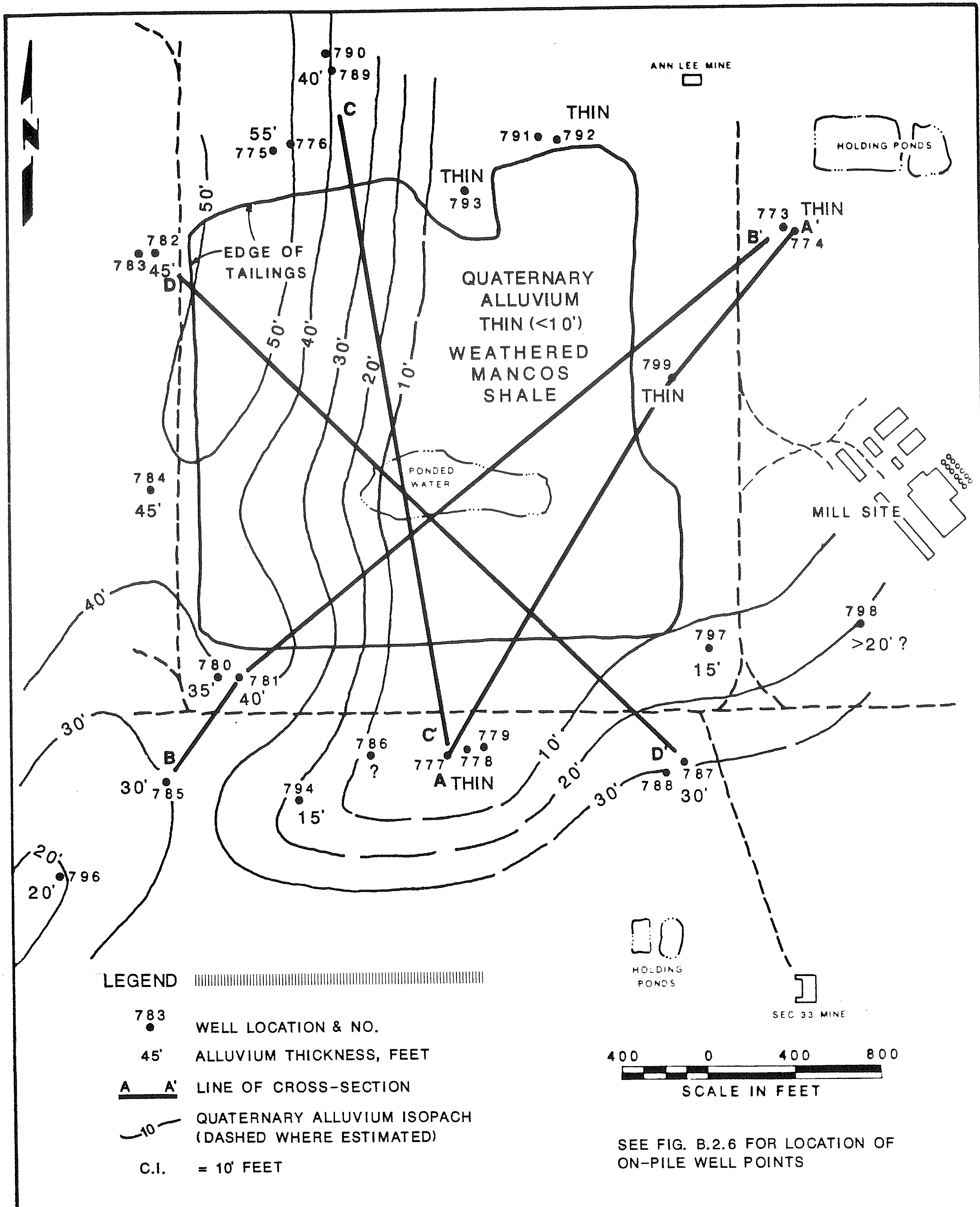


FIGURE B.2.1 LOCATION OF CROSS-SECTIONS, DOE MONITOR WELLS, & QUATERNARY ALLUVIUM ISOPACH

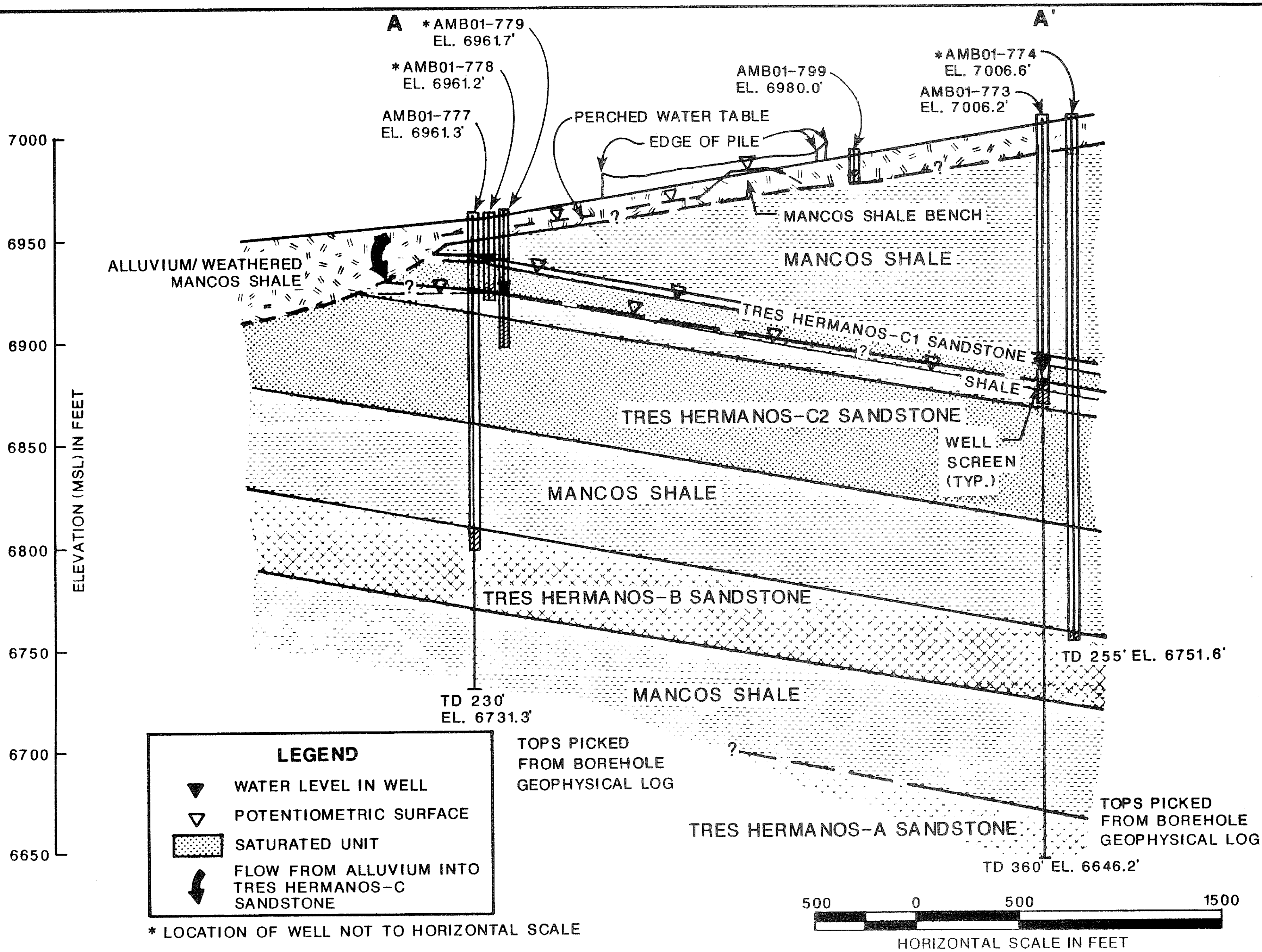


FIGURE B.2.2 HYDROGEOLOGIC CROSS-SECTION A-A'

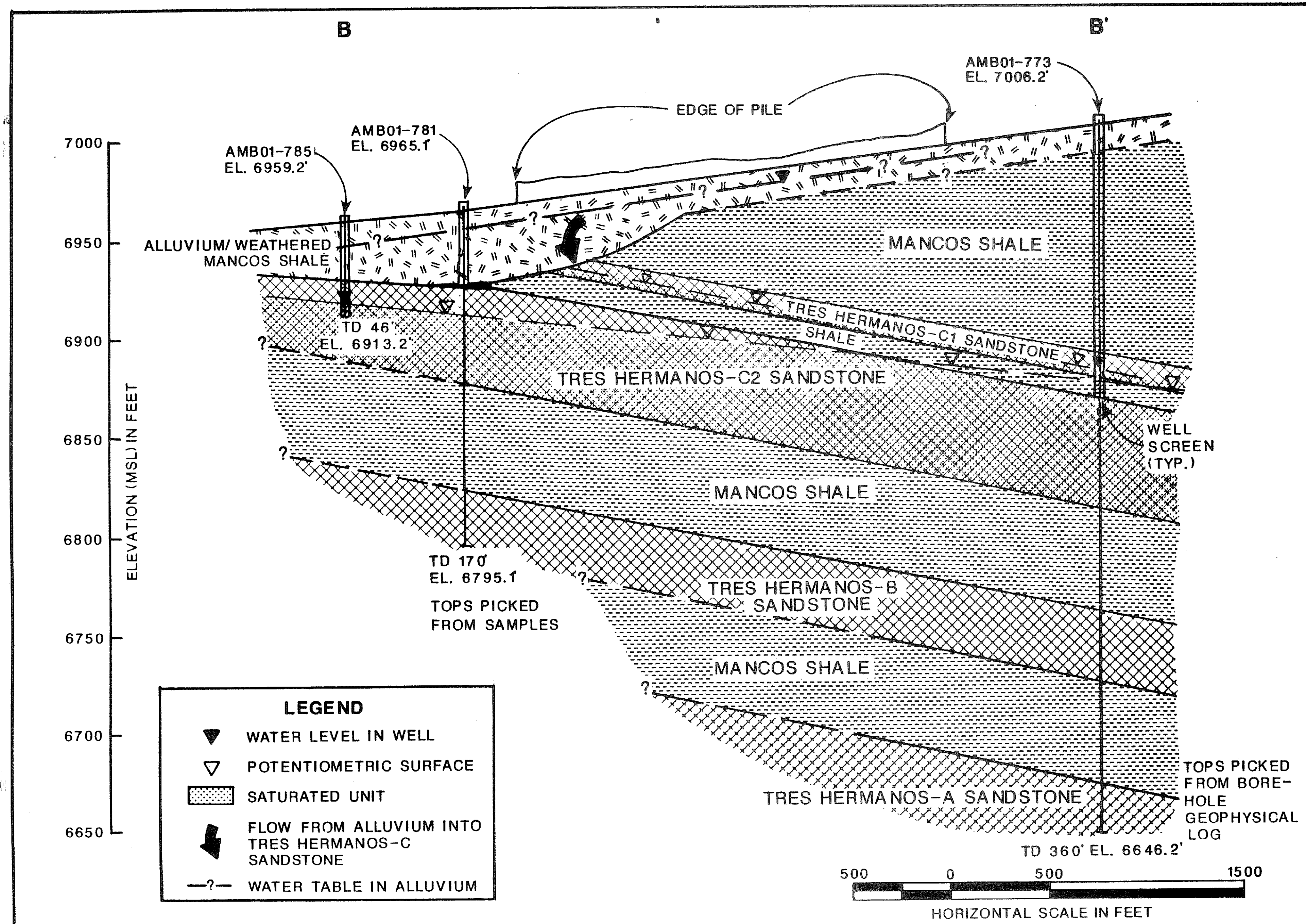


FIGURE B.2.3 HYDROGEOLOGIC CROSS-SECTION B-B'

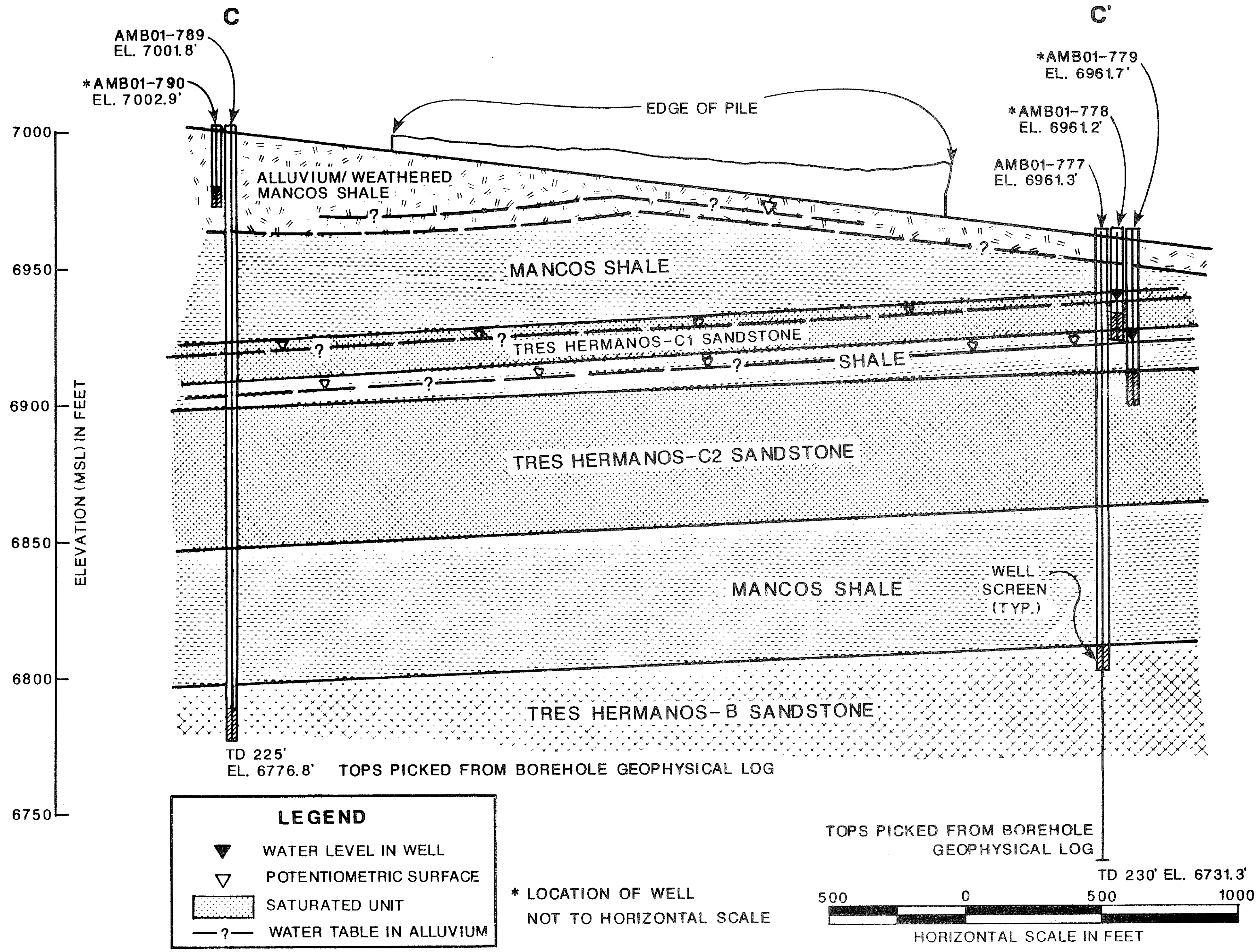


FIGURE B.2.4 HYDROGEOLOGIC CROSS-SECTION C-C'

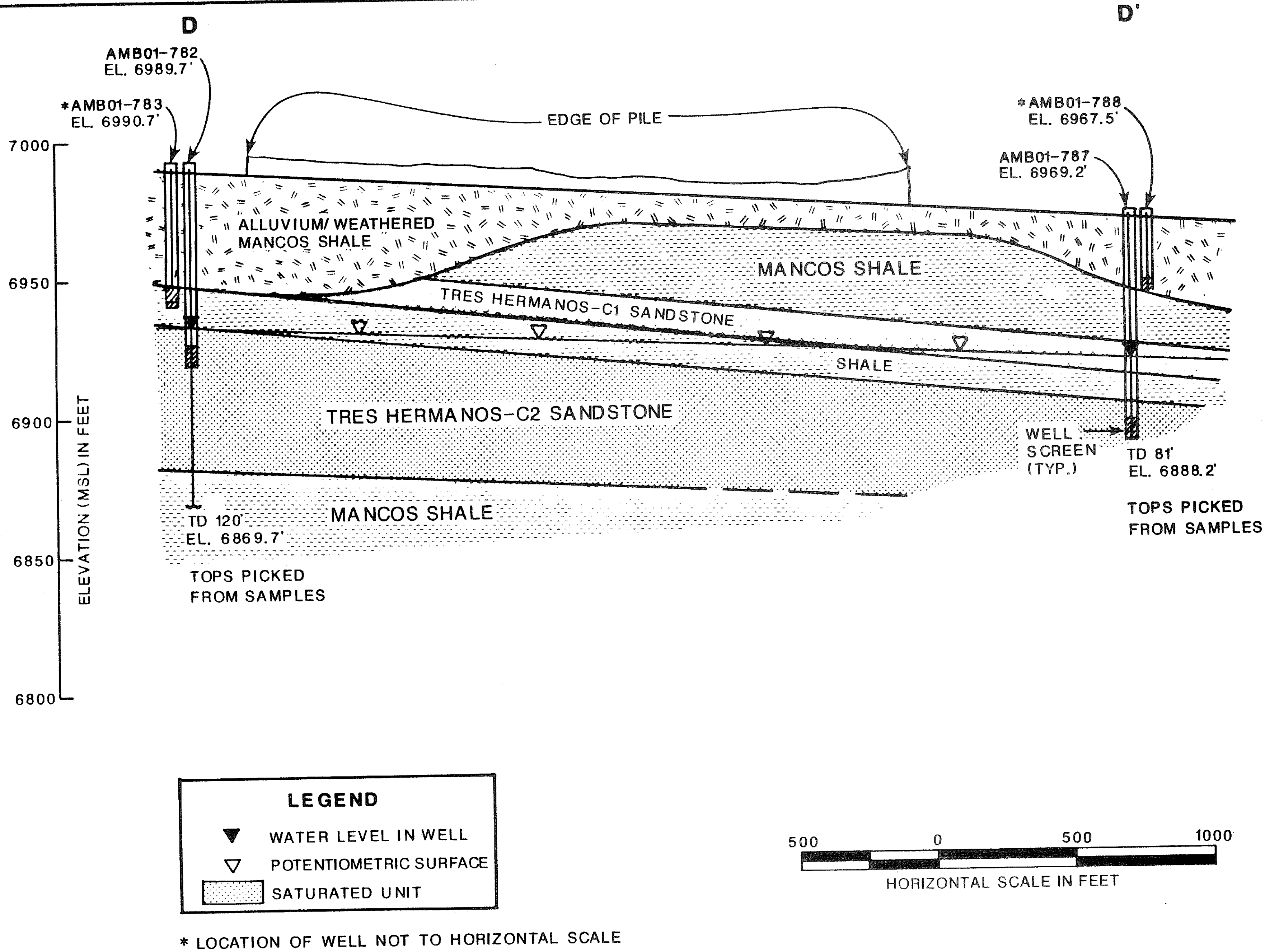
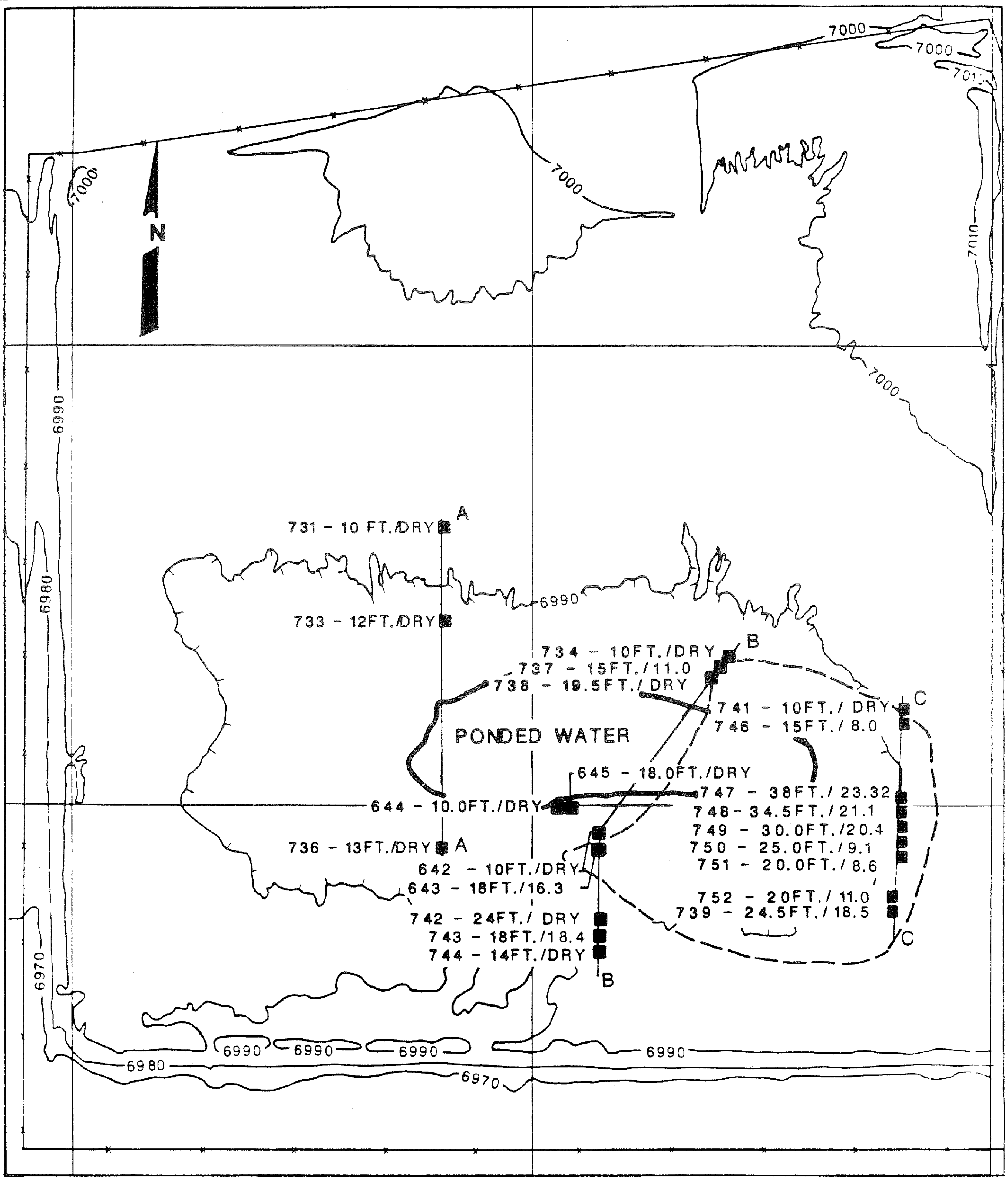


FIGURE B.2.5 HYDROGEOLOGIC CROSS-SECTION D-D'



LEGEND

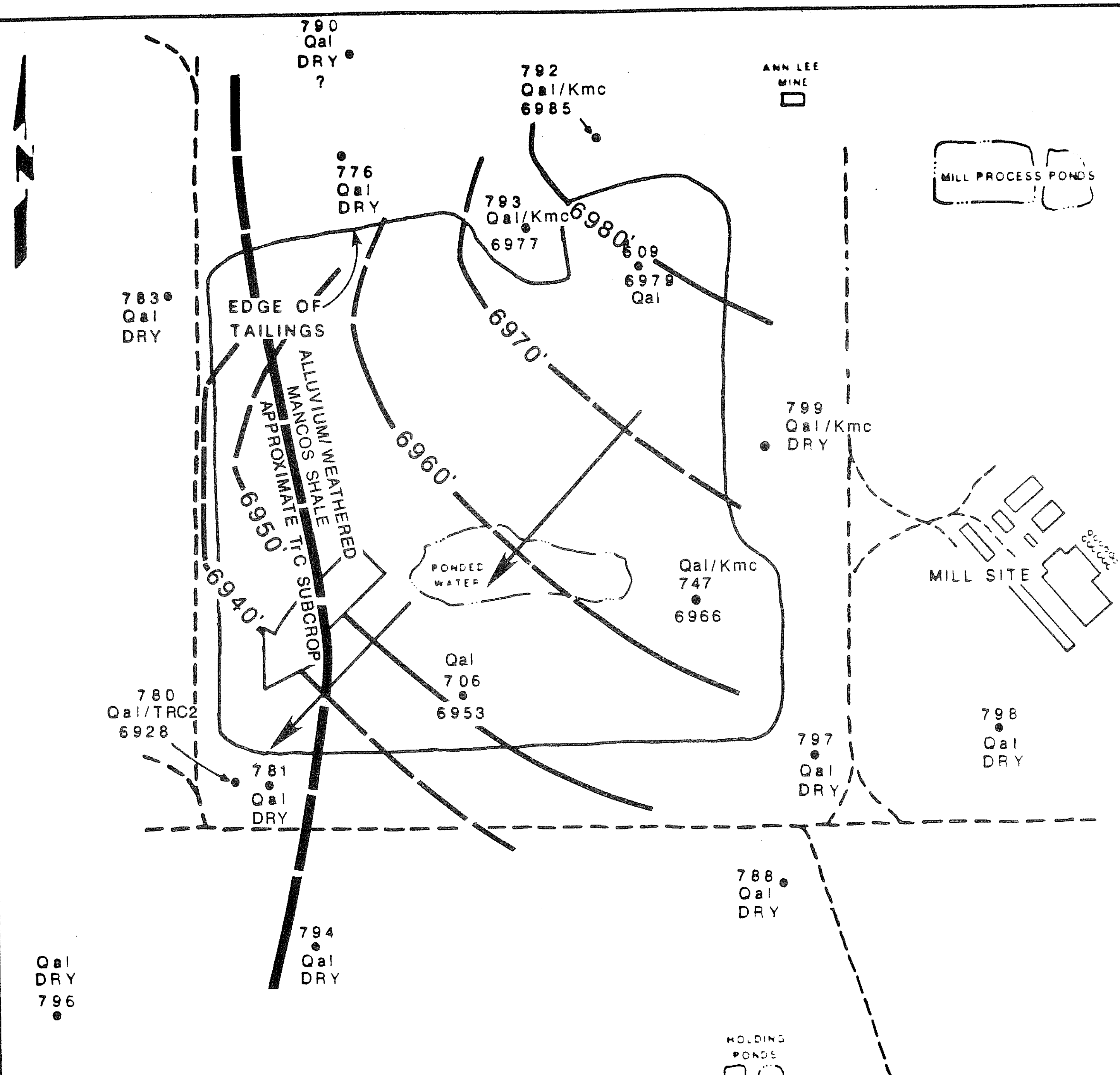
731 - 10 FT/8.42
PIEZOMETER (WELL POINT)LOCATION
LOCATION ID NUMBER
DEPTH OF 6 INCH FILTER SCREEN (FT. FROM PILE SURFACE)
WATER LEVEL 8/24/85 (FT. FROM PILE SURFACE)
7000 SURFACE ELEVATION (FT. MSL.)

0 200 400 600 800
SCALE IN FEET

A | A TRANSECT IDENTIFICATION

— — — APPROXIMATE AREA OF SATURATION WITHIN TAILINGS

FIGURE B.2.6 LOCATIONS OF ON-PILE WELL POINTS



LEGEND

783 ●	WELL LOCATION AND NUMBER
6942	WATER LEVEL ELEVATION (FT. MSL)
Qal	WELL COMPLETED IN THE ALLUVIUM
Qal/Kmc	WELL COMPLETED IN THE ALLUVIUM/WEATHERED MANCOS SHALE
6930	EQUIPOTENTIAL CONTOUR (DASHED WHERE ESTIMATED)
	GROUND-WATER FLOW DIRECTION
	DOWNWARD VERTICAL FLOW COMPONENT FROM ALLUVIUM WEATHERED MANCOS SHALE TO TRES HERMANOS-C SANDSTONE
	STRUCTURE CONTOUR LINE (DASHED WHERE ESTIMATED)

400 0 400 800
SCALE IN FEET

FIGURE B.2.7 WATER TABLE MAP FOR ALLUVIUM/ WEATHERED MANCOS SHALE

alluvium is dry. The water table occurs at approximately 10 feet into the Tres Hermanos-C2 Sandstone in monitor well 780. Monitor well 783, also dry, is located just to the east of the Tres Hermanos-C Sandstone subcrop, and is completed in the alluvium/weathered Mancos Shale (Figure B.2.5).

Six and 8.5 feet of saturation occur in the alluvium/weathered Mancos Shale just north of the pile in alluvial wells 792 and 793, respectively (Figure B.2.7). The most northern alluvial well, 790, did not extend to the base of the alluvium and is dry (see Figure B.2.4).

The results of water level measurements in the monitor wells around the Ambrosia Lake site indicate that the alluvium/weathered Mancos Shale is not continuously saturated. It contains some basal perched ground water where underlain by more impermeable Mancos Shale. Downgradient from the tailings pile, this perched water moves downward into the Tres Hermanos-C Sandstone. Alluvial monitor wells more than 800 feet downgradient from the tailings pile are dry. This is consistent with the findings of Cravens and Hammock (1958) that "The valley fill (alluvium) does not contain much water north of the McKinley County line. All water in the alluvium north of McKinley County line is either seepage from waste ponds at the Kerr-McGee (Quivira) and Phillips (Ambrosia Lake tailings site) mills or mine water, which is pumped to the surface from the Westwater Canyon Member of the Morrison Formation."

The next saturated unit beneath the Ambrosia Lake site is the Tres Hermanos-C Sandstone. It subcrops beneath the southwest corner of the pile (see Figure B.2.7). The Tres Hermanos-C Sandstone dips to the northeast (Figure B.2.8).

Well 775, which is completed in the lower sand facies of the Tres Hermanos-C Sandstone, is dry. This lack of saturation directly north of the eastern portion of the tailings pile indicates that the saturation in the Tres Hermanos-C Sandstone possibly resulted from discharge from the tailings rather than natural sources of recharge.

Wells that are screened over the most permeable zone in the Tres Hermanos Sandstone and which show no saturation serve the very useful purpose of demonstrating that the hydrostratigraphic unit has been at least partially dewatered in that area. Because the hydrostratigraphic unit has been depressurized, screening wells such as wells 773, 774, and 777 at the base of the horizon would have produced even smaller volumes of water.

Monitor well 777 has been screened opposite the cleanest sand interval in the Tres Hermanos-B Sandstone. The cleanest and probably most permeable sand units in the Tres Hermanos-A, -B, and -C Sandstones tend to be toward the top of the sandstones as they are all coarsening upward sequences.

Up to 80 feet of the Mancos Shale separate the alluvium from the Tres Hermanos-C1 and -C2 Sandstones beneath the pile, except where the Tres Hermanos-C1 and -C2 Sandstones subcrop. Portions of the Mancos Shale are an aquitard or aquiclude in the Ambrosia Lake area (Thomson and Heggen, 1981; Brod, 1979; Cooper and John, 1968). Additional

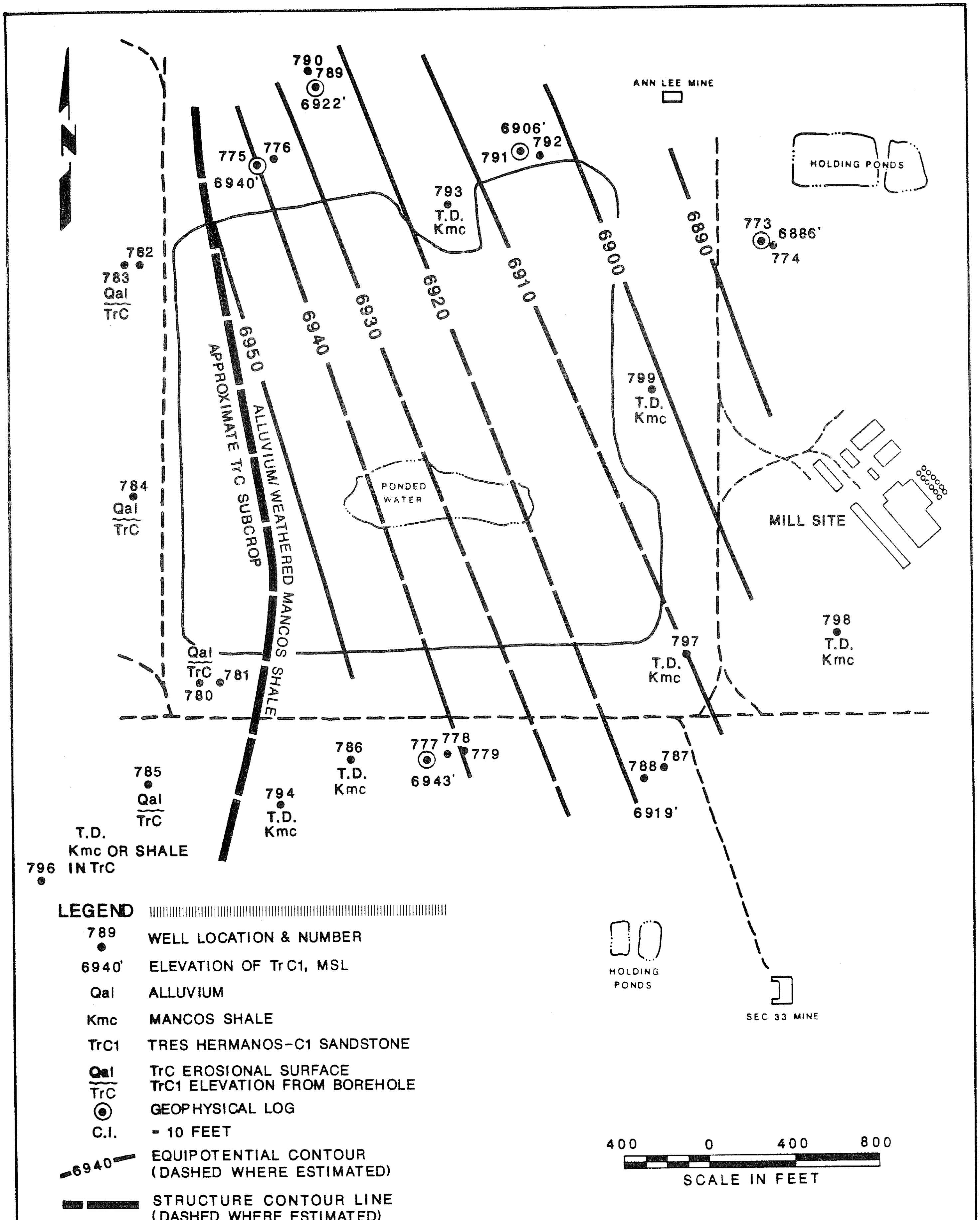


FIGURE B.2.8 STRUCTURE MAP OF TRES HERMANOS-C1 SANDSTONE

evidence of its low permeability is reflected by a seven-foot water-level difference in monitor well pair 778 and 779 (see Figure B.2.4), where Tres Hermanos-C1 and -C2 Sandstones are separated by only 10 to 15 feet of Mancos Shale and there is a downward hydraulic gradient to the deeper underlying Tres Hermanos-C2 Sandstone. Cross sections show that a continuous 50-foot interval of Mancos Shale inhibits vertical migration of contaminants from the Tres Hermanos-C2 Sandstone into the deeper Tres Hermanos-B Sandstone.

The structure contour map of the top of the Tres Hermanos-C1 Sandstone (Figure B.2.8) does not indicate the presence of any faults in the immediate area of the pile. Fractures possibly present in the Mancos Shale probably heal quickly within bentonitic horizons and seal off potential zones for vertical migration of contaminants. The Mancos Shale is an effective vertical hydraulic barrier to flow except where absent (Tres Hermanos-C subcrop).

B.2.3 WATER USES

All the streams in the Ambrosia Lake area are intermittent and are sediment-laden during the short periods of storm runoff. The sole source of water supply is obtained from underground reservoirs. Present ground-water use is approaching pre-1955 use due to the decline of the uranium industry (Brod and Stone, 1981). The three principal ground-water users are the uranium industry, domestic supply, and ranch supply.

Uranium industry

The Westwater Canyon Member of the Morrison Formation is the ore-bearing aquifer in the Ambrosia Lake mining district. Uranium mine dewatering beginning in the mid-1950s withdrew large amounts of ground water to facilitate ore removal from the Westwater Canyon Member. Early pumping totaled 24 million gallons per day for mines located in Ambrosia Lake, San Mateo, and Bluewater-Milan (Cooper and John, 1968). The New Mexico Environmental Improvement Division (NMEID, 1980) indicated pumpage from mines just in the Ambrosia Lake area ranged from eight to 13 million gallons per day. After 20 years of pumping, potentiometric levels were lowered hundreds of feet in the eastern Ambrosia Lake area (Brod and Stone, 1981). Most of the pumped water was discharged to surface drainages where it evaporated or infiltrated to recharge the shallow sediments.

The pumped mine water was considered a resource and was used by the mills for ore processing and by a few ranchers in the area for domestic and stock purposes. It was not until the late 1970s that the quality of mine discharge water came under scrutiny by the state, and settling ponds and water treatment were required. It was also at this time that the quantity of water pumped was monitored.

Presently, the uranium industry is retiring the mines in Ambrosia Lake. Ore is being processed only at the Quivira mill. However, many of the mines are still being dewatered and some water presently pumped from active and inactive mines is being reinjected into the Westwater Canyon Member during a low-scale solution recovery of uranium from the mined-out areas. If uranium production becomes economically viable in the future, water usage would probably be similar in nature and extent as in the past during the 1950s through the 1970s.

Domestic

The nearest municipality operating a public water supply is San Mateo, located 10 miles southeast (hydraulically upgradient) of the Ambrosia Lake site (Figure B.2.9). In the community of Ambrosia Lake, four private wells tap the Westwater Canyon Member and the alluvium along San Mateo Creek to obtain water for homes and trailers. In the early 1970s, deeper wells in the Westwater Canyon Member went dry due to mine pumpage, and Kerr McGee (Quivira) constructed a pipeline to supply domestic needs in the area.

There are no domestic wells completed in any of the Tres Hermanos Sandstones or within the alluvium in the Ambrosia Lake valley. The valley includes the area between San Mateo Mesa and Mesa Montanosa north of New Mexico Highway 53, and within approximately three miles of the tailings site (see Figure B.2.9). These hydrostratigraphic units do not yield an adequate supply of ground water of acceptable quality.

Most of the domestic wells in the Ambrosia Lake valley have been abandoned (Brod and Stone, 1981). A total of seven active wells are known to occur within five miles of the Ambrosia Lake site and four are used for domestic purposes (Table B.2.1). Two domestic wells supply houses and trailers at the junction of New Mexico Highways 53 and 509 (see Figure B.2.9) 4.5 miles southwest of the site. One well completed in the Westwater Canyon Member is reported (Marquez, 1985) at 300 feet deep and supplies poor quality (very hard) water to one house and two trailers. The depth of the second well is unknown.

The third domestic well is on the Phil Harris ranch, which is one mile northwest of the junction of New Mexico Highway 509 and New Mexico Highway 53 (see Figure B.2.9). This well was completed in the Westwater Canyon Member or in deeper formations and supplies the ranch house. The Berryhill ranch, located three miles northwest of the Ambrosia Lake site, has an 800-foot-deep well completed in the Westwater Canyon Member. This well went dry in the early 1970s, and Quivira has supplied the ranch water via a pipeline from their Section 17 mine. A second Berryhill Ranch well was listed in Brod and Stone (1981), but the ranch foreman revealed that water for the trailer, house, and 15 quarter horses is supplied totally by the Quivira pipeline (Baughman, 1985a).

Stock

There are five ranch headquarters in the Ambrosia Lake area. The Berryhill and Harris lands are used for grazing and three wells were reportedly used for stock supply (Table B.2.1). None of these stock wells were completed in the shallow aquifers including the alluvium or

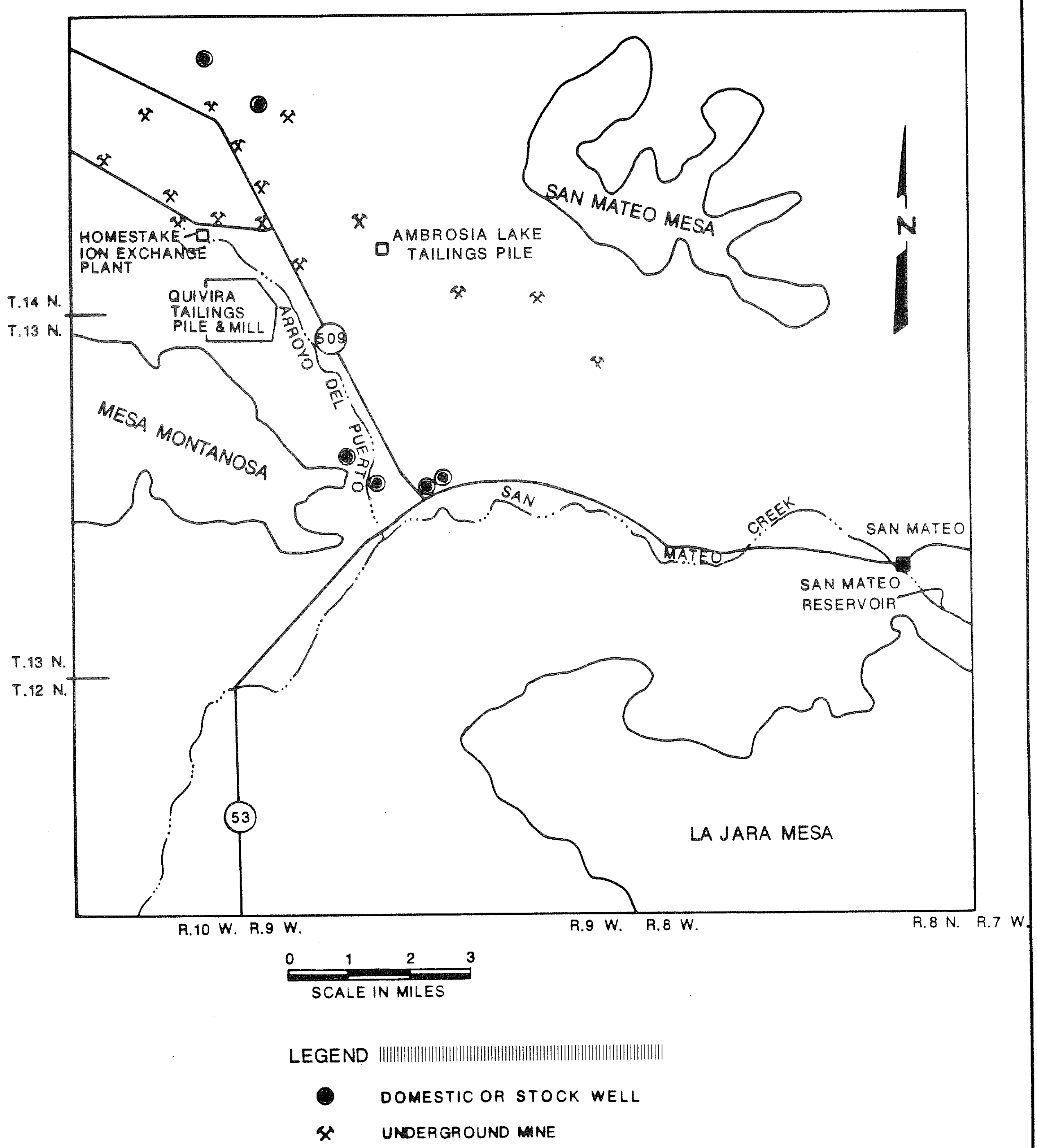


FIGURE B.2.9 LOCATIONS OF DOMESTIC AND STOCK WELLS IN THE AMBROSIA LAKE AREA

Table B.2.1 Records of wells within five miles of the Ambrosia Lake site

Owner or well name[a]	Principal aquifer[b]	Location no.	Total depth (ft)	Year constructed	Use[c]
A. Berryhill	JM	14.9.18.243	800	1957	D
A. Berryhill	JM	14.9.32.314	550	--	-
Malvin Marquez	JM?	13.9.15.34	300	--	D
Malvin Marquez	--	13.9.15.34	--	--	D
Phil Harris	--	13.9.16.422	--	--	D
Phil Harris	S	14.9.17	>3000	--	S
Phil Harris	S	13.9.13	>3000	--	S

[a]Does not include observation wells or known abandoned wells.
[b]JM = Westwater Canyon Member, Morrison Formation; S = San Andres Limestone.
[c]D is domestic; S is stock.

Ref. Brod and Stone, 1981; Marquez, 1985; Baughman, 1985b.

Tres Hermanos Sandstones (Baughman, 1985b). All stock supply wells in the valley were completed in the Westwater Canyon Member or San Andres Limestone at depths of 500 to 3000 feet. There is no present or historical irrigation within the Ambrosia Lake valley and no demand is anticipated due to low precipitation, poor soils, and limited good-quality ground water.

Prior to mining, there was little development in the Ambrosia Lake area and limited use of ground water. The twenty-year period of uranium mining and milling activity spurred the temporary development of the valley and drastically altered the quality and quantity of ground-water resources. Future ground-water development in the valley is expected to be even more limited than pre-mining times due to the unknown residual effects of the mining industry. There is an extremely minor potential for future use of shallow ground water because of the large areal extent of naturally poor quality water, limited yield capability, artifically saturated zones drying up, and regional contamination of the ground water due to mine dewatering and discharge of mill effluents.

B.2.4 GROUND-WATER FLOW HYDRAULICS

The shallow ground-water flow system developed beneath the Ambrosia Lake site is dependent on (1) geometry of the flow system; (2) hydraulic conductivity of the hydrostratigraphic units; and (3) spatial disposition of natural and artificial recharge and discharge areas. The geometry of the flow system beneath the pile is shown in cross sections (see Figures B.2.2 through B.2.5).

The cumulative impact of the mining and milling operation at the Ambrosia Lake site was to create an artificial recharge area above the unsaturated alluvium/weathered Mancos Shale. This water is locally perched upon deeper relatively impermeable and unweathered Mancos Shale and moves downgradient to the southwest until it encounters the permeable Tres Hermanos-C1 Sandstone subcrop. Here, the water originating as artifical recharge moves into the Tres Hermanos-C1 Sandstone and flows to the northeast coincident with the regional dip of the bedrock units.

The sources and occurrences of artificial recharge events at the Ambrosia Lake site have varied significantly over the years. United Nuclear has historically pumped discharges from the Ann Lee, Section 27, and Sandstone mines in Section 34, Township 14 North, Range 9 West, to the unlined mill process pond northeast of the tailings pile (Figure B.2.10). Water from this pond was run through the ion exchange facility in the mill, and then recirculated back to the mines or discharged to the tailings pond or ground surface on the site. Table B.2.2 lists some possible incidents of discharges of mine water to the ground surface. Other sources include a sewage lagoon and a heap leach site. It is suspected that infiltration of tailings seepage from the tailings pile represents a majority of recharge to the alluvium at the site.

The mill at the Ambrosia Lake site operated from 1958 to 1963, and disposed tailings and spent chemicals in an unlined tailings

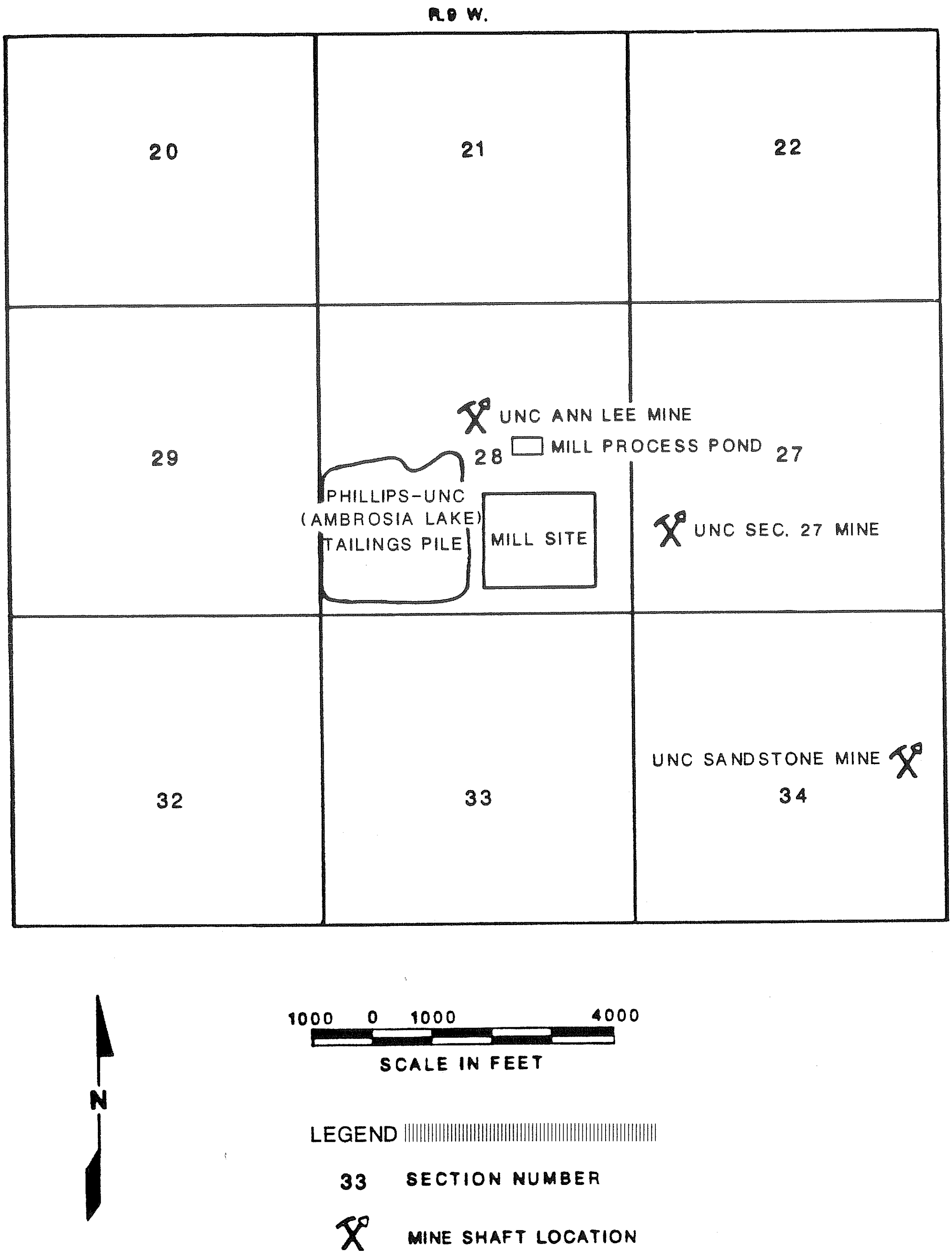


FIGURE B.2.10 LOCATIONS OF THE AMBROSIA LAKE (PHILLIPS-UNITED NUCLEAR) MINES, MILL SITE, AND TAILINGS PILE

Table B.2.2 Some sources of shallow ground-water recharge near the Ambrosia Lake site

Source	Incident	Origin of water	Reference
Ann Lee Mine settling pond just north of tailings pile	Overflow 06/07/77	Ann Lee Mine	Blubaugh (1977a)
Leaky buried pipe from Ann Lee Mine to mine water holding pond northeast of pile	Inspection by NMEIA 08/23/77	Ann Lee Mine	Blubaugh (1977b)
IX plant discharge to ditch just east of mill site property boundary	Pump failure at UNC Sandstone mine to recirculate water, 12/12/77; ponding over 2.5 acres	Sandstone mine (plus other UNC mines)	Brough (1978a)
IX plant discharge to pipes along ground north of tailings pile	Break in IX injection line 01/08/78-01/11/78; ponded over north Sections 28 and 29	Section 27, Ann Lee, and Sandstone mines after IX treatment	Brough (1978b)

impoundment. At the present time there are no known sources of active artificial recharge at the Ambrosia Lake site. There is, however, an almost continual body of ponded water on the south central half of the tailings pile. Inspection of the pond showed the basal material beneath the pond consists of a very stiff, clayey, slime material that may restrict water movement.

To determine if this pond is a source of recharge to the subsurface, three transects of 1.25-inch well points were installed in July, 1985, around the ponded water (see Figure B.2.6). The well points, constructed especially for use in extremely fine-grained materials, consisted of a porous polyethylene cartridge (Vyon) with a 50-micrometer pore size used as the screen. This porous cartridge formed a sleeve over a 1.25-inch diameter, Schedule 80 PVC-perforated barrel, and was placed between the drive point tip and a female coupling (Blackport, 1980).

The well points were inserted through a hollow-stem auger to the depths of greatest moisture content, as determined from tailings samples at selected intervals. These zones generally coincided with thicker layers of slimes (fine-grained, clay-like tailings). Saturated conditions were encountered predominantly in well points along transect-C (Table B.2.3). The bottom eight feet of tailings east of the ponded water were saturated. This saturation coincides with the area of perched water upon the Mancos Shale bench at the southeast corner of the pile (see Figure B.2.2). It appears that relict seepage has migrated to the Mancos Shale and created a mound that extends into the base of the tailings within this localized area. Well points 739, 747, 748, and 749 were installed in the alluvium/weathered Mancos Shale beneath the tailings. Water elevations from these points represent the ground-water surface present in the surrounding alluvium/weathered Mancos Shale monitoring wells (see Figure B.2.7).

Hydraulic conductivity is the water transmitting capacity of a particular stratigraphic unit. In an isotropic, homogeneous, porous medium, it is defined as the volume of water that will move in unit time under a unit hydraulic gradient through a unit area of aquifer measured at right angles to the direction of flow (Lohman et al., 1972). Data regarding hydraulic conductivity are available from previous studies conducted in the Ambrosia Lake valley (Table B.2.4) and from slug tests conducted at the site. The range of hydraulic conductivity values from previous work indicates that values for the alluvium and Tres Hermanos-B Sandstone are in the range for silty sands, and values measured in the weathered Mancos Shale are at the upper bounds for shales (Freeze and Cherry, 1979).

Quivira Mining Corporation obtained an average hydraulic conductivity of 1.3 feet per day in the alluvium from two pumping tests performed in test wells AW-1 and AW-2 (Figure B.2.11). An unconfined storage coefficient of 2×10^{-1} was determined from one of the pumping tests. These tests were performed in areas where the alluvium is 70 feet thick, about one mile west of the Ambrosia Lake tailings

Table B.2.3 Water levels measured in on-pile DOE well points

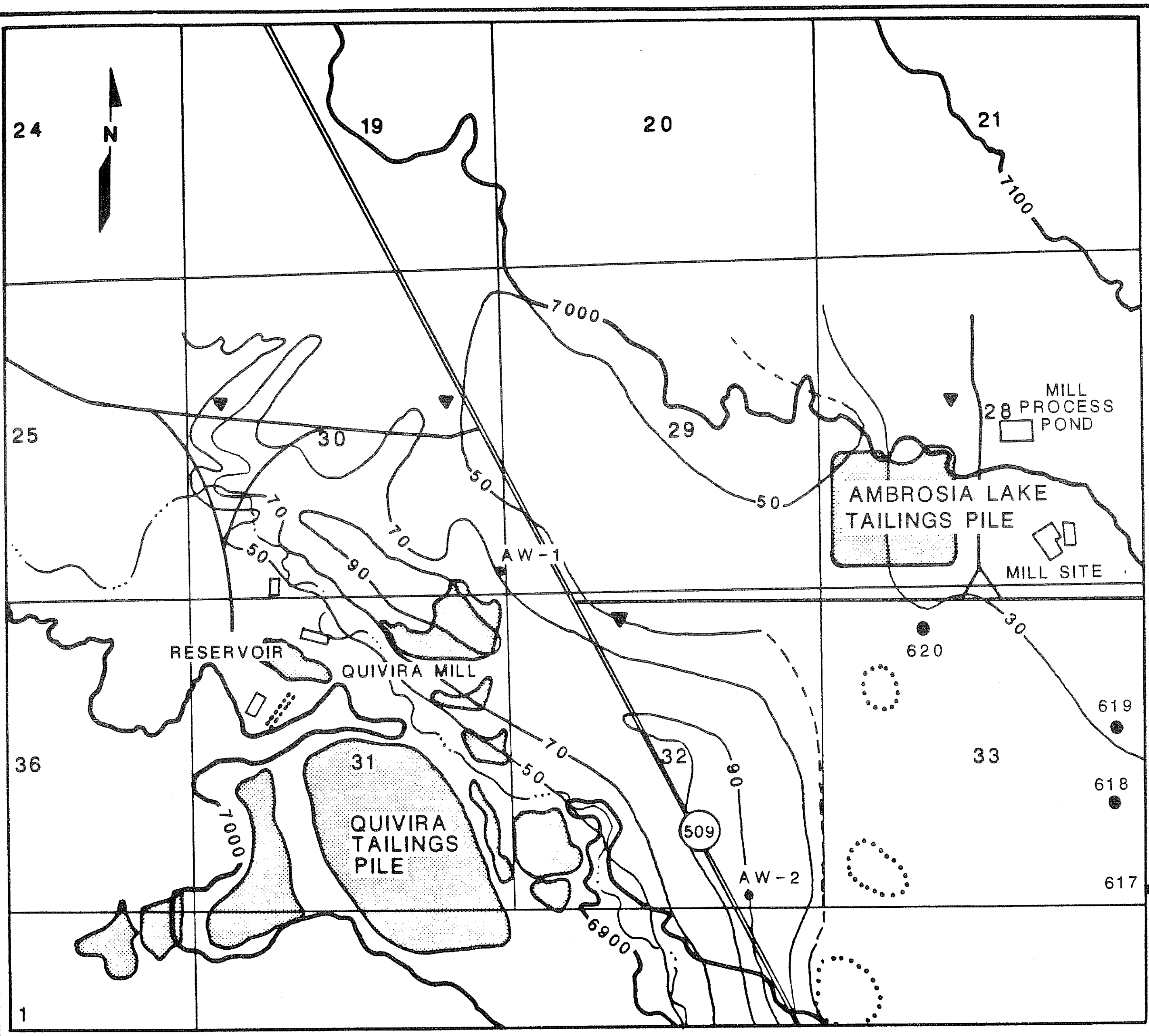
Well location number	Depth of piezometer (feet)	Depth to water (feet)[a]	Ground-water elevations (feet MSL)
Transect A			
731[b]	10.0	dry[c]	< 6981.2
733[b]	12.0	dry	< 6976.4
736[b]	13.0	dry	< 6976.5
Transect B			
734[b]	10.0	dry	< 6979.3
737[b]	15.0	12.0[d]	6977.9
738[b]	19.5	17.4[e]	6972.9
644[b]	10.0	dry	< 6979.2
645[b]	18.0	dry	< 6971.3
642[b]	10.0	dry	< 6978.2
643[b]	18.0	16.3	6975.0
742[b]	24.0	21.9[e]	6967.8
743[b]	18.0	18.4[e]	6972.8
744[b]	14.0	dry	< 6974.6
Transect C			
741[b]	10.0	dry	< 6979.1
746[b]	15.0	9.1[e]	6980.3
747[f]	38.0	25.9[e]	6965.5
748[f]	34.5	24.1[d]	6967.6
749[f]	30.0	21.2[d]	6968.5
750[b]	25.0	10.0[e]	6979.5
751[b]	20.0	9.5[e]	6979.7
752[b]	20.0	11.9[e]	6986.4
739[f]	24.5	18.5[e]	6972.6

[a]Measured from top of casing.
[b]Piezometers completed in tailings.
[c]Wells determined dry 10/85 and 5/86.
[d]Water levels measured 5/86.
[e]Water levels measured 10/85.
[f]Piezometers completed in alluvium.

Table B.2.4 Hydraulic conductivities reported for the alluvium and Tres Hermanos-B Sandstone in Ambrosia Lake Valley

Unit	Hydraulic conductivity[a]	Method and reference
Alluvium	2×10^{-4} to 5×10^{-4} cm/sec (0.6 to 1.4 ft/day)[b]	Two pumping tests by Quivira Mining Co., 1980 (Ganus, 1980)
Alluvium	2×10^{-5} cm/sec (0.057 ft/day)[b]	Pumping test in monitor well H-9 (FBD, 1983)
Alluvium	1.0×10^{-3} to 5.0×10^{-3} cm/sec (2.8 to 14.2 ft/day)[c]	Falling head permeability tests (Thomson and Heggen, 1981)
Tres Hermanos-B Sandstone	1×10^{-4} to 1×10^{-3} cm/sec (0.28 to 2.8 ft/day)[b]	In-situ single packer permeability tests by Woodward-Clyde Consultants for Quivira (WCC, 1983)
Tres Hermanos-B Sandstone/ Mancos Shale	2×10^{-5} cm/sec (0.057 ft/day)[b]	In-situ permeability tests by Woodward-Clyde Consultants for Quivira (WCC, 1983)
Mancos Shale (weathered)	1.4×10^{-7} to 1.4×10^{-6} cm/sec (3.96×10^{-4} to 3.97×10^{-3} ft/day)[b]	Measured by Gulf Corp. in their San Mateo mine in T14N R8W (Brod and Stone, 1981)
Mancos Shale	4.33×10^{-8} cm/sec (1.23×10^{-4} ft/day)[d]	Grinding then estimated from a consolidation test (Thomson and Heggen, 1981)

[a]cm/sec = centimeters per second; ft/day = feet per day.
[b]Feld test of horizontal conductivity.
[c]Laboratory test of horizontal conductivity.
[d]Laboratory test without horizontal conductivity or vertical orientation.



LEGEND

7000	ELEVATION (FT. MSL.)
70	LINE OF EQUAL THICKNESS OF ALLUVIUM (FT.) DASHED LINE SHOWS EXTRAPOLATION
....	ALLUVIUM-BEDROCK CONTACT (SANTOS & THADEN, 1966)
	MILL TAILINGS PILES & EVAPORATION PONDS
—··· —	ARROYO DEL PUERTO
▼	MINE

1000 0 1000 2000
SCALE IN FEET

REF: GANUS, 1980

FIGURE B.2.11 ISOPACH MAP OF ALLUVIUM IN THE AMBROSIA LAKE VALLEY

pile, and 90 feet thick one mile southwest of the Ambrosia Lake tailings pile. Saturation in these wells along the channel of the Arroyo del Puerto is the result of infiltration of mine discharge water along the course of the arroyo. This saturation does not extend as far east as the Ambrosia Lake tailings site.

Figure B.2.11 is an isopach map of the alluvium in the valley adapted from Quivira's 1980 ground-water discharge plan (Ganus, 1980). The alluvium thins from the Quivira test wells toward the Ambrosia Lake site. Thickness of the alluvium at the Ambrosia Lake site is shown by the isopachs superimposed on Figure B.2.1.

Slug tests were conducted to determine a representative hydraulic conductivity value for the alluvium/weathered Mancos Shale at the Ambrosia Lake site. These tests are used to measure hydraulic conductivity of an aquifer near a well by measuring the rate of rise of the water level in the well after a known volume of water is suddenly removed. This method is ideal for use at the Ambrosia Lake site because of the limited extent of saturation in the alluvium and low permeability of the alluvium and Tres Hermanos-C Sandstone (Table B.2.5). Field slug test data were analyzed with the computer program SLUG/BAS. The program has been documented according to NUREG specifications (NRC, 1983) and is on file in the DOE UMTRA Project Albuquerque Operations Office.

Slug tests were performed on eight monitor wells: three in confined stratum, one semi-confined stratum (well number 780), and five unconfined stratum (Table B.2.5). Three wells penetrate the Tres Hermanos-C Sandstone and are confined beneath an interval of Mancos Shale. Well 780 terminated at the top of the Tres Hermanos-C2 Sandstone where the confining layer of Mancos Shale pinches out (see Figure B.2.2) and is considered semiconfined. Slug test data from wells in confined units were analyzed by the Skibitzke (USGS, 1963), Ferris-Knowles (USGS, 1963), and Cooper-Papadapolous-Bredehoeft (Lohman, 1972) methods.

The Ferris-Knowles method is a graphical solution in which the data, plotted as residual drawdown verses 1/time, should fit a straight line that passes through the origin. The method requires large times (t) in order to extrapolate a line through the origin; except for well 780, the Tres Hermanos-C Sandstone tests were not long enough for this method to be used.

The Cooper-Papadapolous-Bredehoeft method utilizes a curve-matching technique, and was developed for confined aquifers.

The Skibitzke method can be applied to confined units with low hydraulic conductivity, and uses the residual drawdown for the last measurement at the well. The basic assumptions in this method were applicable to wells 779, 787, and 791 completed in the Tres Hermanos-C Sandstone. A narrow range of hydraulic conductivities from 1.1×10^{-5} to 3.1×10^{-5} cm/sec were calculated (Table B.2.5) for the Tres Hermanos-C1 and -C2 Sandstones.

Table B.2.5 Slug test results from the Ambrosia Lake site monitor wells

Well location number[b]	Hydraulic conductivity methods and results[a]							Geologic unit
	Skibitzke	Ferris-Knowles	Cooper-Papadopolous-Bredehoeft	Bouwer-Rice	Hvorslev	K	K ave.	
Confined								
779	1.13×10^{-5}	Not valid[c]	Not valid	N/A	N/A	1.13×10^{-5}	0	TrC2[d]
787	2.08×10^{-5}	Not valid	Not valid	N/A	N/A	2.08×10^{-5}	0	TrC2
791	1.46×10^{-5}	Not valid	Not valid	N/A	N/A	1.46×10^{-5}	0	TrC1[e]
Semi-confined								
780	3.06×10^{-5}	3.86×10^{-5}	1.88×10^{-4}	7.31×10^{-5}	1.03×10^{-4}	8.66×10^{-5}	6.36×10^{-5}	QAL[f]/TrC2
Unconfined								
778	N/A[g]	N/A	N/A	1.21×10^{-3}	1.53×10^{-3}	1.37×10^{-3}	2.26×10^{-4}	TrC1
782	N/A	N/A	N/A	1.64×10^{-4}	1.82×10^{-4}	1.73×10^{-4}	1.27×10^{-5}	TrC2
785	N/A	N/A	N/A	2.48×10^{-4}	Not valid	2.48×10^{-4}	0	TrC2
786	N/A	N/A	N/A	1.13×10^{-4}	1.74×10^{-4}	1.44×10^{-4}	4.31×10^{-5}	TrC1?

[a]cm/sec - centimeters per second.
[b]Well locations plotted on Figure B.2.1.
[c]Not valid - data did not fit the assumptions of the method.
[d]TrC2 - Tres Hermanos-C2 Sandstone.
[e]TrC1 - Tres Hermanos-C1 Sandstone.
[f]QAL - alluvium.
[g]NA - Method not applicable.

DOE wells 778, 782, 785, and 786 were completed in unconfined hydrostratigraphic units. Aquifer performance test methods applicable to these wells were Hvorslev (Freeze and Cherry, 1979) and Bouwer-Rice (Bouwer, 1978). The Bouwer-Rice method uses an empirical relationship to compute the ratio of the effective radius (R_e) of the aquifer tested to the radius of disturbance (r_w), or well radius plus sand pack radius. The data for well 780, completed in the semiconfined Tres Hermanos-C2 Sandstone, were valid. The range of hydraulic conductivity values calculated from the Bouwer-Rice method for unconfined wells ranged from 1.13×10^{-4} to 1.21×10^{-3} cm/sec (Table B.2.5).

The Hvorslev method requires the data to fit a reasonably straight line which passes through the point (1,0) on a graph of the log ratio of the drawdown at a time (t) to initial drawdown versus time. The data for all wells completed in the unconfined Tres Hermanos-C Sandstone except 785 fit a valid plot, and the range of conductivity values is 1.74×10^{-4} to 1.53×10^{-3} cm/sec (Table B.2.5).

The average hydraulic conductivities calculated from slug tests in the Tres Hermanos-C1 and -C2 Sandstones are 5.2×10^{-4} and 1.1×10^{-4} cm/sec, respectively. These are similar to values obtained by Woodward-Clyde Consultants' (WCC, 1983) in-situ permeability tests (2×10^{-5} cm/sec) (see Table B.2.4) and in-situ single packer permeability tests (range of 1×10^{-4} to 1×10^{-3} cm/sec) for the Tres Hermanos-B Sandstone. This is to be expected as the depositional environments of the Tres Hermanos-B and -C Sandstones are similar. The average hydraulic conductivity calculated from the slug tests on wells in the alluvium is 6.4×10^{-5} cm/sec. This value is close to the values calculated from the Quivira pumping tests in the alluvium one mile east and southeast of the site, near the Arroyo del Puerto (Ganus, 1980) (see Table B.2.4).

An aquifer performance test was conducted in the 35-foot-thick alluvium immediately south of the Ambrosia Lake tailings pile (FBD, 1983). The test was conducted for only 20 minutes and sustained a discharge of only 0.15 gpm indicating that the saturation perched in the basal alluvium south of the pile is of a limited extent.

While Figures B.2.2 through B.2.5 show the geometry of the flow system beneath the site, the direction of ground-water movement and the hydraulic gradient can be determined from construction of an equipotential or water-table map. Figures B.2.7, B.2.12, and B.2.13 show lines of equal hydraulic head (equipotentials) where saturation occurs in the alluvium/weathered Mancos Shale, and the Tres Hermanos-C1 and -C2 Sandstones, respectively.

The potentiometric maps were constructed using the water level elevations determined at each monitor well completed in the given hydrostratigraphic unit. Thirty-seven monitor wells have been installed at the Ambrosia Lake site, 26 completed by the DOE and 11 preexisting (Table B.2.6). Table B.2.7 tabulates the water level elevations and the data of each measurement. No significant variation was observed in water levels measured between October, 1985, and May, 1986. All measurements were reproducible within 1.5 feet.

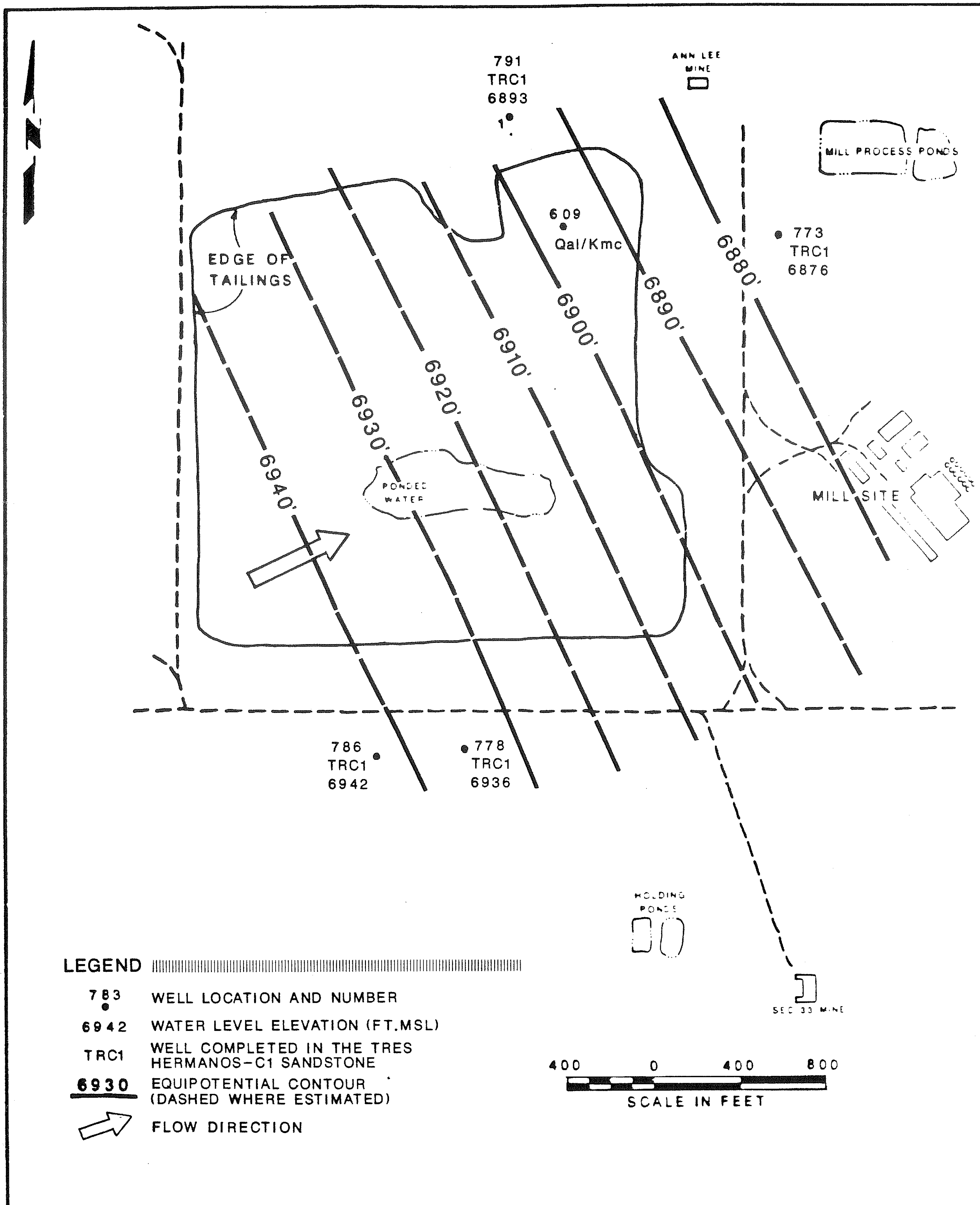


FIGURE B.2.12 EQUIPOTENTIAL MAP FOR TRES HERMANOS-C1 SANDSTONE

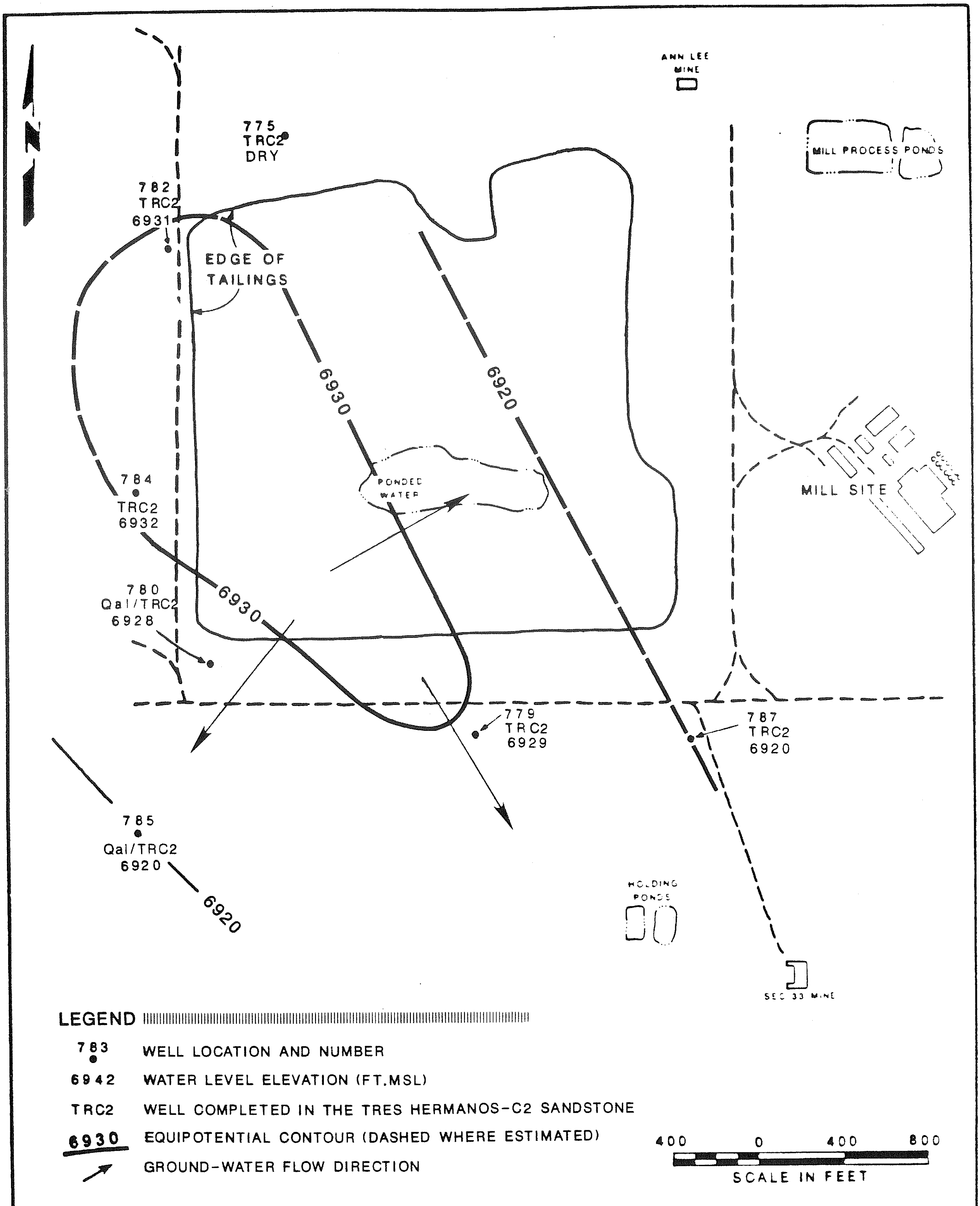


FIGURE B.2.13 EQUIPOTENTIAL MAP FOR TRES HERMANOS-C2 SANDSTONE

Table B.2.6 Ambrosia Lake site monitor well information

Well location number[a]	Well installer[b]	Well diameter (inches)	Total depth (feet)	Ground surface elevation (feet MSL)	Top of casing (feet MSL)	Screened interval: Begin depth (feet from top of casing)	Screened interval: Length (feet)	Screened interval: Formation[c]
773	DOE	4.0	137.0	7006.2	7007.7	132.0	5.0	TrC1
774	DOE	4.0	255.0	7006.6	7007.4	250.0	5.0	TrB
775	DOE	4.0	95.0	6996.5	6998.7	90.0	5.0	TrC2
776	DOE	4.0	50.0	6997.0	6999.1	45.0	5.0	QAL
777	DOE	4.0	158.0	6961.3	6963.2	153.0	5.0	TrB
778	DOE	4.0	37.0	6961.2	6962.7	30.0	5.0	TrC1
779	DOE	4.0	62.0	6961.7	6964.0	57.0	5.0	TrC2
780	DOE	4.0	43.0	6966.0	6968.5	38.0	5.0	QAL/TrC2
781	DOE	4.0	40.0	6965.1	6968.4	35.0	5.0	QAL
782	DOE	4.0	70.0	6989.7	6991.8	65.0	5.0	TrC2
783	DOE	4.0	50.0	6990.7	6993.2	45.0	5.0	QAL
784	DOE	4.0	55.0	6974.8	6977.3	50.0	5.0	TrC2
785	DOE	4.0	45.0	6959.2	6961.3	40.0	5.0	TrC2
786	DOE	4.0	35.0	6961.5	6963.4	30.0	5.0	TrC1?
787	DOE	4.0	80.0	6969.2	6971.3	75.0	5.0	TrC2
788	DOE	4.0	30.0	6967.5	6969.8	25.0	5.0	QAL
789	DOE	4.0	226.0	7001.8	7003.9	216.0	10.0	TrB
790	DOE	4.0	30.0	7002.9	7004.6	25.0	5.0	QAL
791	DOE	4.0	115.0	6998.8	7000.8	110.0	5.0	TrC1
792	DOE	4.0	20.0	6999.0	7001.1	15.0	5.0	QAL/weathered Kmc
793	DOE	4.0	28.0	6996.6	6998.6	23.0	5.0	QAL/weathered Kmc
794	DOE	4.0	22.0	6961.9	6964.2	17.0	5.0	QAL/weathered Kmc
796	DOE	4.0	23.0	6955.1	6957.3	18.0	5.0	QAL
797	DOE	4.0	21.5	6969.7	6972.0	16.5	5.0	QAL/weathered Kmc
798	DOE	4.0	20.0	6978.2	6980.4	15.0	5.0	QAL
799	DOE	4.0	12.0	6980.7	6892.8	7.0	5.0	QAL/weathered Kmc

Table B.2.6 Ambrosia Lake site monitor well information (Concluded)

Well location number[a]	Well installer[b]	Well diameter (inches)	Total depth (feet)	Ground surface elevation (feet MSL)	Top of casing (feet MSL)	Screened interval: Begin depth (feet from top of casing)	Screened interval: Length (feet)	Formation[c]
609[d]	SNL	4.0	30.0	6998.9	7000.89	17.5	10.0	QAL
706[d]	SNL	4.0	45.0	6989.5	6990.45	35.0	10.0	QAL
708[d]	SNL	4.0	40.0	6962.0	6964.01	30.0	10.0	TrCl?
569[e]	QMC	8.0	165.0	6915.7	6917.70	60.0	10.0	QAL
617[f]	QMC	4.0	31.0	6939.6	6941.60	19.0	10.0	QAL
618[f]	QMC	4.0	36.0	6951.9	6953.90	24.0	10.0	QAL
619[f]	QMC	4.0	31.0	6965.7	6967.70	19.0	10.0	QAL
620[f]	QMC	4.0	36.0	6951.9	6953.90	37.0	5.0	QAL
718[e]	QMC	4.0	60.0	6930.5	6932.50			QAL

[a]Well locations plotted on Figure B.2.1.
[b]Well installer: DOE - wells installed for the U.S. Department of Energy by the Technical Assistance Contractor; SNL - Sandia National Laboratories; QMC - Quivira Mining Co.
[c]Formation: TrCl - Tres Hermanos-Cl; TrC2 - Tres Hermanos-C2; TrB - Tres Hermanos-B; TrA - Tres Hermanos-A; Kmc - Mancos Shale; QAL - Alluvium.
[d]Well locations plotted on Figure B.2.14.
[e]Well locations plotted on Figure B.2.15.
[f]Well locations plotted on Figure B.2.11.

Table B.2.7 Water-level elevations at the Ambrosia Lake tailings site

Date of water level measurement	Well location number	Ground elevation	Top casing elevation	Completed formation[a]	Water level depth (feet from top of casing)	Water level elevation (feet MSL)
10/08/85	773	7006.2	7007.7	TrC1	132.10	6875.6
10/08/85	774	7006.6	7007.4	TrB	dry	--
10/08/85	775	6996.5	6998.7	TrC2	dry	--
09/25/85	776	6997.0	6999.1	QAL	dry	--
09/25/85	777	6961.3	6963.2	TrB	dry	--
10/08/85	778	6961.2	6962.7	TrC1	26.88	6935.8
10/08/85	779	6961.7	6964.0	TrC2	35.05	6929.0
10/05/85	780	6966.0	6968.5	QAL/TrC2	40.91	6927.6
10/08/85	781	6965.1	6968.4	QAL	dry	--
10/08/85	782	6989.7	6991.8	TrC2	60.56	6931.2
10/08/85	783	6990.7	6993.2	QAL	--	--
10/08/85	784	6974.8	6977.3	TrC2	45.31	6932.0
10/08/85	785	6959.2	6961.3	TrC2	41.82	6919.5
10/08/85	786	6961.5	6963.4	TrC1?	21.49	6941.9
10/06/85	787	6969.2	6971.3	TrC2	51.80	6919.5
10/08/85	788	6967.5	6969.8	QAL	dry	--
10/08/85	789	7001.8	7003.9	TrB	dry	--
10/08/85	790	7002.9	7004.6	QAL	dry	--
10/08/85	791	6998.8	7000.8	TrC1	107.55	6893.3
10/08/85	792	6999.0	7001.1	QAL/Kmc	15.79	6985.3
10/08/85	793	6996.6	6998.6	QAL/Kmc	21.40	6977.2
10/08/85	794	6961.9	6964.2	QAL/Kmc	dry	--
10/08/85	796	6955.1	6957.3	QAL	dry	--
10/08/85	797	6969.7	6972.0	QAL/Kmc	dry	--
10/08/85	798	6978.2	6980.4	QAL	dry	--
10/08/85	799	6980.7	6982.8	QAL/Kmc	dry	--
10/08/85	609	6998.9	7000.89	QAL	21.60	6979.3
10/08/85	706	6989.5	6990.45	QAL	37.50	6952.9
10/08/85	708	6962.1	6964.1	TrC1?	--	--
10/08/85	569	6915.7	6917.7	QAL	--	--
10/04/85	617	6939.6	6941.6	QAL	dry	--
10/01/85	618	6951.9	6953.9	QAL	dry	--
10/08/85	619	6965.7	6967.7	QAL	24.61	6943.1
10/08/85	620	6951.9	6953.9	QAL	31.76	6922.1
10/04/85	718	6930.5	6932.5	QAL	dry	--

[a]Formation: TrC1 - Tres Hermanos-C1; TrC2 - Tres Hermanos-C2; TrB - Tres Hermanos-B; TrA - Tres Hermanos-A; Kmc - weathered Mancos Shale; QAL - alluvium.

Perched ground water at the base of the alluvium/weathered Mancos Shale moves beneath the northeast corner of the pile predominantly to the south and southwest as indicated by the flow directional arrows. Ground water in the vicinity of monitor well 620 probably travels to the south-southwest and may discharge into the Arroyo del Puerto. Ground-water quality in the alluvium near Arroyo del Puerto (well 650) is of poorer quality than in the vicinity of monitor well 620 (Bostick, 1985). Since poorer ground-water quality presently exists near Arroyo del Puerto, the WQCC standards presently will not be violated beyond background concentrations (represented by tailings seepage from the site) (Bostick, 1986).

The Mancos Shale and the Tres Hermanos-C Sandstone are truncated west of the site in the general direction of alluvial/weathered Mancos Shale ground-water flow. Along the Tres Hermanos-C Sandstone subcrop, ground water perched in the alluvial/weathered Mancos Shale moves downward into the Tres Hermanos-C Sandstone. Monitor wells completed at the base of the alluvium and located downgradient from the pile are dry (wells 781, 794, and 796); alluvial/weathered Mancos Shale well 799 off the east edge of the pile, alluvial wells 788, 797, 780, and 798 off the southeast corner of the pile, and alluvial well 783 on the west edge of the pile are also dry. This is evidence that the alluvium/weathered Mancos Shale in the site area is unsaturated in their natural state, and the extant perched water encountered in site monitor wells is the result of previous recharge from the tailings pond, mine discharge pond, and runoff collection ponds north of the pile. The most northern alluvial well, 790, was completed above the base of the alluvium (see Figure B.2.4). Therefore, it is not known if saturation extends this far north of the pile. The extent of the perched alluvial ground water north of the tailings pile is uncertain, as indicated in Figure B.2.7. Since this area is upgradient of the major recharge sources, the alluvium is probably dry several thousand feet north of the pile.

Figure B.2.12 is an equipotential map for the Tres Hermanos-C1 Sandstone. Most of the Tres Hermanos-C Sandstone wells do not penetrate the full thickness of the unit (see Figures B.2.2 through B.2.5). Borehole geophysical logs and cores (from boreholes 774 and 777) indicate that the cleanest, most sandy intervals of the Tres Hermanos-C Sandstone occur at the top of the unit. The Tres Hermanos-C1 Sandstone is the uppermost clean sand in the Tres Hermanos-C Sandstone. DOE wells were screened opposite the most permeable zone of the Tres Hermanos-C1 Sandstone. Borehole geophysical logs and complete lithologic descriptions of the DOE boreholes are on file in the DOE UMTRA Project Albuquerque Operations Office. Ground water in the Tres Hermanos-C1 Sandstone moves from the southwest to northeast following the dip of the bedrock (see Figures B.2.8 and B.2.12).

The Tres Hermanos-C2 Sandstone equipotential map is shown in Figure B.2.13. This hydrostratigraphic unit occurs beneath the C1 Sandstone and is separated from it by 10 to 15 feet of typical Mancos Shale. This hydrostratigraphic unit grades downward gradually into unweathered Mancos Shale.

The average linear velocity of ground water along a flow path can be calculated from Darcy's Law. The equation is (Freeze and Cherry, 1979):

$$v = \frac{Ki}{n_e}$$

where

- v = average linear velocity along the preferential flow path (cm/sec).
- K = hydraulic conductivity (cm/sec).
- i = hydraulic gradient; drop in head per horizontal distance along a flow path.
- n_e = effective porosity; volume of the saturated unit through which flow occurs relative to the entire volume of the saturated unit.

The average linear velocity of the ground water in the Ambrosia Lake area was calculated using minimum, maximum, and average values of hydraulic conductivity, hydraulic gradient, and effective porosity. The hydraulic conductivity values were determined from slug tests and pumping tests, and laboratory values when available (see Tables B.2.4 and B.2.5). The assumed average effective porosity was approximately 0.33 times the average total porosity (Todd, 1980) and the average hydraulic gradient was measured from Figures B.2.7, B.2.12, and B.2.13. A range of plus or minus 20 percent around the assumed values was used to bound the average effective porosity. The average linear velocities calculated for the alluvium, Tres Hermanos-C1 and -C2 Sandstones, and Westwater Canyon Member are presented in Table B.2.8.

B.2.5 WATER QUALITY AND CONTAMINANT MIGRATION

To chemically characterize the contaminant source and to identify those chemical constituents that have migrated from the tailings into the local ground water, a suite of water-quality samples was collected at the Ambrosia Lake site (Table B.2.9). A major consideration in assessing the chemical data is that there is no basis for determining background water-quality conditions (Kaufmann et al., 1976). This is because limited chemical data exist for ground water in the Ambrosia Lake area before mining began in the early 1950s and there is no uncontaminated water available for sampling at the present time near the site.

The source of contaminated ground water at the Ambrosia Lake tailings site is the result of mine water discharge and tailings seepage from the tailings pile. Approximately six billion gallons per year have been pumped from local hydrostratigraphic units to facilitate uranium mining (Brod and Stone, 1981). This water has been discharged to unlined holding ponds and used for ion exchange uranium recovery, or used for mill processing water, or discharged to the channel of the Arroyo del Puerto. This large-scale pumping has been the primary factor in the occurrence, flow, and quality of shallow ground water.

Table B.2.8 Average linear ground-water velocites for Ambrosia Lake site

Hydrostratigraphic unit	Parameter	Velocity		
		Minimum	Maximum	Average
Alluvium/weathered Mancos Shale	Inputs:			
	Hydraulic conductivity (k)(ft/day)	0.25	2.83	1.53
	Hydraulic gradient (i)	0.017	0.033	0.025
	Effective porosity (n_e)	0.16	0.10	0.13
	Average linear velocity ($v = \frac{Ki}{N_e}$)(ft/day)	0.03	0.93	0.29
Tres Hermanos-C1 Sandstone	Inputs:			
	Hydraulic conductivity (k)(ft/day)	0.04	3.97	1.47
	Hydraulic gradient (i)	0.019	0.033	0.026
	Effective porosity (n_e)	0.06	0.04	0.05[a]
	Average linear velocity ($v = \frac{Ki}{N_e}$)(ft/day)	0.01	3.3	0.77
Tres Hermanos-C2 Sandstone	Inputs:			
	Hydraulic conductivity (k)(ft/day)	0.03	0.71	0.31
	Hydraulic gradient (i)	0.014	0.033	0.024
	Effective porosity (n_e)	0.06	0.04	0.05[a]
	Average linear velocity ($v = \frac{Ki}{N_e}$)(ft/day)	0.01	0.58	0.15
Westwater Canyon Member	Inputs:			
	Hydraulic conductivity (k)(ft/day)[a]	1.08	1.33	1.22
	Hydraulic gradient (i)	0.019[b]	0.033[b]	0.0265[b]
	Effective porosity (n_e)	0.12	0.08	0.10[a]
	Average linear velocity ($v = \frac{Ki}{N_e}$)(ft/day)	0.17	0.55	0.32

[a]Ref. Brod, 1979.
[b]Assumed to be similar to the Tres Hermanos-C1 and -C2 Sandstones as the dip of the geologic units is identical and the hydraulic conductivities are similar.

Table B.2.9 DOE water-quality samples collected from the Ambrosia Lake site and valley

Well location number	Formation sampled	Hydraulic position
Lysimeter		
757[a]	QAL/Kmc pore water	Source area
759[a]	Tailings pore water	Source area
Well point		
737[a]	Tailings water	Source area
743[a]	Tailings water	Source area
746[a]	Tailings water	Source area
747[a]	QAL/Kmc water	Source area
748[a]	QAL/Kmc water	Source area
749[a]	QAL/Kmc water	Source area
750[a]	Tailings water	Source area
751[a]	Tailings water	Source area
752[a]	Tailings water	Source area
Monitor well		
609[a]	QAL/Kmc	Source area
619[a]	QAL	Crossgradient
620[a]	QAL	Crossgradient
650 (AW-2)[b]	QAL	Background
706[a]	QAL/Kmc	Source area
708[a]	TrC1?	Downgradient
709[a]	QAL/Kmc?	Upgradient
710[a]	QAL/Kmc?	Upgradient
718[b]	QAL	Background
773[a]	TrC1	Downgradient
778[a]	TrC1	Downgradient
779[a]	TrC2	Downgradient
780[a]	QAL/TrC2	Downgradient
782[a]	TrC2	Crossgradient
784[a]	TrC2	Downgradient
785[a]	TrC2	Downgradient
786[a]	TrC1?	Downgradient
787[a]	TrC2	Downgradient
791[a]	TrC1	Downgradient
792[a]	QAL/Kmc	Upgradient
793[a]	QAL/Kmc	Upgradient

[a]Well locations plotted in Figure B.2.14.
[b]Well locations plotted in Figure B.2.15.

Abbreviations: QAL - alluvium
Kmc - Mancos Shale
TrC - Tres Hermanos-C Sandstone

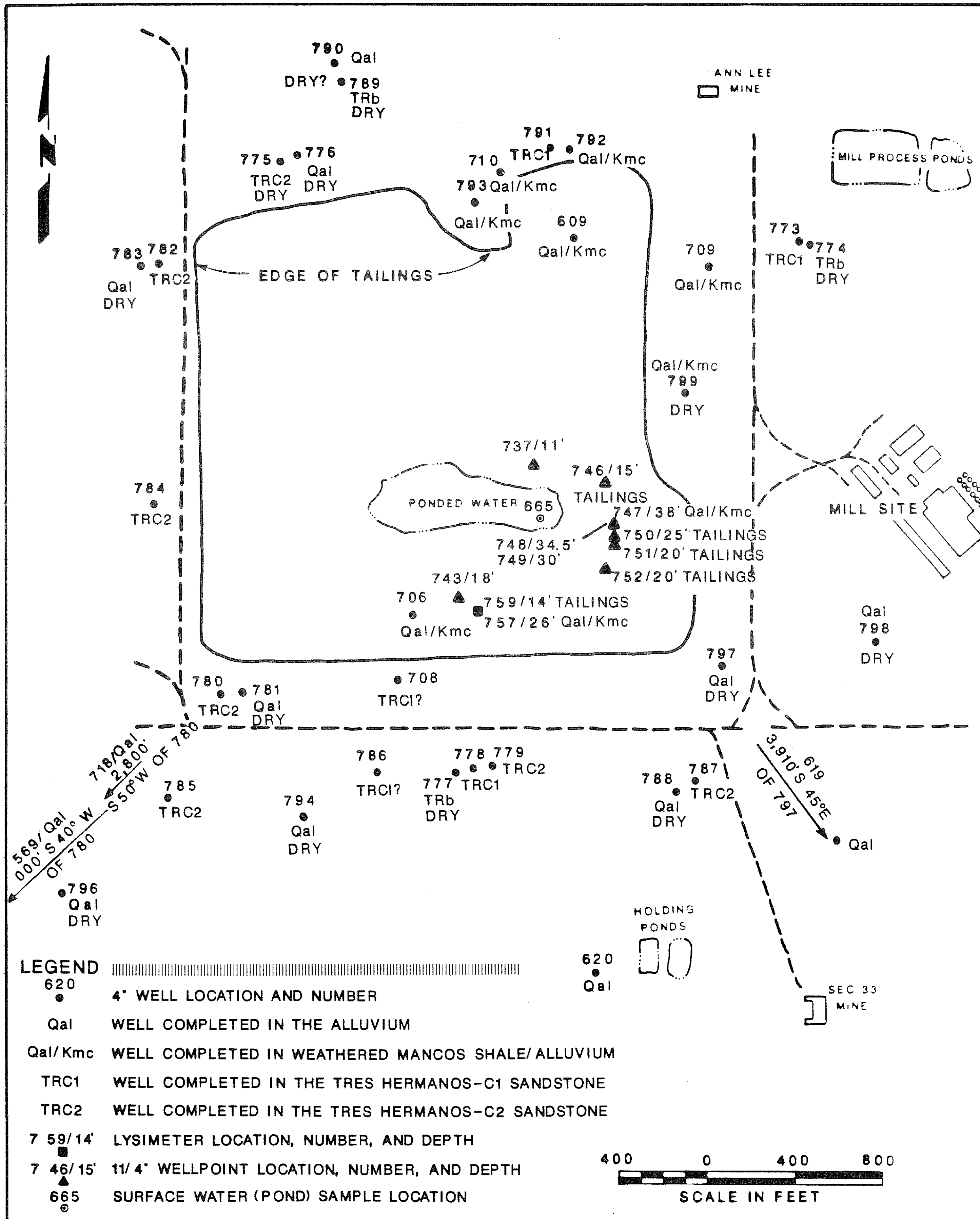


FIGURE B.2.14 DOE WATER-QUALITY SAMPLING LOCATIONS

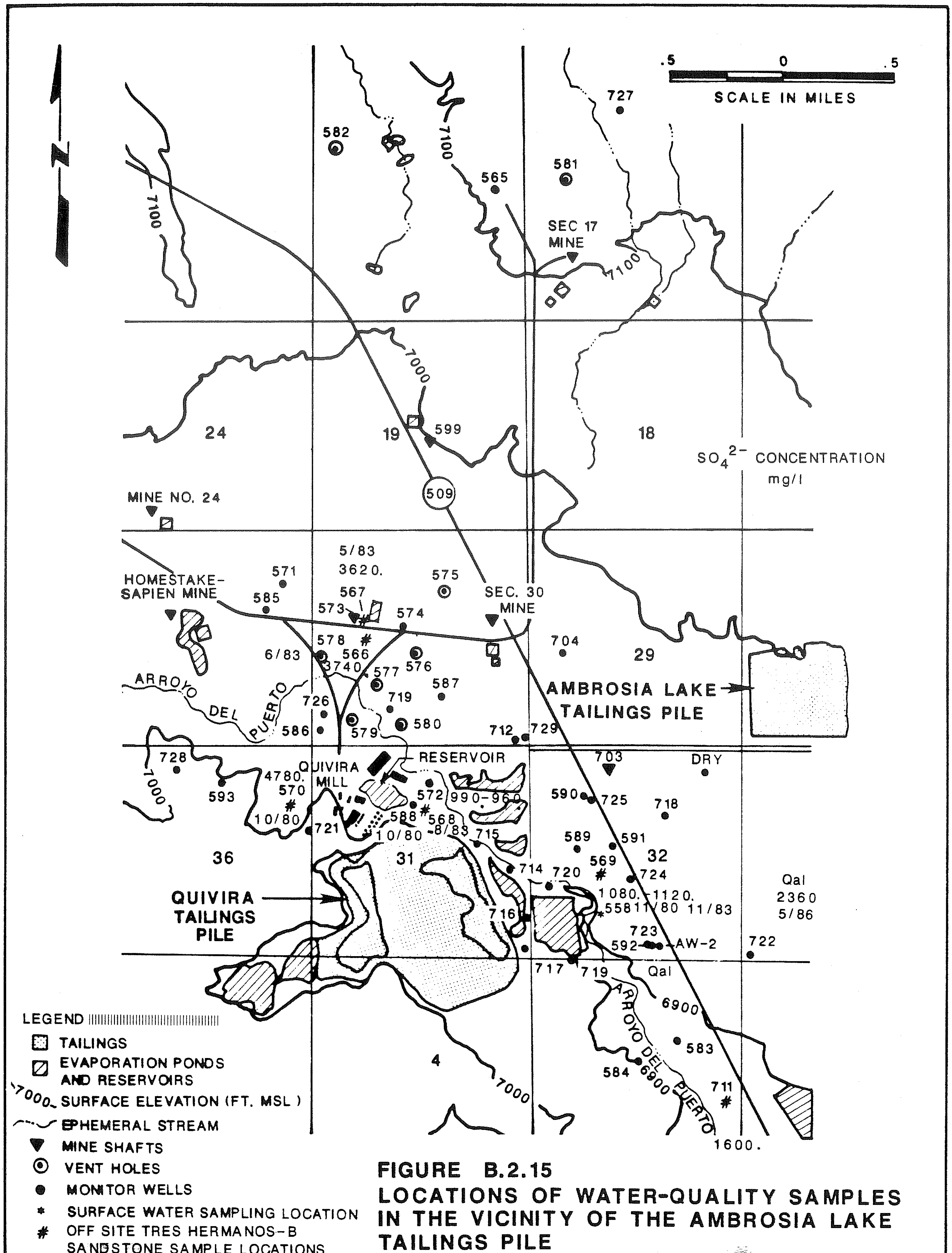


FIGURE B.2.15
LOCATIONS OF WATER-QUALITY SAMPLES IN THE VICINITY OF THE AMBROSIA LAKE TAILINGS PILE

Water-quality data of water pumped from United Nuclear mines to the Ambrosia Lake site mill pond (see Figure B.2.10) show that state and/or Federal standards for selenium, molybdenum, sulfate, total dissolved solids, and Ra-226 plus Ra-228 were regularly exceeded (Table B.2.10). Shallow ground water at the Ambrosia Lake site can be attributed to infiltration from the unlined mill process pond. This water would be expected to exceed some Federal and/or state water quality standards.

Determination of ground-water contamination via seepage from the tailings pile is based upon an assessment of (1) the milling circuit and waste effluents; (2) water-quality results from samples from the tailings pile (source area); and (3) water-quality results from samples from the alluvium/weathered Mancos Shale and Tres Hermanos-C1 and -C2 Sandstones proximal to the tailings pile.

Uranium ore was extracted using an alkaline leach circuit from 1958 to 1963 at the Ambrosia Lake site (Figure B.2.16). The main chemicals added in the mill circuit were sodium carbonate (Na_2CO_3) and sodium hydroxide (NaOH) (caustic). In the precipitation process, sulfuric acid and ammonia are converted to a sodium salt and this salt, along with other chemical constituents (Table B.2.11), was disposed of in the tailings pond. A complete chemical analysis of this effluent is not available; however, chemical compositions of similar alkaline-leach effluent are found in literature (Table B.2.12). The constituents of most concern for ground-water contamination, due to their high concentrations or potential health impacts, are selenium, molybdenum, nitrate, sodium, Ra-226, sulfate, and uranium.

Chemical quality of the Ambrosia Lake site ground water

Some of the monitor wells, well points, and lysimeters shown in Figures B.2.1 and B.2.6 were not sampled, either because they were dry or because they contained too little water to collect a representative sample. In addition, since many wells (706, 718, 773, 728, 782, 784, 785, 792, and 793) were not capable of producing more than one well volume of water prior to collecting a sample, it is possible that oxidation of standing water in wells may have affected some water analysis results. Complete chemical analyses of each sampled location including the major cations/anions, metals, trace constituents, and radionuclides are listed in Tables B.2.13 through B.2.15. Those constituents (maximum values) exceeding state and/or Federal water-quality standards are noted in each table following the presentation of all measured concentrations.

The quality assurance program established by DOE for chemical analysis of water samples collected for the UMTRA Project includes:

- o Samples are divided into lots of no more than ten samples.
- o No less than one in ten samples would be a known sample prepared by a laboratory other than the laboratory analyzing the sample. The analyzing laboratory must meet established accuracy criteria for each constitutent in the known sample.

Table B.2.10 United Nuclear Corporation mine water discharge quality

Constituent	Unit of measurement	Sample Dates 10/27/77	11/17/78	11/07/79
Total suspended solids	mg/l	1.1	1.0	2.0
Total dissolved solids	mg/l	1852[a,b]	1903[a,b]	2441[a,b]
Conductivity	µmhos	2657	2241	3288
pH	S.U.	8.08	--	8.12
Arsenic	mg/l	<0.005	<0.005	0.009
Barium	mg/l	0.27	0.074	<0.100
Selenium	mg/l	0.268[c,d]	0.171[c,d]	0.122[c,d]
Molybdenum	mg/l	3.20[e]	1.914[e]	3.05[e]
Ammonia	mg/l	0.015	0	0.05
Sodium	mg/l	428	421	511
Chloride	mg/l	108	97.5	188
Sulfate	mg/l	1060[a,b]	1115[a,b]	1280[a,b]
Calcium	mg/l	--	150	194
Potassium	mg/l	--	8.19	9.75
Bicarbonate	mg/l	--	228	174.0
Cadmium	mg/l	<0.001	<0.001	--
Nitrate (as N)	mg/l	0.11	<0.01	--
Magnesium	mg/l	--	--	45.3
Vanadium	mg/l	--	<0.010	<0.010
Zinc	mg/l	--	<0.100	<0.250
Aluminum	mg/l	--	--	<0.250
Lead	mg/l	--	<0.005	<0.005
Gross alpha	pCi/l		570±70[f]	360±60[f]
Radium-226	pCi/l	29±1[a,d]	65±1[d,f]	19±6[f]
Radium-228	pCi/l	0±2	--	--
Lead-210	pCi/l	17±6	--	--
Uranium	mg/l	0.32	2.23	1.31

[a]Exceeds Federal secondary drinking water standards.
[b]Exceeds State of New Mexico standards for domestic water supply.
[c]Exceeds Federal interim primary drinking water standards.
[d]Exceeds State of New Mexico human health standards.
[e]Exceeds State of New Mexico standards for irrigation use.
[f]Exceeds standards for management of uranium byproduct materials.

Ref. NMEID, 1980.

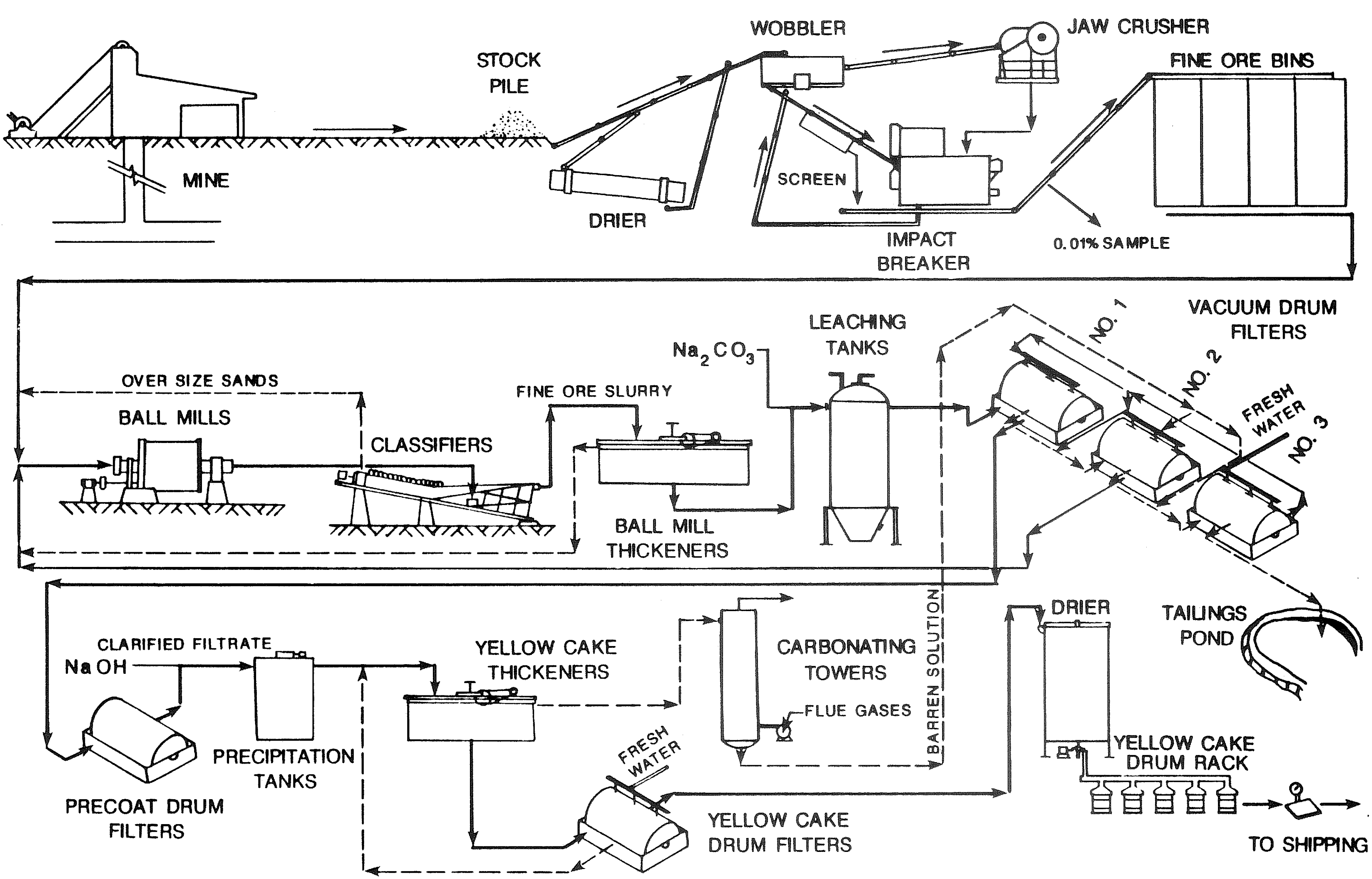


FIGURE B.2.16 AMBROSIA LAKE MILL SIMPLIFIED FLOW SHEET

Table B.2.11 Composition of mill effluent at the Ambrosia Lake tailings pond

Constituent[a]	Unit of measurement[b]	Concentration
Sodium sulfate	mg/l	10,000
Sodium carbonate	mg/l	5,000
Uranium	mg/l	5
Vanadium	mg/l	114
Molybdenum	mg/l	178
Silicon dioxide	mg/l	228
Percent solids		45
Percent liquid		55

[a]Small amounts of chloride, selenium, fluoride, and phosphate also present.
[b]mg/l = milligrams per liter.

Ref. Hunter, 1958.

Table B.2.12 Chemical composition of alkaline leach mill effluents

Constituents	Unit of measurement[a]	Mill: United Nuclear-Homestake Partners (Milan, New Mexico)	Mill: An alkaline leach mill in New Mexico (median from 3 samples)
Total suspended solids	mg/l	52.0	--
Total dissolved solids	mg/l	20,710	20,700
Conductivity	(μmhos/cm)	23,990	--
pH	S.U.	10.2	10.2
Arsenic	mg/l	7.19	5.0
Barium	mg/l	0.051	--
Selenium	mg/l	31.16	31.0
Molybdenum	mg/l	105	104
Ammonia	mg/l	13.9	--
Sodium	mg/l	8,464	8,460
Chloride	mg/l	1,014	1,010
Sulfate	mg/l	8,346	8,350
Calcium	mg/l	10.0	--
Potassium	mg/l	31.2	--
Bicarbonate	mg/l	--	--
Cadmium	mg/l	0.028	--
Nitrate (as N)	mg/l	22.42	--
Magnesium	mg/l	--	--
Vanadium	mg/l	13.6	--
Zinc	mg/l	<0.10	--
Aluminum	mg/l	--	--
Lead	mg/l	<0.005	--
Gross alpha	pCi/l	10,000 ± 1,000	6,700
Radium	pCi/l	90 ± 1	58 ± 4
Lead	pCi/l	49 ± 8	--
Uranium	mg/l	52.8	44

[a]mg/l - milligrams per liter, S.U. - Standard Units, pCi/l - picocuries per liter ± one standard deviation; μmhos/cm.

Ref. NMEID, 1980; Gallaher and Goad, 1981; presumably the United Nuclear-Homestake Partners mill, although not stated.

Table B.2.13 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
09/26/85 TO 05/15/86

FORMATION OF COMPLETION: URANIUM MILL TAILINGS

PARAMETER	UNIT OF MEASURE	737-01 05/13/86 PARAMETER VALUE+/-UNCERTAINTY [a]		743-01 05/13/86 PARAMETER VALUE+/-UNCERTAINTY		746-01 09/26/85 PARAMETER VALUE+/-UNCERTAINTY		750-01 09/26/85 PARAMETER VALUE+/-UNCERTAINTY		751-01 10/09/85 PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	6175.		6371.		4341.		2258.		4501.	
ALUMINUM	MG/L	- [b]		-		0.4		0.5		0.2	
AMMONIUM	MG/L	-		-		0.2		0.2		1.6	
ANTIMONY	MG/L	-		-		< 0.003		0.056		< 0.003	
ARSENIC	MG/L	< [c] 0.01		< 0.01		< 0.01		< 0.01		0.01	
BARIUM	MG/L	-		-		0.3		0.1		0.1	
BORON	MG/L	-		-		0.7		0.3		0.4	
CADMIUM	MG/L	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
CALCIUM	MG/L	10.6		16.2		4.32		36.7		1.94	
CHLORIDE	MG/L	200.		110.		12.		22.		16.	
CHROMIUM	MG/L	0.03		0.1		0.03		0.04		0.03	
COBALT	MG/L	0.1		0.1		0.08		0.07		0.08	
CONDUCTANCE	UMHO/CM	14000.		16500.		14000.		10000.		12000.	
COPPER	MG/L	-		-		0.04		0.05		0.03	
CYANIDE	MG/L	-		-		< 0.01		< 0.01		< 0.01	
FLUORIDE	MG/L	15.		19.		19.		21.		14.	
IRON	MG/L	0.49		0.47		0.21		0.23		0.13	
LEAD	MG/L	-		-		< 0.01		< 0.01		< 0.01	
MAGNESIUM	MG/L	3.01		5.65		1.29		18.1		0.225	
MANGANESE	MG/L	0.03		0.02		0.02		0.02		0.03	
MERCURY	MG/L	-		-		< 0.0002		< 0.0002		< 0.0002	
MOLYBDENUM	MG/L	250.		161.		113.		95.9		99.	
NICKEL	MG/L	-		-		0.14		0.13		0.13	
NITRATE	MG/L	10.		6.		3.		1.		3600.	
NITRITE	MG/L	-		-		< 0.1		< 0.1		< 0.1	
PB-210	PCI/L	-		-		-		55.	3	52.	3
PH	SU	9.74		9.71		9.97		9.61		10.13	
PHOSPHATE	MG/L	-		-		14.		4.8		15.	
POTASSIUM	MG/L	17.1		25.		16.8		22.3		25.1	
RA-226	PCI/L	71.	11	-		140.	10	90.	10	220.	20
RA-228	PCI/L	-		-		0.	3.3	0.1	3.2	0.	3.9
SELENIUM	MG/L	< 0.005		< 0.005		< 0.005		< 0.005		0.019	
SILICA	MG/L	-		-		13.		9.		10.	
SILVER	MG/L	-		-		< 0.01		< 0.01		< 0.01	
SODIUM	MG/L	6620.		5920.		4810.		4190.		5240.	
STRONTIUM	MG/L	< 0.1		0.2		< 0.1		0.5		< 0.1	
SULFATE	MG/L	7700.		7890.		5890.		6550.		5416.	
SULFIDE	MG/L	-		-		< 0.1		< 0.1		< 0.1	
TEMPERATURE	C - DEGREE	14.		18.		18.		17.		15.	
TH-230	PCI/L	58.	11	-		34.	9	-		70.	10
TIN	MG/L	-		-		< 0.005		< 0.005		< 0.005	
TOTAL SOLIDS	MG/L	-		-		13600.		13100.		13300.	
URANIUM	MG/L	10.7		2.47		1.32		6.27		2.49	
VANADIUM	MG/L	0.57		0.56		0.09		< 0.01		< 0.01	
ZINC	MG/L	-		-		0.04		0.053		0.044	

Table B.2.13 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
09/26/85 TO 05/15/86 (Continued)

FORMATION OF COMPLETION: URANIUM MILL TAILINGS

PARAMETER	UNIT OF MEASURE	751-02 10/09/85 PARAMETER VALUE	+/-UNCERTAINTY	751-03 10/09/85 PARAMETER VALUE	+/-UNCERTAINTY	751-04 10/09/85 PARAMETER VALUE	+/-UNCERTAINTY	751-05 10/09/85 PARAMETER VALUE	+/-UNCERTAINTY	752-04 09/26/85 PARAMETER VALUE	+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	4501.		4501.		4501.		4501.		6828.	
ALUMINUM	MG/L	0.4		0.5		0.4		0.3		0.4	
AMMONIUM	MG/L	1.6		1.8		1.6		1.6		< 0.1	
ANTIMONY	MG/L	< 0.003		< 0.003		< 0.003		< 0.003		< 0.003	
ARSENIC	MG/L	0.01		0.01		0.01		0.01		< 0.01	
BARIUM	MG/L	0.1		0.1		0.1		0.1		0.1	
BORON	MG/L	0.4		0.3		0.3		0.4		0.4	
CADMIUM	MG/L	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
CALCIUM	MG/L	1.94		3.63		2.52		1.94		4.28	
CHLORIDE	MG/L	20.		26.		21.		15.		6.	
CHROMIUM	MG/L	0.02		0.02		0.04		0.02		0.02	
COBALT	MG/L	0.07		0.07		0.06		0.07		0.07	
CONDUCTANCE	UMHO/CM	12000.		12000.		12000.		12000.		17000.	
COPPER	MG/L	0.03		0.04		0.04		0.03		0.04	
CYANIDE	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	
FLUORIDE	MG/L	14.		14.		14.		1.4		16.	
IRON	MG/L	0.1		0.15		0.18		0.12		0.18	
LEAD	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	
MAGNESIUM	MG/L	0.196		0.571		0.282		0.22		2.3	
MANGANESE	MG/L	0.02		0.02		0.04		0.04		0.02	
MERCURY	MG/L	< 0.0002		< 0.0002		< 0.0002		< 0.0002		< 0.0002	
MOLYBDENUM	MG/L	102.		97.5		102.		104.		148.	
NICKEL	MG/L	0.15		0.18		0.13		0.13		0.13	
NITRATE	MG/L	2600.		4900.		2500.		350.		3.	
NITRITE	MG/L	< 0.1		< 0.1		< 0.1		< 0.1		< 0.1	
PB-210	PCI/L	48.	3	90.	4	52.	3	-		66.	3
PH	SU	10.43		10.43		10.43		10.43		9.97	
PHOSPHATE	MG/L	13.		17.		13.		14.		19.	
POTASSIUM	MG/L	24.8		24.7		25.1		25.6		38.8	
RA-226	PCI/L	240.	20	190.	10	230.	10	200.	10	22.	4
RA-228	PCI/L	0.	4	0.6	4.7	0.	3.1	0.8	3.6	0.1	3.6
SELENIUM	MG/L	0.015		0.015		0.016		0.018		< 0.005	
SILICA	MG/L	10.		10.		10.		10.		12.	
SILVER	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	
SODIUM	MG/L	4870.		5860.		4870.		4840.		5730.	
STRONTIUM	MG/L	< 0.1		< 0.1		< 0.1		< 0.1		-	
SULFATE	MG/L	5130.		5400.		5320.		5290.		6660.	
SULFIDE	MG/L	< 0.1		< 0.1		< 0.1		< 0.1		< 0.1	
TEMPERATURE	C - DEGREE	15.		15.		15.		15.		16.	
TH-230	PCI/L	60.	10	50.	10	50.	10	60.	10	120.	30
TIN	MG/L	< 0.005		< 0.005		< 0.005		< 0.005		< 0.005	
TOTAL SOLIDS	MG/L	12700.		13100.		13000.		13000.		17200.	
URANIUM	MG/L	2.65		5.68		2.46		2.22		8.65	
VANADIUM	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	
ZINC	MG/L	0.017		0.046		0.031		0.025		0.078	

Table B.2.13 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
09/26/85 TO 05/15/86 (Continued)

FORMATION OF COMPLETION: URANIUM MILL TAILINGS

		LOCATION ID - SAMPLE ID AND LOG DATE				
		757-01 10/16/85	757-01 05/15/86	759-01 10/16/85		
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	-	5594.	-		
ALUMINUM	MG/L	0.6	-	0.2		
AMMONIUM	MG/L	3.1	-	3.1		
ANTIMONY	MG/L	< 0.003	-	< 0.003		
ARSENIC	MG/L	0.01	< 0.01	< 0.01		
BARIUM	MG/L	0.1	-	0.1		
BORON	MG/L	0.6	-	0.3		
CADMIUM	MG/L	< 0.001	< 0.001	< 0.001		
CALCIUM	MG/L	3.4	20.2	8.38		
CHLORIDE	MG/L	15.	39.	-		
CHROMIUM	MG/L	0.02	< 0.01	0.02		
COBALT	MG/L	0.07	0.1	< 0.05		
CONDUCTANCE	UMHO/CM	-	15000.	-		
COPPER	MG/L	0.03	-	0.03		
CYANIDE	MG/L	< 0.01	-	< 0.01		
FLUORIDE	MG/L	-	-	-		
IRON	MG/L	-	0.65	-		
LEAD	MG/L	< 0.01	-	< 0.01		
MAGNESIUM	MG/L	0.899	3.63	2.63		
MANGANESE	MG/L	0.03	0.06	0.03		
MERCURY	MG/L	-	-	-		
MOLYBDENUM	MG/L	155.	158.	247.		
NICKEL	MG/L	-	-	-		
NITRATE	MG/L	150.	-	-		
NITRITE	MG/L	< 0.1	-	< 0.1		
PB-210	PCI/L	-	-	-		
PH	SU	-	9.97	-		
PHOSPHATE	MG/L	-	-	-		
POTASSIUM	MG/L	40.3	38.1	46.7		
RA-226	PCI/L	-	-	-		
RA-228	PCI/L	-	-	-		
SELENIUM	MG/L	0.016	< 0.005	0.017		
SILICA	MG/L	-	-	-		
SILVER	MG/L	< 0.01	-	< 0.01		
SODIUM	MG/L	4790.	6090.	9880.		
STRONTIUM	MG/L	-	0.1	-		
SULFATE	MG/L	7640.	8010.	11000.		
SULFIDE	MG/L	< 0.1	-	< 0.1		
TEMPERATURE	C - DEGREE	-	47.	-		
TH-230	PCI/L	-	-	-		
TIN	MG/L	< 0.005	-	< 0.005		
TOTAL SOLIDS	MG/L	17000.	-	25800.		
URANIUM	MG/L	9.84	14.7	-		
VANADIUM	MG/L	< 0.01	0.45	< 0.01		
ZINC	MG/L	0.01	-	0.025		

Table B.2.13 GROUND WATER QUALITY MEASUREMENTS EXCEEDING STANDARDS
SITE: AMBROSIA LAKE
09/26/85 TO 05/15/86 (Continued)

FORMATION OF COMPLETION: URANIUM MILL TAILINGS

PARAMETER	UNITS OF MEASURE	MAXIMUM VALUE[d]	LOCATION ID	SAMPLE ID	LOG DATE	PARAMETER VALUE+/-UNCERTAINTY
ALUMINUM	MG/L	5.0	-	-	-	-
ARSENIC	MG/L	0.05	-	-	-	-
BARIUM	MG/L	1.0	-	-	-	-
BORON	MG/L	0.75	-	-	-	-
CADMIUM	MG/L	0.01	-	-	-	-
CHLORIDE	MG/L	250.0	-	-	-	-
CHROMIUM	MG/L	0.05	743	01	05/13/86	.1000
**** SAMPLES EXCEEDING MAXIMUM VALUE = 7 % ****						
COBALT	MG/L	0.05	737	01	05/13/86	.1000
			743	01	05/13/86	.1000
			746	01	09/26/85	.0800
			750	01	09/26/85	.0700
			751	01	10/09/85	.0800
			751	02	10/09/85	.0700
			751	03	10/09/85	.0700
			751	04	10/09/85	.0600
			751	05	10/09/85	.0700
			752	01	09/26/85	.0700
			757	01	10/16/85	.0700
			757	01	05/15/86	.1000
**** SAMPLES EXCEEDING MAXIMUM VALUE = 92 % ****						
COPPER	MG/L	1.0	-	-	-	-
FLUORIDE	MG/L	1.4	737	01	05/13/86	15.0000
			743	01	05/13/86	19.0000
			746	01	09/26/85	19.0000
			750	01	09/26/85	21.0000
			751	01	10/09/85	11.0000
			751	02	10/09/85	14.0000
			751	03	10/09/85	14.0000
			751	04	10/09/85	14.0000
			752	01	09/26/85	16.0000
**** SAMPLES EXCEEDING MAXIMUM VALUE = 89 % ****						
GROSS ALPHA	PCI/L	15.0	-	-	-	-
IRON	MG/L	0.3	737	01	05/13/86	.4900
			743	01	05/13/86	.4700
			757	01	05/15/86	.6500
**** SAMPLES EXCEEDING MAXIMUM VALUE = 27 % ****						
LEAD	MG/L	0.05	-	-	-	-
MANGANESE	MG/L	0.05	757	01	05/15/86	.0600
**** SAMPLES EXCEEDING MAXIMUM VALUE = 7 % ****						
MERCURY	MG/L	0.002	-	-	-	-
MOLYBDENUM	MG/L	1.00	737	01	05/13/86	250.0000

Table B.2.13 GROUND WATER QUALITY MEASUREMENTS EXCEEDING STANDARDS
SITE: AMBROSIA LAKE
09/26/85 TO 05/15/86 (Continued)

FORMATION OF COMPLETION: URANIUM MILL TAILINGS

PARAMETER	UNITS OF MEASURE	MAXIMUM VALUE	LOCATION ID	SAMPLE ID	LOG DATE	PARAMETER VALUE+/-UNCERTAINTY	
MOLYBDENUM	MG/L	1.00	743	01	05/13/86	161.0000	
			746	01	09/26/85	113.0000	
			750	01	09/26/85	95.9000	
			751	01	10/09/85	99.0000	
			751	02	10/09/85	102.0000	
			751	03	10/09/85	97.5000	
			751	04	10/09/85	102.0000	
			751	05	10/09/85	104.0000	
			752	01	09/26/85	148.0000	
			757	01	10/16/85	155.0000	
			757	01	05/15/86	158.0000	
			759	01	10/16/85	247.0000	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 100 % ****							
NICKEL	MG/L	0.20	-	-	-	-	
NITRATE	MG/L	44.0	751	01	10/09/85	3600.0000	
			751	02	10/09/85	2600.0000	
			751	03	10/09/85	1900.0000	
			751	04	10/09/85	2500.0000	
			751	05	10/09/85	350.0000	
			757	01	10/16/85	150.0000	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 54 % ****							
PH	SU	6.5 TO 8.5	737	01	05/13/86	9.7400	
			743	01	05/13/86	9.7100	
			746	01	09/26/85	9.9700	
			750	01	09/26/85	9.6100	
			751	01	10/09/85	10.1300	
			751	02	10/09/85	10.1300	
			751	03	10/09/85	10.1300	
			751	04	10/09/85	10.1300	
			751	05	10/09/85	10.1300	
			752	01	09/26/85	9.9700	
			757	01	05/15/86	9.9700	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 100 % ****							
RA226+RA228	PCI/L	5.0	737	01	05/13/86	71.0000	11
			746	01	09/26/85	110.0000	10
			750	01	09/26/85	90.1000	10
			751	01	10/09/85	220.0000	20
			751	02	10/09/85	240.0000	20
			751	03	10/09/85	190.6000	10
			751	04	10/09/85	230.0000	10
			751	05	10/09/85	200.8000	10
			752	01	09/26/85	22.1000	4
**** SAMPLES EXCEEDING MAXIMUM VALUE = 100 % ****							

Table B.2.13 GROUND WATER QUALITY MEASUREMENTS EXCEEDING STANDARDS
SITE: AMBROSIA LAKE
09/26/85 TO 05/15/86 (Concluded)

FORMATION OF COMPLETION: URANIUM MILL TAILINGS

PARAMETER	UNITS OF MEASURE	MAXIMUM VALUE	LOCATION ID	SAMPLE ID	LOG DATE	PARAMETER VALUE+/-UNCERTAINTY
SELENIUM	MG/L	0.01	751	01	10/09/85	.0190
			751	02	10/09/85	.0150
			751	03	10/09/85	.0150
			751	04	10/09/85	.0160
			751	05	10/09/85	.0180
			757	01	10/16/85	.0160
			759	01	10/16/85	.0170
**** SAMPLES EXCEEDING MAXIMUM VALUE = 53 % ****						
SILVER	MG/L	0.05	-	-	-	-
SULFATE	MG/L	250.0	737	01	05/13/86	7700.0000
			743	01	05/13/86	7890.0000
			746	01	09/26/85	5890.0000
			750	01	09/26/85	6550.0000
			751	01	10/09/85	5416.0000
			751	02	10/09/85	5130.0000
			751	03	10/09/85	5400.0000
			751	04	10/09/85	5320.0000
			751	05	10/09/85	5290.0000
			752	01	09/26/85	6660.0000
			757	01	10/16/85	7640.0000
			757	01	05/15/86	8010.0000
			759	01	10/16/85	11000.0000
**** SAMPLES EXCEEDING MAXIMUM VALUE = 100 % ****						
TOTAL SOLIDS	MG/L	500.0	746	01	09/26/85	13600.0000
			750	01	09/26/85	13100.0000
			751	01	10/09/85	13300.0000
			751	02	10/09/85	12700.0000
			751	03	10/09/85	13100.0000
			751	04	10/09/85	13000.0000
			751	05	10/09/85	13000.0000
			752	01	09/26/85	17200.0000
			757	01	10/16/85	17000.0000
			759	01	10/16/85	25800.0000
**** SAMPLES EXCEEDING MAXIMUM VALUE = 100 % ****						
URANIUM	MG/L	5.0	737	01	05/13/86	10.7000
			750	01	09/26/85	6.2700
			751	03	10/09/85	5.6800
			752	01	09/26/85	8.6500
			757	01	10/16/85	9.8400
			757	01	05/15/86	14.7000
**** SAMPLES EXCEEDING MAXIMUM VALUE = 50 % ****						
ZINC	MG/L	5.0	-	-	-	-

[a] Parameter value $\pm$ uncertainty applies to radionuclides Pb-210, Ra-226, and Th-230.
[b] - indicates analysis not performed.
[c] 0.01 parameter value is less than 0.01
[d] Maximum value is WQCC standard or Federal standard, whichever is less.

Table B.2.14 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86

FORMATION OF COMPLETION: ALLUVIUM

		LOCATION ID - SAMPLE ID AND LOG DATE									
		609-01 09/30/85		609-02 09/30/85		609-03 09/30/85		609-04 09/30/85		609-05 09/30/85	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY[a]		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	462.		462.		462.		462.		462.	
ALUMINUM	MG/L	- [b]		0.3		0.3		0.2		0.3	
AMMONIUM	MG/L	-		< 0.1		< 0.1		< 0.1		< 0.1	
ANTIMONY	MG/L	-		< 0.003		< 0.003		< 0.003		< 0.003	
ARSENIC	MG/L	<[c] 0.01		< 0.01		< 0.01		< 0.01		< 0.01	
BARIUM	MG/L	-		0.1		0.1		0.1		0.1	
BICARBONATE	MG/L	-		-		-		-		-	
BORON	MG/L	-		0.4		0.5		0.6		0.5	
CADMIUM	MG/L	-		< 0.001		< 0.001		< 0.001		< 0.001	
CALCIUM	MG/L	562.		610.		536.		540.		492.	
CHLORIDE	MG/L	148.		150.		150.		150.		150.	
CHROMIUM	MG/L	-		0.04		0.03		0.05		0.04	
COBALT	MG/L	-		0.07		0.06		0.07		0.09	
CONDUCTANCE	UMHO/CM	3200.		3200.		3200.		3200.		3200.	
COPPER	MG/L	-		0.03		0.05		0.04		0.04	
CYANIDE	MG/L	-		< 0.01		< 0.01		< 0.01		< 0.01	
FLUORIDE	MG/L	-		0.5		0.4		0.4		0.6	
GROSS ALPHA	PCI/L	-		-		-		-		-	
IRON	MG/L	-		< 0.03		< 0.03		0.04		< 0.03	
LEAD	MG/L	-		< 0.01		< 0.01		< 0.01		< 0.01	
MAGNESIUM	MG/L	156.		142.		157.		160.		164.	
MANGANESE	MG/L	-		0.47		0.48		0.52		0.49	
MERCURY	MG/L	-		< 0.0002		< 0.0002		< 0.0002		< 0.0002	
MOLYBDENUM	MG/L	1.41		1.47		1.59		1.47		1.47	
NICKEL	MG/L	-		0.09		0.1		0.09		0.1	
NITRATE	MG/L	-		3.		3.		3.		4.	
NITRITE	MG/L	-		< 0.1		< 0.1		< 0.1		< 0.1	
ORG. CARBON	MG/L	-		-		-		-		-	
PB-210	PCI/L	-		3.2	2.5	2.9	2.4	2.6	2.7	2.7	2.8
PH	SU	7.11		7.11		7.11		7.11		7.11	
PHOSPHATE	MG/L	-		0.4		0.4		0.4		0.5	
PO-210	PCI/L	-		-		-		-		-	
POTASSIUM	MG/L	1.06		1.14		1.38		1.14		1.1	
RA-226	PCI/L	-		410.	20	11.	3	8.3	2.9	7.9	3.2
RA-228	PCI/L	-		0.	4	0.2	4.5	0.3	5	0.2	3
SELENIUM	MG/L	0.147		0.01		0.01		0.014		0.013	
SILICA	MG/L	-		11.		11.		10.		12.	
SILVER	MG/L	-		< 0.01		< 0.01		< 0.01		< 0.01	
SODIUM	MG/L	520.		470.		538.		527.		576.	
STRONTIUM	MG/L	-		9.8		10.		12.		12.	
SULFATE	MG/L	2420.		2400.		2400.		2400.		2390.	
SULFIDE	MG/L	-		< 0.1		< 0.1		< 0.1		< 0.1	
TEMPERATURE	C - DEGREE	12.		12.		12.		12.		12.	
TH-230	PCI/L	-		1.4	1.1	0.9	0.9	0.9	0.9	0.5	0.8
TIN	MG/L	-		< 0.005		< 0.005		< 0.005		< 0.005	
TOTAL SOLIDS	MG/L	4310.		4370.		4330.		4350.		4360.	
TOTAL SS	MG/L	-		-		-		-		-	

Table B.2.14 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

		LOCATION ID - SAMPLE ID AND LOG DATE				
		609-01 09/30/85	609-02 09/30/85	609-03 09/30/85	609-04 09/30/85	609-05 09/30/85
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
U-234	PCI/L	-	-	-	-	-
URANIUM	MG/L	0.0807	0.102	0.0991	0.0848	0.0885
VANADIUM	MG/L	-	< 0.01	< 0.01	< 0.01	< 0.01
ZINC	MG/L	-	0.069	0.063	0.075	0.066

Table B.2.14 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

		LOCATION ID - SAMPLE ID AND LOG DATE				
		609-01 05/13/86	609-02 05/13/86	609-03 05/13/86	609-04 05/13/86	609-05 05/13/86
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	463.	463.	463.	463.	463.
ALUMINUM	MG/L	-	-	-	-	-
AMMONIUM	MG/L	-	-	-	-	-
ANTIMONY	MG/L	-	-	-	-	-
ARSENIC	MG/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
BARIUM	MG/L	-	-	-	-	-
BICARBONATE	MG/L	-	-	-	-	-
BORON	MG/L	1.	1.	1.	1.	1.
CADMIUM	MG/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
CALCIUM	MG/L	566.	566.	566.	566.	566.
CHLORIDE	MG/L	160.	160.	160.	160.	160.
CHROMIUM	MG/L	0.2	0.02	0.02	0.02	0.02
COBALT	MG/L	0.09	0.09	0.09	0.09	0.09
CONDUCTANCE	UMHO/CM	3450.	3450.	3450.	3450.	3450.
COPPER	MG/L	-	-	-	-	
CYANIDE	MG/L	-	-	-	-	-
FLUORIDE	MG/L	0.4	0.3	0.3	0.3	0.3
GROSS ALPHA	PCI/L	-	-	-	-	-
IRON	MG/L	0.05	0.05	0.05	0.05	0.05
LEAD	MG/L	-	-	-	-	-
MAGNESIUM	MG/L	149.	149.	149.	150.	149.
MANGANESE	MG/L	0.68	0.68	0.68	0.68	0.68
MERCURY	MG/L	-	-	-	-	-
MOLYBDENUM	MG/L	1.41	1.39	1.4	1.41	1.43
NICKEL	MG/L	-	-	-	-	-
NITRATE	MG/L	< 1.	< 1.	< 1.	< 1.	< 1.
NITRITE	MG/L	-	-	-	-	-
ORG. CARBON	MG/L	-	-	-	-	-
PB-210	PCI/L	-	-	-	-	-
PH	SU	6.87	6.87	6.87	6.87	6.87
PHOSPHATE	MG/L	-	-	-	-	-
PO-210	PCI/L	-	-	-	-	-
POTASSIUM	MG/L	0.83	0.83	0.83	0.83	0.83
RA-226	PCI/L	-	-	-	-	-
RA-228	PCI/L	-	-	-	-	-
SELENIUM	MG/L	0.009	0.009	0.009	0.009	0.009
SILICA	MG/L	-	-	-	-	-
SILVER	MG/L	-	-	-	-	-
SODIUM	MG/L	590.	590.	590.	590.	590.
STRONTIUM	MG/L	0.8	0.8	0.8	0.8	0.8
SULFATE	MG/L	2540.	2530.	2520.	2540.	2530.
SULFIDE	MG/L	-	-	-	-	-
TEMPERATURE	C - DEGREE	16.	16.	16.	16.	16.
TH-230	PCI/L	-	-	-	-	-
TIN	MG/L	-	-	-	-	-
TOTAL SOLIDS	MG/L	4360.	4390.	1540.	4370.	4390.
TOTAL SS	MG/L	-	-	-	-	-

Table B.2.14 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

		LOCATION ID - SAMPLE ID AND LOG DATE				
		609-01 05/13/86	609-02 05/13/86	609-03 05/13/86	609-04 05/13/86	609-05 05/13/86
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
U-234	PCI/L	-	-	-	-	-
URANIUM	MG/L	0.0537	0.0534	0.0547	0.05	0.0506
VANADIUM	MG/L	0.41	0.41	0.4	0.4	0.42
ZINC	MG/L	-	-	-	-	-

Table B.2.14 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

PARAMETER	UNIT OF MEASURE	619-01 10/02/85 PARAMETER VALUE+/-UNCERTAINTY		620-01 10/02/85 PARAMETER VALUE+/-UNCERTAINTY		650-01 05/22/86 PARAMETER VALUE+/-UNCERTAINTY		650-02 05/22/86 PARAMETER VALUE+/-UNCERTAINTY		650-03 05/22/86 PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	597.		294.		260.		260.		260.	
ALUMINUM	MG/L	-		0.4		-		-		-	
AMMONIUM	MG/L	-		< 0.1		-		-		-	
ANTIMONY	MG/L	-		< 0.003		-		-		-	
ARSENIC	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	
BARIUM	MG/L	-		0.1		-		-		-	
BICARBONATE	MG/L	-		-		-		-		-	
BORON	MG/L	-		0.4		0.5		0.6		0.5	
CADMIUM	MG/L	-		< 0.001		< 0.001		< 0.001		< 0.001	
CALCIUM	MG/L	380.		533.		565.		565.		565.	
CHLORIDE	MG/L	165.		36.		240.		240.		240.	
CHROMIUM	MG/L	-		0.04		0.04		0.04		0.04	
COBALT	MG/L	-		0.06		0.08		0.08		0.08	
CONDUCTANCE	UMHO/CM	2600.		3100.		3200.		3200.		3200.	
COPPER	MG/L	-		0.03		-		-		-	
CYANIDE	MG/L	-		< 0.01		-		-		-	
FLUORIDE	MG/L	-		0.8		0.6		0.6		0.6	
GROSS ALPHA	PCI/L	-		-		-		-		-	
IRON	MG/L	-		< 0.03		0.05		0.05		0.05	
LEAD	MG/L	-		< 0.01		-		-		-	
MAGNESIUM	MG/L	110.		142.		171.		171.		171.	
MANGANESE	MG/L	-		0.02		0.17		0.17		0.17	
MERCURY	MG/L	-		< 0.0002		-		-		-	
MOLYBDENUM	MG/L	0.22		0.5		0.14		0.15		0.14	
NICKEL	MG/L	-		0.06		-		-		-	
NITRATE	MG/L	-		3.		5.		5.		5.	
NITRITE	MG/L	-		< 0.1		-		-		-	
ORG. CARBON	MG/L	-		63.		-		-		-	
PB-210	PCI/L	-		102.	4	-		-		-	
PH	SU	7.01		7.22		7.06		7.06		7.06	
PHOSPHATE	MG/L	-		0.6		-		-		-	
PO-210	PCI/L	-		1.9	0.9	-		-		-	
POTASSIUM	MG/L	5.38		1.12		7.92		7.92		7.92	
RA-226	PCI/L	-		2.9	0.6	-		-		-	
RA-228	PCI/L	-		0.9	1.1	-		-		-	
SELENIUM	MG/L	0.033		0.011		< 0.005		< 0.005		< 0.005	
SILICA	MG/L	-		11.		-		-		-	
SILVER	MG/L	-		< 0.01		-		-		-	
SODIUM	MG/L	555.		434.		367.		367.		367.	
STRONTIUM	MG/L	-		8.4		0.7		0.7		0.7	
SULFATE	MG/L	1770.		2440.		2360.		2360.		2360.	
SULFIDE	MG/L	-		< 0.1		-		-		-	
TEMPERATURE	C - DEGREE	12.		12.		13.		13.		13.	
TH-230	PCI/L	-		4.	1.2	-		-		-	
TIN	MG/L	-		< 0.005		-		-		-	
TOTAL SOLIDS	MG/L	3200.		4060.		4330.		4310.		4290.	
TOTAL SS	MG/L	-		-		-		-		-	

Table B.2.14 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

		LOCATION ID - SAMPLE ID AND LOG DATE				
		619-01 10/02/85	620-01 10/02/85	650-01 05/22/86	650-02 05/22/86	650-03 05/22/86
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
U-234	PCI/L	-	-	-	-	-
URANIUM	MG/L	0.95	5.34	0.0305	0.0299	0.0297
VANADIUM	MG/L	-	< 0.01	0.23	0.23	0.23
ZINC	MG/L	-	0.047	-	-	-

Table B.2.14 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

PARAMETER	UNIT OF MEASURE	650-04 05/22/86 PARAMETER VALUE+/-UNCERTAINTY	650-05 05/22/86 PARAMETER VALUE+/-UNCERTAINTY	706-01 06/21/82 PARAMETER VALUE+/-UNCERTAINTY	706-01 09/30/85 PARAMETER VALUE+/-UNCERTAINTY	706-01 05/13/86 PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	260.	260.	2300.	4765.	764.
ALUMINUM	MG/L	-	-	< 0.1	-	-
AMMONIUM	MG/L	-	-	-	-	-
ANTIMONY	MG/L	-	-	-	-	-
ARSENIC	MG/L	< 0.01	< 0.01	0.33	< 0.01	< 0.01
BARIUM	MG/L	-	-	< 0.1	-	-
BICARBONATE	MG/L	-	-	5613.	-	-
BORON	MG/L	0.5	0.5	-	-	0.7
CADMIUM	MG/L	< 0.001	< 0.001	< 0.1	-	< 0.001
CALCIUM	MG/L	565.	565.	12.	10.7	520.
CHLORIDE	MG/L	240.	240.	290.	300.	460.
CHROMIUM	MG/L	0.04	0.04	0.03	-	0.06
COBALT	MG/L	0.08	0.08	-	-	0.12
CONDUCTANCE	UMHO/CM	3200.	3200.	22200.	17000.	4500.
COPPER	MG/L	-	-	0.2	-	-
CYANIDE	MG/L	-	-	-	-	-
FLUORIDE	MG/L	0.6	0.6	15.	-	0.5
GROSS ALPHA	PCI/L	-	-	15000.	-	-
IRON	MG/L	0.05	0.05	1.	-	0.14
LEAD	MG/L	-	-	0.02	-	-
MAGNESIUM	MG/L	171.	171.	55.	43.2	273.
MANGANESE	MG/L	0.17	0.17	-	-	0.22
MERCURY	MG/L	-	-	< 0.002	-	-
MOLYBDENUM	MG/L	0.15	0.14	225.	223.	9.37
NICKEL	MG/L	-	-	-	-	-
NITRATE	MG/L	5.	5.	< 1.	-	25.
NITRITE	MG/L	-	-	-	-	-
ORG. CARBON	MG/L	-	-	-	-	-
PB-210	PCI/L	-	-	-	-	-
PH	SU	7.06	7.06	8.4	9.12	7.25
PHOSPHATE	MG/L	-	-	-	-	-
PO-210	PCI/L	-	-	-	-	-
POTASSIUM	MG/L	7.92	7.92	9.	13.3	15.8
RA-226	PCI/L	-	-	4.	-	-
RA-228	PCI/L	-	-	-	-	-
SELENIUM	MG/L	< 0.005	< 0.005	0.037	0.088	0.01
SILICA	MG/L	-	-	6.5	-	-
SILVER	MG/L	-	-	0.15	-	-
SODIUM	MG/L	367.	367.	7400.	7020.	1140.
STRONTIUM	MG/L	0.7	0.7	-	-	1.2
SULFATE	MG/L	2360.	2360.	8680.	10000.	3420.
SULFIDE	MG/L	-	-	-	-	-
TEMPERATURE	C - DEGREE	13.	13.	23.	14.	13.
TH-230	PCI/L	-	-	-	-	-
TIN	MG/L	-	-	-	-	-
TOTAL SOLIDS	MG/L	1290.	1450.	19200.	20900.	6900.
TOTAL SS	MG/L	-	-	-	-	-

Table B.2.14 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

		LOCATION ID - SAMPLE ID AND LOG DATE				
		650-04 05/22/86	650-05 05/22/86	706-01 06/21/82	706-01 09/30/85	706-01 05/13/86
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
U-234	PCI/L	-	-	10.1	-	-
URANIUM	MG/L	0.0299	0.0351	-	11.1	3.92
VANADIUM	MG/L	0.23	0.23	0.048	-	0.51
ZINC	MG/L	-	-	-	-	-

Table B.2.14 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

PARAMETER	UNIT OF MEASURE	709-01 06/21/82 PARAMETER VALUE+/-UNCERTAINTY	710-01 06/21/82 PARAMETER VALUE+/-UNCERTAINTY	718-01 06/25/80 PARAMETER VALUE+/-UNCERTAINTY	718-01 10/16/85 PARAMETER VALUE+/-UNCERTAINTY	718-01 05/17/84 PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	150.	120.	149.	476.	817.
ALUMINUM	MG/L	0.15	< 0.1	0.89	-	-
AMMONIUM	MG/L	-	-	-	-	-
ANTIMONY	MG/L	-	-	-	-	-
ARSENIC	MG/L	0.002	0.002	0.18	< 0.01	< 0.01
BARIUM	MG/L	< 0.1	< 0.1	< 0.001	-	-
BICARBONATE	MG/L	366.	293.	363.	-	-
BORON	MG/L	-	-	0.91	-	0.7
CADMIUM	MG/L	< 0.01	< 0.01	< 0.008	-	< 0.001
CALCIUM	MG/L	493.	503.	460.	446.	363.
CHLORIDE	MG/L	472.	65.	184.	190.	180.
CHROMIUM	MG/L	< 0.01	< 0.01	< 0.001	-	0.04
COBALT	MG/L	-	-	< 0.006	-	0.09
CONDUCTANCE	UMHO/CM	4440.	3820.	7140.	7000.	5000.
COPPER	MG/L	0.025	< 0.025	0.015	-	-
CYANIDE	MG/L	-	-	-	-	-
FLUORIDE	MG/L	2.	2.	0.25	-	0.4
GROSS ALPHA	PCI/L	158.	300.	-	-	-
IRON	MG/L	0.19	0.02	0.022	-	0.61
LEAD	MG/L	< 0.01	< 0.01	0.01	-	-
MAGNESIUM	MG/L	199.	213.	240.	395.	246.
MANGANESE	MG/L	-	-	0.012	-	0.12
MERCURY	MG/L	< 0.002	< 0.002	< 0.001	-	-
MOLYBDENUM	MG/L	< 0.025	0.59	0.046	0.17	0.22
NICKEL	MG/L	-	-	0.023	-	-
NITRATE	MG/L	1.	3.	10.	-	15.
NITRITE	MG/L	-	-	-	-	-
ORG. CARBON	MG/L	-	-	-	-	-
PB-210	PCI/L	-	-	-	-	-
PH	SU	6.88	7.05	7.7	7.15	7.8
PHOSPHATE	MG/L	-	-	-	-	-
PO-210	PCI/L	-	-	-	-	-
POTASSIUM	MG/L	4.	3.	8.4	7.61	14.
RA-226	PCI/L	5.	4.	2.65	-	-
RA-228	PCI/L	-	-	-	-	-
SELENIUM	MG/L	0.15	0.53	0.95	< 0.005	0.008
SILICA	MG/L	6.1	6.8	-	-	-
SILVER	MG/L	0.008	0.01	0.018	-	-
SODIUM	MG/L	550.	350.	1200.	1650.	1830.
STRONTIUM	MG/L	-	-	-	-	0.7
SULFATE	MG/L	2750.	2460.	4290.	4940.	4620.
SULFIDE	MG/L	-	-	-	-	-
TEMPERATURE	C - DEGREE	14.	13.	-	12.	13.
TH-230	PCI/L	-	-	-	-	-
TIN	MG/L	-	-	-	-	-
TOTAL SOLIDS	MG/L	4360.	3760.	6920.	8080.	7440.
TOTAL SS	MG/L	-	-	81.	-	-

Table B.2.14 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

		LOCATION ID - SAMPLE ID AND LOG DATE				
		709-01 06/21/82	710-01 06/21/82	718-01 06/25/80	718-01 10/16/85	718-01 05/17/86
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
U-234	PCI/L	0.032	-	-	-	-
URANIUM	MG/L	-	0.071	0.42	0.712	1.26
VANADIUM	MG/L	< 0.01	< 0.01	< 0.003	-	0.23
ZINC	MG/L	-	-	0.069	-	-

Table B.2.14 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

PARAMETER	UNIT OF MEASURE	747-04 09/26/85 PARAMETER VALUE	+/-UNCERTAINTY	748-01 05/13/86 PARAMETER VALUE	+/-UNCERTAINTY	749-01 05/13/86 PARAMETER VALUE	+/-UNCERTAINTY	780-01 10/05/85 PARAMETER VALUE	+/-UNCERTAINTY	780-01 05/13/86 PARAMETER VALUE	+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	397.		681.		1172.		401.		1947.	
ALUMINUM	MG/L	0.4		-		-		0.3		-	
AMMONIUM	MG/L	1.2		-		-		0.3		-	
ANTIMONY	MG/L	< 0.003		-		-		< 0.003		-	
ARSENIC	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	
BARIUM	MG/L	0.1		-		-		< 0.1		-	
BICARBONATE	MG/L	-		-		-		-		-	
BORON	MG/L	0.6		-		-		1.2		1.5	
CADMIUM	MG/L	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
CALCIUM	MG/L	320.		412.		408.		404.		746.	
CHLORIDE	MG/L	190.		190.		160.		210.		280.	
CHROMIUM	MG/L	0.04		0.05		0.05		0.03		0.03	
COBALT	MG/L	0.09		0.12		0.11		0.07		0.24	
CONDUCTANCE	UMHO/CM	10000.		7000.		9000.		6000.		4400.	
COPPER	MG/L	0.05		-		-		0.03		-	
CYANIDE	MG/L	< 0.1		-		-		< 0.001		-	
FLUORIDE	MG/L	2.8		-		-		2.2		1.	
GROSS ALPHA	PCI/L	-		-		-		-		-	
IRON	MG/L	0.29		0.44		5.49		0.49		4.13	
LEAD	MG/L	< 0.01		-		-		< 0.01		-	
MAGNESIUM	MG/L	82.8		158.		155.		222.		442.	
MANGANESE	MG/L	0.1		0.34		0.61		0.56		1.23	
MERCURY	MG/L	< 0.0002		-		-		< 0.0002		-	
MOLYBDENUM	MG/L	48.7		29.1		66.3		3.17		1.22	
NICKEL	MG/L	0.14		-		-		0.1		-	
NITRATE	MG/L	3.		2.		1.		9.		75.	
NITRITE	MG/L	< 0.1		-		-		< 0.1		-	
ORG. CARBON	MG/L	-		-		-		25.		-	
PB-210	PCI/L	21.	3	-		-		-		-	
PH	SU	8.11		7.41		7.45		7.64		7.28	
PHOSPHATE	MG/L	0.4		-		-		0.3		-	
PO-210	PCI/L	-		-		-		-		-	
POTASSIUM	MG/L	24.2		18.2		16.		9.54		9.67	
RA-226	PCI/L	190.	20	113.	4	117.	8	-		2.5	0.7
RA-228	PCI/L	0.	4.9	-		-		-		-	
SELENIUM	MG/L	< 0.005		< 0.005		< 0.005		0.127		0.009	
SILICA	MG/L	15.		-		-		15.		-	
SILVER	MG/L	< 0.01		-		-		< 0.01		-	
SODIUM	MG/L	2500.		2030.		2650.		1140.		1430.	
STRONTIUM	MG/L	3.9		8.3		9.1		7.8		1.1	
SULFATE	MG/L	5940.		5650.		5940.		3610.		4300.	
SULFIDE	MG/L	< 0.1		-		-		< 0.1		-	
TEMPERATURE	C - DEGREE	15.		15.		15.		14.		12.	
TH-230	PCI/L	0.9	0.9	0.8	1.6	1.9	2.2	-		0.2	0.3
TIN	MG/L	< 0.005		-		-		< 0.005		-	
TOTAL SOLIDS	MG/L	9560.		8720.		9230.		6180.		7250.	
TOTAL SS	MG/L	-		-		-		-		-	

Table B.2.14 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

		LOCATION ID - SAMPLE ID AND LOG DATE				
		747-01 09/26/85	748-01 05/13/86	749-01 05/13/86	780-01 10/05/85	780-01 05/13/86
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
U-234	PCI/L	-	-	-	-	-
URANIUM	MG/L	1.24	5.84	5.76	2.8	0.0933
VANADIUM	MG/L	< 0.01	0.54	0.55	0.5	0.5
ZINC	MG/L	1.73	-	-	0.098	-

Table B.2.14 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

PARAMETER	UNIT OF MEASURE	792-01 05/15/86 PARAMETER VALUE+/-UNCERTAINTY			793-01 05/15/86 PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3		329.			672.				
ALUMINUM	MG/L		-			-				
AMMONIUM	MG/L		-			-				
ANTIMONY	MG/L		-			-				
ARSENIC	MG/L	<	0.01		<	0.01				
BARIUM	MG/L		-			-				
BICARBONATE	MG/L		-			-				
BORON	MG/L		0.4			0.6				
CADMIUM	MG/L	<	0.001		<	0.001				
CALCIUM	MG/L		502.			510.				
CHLORIDE	MG/L		180.			230.				
CHROMIUM	MG/L		0.04			0.03				
COBALT	MG/L		0.11			0.08				
CONDUCTANCE	UMHO/CM		3300.			3350.				
COPPER	MG/L		-			-				
CYANIDE	MG/L		-			-				
FLUORIDE	MG/L		1.1			2.2				
GROSS ALPHA	PCI/L		-			-				
IRON	MG/L		0.04			0.04				
LEAD	MG/L		-			-				
MAGNESIUM	MG/L		82.5			138.				
MANGANESE	MG/L		0.05			0.07				
MERCURY	MG/L		-			-				
MOLYBDENUM	MG/L		1.87			1.59				
NICKEL	MG/L		-			-				
NITRATE	MG/L	<	1.			55.				
NITRITE	MG/L		-			-				
ORG. CARBON	MG/L		-			-				
PB-210	PCI/L		-			-				
PH	SU		7.35			7.37				
PHOSPHATE	MG/L		-			-				
PO-210	PCI/L		-			-				
POTASSIUM	MG/L		1.01			2.49				
RA-226	PCI/L		0.8	0.4		0.7	0.3			
RA-228	PCI/L		-			-				
SELENIUM	MG/L	<	0.005			0.003				
SILICA	MG/L		-			-				
SILVER	MG/L		-			-				
SODIUM	MG/L		730.			600.				
STRONTIUM	MG/L		0.6			1.1				
SULFATE	MG/L		2550.			2530.				
SULFIDE	MG/L		-			-				
TEMPERATURE	C - DEGREE		16.			16.				
TH-230	PCI/L		0.4	0.4		0.3	0.3			
TIN	MG/L		-			-				
TOTAL SOLIDS	MG/L		4110.			4400.				
TOTAL SS	MG/L		-			-				

Table B.2.14 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

		LOCATION ID - SAMPLE ID AND LOG DATE	
		792-01 05/15/86	793-01 05/15/86
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
U-234	PCI/L	-	-
URANIUM	MG/L	3.31	0.288
VANADIUM	MG/L	0.26	0.39
ZINC	MG/L	-	-

Table 2.14 GROUND WATER QUALITY MEASUREMENTS EXCEEDING STANDARDS
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

PARAMETER	UNITS OF MEASURE	MAXIMUM VALUE[d]	LOCATION ID	SAMPLE ID	LOG DATE	PARAMETER VALUE+/-UNCERTAINTY
ALUMINUM	MG/L	5.0	-	-	-	-
ARSENIC	MG/L	0.05	706	01	06/21/82	.3300
			718	01	06/25/80	.1800
**** SAMPLES EXCEEDING MAXIMUM VALUE = 6 % ****						
BARIUM	MG/L	1.0	-	-	-	-
BORON	MG/L	0.75	609	01	05/13/86	1.0000
			609	02	05/13/86	1.0000
			609	03	05/13/86	1.0000
			609	04	05/13/86	1.0000
			609	05	05/13/86	1.0000
			718	01	06/25/80	.9100
			780	01	10/05/85	1.2000
			780	01	05/13/86	1.5000
**** SAMPLES EXCEEDING MAXIMUM VALUE = 34 % ****						
CADMIUM	MG/L	0.01	706	01	06/21/82 <	.1000
**** SAMPLES EXCEEDING MAXIMUM VALUE = 3 % ****						
CHLORIDE	MG/L	250.0	706	01	06/21/82	290.0000
			706	01	09/30/85	300.0000
			706	01	05/13/86	460.0000
			780	01	05/13/86	280.0000
**** SAMPLES EXCEEDING MAXIMUM VALUE = 12 % ****						
CHROMIUM	MG/L	0.05	609	01	05/13/86	.2000
			706	01	05/13/86	.0600
**** SAMPLES EXCEEDING MAXIMUM VALUE = 7 % ****						
COBALT	MG/L	0.05	609	02	09/30/85	.0700
			609	03	09/30/85	.0600
			609	04	09/30/85	.0700
			609	05	09/30/85	.0900
			609	01	05/13/86	.0900
			609	02	05/13/86	.0900
			609	03	05/13/86	.0900
			609	04	05/13/86	.0900
			609	05	05/13/86	.0900
			620	01	10/02/85	.0600
			650	01	05/22/86	.0800
			650	02	05/22/86	.0800
			650	03	05/22/86	.0800
			650	04	05/22/86	.0800
			650	05	05/22/86	.0800
			706	01	05/13/86	.1200
			718	01	05/17/86	.0900
			747	01	09/26/85	.0900

Table B.2.14 GROUND WATER QUALITY MEASUREMENTS EXCEEDING STANDARDS
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

PARAMETER	UNITS OF MEASURE	MAXIMUM VALUE	LOCATION ID	SAMPLE ID	LOG DATE	PARAMETER VALUE+/-UNCERTAINTY
COBALT	MG/L	0.05	748	01	05/13/86	.1200
			749	01	05/13/86	.1100
			780	01	10/05/85	.0700
			780	01	05/13/86	.2400
			792	01	05/15/86	.1100
			793	01	05/15/86	.0800
#### SAMPLES EXCEEDING MAXIMUM VALUE = 95 % ####						
COPPER	MG/L	1.0	-	-	-	-
FLUORIDE	MG/L	1.4	706	01	06/21/82	15.0000
			709	01	06/21/82	2.0000
			710	01	06/21/82	2.0000
			747	01	09/26/85	2.8000
			780	01	10/05/85	2.2000
			793	01	05/15/86	2.2000
#### SAMPLES EXCEEDING MAXIMUM VALUE = 23 % ####						
GROSS ALPHA	PCI/L	15.0	706	01	06/21/82	15000.0000
			709	01	06/21/82	158.0000
			710	01	06/21/82	300.0000
#### SAMPLES EXCEEDING MAXIMUM VALUE = 100 % ####						
IRON	MG/L	0.3	706	01	06/21/82	1.0000
			718	01	05/17/86	.6100
			748	01	05/13/86	.4400
			749	01	05/13/86	5.4900
			780	01	10/05/85	.4900
			780	01	05/13/86	4.1300
#### SAMPLES EXCEEDING MAXIMUM VALUE = 21 % ####						
LEAD	MG/L	0.05	-	-	-	-
MANGANESE	MG/L	0.05	609	02	09/30/85	.4700
			609	03	09/30/85	.4800
			609	04	09/30/85	.5200
			609	05	09/30/85	.4900
			609	01	05/13/86	.6800
			609	02	05/13/86	.6800
			609	03	05/13/86	.6800
			609	04	05/13/86	.6800
			609	05	05/13/86	.6800
			650	01	05/22/86	.1700
			650	02	05/22/86	.1700
			650	03	05/22/86	.1700
			650	04	05/22/86	.1700
			650	05	05/22/86	.1700
			706	01	05/13/86	.2200
			718	01	05/17/86	.1200

Table B.2.14 GROUND WATER QUALITY MEASUREMENTS EXCEEDING STANDARDS
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

PARAMETER	UNITS OF MEASURE	MAXIMUM VALUE	LOCATION ID	SAMPLE ID	LOG DATE	PARAMETER VALUE+/-UNCERTAINTY	
MANGANESE	MG/L	0.05	747	01	09/26/85	.1000	
			748	01	05/13/86	.3400	
			749	01	05/13/86	.6100	
			780	01	10/05/85	.5600	
			780	01	05/13/86	1.2300	
			793	01	05/15/86	.0700	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 87 % ****							
MERCURY	MG/L	0.002	-	-	-	-	
MOLYBDENUM	MG/L	1.00	609	01	09/30/85	1.4100	
			609	02	09/30/85	1.4700	
			609	03	09/30/85	1.5900	
			609	04	09/30/85	1.4700	
			609	05	09/30/85	1.4700	
			609	01	05/13/86	1.4100	
			609	02	05/13/86	1.3900	
			609	03	05/13/86	1.4000	
			609	04	05/13/86	1.4100	
			609	05	05/13/86	1.4300	
			706	01	06/21/82	225.0000	
			706	01	09/30/85	223.0000	
			706	01	05/13/86	9.3700	
			747	01	09/26/85	48.7000	
			748	01	05/13/86	29.1000	
			749	01	05/13/86	66.3000	
			780	01	10/05/85	3.1700	
			780	01	05/13/86	1.2200	
			792	01	05/15/86	1.8700	
			793	01	05/15/86	1.5900	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 62 % ****							
NICKEL	MG/L	0.20	-	-	-	-	
NITRATE	MG/L	44.0	748	01	05/17/86	45.0000	
			780	01	05/13/86	75.0000	
			793	01	05/15/86	55.0000	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 10 % ****							
PH	SU	6.5 TO 8.5	706	01	09/30/85	9.1200	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 3 % ****							
RA226+RA228	PCI/L	5.0	609	02	09/30/85	410.0000	20
			609	03	09/30/85	11.2000	3
			609	04	09/30/85	8.6000	2.9
			609	05	09/30/85	8.1000	3.2
			706	01	06/21/82	8.7000	
			710	01	06/21/82	9.0000	
			747	01	09/26/85	192.6500	20

Table B.2.14 GROUND WATER QUALITY MEASUREMENTS EXCEEDING STANDARDS
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

PARAMETER	UNITS OF MEASURE	MAXIMUM VALUE	LOCATION ID	SAMPLE ID	LOG DATE	PARAMETER VALUE+/-UNCERTAINTY	
RA226+RA228	PCI/L	5.0	748	01	05/13/86	113.0000	4
			749	01	05/13/86	117.0000	8
**** SAMPLES EXCEEDING MAXIMUM VALUE = 56 % ****							
SELENIUM	MG/L	0.01	609	01	09/30/85	.1470	
			609	04	09/30/85	.0140	
			609	05	09/30/85	.0130	
			619	01	10/02/85	.0330	
			620	01	10/02/85	.0110	
			706	01	06/21/82	.0370	
			706	01	09/30/85	.0880	
			709	01	06/21/82	.1500	
			710	01	06/21/82	.5300	
			718	01	06/25/80	.9500	
			780	01	10/05/85	.1270	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 34 % ****							
SILVER	MG/L	0.05	706	01	06/21/82	.1500	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 9 % ****							
SULFATE	MG/L	250.0	609	01	09/30/85	2420.0000	
			609	02	09/30/85	2400.0000	
			609	03	09/30/85	2400.0000	
			609	04	09/30/85	2400.0000	
			609	05	09/30/85	2390.0000	
			609	01	05/13/86	2540.0000	
			609	02	05/13/86	2530.0000	
			609	03	05/13/86	2520.0000	
			609	04	05/13/86	2540.0000	
			609	05	05/13/86	2530.0000	
			619	01	10/02/85	1770.0000	
			620	01	10/02/85	2440.0000	
			650	01	05/22/86	2360.0000	
			650	02	05/22/86	2360.0000	
			650	03	05/22/86	2360.0000	
			650	04	05/22/86	2360.0000	
			650	05	05/22/86	2360.0000	
			706	01	06/21/82	8680.0000	
			706	01	09/30/85	10000.0000	
			706	01	05/13/86	3420.0000	
			709	01	06/21/82	2750.0000	
			710	01	06/21/82	2460.0000	
			718	01	06/25/80	4290.0000	
			718	01	10/16/85	4940.0000	
			718	01	05/17/86	4620.0000	
			747	01	09/26/85	5940.0000	
			748	01	05/13/86	5650.0000	

Table B.2.14 GROUND WATER QUALITY MEASUREMENTS EXCEEDING STANDARDS
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Continued)

FORMATION OF COMPLETION: ALLUVIUM

PARAMETER	UNITS OF MEASURE	MAXIMUM VALUE	LOCATION ID	SAMPLE ID	LOG DATE	PARAMETER VALUE+/-UNCERTAINTY
SULFATE	MG/L	250.0	749	01	05/13/86	5940.0000
			780	01	10/05/85	3610.0000
			780	01	05/13/86	4300.0000
			792	01	05/15/86	2550.0000
			793	01	05/15/86	2530.0000

**** SAMPLES EXCEEDING MAXIMUM VALUE = 100 % ****

PARAMETER	UNITS OF MEASURE	MAXIMUM VALUE	LOCATION ID	SAMPLE ID	LOG DATE	PARAMETER VALUE+/-UNCERTAINTY
TOTAL SOLIDS	MG/L	500.0	609	01	09/30/85	4310.0000
			609	02	09/30/85	4370.0000
			609	03	09/30/85	4330.0000
			609	04	09/30/85	4350.0000
			609	05	09/30/85	4360.0000
			609	01	05/13/86	4360.0000
			609	02	05/13/86	4390.0000
			609	03	05/13/86	4540.0000
			609	04	05/13/86	4370.0000
			609	05	05/13/86	4390.0000
			619	01	10/02/85	3200.0000
			620	01	10/02/85	4060.0000
			650	01	05/22/86	4330.0000
			650	02	05/22/86	4310.0000
			650	03	05/22/86	4290.0000
			650	04	05/22/86	4290.0000
			650	05	05/22/86	4450.0000
			706	01	06/21/82	19200.0000
			706	01	09/30/85	20900.0000
			706	01	05/13/86	6900.0000
			709	01	06/21/82	4360.0000
			710	01	06/21/82	3760.0000
			718	01	06/25/80	6920.0000
			718	01	10/16/85	8080.0000
			718	01	05/17/86	7440.0000
			747	01	09/26/85	9560.0000
			748	01	05/13/86	8720.0000
			749	01	05/13/86	9230.0000
			780	01	10/05/85	6180.0000
			780	01	05/13/86	7250.0000
			792	01	05/15/86	4110.0000
			793	01	05/15/86	4400.0000

**** SAMPLES EXCEEDING MAXIMUM VALUE = 100 % ****

PARAMETER	UNITS OF MEASURE	MAXIMUM VALUE	LOCATION ID	SAMPLE ID	LOG DATE	PARAMETER VALUE+/-UNCERTAINTY
URANIUM	MG/L	5.0	620	01	10/02/85	5.3400
			706	01	09/30/85	11.1000
			748	01	05/13/86	5.8400
			749	01	05/13/86	5.7600

**** SAMPLES EXCEEDING MAXIMUM VALUE = 43 % ****

Table B.2.14 GROUND WATER QUALITY MEASUREMENTS EXCEEDING STANDARDS
SITE: AMBROSIA LAKE
06/21/82 TO 05/22/86 (Concluded)

FORMATION OF COMPLETION: ALLUVIUM

PARAMETER	UNITS OF MEASURE	MAXIMUM VALUE	LOCATION ID	SAMPLE ID	LOG DATE	PARAMETER VALUE+/-UNCERTAINTY
ZINC	MG/L	5.0	-	-	-	-

[a]Parameter value ± uncertainty applies to radionuclides Pb-210, Ra-226, and Th-230.
[b]- indicates analysis not performed.
[c]<0.01 parameter value is less than 0.01.
[d]Maximum value is WQCC standard or Federal standard, whichever is less.

Table B.2.15 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/21/86

FORMATION OF COMPLETION: TRES HERMANOS - C1 AND C2 SANDSTONE

PARAMETER	UNIT OF MEASURE	708-01 06/21/82 PARAMETER VALUE+/-UNCERTAINTY [a]		773-01 05/11/86 PARAMETER VALUE+/-UNCERTAINTY		778-01 10/11/85 PARAMETER VALUE+/-UNCERTAINTY		778-01 05/15/86 PARAMETER VALUE+/-UNCERTAINTY		779-01 10/10/85 PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	320.		2735.		420.		411.		672.	
ALUMINUM	MG/L	[b] < 0.1		-		0.2		-		0.2	
AMMONIUM	MG/L	- [c]		-		0.2		-		0.4	
ANTIMONY	MG/L	-		-		< 0.003		-		< 0.003	
ARSENIC	MG/L	0.002		< 0.01		< 0.01		< 0.01		< 0.01	
BARIUM	MG/L	< 0.1		-		< 0.1		-		0.3	
BICARBONATE	MG/L	781.		-		-		-		-	
BORON	MG/L	-		0.1		1.1		0.4		0.7	
CADMIUM	MG/L	< 0.01		< 0.001		< 0.001		< 0.001		< 0.001	
CALCIUM	MG/L	470.		168.		438.		524.		403.	
CHLORIDE	MG/L	260.		10.		250.		270.		2.	
CHROMIUM	MG/L	< 0.01		0.05		0.03		0.05		0.04	
COBALT	MG/L	-		0.07		< 0.05		0.08		0.07	
CONDUCTANCE	UMHO/CM	8280.		10000.		4500.		4700.		4000.	
COPPER	MG/L	< 0.025		-		0.05		-		0.03	
CYANIDE	MG/L	-		-		< 0.01		-		< 0.01	
FLUORIDE	MG/L	2.		1.1		0.5		0.6		0.5	
GROSS ALPHA	PCI/L	31000.		-		-		-		-	
IRON	MG/L	0.26		0.05		0.09		0.09		0.07	
LEAD	MG/L	< 0.01		-		< 0.01		-		< 0.01	
MAGNESIUM	MG/L	333.		0.022		171.		202.		303.	
MANGANESE	MG/L	-		0.03		0.06		0.13		0.84	
MERCURY	MG/L	< 0.002		-		< 0.0002		-		< 0.0002	
MOLYBDENUM	MG/L	10.3		0.32		0.16		0.13		0.14	
NICKEL	MG/L	-		-		0.07		-		0.14	
NITRATE	MG/L	24.		2.		400.		3.		2.	
NITRITE	MG/L	-		-		< 0.1		-		< 0.1	
ORG. CARBON	MG/L	-		-		81.		-		-	
PB-210	PCI/L	-		-		110.	4	-		1.1	1.6
PH	SU	7.8		12.11		6.9		7.23		6.66	
PHOSPHATE	MG/L	-		-		0.5		-		0.4	
PO-210	PCI/L	-		-		1.1	0.8	-		0.	0.6
POTASSIUM	MG/L	10.		56.5		24.5		4.18		23.9	
RA-226	PCI/L	5.		22.	2	0.4	0.2	2.5	0.5	1.4	0.7
RA-228	PCI/L	-		-		0.	1.2	-		1.2	1.1
SELENIUM	MG/L	0.225		< 0.005		< 0.005		< 0.005		< 0.005	
SILICA	MG/L	6.8		-		15.		-		16.	
SILVER	MG/L	0.019		-		< 0.01		-		< 0.01	
SODIUM	MG/L	1590.		1140.		965.		875.		688.	
STRONTIUM	MG/L	-		4.7		10.		9.9		10.	
SULFATE	MG/L	4010.		435.		2930.		3150.		3310.	
SULFIDE	MG/L	-		-		< 0.1		-		< 0.1	
TEMPERATURE	C - DEGREE	15.		17.		12.		16.		12.	
TH-230	PCI/L	-		0.	0.1	5.5	1.4	3.	1	0.2	0.3
TIN	MG/L	-		-		< 0.005		-		< 0.005	
TOTAL SOLIDS	MG/L	7190.		3040.		5610.		5920.		5900.	
U-234	PCI/L	11.5		-		-		-		-	

Table B.2.15 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/21/86 (Continued)

FORMATION OF COMPLETION: TRES HERMANOS - C1 AND C2 SANDSTONE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		708-01 06/21/82	773-01 05/14/86	778-01 10/11/85	778-01 05/15/86	779-01 10/10/85
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
URANIUM	MG/L	-	< 0.0003	11.8	9.31	0.0238
VANADIUM	MG/L	< 0.01	0.21	< 0.01	0.23	< 0.01
ZINC	MG/L	-	-	0.039	-	0.074

Table B.2.15 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/21/86 (Continued)

FORMATION OF COMPLETION: TRES HERMANOS - C1 AND C2 SANDSTONE

		LOCATION ID - SAMPLE ID AND LOG DATE									
		779-01 05/14/86		782-01 10/09/85		782-01 05/16/86		784-01 05/15/86		785-01 10/15/85	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE	+/-UNCERTAINTY	PARAMETER VALUE	+/-UNCERTAINTY	PARAMETER VALUE	+/-UNCERTAINTY	PARAMETER VALUE	+/-UNCERTAINTY	PARAMETER VALUE	+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	747.		1072.		449.		670.		350.	
ALUMINUM	MG/L	-		0.4		-		-		0.3	
AMMONIUM	MG/L	-		0.8		-		-		0.2	
ANTIMONY	MG/L	-		< 0.003		-		-		< 0.003	
ARSENIC	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	
BARIUM	MG/L	-		0.3		-		-		0.1	
BICARBONATE	MG/L	-		-		-		-		-	
BORON	MG/L	1.1		0.2		0.2		0.2		0.3	
CADMIUM	MG/L	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
CALCIUM	MG/L	493.		258.		192.		183.		198.	
CHLORIDE	MG/L	24.		20.		12.		95.		81.	
CHROMIUM	MG/L	0.04		0.04		0.03		0.11		0.02	
COBALT	MG/L	0.1		< 0.05		< 0.05		< 0.05		< 0.05	
CONDUCTANCE	UMHO/CM	4000.		4100.		2450.		3000.		2200.	
COPPER	MG/L	-		0.02		-		-		0.03	
CYANIDE	MG/L	-		< 0.01		-		-		< 0.01	
FLUORIDE	MG/L	0.4		0.9		0.6		0.8		1.4	
GROSS ALPHA	PCI/L	-		-		-		-		-	
IRON	MG/L	0.47		< 0.03		< 0.03		0.05		< 0.03	
LEAD	MG/L	-		< 0.01		-		-		< 0.01	
MAGNESIUM	MG/L	388.		0.167		0.161		0.481		80.6	
MANGANESE	MG/L	1.02		0.02		0.01		0.02		0.14	
MERCURY	MG/L	-		< 0.0002		-		-		< 0.0002	
MOLYBDENUM	MG/L	0.08		0.16		0.17		0.19		0.35	
NICKEL	MG/L	-		0.06		-		-		< 0.04	
NITRATE	MG/L	< 1.		4.		< 1.		5.		20.	
NITRITE	MG/L	-		< 0.1		-		-		< 0.1	
ORG. CARBON	MG/L	-		18.		-		-		-	
PB-210	PCI/L	-		2.9	1.5	-		-		5.5	2.9
PH	SU	6.62		12.2		11.46		11.92		7.87	
PHOSPHATE	MG/L	-		0.4		-		-		0.4	
PO-210	PCI/L	-		0.	0.6	-		-		-	
POTASSIUM	MG/L	25.7		24.9		15.3		23.		7.73	
RA-226	PCI/L	-		2.4	0.5	1.	0.4	0.8	0.4	0.4	1.9
RA-228	PCI/L	-		0.4	0.9	-		-		0.4	4.5
SELENIUM	MG/L	< 0.005		< 0.005		< 0.005		0.007		< 0.003	
SILICA	MG/L	-		4.		-		-		19.	
SILVER	MG/L	-		< 0.01		-		-		< 0.01	
SODIUM	MG/L	898.		264.		292.		395.		564.	
STRONTIUM	MG/L	10.4		2.6		2.1		2.8		2.2	
SULFATE	MG/L	3840.		516.		633.		557.		1560.	
SULFIDE	MG/L	-		< 0.1		-		-		< 0.1	
TEMPERATURE	C - DEGREE	14.		12.5		16.		16.		11.	
TH-230	PCI/L	-		0.5	0.5	0.1	0.2	1.6	0.7	1.5	2.5
TIN	MG/L	-		< 0.005		-		-		< 0.005	
TOTAL SOLIDS	MG/L	6490.		1880.		1340.		1560.		2670.	
U-234	PCI/L	-		-		-		-		-	

Table B.2.15 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/21/86 (Continued)

FORMATION OF COMPLETION: TRES HERMANOS - C1 AND C2 SANDSTONE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		779-01 05/14/86	782-01 10/09/85	782-01 05/16/86	784-01 05/15/86	785-01 10/15/85
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
URANIUM	MG/L	0.0066	0.0031	< 0.0003	< 0.0003	0.806
VANADIUM	MG/L	0.34	< 0.01	0.21	0.38	< 0.01
ZINC	MG/L	-	< 0.005	-	-	0.015

Table B.2.15 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/21/86 (Continued)

FORMATION OF COMPLETION: TRES HERMANOS - C1 AND C2 SANDSTONE

		LOCATION ID - SAMPLE ID AND LOG DATE								
		785-01 05/15/86		786-01 10/03/85		786-02 10/03/85		786-03 10/03/85		786-04 10/03/85
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	841.		384.		384.		384.		384.
ALUMINUM	MG/L	-		0.4		0.3		0.2		0.2
AMMONIUM	MG/L	-		< 0.1		< 0.1		0.2		< 0.1
ANTIMONY	MG/L	-		< 0.003		< 0.003		< 0.003		< 0.003
ARSENIC	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01
BARIUM	MG/L	-		0.2		0.2		0.3		0.2
BICARBONATE	MG/L	-		-		-		-		-
BORON	MG/L	0.3		1.3		1.3		1.3		1.4
CADMIUM	MG/L	< 0.001		< 0.001		< 0.001		0.003		< 0.001
CALCIUM	MG/L	531.		404.		426.		448.		451.
CHLORIDE	MG/L	190.		140.		130.		130.		130.
CHROMIUM	MG/L	0.07		0.04		0.04		0.04		0.04
COBALT	MG/L	0.1		0.07		0.06		0.07		0.08
CONDUCTANCE	UMHO/CM	4500.		3600.		3600.		3600.		3600.
COPPER	MG/L	-		0.03		0.04		0.04		0.04
CYANIDE	MG/L	-		< 0.01		< 0.01		< 0.01		< 0.01
FLUORIDE	MG/L	0.6		2.1		2.1		2.1		2.1
GROSS ALPHA	PCI/L	-		-		-		-		-
IRON	MG/L	28.8		0.09		0.1		0.15		0.1
LEAD	MG/L	-		< 0.01		< 0.01		< 0.01		< 0.01
MAGNESIUM	MG/L	241.		279.		278.		280.		283.
MANGANESE	MG/L	1.82		0.05		0.06		0.06		0.06
MERCURY	MG/L	-		< 0.0002		< 0.0002		< 0.0002		< 0.0002
MOLYBDENUM	MG/L	0.2		0.2		0.34		0.22		0.1
NICKEL	MG/L	-		0.1		0.1		0.09		0.09
NITRATE	MG/L	< 1.		45.		55.		55.		55.
NITRITE	MG/L	-		< 0.1		< 0.1		< 0.1		< 0.1
ORG. CARBON	MG/L	-		-		83.		83.		-
PB-210	PCI/L	-		7.1	1.6	8.3	1.7	8.8	1.5	8.2	1.5
PH	SU	7.35		7.		7.		7.		7.
PHOSPHATE	MG/L	-		0.4		0.4		0.3		0.4
PO-210	PCI/L	-		0.	0.6	0.	0.6	0.	0.6	0.	0.6
POTASSIUM	MG/L	11.7		5.83		5.65		5.71		5.95
RA-226	PCI/L	-		1.7	0.5	1.9	0.5	1.4	0.4	1.9	0.5
RA-228	PCI/L	-		2.	2.8	0.	1.3	0.3	0.9	0.1	1
SELENIUM	MG/L	< 0.005		0.044		0.045		< 0.005		< 0.005
SILICA	MG/L	-		11.		10.		11.		13.
SILVER	MG/L	-		< 0.01		< 0.01		< 0.01		< 0.01
SODIUM	MG/L	913.		883.		663.		668.		660.
STRONTIUM	MG/L	4.4		10.		10.		11.		11.
SULFATE	MG/L	3370.		3010.		3040.		2960.		3040.
SULFIDE	MG/L	-		< 0.1		< 0.1		< 0.1		< 0.1
TEMPERATURE	C - DEGREE	17.		12.		12.		12.		12.
TH-230	PCI/L	-		0.1	0.3	0.1	0.3	0.4	0.4	1.1	0.7
TIN	MG/L	-		< 0.005		< 0.005		< 0.005		< 0.005
TOTAL SOLIDS	MG/L	5690.		5250.		5290.		5270.		5240.
U-234	PCI/L	-		-		-		-		-

Table B.2.15 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/24/82 TO 05/24/86 (Continued)

FORMATION OF COMPLETION: TRES HERMANOS - C1 AND C2 SANDSTONE

		LOCATION ID - SAMPLE ID AND LOG DATE								
		785-01 05/15/86		786-01 10/03/85		786-02 10/03/85		786-03 10/03/85		786-04 10/03/85
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY
URANIUM	MG/L	1.25		0.721		0.775		0.721		0.695
VANADIUM	MG/L	0.4	<	0.01	<	0.01	<	0.01		0.05
ZINC	MG/L	-		0.036		0.05		0.034		0.038

Table B.2.15 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/21/86 (Continued)

FORMATION OF COMPLETION: TRES HERMANOS - C1 AND C2 SANDSTONE

PARAMETER	UNIT OF MEASURE	786-05 10/03/85 PARAMETER VALUE	+/-UNCERTAINTY	786-04 05/14/86 PARAMETER VALUE	+/-UNCERTAINTY	787-04 10/06/85 PARAMETER VALUE	+/-UNCERTAINTY	787-04 05/15/86 PARAMETER VALUE	+/-UNCERTAINTY	791-04 10/11/85 PARAMETER VALUE	+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	381.		349.		405.		418.		451.	
ALUMINUM	MG/L	0.3		-		0.6		-		0.6	
AMMONIUM	MG/L	< 0.1		-		1.		-		1.6	
ANTIMONY	MG/L	< 0.003		-		< 0.003		-		< 0.003	
ARSENIC	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		0.02	
BARIUM	MG/L	0.2		-		< 0.1		-		0.1	
BICARBONATE	MG/L	-		-		-		-		-	
BORON	MG/L	1.3		1.4		0.5		0.6		0.3	
CADMIUM	MG/L	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
CALCIUM	MG/L	455.		492.		351.		308.		34.	
CHLORIDE	MG/L	130.		140.		2.8		11.		31.	
CHROMIUM	MG/L	0.04		0.03		0.04		0.03		0.21	
COBALT	MG/L	0.08		0.09		< 0.05		< 0.05		< 0.05	
CONDUCTANCE	UMHO/CM	3600.		2950.		3300.		3200.		3000.	
COPPER	MG/L	0.03		-		0.03		-		< 0.02	
CYANIDE	MG/L	< 0.01		-		< 0.01		-		< 0.01	
FLUORIDE	MG/L	2.1		0.6		0.5		0.5		1.1	
GROSS ALPHA	PCI/L	-		-		-		-		-	
IRON	MG/L	0.15		0.18		0.18		0.63		< 0.03	
LEAD	MG/L	< 0.01		-		< 0.01		-		< 0.01	
MAGNESIUM	MG/L	286.		274.		154.		131.		5.19	
MANGANESE	MG/L	0.05		0.07		0.27		0.61		0.02	
MERCURY	MG/L	< 0.0002		-		< 0.0002		-		< 0.0002	
MOLYBDENUM	MG/L	0.2		0.16		0.25		0.19		0.1	
NICKEL	MG/L	< 0.04		-		0.08		-		0.07	
NITRATE	MG/L	55.		< 1.		4.		2.		8.	
NITRITE	MG/L	< 0.1		-		< 0.1		-		< 0.1	
ORG. CARBON	MG/L	83.		-		53.		-		-	
PB-210	PCI/L	6.2	1.4	-		0.	1.1	-		0.7	1.9
PH	SU	7.		7.88		7.08		7.		12.09	
PHOSPHATE	MG/L	0.4		-		0.5		-		0.4	
PO-210	PCI/L	0.	0.6	-		0.	0.6	-		-	
POTASSIUM	MG/L	5.72		6.26		22.5		23.1		22.3	
RA-226	PCI/L	8.6	1.1	-		0.8	0.3	-		0.3	1.6
RA-228	PCI/L	0.8	1.1	-		1.5	1.2	-		1.2	3.8
SELENIUM	MG/L	< 0.005		< 0.005		< 0.005		< 0.005		0.016	
SILICA	MG/L	12.		-		16.		-		6.	
SILVER	MG/L	< 0.01		-		< 0.01		-		< 0.01	
SODIUM	MG/L	600.		688.		463.		755.		690.	
STRONTIUM	MG/L	11.		9.		8.6		0.7		1.5	
SULFATE	MG/L	2930.		3470.		2250.		2470.		1200.	
SULFIDE	MG/L	< 0.1		-		< 0.1		-		< 0.1	
TEMPERATURE	C - DEGREE	12.		15.		13.5		13.		11.	
TH-230	PCI/L	2.5	1.4	-		0.7	0.5	-		1.1	2.5
TIN	MG/L	< 0.005		-		< 0.005		-		< 0.005	
TOTAL SOLIDS	MG/L	5330.		5230.		3730.		3810.		1950.	
U-234	PCI/L	-		-		-		-		-	

Table B.2.15 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/21/86 (Continued)

FORMATION OF COMPLETION: TRES HERMANOS - C1 AND C2 SANDSTONE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		786-05 10/03/85	786-01 05/14/86	787-01 10/06/85	787-01 05/15/86	791-01 10/11/85
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
URANIUM	MG/L	0.475	0.699	0.0464	0.0053	0.0007
VANADIUM	MG/L	< 0.1	0.42	< 0.01	0.29	< 0.01
ZINC	MG/L	0.031	-	0.061	-	< 0.005

Table B.2.15 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/24/82 TO 05/21/86 (Continued)

FORMATION OF COMPLETION: TRES HERMANOS - C1 AND C2 SANDSTONE

PARAMETER	UNIT OF MEASURE	791-01 05/21/86 PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	2650.
ALUMINUM	MG/L	-
AMMONIUM	MG/L	-
ANTIMONY	MG/L	-
ARSENIC	MG/L	< 0.01
BARIUM	MG/L	-
BICARBONATE	MG/L	-
BORON	MG/L	0.3
CADMIUM	MG/L	< 0.001
CALCIUM	MG/L	181.
CHLORIDE	MG/L	38.
CHROMIUM	MG/L	0.04
COBALT	MG/L	0.06
CONDUCTANCE	UMHO/CM	8000.
COPPER	MG/L	-
CYANIDE	MG/L	-
FLUORIDE	MG/L	0.4
GROSS ALPHA	PCI/L	-
IRON	MG/L	< 0.03
LEAD	MG/L	-
MAGNESIUM	MG/L	0.022
MANGANESE	MG/L	< 0.01
MERCURY	MG/L	-
MOLYBDENUM	MG/L	0.21
NICKEL	MG/L	-
NITRATE	MG/L	2.
NITRITE	MG/L	-
ORG. CARBON	MG/L	-
PB-210	PCI/L	-
PH	SU	12.46
PHOSPHATE	MG/L	-
PO-210	PCI/L	-
POTASSIUM	MG/L	43.6
RA-226	PCI/L	-
RA-228	PCI/L	-
SELENIUM	MG/L	< 0.005
SILICA	MG/L	-
SILVER	MG/L	-
SODIUM	MG/L	1110.
STRONTIUM	MG/L	8.1
SULFATE	MG/L	240.
SULFIDE	MG/L	-
TEMPERATURE	C - DEGREE	15.
TH-230	PCI/L	-
TIN	MG/L	-
TOTAL SOLIDS	MG/L	3520.
U-234	PCI/L	-

Table B.2.15 GROUND WATER QUALITY DATA BY LOCATION
SITE: AMBROSIA LAKE
06/21/82 TO 05/21/86 (Continued)

FORMATION OF COMPLETION: TRES HERMANOS - C1 AND C2 SANDSTONE

PARAMETER	UNIT OF MEASURE	LOCATION ID - SAMPLE ID AND LOG DATE: 791-01 05/21/86 PARAMETER VALUE+/-UNCERTAINTY
URANIUM	MG/L	< 0.0003
VANADIUM	MG/L	0.3
ZINC	MG/L	-

Table B.2.15 GROUND WATER QUALITY MEASUREMENTS EXCEEDING STANDARDS
SITE: AMBROSIA LAKE
06/24/82 TO 05/24/86 (Continued)

FORMATION OF COMPLETION: TRES HERMANOS - C1 AND C2 SANDSTONE

PARAMETER	UNITS OF MEASURE	MAXIMUM VALUE d	LOCATION ID	SAMPLE ID	LOG DATE	PARAMETER VALUE+/-UNCERTAINTY
ALUMINUM	MG/L	5.0	-	-	-	-
ARSENIC	MG/L	0.05	-	-	-	-
BARIUM	MG/L	1.0	-	-	-	-
BORON	MG/L	0.75	778	01	10/11/85	1.1000
			779	01	05/14/86	1.1000
			786	01	10/03/85	1.3000
			786	02	10/03/85	1.3000
			786	03	10/03/85	1.3000
			786	04	10/03/85	1.4000
			786	05	10/03/85	1.3000
			786	01	05/14/86	1.4000
**** SAMPLES EXCEEDING MAXIMUM VALUE = 39 % ****						
CADMIUM	MG/L	0.01	-	-	-	-
CHLORIDE	MG/L	250.0	708	01	06/24/82	260.0000
			778	01	05/15/86	270.0000
**** SAMPLES EXCEEDING MAXIMUM VALUE = 9 % ****						
CHROMIUM	MG/L	0.05	784	01	05/15/86	.1100
			785	01	05/15/86	.0700
			791	01	10/11/85	.2100
**** SAMPLES EXCEEDING MAXIMUM VALUE = 14 % ****						
COBALT	MG/L	0.05	773	01	05/14/86	.0700
			778	01	05/15/86	.0800
			779	01	10/10/85	.0700
			779	01	05/14/86	.1000
			785	01	05/15/86	.1000
			786	01	10/03/85	.0700
			786	02	10/03/85	.0600
			786	03	10/03/85	.0700
			786	04	10/03/85	.0800
			786	05	10/03/85	.0800
			786	01	05/14/86	.0900
			791	01	05/21/86	.0600
**** SAMPLES EXCEEDING MAXIMUM VALUE = 59 % ****						
COPPER	MG/L	1.0	-	-	-	-
FLUORIDE	MG/L	1.4	708	01	06/24/82	2.0000
			786	01	10/03/85	2.1000
			786	02	10/03/85	2.1000
			786	03	10/03/85	2.1000
			786	04	10/03/85	2.1000
			786	05	10/03/85	2.1000
**** SAMPLES EXCEEDING MAXIMUM VALUE = 28 % ****						
GROSS ALPHA	PCI/L	15.0	708	01	06/24/82	31000.0000

Table B.2.15 GROUND WATER QUALITY MEASUREMENTS EXCEEDING STANDARDS
SITE: AMBROSIA LAKE
06/21/82 TO 05/21/86 (Continued)

FORMATION OF COMPLETION: TRES HERMANOS - C1 AND C2 SANDSTONE

PARAMETER	UNITS OF MEASURE	MAXIMUM VALUE	LOCATION ID	SAMPLE ID	LOG DATE	PARAMETER VALUE+/-UNCERTAINTY	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 100 % ****							
IRON	MG/L	0.3	779	01	05/14/86	.4700	
			785	01	05/15/86	28.8000	
			787	01	05/15/86	.6300	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 14 % ****							
LEAD	MG/L	0.05	-	-	-	-	
MANGANESE	MG/L	0.05	778	01	10/11/85	.0600	
			778	01	05/15/86	.1300	
			779	01	10/10/85	.8400	
			779	01	05/14/86	1.0200	
			785	01	10/15/85	.1400	
			785	01	05/15/86	1.8200	
			786	02	10/03/85	.0600	
			786	03	10/03/85	.0600	
			786	04	10/03/85	.0600	
			786	01	05/14/86	.0700	
			787	01	10/06/85	.2700	
			787	01	05/15/86	.6100	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 59 % ****							
MERCURY	MG/L	0.002	-	-	-	-	
MOLYBDENUM	MG/L	1.00	708	01	06/21/82	10.3000	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 4 % ****							
NICKEL	MG/L	0.20	-	-	-	-	
NITRATE	MG/L	44.0	778	01	10/11/85	400.0000	
			786	01	10/03/85	45.0000	
			786	02	10/03/85	55.0000	
			786	03	10/03/85	55.0000	
			786	04	10/03/85	55.0000	
			786	05	10/03/85	55.0000	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 28 % ****							
PH	SU	6.5 TO 8.5	773	01	05/14/86	12.4100	
			782	01	10/09/85	12.2000	
			782	01	05/16/86	11.4600	
			784	01	05/15/86	11.9200	
			786	05	10/03/85	12.0000	
			791	01	10/11/85	12.0900	
			791	01	05/21/86	12.4600	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 33 % ****							
RA226+RA228	PCI/L	5.0	773	01	05/14/86	27.0000	2
			779	01	10/10/85	8.5000	0.7
			785	01	10/15/85	5.8000	1.9

Table B.2.15 GROUND WATER QUALITY MEASUREMENTS EXCEEDING STANDARDS
SITE: AMBROSIA LAKE
06/21/82 TO 05/21/86 (Continued)

FORMATION OF COMPLETION: TRES HERMANOS - C1 AND C2 SANDSTONE

PARAMETER	UNITS OF MEASURE	MAXIMUM VALUE	LOCATION ID	SAMPLE ID	LOG DATE	PARAMETER VALUE	+/-UNCERTAINTY
RA226+RA228	PCI/L	5.0	786	01	10/03/85	5.7000	2.8
			786	04	10/03/85	5.9000	0.5
			786	05	10/03/85	9.4000	1.1
			791	01	10/11/85	5.3000	1.6
**** SAMPLES EXCEEDING MAXIMUM VALUE = 31 % ****							
SELENIUM	MG/L	0.01	708	01	06/21/82	.2250	
			786	01	10/03/85	.0140	
			786	02	10/03/85	.0150	
			791	01	10/11/85	.0160	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 19 % ****							
SILVER	MG/L	0.05	-	-	-	-	
SULFATE	MG/L	250.0	708	01	06/21/82	4010.0000	
			778	01	10/11/85	2930.0000	
			778	01	05/15/86	3150.0000	
			779	01	10/10/85	3310.0000	
			779	01	05/14/86	3840.0000	
			782	01	10/09/85	516.0000	
			782	01	05/16/86	633.0000	
			784	01	05/15/86	557.0000	
			785	01	10/15/85	1560.0000	
			785	01	05/15/86	3370.0000	
			786	01	10/03/85	3010.0000	
			786	02	10/03/85	3010.0000	
			786	03	10/03/85	2960.0000	
			786	04	10/03/85	3040.0000	
			786	05	10/03/85	2930.0000	
			786	01	05/14/86	3170.0000	
			787	01	10/06/85	2250.0000	
			787	01	05/15/86	2470.0000	
			791	01	10/11/85	1200.0000	
**** SAMPLES EXCEEDING MAXIMUM VALUE = 90 % ****							
TOTAL SOLIDS	MG/L	500.0	708	01	06/21/82	7190.0000	
			773	01	05/14/86	3040.0000	
			778	01	10/11/85	5610.0000	
			778	01	05/15/86	5920.0000	
			779	01	10/10/85	5900.0000	
			779	01	05/14/86	6490.0000	
			782	01	10/09/85	1880.0000	
			782	01	05/16/86	1340.0000	
			784	01	05/15/86	1560.0000	
			785	01	10/15/85	2670.0000	
			785	01	05/15/86	5690.0000	
			786	01	10/03/85	5250.0000	
			786	02	10/03/85	5290.0000	

Table B.2.15 GROUND WATER QUALITY MEASUREMENTS EXCEEDING STANDARDS
SITE: AMBROSIA LAKE
06/21/82 TO 05/21/86 (Concluded)

FORMATION OF COMPLETION: TRES HERMANOS - C1 AND C2 SANDSTONE

PARAMETER[a]	UNITS OF MEASURE	MAXIMUM VALUE	LOCATION ID	SAMPLE ID	LOG DATE	PARAMETER VALUE+/-UNCERTAINTY
TOTAL SOLIDS	MG/L	500.0	786	03	10/03/85	5270.0000
			786	04	10/03/85	5240.0000
			786	05	10/03/85	5330.0000
			786	01	05/14/86	5230.0000
			787	01	10/06/85	3730.0000
			787	01	05/15/86	3810.0000
			791	01	10/11/85	1950.0000
			791	01	05/21/86	3520.0000
**** SAMPLES EXCEEDING MAXIMUM VALUE = 100 % ****						
URANIUM	MG/L	5.0	778	01	10/11/85	11.8000
			778	01	05/15/86	9.3100
**** SAMPLES EXCEEDING MAXIMUM VALUE = 9 % ****						
ZINC	MG/L	5.0	-	-	-	-

[a]Parameter value ± uncertainty applies to radionuclides Pb-210, Ra-226, and Th-230.
[b]0.01 parameter value is less than 0.01.
[c]- indicates analysis not performed.
[d]Maxixum value is WQCC standard or Federal standard, whichever is less.

If the analysis of a constituent does not satisfy the accuracy criterion, then the known sample and other samples in the lot must be reanalyzed for that constituent until the criterion is satisfied.

- All samples must have a cation/anion balance error of less than an absolute value of five percent. Samples must be reanalyzed until this criterion is satisfied.

- One sample per lot is split five ways to check for laboratory precision.

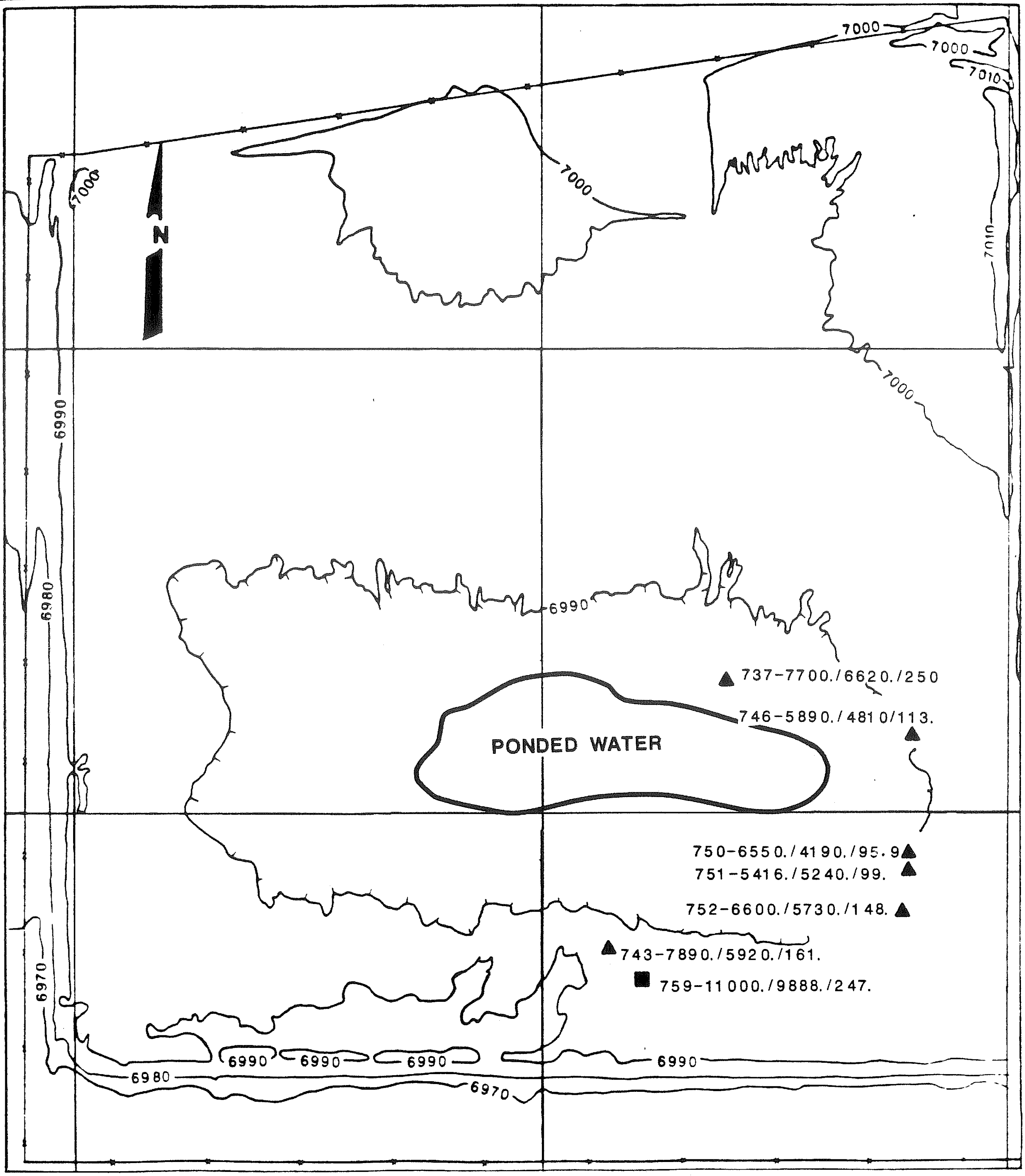
In addition, standard procedures have been developed for well installation sample collection and shipping. Documentation of field procedures and quality assurance measures is available at the UMTRA Project Office in Albuquerque, New Mexico.

Major ions used to trace the extent of pond seepage migration in ground water are sulfate and sodium. A sulfate salt was the predominant component of the mill waste effluent discharged to the pile (see Table B.2.11). Sulfate is a conservative species that travels relatively unimpeded in most ground-water flow systems. Sodium was discharged in the form of soluble salts to the tailings pile. Sodium is not a conservative tracer, since it is subject to ion exchange reactions. However, the large amount of soluble sodium discharged to the pile makes it a prime indicator for tailings pile seepage. Molybdenum, also not a conservative tracer, was used as an additional indicator for tailings pile seepage.

Piezometers were installed within the tailings impoundment at depths where augered samples showed the greatest moisture content (typically slime zones), in order to locate any potentially perched water zones. After installation, these piezometers typically did not yield water, emphasizing the fact that, although close to saturation, water is held in the slime layers under capillary pressure. The only saturated portion of the tailings is fairly well-defined by the eastern and southern edge of the pile. The nests indicate a downward vertical hydraulic gradient.

Slug tests to measure in-situ hydraulic conductivity in the tailings were not performed because the piezometers demonstrated that the surface pond is not a significant present source of recharge to the tailings and that a saturated flow condition within the pile no longer exists except for some residual perched water near the southeast corner of the pile. Laboratory values for the hydraulic conductivity of sand and slime tailings materials are reported in Appendix D of the RAP, Table D.7.5.

Concentrations of sulfate, sodium, and molybdenum in the tailings pore water are shown in Figure B.2.17. Lysimeter 759 recovered pore water having sulfate, sodium, and molybdenum concentrations of 11,000, 9880, and 247 mg/l, respectively. Tailings water from well points had concentrations of sulfate ranging from 5416 to 7890 mg/l, sodium ranging from 4190 to 6620 mg/l, and molybdenum ranging from 95.9 to 250 mg/l. These values are consistent with the chemical composition of alkaline leach mill effluent given in Table B.2.12.



■ 759 LYSIMETER LOCATION

▲ 737-7700./6620./250.

→ PIEZOMETER (WELL POINT) LOCATION

→ WELL POINT OR LYSIMETER NUMBER

→ SULFATE CONCENTRATION (mg/l)

→ SODIUM CONCENTRATION (mg/l)

→ MOLYBDENUM CONCENTRATION (mg/l)

LEGEND

0 200 400 600 800

SCALE IN FEET

7000 SURFACE ELEVATION (FT. MSL)

FIGURE B.2.17 TAILINGS PORE WATER QUALITY

A list of well points and lysimeters installed in the tailings having chemical constituents that exceed state and/or Federal ground-water standards is given in Table B.2.13. The following constituents exceed the standards for most samples: cobalt, fluoride, molybdenum, pH, radium-226 plus radium-228, selenium, sulfate, total dissolved solids, and uranium. Chromium, iron, manganese, and nitrate standards were exceeded by a small number of samples.

Lysimeter 757 was installed in the unsaturated alluvium/weathered Mancos Shale, beneath the tailings pile and above the perched water table. The analyses of two pore water samples collected from 757 are listed in Table B.2.13. Concentrations of sulfate ranged from 7640 to 8010 mg/l, sodium ranged from 4790 to 6090 mg/l, and molybdenum concentrations ranged from 155 to 158 mg/l. These values are well within the range measured in the tailings pore water. This is to be expected as no mixing has taken place with the underlying perched water.

Chemical constituents analyzed from water samples collected from lysimeter 757 that exceed state and/or Federal standards are listed in Table B.2.13 and include cobalt, iron, manganese, molybdenum, nitrate, pH, selenium, sulfate, total solids, and uranium.

Sulfate, sodium, and molybdenum isopleth maps for ground water in the perched alluvium/weathered Mancos Shale are shown in Figures B.2.18 through B.2.20, respectively. Each map shows a northeast to southwest trending contaminant plume with a maximum just south of the ponded water within the tailings pile. These plumes are consistent with the water table map of the alluvium/weathered Mancos Shale (see Figure B.2.7), which shows ground-water flow to the southwest into the Tres Hermanos-C Sandstone. Monitor wells 609, 792, and 793 (alluvium/weathered Mancos Shale completions) and cross-gradient wells 782 and 784 (Tres Hermanos-C2 Sandstone completions) show values considerably lower than the main body of the plume. Additionally, alluvial/weathered Mancos Shale ground water is noticeably higher in calcium and chloride than the tailings pore water. The higher concentrations downgradient of the source may indicate that the source concentration was greater during active milling than it is presently.

A list of monitor wells installed in the alluvium/weathered Mancos Shale having chemical constituents which exceed state and/or Federal ground-water standards is given in Table B.2.14. Monitor well 799 completed in the alluvium/weathered Mancos Shale well east of the pile alluvial wells (783 and 794) west and south of the pile were all dry, while monitor well 620, which is approximately 2000 feet south of the tailings pile near the holding ponds contains water. The following constituents exceed the standards for most samples: cobalt, manganese, molybdenum, combined radium-226 and -228, sulfate, and total dissolved solids. Arsenic, boron, cadmium, chloride, chromium, fluoride, gross-alpha activity, iron, nitrate, pH, selenium, silver, and uranium standards were exceeded by a small number of samples.

Concentrations of several contaminants have decreased significantly as a result of tailings water undergoing chemical reactions with the host rocks and hydrodynamic dispersion. The number of samples exceeding state and/or Federal standards for pH is clearly reduced.

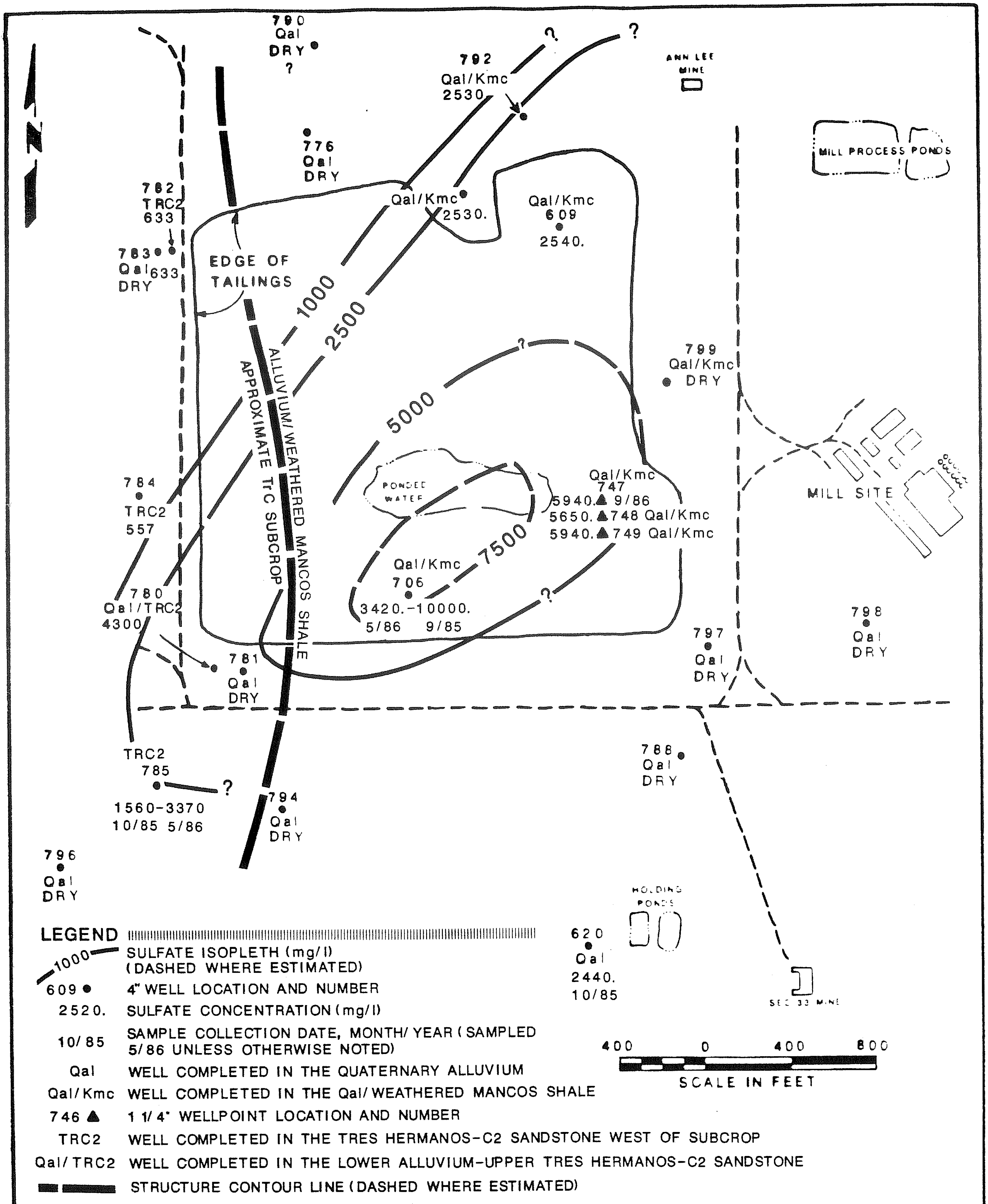
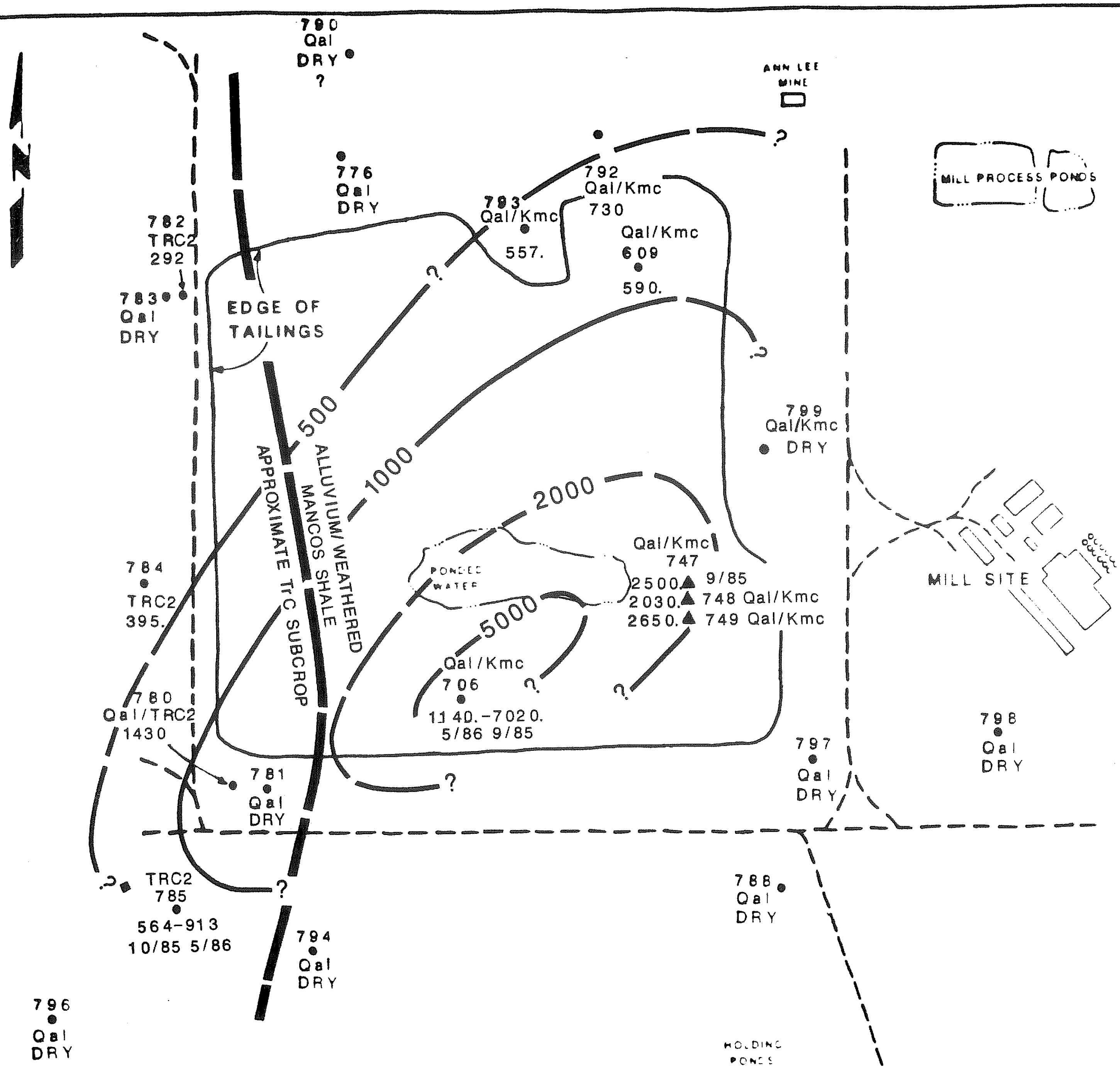


FIGURE B.2.18 SULFATE ISOPLETH MAP FOR GROUND WATER IN ALLUVIUM/WEATHERED MANCOS SHALE AND UNCONFINED TRES HERMANOS-C2 SANDSTONE



LEGEND

500	SODIUM ISOPLETH (mg/l) (DASHED WHERE ESTIMATED)
609	4" WELL LOCATION AND NUMBER
590.	SODIUM CONCENTRATION (mg/l) 10/85
10/85	SAMPLE COLLECTION DATE, MONTH/YEAR (SAMPLED 5/86 UNLESS OTHERWISE NOTED)
Qal	WELL COMPLETED IN THE ALLUVIUM
Qal/Kmc	WELL COMPLETED IN THE ALLUVIUM/WEATHERED MANCOS SHALE
746/15'	1 1/4" WELLPOINT LOCATION AND NUMBER
TRC2	WELL COMPLETED IN TRES HERMANOS-C2 SANDSTONE WEST OF SUBCROP
Qal/TRC2	WELL COMPLETED IN THE LOWER ALLUVIUM-UPPER TRES HERMANOS-C2 SANDSTONE
▬ ▬	STRUCTURE CONTOUR LINE (DASHED WHERE ESTIMATED)

HOLDING PONDS

620 Qal 434.

SEC 33 MINE

400 0 400 800

SCALE IN FEET

FIGURE B.2.19 SODIUM ISOPLETH MAP FOR GROUND WATER IN ALLUVIUM/WEATHERED MANCOS SHALE AND UNCONFINED TRES HERMANOS-C2 SANDSTONE

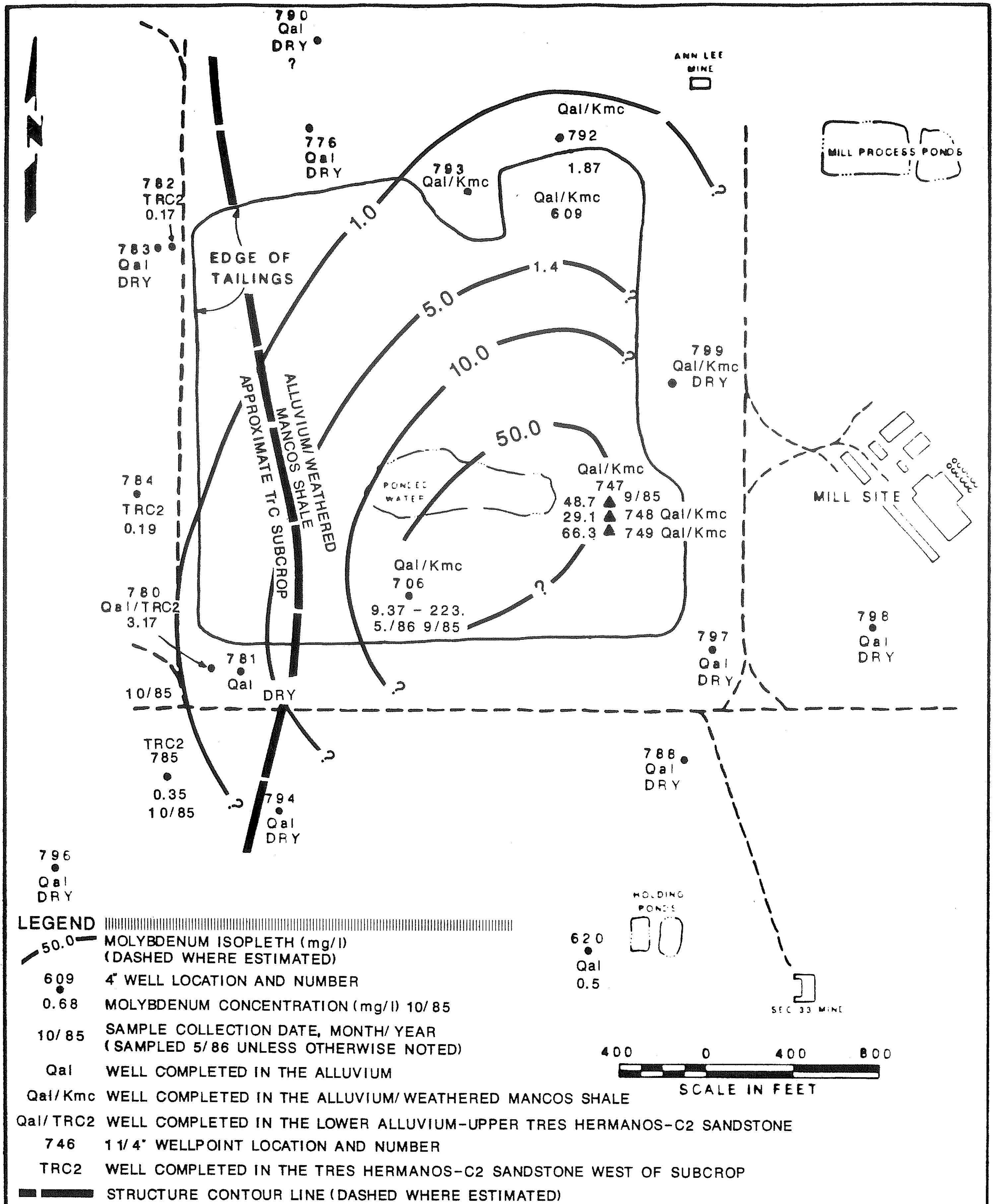


FIGURE B.2.20 MOLYBDENUM ISOPLETH MAP FOR GROUND WATER IN ALLUVIUM/WEATHERED MANCOS SHALE AND UNCONFINED TRES HERMANOS-C2 SANDSTONE

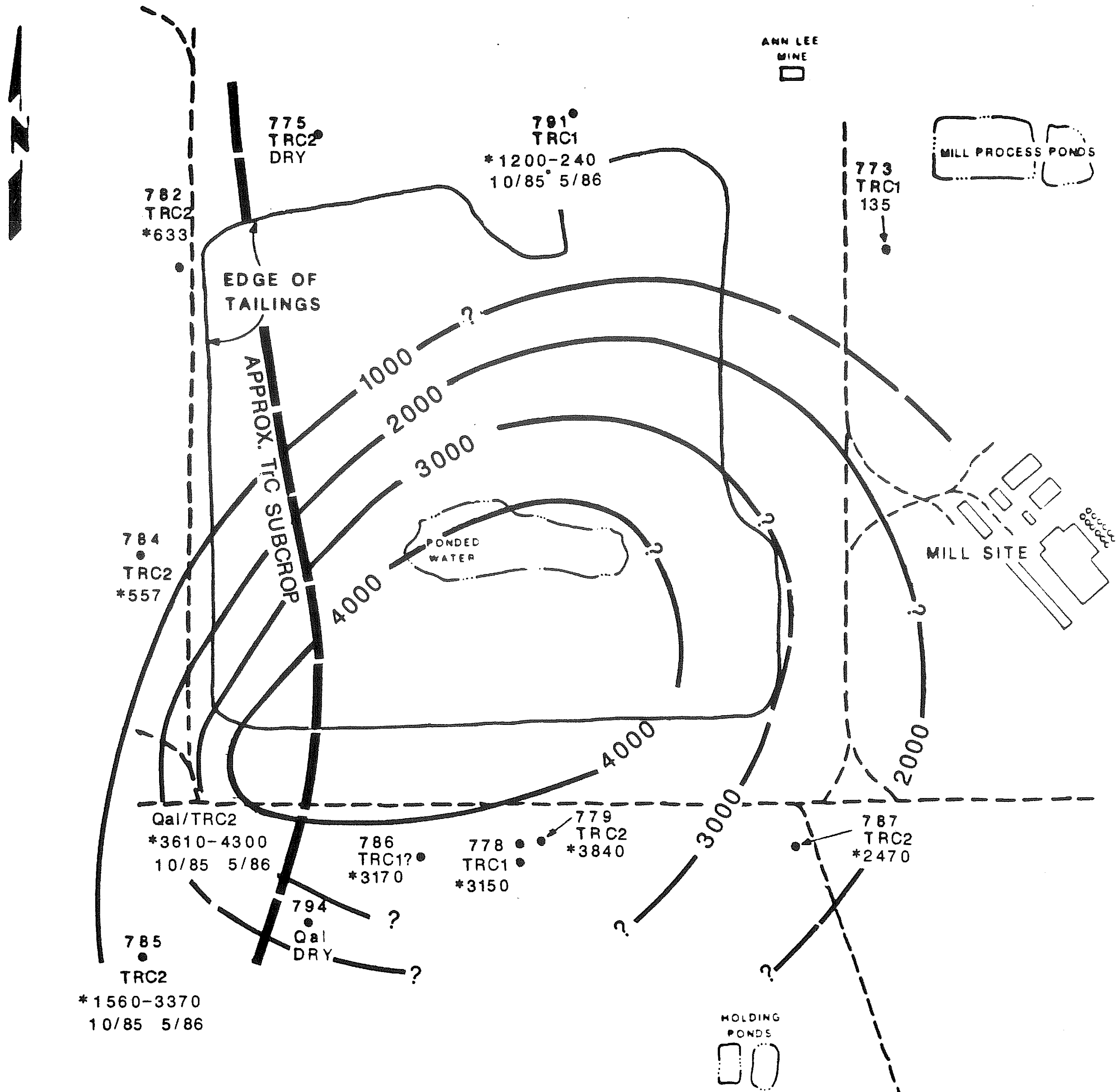
A small number of samples showed considerable variation in concentrations of various chemical constituents between the September-October, 1985, and May, 1986, sampling dates. For example, well 706 was sampled in October, 1985, and May, 1986, with sulfate values of 10,000 and 3420 mg/l, respectively. This variation is by a factor of three. The interpretation of the contaminant plume, however, is not altered as a result of this variation.

Sulfate, sodium, and molybdenum isopleth maps for ground water in the Tres Hermanos-C1 and -C2 Sandstones are shown in Figures B.2.21 through B.2.23, respectively. Water chemistry data for the Tres Hermanos-C1 and -C2 Sandstones were combined into a single map. This is justified because these hydrostratigraphic units are both recharged by tailings seepage within the alluvium/weathered Mancos Shale and they have similar hydraulic conductivities and thicknesses (see Sections B.2.2 and B.2.4). Each map shows a southwest to northeast trending contaminant plume migrating downgradient in the direction of the Ann Lee Mine shaft. This is consistent with the equipotential maps constructed for the Tres Hermanos-C1 and -C2 Sandstones (Figures B.2.12 and B.2.13). Sulfate, sodium, and molybdenum concentrations are higher for downgradient wells 773 and 791 than for cross-gradient wells 782 and 784.

Monitor wells installed in the Tres Hermanos-C1 and -C2 Sandstones with water samples having chemical constituents exceeding state and/or Federal ground-water standards are listed in Table B.2.15. The following constituents exceed the standards for most samples: boron, cobalt fluoride, pH, manganese, nitrate, radium-226 and -228, sulfate, and total dissolved solids. Chloride, chromium, gross alpha, iron, molybdenum, selenium, and uranium standards were exceeded by a small number of samples.

Concentrations of some contaminants have decreased significantly in the alluvium and the Tres Hermanos-C1 and -C2 Sandstones. These include cobalt, fluoride, molybdenum, and uranium. Processes contributing to these decreases may include chemical attenuation and hydrodynamic dispersion.

Determination of local background water quality for the alluvium/weathered Mancos Shale is difficult, because it is unsaturated elsewhere in the Ambrosia Lake valley. Saturation in the alluvium/weathered Mancos Shale at the Ambrosia Lake site is most probably due to the tailings pile, mill holding ponds, and other recharge areas in the immediate vicinity. Quaternary alluvium wells south and west of the tailings pile (wells 619, 620, 650, and 718) were sampled. Well 620 is approximately 1600 feet south of the tailings pile and 200 feet west of the holding ponds. Constituents exceeding state and/or Federal standards include cobalt, selenium, sulfate, total dissolved solids, and uranium. The alluvial ground water in well 620 has without question been impacted by past activities at the Ambrosia Lake site. Well 619 is located approximately 4000 feet southeast of the Ambrosia Lake tailings pile. Constituents from water sampled from well 619 exceeding state and/or Federal standards include only sulfate and total dissolved solids. This well has been impacted far less than well 620; however, the high sulfate and total dissolved solids values are probably also



LEGEND

1000	SULFATE ISOPLETH (mg/l) (DASHED WHERE ESTIMATED)
TRC1	TRES HERMANOS-C1 SANDSTONE
TRC2	TRES HERMANOS-C2 SANDSTONE
784 •	WELL LOCATION AND NUMBER
4310	SULFATE CONCENTRATION (mg/l)
QAL	QUATERNARY ALLUVIUM 10/85-SAMPLE COLLECTION DATE, MONTH/YEAR (SAMPLED 5/86 UNLESS OTHERWISE NOTED)
(heavy line)	STRUCTURE CONTOUR LINE (DASHED WHERE ESTIMATED)
*	EXCEEDS STATE AND/OR FEDERAL WATER QUALITY STANDARDS

400 0 400 800

SCALE IN FEET

FIGURE B.2.21 SULFATE ISOPLETH MAP FOR GROUND WATER IN THE TRES HERMANOS-C1 AND C2 SANDSTONES

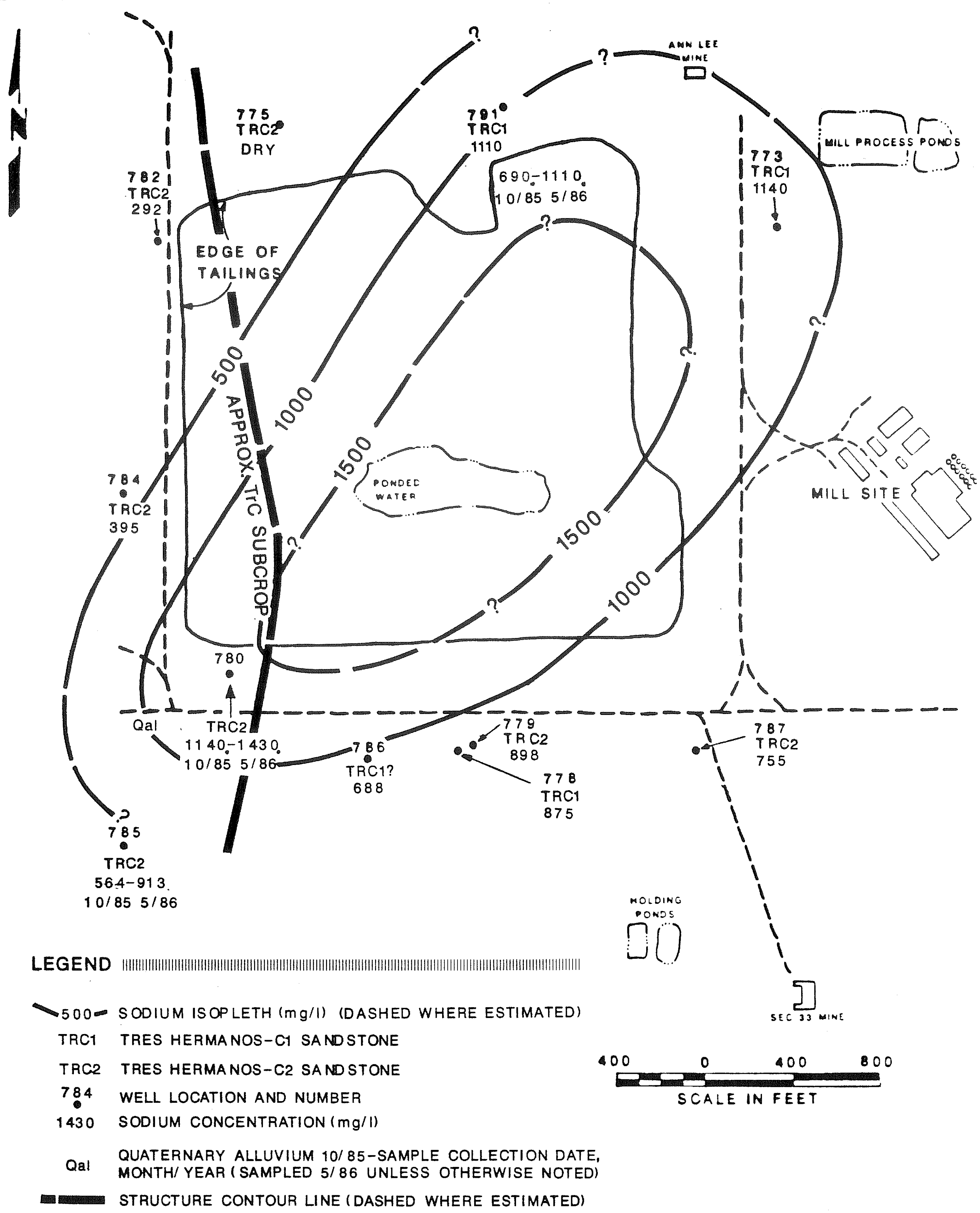
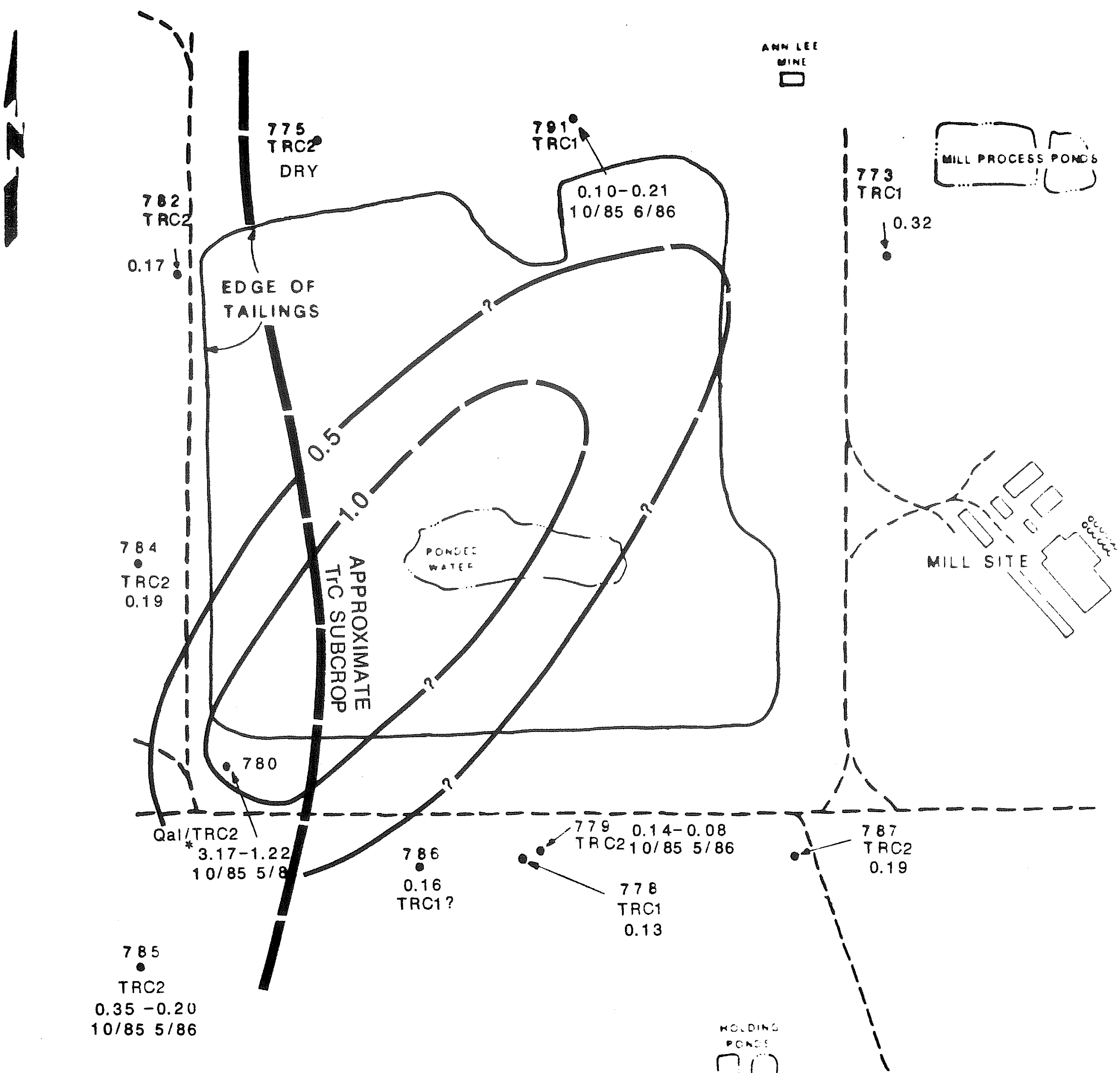


FIGURE B.2.22 SODIUM ISOPLETH MAP FOR GROUND WATER IN THE TRES HERMANOS-C1 AND C2 SANDSTONES



LEGEND

- 1.0 — MOLYBDENUM ISOPLETH (mg/l) (DASHED WHERE ESTIMATED)
- TRC1 — TRES HERMANOS-C1 SANDSTONE
- TRC2 — TRES HERMANOS-C2 SANDSTONE
- 784 ● — WELL LOCATION AND NUMBER CONCENTRATION
- Qal — QUATERNARY ALLUVIUM 10/85 SAMPLE COLLECTION DATE, MONTH/YEAR (SAMPLED 5/86 UNLESS OTHERWISE NOTED)
- ▬ ▬ — STRUCTURE CONTOUR LINE (DASHED WHERE ESTIMATED)
- * — EXCEEDS STATE AND/OR FEDERAL WATER QUALITY STANDARDS

SEC 33 MINE

400 0 400 800

SCALE IN FEET

FIGURE B.2.23 MOLYBDENUM ISOPLETH MAP FOR GROUND WATER IN THE TRES HERMANOS-C1 AND C2 SANDSTONES

related to past activity in the Ambrosia Lake valley. Sulfate levels in wells 619 and 620 are 1770 and 2440 mg/l, respectively, and are in the same range as upgradient wells 792 and 793 completed in the alluvium/weathered Mancos Shale. Well 650 (AW-2) is located approximately one mile southwest of the Ambrosia Lake pile, and approximately 2000 feet east (and downgradient) from the Quivira tailings piles. Constituents in well 650 (AW-2) exceeding state and/or Federal standards include cobalt, manganese, sulfate, and total dissolved solids. Well 718 is equidistant between the Ambrosia Lake tailings pile and the Quivira tailings piles. It is also downgradient of the Quivira tailings piles. Constituents exceeding state and/or Federal water quality standards for well 718 include arsenic, boron, cobalt, iron, manganese, nitrate, selenium, sulfate, and total dissolved solids. It is obvious that these Quaternary alluvium "background" (or affected upgradient) wells have all been impacted by uranium activity in the Ambrosia Lake valley, and, therefore, do not represent native ground water. In fact, as previously mentioned, the alluvium and probably the Tres Hermanos-C Sandstone in the vicinity of the site were unsaturated prior to uranium activity in the Ambrosia Lake valley.

Background water quality data for the Tres Hermanos-A, -B, and -C Sandstones are lacking for the period prior to active mining. Ground-water constituents in the Tres Hermanos-C1 and -C2 Sandstones exceeding applicable state and/or Federal water-quality standards in at least one of the samples from the Ambrosia Lake site include boron, chloride, chromium, cobalt, fluoride, gross alpha, iron, manganese, molybdenum, nitrate, radium-226 plus radium-228, selenium, sulfate, total solids, and uranium.

The probable source of alkaline field pH values (11.5 to 12.5) from ground water sampled from DOE wells 773, 782, 784, and 791 is grout contamination. Water analyses from these wells are more suspect than wells with normal pH values (6.65 to 8.5). However, the qualitative use of these analyses is justified as grout contamination should not distort concentration levels in ground water, excluding calcium and field alkalinity, to such a level that analyses should be completely discounted. This is particularly true for sulfate concentrations.

DOE well 775 was drilled into the Tres Hermanos-B Sandstone and completed in the Tres Hermanos-C2 Sandstone. Attempts were made to measure water levels in October, 1985, and May, 1986, with no success. Well 775 is dry. This implies that the Tres Hermanos-C Sandstone ground water in the immediate vicinity of the Ambrosia Lake tailings pile originates from seepage from the alluvium/weathered Mancos Shale ground water. The ground water in the alluvium/weathered Mancos Shale owes its origin to the presence of the tailings pile and the holding ponds (upgradient from the tailings pile). A viable ground-water resource does not exist in the immediate vicinity of the Ambrosia Lake tailings pile. Thus, existing concentrations are considered to be background since the alluvium/weathered Mancos Shale and Tres Hermanos-C Sandstone were not saturated prior to mining and milling activities at the site.

The previous discussion shows the Ambrosia Lake tailings pile to be a source of contamination to the alluvium/weathered Mancos Shale ground water by downward percolation. This contaminated ground water then moves downgradient to the southwest toward the Tres Hermanos-C Sandstone subcrop, where the contaminated water flows into the Tres Hermanos-C1 and -C2 Sandstones downgradient to the northeast toward the Ann Lee Mine. Chemical attenuation and hydrodynamic dispersion decrease contaminant concentrations in the Tres Hermanos-C Sandstone ground water before it reaches the Ann Lee Mine.

B.2.6 SOLUTE TRANSPORT AND THE EFFECTS OF REMEDIAL ACTION

Ground-water contamination beneath the Ambrosia Lake tailings site depends upon (1) the quantity of seepage released from the tailings pile; (2) the rate at which contaminants enter the ground water; (3) the ground-water flow system; and (4) geochemical interactions between tailings seepage and the host rock. The mechanics of seepage depend upon the characteristics of the tailings impoundment and the foundation materials beneath the pile. The Ambrosia Lake site characterization gives a general indication of the present potential contaminant pathways from the tailings pile to the Tres Hermanos-C Sandstone ground water. However, the existing ground-water contamination attributable to the Ambrosia Lake (also known as the Phillips-UNC) tailings pile was largely produced during the milling operation from 1958 to 1963.

To simplify the historical, present, and projected seepage, three phases of seepage analysis can be considered. Phase I occurred when the mill was operating and a large volume of tailings seepage was entering the alluvium/weathered Mancos Shale from the tailings pile. Phase II is the tailings seepage condition where significant recharge through the tailings pile has ceased and the tailings have drained, other than a small area of perched water which exists in the southeastern corner of the pile. Phase III is the predicted condition that would occur when the tailings pile is consolidated and stabilized following the remedial action.

During Phase I, when most of the existing contaminant plume was produced, effluents discharged to the tailings pile created a larger area of saturation and a steeply downward vertical hydraulic gradient within the pile and thus areas with greater flow velocities and less chemical attenuation. There was the greatest potential for contaminant release to ground water in the areas with downward flow gradients. During this phase, a seepage front advanced from the base of the tailings and augmented the perched alluvial/weathered Mancos Shale ground-water system that was developing from recharge of mine water. The existing ground-water mound, which contacts the bottom of the impoundment, probably was much larger during this phase. Lateral flow from the mound beneath the impoundment was under a large driving head. This caused contaminants to move from the pile through the alluvium/weathered Mancos Shale to the recharge area of the Tres Hermanos-C Sandstone subcrop.

Phase II exists presently. The volume of recharge to the pile has decreased to only that produced by precipitation on the pile. The tailings pile has drained and the ground-water mound is dissipating to the underlying hydrostratigraphic units. The seepage from the tailings pile has decreased relative to Phase I seepage. Delineation of flow paths within and beneath the tailings is problematic because of the complex stratification in the tailings and the uncertainty of the exact thickness and disposition of underlying alluvium and weathered Mancos Shale. A detailed study of ground-water flux into and out of a similar Canadian tailings pile (Blackport, 1980) utilized twice as many well points within the pile and concluded that detailed delineation of flow paths was not feasible with data collected over a two-month time period. However, the general flow from the tailings to the alluvium/weathered Mancos Shale, to the Tres Hermanos-C Sandstone, to the Westwater Canyon Member through mine shafts has been identified.

Samples from the lysimeters and well points (Table B.2.13 and Figure B.2.17) show that the chemical composition of pore water in the tailings, under both negative and positive pressure, is highly variable. The most highly concentrated pore waters are under suction (negative) pressure, and concentration levels decrease as tailings seepage moves through the alluvium/weathered Mancos Shale to the Tres Hermanos-C Sandstone.

Tailings samples obtained during installation of the well points showed that intervals of fine material (slimes) contained over 90 percent saturation and that thicker intervals of more sandy material were fairly well drained (saturation less than 60 percent). Due to the heterogeneous nature of the Ambrosia Lake pile, there are areas where flow is mainly horizontal, and areas where there is an upward or a downward component of flow. Once contaminants are transported across the tailings-alluvium interface, horizontal movement (assuming constituents travel at the rate of ground water) within the alluvium/weathered Mancos Shale is slow (0.29 ft/day). At this rate, tailings seepage that entered the alluvium/weathered Mancos Shale at the northern side of the pile at the end of the milling operation (1963) would not have reached the subcrop of the Tres Hermanos-C Sandstone at the southwest corner of the pile. Therefore, concentrations of contaminant species now measured in alluvium/weathered Mancos Shale samples may have been transported to the subsurface during Phase I.

Phase III is the condition following remedial action. The principal features of the remedial action that would affect seepage release from the pile are (1) the recontouring of the pile to promote surface runoff from the pile with the addition of a 3.5-foot, low-permeability cover material to minimize infiltration; and (2) the consolidation of all of the tailings and windblown material on and around the southern portion of the pile, which would change the existing flow pattern within the tailings.

Feature (1), above, would reduce the naturally low percolation rate through the pile and therefore reduce the long-term quantity and the rate of seepage from the tailings pile. The reconstruction and compaction of the tailings in feature (2) involves the addition of water during compaction and the redistribution of existing pore water in the tailings during recontouring and settling of the tailings. This volume of water added during the remedial action and the redistribution of water within the tailings would temporarily change flow patterns within the pile. This distributed volume of water added during the remedial action, however, is minimal when compared to the volume of effluent added to the tailings during Phase I, which produced most of the existing contamination beneath the site.

The average extent of saturation for the sand-slime mixtures and slimes contained in the tailings are near 88 and 93 percent, respectively. Following consolidation and compaction of the tailings and contaminated materials and placement of the radon and erosion protection barriers, the in-situ tailings would approach saturations of 100 percent. Since the subpile soils are essentially saturated at the end of loading, a small quantity of free water in the voids would gradually drain by gravity from the tailings into the alluvium/weathered Mancos Shale.

During Phase III the reconfiguration and compaction of the pile would decrease the rates or quantity of seepage released from the tailings pile. The steepened uniform slopes and low-permeability radon barrier would promote runoff rather than infiltration. Therefore, the contaminant levels presently found in the ground water should decrease.

During remedial action, the existing ground water beneath the pile should dissipate as the source of infiltrating water through the pile decreases. Perched water contained within the alluvium/weathered Mancos Shale will continue to move slowly to the southwest, until it encounters the Tres Hermanos-C Sandstone subcrop. In these areas, the contaminated alluvial water will move downward into the Tres Hermanos-C Sandstone. The principal source of local alluvial recharge, mine water discharges to the surface and to an unlined holding pond, has also ceased, so that the total volume of alluvial/weathered Mancos Shale ground water should decrease. Rates of advective contaminant transport in the alluvium/weathered Mancos Shale should also decrease. Water levels in the Tres Hermanos-C Sandstone should decrease with time due to decreasing rates of alluvial recharge and should eventually desaturate.

To analyze the time for the alluvium/weathered Mancos Shale and the Tres Hermanos-C Sandstone to dewater, the following were considered:

- Assume no infiltration and no evapotranspiration.
- The effective volume of water contained in a unit width of alluvium is in a wedge 30 feet high and 2300 feet long with an effective porosity of 0.13 (4485 ft^2/unit width).
- The volumetric flow rate per unit width is controlled by a hydraulic gradient of magnitude 0.017, a hydraulic conductivity of 1.53 ft/day, and an average height of flow of 15 feet (0.39 ft^2/day).

- o The volume of water contained in a unit width of Tres Hermanos-C Sandstone is in a wedge 20 feet high and 2700 feet long (from the subcrop to the Ann Lee Mine) with an effective porosity of 0.05 (2700 ft^2/unit width).

- o The volume of water per unit width that will drain to the Ann Lee Mine is the sum of the water in the alluvium and the Tres Hermanos-C Sandstone (7385 ft^2/unit width).

- o The volumetric flow rate per unit width is controlled by a hydraulic gradient of magnitude, 0.025, a hydraulic conductivity of 0.89 ft/day and an average height of 10 feet (0.22 ft^2/day).

Given these assumptions, the following conclusions were drawn:

- o It would require 11,500 days or 32 years to drain the alluvium into the Tres Hermanos-C Sandstone.

- o It would require 33,600 days or 92 years to drain the Tres Hermanos-C Sandstone.

A two-dimensional solute transport equation (Javandel et al., 1984) was solved to predict contaminant migration resulting from tailings seepage at the Ambrosia Lake site. The equation describes flow in a two-dimensional, isotropic, and homogeneous porous medium having a unidirectional steady state flow. The tailings pile was treated as a line source for a model input term. The dispersion coefficients are parallel and orthogonal to the direction of flow. Retardation, exponential decay of the solute (for radionuclides), and exponential decay of the source can be simulated. The flow equation only considers dispersion in two dimensions and advection (average linear velocity) along the flow direction in one dimension. The computer code which numerically solves this equation is documented and is available for review in the Document Control Center of the UMTRA Project Office, Albuquerque, New Mexico.

The objective of the modeling was to determine if the Westwater Canyon Member, a viable drinking water source, would be impacted by contamination from the Ambrosia Lake tailings. The model was applied assuming present conditions (Phase II). The model provides conservative results for long-term predictions, because lesser rates of contaminant migration should occur following remedial action (Phase III).

The Westwater Canyon Member was used in the model instead of the Dakota Sandstone because the mine shafts in the Ambrosia Lake mining district end in the Westwater Canyon Member and ground-water flow to the underlying shale rich Recapture Member is unlikely. This formation is several hundred feet thick in the Ambrosia Lake area (Cooper and John, 1968). Therefore, it is the more likely pathway for contaminant migration. Also, the Westwater Canyon Member contains higher quality water than the Dakota Sandstone. The model results for the Westwater Canyon Member provide a conservative case for the Dakota Sandstone. The pathway of contamination is tailings seepage to the alluvium/ weathered Mancos Shale, ground-water flow to the Tres Hermanos-C1 and

-C2 Sandstones (see Figure B.2.3 for a cross-section showing alluvium-Tres Hermanos contact), and discharge to the Ann Lee Mine shaft or any other mine shafts and vent holes. The mine shafts and vent holes provide a direct hydraulic connnection to the Westwater Canyon Member.

The solute transport modeling was conducted in two steps. First, contaminant migration in the Tres Hermanos-C Sandstone was modeled to estimate travel times and concentrations of contaminants at the Ann Lee Mine shaft (the closest mine shaft to the site). The second step was to assess the impact of contaminated water discharging to the Ann Lee Mine shaft on the Westwater Canyon Member.

Sulfate was used as a general indicator of contaminant migration. Sulfate was chosen because (1) average sulfate concentrations exceeded drinking water standards by greater amounts than other constituents; and (2) sulfate is generally non-reactive. A conservative retardation factor of one, indicating zero attenuation, was used in the model.

The source of contamination in the Tres Hermanos-C1 and -C2 Sandstones is the alluvium/weathered Mancos Shale beneath the tailings. Prior to mining operations, the alluvium/weathered Mancos Shale was dry. After remedial action is complete and a low infiltration barrier is in place, the alluvium/weathered Mancos Shale will drain and the source of contamination will be removed. The length of time for this to occur was estimated using alluvial ground-water velocities and travel distances. Decay factors of the source were used that represented declining source concentrations with time.

Input values of the decay factor for the source, initial source concentration, velocity, and dispersivity were varied to give least conservative, most conservative, and most reasonable results. The inputs used in the model are listed in Table B.2.16. Since no field values of dispersivity were available, a range of values reported in the literature (Freeze and Cherry, 1979) were used in the model. Effective porosities used in calculated average linear velocities were also estimated from the literature. Due to these uncertainties in the model, the results should be interpreted as a range of expected values rather than a single-value assessment of contamination. The results of the model are presented in Table B.2.17.

Even when the most conservative source decay factors, dispersivities, and velocities were input to the model, the results show that the maximum extent of contamination in the Westwater Canyon Member will be approximately 400 feet downgradient from the mine shaft (and 2700 feet from the subcrop) over 100 years (Table B.2.17). At this location, sulfate concentrations are predicted to be 250 mg/l (Federal drinking water standard). No impacts to ground-water quality are predicted beyond 400 feet from the mine shaft. Consequently, any wells that do not have a cone of influence within 400 feet of the mine shaft will not be affected by seepage from the Ambrosia Lake site.

The likelihood of the Ambrosia Lake tailings pile impacting the Tres Hermanos-A and -B Sandstones is very low. DOE wells 774, 777, and 789 were completed in the uppermost transmissive unit of the Tres

Table B.2.16 Input parameters to solute transport model

Input	Minimum	Maximum	Average
Velocity (ft/yr) Tres Hermanos-C1 Sandstone	5	1200	280
Velocity (ft/yr) Tres Hermanos-C2 Sandstone	3	210	55
Velocity (ft/yr) Westwater Canyon Member	60	200	100
Longitudinal dispersion coefficient (ft^2/yr) Tres Hermanos-C1 Sandstone	500	360,000	21,000
Longitudinal dispersion coefficient (ft^2/yr) Tres Hermanos-C2 Sandstone	300	64,000	56,000
Dispersion coefficient (ft^2/yr) Westwater Canyon Member	6400	59,000	23,000
Ratio of longitudinal to transverse dispersivity	2	8	5
Initial source concentration (mg/l SO_4)	2500	4300	3100
Half-length of source (ft) Tres Hermanos Sandstones	800	1500	1000
Half-length of source (ft) Westwater Canyon Member (Ann Lee Mine shaft)	3	7	5
Decay factor of source[a] ($years^{-1}$)	0.016	2.8	0.23

[a]The decay factor of source does not represent radioactive decay of the solute constituent but represents an exponential decay of the source due to less net percolation or decreased source concentrations as a result of leaching with time. The equation used is $\frac{C}{C_0} = e^{-at}$

where: C_0 is initial concentration
t is the elapsed time
a is the decay factor
e is the concentration at time, t.

Table B.2.17 Calculated extent of contamination in Tres Hermanos-C Sandstone and Westwater Canyon Member

	Most conservative estimate	Least conservative estimate	Most reasonable estimate
Time for contaminated water in Tres Hermanos-C1 and -C2 Sandstones to reach the Ann Lee Mine (yrs) from tailings pile	1	Never	7
Time for sulfate concentrations at Ann Lee Mine to reach background after remedial action is complete (yrs)	120	3	22
Extent of contamination in the Westwater Canyon Member (ft from source)	400	No impact	250
Duration of contamination in the Westwater Canyon Member (yrs)	100	No impact	60

Hermanos-B Sandstone utilizing borehole geophysical logs. This transmissive unit is underlain by shale, and the shale by less transmissive shaly sandstones. These wells did not yield any fluid for water quality analysis because they were dry. The Quivira Mining Company's tailings piles are located on the outcrop and above the subcrop of the Tres Hermanos-B Sandstone. It is probable that any contamination of ground water in the Tres Hermanos-B Sandstone is due to Quivira's operations, since 50 to 60 feet of relatively impermeable, unweathered Mancos Shale separate the Tres Hermanos-B Sandstone from the Tres Hermanos-C Sandstone underneath the Ambrosia Lake tailings pile.

DOE well 773 was drilled into the top of the Tres Hermanos-A Sandstone. However, this well was completed in the Tres Hermanos-C1 Sandstone. No water-quality data are available for the Tres Hermanos-A Sandstone in the vicinity of the Ambrosia Lake tailings pile. Again, it is unlikely that ground water in this sandstone would be contaminated, as it is separated from the Tres Hermanos-B Sandstone by 50 to 60 feet of relatively impermeable, unweathered Mancos Shale.

The Westwater Canyon Member is the only potentially affected viable aquifer in the Ambrosia Lake area. Therefore, to evaluate the impact of seepage into the Ann Lee mine shaft on deeper water quality, Table B.2.18 lists water quality analyses for the Westwater Canyon Member and Dakota Sandstone taken from nearby mines, vent shafts, and wells (the Ambrosia Lake tailings pile is in the southwest quarter of Section 28-T14N-R9W). Note that both sulfate and total dissolved solids concentrations for the Dakota Sandstone exceed state and/or Federal water quality standards. For the Westwater Canyon Member, three out of four of the total dissolved solids concentrations, and one out of four sulfate concentrations exceed state and/or Federal water quality standards.

Geochemical modeling using PHREEQE (Parkhurst et al., 1980), a FORTRAN IV computer code, was selected to determine if the chemical composition of tailings solution approximates ground-water chemistry of the alluvium and the Tres Hermanos-C Sandstone. Water-quality analysis of monitor well 752-01 (completed in the tailings pile), sampled on September 26, 1985, was used as an input term in the model. For the model simulation, Ambrosia Lake tailings solution was volumetrically mixed with Westwater Canyon Member ground water as this ground water was the source of water supply for the mill. Tailings solution containing Westwater Canyon Member water was discharged to the tailings site after uranium recovery. Variability of ground-water quality within the alluvium and Tres Hermanos-C Sandstone may be controlled by the amount of mill supply water (Westwater Canyon Member) present within the alkaline tailings solution. That is, greater amounts of mill supply water produce relatively less contaminated ground water. Accordingly, the TDS of the tailings seepage would be relatively low. Water-quality analysis of the Homestake Mine (Sec 32, T14N, R9W) reported above was used as a Westwater Canyon Member input term in the model simulation.

Ambrosia Lake tailings solution was volumetrically mixed with Westwater Canyon Member ground water at ratios of 0.0, 0.05, 0.1, 0.2, 0.4, 0.6, 0.8, and 1.0. From these eight mixing ratios, mixing curves

Table B.2.18 Westwater Canyon Member and Dakota Sandstone ground-water quality in Ambrosia Lake Valley[a]

Location Sample date	Sec 17-T14N-R9W Kerr-McGee Mine 8/8/62[b]	Sec 32-T14N-R9W NE/4 NE/4 NW/4 Homestake Mine 2/14/58[b]	Sec 32-T14N-R9W SE/4 NW/4 SW/4 8/11/59[b]	Sec 34-T14N-R9W NE/4 NE/4 SE/4 Sandstone Mine 4/24/63[b]	Sec 17-T14N-R9W Kerr-McGee Mine 8/8/62[c]
<u>Parameter mg/l</u>					
Bicarbonate	275	238	220	252	296
Calcium	29	5.6	46	15	71
Chloride	8.8	6.0	8.0	7.7	14
Magnesium	6.2	0.5	12	4.9	2.7
Nitrate (as N)	0.1	0.0	0.0	0.2	0.2
Potassium	6.0	2.4	7.6	3.7	6.5
Sodium	172	145	114	226	346
Sulfate	230	123	218	322[d]	772[d]
Total Dissolved Solids	606[d]	426	512[d]	718[d]	1410[d]

[a]Ref. Brod (1979).
[b]Westwater Canyon Member (Morrison Formation).
[c]Dakota Sandstone.
[d]Exceeds state and/or Federal water quality standards.

for sodium and sulfate were produced to determine the variability of ground-water quality within the alluvium and Tres Hermanos-C Sandstone.

Since both the alluvium and Tres Hermanos-C Sandstone probably were unsaturated prior to mining and milling activities at the site, mixing of tailings seepage with native ground water is unlikely. Therefore, variations in water quality within the alluvium and Tres Hermanos-C Sandstone are mainly due to chemical interactions between tailings seepage and the host rock. Sodium and sulfate are conservative species associated with tailings seepage; only these two species were used to model water quality in the alluvium and the Tres Hermanos-C Sandstone.

According to the model simulation, 3.6 to 47 volume percent and 25 to 84 volume percent of sodium and sulfate, respectively, are present in alluvial ground water. Tailings solution contains 100 percent of these species since this solution represents the source term. Within the Tres Hermanos-C Sandstone, 2.4 to 27 volume percent and 6.2 to 60 volume percent of sodium and sulfate, respectively, are present. Concentration decreases of sodium and sulfate within the alluvium and Tres Hermanos-C Sandstone are attributed to precipitation dissolution reactions involving calcite and gypsum, hydrodynamic dispersion of the contaminant plume, and possible ion exchange reactions. Ion exchange reactions were not modeled with PHREEQE. Calcite, gypsum, and $Fe(OH)_3$ are predicted to be in equilibrium with tailings seepage, where pH is buffered by calcite, and sulfate concentrations are controlled by gypsum. Model pH values range from 6.88 to 6.97, which are in agreement with measured field pH values reported in Tables B.2.14 and B.2.15. The Eh of the tailings solution was set at 120 millivolts (pe = 2.03 volts). Similar values of field Eh measurements have been made by the New Mexico Environmental Improvement Division for the Homestake alkaline leach tailings solution.

Results of the model support the concept of tailings seepage creating saturated flow conditions within the alluvium and Tres Hermanos-C Sandstone. Water quality improves along the flow paths within these two formations. Solute species including calcium, sodium, bicarbonate, and sulfate are abundant in both tailings solution and ground water suggesting that mixing between two chemically different waters is not occurring. Concentrations of solute species including sodium and sulfate predicted by PHREEQE compare well with analytical results reported in Tables B.2.14 and B.2.15 for the alluvium and Tres Hermanos-C Sandstone, respectively.

Background water quality for the alluvium and Tres Hermanos-C Sandstone is representative of tailings seepage, since unsaturated conditions probably existed prior to mining and milling activities at the site. The existing concentrations of the solutes associated with tailings seepage exceed the standards of Section 3-103 of the NMWQCC Regulations; therefore, no degradation of ground water beyond the existing concentrations will be allowed (Bostick, 1986). Decreases in solute concentrations are expected to occur in the future, because the tailings pile represents a discontinuous source term.

Results of the PHREEQE simulation are on file in the DOE UMTRA Project Office, Albuquerque, New Mexico.

Aquifer restoration is not a realistic alternative for the contaminated ground water downgradient of the Ambrosia Lake site because:

- o The alluvium/weathered Mancos Shale is not an aquifer, because it will probably "dry up" as mine discharge ceases.

- o The Tres Hermanos-C Sandstone is not an aquifer, due to low yields, naturally poor water quality, and the possibility that the formation will not remain saturated.

- o The Westwater Canyon Member is a viable aquifer; however, solute transport calculations indicate that the effects of contamination to the aquifer should impact only a small area (400 feet downgradient of the Ann Lee mine shaft in the most conservative estimate) and for a time frame of 100 years.

Regardless, when the EPA issues revisions to the water protection standards, the DOE will re-evaluate the ground-water issues at the Ambrosia Lake site to assure that the revised standards are met. Performing remedial action to stabilize the tailings prior to the EPA issuing new standards will not affect the measures that are ultimately required to meet the revised EPA protection standards. The DOE has characterized conditions at the Ambrosia Lake site and does not anticipate that any substantial changes to the remedial action will be required. However, after the EPA re-issues the water protection standards, the DOE will determine the need for institutional controls, aquifer restoration, or other controls and take such appropriate action so as to comply with the re-issued standards.

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APPENDIX C

FLORA AND FAUNA

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C.1 FLORA AND FAUNA - AFFECTED ENVIRONMENT

The Ambrosia Lake tailings site is located in an arid desert environment and the flora and fauna of this area are adapted to the dry desert conditions. This characterization of the biota at the tailings and borrow sites is based on field surveys in the area (FBD, 1983; TAC 1985), consultations with natural resource personnel from state and Federal agencies, and review of the pertinent literature. A list of flora and fauna observed or expected to occur at the site plus scientific names of species referred to in this appendix appear in Tables C.1.1 through C.1.4.

These tables do not represent a complete listing of species from this area. Rather, they are common species observed at the site during reconnaisance-level surveys or species observed in the region by other workers. The plant list was derived from site-specific surveys (FBD, 1983) and a regional study conducted by Albee (1982). Faunal lists are based on limited site-specific data (FBD, 1983) and more detailed information from other sources as referenced on the tables. Table C.1.3 lists only nesting bird species observed or expected to occur in the area. The number of additional species that would be expected at the site as migrants or winter visitors may be as high as 86 (Albee, 1982).

Ambrosia Lake tailings site

The tailings pile has large areas devoid of vegetation with other areas sparsely populated with early successional species such as Russian thistle, squirreltail grass, and snakeweed. Small permanently wet areas occur at the base of the containment dikes and support bulrush, cattail, and a few willow, Russian olive, and salt cedar (FBD, 1983).

Wildlife use of the tailings pile is minimal. Ponded water on top of the tailings supports a limited number of migratory waterfowl and shorebirds (FBD, 1983). Pocket gophers were observed near the base of the dikes along with the red-spotted toad in the wet areas. In June of 1985, numerous cliff swallows were observed feeding near the tailings and Brewer's blackbird was noted nearby.

Borrow site 1

Borrow site 1 and the windblown contaminated area adjacent to the tailings pile are located in the Great Basin Grasslands habitat (Brown, 1982). Historically, these grasslands were dominated by sod-forming grasses such as grama grass (Bouteloua spp.). Presently, many of these areas are overgrazed causing a breakdown in the sod cover and enhancing the growth of various forbs and shrubs. Overgrazing has occurred in the region (Kinsky, 1977; DOI, 1980; Brown, 1982; Hubbard, 1985a) and at the site (FBD, 1983). Only vestiges of the grama grass association occur at the sites with species such as blue grama, bush muhly, and Fendler threeawn present. Common species include narrow leaf goosefoot, alkali sacaton, galleta, and other annual herbs and grasses. Scattered juniper are present at the west end of the sites (FBD, 1983).

Table C.1.1 Plant species observed in the Ambrosia Lake area

Species			
Scientific name	Common name	Observed at site	Observed in region
Abronia sp.	sandverbena		X
Agropyron smithii	western wheatgrass		X
Aristida fendleriana	Fendler threeawn	X	
Aristida longiseta	red threeawn		X
Aristida purpurea	purple threeawn		X
Artemisia nova	black sagebrush	X	X
Astragalus sp.	milkvetch		X
Aster sp.	aster		X
Atriplex canescens	fourwing saltbush	X	X
Atriplex confertifolia	shadscale		X
Atriplex obovata	saltbush		X
Atriplex saccaria	saltbush		X
Bouteloua gracilis	blue grama	X	
Bromus tectorum	cheatgrass		X
Cercocarpus montanus[a]	mountain mahogany	X	
Chenopodium dessicatum	goosefoot	X	
Chrysothamnus nauseosus	rubber rabbitbrush	X	X
Chrysothamnus viscidiflorus	green rabbitbrush		X
Cleome serrulata	Rocky Mountain beeplant	X	
Cowania mexicana	cliff rose		X
Cryptantha crassisepala	cats eye		X
Dithyrea wislizenii	spectaclepod		X
Elaeagnus angustifolia	Russian olive	X	
Ephedra torreyana	ephedra		X
Eriogonum sp.	buckwheat		X
Euphorbia fendleri	spurge		X
Eurotia lanata	winterfat		X
Festuca octoflora	sixweek fescue		X
Gutierrezia sarothrae	snakeweed	X	X
Haplopappus spinulosus	ironplant goldenweed	X	
Helianthus annuus	common sunflower	X	
Hilaria jamesii	galleta	X	
Hordeum pusillum	little barley		X
Juniperus sp.	juniper	X	X
Lactuca sp.	wild lettuce		X
Lappula sp.	stickseed		X
Leucelene ericoides	white aster	X	
Lycium pallidum	pale wolfberry		X
Muhlenbergia porteri	bush muhly	X	
Muhlenbergia torreyi	ring muhly		X
Oenothera albicaulis	evening primrose		X
Oenothera pallida	pale evening primrose		X
Opuntia macrorhiza	plains prickly pear	X	

Table C.1.1 Plant species observed in the Ambrosia Lake area (Concluded)

Species: Scientific name	Species: Common name	Observed at site	Observed in region
Opuntia whipplei	Whipple cholla	X	
Oryzopsis hymenoides	Indian ricegrass	X	X
Penstemon sp.	penstemon	X	X
Phacelia corrugata	scorpion weed		X
Phlox sp.	phlox		X
Pinus edulis[a]	pinon pine	X	
Pinus ponderosa[a]	ponderosa pine	X	
Plantago purshii	plantain		X
Psoralea lanceolata	scurfpea		X
Purshia tridentata	antelope bitterbrush		X
Rhus trilobata	skunkbush sumac		X
Rumex crispus	curly dock		X
Salix sp.	willow	X	
Salsola iberica	Russian thistle	X	
Sarcobatus vermiculatus	greasewood	X	X
Scirpus pallidus	bulrush	X	
Sisymbrium altissimum	tumble mustard	X	X
Sitanion hystrix	bottlebrush squirreltail	X	X
Solanum jamesii	James nightshade	X	
Sphaeralcea coccinea	scarlet globemallow	X	
Sphaeralcea parvifolia	globemallow		X
Sporobolus airoides	alkali sacaton		X
Sporobolus contractus	spike dropseed		X
Sporobolus cryptandrus	sand dropseed		X
Sporobolus giganteus	giant dropseed		X
Stipa comata	needle and thread		X
Stipa neomexicana	feathergrass		X
Suaeda torreyana	seepweed		X
Tamarix pentandra	saltcedar	X	
Tridens pulchellus	fluffgrass		X
Typha sp.	cattail	X	
Verbesina encelioides	golden crownsbeard		X
Yucca sp.	yucca	X	X
Zinnia grandiflora	desert zinnia	X	

[a]Observed only at borrow site 2.

Ref. FBD, 1983; Albee, 1982; McDougall, 1973; Isler and Middleton, 1985.

Table C.1.2 Amphibians and reptiles observed or expected to occur at the Ambrosia Lake tailings site

Species	Habitat: Grassland/ shrub	Habitat: Rocky slope/ cliffs	Habitat: Pinon-juniper/ forest	Comments
Plains spadefoot toad _Scaphiopus bombifrons_	X			Inhabits plains and hills in areas of low rainfall. Requires temporary or permanent bodies of water for reproduction.
Western spadefoot toad _Scaphiopus hammondi_	X			Inhabits areas of open vegetation in washes and floodplains. Requires temporary or permanent bodies of water for reproduction.
Red-spotted toad[a] _Bufo punctatus_	X			Occurs in rocky canyons, open grassland, and arroyos. Larva observed in wet area near tailings pile.
Tiger salamander _Ambystoma tigrinum_	X			Principally subterranean. Breeds in temporary or permanent water bodies.
Lesser earless lizard _Holbrookia maculata_	X			Common in areas with open vegetation and sandy soil.
Collared lizard _Crotaphytus collaris_		X	X	Inhabits rocky ledges, talus slopes, and brush near cliffs. Sparsely distributed in area.
Northern plateau lizard _Sceloporus undulatus_		X	X	Common in area. Cliff face and large boulders preferred.
Sagebrush lizard _Sceloporus graciosus_	X	X	X	Common in area. Prefers dense shrubs and sandy soils.

Table C.1.2 Amphibians and reptiles observed or expected to occur at the Ambrosia Lake tailings site (Concluded)

Species	Habitat: Grassland/ shrub	Habitat: Rocky slope/ cliffs	Habitat: Pinon-juniper/ forest	Comments
Side-blotched lizard[a] *Uta stansburiana*		X	X	Common on cliffs, talus slopes, and isolated large rocks.
Northern tree lizard *Urosaurus ornatus*		X	X	Found only in rocky areas. Uncommon in area.
Short-horned lizard[a] *Phrynosoma douglassi*	X			Occurs in grassland habitat. Observed in windblown contaminated area near tailings.
Plateau whiptail[a] *Cnemidophorus velox*	X		X	Observed in pinon-juniper woods at borrow site 2. Also occurs in open shrub desert.
Desert striped whipsnake *Masticophis taeniatus*	X			Inhabits shrubby areas. Uncommonly observed in area.
Painted desert glossy snake *Arizona elegans*		X		Inhabits rocky areas. Uncommon in area.
Gopher snake *Pituophis melanoleucus*	X	X	X	Occurs in all habitat types in area.
Prairie rattlesnake *Crotalus viridis*	X	X	X	Occurs in mixed grass/ shrub areas and rocky areas. Distributed at low density throughout area.

[a]Observed at the Ambrosia Lake tailings site.

Ref. Albee, 1982; FBD, 1983; Jones, 1970; Stebbins, 1966.

Table C.1.3 Nesting birds observed or expected to occur at the Ambrosia Lake tailings site

Species	Habitat			Relative abundance		
	Grassland/ shrub	Rocky slope/ cliffs	Pinon-juniper/ forest	Common	Uncommon	Rare
Sharp-shinned hawk[a] *Accipiter striatus*		X	X		X	
Northern harrier *Circus cyaneus*	X			X		
Ferruginous hawk *Buteo regalis*			X			X
Red-tailed hawk[a] *Buteo jamaicensis*		X	X	X		
Swainson's hawk *Buteo swainsoni*			X			X
Golden eagle *Aquila chrysaetos*		X			X	
Prairie falcon *Falco mexicanus*		X			X	
American kestrel[a] *Falco sparverius*		X	X	X		
Scaled quail *Callipepla squamata*	X					X
Mourning dove[a] *Zenalda macroura*	X		X	X		
Roadrunner *Geococcyx californianus*	X		X			X
Great horned owl *Bubo virginianus*		X	X			X
Poorwill *Phalaenoptilus nuttallii*			X		X	
Common nighthawk *Chordeiles minor*	X				X	

Table C.1.3 Nesting birds observed or expected to occur at the Ambrosia Lake tailings site (Continued)

Species	Habitat			Relative abundance		
	Grassland/ shrub	Rocky slope/ cliffs	Pinon- juniper/ forest	Common	Uncommon	Rare
White-throated swift *Aeronautes saxatalis*		X			X	
Black-chinned hummingbird *Archilochus alexandri*	X				X	
Northern flicker[a] *Colaptes auratus*			X	X		
Western kingbird[a] *Tyrannus verticalis*	X				X	
Cassin's kingbird *Tyrannus vociferans*		X			X	
Ash-throated flycatcher *Myiarchus cinerascens*	X		X	X		
Say's phoebe[a] *Sayornis saya*	X	X	X	X		
Horned lark[a] *Eremophila alpestris*	X			X		
Cliff swallow[a] *Hirundo pyrrhonota*	X			X		
Scrub jay[a] *Aphelocoma coerulescens*			X	X		
Pinon jay[a] *Gymnorhinus cyanocephalus*	X	X			X	
Common raven[a] *Corvus corax*		X	X	X		
Plain titmouse *Parus inornatus*	X	X	X	X		
Bushtit *Psaltriparus minimus*			X	X		

Table C.1.3 Nesting birds observed or expected to occur at the Ambrosia Lake tailings site (Continued)

Species	Habitat			Relative abundance		
	Grassland/ shrub	Rocky slope/ cliffs	Pinon-juniper/ forest	Common	Uncommon	Rare
Bewick's wren[a] *Thryomanes bewickii*	X		X		X	
Rock wren[a] *Salpinctes obsoletus*		X	X	X		
Canyon wren *Catherpes mexicanus*		X			X	
Mountain bluebird *Sialia currucoides*			X	X		
Mockingbird[a] *Mimus polyglottos*	X			X		
Sage thrasher *Oreoscoptes montanus*	X		X	X		
Bendire's thrasher *Toxostoma bendirei*	X		X	X		
Loggerhead shrike[a] *Lanius ludovicianus*	X		X	X		
Western meadowlark[a] *Sturnella neglecta*	X			X		
Brewer's blackbird[a] *Euphagus cyanocephalus*	X				X	
House finch *Carpodacus mexicanus*	X		X	X		
Green-tailed towhee *Pipilo chlorurus*	X		X		X	
Brown towhee *Pipilo fuscus*	X		X	X		

Table C.1.3 Nesting birds observed or expected to occur at the Ambrosia Lake tailings site (Concluded)

Species	Habitat			Relative abundance		
	Grassland/ shrub	Rocky slope/ cliffs	Pinon-juniper/ forest	Common	Uncommon	Rare
Lark sparrow[a] *Chondestes grammacus*	X			X		
Black-throated sparrow[a] *Amphispiza bilineata*	X		X	X		
Sage sparrow *Amphispiza belli*	X		X	X		
Chipping sparrow *Spizella passerina*	X		X		X	
Brewer's sparrow *Spizella breweri*	X		X		X	

[a]Observed at Ambrosia Lake tailings site.

Ref. Albee, 1982; FBD, 1983; Kinsky, 1977.

Table C.1.4 Mammals observed or expected to occur at the Ambrosia Lake tailings site

Species	Habitat: Grassland/ shrub	Habitat: Rocky slope/ cliffs	Habitat: Pinon-juniper/ forest	Relative abundance: Common	Relative abundance: Uncommon	Relative abundance: Rare
Desert shrew *Notiosorex crawfordi*	X					X
Yuma myotis *Myotis yumanensis*	X					X
California myotis *Myotis californicus*		X				X
Silver-haired bat *Lasionycteris noctivagans*			X		X	
Townsend's big-eared bat *Plecotus townsendii*		X				X
Pallid bat *Antrozous pallidus*	X	X				X
Western pipistrelle *Pipistrellus hesperus*		X				X
Desert cottontail[a] *Sylvilagus audubonii*	X		X	X		
Black-tailed jackrabbit[a] *Lepus californicus*	X		X	X		
Colorado chipmunk *Eutamias quadrivittatus*			X	X		
White-tailed antelope squirrel *Ammospermophilus leucurus*	X	X	X	X		
Spotted ground squirrel *Spermophilus spilosoma*	X				X	
Botta's pocket gopher *Thomomys bottae*	X	X	X	X		
Plains pocket mouse *Perognathus flavescens*	X		X		X	

Table C.1.4 Mammals observed or expected to occur at the Ambrosia Lake tailings site (Continued)

Species	Habitat			Relative abundance		
	Grassland/ shrub	Rocky slope/ cliffs	Pinon-juniper/ forest	Common	Uncommon	Rare
Silky pocket mouse *Perognathus flavus*	X	X	X		X	
Ord's kangaroo rat *Dipodomys ordii*	X			X		
Banner-tailed kangaroo rat *Dipodomys spectabilis*	X				X	
Western harvest mouse *Reithrodontomys megalotis*	X		X		X	
Deer mouse *Peromyscus maniculatus*	X	X	X	X		
Canyon mouse *Peromyscus crinitus*		X	X		X	
Pinon mouse *Peromyscus truei*		X	X		X	
Northern grasshopper mouse *Onychomys leucogaster*	X	X			X	
White-throated woodrat *Neotoma albigula*	X		X		X	
Stephens woodrat *Neotoma stephensi*		X			X	
Bushy-tailed woodrat *Neotoma cinerea*		X	X		X	
Coyote[a] *Canis latrans*	X	X	X	X		
Red fox *Vulpes vulpes*	X	X	X			X
Kit fox *Vulpes macrotis*	X	X	X		X	

Table C.1.4 Mammals observed or expected to occur at the Ambrosia Lake tailings site (Concluded)

Species	Habitat: Grassland/ shrub	Habitat: Rocky slope/ cliffs	Habitat: Pinon-juniper/ forest	Relative abundance: Common	Relative abundance: Uncommon	Relative abundance: Rare
Badger *Taxidea taxus*	X				X	
Spotted skunk *Spilogale gracilis*	X	X	X			X
Striped skunk *Mephitis mephitis*	X	X	X			X
Bobcat *Felis rufus*		X	X		X	
Mule deer[b] *Odocoileus hemionus*	X	X	X	X		
Elk[b] *Cervus elaphus*			X		X	

[a]Observed at the Ambrosia Lake tailings site.
[b]Sign observed only.

Ref. Albee, 1982; Bailey, 1971; FBD, 1983; Kinsky, 1977; Whitaker, 1980.

The two principal wildlife habitat types which occur at these sites are grassland and rocky slopes-cliffs. The grassland habitat is the dominant type with rocky slopes-cliffs occurring at the west end near Roman Hill. Sixty-two species of wildlife were observed or are expected to occur in the grassland habitat while 42 species may be found in the cliff area (see Tables C.1.2 through C.1.4); an additional 30 to 40 species would be expected at the sites as migrants or wintering species (Albee, 1982).

A total of 11 species of reptiles and amphibians may occur at these sites (see Table C.1.2). Of the eight species of lizards listed, only the short-horned lizard and side-blotched lizard were observed. Three species are found principally in grasslands, four are more common in rock slopes-cliff areas, while one is expected from both habitat types. Amphibians and snakes are less common in terms of the number of species. The amphibians are most common in wet areas such as occur at the tailings pile, stock tanks, and ephemeral bodies of water. Very few snakes were encountered during herpetological investigations in the region (Jones, 1970; Albee, 1982).

A total of 28 species of nesting birds may occur in the grassland habitat and 14 species in the rocky slopes-cliff habitat (see Table C.1.3). The meadowlark and horned lark were the most common nesting birds observed in 1985 (TAC, 1985). Eleven additional species were observed in the grassland habitat. Reconnaissance of the Roman Hill area during the 1985 breeding season resulted in the observation of a sharp-shinned hawk, an active raven's nest, and an abandoned cliff nest that may have been used by prairie falcons. The mourning dove was the only gamebird observed. The scaled quail may occur rarely at the site because shrub cover necessary for this species is generally lacking.

A total of 23 species of mammals may occur in the grassland habitat while 20 species are expected in the rock-cliff area (see Table C.1.4). The only species observed on the site were the desert cottontail and coyote. The mule deer is the most common and widely distributed big game species in the region. The sites are not within the summer range of this species (Kinsky, 1977; DOI, 1980) although they do winter on the San Mateo Mesa directly west of the site (DOI, 1980). Occasional wintering animals from this area may use the site especially in the Roman Hill area. Elk also winter on the San Mateo Mesa (DOI, 1980) but would not be expected to occur at the borrow site or windblown area. The impact of overgrazing at these sites has reduced the carrying capacity for wildlife (DOI, 1980) and has resulted in much reduced use of the area by mule deer and the elimination of the pronghorn antelope (*Antilocapra americana*) from the area.

Borrow site 2

Borrow site 2 is located in the Great Basin conifer woodland type (Brown, 1982) with pinon pine and juniper being the dominant plant species. This site is almost completely wooded except for disturbed areas near the abandoned San Mateo uranium mine and clearings dominated by grass. A floristic survey was not conducted at this site but many of the species listed in Table C.1.1 occur at this site. Although a field survey was not conducted, consultation was performed regarding the possible occurrence of threatened and endangered plant species at borrow site 2 (Price, 1985b). A computerized file search of the

New Mexico Natural Resources Information System indicated that none of the plant species being tracked by the New Mexico Natural Resources Department have been recorded in the Ambrosia Lake area and that appropriate habitat for these species is also lacking. Based on this consultation, additional surveys for threatened and endangered plants at borrow site 2 are not warranted at this time.

Fifty-nine species of wildlife were observed or are expected to occur in this area (see Tables C.1.2 through C.1.4). Eight species of herptiles may occur at the site (see Table C.1.2); the plateau whiptail was the only species observed (TAC, 1985). A total of 29 species of birds may nest at the site (see Table C.1.3). Five species of raptors may nest in this area; the red-tailed hawk and kestrel were the only species observed. The ferruginous and Swainson's hawks nest in pinon-pine woodlands (Smith and Murphy, 1982; Thurow and White, 1983), sometimes in close association with each other (Schmutz et al., 1980; Thurow and White, 1983). The proposed borrow site is located on the fringe of the ferruginous hawk breeding range (Armbruster, 1983). In addition, an extensive wildlife survey in the Chaco strippable coal area approximately 25 air miles north of the site resulted in the location of only four ferruginous hawk and one Swainson's hawk nests. This information indicates that it is unlikely that these two species nest at the proposed borrow site area.

A total of 22 species of mammals are expected to occur in the borrow site area; the black-tailed jackrabbit, desert cottontail, and coyote were the only species observed (see Table C.1.4). In addition, mule deer and elk sign were noted. Borrow site 2 is located within the winter range of both the mule deer and elk on the La Jara Mesa (Kinsky, 1977; DOI, 1980). Consultations with the New Mexico Department of Game and Fish indicate that borrow site 2 is located within critical wintering habitat for both species (Isler and Middleton, 1985). As the snow deepens on the La Jara Mesa, both species move downslope and typically by December are concentrated on the slopes of the mesa which include the borrow site 2 area. Browse transects conducted by the New Mexico Department of Game and Fish indicate that important browse species such as mountain mahogany and fourwing saltbush occur on the site and are used extensively during the winter (Isler and Middleton, 1985).

Threatened and endangered species

A total of 22 species of plants and animals are considered threatened or endangered (T and E) by the Federal government in New Mexico (USFWS, 1984, 1985). The black-footed ferret (*Mustela nigripes*), peregrine falcon (*Falco peregrinus*), and bald eagle (*Haliaeetus leucocephalus*) are the only species whose ranges include the Ambrosia Lake site. Consultation with the U.S. Fish and Wildlife Service (USFWS) resulted in a list of two endangered (black-footed ferret, American peregrine falcon), one proposed (rhizome fleabane, *Erigeron rhizomatus*), and one candidate (Pecos sunflower, *Helianthus paradoxus*) species which the Service feels may be affected by the project (Peterson, 1985a,b).

Bailey (1971) indicates that black-footed ferret range in New Mexico includes the plains region in the eastern and northern parts of the state. The nearest known observation of this species to the site was a ferret captured in a trap set for coyote near San Mateo in 1918 (Bailey, 1971). There have not been any confirmed sightings of this species in the state in recent decades (Hubbard et al., 1979) and the only known population occurs in Wyoming (Clark et al., 1984). This species is highly dependent on praire dogs and all active prarie dog towns are considered potential ferret habitat (Clark et al., 1984). Observations at the tailings pile, windblown area, and borrow sites indicate that prarie dogs do not exist on the sites (FBD, 1983; TAC, 1985). Therefore, it is unlikely that the black-footed ferret occurs at any of the sites.

The peregrine falcon is a rare and localized breeding species in mountainous regions of New Mexico (Hubbard et al., 1979). It migrates through the state and winters statewide. Peregrine falcons require steep cliffs fairly near water (usually flowing) for nesting purposes. Steep cliffs do occur near the site along the San Mateo Mesa but they are not near water. In addition, this species is not presently known to nest near or within 10 miles of the site (Hubbard, 1985b).

The bald eagle does not nest in New Mexico (USFWS, 1984) but it does winter within the state (Grubb and Kennedy, 1982). Wintering birds are typically found along major rivers or lakes with some also feeding in upland areas (Grubb and Kennedy, 1982). It is unlikely that the bald eagle winters anywhere near the study sites, though an occasional bird may fly over during migration.

In 1980, the rhizome fleabane was included in category one, candidate species being considered for threatened or endangered status (42 FR 82480). A proposed rule to list this species as threatened was submitted in 1984 (49 FR 17548) and, as yet, no action has been taken on this proposed ruling. The rhizome fleabane was first collected in 1943 in the Zuni Mountains near Ft. Wingate, New Mexico. This species was subsequently rediscovered near its type locality and in the Datil Mountains to the south (Sabo, 1982). Knight (1981) feels that it is unlikely that this species will be found outside this range. In all cases, this species occurs in soils " . . . partially derived from outcrops of Chinle Shale" (Sabo, 1982) and is found in ponderosa pine or pinon-juniper forest associations. Rock outcrops at borrow sites 1 and 2 are Mancos Shale and the appropriate plant community type does not occur near the tailings pile or the borrow site 1 area. For this reason, it is very unlikely that this species occurs at or near the tailings pile, windblown area, or borrow sites.

The Pecos sunflower (Helianthus paradoxus) is a Federal candidate species for listing as threatened or endangered. This species was originally observed in Pecos County, Texas (Heiser et al., 1969). Recently this species was discovered in Chaves and Cibola Counties, New Mexico (Seiler et al., 1981; NMNPPAC, 1984). This species is found in standing water or areas of shallow water table in heavy-saline soils. It typically occurs in wet areas along perennial streams or irrigation ditches. The only standing water at the site is on top of the tailings pile and this area is essentially devoid of vegetation. Given the lack of wetland habitat or perennial water bodies, it is assumed that this species does not occur at the Ambrosia Lake site or borrow sites.

Sixty-eight species of wildlife are listed as endangered in New Mexico. A review of the ranges of these species indicates that four may occur at the Ambrosia Lake site. Three (black-footed ferret, peregrine falcon, and bald eagle) were discussed above and the fourth species is the red-headed woodpecker (Melanerpes erythrocephalus). This species nests in riparian woods or planted groves of trees (Hubbard et al., 1979) and would not be expected to occur at the site.

The State of New Mexico has proposed legislation to create a list of state endangered plant species (NRD, 1985). A total of 55 plant taxa is proposed for listing. The rhizome fleabane and Pecos sunflower were included in this list and were discussed above. A computerized file search of the Natural Resources Information System (NRIS) conducted by personnel of the New Mexico Natural Resources Department indicated that there are no records of these proposed species at the Ambrosia Lake sites. In addition, appropriate habitat for the species being tracked by NRIS is also lacking at the Ambrosia Lake sites (Price, 1985a,b).

C.2 FLORA AND FAUNA - IMPACTS

Impacts to flora and fauna associated with stabilization in place are addressed in this appendix. Impacts of the no action and disposal at the Section 21 site alternatives are briefly addressed in Section 4.6 of the Environmental Assessment (EA).

Terrestrial ecosystems would be impacted directly and indirectly by the remedial action. Direct impacts include destruction of flora and fauna and loss of habitat and would result from the disposal of tailings, excavation of contaminated soils, borrow activities, and construction or upgrading of haulage roads. Indirect impacts include increased fugitive dust emissions, elevated noise levels, and human activities and would occur adjacent to the direct impact area. Direct impacts can either be short-term or long-term while indirect impacts are short-term (i.e., for the duration of the project).

A total of 799 acres would be affected during stabilization in place. This includes 111 acres at the existing tailings pile, 570 acres of windblown contamination adjacent to the pile, 60 acres at borrow site 1, 50 acres at borrow site 2, and eight acres along haulage roads. Presently, the tailings pile is almost devoid of vegetation and has little wildlife value. For this reason, the impact of remedial action activities on vegetation and wildlife at the tailings pile would be minimal.

Remedial action activities at the area of windblown contamination and at borrow site 1 (including haulage road construction) would impact approximately 631 acres of grassland habitat. Much of this area is overgrazed and represents marginal wildlife habitat. However, 62 species of vertebrates have been observed or are expected to occur in this area. Excavation of contaminated soils or borrow materials would result in the destruction of many less mobile animals such as small mammals and reptiles and force larger mammals and birds to vacate the area. These animals would be forced to compete with existing resident individuals or inhabit marginal habitat. The net result would be a reduced survivorship for these displaced individuals. Analysis of plant and animal species which inhabit this area indicates that no concentration areas or important habitat features for economically important species would be disturbed. In addition, no threatened or endangered species are known to occur in this area.

Borrow site 2 is comprised of a pinon-pine plant community. An estimated 59 species of wildlife may occur in the area. The exact location of borrow site 2 within the proposed area would be determined by the Remedial Action Contractor (RAC) and the U.S. Department of Energy (DOE). Direct impacts on wildlife in this area would be similar to those described for the windblown area and borrow site 1. The major direct impact on wildlife would be the elimination of approximately 50 acres of critical winter habitat for mule deer and elk. Mule deer and elk sign were found to increase upslope (southwest) from the San Mateo Mine (Isler and Middleton, 1985; TAC, 1985). In addition, the area near the San Mateo Mine is on the periphery of the winter range which would indicate that the closer the borrow site is to the mine, the lower would be the direct impacts on wintering mule deer and elk.

The duration of direct impacts from remedial action activities would depend on the level of restoration undertaken. Research has shown that the rate and extent of vegetation recovery on untreated mine lands varies widely depending on the restoration method employed (Wagner et al., 1978; Aldon, 1981). The hypothetical maximum impact would involve no restoration which would result in the recovery of the biotic community on land devoid of topsoil. In this case primary succession (i.e., a sequence of plant communities developing in a newly exposed habitat devoid of life) (Ricklefs, 1979) would take place and recovery would take years. Full recovery of a pinon-juniper plant community at borrow site 2 could take approximately 100 to 300 years (Tausch and Tueller, 1977; Everett and Ward, 1984). In addition, the reestablishment of important shrub browse species for wintering mule deer would be difficult. The establishment of a grassland habitat at the site may benefit wintering elk (Isler and Middleton, 1985).

Prior to initiation of surface disturbing activities, the plan for restoration of excavated areas would be determined by the RAC and the DOE in consultation with the appropriate regulatory agency or other authority. Requirements for restoration typically include measures such as backfilling, recontouring, and revegetating. Impacts would be mitigated by sequencing restoration as soon as possible after completion of surface disturbing activities.

Indirect impacts on plants and wildlife would result from increased fugitive dust emissions, elevated noise levels, and human activity, and would occur primarily outside the direct impact zone. The effects of fugitive dust include reduced palatability of vegetation for wildlife and physiological stress on plants. It is estimated that these dust emissions would preclude wildlife use within 200 feet of the source; this impact would decrease to zero 1200 feet from the dust emission source (Hoover and Associates, 1984).

The effect of noise on wildlife varies from direct effects on hearing to indirect effects such as masking (the inability to hear important environmental cues) and loss of usable habitat. The effects of noise can be compounded by the presence of humans and the impact of noise and human presence is often hard to separate (Dufour, 1980). The projected noise levels would increase from background levels of 35 to 40 decibels to about 90 decibels 100 feet from construction activities and 50 to 60 decibels one mile from the source. The impact of noise on wildlife is poorly understood but many species of wildlife seem to be able to adjust to relatively constant noise levels of up to 70 decibels (Dufour, 1980). Noise levels of this magnitude or greater can be expected up to 2000 feet from the source and wildlife use in this zone would be impacted.

The effects of dust, noise, and human activity at the tailings site, windblown area, and borrow site 1 would influence wildlife use in approximately a 1500-acre area (Figure C.2.1). Most of this area (1450 acres) would be low-quality overgrazed wildlife habitat while the remaining 50 acres would be rocky slopes and cliff habitat near Roman Hill. A total of 43 species of wildlife were observed and/or are expected to occur in the rocky slope-cliff habitat; 24 species are more or less restricted to this habitat type (see Tables C.1.2 through C.1.4). Birds of prey may nest in the cliff habitat and

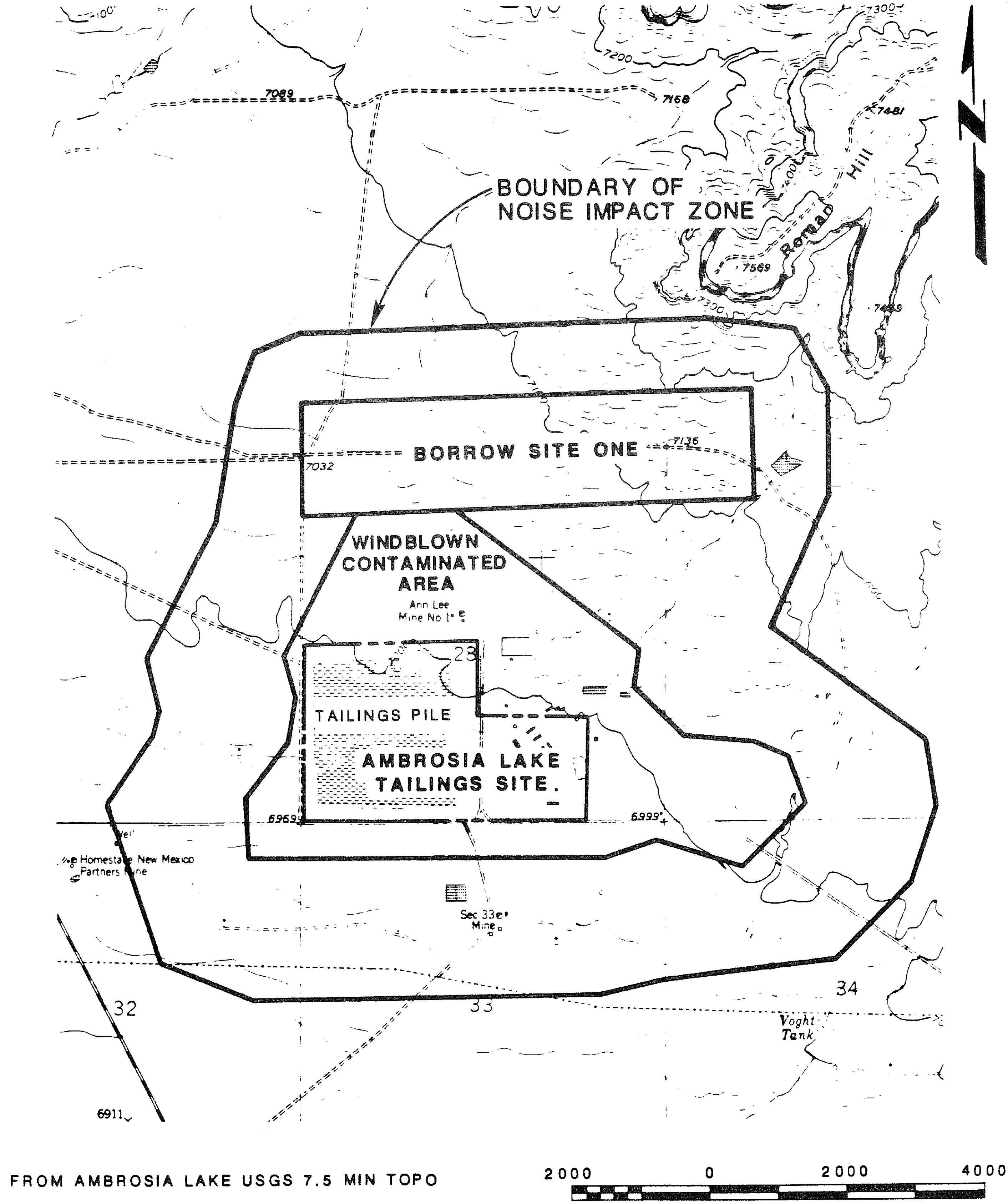

FIGURE C.2.1
NOISE IMPACT ZONE AT AND AROUND
THE AMBROSIA LAKE TAILINGS SITE AND BORROW SITE ONE

project-generated noise may preclude their use of about 3000 feet of the cliff habitat at Roman Hill. These impacts would occur only during the 18-month project duration.

The effects of dust, noise, and human activity on biota at borrow site 2 may extend out for 700 feet from the site (Figure C.2.2). For purposes of analysis, borrow site 2 was assumed to be in the center of the proposed area. The most important indirect impact at borrow site 2 would be the disturbance of wintering mule deer and elk over a 132-acre area. Mule deer and elk use the same winter range from year to year (Kerr, 1981; Young, 1982). It is expected that animals who traditionally use at least part of the 700-foot area around the site would be displaced as has been observed by various researchers for human disturbance associated with logging and mining (Kuck et al., 1985; Edge et al., 1985). The magnitude of these short-term impacts would be relatively minor during the non-wintering period (April through November) and greatest during the wintering period (December through March). It is expected that these construction related activities would not extend the full 700 feet from the source since the disturbance would be buffered by extensive vegetative cover and topographic barriers as has been observed in other studies (Edge et al., 1985). In summary, the indirect short-term impacts of the seven-month construction period at this site would be minor during the non-wintering period but would affect a relatively large number of animals during the wintering period.

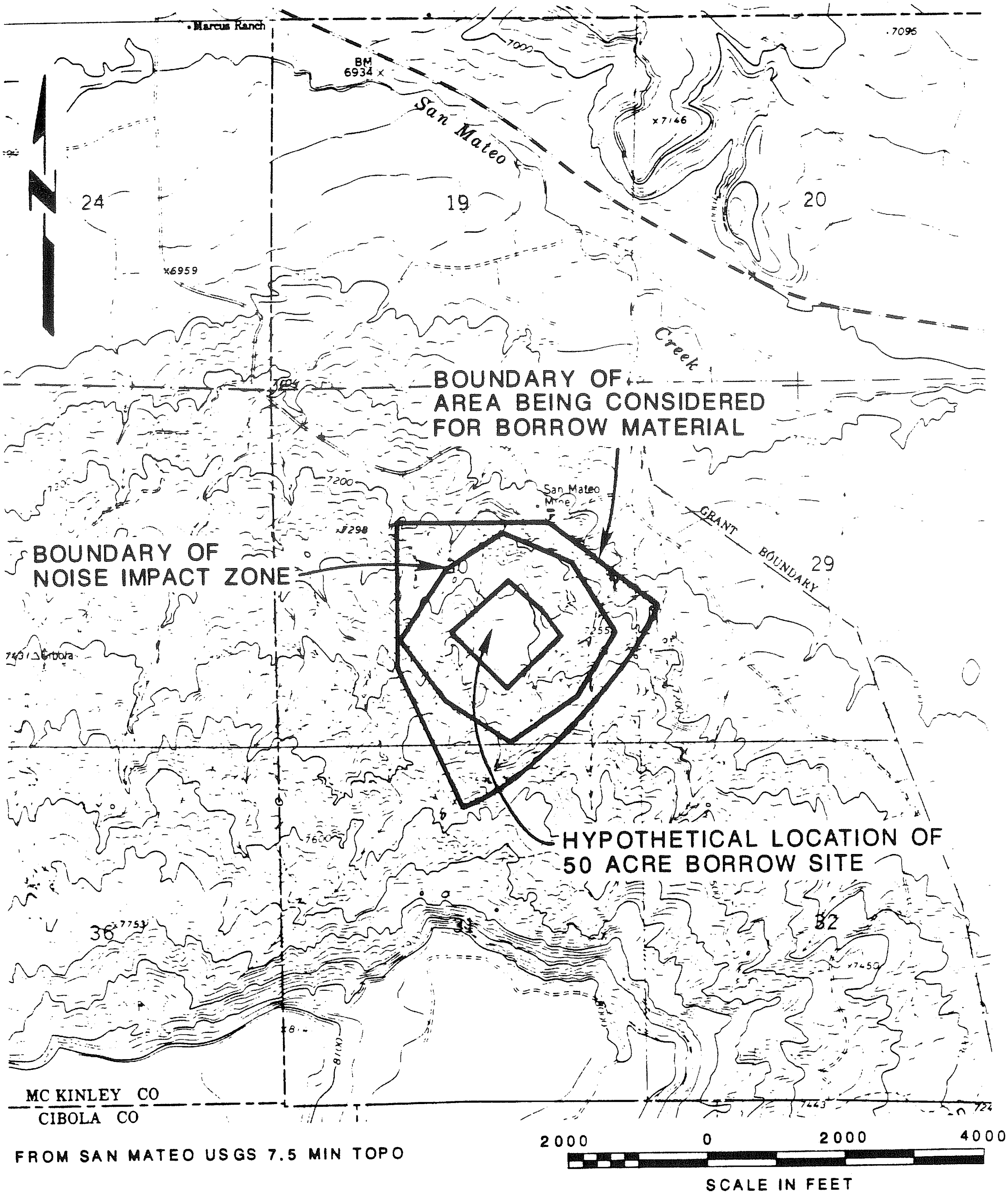

FIGURE C.2.2
NOISE IMPACT ZONE AROUND BORROW SITE TWO

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APPENDIX D

RADIATION

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D.1 RADIATION

This appendix addresses the increased radiation doses and health impacts to the general public and remedial action workers for the remedial action at the Ambrosia Lake tailings site. The slightly increased doses can, in a statistical sense, increase the potential for individual and general public health effects (excess fatal cancers) above those naturally expected. Assumptions made during the calculations of excess health effects for the general public and remedial action workers are conservative, and represent an upper limit of the excess health effects that might occur because of exposure to low levels of radiation from the tailings.

D.1.1 BASIC FACTS ABOUT RADIATION AND ITS MEASUREMENT

Atoms that spontaneously transform, or decay, into new atoms are termed radioactive. The decaying atom is called the parent, and the atom produced by the transformation is called the daughter. The rate at which atoms decay is the radioactivity, measured by the unit curie (Ci). A more convenient unit for measuring the radioactivity of tailings piles is the picocurie (pCi), which is one-millionth of one-millionth (1×10^{-12}) of a curie. The half-life of a radioactive substance (i.e., radionuclide) is the time required for it to lose 50 percent of its radioactivity by decay. Each radionuclide has a unique half-life.

When atoms undergo radioactive decay, they emit radiation. The most common types of radiation are alpha particles, beta particles, and gamma rays. Alpha and beta radiation are tiny particles with excess energy, and gamma radiation is pure energy without mass. Radiation transmits energy to matter as it travels through matter. Alpha radiation penetrates only a few micrometers into matter, beta radiation penetrates a few centimeters, and gamma radiation, like X-rays, penetrates deeper into matter. Alpha radiation will not penetrate through a layer of dead skin, whereas gamma radiation can easily penetrate tissue and hence deliver a dose to any internal organ. However, alpha radiation, if inside the body, will deliver a larger dose to the immediate tissues since all of its energy will be deposited in living tissues.

The amount of radiation to which an individual is exposed may be expressed in terms of the amount of energy imparted to cells and tissue by the radiation and the degree of biological damage associated with the energy as it is absorbed. This absorbed energy is termed the absorbed dose and is given in units of rads, where one rad equals 100 ergs of energy absorbed per gram of material irradiated. When the irradiated material is living tissue, the damage per rad varies depending on the type of radiation. By mathematically applying a "quality factor" to each specific type of radiation, the degree of biological damage can be expressed independently of the type of radiation causing it. The biologically relevant absorbed energy is termed the dose equivalent, and the unit is the rem. One rad is equal to one rem for less damaging radiations where the quality factor is equal to one (e.g., gamma rays). For comparison, one rad of internal alpha-deposited energy is equal to 20 rem because alpha particles are more damaging to tissue and the quality factor for alpha radiation is 20. The millirem equals one-thousandth (1×10^{-3}) of a rem and is in more common usage when expressing doses from environmental levels of radiation. When the radiation dose in rads is corrected by the quality factor to reflect the differences in tissue damage from the different types of radiation, then the value obtained in rems is called a dose equivalent. In addition, when the dose being calculated is from radioactive material deposited permanently in the body, total dose committed to the person's body over his lifetime is usually calculated. This is termed the dose equivalent commitment.

When a succession of radioactive parent atoms decay to radioactive daughter atoms, a radioactive decay series is formed. Uranium-238 (U-238) is such a radioactive parent atom and the U-238 decay series is shown in Figure D.1.1 (Lederer et al., 1967; BRH, 1970). The U-238 decay series includes thorium-230 (Th-230), radium-226 (Ra-226), radon-222 (radon or Rn-222), short-lived radon daughters, and other long-lived radioactive atoms. The U-238 decay series ends with lead-206 (Pb-206), an atom that is stable and not radioactive. When the daughter products in a radioactive decay chain have shorter half-lives than the parent, the daughter radioactivities will increase, termed ingrowth, until they equal the radioactivity of the parent.

Radon is the radionuclide of primary importance to the UMTRA Project because it represents the largest radiation exposure pathway to the general public. The half-life of radon (3.8 days) is short relative to the half-life of Ra-226 (1602 years). As Ra-226 decays, the newly produced radon will begin to decay, and the radon radioactivity will become equal to the Ra-226 radioactivity within 30 days. Similarly, the short-lived radon daughter radioactivities will ingrow within four hours to equal the radioactivity of radon and Ra-226. When the radioactivities of the parent and its daughters are equal, the daughters are said to be in 100 percent equilibrium or simply in equilibrium. If the daughters are diluted or carried away in the air as they are formed, they will not reach 100 percent equilibrium.

The only member of the U-238 decay series that is not a solid is radon. Radon is an inert gas and does not react chemically with other elements; it therefore can diffuse out of matter and into the atmosphere. The atmospheric radon concentration is measured in units of picocurie per liter (pCi/l). In the uranium milling process, Ra-226, the parent of radon, is left in the tailings, which then becomes a source from which radon diffuses into the atmosphere. Once in the atmosphere, radon is transported downwind and, according to its 3.8-day half-life, decays into the short-lived radon daughters which can attach to particulates in the air. Since radon is an inert gas, it is inhaled and exhaled, contributing very little radiation exposure to the lung. The radon daughters are solids, however, and once inhaled can deposit in or attach to the lung and then decay, transmitting alpha energy in the lung. Because of the short half-life, these daughters may decay before being removed from the lung.

Nuclide	Historical name	Half-life	Major radiation energies (MeV) and intensities† α	β	γ
${}^{238}_{92}U$	Uranium I	4.51×10^{9} y	4.15 (25%) 4.20 (75%)	---	---
${}^{234}_{90}Th$	Uranium X_1	24.1d	---	0.103 (21%) 0.193 (79%)	0.063c‡ (3.5%) 0.093c (4%)
${}^{234}_{91}Pa^{m}$ (99.87% / 0.13%)	Uranium X_2	1.17m	---	2.29 (98%)	0.765 (0.30%) 1.001 (0.60%)
${}^{234}_{91}Pa$	Uranium Z	6.75h	---	0.53 (66%) 1.13 (13%)	0.100 (50%) 0.70 (24%) 0.90 (70%)
${}^{234}_{92}U$	Uranium II	2.47×10^{5} y	4.72 (28%) 4.77 (72%)	---	0.053 (0.2%)
${}^{230}_{90}Th$	Ionium	8.0×10^{4} y	4.62 (24%) 4.68 (76%)	---	0.068 (0.6%) 0.142 (0.07%)
${}^{226}_{88}Ra$	Radium	1602y	4.60 (6%) 4.78 (95%)	---	0.186 (4%)
${}^{222}_{86}Rn$	Emanation Radon (Rn)	3.823d	5.49 (100%)	---	0.510 (0.07%)
${}^{218}_{84}Po$ (99.98% / 0.02%)	Radium A	3.05m	6.00 (~100%)	0.33 (~0.019%)	---
${}^{214}_{82}Pb$	Radium B	26.8m	---	0.65 (50%) 0.71 (40%) 0.98 (6%)	0.295 (19%) 0.352 (36%)
${}^{218}_{85}At$	Astatine	~2s	6.65 (6%) 6.70 (94%)	? (~0.1%)	---
${}^{214}_{83}Bi$ (99.98% / 0.02%)	Radium C	19.7m	5.45 (0.012%) 5.51 (0.008%)	1.0 (23%) 1.51 (40%) 3.26 (19%)	0.609 (47%) 1.120 (17%) 1.764 (17%)
${}^{214}_{84}Po$	Radium C'	164 µs	7.69 (100%)	---	0.799 (0.014%)
${}^{210}_{81}Tl$	Radium C"	1.3m	---	1.3 (25%) 1.9 (56%) 2.3 (19%)	0.296 (80%) 0.795 (100%) 1.31 (21%)
${}^{210}_{82}Pb$	Radium D	21y	3.72 (.000002%)	0.016 (85%) 0.061 (15%)	0.047 (4%)
${}^{210}_{83}Bi$ (~100% / .00013%)	Radium E	5.01d	4.65 (.00007%) 4.69 (.00005%)	1.161 (~100%)	---
${}^{210}_{84}Po$	Radium F	138.4d	5.305 (100%)	---	0.803 (0.0011%)
${}^{206}_{81}Tl$	Radium E"	4.19m	---	1.571 (100%)	---
${}^{206}_{82}Pb$	Radium G	Stable	---	---	---

FIGURE D.1.1 URANIUM 238 DECAY SERIES

Trace amounts of U-238 and its daughters are found everywhere on the earth. Therefore, radon and its short-lived daughters contribute significantly to the natural background radiation exposure of the general public. Human exposure to radiation originates from both natural and man-made sources. The major natural radiations originate from cosmic and terrestrial external sources, and from naturally occurring radionuclides which are deposited inside the body via the ingestion and inhalation pathways. Exposure to man-made sources results primarily from medical exposures (e.g., diagnostic X-rays), atmospheric weapons tests, the nuclear industry, consumer products, and technologically enhanced natural radiation.

Medical usage of radiation is responsible for the highest contribution to man's radiation exposure, accounting for approximately 50 percent of man's total radiation exposure. Other man-made contributors, including airline travel, atmospheric weapons tests, the nuclear industry, and consumer and industrial products together account for approximately five percent. The remaining 45 percent of man's total radiation exposure results from exposure to natural radiation sources.

D.2 METHOD OF ANALYSIS

Radiation and its associated health effects have been studied more thoroughly than health effects from other carcinogenic agents. The evaluation of health effects caused by low-level radiation is, however, a difficult task, and many uncertainties are associated with the estimation of risks from low-level radiation. The traditional approach for estimating risks from low-level radiation exposures is to extrapolate from effects observed at high radiation exposures using the linear-dose response and no threshold assumptions.

There are five principal pathways which could potentially result in exposure of man to radiation from the tailings pile (NRC, 1980a). These are: (1) inhalation of radon daughters; (2) direct exposure to gamma radiation emitted from the contaminated area; (3) inhalation and ingestion of, and submersion in, airborne radioactive particulates; (4) ingestion of ground and surface waters contaminated with radioactive materials; and (5) ingestion of contaminated foodstuff produced in areas contaminated by tailings.

For detailed calculations of health effects in this appendix, only the most significant radiation exposure pathways are considered; these are inhalation of radon daughters, direct exposure to gamma radiation, and food ingestion. Analyses of radiation health effects from air particulates at other Uranium Mill Tailings Remedial Action (UMTRA) Project sites and at active uranium mill tailings sites in the vicinity of Ambrosia Lake indicate that this pathway would result in excess health effects orders of magnitude less than those from inhalation of radon daughters (DOE, 1983, 1984, 1985a; Millard and Baggett, 1984). The water ingestion pathway has also been shown to be a relatively insignificant cause of excess health effects (DOE, 1984, 1985a). This is expected to be the case at the Ambrosia Lake site since the aquifer contaminated by the tailings is not used as a source of drinking water or for agricultural purposes. For these reasons, the air particulate and drinking water ingestion pathways are not considered further in this appendix. The food ingestion pathway is considered for local residents in the vicinity of the Ambrosia Lake site who regularly consume livestock raised on grazing lands which include the Ambrosia Lake tailings site and area of windblown contamination. Consumption of contaminated livestock as a sole source of meat by local ranchers has been shown to be potentially important (Lapham et al., 1985). Consumption of other foodstuffs grown is not considered since the nearest residence is 2.5 miles from the tailings site.

Health risk estimates in this appendix make use of recommendations published in scientific reports and journals (NCRP, 1984; Evans et al., 1981; Evans, 1980; NAS, 1980; ICRP, 1977; UNSCEAR, 1977).

Quantitative risk estimation of somatic effects (e.g., cancer) for various organs of the body can be obtained using available human radiation exposure data. The manifestation of a cancer caused by radiation exposure would occur after a latent period of up to 25 years or more, depending on the type of cancer and the age of the person exposed. The risks from radiation vary with adult age and sex but are presented here as average values assuming that the variation due to adult age and sex is small. No data are available that indicate whether risk estimates for adults are appropriate for radiation exposure during childhood.

D.2.1 HEALTH EFFECTS OF EXPOSURE TO RADON DAUGHTERS

The health effects of radon diffusion from tailings arise from inhalation of the short-lived radon daughters which deposit alpha energy in the lung. For radiation protection purposes, the International Commission on Radiological Protection (ICRP, 1977) proposed an individual lung cancer risk factor of 20 x 10^{-6} per rem, or 20 excess fatal cancers where one million individuals each receive a one-rem lung dose equivalent commitment.

Health effects from radon daughter inhalation can also be expressed as excess risk of lung cancer based on the lung collective dose equivalent commitment in person-working-level months (person-WLM). The unit of working level (WL) is defined as any combination of short-lived radon daughters in one liter of air which, on complete decay, gives a total emission of 1.3 x 10^5 million electron volts of alpha radiation. One WL is equivalent to 100 pCi of radon per liter of air with the short-lived radon daughters in 100 percent equilibrium. At equilibrium levels less than 100 percent, the WL corresponding to a given radon concentration is reduced. The working-level month (WLM) is a unit defined as the exposure resulting from the inhalation of air with a concentration of one WL of radon daughters for 170 working hours. The total dose of one or more persons is the product of the number of persons and the average dose they receive; the unit for the measurement of such a population dose is the person-WLM.

Following are estimates of excess lung cancers given in terms of person-WLM. The United Nations Scientific Committee on the Effects of Atomic Radiation quoted a range of 200 to 450 x 10^{-6} lung cancers per person-WLM (UNSCEAR, 1977), the NRC in its environmental impact statement on uranium milling quoted 360 x 10^{-6} fatal cancers per person-WLM (NRC, 1980a), the BEIR-III report (NAS, 1980) indicated 850 x 10^{-6} lung cancers per person-WLM, and EPA quoted 860 x 10^{-6} lung cancers per person-WLM (NCRP, 1984). The ICRP (1981) has adopted 150 to 450 x 10^{-6} as the risk of lung cancer per person-WLM. Evans et al. (1981) reviewed the BEIR-III study, lung cancer risk estimates published by other authors, and epidemiological evidence. They concluded that the most defensible upper bound to the lifetime lung cancer risk for the general public is 100 x 10^{-6} lung cancers per person-WLM. Table D.2.1 presents these risk factors.

The National Council on Radiation Protection (NCRP, 1984) reported a conversion factor of one WLM approximately equal to a 12.6 rem/WLM to 25 rem/WLM dose equivalent commitment to the lung. Using the previously mentioned ICRP individual lung cancer risk factor of 20 x 10^{-6} per rem, the NCRP dose conversion factors correspond to 250 to 500 x 10^{-6} lung cancers per person-WLM. A risk factor of 300 x 10^{-6} deaths per person-WLM is used in this appendix for calculating health effects due to exposure to radon daughters. This is equivalent to a conversion factor of one WLM approximately equal to a 15-rem dose equivalent commitment to the lung. The risk factor used in the EA of 300 x 10^{-6} is close to an average of all risk factors reported in the literature and provides the consistency needed to compare alternatives in terms of health effects.

Table D.2.1 Lifetime risk factors for excess lung cancers reported in the literature.

Source[a]	Risk estimate[b]
1. Evans et al.	100
2. NCRP	130
3. UNSCEAR	200-450
4. USNRC	360
5. AECB	600
6. USEPA	760
7. BEIR-III	850

[a]References are as follows: (1) Evans et al., 1981; (2) National Council on Radiation Protection: NCRP, 1984; (3) United Nations Scientific Committee on the Effects of Atomic Radiation: UNSCEAR, 1977; (4) U.S. Nuclear Regulatory Commission: NRC, 1980a; (5) Atomic Energy Control Board: AECB, 1982; (6) U.S. Environmental Protection Agency: EPA, 1984; and (7) National Academy of Sciences, Committee of Biological Effects of Ionizing Radiation: NAS, 1980.

[b]Risk estimates are in units of excess cancers per million person working level months.

D.2.2 HEALTH EFFECTS OF EXPOSURE TO GAMMA RADIATION

Tailings piles emit gamma radiation that delivers an external exposure to the whole body of a person near the pile. The BEIR-III report contains several models for estimating cancer risk resulting from exposure to gamma radiation. Health effects estimates in this appendix for excess cancers due to gamma radiation use a risk factor of 120 x 10^{-6} cancers per person-rem (NAS, 1980; Cohen, 1981). This is equivalent to 120 excess cancers in an exposed population for each 1,000,000 person-rems of collective dose equivalent. A person-rem is the product of the radiation dose equivalent multiplied by the number of people receiving that dose.

For gamma radiation, one rem is approximately equal to one roentgen (R) which is the unit for measuring gamma radiation intensity in air. A microroentgen (microR) is 1 x 10^{-6} R, and typical environmental gamma radiation levels are expressed in microR per hour (microR/hr).

The health effects attributed to a gamma radiation dose are categorized into two general types: somatic and genetic. Somatic effects are manifested in the exposed individual (e.g., cancer) and genetic effects are manifested in the descendants of the exposed individual. The ICRP (1977) reported that the average risk estimated for genetic effects, as expressed in the first two generations and considered genetically significant, is 40 x 10^{-6} per rem. For all subsequent generations, the risk is estimated to be equal to that expressed in the first two generations. The total genetic risk (all generations) is, therefore, 80 x 10^{-6} per rem. Measures taken to reduce the somatic effects would also reduce the genetic effects, thus the calculations in this appendix reflect only the somatic risk.

D.2.3 HEALTH EFFECTS OF EXPOSURE TO CONTAMINATED LIVESTOCK

The internal dose that might be received by a person consuming livestock raised on grazing lands contaminated by uranium mining operations was estimated by Lapham et al. (1985). The internal dose commitment received by a person ingesting these contaminated tissues for one year was estimated for four groups of cattle. These four groups of cattle were chosen from three areas in New Mexico; two groups from Ambrosia Lake and one each from Church Rock and Crownpoint.

The mean concentrations of radionuclides in muscle, liver, and kidney from each of the four groups were determined and used to calculate radiation dose commitments and cancer risks incurred from regularly eating these tissues according to the following scenarios:

scenario 1. 74 kg muscle, 2.7 kg liver, and 1.3 kg kidney (consumption of 78 kg of meat per year, the U.S. per capita annual average meat consumption, and muscle, liver, and kidney in proportion to the organ's percentage weight in edible beef).

scenario 2. 78 kg of muscle and no liver or kidney.

scenario 3. 62.3 kg muscle, 13.1 kg liver, and 2.6 kg kidney (a worst-case scenario calculated using a recent dietary survey of New Mexicans).

Cancer risks were estimated by converting the mean tissue concentrations for the radionuclides in the tissues to mrem by using the appropriate factors for absorption of specific radionuclides across the human gut and the effective dose equivalent conversion factors of Dunning (ICRP, 1977; Dunning, 1985). The expected number of cancer deaths was then estimated by multiplying the total effective dose equivalent by the appropriate ICRP risk coefficient of 125×10^{-6} per rem (ICRP, 1977).

Cancer risks associated with scenario 1 are one chance in 1,310,000 from ingesting control beef, one chance in 1,170,000 from Church Rock cattle, and one chance in 940,000 and one chance in 280,000 from each of the cattle groups from Ambrosia Lake.

Cancer risks for scenario 2 are much lower; e.g. one chance in 534,000 (compared to one in 280,000 for scenario one) for one of the Ambrosia Lake cattle groups.

The worst-case estimates of scenario 3 indicated greater risks. Cancer risk estimates, per year of ingestion, are one chance in 630,000 for Crownpoint and Church Rock cattle, one chance in 400,000 and one chance in 120,000 from each of the cattle groups from Ambrosia Lake.

The degree of health risk from eating these contaminated tissues is directly proportional to the amount of tissues consumed and the duration of the exposure. Eating liver and kidney from these contaminated cattle causes larger internal doses and therefore greater risk. The risk to the general public is considered minimal, however, since few individuals would be likely to continually consume cattle raised in these areas.

D.3 CALCULATIONS OF HEALTH EFFECTS

D.3.1 STABILIZATION IN PLACE

General public health effects from radon daughter exposure

The population distribution in the vicinity of the Ambrosia Lake tailings site was used as a basis to calculate the health effects to the general public during stabilization in place. There are no people within two miles; approximately 60 people live within a six-mile radius of the tailings pile distributed by sector as shown in Table D.3.1. For conservatism, an average of five occupants per household was assumed to calculate the population estimate. It was also assumed that people spend 75 percent of their time in the immediate vicinity of their residences (25 percent outdoors and 50 percent indoors) and 25 percent of their time beyond a distance at which effects from the tailings become negligible.

To develop the radon source term during stabilization in place, the radon flux was calculated using the NRC (1979) radium concentration to radon flux conversion factor. For wet tailings, a concentration ratio of 0.35 pCi/m^2s per 1.0 pCi/g Ra-226 is appropriate, and for dry tailings a ratio of 1.2 pCi/m^2s per 1.0 pCi/g Ra-226 is correct. The NRC, however, suggests using the generic value of 1.0 pCi/m^2s per 1.0 pCi/g Ra-226 for this conversion.

Stabilization in place involves the relocation of tailings from the northern portion of the pile onto the southern portion of the pile. Windblown tailings and contaminated soils from off-pile areas would then be placed on and around the reshaped tailings pile. The radium content of the tailings differs markedly from that of the windblown contamination. Two source terms were developed, therefore, and the site source term was calculated using the sum of the two separate source terms.

To investigate the radium content and distribution of the Ambrosia Lake tailings pile, boreholes were drilled across the pile on a regular grid. Split-spoon samples were collected from these holes down to the physical interface between tailings and sub-base material. In a number of cases, samples were collected several feet beyond the physical interface. These samples were later analyzed by gamma spectroscopy for radium content. Some of the samples were also examined by Sandia National Laboratories personnel at the site. These were placed in a shielded sodium iodide detector assembly, and the radium content of the split-spoon sample was estimated. Missing values of concentrations at all depths were estimated from an average of the nearest neighbor's concentrations. This was done by using existing data from the nearest lateral neighbor at the same height. The resulting three-dimensional grid is the best estimate of the radium concentration distribution within the pile based on existing data. The results allowed an estimate of the distribution of radium within the pile. They also allow an estimate of the depth below the physical interface at which the EPA standard for soil is met. This provided the volume of material to be

Table D.3.1 Ambrosia Lake estimated 1985 population distribution[a]

	Radius (miles from the tailings pile edge)																
Direction	0.25	0.5	0.75	1.0	1.25	1.5	1.75	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	Total
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5
SSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0	5	5	15	0	0	25
SSW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	20
W	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5
WNW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5
NNW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	5	5	0	5	5	35	5	0	60

[a]Five persons per household assumed.

Ref. TAC, 1985.

excavated if the pile were to be moved for stabilization, as well as the radon source term used for cover design.

For source term calculations, the average Ra-226 concentration of the tailings pile was determined based on 407 samples from 106 boreholes (BFEC, 1985; MSRD, 1982). These samples were divided into three groups: (1) samples in the top 2.5-foot layer of the pile (n = 46, $\bar{X}$ = 724 ± 286 pCi/g); (2) samples in the region from the pile surface to the physical interface (n = 107, $\bar{X}$ = 571 ± 284 pCi/g); and (3) samples in the region from pile surface to the 15 pCi/g interface (n = 300, $\bar{X}$ = 455 ± 259 pCi/g). In terms of sample regions the three averages were regarded as being different. It should be noted, however, that the average values are not statistically different; therefore, given the degree of insignificance of the estimated radiation induced health effects, it was not considered beneficial to estimate and discuss the variance for Ra-226 and Rn-222 inventories. For conservatism, the top 2.5-foot layer Ra-226 concentration of 724 pCi/g was used, resulting in a tailings pile area average radon flux of 724 pCi/m^2s. For the 111-acre tailings pile area, this is equivalent to a radon source term of 10,257 Ci/year.

The off-pile contamination was determined to have a radon flux of 52.4 pCi/m^2s based on an average Ra-226 concentration of 52.4 pCi/g. For this 570-acre area of windblown contamination, the radon source term was determined to be 3812 Ci/year.

The remedial action for on-site stabilization of the tailings pile is expected to take 18 months. During this period, disturbance and exposure of the tailings would occur for a maximum of 13 months. Radon releases would be increased somewhat during disturbance of the material. It is assumed that the tailings to be moved would be handled and moved once during remedial action and that all radon in the tailings pore spaces would be released instantaneously to the atmosphere when the tailings were moved. Assuming the radon to be in secular equilibrium with Ra-226 and using the average Ra-226 concentration to the 15 pCi/g interface (455 pCi/g Ra-226), an emanation fraction of 0.33 (Nelson, 1984), and a tailings volume of 5.40 x 10^5 cubic yards, (20 percent of the pile), the calculation resulted in a release of 99 Ci of radon determined as follows:

$$[(5.40 \times 10^5 yd^3) \times (455\ pCi/g) \times (1.6\ g/cm^3) \times (7.64 \times 10^5 cm^3/yd^3) \times (1 \times 10^{-12}\ Ci/pCi)] \times 0.33 = 99\ Ci.$$

One hundred percent of the off-pile contamination would be disturbed releasing all radon from the tailings pore spaces. A total volume of 930,000 cubic yards with an average Ra-226 concentration of 52.4 pCi/g would result in a radon puff release of 60 Ci, calculated as follows:

$$[(9.30 \times 10^5 yd^3) \times (52.4\ pCi/g) \times (1.6\ g/cm^3) \times (7.646 \times 10^5 cm^3/yd^3) \times (1 \times 10^{-12}\ Ci/pCi)] \times 0.33 = 60\ Ci.$$

The total radon source term for 13 months during stabilization in place would be the sum of the source terms from the tailings (10,257 Ci/year), windblown contaminated area (3812 Ci/year), the radon puff release from the interstitial pore spaces of the tailings (99 Ci), and off-pile material (60 Ci). The total radon source term is 15,400 Ci. The radon flux from the tailings pile and off-pile areas would decrease as the radon barrier is placed over the contaminated materials. This reduction in radon flux, however, was not included in the site flux.

The radon concentration on the pile during remedial action was determined using a 758 pCi/m^2s radon flux from the pile and a 53.6 pCi/m^2s flux from the windblown area (these fluxes include the pore space fluxes), an average wind speed of three meters per second (calculated by weighting each wind speed by its frequency of occurrence), an approximate pile radius of 378 meters, and an approximate windblown radius of 857 meters. For calculation purposes, a conservative distribution of stability classes was used based upon meteorological data from Ambrosia Lake (NMSHD, 1985), and the pile and windblown geometries were assumed to be circular. The radon concentration at the center of the circular pile was estimated by calculating the concentration for each of the six standard stability classes, weighting each by the frequency of occurrence, and summing the weighted values. The concentration at the pile center for each stability class was calculated by integrating the functional form of sigma Z as a function of distance from the pile center back to the pile edge, ignoring crosswind spreading. This is similar to assuming that the center of the pile is always at the edge of an infinite strip of area source, with the width equal to the pile radius. The resulting radon concentration on the pile was calculated to average 19.1 pCi/l during remedial action.

To estimate the radon concentration and working level downwind from the tailings pile, annual average radon concentrations and working levels as a function of distance from the pile were calculated using a sector average form of the Gaussian diffusion equation (Turner, 1969) and a calculation of the ingrowth of radon daughters as a function of time (Evans, 1980). The area source (tailings pile and windblown) was treated as a point source at the site center with a source strength equivalent to the area weighted flux for the site (168 pCi/m^2s per 681 acres). The calculated radon concentration is a function of wind speed and stability class for each distance downwind. A conservative distribution of wind speed and stability class was assumed that would result in maximized radon and radon daughter concentrations downwind for a sector as summarized in Table D.3.2. This bi-variate joint frequency distribution was then used to time-weight the radon concentration calculated at a given downwind distance according to the percent of the time that each wind speed and stability class pair occurs. Similarly, the percent ingrowth of daughters at a given downwind distance was calculated based on the transit time of the radon from the area source center. The working level due to the pile at varying distances from the pile is dependent on the percent ingrowth of radon daughters. Between a transit time of one minute and 40 minutes, the WL grown into 100 pCi/l of radon can be represented within plus five percent by the approximate analytical expression (Evans, 1980):

Table D.3.2 Joint frequency distribution between wind speed and stability class for a conservative sector

Stability class	Wind speed (miles per hour) 0-3	4-7	8-12	13-18	19-24	>25	Total
A	0.35	0.23	0	0	0	0	0.58
B	0.06	1.16	0.12	0	0	0	1.33
C	0.58	0.58	0.46	0	0	0	1.62
D	6.25	7.52	6.48	1.62	0	0	21.88
E	19.91	23.73	3.24	0	0	0	46.87
F	11.11	16.09	0	0	0	0	27.20

NOTE: The distribution of frequencies in the table refers to the percentage of time that wind blew for each class from the conservative sector.

$$WL = 0.023\ T^{0.85}$$

where

WL = working level.
T = transit time in minutes.

The working level for each wind speed and stability class was also time-weighted using the assumed joint frequency distribution.

The use of the sector average model, with the area source replaced by a point source, tends to overpredict the concentrations at distances close to the source. At distances greater than several source diameters from the edge of the source, the model is reasonably accurate. At distances less than several source diameters, however, overprediction can be up to a factor of two.

The area of the source (tailings pile and windblown area) is large, and therefore the model overpredicts radon concentrations at distances closer than three miles from the edge of the site.

To estimate radon concentrations within this overprediction-area, interpolation was done on a log-log basis between the previously calculated on-pile radon concentration (19.1 pCi/l) and the modeled radon concentrations beyond three miles of the site edge. Similarly, the working level exposures within three miles of Ambrosia Lake were determined by extrapolating on a semi-logarithmic basis from the modeled working levels beyond three miles.

For the general public health effects calculations, assumptions were made which resulted in a conservative estimate of working levels as a function of distance from the pile edge. A wind direction frequency in the NNE sector of 8.3 percent from the Ambrosia Lake, New Mexico, area (NMSHD, 1985) was determined to represent the worst case conservative sector. All of the population was assumed to live in this conservative sector of interest. These assumptions provide a reasonable upper bound for the general public health effects estimates.

The radon concentration and working levels due to the pile at varying distances from the pile edge are presented in Table D.3.3. The percent ingrowth formula used to derive working levels assumes that no radon daughter products are removed from the air by plate-out on walls. Plate-out occurs when the electrically charged radon daughters attach to walls or other surfaces and are removed from the air, thereby reducing the percent equilibrium of radon daughters in the air inhaled. To account for plate-out in health effects calculations for outdoor conditions, the working level in inhaled air was assumed to be one-half of that calculated from the ingrowth formula; that is, 50 percent plate-out was assumed. For indoor working levels, the outdoor radon concentration as a function of distance was multiplied by a 50 percent equilibrium factor for radon daughters. This is applied in Equation D.3.1 to both outdoor and indoor inhalation.

Table D.3.3 Radon daughter health effects to the general public during remedial action for stabilization in place

Distance from pile edge (miles)	Population	Modeled outdoor radon concentration (pCi/l)	Modeled outdoor working level (r) x 10^{-4}	Calculated WLM (r) x 10^{-4}	Excess health effects x 10^{-4}
2.5	5	0.320	23.6	611	0.92
3.0	5	0.246	20.7	486	0.73
4.0	5	0.162	14.2	325	0.49
4.5	5	0.137	12.2	276	0.42
5.0	35	0.118	10.6	239	2.5
5.5	5	0.103	0.9	210	0.31
Total	60				5.4

For each distance, the number of working-level months was calculated using the equation:

Equation D.3.1

$$WLM(r) = \left(\frac{R(r)}{100} \times I + (WL(r) \times O)\right) \times \left(\frac{H}{170\ (hr/WLM)} \times T\right)$$

where

- WLM(r) = working-level months at distance r (WLM).
- R(r) = radon concentration at distance r (pCi/l).
- WL(r) = working level at distance r (WL).
- O = fraction of time spent outdoors multiplied by radon daughter equilibrium factor (0.25 x 0.5).
- I = fraction of time spent indoors multiplied by radon daughter plate-out factor (0.5 percent x 0.5).
- H = hours per year (8760 hours).
- T = duration of exposure (years).

The results of the above calculations are presented in Table D.3.3. The health effects were calculated by multiplying the working-level months by the population at each distance and by the conversion factor of 300×10^{-6} effects per person-WLM. Health effects were then summed over the distances.

The estimated number of excess health effects due to the 13-month tailings pile disturbance for the general public population within six miles of the Ambrosia Lake tailings pile was calculated as 5.4×10^{-4}, or 0.00054 excess health effects for stabilization in place.

General public health effects from gamma exposure

The nearest general public living or working around Ambrosia Lake is 2.5 miles from the edge of the tailings pile. A predictive model (Yuan et al., 1983) which plots the ratio of direct gamma exposure rate divided by tailings Ra-226 concentration (microR/hr per pCi/g) as a function of distance from a tailings pile edge, has been used at other UMTRA Project sites (DOE, 1985b) to estimate gamma radiation exposure rates contributed by the tailings to the general public. Using this model, the contribution from the tailings pile to gamma radiation levels has been determined to be negligible beyond 0.3 mile from the tailings pile perimeter. Therefore, since there are no residents within 2.5 miles of the tailings pile, the individual risk to the general public of fatal cancer from gamma exposure due to the tailings at Ambrosia Lake is negligible.

Remedial action worker health effects from radon daughter exposure

An average of approximately 62 workers would be required during the 18-month remedial action period for stabilization in place. To estimate an upper bound for excess health effects to remedial action workers, it was assumed that each worker would spend eight hours per day, 19.25 days per month over 18 months outside on the pile and be exposed to a radon concentration of 19.1 pCi/l as calculated previously for the 13-month period of tailings pile disturbance. The radon daughter percent equilibrium on the pile was conservatively assumed to be 20 percent based on percent equilibrium measurements made near the Grand Junction uranium tailings pile (Borak and Inkret, 1983). The estimated excess health effects to site workers during the 13-month period of tailings pile disturbance are (19.1 pCi/l per 100 pCi/l-WL) (0.2 equilibrium fraction) (1848 hours per year) (one month per 170 hours) (1.08 year) (62 persons) (300 x 10^{-6} health effects per person-WLM), which equals 84 x 10^{-4}, or 0.0084 excess health effects.

Remedial action worker health effects from gamma exposure

Remedial action workers on the pile would be exposed to gamma radiation from tailings, as well as to radon daughters. The estimated gamma exposure rate on the pile in microR/hr is 2.5 times the Ra-226 concentration in pCi/g (Schiager, 1974), or 1810 microR/hr based on the measured average Ra-226 concentration of 724 pCi/g. It should be noted that this is a highly conservative estimate and represents an upper bound which, in practice, is not expected to be reached. On a partially stabilized tailings pile, the exposure rate would be reduced by a factor of 10 for each foot of cover material. The majority of workers would be enclosed in cabs of earthmoving equipment which would provide shielding from the tailings, where one inch of steel reduces gamma-ray transmission by a factor of 10. A more realistic average gamma radiation exposure rate to remedial action workers would therefore be a factor of 10 below 1810 microR/hr, or approximately 181 microR/hr. Based on 181 microR/hr, the external gamma radiation exposure that a worker could be expected to receive from working 2002 hours over a 13-month period would be 0.36 rem, which is within the standard limit of 5 rem per year for occupational exposure (NRC, 1980b). For 62 remedial action workers, the estimate for excess health effects due to gamma radiation is 2.7 x 10^{-3} or 0.0027.

The total estimated health effects to remedial action workers during stabilization in place from radon daughter inhalation and gamma radiation is 0.01 excess health effects.

D.3.2 NO ACTION

General public health effects from radon daughter exposure

For the no action alternative, the annual average radon flux was calculated to be 162 pCi/m^2s or approximately 14,000 Ci/year from the 681 acres of tailings pile and off-pile contamination. The total site source term is slightly lower than the source term calculated for the stabilization in place alternative because tailings would not be moved, and thus the radon within the tailings pore spaces would not be released. The downwind radon concentrations were determined using the long-term sector average model as previously applied for stabilization in place. Table D.3.4 provides the predicted radon concentrations and working levels as a function of distance from the pile edge. The radon concentration on the pile was determined using the same method as in the stabilization in place analysis. The estimated average radon concentration was approximately 19.1 pCi/l.

Table D.3.4 Radon daughter health effects to the general public per year for the no action alternative

Distance from pile edge (miles)	Population	Modeled outdoor radon concentration (pCi/l)	Modeled outdoor working level (r) x 10^{-4}	Calculated annual WLM (r) x 10^{-4}	Excess health effects x 10^{-4} per year
2.5	5	0.307	22.68	541	0.82
3.0	5	0.236	19.88	432	0.65
4.0	5	0.156	13.64	289	0.44
4.5	5	0.132	11.74	246	0.37
5.0	35	0.173	10.28	212	2.2
5.5	5	0.099	9.13	186	0.28
Total	60				4.8

Equation D.3.1 was applied to determine excess radon daughter health effects to the general public within six miles of the tailings and resulted in an estimated 4.8 x 10^{-4} excess health effects per year (Table D.3.4). This is equivalent to an individual risk of one chance in 125,000 per year.

The annual excess radon daughter health effects for the general public for no action would be approximately 89 percent of the excess radon daughter health effects during stabilization in place.

General public health effects from gamma exposure

The nearest residence to the Ambrosia Lake site is 2.5 miles from the edge of the tailings pile. At this distance, no gamma exposure will be present and the individual risk to the general public of fatal cancer from gamma exposure from the tailings would be negligible.

General public health effects from consumption of local livestock

The problem of potential contamination of livestock raised near uranium mines and mills and the subsequent public health risk to humans from consuming such cattle raised in these areas has been investigated by Lapham et al. (1985). The study included two groups of cattle that were raised at Ambrosia Lake. The study concluded that the cancer risk for a hypothetical rancher who eats these cattle for one year may be as great as one chance in 120,000. Assuming an exposed population of 60, this corresponds to 0.00050 excess health effects per year of consumption.

Remedial action worker health effects

No remedial action workers would be exposed to radon daughters or gamma radiation for the no action alternative.

D.3.3 EXPOSURES AFTER REMEDIAL ACTION

The only radiation exposure pathway of significance after remedial action would be that due to inhalation of radon daughters from the stabilized tailings pile. Following remedial action, there would be essentially no gamma radiation exposure, and the general public gamma health effects are considered to be zero for both remedial action alternatives.

Independent of which alternative was chosen, the EPA standard for the final stabilized tailings pile established an upper limit for the radon concentration at the pile edge of 0.5 pCi/l above background. Table D.3.5 gives maximum radon and radon daughter concentrations downwind, and calculated increases in health effects for stabilization in place following remedial action. Values are based upon the radon flux rate of 20 pCi/m^2s and a final pile surface area of 90 acres. The excess health effects to the general public within six miles of the tailings site following stabilization in place were calculated to be 8 x 10^{-6} per year, which is a factor of approximately 60 lower than the health effects estimate for the no action alternative.

Table D.3.5 Radon daughter health effects to the general public after remedial action for stabilization in place

Distance from pile edge (miles)	Population	Modeled outdoor radon concentration (pCi/l)	Modeled outdoor working level (r) x 10^{-4}	Calculated annual WLM (r) x 10^{-4}	Excess health effects x 10^{-6} per year
2.5	5	0.005	0.415	9.16	1.4
3.0	5	0.004	0.325	7.06	1.1
4.0	5	0.003	0.223	4.71	0.71
4.5	5	0.002	0.191	4.00	0.60
5.0	35	0.002	0.137	3.46	3.6
5.5	5	0.002	0.149	3.04	0.46
Total	60				7.8

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APPENDIX E

PERMITS, LICENSES, APPROVALS

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LIST OF TABLES

E.1 INTRODUCTION

This appendix contains a listing of the permits, licenses, and approvals that may be required for various aspects of the proposed remedial action at the Ambrosia Lake, New Mexico, uranium mill tailings site. In most cases, a determination of the applicability of regulatory permits, licenses, and approvals would be made by the Remedial Action Contractor (RAC) or the U.S. Department of Energy (DOE) in consultation with the appropriate regulatory agency or other authority. Permits, licenses, and approvals would be obtained prior to remedial action by the RAC or the DOE.

E.1.1 Permits, licenses, and approvals for remedial action at the Ambrosia Lake site

Permit, license, or approval	Granting or approving agency	Statute or regulation	Activity
Free Use Permit	U.S. Forest Service	Material Sales Act of 1947; PL 167; 43 CFR 3620; 36 CFR 228(c)	Excavation of borrow materials.
Threatened and Endangered Species Consultation Process	U.S. Fish and Wildlife Service	Endangered Species Act of 1973, Section 7.16	Any action which might affect threatened or endangered species.
Cultural Resource Clearance	New Mexico State Historic Preservation Office	National Historic Preservation Act	Any action which might affect cultural or historic resources.
Notice of Intent to Discharge	New Mexico Health and Environment Department	New Mexico Water Quality Act, 74-6-1 through 74-6-13, NMSA, 1978	Control of surface-water discharge.
National Pollutant Discharge Elimination System (NPDES) Permit	U.S. Environmental Protection Agency	Clean Water Act of 1977	Controlled surface discharge of waste water.
Air Quality Construction Permit	New Mexico Health and Environment Department	New Mexico Air Quality Control Act, 74-2-1 through 74-2-17, NMSA, 1978 as amended in 1981	Equipment operation during remedial action.

E.1.1 Permits, licenses, and approvals for remedial action at the Ambrosia Lake site (Concluded)

Permit, license, or approval	Granting or approving agency	Statute or regulation	Activity
Permit to Appropriate Public Surface Water	Office of the New Mexico State Engineer	NMSA, 1978, 72-5	Activities including the diversion, channeling, or impoundment of surface water.
Permit to Appropriate Ground Water	Office of the New Mexico State Engineer	NMSA, 1978, 72-12-1; also, 6a-3-6	Activities which would withdraw or appropriate ground water.
Approval of drill hole or monitor well plugging	Office of the New Mexico State Engineer	NMSA, 1978, 6a-3-6	Sealing and abandonment of boreholes and monitor wells.
General Construction Permit	New Mexico Construction Industries Permit	New Mexico Construction Industries Act, 1978	Applicable for construction of permanent structures or demolition.